AMERICAN RAILWAY BRIDGES AND BUILDINGS

OFFICIAL REPORTS

ASSOCIATION RAILWAY SUPERINTENDENTS
BRIDGES AND BUILDINGS

COMPILED AND EDITED BY

WALTER G. BERG

Principal Assistant Engineer, Lehigh Valley Railroad
President, Association Railway Superintendents Bridges and Buildings

CHICAGO
ROADMASTER AND FOREMAN
91 93 S. Jefferson St.
1898

PREFACE.

In this progressive age the best results are obtained by applying past experiences to the problems of to-day. The Department of Bridges and Buildings on American Railroads is a very important division in Railway Administration and the only authentic published records of the varied kinds of work coming under this head consisted in the Annual Reports of the Association of Railway Superintendents of Bridges and Buildings, but which were issued each year only in limited numbers and not in desirable form to be of greatest value.

In order to extend the usefulness of this information and make it available to every one interested, we present in this volume all the reports, papers and important information gathered by the Association during the last seven years, all of which has been carefully compiled and edited by WALTER G. BERG, Principal Assistant Engineer Lehigh Valley Railroad, and President of the Association, and published herewith in a form suitable for a handy reference book. The design, we believe, has been fully accomplished, and trust that the volume will be a means of improving the general railway service by improving some of its elements.

B. S. WASSON & Co., Publishers.

INDEX OF SUBJECTS BY CHAPTERS.

CHAPTER I.

CHAPTER II.

CHAPTER III.

CHAPTER IV.

CHAPTER V.

CHAPTER VI.

General Alphabetical Index.

B.

C.

D.

E.

F.

G.

H.

CHAPTER I.*

1, REPORT: PAINTING IRON BRIDGES FOR RAILROADS —2 REPORT: FRAMING AND PROTECTION OF HOWE TRUSS AND OTHER WOODEN BRIDGES AGAINST FIRE AND DECAY—3, DISCUSSION: SUBJECT, FRAMING AND PROTECTION OF HOWE TRUSS AND OTHER WOODEN BRIDGES AGAINST FIRE AND DECAY—4, REPORT: FRAME AND PILE TRESTLES—5, DISCUSSION: SUBJECT, PILE AND TRESTLE BRIDGES—6, DISCUSSION: SUBJECT, THE ADVISABILITY OF SHARPENING PILES BEFORE DRIVING THEM—7, DISCUSSION: SUBJECT, WOODEN TRUSSES—8, REPORT: SURFACE CATTLE GUARDS—9, REPORT: PIT AND SURFACE CATTLE GUARDS—10, REPORT: SURFACE VS. PIT CATTLE GUARDS—11, DISCUSSION: SUBJECT, SURFACE CATTLE GUARDS—12, REPORT: INTERLOCKING SIGNALS—13, REPORT: IRON AND VITRIFIED PIPE FOR WATERWAYS—14, REPORT: WATER-SUPPLY ON RAILROADS—15, CONSTRUCTION OF TRACK TANKS—16, DISCUSSION: SUBJECT, WATER PIPES COMPLETE, INCLUDING PUMPS AND COAL HOUSES.

REPORT: PAINTING IRON BRIDGES FOR RAILROADS.

Iron bridges surely need paint to prevent oxidation, in order to preserve the metal; and the great question is, What paints shall we use? All the iron ore paints contain phosphorus and sulphur, unless the ore has been burned to eliminate those properties; and either sulphur or phosphorus is inimical to iron. Asphaltum paints are usually well supplied with benzine, or some other volatile product, which soon evaporates after it has been spread upon the iron, and leaves a rough surface upon which soot and sulphur from the burning coal in the locomotives accumulate, and with setting of fog and dew upon the iron produces an acid which, by contact with the iron, causes oxidation on the surface of the metal, which causes serious injury to the structure, and very soon requires a thorough cleaning and repainting. Many of the cheaper paints are of a thick, syrupy nature, and require a large admixture of

*Reports presented at Second Annual Convention, held at Cincinnati, Ohio, October, 1892.

naptha, benzine, or turpentine, to let them spread readily. These paints are of short duration, and require such frequent renewals that they become expensive.

I think, on the whole, that pure linseed oil and lead, properly put on, and colored so as not to draw or absorb heat from the sun's rays, make the most lasting paint, and gives the best protection to the iron. In my judgment, all iron in bridges should be first coated with boiled linseed oil. In warm weather this can readily be put on so as to cover all the inequalities of surface; and when two or more pieces are to be riveted together, each surface should receive a coat of paint carefully applied in the shops where the work is being done. Then, when the structure is erected, it should receive two coats of lead and oil paint of some light gray or stone color. And before painting, all places where rust has taken place should be thoroughly cleaned before painting. Experience shows that bridges cared for in this manner have given better results and are really more economical in time than those painted with other than lead and oil paints. G. M. REID, L. S. & M. S. R. R.

REPORT: FRAMING AND PROTECTION OF HOWE TRUSS AND OTHER WOODEN BRIDGES AGAINST FIRE AND DECAY.

In writing on the subject of "Framing and Protection of Howe Truss and Other Wooden Bridges Against Fire and Decay," I know of no better way than that of giving my personal experience. For this purpose, I will first speak of the unprotected Howe truss, and take for reference eight Howe truss bridges that I built in the years of 1883, 1884, and 1885. They average one mile apart, and all span the same stream. The longest span is 158 6 inches, and the shortest one is 89 feet, the average length being 120 feet. Two of the 134-feet spans, built in 1884, were replaced with iron bridges last year. One of the 158 feet 6-inch spans built 1885, and two of the 89-feet spans built in 1883, will be replaced with iron this year. One 89-feet and one 108-feet span are to be replaced with iron next year. The lower chord of the remaining span (158 feet 6 inches long) parted, and a new chord was put in in October, 1889. From this it will be seen that the average life of the eight spans has been seven and five-eighths years, the cause of removal in each case being decay, which affected the lower chords, champs and packers. That the life of these structures would have been lengthened by proper protection from the weather is apparent to all; and the best means of accomplishing this, in my experience, is given in another paragraph.

Bridge Protection from Weather and Fire.—I have watched this very important question with great interest. The custom of housing Howe truss bridges, as adopted by some roads, has proved dangerous, owing to the fact that engines throw fire up against and under the roof. The only practical way, in my opinion, and one in which I have had some experience, is to cover the chord only with galvanized iron, running it under the angle blocks and gib plates. The cost is nominal, taking into consideration the length of life it adds to the structure. I have kept an account of the cost of covering the chords in this manner, and find it to be 11¼ to 15 cents per lineal foot. I have on my line one bridge with the stringers covered with No. 26 galvanized iron. It was put on in 1885, at a cost of 17 cents per lineal foot of the bridge, and the stringers are as good now as when they were put in. I find only one objection to this—the hard oak ties have a tendency to cut or break the iron at their edges.

Concerning the best method of framing and packing Howe truss chords, there can be very little improvement in framing so long as the workmanship is close. In packing I use iron, and would not use anything else, giving this as my reason: Two years ago I removed a 97-foot span, built in 1878, having had a life of twelve years. The chords were packed with wood, and the clamps used were iron. The chords were perfectly sound when taken out, except where they came in contact with the wood packers, at which place they had decayed to a depth of from one to two inches, a condition not found to exist where iron packers are used. The timber used in this span was long-leaf Southern pine. I use it in all cases for my chords as I consider it far better and stronger than Northern pine.

J. H. MARKLEY, T. P. & W. R. R.

DISCUSSION: SUBJECT—FRAMING AND PROTECTION OF HOWE TRUSS AND OTHER WOODEN BRIDGES AGAINST FIRE AND DECAY.

Mr. W. A. McGonagle, D. & I. R. Ry.—I have had but a limited experience on the subject of Howe truss bridges, but could speak a little more on the subject of pile and trestle bridges. The point I want particularly to bring out is the subject of length of span. I think our spans are too long for the loads we are placing on our bridges to-day. I have adopted a span of 11 ft. 9 in. and use 24 ft. stringer, 3 stringers 8x16 under each rail and an 8x16 jack stringer. I use an 8x10 guard rail; I place the ties 6 inches apart. I get very good results in economy of maintenance. Have to do considerable work in repairing bridges built by contract with a 15 ft. 6 in. length of span, and I am thoroughly convinced that is too long a span in the railroad bridge of to-day.

Another point is the number of piles. I don't think four piles are enough for the load that is passing to-day, and I try to place two piles under each main stringer, the point being to divide the blow dealt by the driving wheel. I find with one pile placed directly under the main stringer we get bent caps and broken caps very frequently, but with two piles our results are much better, and I think it is good enonomy to drive at least five and very often six piles to the bent, especially in soft ground. I am driving on all repairs six piles to the bent and get very good results.

Mr. A. C. Olney, Savannah, Florida & Western Ry.—Speaking of pile bridges: The line I have runs from Savannah to Jacksonville and west—a very swampy country. I have been using four piles to the bent and if well driven I have no trouble, but one great trouble exists in the pile machine workmen on a main line. If they start out to drive a pile and the train is due they will saw off that pile, which gives us trouble and causes the cap to break. The way we have been driving is two plumb and two batter piles, and using 10x12 and 6x12 caps, double caps on that line.

Q.—What is the object of your double cap? A.—We have a great many old bridges and in settling all our surfacing is done between two caps. When we go to surface a bridge we have a wedge and drive it between two caps, put in a shim which will run the length of the cap and nail it. Fastened in such a way it gives no more trouble. It is better protection, we think, than putting under stringer.

Q.—In using the double cap, when you first put it on, do you put anything between at all? A.—No shim at all, nothing between. If they should settle then we shim.

I had a good many caps that would rot. I want to bring this up for discussion. I would ask if you have any trouble with your caps rotting. We have had some trouble. The lower caps do rot; have known cases where they bursted before found.

Q.—What size stringer do you use on 10 ft. reach? A.—7x15 double.

Mr. G. W. Andrews, B. & O. R. R.—I am very thankful to say that on the branch of road we have there is no such thing as pile trestles. I want to ask Mr. McGonagle and Mr. Olney what in their experience has been the life of piles?

Mr. McGonagle, D. & I. R. Ry.—In regard to the Duluth & Iron Range road we are using almost exclusively Norway pine piling, and we find the life of the Norway pine pile to be about eight years at the extreme; in many cases we are compelled to renew at the end of six years. In stringers, we find the Norway pine is not at all suitable. It will rot and gives no warning whatever. We confine ourselves exclusively to white pine. We have no oak in our country—oak is very expensive there—an ordinary track tie would cost us 60 cents.

Q.—What is the size of your cap? A.—12x14.

I would like to bring out the point of pile driving as to when a pile is driven. I would like to have the gentlemen here discuss that a little. I talked to an Irishman in charge of a pile driver once who gave me the best answer to that question I ever heard. Asked when he considered a pile driven his answer was, "When it won't go any more."

Mr. A. C. Olney, S. F. & W. Ry.—In reply to the question about life of ties I would state we use cypress from the Altamaha River. It is a spongy wood but it lasts from twelve to fourteen years. We have to drive extra long lengths so we can get good timber to cap on. We have also had some experience with creosoted piles, but at present I am not able to make a report, as I do not think the piles have been in test a sufficient time. Pine timber, if good inspection be made when taken from the woods, will last from six to eight years. We use Georgia yellow leaf pine.

Mr. Joseph Staten, C. & O. Ry.—In answer to Mr. Andrews' query in regard to Virginia pine as a pile, being a Virginian, I think I can give some points on that. Virginia bull pine is perfectly worthless; it is nearly all sap. It will last well for stringer purposes, caps and such as that, but it is worthless entirely as pile, and no pine we grow in Virginia is perfect for piles to be used constantly. We chiefly use a good white oak. Oak will last a long time, anywhere from seven to thirteen years.

Mr. Andrews—When I asked the question I stated we had no pile trestles. I wish to say we have quite a number of piers which I have to take care of, and we have quite a lot of pile driving to do on them. My object in asking is to find out how long they will last. About the time we get our work in good condition tug boats and barges will come in and tear it out for us. Therefore it gives us no chance to know how long they would last, if subject only to natural causes.

In response to Mr. McGonagle's Irish quotation, I would state sometimes a pile won't go any farther for a number of blows, and then one more blow will carry it several inches. That has been my experience in the matter. I have driven pile walls under the inspection of city engineers by contract where we were endeavoring to make just as much money as possible, and when the pile failed to go half an inch or less under two or three blows we always tried to stop. On one occasion the engineer would not allow us to stop, and very much to our dissatisfaction compelled us to give two more blows. The last two settled the pile six inches. Therefore the Irishman's quotation does not answer for all purposes.

Mr. G. M. Reid, L. S. & M. S. Ry.—We have a little experience in pile driving on a great many branches on the Lake Shore three feet longer than the ties. The result was the knocking of the cap down, and the bent fell down, and the supposition is that the track fell down.

I am using some very long cypress piles. I am driving some now on the Little Wabash River 70 ft. long. We had to use them; they are red cypress and expensive, but expect they will last a long time, fourteen years at any rate. White cypress is of no service at all. For stringers, good white pine is good, but for strength—I don't think for durability, long leaf yellow pine is the strongest. As a matter of course they are more expensive and harder to handle, but, at the same time, they are stronger. Am positive about that.

Mr. James H. Travis, Illinois Central Ry.—In regard to length of panel for pile trestle, we have not very many pile trestles on the main line of the Illinois Central, but we have a great many on the branches, and outside of the experience I have had on the Illinois Central, I have had a great deal of experience on other roads, and I am a good deal of Mr. Wallace's opinion, I don't want to cut down to 10 or 12 ft. This might do very well in a country where you have standing water or you might run them in a current, but every bent you get in is both expensive and also takes up that much space of water and air, which you cannot very well get along without in our country—Missouri and Illinois. I think 14 ft. is a very good length, and I think as a general thing you will get a little better material in ordinary 28 ft. stringer than 32-foot stringer. Think there ought to be three stringers under each rail and no jack stringer—I mean by this an outside stringer. I don't think a jack stringer is of any benefit, because I don't believe in using long ties. As Mr. Wallace states, ties on bridges are very expensive—they are short-lived. I think a 10-foot tie is long enough. I think there is better result from the stringer, and the life of the stringer, by leaving the joints open; I don't think it is best to cut the stringers square and make close joints, but I think a half inch opening at the bottom is a very good idea and is of very material benefit to the stringer and the cap. There should be no notching on the stringer; your sizing should be sized to just as near as the timber will work; an 8x16 should be sized to 15¾, then a long shaving taken off; no square cuts on it at all. The ties I think should be treated the same way—they should not be cut. We have been using some 8x8 pine ties and putting them 12 inches from center to center, and they so far have made a very good deck.

In regard to the size of guard rail, in the Northern country we would have to use a different guard rail from the Southern country. They might have a larger guard rail than we could use in the North, on account of snow plow. We have to use a 5x8 guard rail, notched down one inch, in order to give room for snow plows. That is about the standard we use and 14-foot bent.

Q.—How do you fasten your stringers to cap? A.—Drift-bolts.

REPORT: FRAME AND PILE TRESTLES.

Realizing that the subject is a very important one to this association, and to the railway companies whose interests we represent here, the question presents a varied scope, and we can only touch the points that we consider of the most importance to all concerned. To be benefited by our own experience and that of others ha been the aim of your committee. The use of wood in the construction of trestle bridges is pre-eminently an American practice; at least, American engineers were the first to use it in this shape to any extent. The question of the use of wood for railroad trestle bridges is of great importance to the railroad interests of this country and especially to the bridge men in their employ, from the fact that all wooden structures on a railroad are usually designed and erected by the engineer or superintendent of bridges in charge of the work, while a more elaborate, and consequently more expensive, piece of iron work is turned over to and depends upon some expert on the subject.

There are many objections and disadvantages connected with the use of wood for bridge and trestle construction, among which are danger from fire, certainty of decay and of defective timber that is not visible on the outsides of the stick, which involves the expense of partial and complete renewals.

They also require never-ceasing watchfulness, especially after they have been in service from four to six years. The amount of importance that should be given to the evils mentioned, depends on the character of the train service over them, that is, the number and weight of daily trains, etc., the location of the structure as to grade and alignment, and especially does this apply to a bridge situated on a sharp curve in such a position that they are not clearly visible from approaching trains. We find that in the details of construction of both wood and pile trestles on the most important railroad of our country, a great variety exists, more especially in the road ways of floor systems.

The general design of all standard wooden trestles presents a great similarity, the difference in them being in the details of construction.

There are several points upon which bridge men do not agree, among which are the best method of holding together the joints, and the best design for floor systems as regards safety and economy; and we wish to call attention to some of the different methods used in the details of these two points, together with some of the advantages connected with the use of each.

With regard to the details of the joints, the following are the principal methods in use: Mortise and tenon, dowels, drift-bolts, metal plates, and metal straps. The mortise and tenon seems to be the one in most general use, and were it not for the extraordinary cost arising from the use of high-priced carpenter work, and the necessity for the great accuracy in framing, it would be the best method for holding together joints.

There are, however, several serious objections to this method, among which are the liability to rot on account of the mortise offering a receptacle for water, even though drained in a most approved manner. Every bridge man knows from his own experience and observation that the joints, especially where mortise and tenon is employed, decay long before signs of decay are visible at other points. This decay makes the renewing of the timber necessary, and as the balance of the stick is sound, much good timber is lost. This timber can be, and it generally is, used for shorter work, but at a cost nearly equal to new timber. Notwithstanding these defects in the mortise and tenon joint, it is the form generally in use, and will probably continue to be so as long as wooden bridge trestles are used. The advantage of its use are a maximum strength and stability to the structure, which is the point most important in the construction of a good trestle. The best form or rule to be observed in designing a mortise and tenon joint for trestle construction is to make the thickness of the mortise and tenon equal to one-third of the thickness of the timber over all. All of the weight or strain should be carried by the shoulder, and in the case of batter posts, where the timbers are not at right angles, the resulting horizontal thrust must be taken by the boxing or daping of the caps and not by the tenon. One good method of obviating many of the defects in the mortise and tenon joints is by the use of double caps, posts, and sills. That is, in the place of using 12x12 inch timbers, two timbers, 6x12 inches, can be used, and being properly fitted and securely bolted together, not only give good results as to strength and durability, but expose all defects frequently found in the center of large timbers. Also, being of only one-half the size and weight, it can be handled much more rapidly, and consequently much more cheaply, and renders the renewals much easier to get at. Especially is this the case where trains are to be carried during the renewals.

There is no method of constructing train trestles where the economy of renewals is so great as this method posseses, and it has all of the advantages possessed by the ordinary mortise and tenon joint. The second method of holding together trestle joints is by means of dowels: the manner of their use being fully understood by the members of this association, it needs no explanation. This method, although cheap as to first cost, has many objectionable features. First, it does not give a rigid joint, and in the matter of renewals it is seriously in the way of renewing defective timbers where the time between trains is limited, for where a tenon can readily be cut off with a saw, the dowel would have to be cut off with a heavy chisel bar and a maul, or the wood cut away from it sufficiently to release the timber. The third method used is by means of drift-bolts, which act exactly as a nail or spike. It not only prevents any lateral movements in the timbers, but prevents the contiguous faces from drawing apart, by the friction of the wood on its side. Drift-bolts are very much the simplest and least expensive of the various types of fastenings used, and were it not for the same disadvantages we find in the use of the dowel, they would be more universally used. However, this method is very common, and for all temporary work is the best and the most rigid manner of securing a strong joint at so slight a cost. The fourth method, that of using bent metal plates, has given very good results. These plates are made of thin boiler-plate iron, generally one-fourth of an inch in thickness, cut and bent with flanges in opposite directions at right angles to opposite sides of the plates, one set of flanges engaging the cap or sill, and the other set engaging the posts of the trestle bent. They can be rapidly and cheaply made to suit any sized timber and at any angle at which the timber meets, leaving but little work to do in the field—that of squaring the timber and sizing it down to fit between the flanges on the plates, and spiking them in place. This method produces a joint of considerable strength, and is free from many of the objectionable features found in the dowel and drift-bolt joint. The fourth plan is that of using bent metal straps, usually called pile straps, being straps about ½x2½ inches by 5 feet in length, bent to engage the trestle caps or sills with legs 2 feet in length on either side of the post, and secured with heavy spikes to the cap or sill and posts. This fastening, for pile trestles more especially, is being used by some of the best railroads with good results, and being easy to remove in case of defective timbers, it is considered a good device. In its use in securing the caps of the pile trestles, the piles, after being cut off to receive the caps, should be squared or sized down to fit snugly the daping or boxing in the lower side of the caps, which should be made at least one inch in depth. No dowels should be used except in case of a refractory pile which could not be held in place without them. This plan of securing the caps for pile trestles bent makes a secure joint, and admits of easy and speedy renewal of timbers when renewals become necessary.

One point that should receive the most careful attention in the designing and construction of a trestle is the matter of sway and longitudinal bracing. Great care should be taken in having the braces sufficiently large to insure them against springing or buckling under heavy strains, or from the impact of having heavy trains passing rapidly over them. Particular attention should be paid to the manner of securing them to the caps, posts, and sills of the trestle bent, more especially those situated on sharp curves, or heavy grades, or on high and important trestles. The best method of securing them is by the use of bolts of sufficient strength, say three-quarter inch round bolts, with cast-iron headers and washers and a good nut lock. This manner of fastening, if properly tightened, will insure a rigid structure so far as the bracing is concerned.

The weak point in most trestles and bridges is the floor system; the track stringers are often too light and the ties too small, and the arrangement of the ties and guard rails faulty. There are a number of types of stringers in use, among which is the single stick stringer without corbels, and the same with corbels, the packed stringer, with and without corbels, and the stringer built of timber in two or more thicknesses lapping over each other and passing across the caps, generally called the lap stringer. The first three types named are made in both single and double length, that is, to cover one or two panels or spans of trestle. A stringer composed of two or more pieces of timber of sufficient section to carry the engines and the trains in use on the road where it is employed, properly packed with cast-iron packing-blocks of not less than one inch in thickness, made as light as possible, and well provided for drainage, with corbels of the same size laterally and 12 to 14 inches in depth, the stringers to cover two panels or spans, all secured with bolts of proper size, is, in the opinion of your committee, the best wooden stringer that can be made. This plan makes it possible and practicable to break joints thoroughly and make a stringer of any desired dimensions or length and strength. One joint only should come upon each cap in the stringer; the panels, when it is practical to make them so, should not exceed 15 feet in length. An outside stringer of one-half the size of the track stringers should be used in all first-class work. This stringer should come directly under the modern guard-rail, and the guard-rail bolts should pass through the guard-rail tie and outside stringer when it is practicable to place the guard-rail directly over the stringer—this, in case of derailment, offers a substantial floor to carry the derailed engine or train over the structure. The dimensions of the strings can easily be determined when the length of panel or spans and the weights of engines used are known; a strong factor of safety or excess of strength should be used.

Serious mistakes are often made in making the ties too small and placing them too far apart, and they are frequently too short;

the great object for which ties are used being to provide a floor of sufficient strength and width to support and carry a train in case of a derailment on the trestle or bridge, or one running over the roadway that had some of the wheels off before reaching the trestle.

Rails could be supported and carried and held to gauge at much less expense than by the use of cross ties. No pains should be spared to answer the purpose for which they are intended. A good re-railing device, placed from 100 to 150 feet from each end of a bridge or trestle, will often prevent any wheels or trucks of a train being off the rails when a bridge or trestle is reached. Of this device we will speak later, but in order to reduce the danger of derailment to a minimum, the floor of the bridge or trestle should be so constructed that the wheels, even if not upon the rails, can run over and across it, and by a good guard-rail and strong ties placed at the proper distance, will not get too far from the rails and allow the trucks to slew across the track.

To this end the ties should not be exceeding 6 inches apart in the clear, and should be large enough to withstand the blows they will receive from the wheels passing over them. They should not be less than 8 by 9 inches, and not less than 12 feet in length.

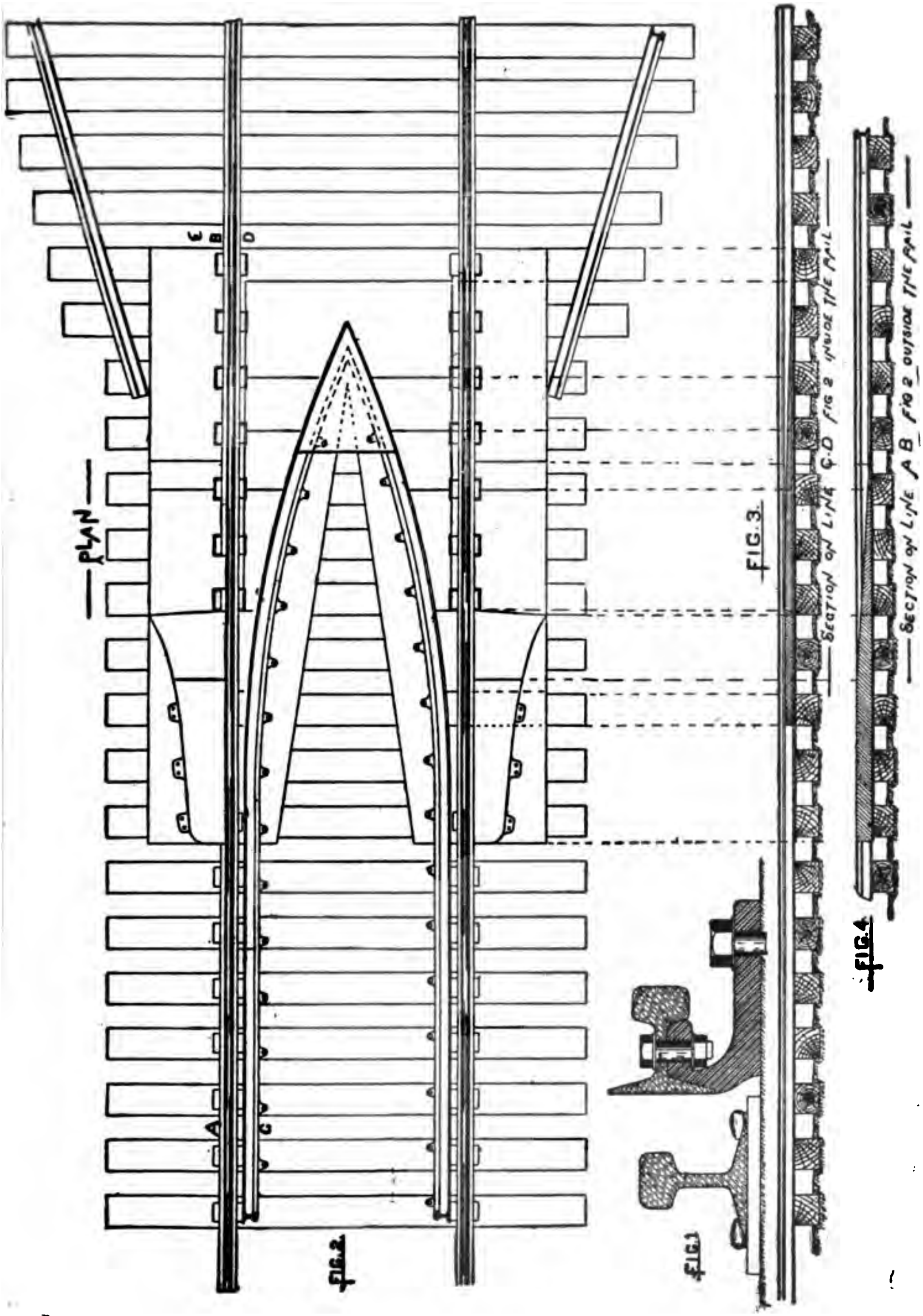
The holding of the ties in place is a matter of great importance, especially to prevent them from bunching in case of an accident to the trestle. For this purpose the guard-rail (which should not be less than 8 by 10 inches in section) should be notched down 1 inch over the ties, and bolted through the guard-rail tie and outside stringer, as before mentioned, every fourth tie. These bolts, like the bolts for sway and longitudinal braces, should be carefully watched and kept well tightened up, thus making a roadway rigid and strong.

The importance of a practical and efficient device near the approach of every bridge and trestle to prevent injury to them from the derailment of cars or engines, is of the utmost importance.

A re-railing device for this purpose, to be effective, must meet certain general conditions, which are as follows: It must be so constructed that it cannot in any way or manner cause a derailment, and for that reason there should be sufficient room for the full passage of wheels of any kind and any construction. It must not come in contact with the weak points of the derailed car, but with the wheels only. It must guide the wheels of a derailed car or engine back upon the track in the shortest possible space, without offering any sudden or severe resistance to the running gear. It must be constructed of durable and strong material; and in a manner that will insure it against destruction when it is brought into use. It must also permit of tamping the ties. It must be simple in design and easily repaired. When necessary, it must be so constructed that it will not require the cutting away and weakening of the ties on which it is placed. A bridge guard, or re-railer, of this description, or one offering all of these requirements, would be a great factor of safety for the protection of bridges and trestles. Several plans for that purpose have been furnished your committee, among which is one used by the Netherland State Railroad. Following is a description of this device:

Seven ties are placed in a thick bed of large gravel or broken stone, and on these are placed a floor of steel plates fastened to the ties by bolts. The re-railing apparatus is mounted on this floor. The plates outside of the rails can easily be removed when the ties are to be tamped. The derailed wheels are gradually brought up to the height where they take the rails again by the inclined planes, outside and inside of the rails. These planes are formed by blocks attached to the plates, the thinner ones being forged and riveted, the heavier ones being bolted. These are shown in section in Figures 3 and 4. Three is a section on the line C D, Fig. 2, inside of the rail, and Fig. 4 is a section on A B outside of the rail. A derailed wheel which strikes this plane between the rail and center and the center of the track running from D toward C on the flange of the wheels at the points where the horizontal distance, Fig. 2, between the rail and the guard-rail, becomes too small to admit the passage of the widest tires, say 6 inches, is already at the top of the inclined plane, that is, about seven-tenths inch below the top of the rail. As the depth of the rail flanges never vary from 1 inch to 1⅜ inches the tread of the wheel will be at least two-tenths inch above the top of the rail. The plane then descends slightly, as shown in Fig. 3, until the tread of the wheel begins to bear on the rail. On the inside of the rail the blocks are from 2 8-10 to 4 inches from the rail, so as to give free passage for the flanges of those wheels which remain on the track. A derailed wheel which reaches the apparatus outside the rails, rolling from B toward A, will mount the plane traveling on the flange.

The summit of the inclined plane might be the same height as the rail if it were necessary to provide only for new rails and new tires and wheels, but to allow for worn rails and tires it is made seven-tenths inch lower than the top of the rail. In a horizontal position one wheel on each axle of a derailed car is directed toward its rail by a guard-rail which ends in a point in the center of the track, as shown in Fig. 2, and which is to meet conditions. No. 4 is carried the whole length of the bridge, leaving a space of 2 8-10 inches to permit the passage of wheel flanges. This guard-rail is composed of old rails bolted to chairs, as shown in Fig. 1. The points of guard-rails are joined by heavy plates. In view of the space allowed and the maximum wear of rails permitted, the top of the guard-rail is 1 7-10 inch above the top of the rails.



FIGS. 1 TO 4—BRIDGE RE-RAILER, NETHERLAND STATE RAILROAD.

At the point it is brought down to 4 inches below the top to meet condition No. 2; in case a car is so far off the track that one of its wheels would strike the re-railing apparatus beyond the center of the track, the tendency would be to throw the car entirely off the rails. To avoid this, which cannot often happen, there are placed outside of the tracks two rails which incline like the mouth of a funnel, as shown in Fig. 2, which guide the wheel in the desired direction so that it will strike the guard-rails and be returned to its own rail.

H. M. HALL, O. & M. R. R.
W. A. M'GONAGLE, D. & I. R. R. R.
G. W. M'GEHEE, M. & O. R. R.

DISCUSSION: SUBJECT—PILE AND TRESTLE BRIDGES.

Mr. W. F. Pasco, Lehigh Valley Railway—I have heard the question of span discussed; some approved of a span 16 feet long, some of 14 feet, some of 10 feet, some of 11 feet 9 inches and some 12 feet. What I wanted particularly to ask of the gentlemen on the subject was how they determined the length of their span? Why they made it 14 feet, why 16 feet and why 12 feet, and why they used 8x16 or an 8x15 stringer? Another thing, this gentleman of the Iron Range Road is a great believer in a six-pile bent. I cannot see any good reason for using a six-pile bent; think a four-pile bent will give all the satisfaction we could possibly ask of a pile bent. I have had considerable experience in trestle work and I have never had any bad result from a four-pile bent. I would like the gentlemen to take up this question and would like to hear from them in reference to why they have such variation of span. Hardly think the question of economy should figure in against the question of safety.

Mr. J. E. Wallace, Wabash Railway—My idea is that if the piles are driven well, as they should be, of the proper size—they should be over 12 inches at the small end—good white oak is the best (if you cannot get that take what you can), a 16-foot panel is safe, from the fact if you take the length of your locomotive and the length of your cars, you cannot get it all on one panel, on a 12-foot panel. You can get the weight of a pair of trucks, but for a 60,000 capacity car, overloaded, as they usually are, there is both safety and economy in a reasonably long panel with sufficient stringers. The bigger the spans in driving the piling and making the bents, the safer. Then if there is a waterway you have more waterway and less liability to washouts.

Q.—What is the wheel base of your engines? A.—The wheel base of our ordinary passenger engine will cover one panel, that is, the drivers won't, but the weight does not come all on the drivers.

Q.—You have no engine whose wheel base is shorter than 16 feet. A.—No, sir.

Mr. A. C. Olney, S. F. & W. Ry.—There is just where I wanted to get the discussion—between four and six piles to the bent. If I am not mistaken, Trautwine, with which I think you are all familiar, says a pile well driven will hold up 48,000 pounds. Now if one pile will hold up 48,000 pounds, what we want to get is enough support or foundation to the center of that panel to hold the bridge and train with a good allowance for safety on account of decayed timber, and according to my figures, four piles will furnish sufficient for that with a good allowance of safety.

Mr. G. M. Reid, L. S. & M. S. Ry.—There is in our city a swing bridge that stands on masonry, in which every pile in the substructure is loaded with a load of 40,000 pounds actual weight. That bridge is turning ten, twenty and thirty times per day. That is the Cleveland viaduct bridge.

I drove four piles in a marsh in the form of a square and put a rope on them to hoist an engine out that had gone through an opening in a drawbridge, and we had to put the load on two of them. We put block and tackle on them, and put two engines to that load and pulled a thirty-five-ton engine out. We had the weight of the engine and the suction of the mud to contend with. The piles carried it handsomely; did not overstrain them at all. On the Lake Shore & Michigan Southern Railway we use white oak piles. We find good, sound, straight 10-inch timber at the small end and not less than 14-inch timber at the butt, for all piles up to 25 feet. I have not been troubled with piles settling except where they have been driven into soapstone bottom. Four piles ought to carry any engine on the Lake Shore or any other road.

Mr. J. E. Wallace, Wabash Ry.—I would like to get an opinion as to what is the greatest strain that ever comes on a pile where it has been driven.

Mr. G. M. Reid, L. S. & M. S. Ry.—I have a pile hammer that drops forty-one feet when the pile gets down near the track. The hammer weighs 2,365 pounds. It strikes a blow of fifty-three tons on that pile.

Mr. J. E. Wallace, Wabash Ry.—It is very evident that is the greatest weight that could be brought to bear on that pile.

A Member.—Mr. Travis asked a question in regard to the breaking of piles on trestles. I have had experience in driving piles which brought up on solid rock, on which we had a white pine cap, and 15-inch beam stringer, and know several of the piles have been found broken off. I have also had experience with a double cap, not a cap dapped on each other, but a cap bolted together, or two caps for the purpose of having the spans mortise and tenon, and have had these break. This is the only experience I ever had in the breaking of any part of the trestle.

Q.—How deep in the ground were they broken off? A.—About six feet below the bottom of the girder.

Q.—Do you think they were broken by the weight of the moving load over the structure? A.—I do, by the pounding on the iron rod on top. We had no corbel and had to use a cast iron plate on top of cap, and the pounding on that broke those piles; they broke off at an angle.

Q.—Do I understand you to say they were driven to rock foundation? A.—Yes, sir.

Q.—Don't you think there was such a chance as fracturing that pile in driving? A.—It ought to have shown before it did. It was nearly three years after driving that the pile broke. There might have been such a thing as a fracture; the timber might have lost some of its life. I could not see any indication of an old break, but all the indications of a new break. The cap was not broken in that trestle; that was in another trestle.

Mr. McGonagle, D. & I. R. Ry.—In support of my statement I do not consider four piles sufficient for a pile bridge. I shall say I do consider that four piles will hold up a load, but I regard a bridge with four piles in the bent as being acted upon constantly by a pile driver in the driving wheels of the locomotive, and it has been my experience with this constant action that the center piles must be driven harder than the outside piles. I use a wide deck bridge. I can readily see that on roads with a narrow deck four piles would be sufficient, but with a wide deck bridge I consider it absolutely necessary.

Q.—How far do you drive your outside pile between stringers? A.—We drive a pile on each side of stringer, and in all renewals just outside of guard rail and then draw it in three or four inches. We use a 14-foot cap.

Q.—What do you mean by a wide deck bridge? A.—12-foot ties.

Mr. McGonagle, D. & I. R. Ry.—I think you can figure out the theoretical strength of piles and have it tabulated and allow a large factor of safety and then not have a practical result. That has been my experience. You must take experience rather than theory.

Mr. J. H. Travis, Illinois Central Ry.—Has it not been practically accepted that a pile driven say in good soil to a depth of 15, 16 or 18 feet will bear one ton per foot of the pile driven? That has been the theory I have worked on, received from the experience of very prominent engineers. Good strong material well driven, say a pile driven 16 feet, will carry that many ton. If driven 16 feet in good soil it does not settle, that is sufficient evidence it has been well driven. That would be sixty-four tons to the bent of four piles each. That would be giving us a big factor of safety over anything we can possibly get with our heaviest and largest engines.

Again as to strength of pile, the heaviest weight I consider we ever get on a pile is a tank foundation. For instance take a tank foundation supporting a timber tank, 16x30, and we have about 84,000 gallons of water, have close on to 100,000 pounds on each pile. Now there is a case of dead weight; and I have been on roads where we have had in all not more than two or three stone foundations on the road. I believe Mr. Stannard has very few stone foundations, and has never had any difficulty in piles settling. This is pretty good evidence four piles is sufficient with at least 50 per cent of safety. That is a pile of the dimensions as stated by Mr. Wallace.

Mr. Pasco, Lehigh Valley.—I would like to ask some of the gentlemen what method of inspection they adopt in regard to high trestles, and how often they inspect trestles?

Mr. Wallace, Wabash Ry.—Trestles on the Wabash road we are supposed to inspect and do inspect once a month. Our method of inspection, when we have any doubt about the timbers being sound, in the high trestles, we bore where the intersections come. If there is any decay it would likely be at that point. Each pile is inspected from top to bottom in each and every bent.

I have 672 miles and have an inspector, and each foreman is supposed to inspect his own territory and is supposed to be continually on the road.

Mr. Pasco, Lehigh Valley Ry.—I would like to ask Mr. Wallace what method of record he has for keeping the inspection?

Mr. Wallace, Wabash Ry.—Blanks especially for that purpose on which the inspectors report. In addition to that, if there is anything that is extremely likely to give trouble, I go myself; that is, provided it is something of great consequence and cost a great deal of money.

Mr. A. E. Olney, S. F. & W. Ry.—Speaking of the subject of inspection, I guess our system has gone into it more than any other road I know of. The road and bridges are inspected twice a year by an inspector. Every piece of timber is inspected at the top by an ax made for that purpose. It is an ax with a ball at one end and something like an adze at the other. With that the inspector notes the sound of the timber. He also has in addition to that a long steel bar. It should not be over ⅞-inch in diameter, of very good steel and sharpened at the point. At the end of this bar there is also a ball for sounding. Then he has a hatchet. If a piece of timber sounds defective he has three methods of getting into it. By throwing the bar at it, javelin fashion, if decayed enough to come out the bar will go through the shell and go into the heart, and you can detect it very quick. Every piece of timber is thus inspected. I am speaking of trestle bridges now. Stringers are all inspected at the ends and the ties are punched—guard rails the same.

We have a book that has in it in a form: the number of the bridge, the number of miles and the number of the bent, and then come the piles; we allow for so many piles as we drive upon that road; then the sills, posts, caps, stringers and so many ties. Every bent is numbered. The inspector has a record to keep. If the timber he examines is sound he writes the letter "S." If in his opinion the timber is sufficiently decayed to come out in six months he puts a cross with a 6 under it. If the timber need not come out in six months and can last a year he writes "1." Then he makes out from his permanent record the defects, and these are in turn sent to the supervisor, who orders the timber for this placed on the bridge. This enables the road to find out how much timber will be required for that year in each bridge. That permanent record is sent in, and in case of any trouble to the bridge, it can be used in court. There is the condition of that bridge in black and white. In turn, the bridge foreman goes over the bridge and so does the supervisor. He re-inspects this work of the inspector, and takes out this defective timber and signs his name, which is also put on the records. When the time is up for this paper to go in, it is sent to the inspector, who goes over and re-checks everything, and studies and examines the bridge in every way. In this way he comes in contact with every bridge foreman and knows just how everything is. It then at last goes to the vice-president. Of course, there are some flaws in this system—it is a little technical—but I have worked under it for five years and I think it very good.

DISCUSSION: SUBJECT—THE ADVISABILITY OF SHARPENING PILES BEFORE DRIVING THEM.

The general opinion on this question seemed to be that the practice should be governed by the circumstances surrounding each individual case; that in driving piles through gravel they should be sharpened, but where close to a strata of rock or through earth not containing obstructions, square-ended piles could be driven just as readily as those which were sharpened and would give better results after being in place. It was stated that sharpened piles in coming in contact with large stones and obstructions of such a character would become bushy and form a poor footing.

Mr. J. H. Cummin, of the Long Island Railway, stated that the usual practice on his road was to put in all piles with a pile driver under track work. Along the coast where the ground consisted of sand a water jet was frequently used for piles under buildings and piers without tracks.

DICUSSION: SUBJECT—WOODEN TRUSSES.

Mr. Shane, of the C. C. C. & St. L. R. R., thought many of the important points in connection with the construction of wooden trusses were entirely matters of judgment, and that many of them were controlled by a standard for the road established by the engineer and therefore out of the jurisdiction of the bridge and building department. Regarding the corbel, he was opposed to its use, as he believed that the less material in the joints the better, as an increase in the amount of material tends to increase the rapidity of the decay.

Mr. Markley, on the subject of the best style of stringers to use, said that his road was using a white pine stringer 6x11 inches, 14 feet long. They had found serious objection to the use of long stringers, as it was generally found that one end of such timbers was not free from sap. In addition to this objection, the first cost of the long timbers was very much higher than the short ones. He also stated that the C., B. & Q. railway had been using this same type of stringers ever since the establishment of the road, and they were able to keep them in use from ten to twelve years, which was a longer time than long stringers could be made to last.

Mr. H. M. Brient, of the E., J. & E. Railway, stated that they have a very heavy traffic, and the stringer used was of white pine, 12x12 inches, the caps 12x12-inch white pine, 14 feet long, the ties of oak, and spaced 14 inches between centers. They do not use the corbel, and provide all bridges with ample lateral bracing.

Mr. J. T. Carpenter, of the C., N. O. & T. P. Railway, stated that the best deck for bridges he had ever seen was built with caps 12x14 inches, 10 feet long, stringers consisting of three 6x16-inch timbers, 30 feet in length, panels 15 feet long, with the stringers fastened to each cap by the use of two bolts. He objected to the use of drift bolts, as they were hard to get out. The three members which form the stringers were packed with the joints broken, the packing consisting of cast-iron rings, with 3-4-inch bolts, and either cast-iron or cut washers under bolt-heads and nuts. The outside stringer was dispensed with, and ties used were nine to ten feet long, with a bolt through every fourth tie. The deck was independent of the stringer, and a guard-rail 5x8 inches placed inside each track-rail. The ties 6x8 inches, and spaced with 6 inches between them, the track stringers to be covered with No. 16 galvanized iron, in sheets 30 inches wide, fastened with heavy nails, to prevent their creeping, as otherwise they would creep. Mr. Carpenter also said that he believed that long-leafed yellow pine would last much longer than oak; that it was good practice to dress timber all around, as it greatly decreased the amount of work necessary in erecting, and he did not believe in the use of corbels at all.

Mr. J. E. Wallace, of the Wabash Railroad, felt perfectly satisfied that the corbel did not strengthen a stringer. The practice of his road was to use ties 7x7 inches, 12 feet long, every fourth or fifth tie being 7x9 inches and fastened to the stringers; first being dapped down to bring the top sides level, the panels were made 16 feet in length.

Mr. Aaron S. Markley, of the C. & E. I., stated that his company had been using the corbel for fifteen years; their stringer was 8x16 inches and the corbel 8x10 inches, and they believed a stringer would last from 15 to 20 per cent. longer with the use of the corbel than without, for the reason that with its use a timber can be left in place after the end has become quite badly decayed. The guard-rail used by this company was 5x6 inches, and bolted to every tie. He stated that he did not believe in the use of a tie over 9 feet in length, as when a wheel once got off the rail a tie 12 feet long was no better than one 9 feet long.

Mr. G. W. Andrews, of the B. & O., stated that his company was using steel bridges almost exclusively, but that on some of the branch lines wooden bridges were still in existence and being kept in repair. The deck used consisted of stringers 8x16 inches, 25 feet long, two pieces being packed together with joints broken, the packing consisting of a block 1x6 inches, yellow pine, with 5-8-inch bolt and cast washers. The ties were 8x8 inches by 10 feet, spaced with 12-inch centers, the guards 6x8 inches, placed 10 inches from the rail, and bolted to every fourth tie with 5-8-inch bolts. The corbel is never used except in spans of from 18 to 20 feet or over in length, in spans of which length they have found that the deflection was decreased from 25 to 30 per cent. by the use of the bolster.

Mr. J. M. Statten, of the Chesapeake & Ohio, said that the deck used by his company consisted of stringers 9x16 inches by 25 feet; the ties were 8x8 inches by 10 feet; the guard-rail 8x8 inches by 20 feet; placed 16 inches from the rail, and bolted to every fourth tie. The ties are spaced just 4 inches between, instead of making the space from the centers. The stringers are in 25-foot lengths.

Mr. C. B. Keller, of the Big Four, stated that his company were using stringers 8x16 inches, in 30-foot lengths, three-ply, ties, 6x8 inches by 9 feet, the guard rail 5x8 inches and bolted to each tie.

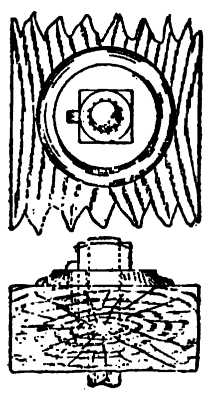


FIG. 5.—SLOTTED CAST WASHER.

Mr. Carpenter, of the C., N. O. & T. P. Ry., stated that he had great difficulty with the dropping out of bolts. It was customary to put the nut on the upper end of the bolt, and these nuts would become loosened, come off, and the bolts drop out. He had instructed the men to bend the bolts slightly before they were placed in position, so that it would be necessary to drive them home with a hammer, and when the nuts came off the bolts would not drop out and be lost. Several members stated that they had been using the slotted cast washer to prevent this trouble, and that in all cases its use had been very satisfactory. This washer is constructed in the manner shown in Fig. 5.

It is provided with a slot extending from one side of the hole, and, after the nut has been screwed home, a nail is driven through the slot against the side of the nut. This prevents the nut from turning, making a simple and efficient nutlock.

REPORT: SURFACE CATTLE GUARDS.

As a member of your Surface Guard Committee, I will say in my experience I have not found a perfect surface guard. The very many different styles of metal guards make it quite difficult to give, without a long series of trials, an emphatic decision on the subject. I think that less improvement has been made in perfecting a surface guard than any other branch of our work. I am inclined to give favor to wooden guard, with end sills, solid stringers, 6x8 ties, and guard rails; they are cheap, and will last from six to twelve years, and in cases of derailment of trains are not usually destroyed. While metal guards are more expensive, and in cases of bad derailment are totally destroyed, they are made of light material, and in a few years would, I think, rust away unless carefully preserved with paint. A perfect metal guard would be of great advantage to our department, and I would be pleased to know that one had been made that could be universally adopted.

W. R. DAMON,
L. E. & St. L. R. R.

REPORT: PIT AND SURFACE CATTLE GUARDS.

While this is a very important subject, and one in regard to which there seems to be a great diversity of opinion with the management of many of the roads in the country, I will, for my present purpose, designate them as two classes, namely, pit and surface guards.

There are many different methods of construction of each of these classes, but without going into the details of any special plan or patent I will confine my remarks for the present to the general merits of each class, and in doing this would say, that while the old pit guard is undoubtedly very effective in turning stock, there are also some serious objections to its use, some of which I will state as follows, namely:

Any opening in the track is more or less dangerous, as in the event of any derailment of cars it is liable to cause a serious wreck, which, were it not for the opening, might otherwise by very trifling.

There is also the difficulty that the pit cattle guard will not settle evenly with the other part of the track, so that unless it is carefully watched by the section men, and the track kept tamped up to it, it is liable to cause further trouble, and when repairs or renewals are needed it is necessary to furnish special material and send higher-priced men to do the work.

In the use of the surface guard, all these difficulties are avoided, and at a special test made about a year ago, at Brightwood, on the C., C., C. & St. Louis Railway, it was demonstrated that their effectiveness in turning stock compared very favorably with the pit guard.

I do not wish to espouse the cause of any special make of surface guard, as there are now several very good kinds in the market, and I do not know that even yet the greatest degree of perfection has been attained, but the surface guard has the advantage of affording the greatest security for travel, is more easily taken care of, and, I believe, forms the safest, best, and cheapest cattle guard.

J. B. MITCHELL,
C., C., C. & St. L. Ry.

REPORT: SURFACE VS. PIT CATTLE GUARDS.

In my estimation there is no barrier to stock more complete than the pit cattle guard, constructed of 6x8-inch ties, 9 feet long, edgeways, well chamfered with 12-inch stringer, and wall plate, making the pit 31 inches deep, with fences running parallel with track the length of the guard. No stock will attempt to cross them, unless forced to do so, they being 8 feet long. We have used them for the past fourteen years, and in that time I am unable to recall a single instance where stock has crossed over them voluntarily. The pit in itself is a horror to stock.

These guards at first cost $14 for material and $5 for labor, making a total of $19; for renewals, $16. They can be framed by skilled labor in yards, and sent out to where used and put in by

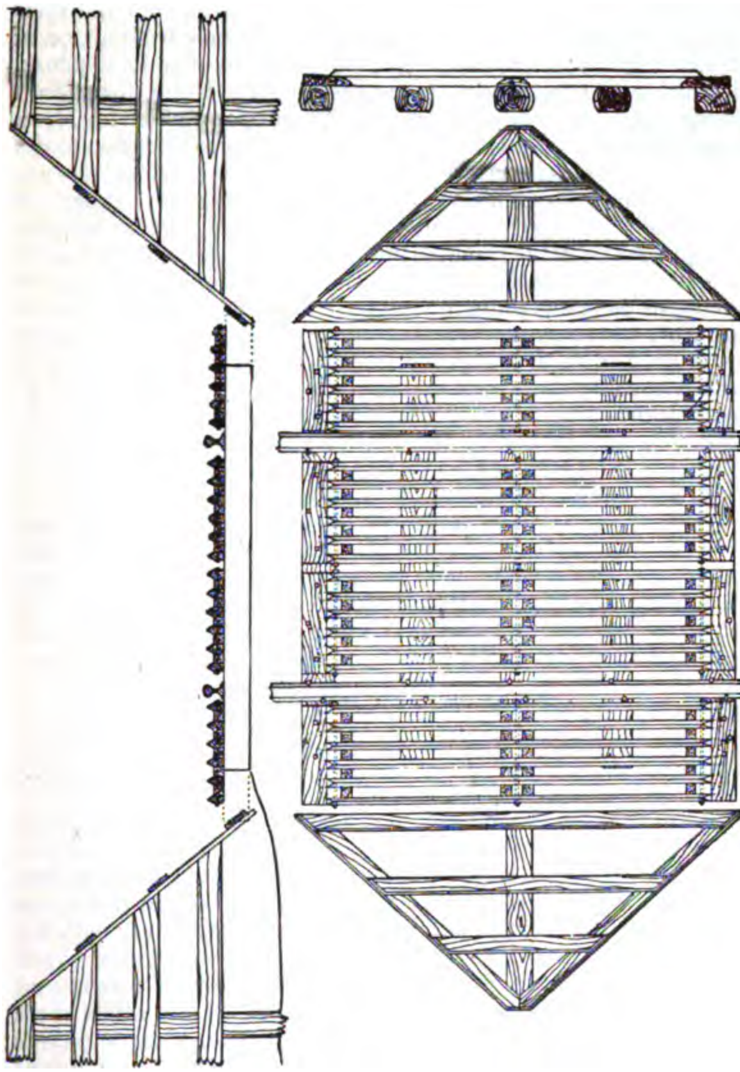


FIG. 6.—WOODEN SURFACE CATTLE GUARD.

common section labor. In cases of derailment, trains will pass over them without damage to cars or structure. The principal objection to these guards is the expense to drain in cuts and their surface in cold weather. In some cases tracks heave from action of frost, making it necessary to keep them surfaced at some expense, during the winter season, in some cases only. None of the iron or surface cattle guards have attained the proper barrier for stock to make them the success and do the work they are designed to do.

Some of them are nearer perfection than others, but do not serve the purpose completely. It is true they overcome one serious objection of the pit guard, the heaving or uneven surface, in cold, freezing weather, in the track. But, in case of derailment, the damage to surface guards is more than that to pit guards, the cost of surface guards being on an average of about $25, against $19 for pit guards. The proper maintaining of surface guards requires them to be painted at least every three or four years, at a cost of twenty-five cents each, and the liability of brake rods and other fastenings dragging and hanging from passing trains, threatens their destruction, which is of quite frequent occurrence. In my judgment, I fail to see where there is any economy in a financial point of view in the adoption and use of surface guards.

In the maintenance of the pit guards, the wall plates last twenty years, stringers ten, and ties eight years, making their maintenance more economical than the patent iron surface guards, notwithstanding nearly all the roads have adopted one kind or the other of the iron cattle guards, and are using them, with the impression that they are the cheapest and best.

AARON S. MARKLEY, C. & E. I. Ry.,
Chairman.

DISCUSSION: SUBJECT—SURFACE CATTLE GUARDS.

Mr. A. Shane, of the C., C., C. & St. L., expressed himself as strongly in favor of the surface guards, and as his reasons said that these guards were much easier kept in repair, and the original cost was less than that of a good pit guard. He also stated that those connected with the bridge and building department were very apt to lose sight of the great dangers in the use of the pit guard which were presented to trains in case of derailment, for the reason that the damage caused to locomotives and trains did not affect them directly, while the keeping in repair and putting in of cattle guards was a portion of their work, and matters which were unimportant in connection therewith would naturally assume an importance which was fictitious.

Mr. C. E. Fuller, of the Terre Haute & Indianapolis road, stated that he had just completed his forty-fifth year in the railway service, and most heartily agreed with Mr. Shane in the belief that the surface guard was the only proper one to use. One of the great difficulties he had in keeping pit guards in proper shape was in keeping the ties from bunching. Great care should be taken in the manufacture of surface guards, to see that the construction was such that parts dragging from passing trains would not catch and tear the guard out of place. In speaking of the objection which had been raised to the expense of keeping surface guards properly painted, he stated that it would not cost $10 to paint and replace a surface guard, and that in all cases where it was not necessary to use the cattle guard as a waterway, the practice with his road was to use surface guards exclusively.

Mr. Shane, C., C., C. & St. L. Ry., stated that where he found it necessary to construct a waterway in connection with a cattle guard, he used thirty-six to forty-eight-inch pipe for the waterway, and placed a surface guard above the pipe; in addition to having a much better guard, the waterway given by this construction was superior to the customary ditch, as, while it might not carry off an equal amount of water, the liability to become clogged up was very much less.

Mr. Quintin McNab, of the Cleveland, Cincinnati, Chicago & St. Louis Railway, agreed with Mr. Shane in both the use of the pipe and also the surface cattle guard, and also stated that it was important in ordering a guard to provide for any extension which might become necessary in putting in additional tracks. The surface guards would be much more efficient if they were constructed less rigidly than is customary, as all stock were reluctant to place their weight upon any yielding surface.

Mr. J. H. Markley, of the Toledo, Peoria & Warsaw Railway, stated that in the past year they had renewed the ties in half of the pit guards on their roads and put in new stringers. He figures that new ties will increase the life of one of these guards ten years: the cost from the time of putting in till worn out is from $40 to $45 each, which in his opinion is more than a good guard should cost. Another great trouble with this guard is, he states, in keeping up the ends. His company was now using the Shorthill guard, and found it very satisfactory in every way; that the original cost was very little more than that of a pit guard, while the cost for maintenance was much less, and a small consideration.

Mr. Aaron S. Markley, C. & E. I. Ry.—We have had occasion to try a number or nearly all of the surface guards now in existence, and so far we find they will not and do not turn stock.

Mr. McGonagle, D. & I. R. Ry.—I will give my experience on the subject of surface cattle guards. We are using the National on the Duluth & Iron Range R. R., and I find it almost an absolute failure. I am not in favor of the pit guard at all, but I do believe something better than the National surface cattle guard could be placed on railroad tracks. I have as yet been unable to find anything to give satisfaction. Have examined all and tried a number of them, and we have yet to get something that will turn stock.

Mr. J. E. Wallace, Wabash Ry.—I am somewhat of the opinion that cattle guards of all descriptions are not a success in every case, but that the safest guard we have is the surface guard. It will probably turn stock as well as the pit guard and in the event of cattle getting on it, it does not make a wreck; it is not so liable as the pit guard. It is possible there could be something better introduced than we now have, but I think the surface guard is the safest, and possibly answers the same purpose as the pit guard.

Mr. Jas. H. Travis, Illinois Central Ry.—We have had quite an extensive experience with surface cattle guards of various kinds. We have not such great fault to find with the surface guards in turning stock, but we have considered the first cost of them and the damage by broken beams or rods or anything that may come in contact with the iron surface guard. These will tear it to pieces and it becomes almost worthless. Probably you can make repairs, but if you do it is very expensive. We are not using any more iron cattle guards; have not put in any more this year; but have adopted instead, wooden surface guards, made of 2x4 oak slats, in the same manner as angle bar or any other shape the iron guard is made out of; putting them together in four sections similar to the sections of an iron surface guard; bolting them together with three ⅝-inch bolts and fastening at the ends with a piece 2x6, beveling to correspond with the angle that the end of the bar is cut to; fasten one end with lag screws and the other with spikes; spike one down and slip in the guard under that end that is spiked and put in some lag screws. In case of a broken beam the section foreman may have a few extra bars on hand, and he can take it off and put in a new bar, and put it back again. These guards are made at an expense not to exceed $7.50 each; that is, unless you have to do the beveling by hand; in that case they would cost more. If the car shops or bridge department have a saw mill of their own, or a little table saw, they can make them for $7.50. We have had about 300 made in the last three months and they have given entire satisfaction. (Fig. 6.) I am very strongly opposed to any shape of pit cattle guard. Have had very favorable results from wooden cattle guards; think they turn stock better than iron. The Chicago & Alton and the C., M. & St. Paul are using this same style of guard. I believe I would recommend they be painted white, as I think it would give good results.

Mr. S. F. Patterson, Concord & Montreal Ry.—The remarks just made are very much in line with my ideas of cattle guards, and our road makes them in a very similar manner to that described. I think the white place is quite a scary thing for cattle. I think they wear very well and are very cheap.

REPORT: INTERLOCKING SIGNALS.

The term interlocking, as here used, means the grouping of levers controlling the movement of switches, turn-outs, and signals, and so arranging them as to make it impossible for operators to give conflicting signals or routes. Signalling applies to the directing of traffic, and derailing is used to prevent two trains colliding, if for any reason the signal is past when set against them. The purpose of using this system of grouping levers under the control of an operator at a convenient point, and arranging signals and derails to co-operate with same in their proper turn is, first, increased safety to life and property; second, increased facility in handling traffic at busy points, and avoiding the necessity of stopping at grade crossings, drawbridges, in the use of joint track, in the use of two or more railroad companies, and other points of danger, and the expense of stopping all trains before crossing or passing said numerous points. It will be easily understood that the matter of expense is the only item that deters railroad officials from equipping such points with an improved device, which will be only a feature of economy in operating trains, but a factor of safety, speed, and comfort to the traveling public.

Sometime before the knowledge of its advantage was appreciated in this country, England had perfected a machine which is now almost universally used there, and is fast coming into service in the United States.

The first system of interlocking erected in this country was placed at East Newark, N. J., in 1874. This was an English machine known as the Saxby & Farmer type. The Union Switch and Signal Company's systems, especially their manual and pneumatic electric machines, are giving good satisfaction.

But, notwithstanding all these improvements, railroads are still liable to dreadful accidents, due to the fact that the trainmen are dependent upon their eyesight alone to determine whether the conditions are favorable for the safe conduct of the trains committed to their care. The most perfectly appointed and equipped train, running upon a perfectly constructed railroad, with its movements directed by a perfect system of dispatching and signal blocking, is still dependent on the unerring action of the engineer. While signals will always be useful upon railroads, it is a fact that a signal will not of itself stop a train. It must be observed and obeyed. It would not be necessary to dwell upon such self-evident truths were it not a fact that an important proportion of all accidents is due to such causes.

It is said that the Kinsman system steps in at this hitherto unprotected point and practically protects, absolutely, quietly, and, compared with the result accomplished, inexpensively against the dangers that lie out of sight around a curve, in the tunnel, at the crossing of other railroads, in the perfect but broken rail, in the unlocked but seemingly closed switch or drawbridge, in color-blind eyes, in inattentive or preoccupied minds, in the brain and hand made careless by long familiarity with danger or with drink, in the hand palsied by long hours, by severe sickness, or sudden death—making what would otherwise be a source of danger automatically operate the electric device, to shut off the steam and bring air brakes into action; it may be made to afford a high degree of security against accident on any railway which adopts it.

The Wuerpel Switch and Signal Company make an interlocking device. As set forth by its promoters, it is a machine that has been adopted by the World's Fair Committee at Chicago. We cannot say as to the cause of the committee's preference for this machine, but it is enough for us to say that it is now in use at both terminals of the St. Louis bridge, and gives satisfactory results. The system of this machine, in using other than manual force to do the work of throwing switches and signals, leaves the operator free to use his mental powers unhampered. They use steam as a motive power and hydraulic columns as conveyors, the combination being simple, and easy to manipulate and understand; also claiming an advantage of having the working parts under ground, and out of harm's way to itself and persons. It is claimed that after once being put in and properly adjusted it requires very little attention, even less than the ordinary hand and lever and wire connecting machine.

B. F. BOND, Ohio & Miss. Ry.,
G. W. HINMAN, L. & N. Ry.
E. C. FULLER, T. H. & I. Ry.,
Committee.

REPORT: IRON AND VITRIFIED PIPE FOR WATER-WAYS.

It is a well known fact with all railroad men who have had experience with, or have had charge of the Maintenance of Way department that fire and water are the two greatest enemies with which we have to contend in the successful operation of railroads, and the best methods of overcoming these difficulties is a question of interest to all.

The point gained in the use of iron pipe for water-ways in place of the wooden structure, where practicable, is removing the

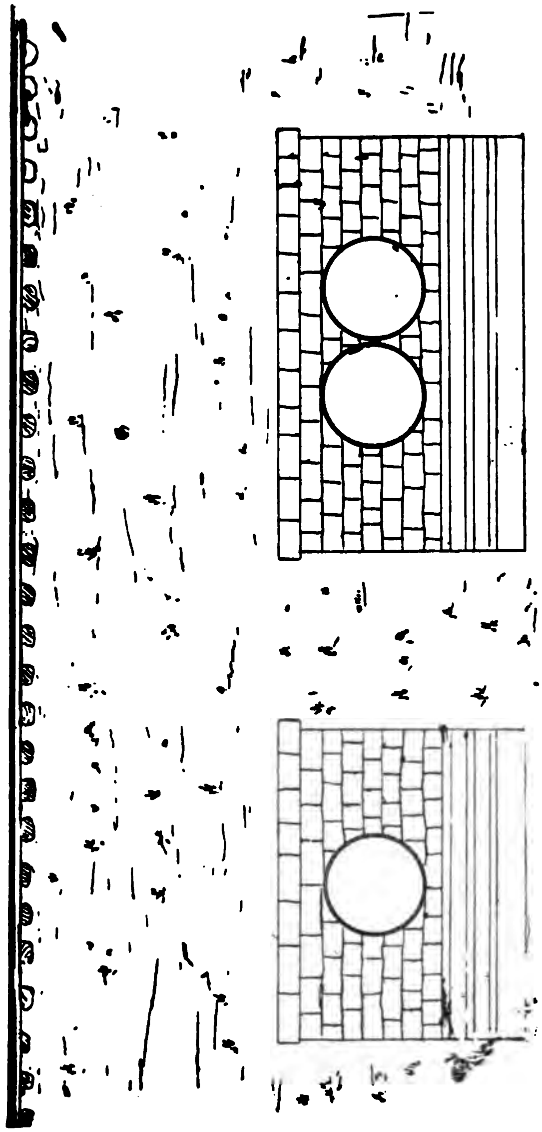


FIG. 7.—POSITION OF PIPE FOR WATERWAYS UNDER RAILROAD EMBANKMENTS.

danger by fire and substituting in its place a more permanent and substantial improvement, with very little cost for maintenance if the work has been properly executed.

There should be the best of judgment exercised in this direction, that sufficient or suitable sixed pipes be provided to carry the required volume of water; also in placing the pipe in position, and protecting the ends of the same.

In our opinion, the outer ends of either side of the embankment should be well protected with masonry laid in good cement mortar, and on the down stream end an apron should be provided of good masonry to protect the embankment.

Where masonry is not used we would recommend that the embankment be well protected with riprap.

We believe the argument is all in favor of the cast-iron pipe for the purpose named, as, in our experience, the vitrified pipe will not withstand the action of the frost where exposed at the ends, and will cause pipe to crack, even if well protected by masonry; also, the joints being shorter is another argument against the successful use of vitrified pipe.

In a deep fill where pipes are used, the greatest expense is putting the pipe in position, and not the original cost of the pipe. If used in a shallow fill, the impact would result in the breaking of the pipe. This has been our experience both in railroading and highway work (we merely mention the highway work for the reason that it comes in connection with some of our railroad crossings approaching the track.) As a matter of economy and safety we would recommend the use of cast-iron pipe for the purpose named.

As for its lasting qualities, we are unable to say from experience; but we are informed that iron pipe put in on the Hoosic Tunnel road in 1878 is still in good state of preservation. The Wabash Railroad has adopted the use of the cast-iron pipe on all three divisions with good results. Will also state the A., T. & S. F. R. R. has adopted the use of the cast-iron pipe for its water-ways to a great extent.

In justice to the vitrified pipe, we will state that, in our experience, it can be successfully used for water-ways on sidings, also for road crossings to take the place of wooden sluice boxes, as its cost is very little in excess of wood, and its lasting qualities are greater and, in our opinion, it is more suitable for this class of work .

JAMES STANNARD, Wabash Ry.,
J. E. WALLACE, Wabash Ry.,
J. O. THORNE, C., B. & Q. Ry.,
Committee.

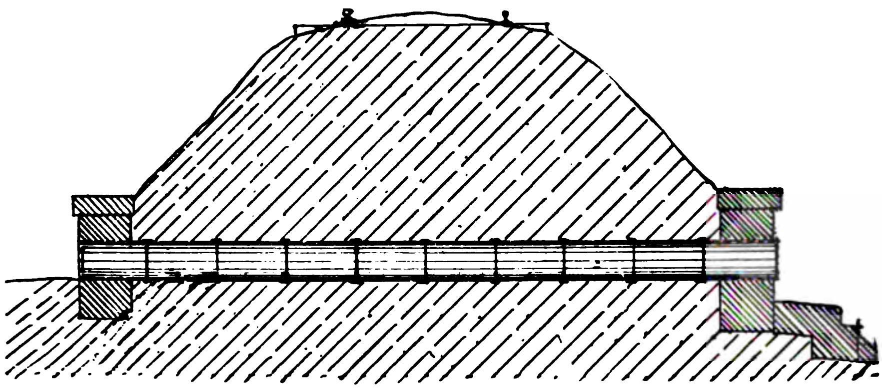


FIG. 8.—SECTION VITRIFIED SEWER PIPE ONE FOOT INTERNAL DIAMETER.

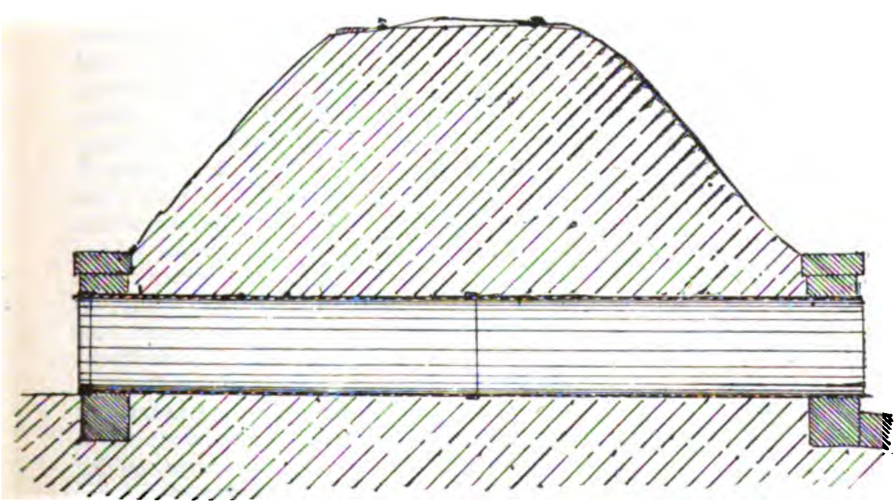


FIG. 9.—SECTION CAST IRON PIPE THREE FEET INTERNAL DIAMETER.

REPORT: WATER-SUPPLY ON RAILROADS.

The water-supply on all railroads has ever been a matter of vast importance, and, to a majority of them, it has been a matter of great expense. Especially is this the case in the Central and Western States. It is true that some railroads are located where there is an inexhaustible supply of water, but the majority of them are not so favorably situated. An ample supply of water at all favorable points is of inestimable value to every railway, but it has baffled the skill of the most expert engineers to procure it. And thousands, yes, tens of thousands, of dollars have been expended in that direction. Much of the money was spent merely in experimenting, and no inconsiderable amount of it was actually lost. Besides, in many instances where water was found, the supply was not equal to the demand, so some other "make-shift" had to be resorted to, which would rapidly swell the expense account. Right here I will make a suggestion or two that may be of some value. Many of the railway managers of the present day are adopting the "limit plan;" that is, so much appropriated or allowed for such and such work, and no more. To me such ideas are fallacious; and the water-supply department alone very clearly demonstrates that such methods are, in many instances, to say the least. Where is the economy in leaving work half done (no matter what the expense), if it is an absolute necessity to have it? On more than one occasion I have seen railway companies start making reservoirs and digging or driving wells, which cost no small amount of money; and, after going half way or more, relinquish the work, claiming that they could not afford to spend any more, when at the same time they were compelled to adopt some other temporary method, which was always very costly and never satisfactory. Often the amount of money spent in that way would have completed the work, and given an ample and enduring supply. At points where water is needed, and must be procured by digging or driving wells or making reservoirs, the question arises: Which of the three is the best? and opens a wide field for discussion. Even after debating the question in any organization of practical men, there would no doubt still be a great diversity of opinion, notwithstanding that the conditions and surroundings were nearly similar. It will be admitted that at some locations water could be procured at less cost and more abundantly by making a reservoir than by digging or driving wells, while at other points it might be the reverse. But the main point in constructing any of the three is to make them large enough, so that the supply of water will be ample for all purposes required, even if the cost should be double the amount estimated to build them; and they will be cheaper, generally speaking, than any other method or temporary expedient you could adopt. Many large reservoirs have been built for railroads purposes, at enormous expense, which were practically useless from the fact that they covered too much space and had but little depth. Besides, there was no provision made when erecting them to exclude the cultivated soil, which generally surrounds their location, from washing into the reservoir during heavy rains. Consequently it would only be a short time before they were full of mud and rubbish, which would cost more to clean out than the first cost of building the reservoir.

Wherever this source of water-supply is adopted the reservoir should always be made as cheap as it can consistent with the location and surroundings, even if the expense is a little over the estimate, as it is depth and not surface measure that constitutes a practical reservoir. Moreover, ever necessary precaution should be taken to prevent dirt or rubbish of any kind from washing into it, as they not only fill up but often pollute the water. An abundant supply of water being secured, the whole question of water tanks, pumps, etc., is nearly settled. Of course, there may be a wide difference of opinion as to which kind of water tanks is the best. I am an advocate of steel tanks rather than wooden ones, believing that their durability will far more than pay the interest on the extra money expended in erecting them. Also, when wooden tanks are used, I would recommend cast or wrought iron frames to support them. It is true that the iron frame like the steel tank is more costly at first, but it is good for half a century, at least, if properly erected, while the wooden frames will not last over t n or twelve years at the utmost, and will require considerable repairs during that time. Besides, the wooden frames are much heavier than the iron ones, and do not leave so much open space under the tank; consequently the bottom, which is always the first to decay, does not last so long. The frost-proofing of the pipes under tanks, or for roof-covering, are better and more durable when constructed with double walls, leaving an air-space between, than in packing with sawdust or any other substitute, as the latter always has a tendency to draw dampness and exclude air, which causes the wood to rot very fast.

Pump and coal houses should be constructed with brick and fire-proof roofs at all permanent water stations. The additional cost of the brick would soon be repaid in their warmth and durability, not to speak of fire risks.

The choice of pumps is another question on which there may be a difference of opinion, as each member can speak only from experience, and some may have used only one make of pumps and some another, while a few may have had experience with several different kinds. For over twenty years I have been a close observer of the work done by six different kinds of steam pumps, and my choice is between the Washington (Dean & Cameron) and Blake.

They are simple, durable, and always give better service than any other pumps with which I have had experience. Of course there may be others equally as good, and perhaps some better; but, if so, I do not know of them.

The question of painting may also cause considerable contention, as each member will have his own choice. I, for one, am not an advocate of patent paints. Pure white lead or red lead ground in linseed oil, colored to choice, is far more durable, and gives better protection to wood or iron than any patent paints I ever used; but when any patent paints have to be used, we would recommend Johnson's Magnetic paints.

G. W. TURNER, St. L. & S. F. Ry.,
Q. M'NAB, C., C., C. & St. L. Ry.

CONSTRUCTION OF TRACK TANKS.

In 1890 the B. & O. R. R. Company adopted a very fast schedule for their trains running between Philadelphia and Baltimore on their Philadelphia division, the time being 1.47 hours for a distance of 92 miles—the actual running time, after deducting for

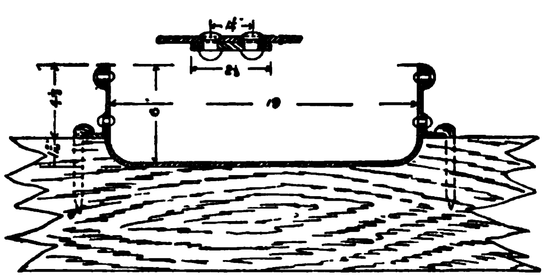


FIG. 10.—CROSS SECTION OF TRACK AND TIE.

stops, etc., being about 55 miles per hour, which must be conceded fast time for regular trains carrying three heavy coaches and two or three sleepers.

It is hardly necessary to say that the road-bed and bridges must be kept in first-class condition for work of this kind; but it was absolutely necessary to make improvements, wherever possible, to assist in the work.

Among the improvements was the placing of track tanks at two points of the division.

LOCATION.

The total distance of 92 miles was divided as nearly as possible into three parts, thus making the distance necessary to run for water about 31 miles.

CONSTRUCTION.

The first work to be done was the preparation of the track at points where tanks were to be placed.

The troughs being 1,200 feet long, it was necessary that the track for that distance be level, running off at each end by easy gradations to the regular grade. This work was done by regular track force. At station No. 1, to get this level, it was necessary to raise from one end, the lower end being 17 feet, running to zero at the other. At this point we have a double track through a truss

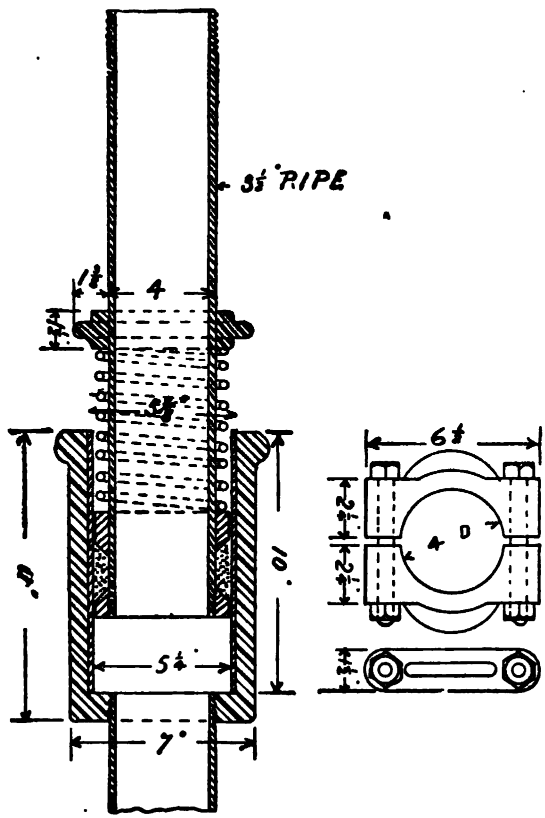


FIG 11.—EXPANSION JOINT.

bridge of 115 feet span, which we were compelled to raise the 17 feet.

Station No. 2 was placed on a fill, where the grades formed a dip of about 4 feet, the grades being about 10.56 feet to the mile.

TIES.

The above work being completed, the hewn ties were taken out and replaced with sawed ties, 8x9, white oak. These were dapped $1\frac{1}{2}$x19 inches, working each way from the center of the ties to form a seat for troughs.

TROUGHS.

The troughs were made of sheet steel 3-16 inch thick, 15 feet length sheets. They are 6 inches deep, 19 inches wide, with

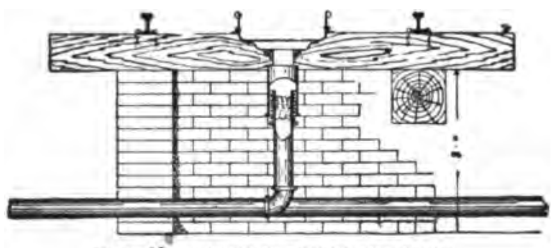


FIG. 12.—SECTION THROUGH INLET.

a $1\frac{1}{2}$x2 inches by $\frac{1}{4}$ inch angle riveted to each side $1\frac{1}{2}$ inches from the bottom. This rests directly upon top of ties, and forms the means by which troughs are fastened to ties, the fastening being done by driving an ordinary track-spike into ties, allowing the head to catch on the small angle mentioned; this allows troughs to expand or contract.

The troughs are fastened firmly at the center, so that they will be stationary at that point, allowing for expansion at the ends.

The troughs were made in 30-foot sections in the shop, and sent to field, where they were set in place, and joined together

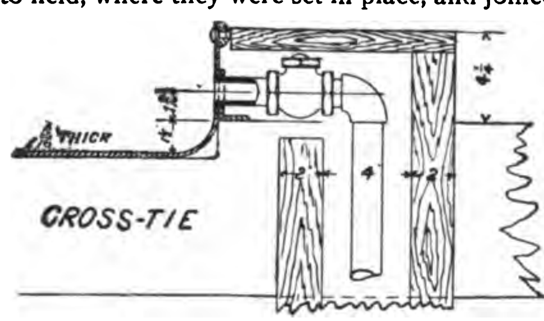


FIG. 13.—STEAM INLET.

for the total length of 1,200 feet, each joint red-leaded, and cold-riveted with 7-16 rivets, twenty to the joint. Each end is placed on an inclined plane, with a total length of 13 feet 8 inches, the inner end of this riveted to the bottom of the trough and the outer end

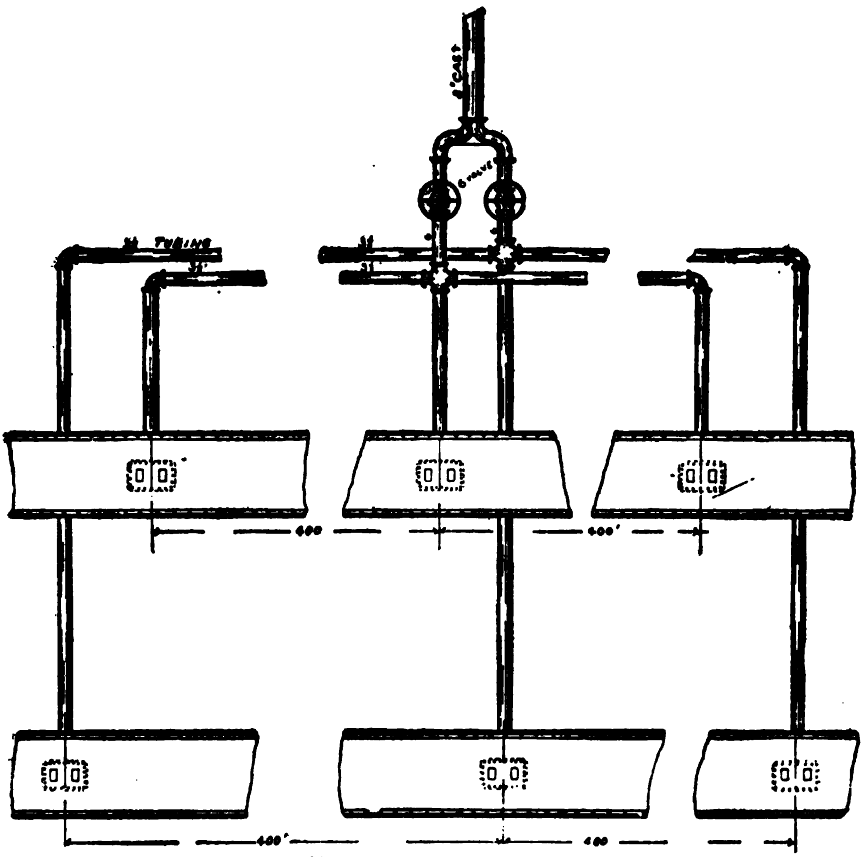


FIG. 14—ARRANGEMENT OF PUMPS.

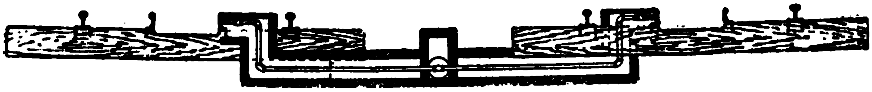


FIG. 15—ARRANGEMENT OF HEATING PIPES.

fastened to timber by means of rail spikes driven on the edge of the plate, with head of spikes resting thereon, thus allowing for expansion in connection with the trough.

The object of this plane is to force scoop on tender of locomotives back in position, should the firemen fail to raise it, thus preventing any damage to either the scoop or trough.

WATER SUPPLY.

This must be governed by location of station. At our Station No. 1 we were compelled to construct a dam 6 feet high and about 75 feet long, or wide, across the stream at that point. From this the water is drawn through 6-inch C. I. high-pressure pipe a distance of 600 feet, by means of a steam pump, and forced into a 40,000-gallon tank at an elevation of 28 feet above the track.

At Station No. 2 the supply is received from a mill-race about 600 feet from the pump-house. From this race the water flows by gravitation to a filtering well at the pump-house; and from this it is forced by a steam pump into a 30,000-gallon tank at an elevation of 28 feet. These tanks are kept full at all times. From the elevated tanks the water is delivered to track troughs in the following manner: An 8-inch C. I. H. P. pipe is connected to the elevated tanks, and runs to a point at or near the pump or boiler-house, where it is reduced to 6 inches. At this point is placed a 6-inch gate valve, by means of which the supply to the trough is regulated. At this point the supply-pipe running direct to the trough branches off to three points by means of cross T or N joints, and reduced at the point of leaving the valve to 3½ inches. Two of the branches are carried and connected to troughs 200 feet from ends. The third one is carried and connected to center of trough, thus giving three outlets for water in the fillings of troughs.

CONNECTION OF WATER PIPE TO TROUGH.

At the points of connection there is built a pit the full width of track, about 3 inches wide and 3 feet 6 inches deep, with side and end walls of masonry, top covered with 2-inch plank, and bottom drained to one side. Into these pits the pipe is run, and connected to trough by means of a 3½-inch pipe flange, nipple and expansion joint, as shown on plan.

The expansion joint used at this point is one of our own design, and I believe the first iron joint used for this purpose. (At this point, some of the Eastern roads use a gum hose, in place of expansion joint, as used by us.)

In the two years we have made no repairs to joint. At this point is placed a 3½-inch Globe valve for use in draining or emptying troughs when cleaning or repairing them.

TO PREVENT FREEZING.

One of the most important questions to be dealt with in the use of these tanks is that of keeping them free from ice during cold weather. This is done in the following manner: A 2½-inch pipe is connected to steam dome on large boiler shown on drawing. This pipe is carried to center of tracks, where it is a double track, or to the end of ties on single tracks.

At this point the pipe is reduced to 2 inches, running to a point of 5 feet from end of trough. On this pipe, at intervals of 45 feet is placed a cross with 1-inch centers, from which 1-inch pipe is carried and connected to troughs. This connection is made with a nipple of extra strong pipe cut 3 inches long, tapped out at one end, and plug with hole ⅛ inch in diameter inclined down, screwed in. Immediately back of this nipple is placed a 1-inch check valve, to prevent the back flow of water when steam is turned off. The 2-inch pipe in center is drained from both ends to supply pipe with a drain cock placed at lowest point. To prevent break through expansion or contraction, expansion joints were placed at intervals of 200 feet. (We afterward connected the steam pipe to small boiler, for use in case of failure of large one.) All steam pipe should be boxed and packed with mineral wool or covered with magnesia or asbestos pipe covering, to prevent, as much as possible, the condensation of steam.

PRESSURE OF STEAM.

We find the pressure of steam necessary to prevent freezing in coldest weather to be about 80 pounds.

BOILERS.

During the warm months, when steam is needed for pumping only, we use an upright boiler of about 25 horse-power.

During cold months, when it is necessary to have live steam constantly in troughs, we use an old locomotive boiler of about 95 horse-power, at one end; at the other, one of 80 horse-power (variations caused by reason of having boilers on hand—the smaller would answer for either place). Our pumps are connected to both boilers, thus enabling us to dispense with the use of either one, at any time.

PUMPS.

At these, as well as all other water stations on the Philadelphia division, we use a No. 9 Blake pump, with capacity of 260 gallons per minute.

SIGNALS.

At the end of trough nearest the approaching train is placed a signal similar to high switch stands—this is to notify engineman and fireman that they have reached the end of trough and should lower scoop. At the distance of 100 feet from the far end is placed a similar signal, at which point the fireman is supposed to raise the scoop, providing he has not filled his tank before reaching that place.

METHOD OF FILLING TROUGHS.

In the earlier part of this paper I mentioned that a 6-inch valve was placed in connection with the supply pipe, at or near the pump house. Over these valves is built a small valve house, with the floor of the same about on a level with the track. After engines have taken water, these valves are opened and water is allowed to run into the trough. The time consumed in filling is from four to six minutes. I will say here that when we first put these tanks in use, there was considerable complaint on the part of enginemen that the troughs were often not more than two-thirds full at the time they reached them, thus preventing them from getting a full tank. On investigation I found that freight trains running over these troughs threw out considerable water by the current of air caused by the passage of trains.

I then instructed the pumpers to inspect the troughs five minutes before the schedule time of trains, to see that they were properly filled, and to remain in the valve house from that time until the passage of trains. Since doing this we have had no further complaints of this kind.

ELEVATED TANKS.

The elevated tanks are built in "frost proof style," circular in form, with hexagonal roof, covered with slate.

The staves and bottom are of 3-inch W. P., the whole bound by eleven hoops of 3-16x4-inch iron. The capacity is 30 and 40 thousand gallons.

MODE OF TAKING WATER.

On the tender there is placed an oblong spout with a hinged scoop on the lower end, as shown in drawing. This scoop is connected to a lever on forward end of tender. When the engine passes the signal at end of trough, the fireman throws this lever back, causing the scoop to drop about 3 inches into the trough. The speed of the engine causes the water to flow through scoop and spout into tender. The speed of engines is variable; often being at a rate of forty-five miles per hour.

COST COMPLETE, NO. 1, SWAN CREEK.

Preparing road-bed	$1,093.75
Labor (placing trough, running pipe, etc.)	2,134.65
Troughs (including all shop work on same)	4,159.15
Hauling	61.00
Material (including ties, pipe-fittings, pipe)	2,939.23
Total	$10,387.78

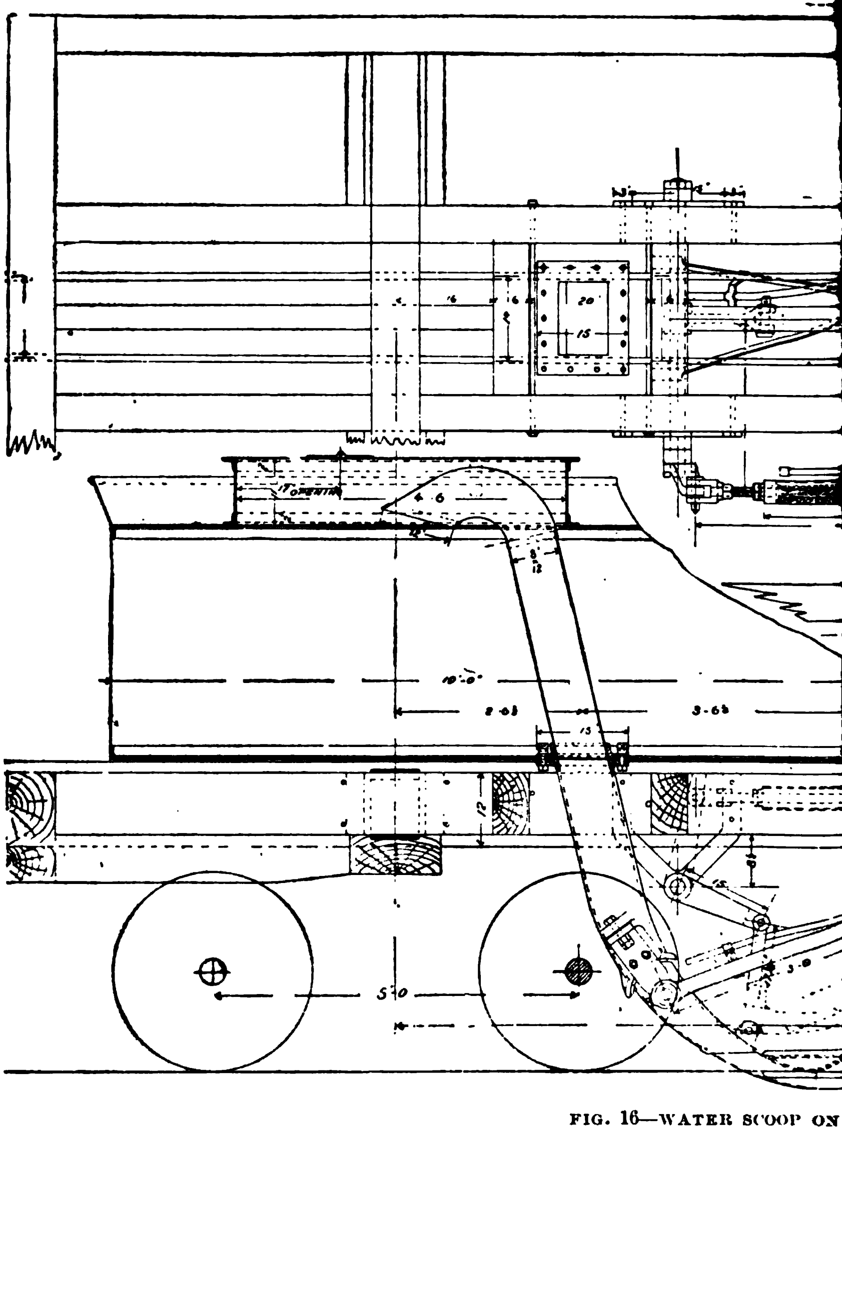
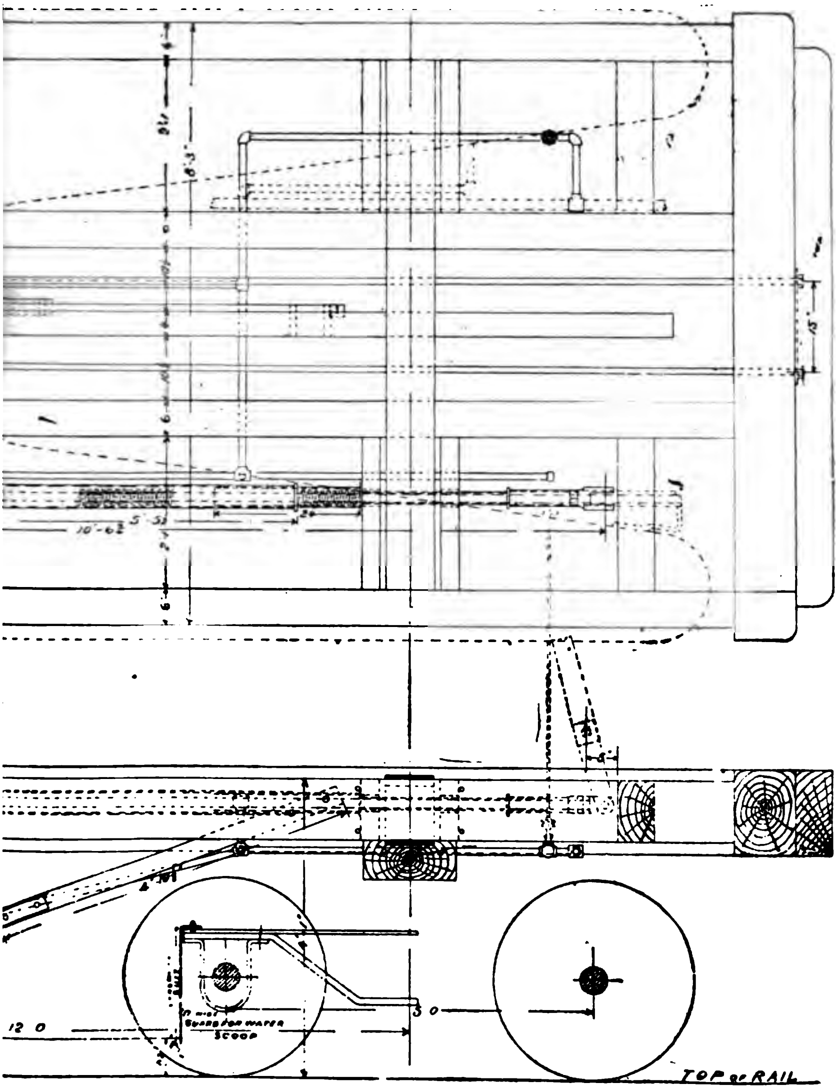


FIG. 16—WATER SCOOP ON



NDER FOR TRACK TANKS.

This includes all labor in field, except grading. Included in the above cost is the running of about 75 feet of 8-inch C. I. pipe and placing of two penstocks or stand-pipes for use of freight engines.

STATION NO. 2.

Preparing road-bed	$2,766.80
Labor (placing troughs, etc., as above)	1,548.75
Troughs (including all shop work on same)	4,159.15
Hauling	30.10
Material (including ties, pipe-fittings, etc.)	3,030.50
Total	$11,535.36

Included in this cost is the running of 600 feet of 8-inch C. I. pipe, and the placing of two penstocks for use of freight engines.

COST OF OPERATING EACH STATION PER MONTH.

Two pumpers, $45 each	$90.00
Average coal per month, 15 tons	22.50
Ordinary repairs	20.00
	$132.50

GEORGE W. ANDREWS, B. & O. Ry.

DISCUSSION: SUBJECT—WATER PIPES COMPLETE, INCLUDING PUMP AND COAL HOUSES.

A Member.—I would like to ask some of these Southern gentlemen who have used cypress for water tanks, what success they have had.

Mr. Pasco, Lehigh Valley Ry.—I have used cypress and have had eleven years' experience. Tanks on the Lehigh Valley to-day are as good as when first built. They are of red cypress. They are on the road giving excellent success.

A Member.—We have three cypress tanks, but they have only been in use for about five years; as yet we see no defect. My opinion of cypress is decidedly in its favor. White pine is good if you can get it without knots. Do not take pine with knots, no matter how sound. The water from the inside will creep out and make it damp. We have taken down two of our white pine tubs this season that we put up in 1871, and they were badly decayed. They would have had to come down in a couple of years.

Mr. Markley.—I would like to know what should be the maximum for the width of a stave for a water tank.

Mr. Wallace.—Not exceeding 6 inches.

Mr. Travis.—I agree with Mr. Wallace, unless we have a stave that is particularly made for tank purposes, and then I think you can go 8 inches very well. As a matter of information I would like to ask Mr. Stannard what condition the 24-foot tank at Glenwood Junction is in now.

Mr. Stannard, Wabash Ry.—It is in very good shape.

Mr. Travis.—I will state in that connection that several years ago I was with the same company and in the same place Mr. Stannard is now in, and that tank at Glenwood Junction has been put up eleven years, and for the benefit of the members here I will state it was in a bridge for nine years before it was put in that tank. The material was sawed out of old stringers. It was white pine.

Mr. Wallace, Wabash Ry.—So far as white pine is concerned, I would like to say we have just taken down one tank that was put up twenty-two years ago at Clayton, Ill.

Q.—I will ask Mr. Wallace if it was kept thoroughly open. A.—It was housed on the outside, which is not the plan just now on any railroad I know of.

Mr. Reid, L. S. & M. S. Ry.—While I am not interested in tanks in a mechanical way (I don't build any) I saw last week a tank that has not been used for a year—it has been standing. They were just filling it with water again. That tank I saw erected in 1869 at Eagle Mills Station. It got so dry, and the city water at Grand Rapids bothered them so, they decided to use that tank again.

Mr. Pasco, Lehigh Valley Ry.—I would like to ask whether the gentlemen have had much experience with iron tanks. I ask the question because I think it was mentioned in discussion l st year, and I wanted to find out if any one was using an iron tank. A.—Xenia, O., the Pullman Co., and the Texas Pacific.

Mr. Wallace, Wabash Ry.—There is only one there. That tank, to my observation, rusted very much and so much so that I do not think they would be a success.

Mr. Markley.—Don't you think, Mr. Wallace, the rust on the inside of an iron tank would damage the water so as to be injurious to the engines?

Mr. Wallace, Wabash Ry.—I don't know that it would. I know that iron rust is not very good, but where it is drawn out so constantly I don't think it would be injurious to the locomotives. The quantity of iron rust would be so small as compared with the amount used, that I don't think it would affect it anything like even the flues of the boiler.

Mr. Pasco, Lehigh Valley Ry.—I would like to ask the question, which tank is the most desirable, the one enclosed in a house or the one exposed; what is known now as a frost-proof tank?

Mr. Markley.—I think there is no question the tank enclosed would last the longest, but to enclose a tank would cost nearly as much as to erect it.

Mr. Doll.—I have had experience of that kind. We have some tanks of which the frame was enclosed and the top exposed, and I believe the frame will rot quicker enclosed than if left open. It is always damp and will not dry up.

Mr. Markley.—I take issue with Mr. Doll. If his tank is closed up and no chance for ventilation, I will agree with Mr. Doll, but I do not believe that would be the proper way to enclose anything without allowing for some ventilation.

Mr. Joseph Doll, C., C., C. & St. L. Ry.—I think it a very good thing to have a roof over your tank. That will protect your tub and will keep your staves tight on the tub.

Mr. Wallace, Wabash Ry.—In regard to the matter of roof of tanks in latitude not necessary to protect yourself against frost, I don't see the object of doing anything further toward a roof than to shut the light out. There is no object in keeping the rain out; in fact this is the best water we have.

Mr. Travis.—I would like to inquire if any one in the house has known of a tank to fall because of defective or decaying timber exclusively? A.—Never had.

Mr. Travis.—I think then that is very good evidence. White pine is a good timber for tanks.

A Member.—I would like to ask, Mr. President, about painting a tank inside. I put up five tanks last year and the engineer had them painted inside as well as outside.

Mr. Doll, C., C., C. & St. L. Ry.—I have coal tarred tanks inside, but have never been in to see whether it is any good or not. I paint the outside of the tank every two years. I have coal tarred several of them and more I have not.

Mr. Markley.—Before this question is passed I would like to hear an opinion on the question of pumps, the question of size of suction and discharge pipes of the pump.

Mr. Wallace, Wabash Ry.—In reply to Mr. Markley's question in regard to the size of pumps, as a larger pump costs more than a smaller, they are usually put up to accommodate the station according to the amount of water taken. The large pumps being more expensive, the suction pipes as a matter of course are proportionately larger than the discharge pipes, but the distance the water is to be thrown cuts quite a figure, as there is considerable friction on both suction and discharge. I think there should not be any pumps for ordinary water stations of less than 2½-inch discharge and 3-inch suction. We don't use anything that small on the Wabash. With us the most favored is a 4-inch suction and a 3-inch and 3½-inch discharge.

Mr. Markley.—Five years ago when I took charge of the water works on our line—previous to that they were under the roadmaster—it was their custom to have the discharge one inch less than the suction, but since then we have adopted a plan making the discharge the same size as the suction, and we find it takes less fuel and less steam and pumps more water and gives better service.

Mr. McGonagle, D. & I. R. Ry.—I would like to state the experience I have had with pipes. I have had considerable difficulty with freezing pipes. The frost in our country goes from six to eight feet deep and it is very difficult to do anything. We adopted a plan of taking all our pipes out of the ground and putting them in wooden boxes. We have put boxes around the pipe and covered them with tar felt, leaving a 2-inch air space. Since the adoption of that plan we have never had a frozen pipe. Our pipes are all on top of the ground.

Mr. J. H. Travis, I. C. Ry.—I would like to ask some of the gentlemen for their experience in regard to water columns. If they have had any difficulty in freezing in extreme cold weather, and what method they have adopted of preventing it?

A Member.—I have had experience with water columns for quite a number of years, and have never had one to freeze up yet, though along the St. Louis Division we have had some very cold weather.

Q.—How deep do you make your pit? A.—Four feet eight inches.

Mr. McGonagle, D. & I. R. Ry.—I have had considerable experience with the subject of water columns. Situated as we are with the pipe in these boxes, we can run the steam pipe to the boiler pump house through the boxes and return from the boiler with a full current of steam and keep the column heated. Blow the steam through the water column and in this way we can keep our columns in service. We have never had a frozen column yet, notwithstanding the cold weather. Our pit is 7 feet 5 inches. We use the Sheffield and two Poag columns.

Mr. H. M. Hall, O. & M. Ry.—I would like to ask if you have a water column under high pressure, say 60 to 80 lbs? A.—We have had one column at the city of Berlin with a very high pressure.

Q.—What has been your experience? Have you had any trouble, any complaints from the water supply men? A.—Not at all. I think our Poag columns give a little better satisfaction than the Sheffield.

Q.—You don't get a direct pressure then on the water column; you don't get the water works' pressure; city pressure? A.—We don't need it.

Q.—I would like to ask how high the floor of your tank is from the base of rail? A.—We use a 16-foot base ordinarily, but we have one tank in the city of Duluth with a 30-foot base.

A Member.—While we are on the subject of water tanks I would like to have the opinion of some of the members as to the best height to put the tank for ordinary use. Not for the purpose of getting pressure on the water column but for quick service in watering trains?

Mr. McNab, C., C., C. & St. L. Ry.—Think a height of 18 feet above the base of rail will give as good satisfaction and will take the water just as fast as one of 60. I have a tank 60 feet high, and we see but little difference in taking water. There may be some little difference, but so little I cannot distinguish.

CHAPTER II.*

1, REPORT: DISCIPLINE, BENEFITS DERIVED, AND WHO ARE THE BENEFICIARIES—2, DISCUSSION: SUBJECT, DISCIPLINE—3, TURNTABLES—THE BEST IN VIEW OF ECONOMY AND STRENGTH—4, DISCUSSION: SUBJECT, TURNTABLES—5, REPORT: WATER COLUMNS—BEST, CHEAPEST, SIMPLEST, AND MOST DURABLE—6, DISCUSSION: SUBJECT, WATER COLUMNS—7, REPORT: COALING STATIONS; INCLUDING STORAGE BINS; APPLIANCES FOR COALING LOCOMOTIVES—8, DISCUSSION: SUBJECT, COALING STATIONS—9, REPORT: CREEPING OF RAILS IN RAILWAY TRACKS; ITS EFFECT ON BRIDGES, AND METHODS TO PREVENT INJURY TO THE BRIDGES—10, DISCUSSION: SUBJECT, CREEPING RAILS—11, REPORTS: GUARD RAILS ON BRIDGES—ADVANTAGES AND DISADVANTAGES—BEST KIND TO BE ADOPTED—12, DISCUSSION: SUBJECT, GUARD RAILS—13, REPORT: PLATFORMS—HEIGHT, DISTANCE FROM RAIL, MODE OF CONSTRUCTION, ETC.—14, DISCUSSION: SUBJECT, PLATFORMS—15, REPORT: BEST BRIDGES—WOOD, COMBINATION OR IRON—16, REPORTS: BEST METHOD OF ELEVATING TRACK FOR CURVES ON BRIDGES—17, DISCUSSION: SUBJECT, BEST METHOD OF ELEVATING OUTER RAIL ON BRIDGES—18, THE DUTIES AND KNOWLEDGE REQUIRED OF A SUPERINTENDENT OF BRIDGES AND BUILDINGS IN THE RAILWAY SERVICE—SEVEN PAPERS.

REPORT: DISCIPLINE—BENEFITS DERIVED, AND WHO ARE THE BENEFICIARIES.

Discipline consists of due subordination to authority; a subjection to rules and regulations, instruction and government comprehending the communication of knowledge and the regulation of practice. It also implies ready obedience to orders of which the reason is not understood, but should rest on the belief that those who give them, have done so for reasons satisfactory to themselves

*Reports presented at Third Annual Convention held at Philadelphia, Pa., October, 1893.

and not for the mere purpose of having their own wishes or desires carried out.

One of the first lessons to be learned by men placed in authority over others, is the necessity of maintaining discipline to achieve proper results. To attain success in these things, the best practice will be that which combines the two elements; disciplined intelligence and the perfection of details applicable to the work to be done, together with the knowledge that all men are entitled to a certain amount of courtesy at the hands of their superior officers, for the simple fact of his being in a position of authority does not justify him in looking upon or treating his subordinates as creatures to be used as may suit his convenience, or governed by the uncertain conditions of temperament.

In considering this subject, as applied to that branch of the railway service, with which we are connected, your committee has divided it into sections as follows:

1. What constitutes discipline as applied to workingmen?

To this we answer: strict and prompt obedience to instructions, a friendly respect by employes to their superior officers, together with a knowledge that they are respected by such officers, coupled with a feeling that so long as their duties are performed correctly, or to the best of their ability, do not violate instructions, rules and regulations, laws of country and society, that they may have a position worthy of their capabilities. Unlike the laws of discipline governing the church and military, coercive measures are neither permissible or desirable. When frequent trangression of rules and regulations occur on the part of any man or men the only safe and sure method is the dismissal of the ones so doing.

Delay in doing this has no doubt caused serious defects in what otherwise have proven excellent systems. One man dissatisfied with conditions governing the work on which he is employed will create a feeling of dissatisfaction and distrust among all others employed on the same work, and will continue as an element of discord so long as he is allowed to remain among them.

2. To obtain correct discipline, the employing official should have full control of men under supervision, that is the authority to hire and discharge on failure to properly fulfil the duties required?

It is the opinion of your committee, that no man can maintain correct discipline unless he does possess such authority. Rules and regulations of the railway service are not to oppress or take away anyone's rights, but they are to protect the public who use the railway, as well as the employe; to see that he is not killed or injured by the carelessness of himself or fellow employe, or cheated by his superior officer, and to see that the property and interests of the company are properly handled. Therefore, the head of each department to properly carry out the instructions issued for the government of the same, should possess the power named, without fear of having his just decision revoked by higher authority. It is not desired that the authority should be such as to prevent appeals where cases of injustice occur, or where the laws governing the authority of the employing official are transgressed. Where this is done, either for personal motives or love of power, the injured should in all cases have the right to appeal to higher authority. There are, however, many cases of insubordination or inattention to assigned duties when appeal should not be considered, but in which the decision of the employing official should be final.

3. Is it advisable or beneficial to employers to give their men such instructions as will tend to make them, not only more useful to employers, but fit them for higher positions in their line of work?

There are many men of mature age, especially in the mechanic arts, whose advantages for acquiring an education in youth were limited, who have at various times seen the advantages derived by young men in having received instruction in the economical and theoretic principles of their chosen work. With this before him as a constant reminder of the beneficent qualities of education, he is often anxious for some means whereby he can improve intellectually, and thus fit himself for promotion, but being compelled to work during the day to support self and family, and in many cases living in communities without public libraries or night schools, he realizes that the opportunities are but slight. Thus in many cases he who would have under other conditions proven an exemplary employe, as well as head of family, has drifted from the paths of rectitude and success, to that of the rum shop or gaming table. It is in cases of this kind that the devoting of a few hours each week by the employing officials, in instructing their men in the fundamental principles of their work, the appropriation of a small sum each year by the railway companies for the support of a library devoted to the use of employes, and an occasional lecture by some intelligent railway official upon themes applicable to the work of railways, will prove highly beneficial to all concerned. A number of our large railroads support libraries for the use of employes, the books of which circulate over their systems and among every class of employes, thus opening a channel for the advancement, intellectually and morally, not only of the employes but of their families as well. That the results of such measures are beneficial is beyond dispute.

4. Are not men who have special training for their work the best disciplined?

This section pertains directly to the subject of section three. All great commanders, eminent prelates, successful engineers and noted architects were and are men who received special training in their life work, and no small part of this training was the principle that good discipline is the fundamental basis by which success must be attained, that he who expects to successfully enforce rules of discipline should not forget the fact that he is also amenable to the same rules under direction of his superior officers. Thus equipped he is prepared to strictly adhere to the rules and regulations laid down for his government and to see that his subordinates do the same. It is hardly possible that any member of our organization will deny that his success in life is primarily due to the training received, either by close observation, strict adherence to details, constant study of methods applicable to the means for accomplishing desired ends, or to the instruction of others who had received like instructions. Several members of your committee have at various times given special instruction to men in their employ and in every case it has proven of benefit, not only to to the men, but to the instruotor as well. By this instruction they have not only been enabled to do their work in a more mechanical and economical manner, but have realized more clearly the beneficent effects to be derived from good discipline.

5. In the present era of trade organizations and wielding as they do a powerful influence in the affairs of railroads, what is the best method of enforcing discipline, without conflicting with the rights claimed by said organization?

Labor organizations properly possess rights, only such as belong to members as individuals. The labor of the workingman is his capital and no one will deny that he is possessed with the right to say what his labor is worth. It then remains with the employer who is in the position of a purchaser of goods, to say if the terms are satisfactory. If an agreement is entered into, then he who is a member of a labor organization should be amenable to the same rules and regulations, and suffer the same penalties for violations, as the men who are not members. Neither party should enter into an agreement unless fully determined to practice honorable policy in their endeavors to comply with the articles of agreement. Each should receive courteous treatment from the other, and in all cases just recompense should be given for the labor performed.

As labor organizations are prone to declare "strikes" for trivial causes, the necessity arises for the employing officials of the railway service to exercise caution in their dealing with members of said organization, the avoiding of hasty action in the discharge of men and the rendering of decisions in cases of dispute, fair and equitable treatment of all employes, and the meeting of all infractions of rules and regulations with firmness and such actions as in his judgment the end may justify; adhering strictly to these principles, he should not be crippled by his superior officers in maintaining with good judgment that discipline so necessary to successful results.

It is only in the last few years that legislation in the different States has seen fit to consider the subject of the rights of these organizations and to define the limits of their authority. As it is beyond the limits of this report, to enter deeply into this subject, your committee will respectfully call your attention to the excellent report for 1889 of Mr. Carroll D. Wright, U. S. Commissioner of Labor, which contains a digest of the laws of the various States upon this subject, together with statistics of material interest and benefit to our members.

6. Are the benefits derived by good discipline co-equal with employer and employe? If not, who derives the greatest benefit?

On this section there was no difference of opinion among the members of your committee, each agreeing that the benefits are equal. On the side of employers, the benefits to be derived by good discipline, are principally in having their work done in an economical and systematic manner, the obviating of the necessity for their constant presence on the work to obtain proper results, faithfulness and despatch in fulfilling orders, and when occasions arise, as they often do in railway service, calling for the exercise of cool judgment and quick action, the one with well disciplined men will achieve results that would otherwise be impossible. The employe is benefitted in obtaining more practical knowledge of the way and manner of doing his work, in being placed in a position which in a large percentage of cases, the permanency depends upon good behavior and the proper performance of duties. He is also by his knowledge of the rules and regulations governing his work enabled to avoid the snares and pitfalls that await the ignorant.

In the practicing and enforcing of these rules, the fact should not be lost sight of by the one so doing, that he must improve and advance with his men both morally and intellectually. The apothegm of Cyrus, "A man is unworthy to be a magistrate who is not better than his subjects," is as applicable for to-day as it was in his time. It is not meant that he should simply occupy higher social positions, or possess greater wealth, but that he should be morally and intellectually their superiors. Therefore, he who would attain success in the control and management of men, should be a close observer of humanity and advance intellectually with his fellowmen. In his dealings with others, practice sincerity and earnestness, and while no one may hope to attain perfection, every ambitious man should study himself as well as other people; endeavor to eradicate failures of temperament, faults of disposition and other bad habits that are sure to retard his progress in life. Many chances of promotion have been lost by the failure to properly discipline the desires, thus causing his superiors to think him irresolute, lacking in judgment and incapable of maintaining discipline among men.

All men placed over others should also endeavor to improve the moral and intellectual conditions of their subordinates, by so doing they not only assist in the making of better citizens, but will experience results in their work, the benefits of which are incalculable.

G. W. ANDREWS, B. & O. Ry.,
W. R. DAMON, L. N. & St. L. Ry.,
G. W. TURNER, St. L. & S. F. Ry.,
T. M. STRAIN, Wabash Ry.,
Committee.

DISCUSSION: SUBJECT—DISCIPLINE.

Mr. G. M. Reid, Lake Shore & Mich. Southern Ry., said discipline was absolutely required, and that he had always endeavored to enforce it, kindly and not arbitrarily. No one derives more benefit from it than the men themselves; the company is also much benefitted by it. He had had men under him for a period of twenty-five years, men who have received theoretical and practical instruction from him. He does not hesitate to award praise when it is due; he has 100 men in his employ and would not hesitate to call upon them at any time of night or in any kind of weather, as he would feel sure of a ready response. He is willing to state that all of his men give satisfaction, and he feels toward them as toward the members of a family and thinks that his method has been a success.

Mr. J. H. Travis, Illinois Central Ry., said that he had always endeavored to maintain good discipline and to make rules that would be lived up to, and that he is particular to live up to them himself. Some conditions seem like a hardship. Smoking on a job is one of the points that he objects to and he never smokes on a job himself. Could call on any of his men regardless of time or weather, and feel sure of a prompt response. He aims not to impose a hardship upon the men longer than is necessary, especially during washouts, where he has had continuous work for weeks. He had a serious wreck when it took thirty-one days to repair the road. Has made it a point to thank the men for their efforts and to show them that he and the company appreciated their services. The company paid them well. He also makes an effort to give the men some little entertainment after their work is done. Believes in keeping up a good standard of wages in the worst weather.

Mr. Pasco, Lehigh Valley Ry., noticed that Mr. Andrews in his report said that the foreman should have charge of the men and be allowed to dispose of them. He wished to show what authority some roads give their men, and read from a book of rules of a certain road showing how a supervisor has the power to discharge men with the authority of the engineer. Under the head of "Foreman's Duties" the foreman is allowed to discharge men without consulting the supervisor or engineer. He thinks these are contrary to the proper order of things and the well-being of all concerned, as the subordinate has apparently more authority than his superior in position.

Mr. Andrews explained the purport of his report as to the foreman having charge of men. The superintendent of bridges on his road is allowed to discharge men, but the men have recourse to an appeal to the superior official above the superintendent of bridges.

Mr. Pasco, Lehigh Valley Ry., said that he wished to call attention to the erroneous wording of the rule in question, and it is in his opinion unjust to the section men and laborers.

Mr. Andrews stated that on all roads there was the right of appeal in case of grievance.

Mr. Wallace, Wabash Ry., said that on the Wabash road the foreman in discharging a man is compelled to place upon the back of the discharge papers the reason of the discharge, and if the foreman has not acted justly the matter is investigated by higher officials.

REPORT: TURNTABLES—THE BEST IN VIEW OF ECONOMY AND STRENGTH.

Three distinct points are presented in this subject, viz: economy, durability and strength in the construction of anything pertaining to the maintenance of our railways. We care not what it is or to what part of the service it belongs, if it is for a permanent purpose, the best manner in which to construct it is by using the best material to be obtained and skilled labor in its construction. The first cost will be greater, but in the end it is economy, and in order to obtain economy you embody strength and durability.

We admit frankly that there are various opinions as to the construction of turntables. We are of the opinion that too much care cannot be taken to obtain a perfect foundation for your table center, in order to prevent settling. To prevent this we are of the opinion that where you have not a rock foundation to start your masonry on, piling should be driven in all cases, upon which to start the masonry to carry the center upon which rests the table and the load it has to carry.

In the construction of centers there are many different kinds. Those with ball bearings and others with spider, with bevel rings and cone rollers made of cast steel. Either is giving satisfaction. As turntables are at all times exposed to the weather and different changes of the atmosphere, the only way of protection or adding to their durability is by a frequent coat of paint.

In the line of economy, strength and durability, metal, either steel wrought or cast iron, is preferable. We are of the opinion that derailments and breakages are by far more liable to occur on cast iron tables than on either wrought iron or steel tables.

In the construction of wrought or steel tables too much care cannot be taken in the punchings for all rivets so as to obviate any chance for deflection under a load. All rivet holes should be reamed so as to form a perfect fit for the rivet.

As the size of engines is being increased yearly no table should be less than 64 feet in length, as this will allow for the perfect balancing of the engine on the table and will allow the table to be worked with ease.

Many roads, in constructing the masonry for the circular track to support the truck on the outer ends of the table, are dispensing with the tie commonly used to support the rail of the circular track, and in place of it are raising the masonry to the proper height so as to support circular rail directly on the masonry. This we consider a good improvement and much more permanent.

Your committee hope, in the discussion of this subject before this convention, to gain valuable information in the construction of turntables.

G. W. MARKLEY, C., C., C. & St. L. Ry.,
JAMES H. TRAVIS, Illinois Central Ry.,
Committee.

DISCUSSION: SUBJECT—TURNTABLES.

Mr. W. G. Berg, Lehigh Valley Ry., said that in mentioning the proper proportioning of turntables, he thought that some reference should have been made to the extra allowance of strength to provide for the impact of locomotives moving on or off the table, and that further, the keeping of the circular rail above the bench wall on cast iron chairs was very desirable, particularly in northern climates where there are liable to be snow-falls at night, and so avoid the necessity of having men to shovel out the pit. For the same reason the keeping of the bottom of the pit below the bottom of the table for quite a distance is a desirable precaution in northern countries. It would have been well in speaking of good foundations for the committee to have emphasized the need of good drainage.

Mr. S. F. Patterson, Concord & Montreal Ry., called attention to the subject of tables run by electricity, costing $1,800 complete, as having been brought to his notice by a party at the convention.

Mr. McGonagle, D. & I. R. Ry., said he used a steel plate deck turntable; digs ten feet into clay for foundation and uses three feet of concrete. Uses concrete for bottom of pit, and provides for drainage below the sub-foundation, if possible. This gives good satisfaction.

Mr. Olney, Savannah, Florida & Western Ry., stated that he never saw snow in his country; drives piles for foundations and tables are built cheap.

Mr. Markley had tables hung with five bolts, all wrought iron tables. Had to take a table out once that was badly rusted. The water from tanks and engines kept it so wet that we could not keep it painted. We had a cast iron table of the Greenleaf pattern put in in 1871 and left till 1888 to 1889, and then taken out on account of being too weak. Is in favor of cast iron tables; think them less defective and more serviceable. The ball or cone-shaped bearing is the only proper center bearing for turntables.

Mr. Pasco, Lehigh Valley Ry.—Can you not get a better adjustment with two hangers instead of more? If you do not get a very careful adjustment the weight will all come on a few bolts.

Mr. Markley thought that the proper adjustment could be provided.

Mr. Pasco stated that the day of cast iron tables had gone by.

REPORT: WATER COLUMNS—BEST, CHEAPEST, SIMPLEST, AND MOST DURABLE.

The requirements of a water column on lines where quick service is desired are:

1. A large area of passage from entrance to exit of water, with a quick operating valve, and with the least possible friction in the pipes.

2. An efficient safety valve to prevent concussion by the sudden stoppage of a large body of water.

3. It should be adapted to high or low pressure and should be frost proof.

4. It should turn automatically to a position parallel with the track and suitable for single or double tracks.

5. Valve should be well balanced for ease of working, valve and all its parts easily accessible and capable of quick removal and replacement of duplicates.

6. A slight disturbance of the vertical alignment should not disturb ease of rotation.

7. It should have a perfect automatic appliance for quick drainage of pipes after use.

To fill the above requirements there are several good stand-pipes on the market, among which we name Poage's Automatic Water Column, Sheffield Automatic Stand-pipe, Mansfield Railroad Water Column, and the Dodge Water Column. Each of these has its staunch friends, proving conclusively that each has its special merits. We therefore leave the question as to which is the best to be determined by the purchaser himself.

C. E. FULLER, T. H. & I. Ry.,
AARON S. MARKLEY, C. & E. I. Ry.,
H. N. SPAULDING, C., H. & I. Ry.,
E. L. CARY, M., R. & B. T. Ry.,

DISCUSSION: SUBJECT—WATER COLUMNS.

Mr. Markley recommended water columns as the only thing to use in cold countries, as tanks give more or less trouble in winter.

Mr. McGonagle, D. & I. R. Ry., had had much experience in water columns. All tanks on his road are set back as far as possible and use stand-pipes, the Poage and Sheffield; pit 7 feet 6 inches deep, double cover with air space. They had no trouble on account of freezing; pipes are all in triple boxes, above ground; discharge pipe 5-inch cast iron, 10-inch box around that, cover that with tar felt, allow 2-inch air space, second and third box arranged similarly. Has low pressure.

Mr. J. H. Travis, Illinois Central Ry., agreed with Mr. McGonagle about placing tanks and using stand-pipes. There were several accidents on the Illinois Central, owing to breaking of tanks, but when located back some distance they can give no trouble to train. On any first-class road an 8-inch column should be used. There should be some improvement made to prevent the goose-neck having to be lowered into the tender. We use four kinds; the Poage and Sheffield, Dodge pattern, the Weldon and the Mansfield. There have been a number of accidents on the Illinois Central from goose-neck. He thought there should be a bonnet similar to that used on the Mansfield, hung high. This column gives good satisfaction. We have no direct pressure where we take city supply. The tank is located within 150 feet of stand-pipe.

Mr. McGonagle, in answer to a question, said the boxes for pipes are made square. He does use in the water tank a center post to carry the roof.

Mr. Berg stated that an additional advantage in using water columns could be found in case additional tracks were to be added later to the road. In this case the water tanks would not be in the way, which very often caused serious interference with contemplated improvements.

REPORT: COALING STATIONS; INCLUDING STORAGE BINS AND APPLANCES FOR COALING LOCOMOTIVES.

I have received correspondence from two members of the

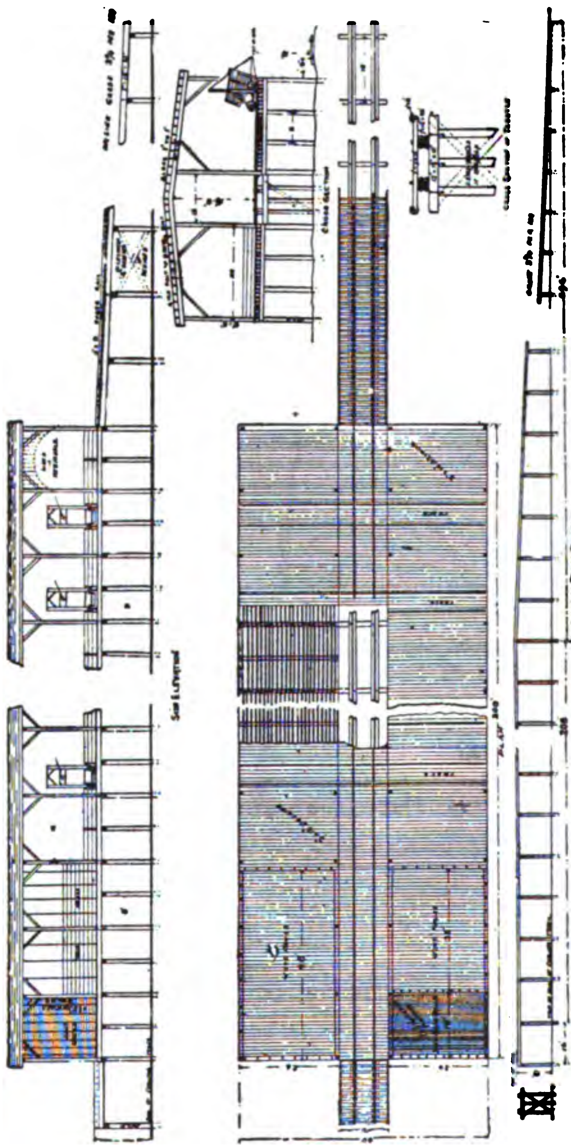


FIG. 17.—COALING STATION WITH STORAGE BIN.

committee, Mr. J. H. Cummin, of the Long Island road, who favors the "C. W. Hunt Company Conveyor." His letter and descriptive catalogue of the conveyor is hereto attached; also one from Mr. G. W. Hinman, of the Louisville and Nashville Railroad, who favors the Kerr chutes, without going into details or giving reasons for his preference.

As I understand it, the object of this association is to give its members, and through them the railroads they represent, the benefit of our experience and observation, and to formulate and adopt such plans as will be both practical, economical and within reach of all the railroads here represented.

A coal chute track should be elevated to sufficient height to permit chutes to be dumped and to freely clean themselves. The elevation of the upper track and chute above lower track should correspond in height with the standard locomotives of the road on which chutes are erected. The chutes should have steel drop aprons, as it has been my experience that steel will clean itself more clearly than any other material.

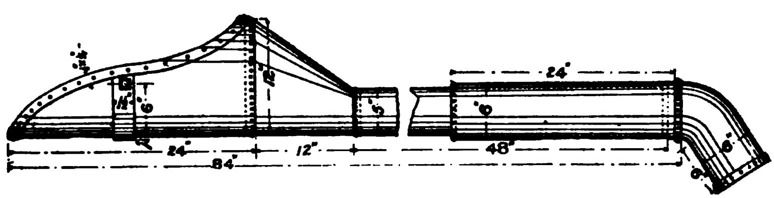


FIG. 18—SAND PIPE.

The chutes should be portable, where storage bin is used, but can be used to advantage without storage bins, yet where practicable, the bin is desirable.

The portable chute track should have a slight incline towards dumping point, and storage bin located at rear of same. Tracks on which portable chutes are to be located can be built with light or narrow gauge iron, and should cross the main track.

If coal is to be taken from both sides of the coaling station then the storage bins must be built of sufficient width to accommodate portable chutes at the rear of same. These chutes can be used without roofing, but it is more desirable to have them roofed with four-ply felt and gravel, which, though not absolutely fire proof, yet is reasonably so, and has the advantage of being inexpensive and durable. Its cost is less than shingles and decidedly less than slate.

If desired siding may be put on the chutes, yet this must, in a measure, be determined by latitude or climate; however, I favor the siding and roofing of all chutes in all climates.

The elevated tracks to chutes should have an incline of about 3½ feet to 100 feet in length.

The entire superstructure may be constructed of pile or frame-work, or all iron, at the option of the management of the company erecting.

As the majority of coaling stations are located near water stations it is advisable to sprinkle the coal, which will add materially to cleanliness and sanitation.

To fully illustrate my view upon this subject I have prepared and submit herewith plans of such elevated coal chute, with storage bin, as I would recommend for a standard plant. This plan also shows a woodshed and sand bin, from which bin sand can be supplied to a locomotive in the same manner as water from a tank. Either or both may be dispensed with. J. E. WALLACE,

Wabash R. R.

BILL OF MATERIAL.

Amount.	Size.	Purpose.
270 Pcs.	24′ long.	Piling — Driven about 12′.
9 "	22′ "	"
6 "	20′ "	"
9 "	18′ "	"
9 "	16′ "	"
9 "	14′ "	"
12 "	12′ "	"
36 "	12x12″x12′	Caps.
54 "	10x12″x24′	"
69 "	7x16″x32′	Stringers.
274 "	7x 7″x12′	Ties.
44 "	5x 8″x16′	Guard rails.
650 "	2x10″x16′	Floor joists.
56 "	8x 8″x20′	Posts.
28 "	8x10″x32′	Principal rafters.
430 "	2x12″x16′	Rafters.
112 "	6x 6″x12′	Braces.
90 "	4x 6″x 4′	Posts.
14,900 sup ft.	2x10″	Decking.
75 Pcs.	2x10″x20′	Studding.
380 "	2x12″x12′	Siding.
2,400 feet	1x 5″	Floor and lining, sand house M. D. inside.
13,500 "	1x12″	Roof sheathing.
134 sqs.		Gravel roofing.
6	Portable dumps.	
1,150 feet	"T" rail for incline and elevating track.	
720 "	Light T rail for portable dumps.	
324 "	¾x21″ drift bolts.	
140 "	⅝x13″ guard rail bolts.	
140 "	¾x27″ stringer bolts.	
560 "	1x3″ "OG" washers.	
140 "	1x3″ packing washers.	
12 kegs.	40d nails.	
6 "	20d nails.	
5 "	40d nails.	
8 "	Track spikes.	

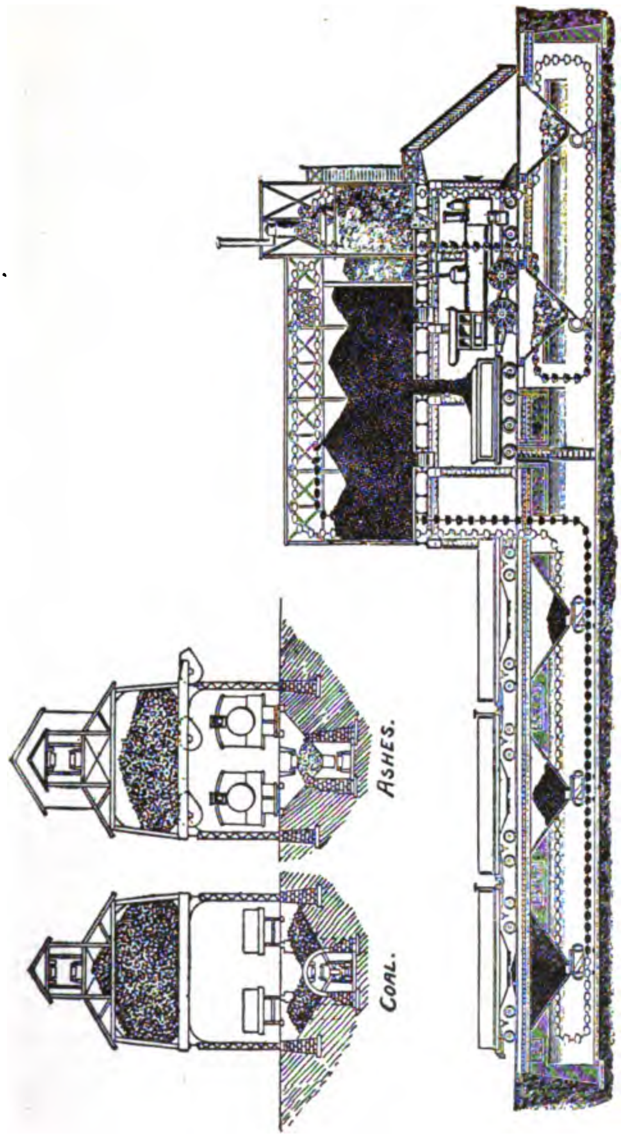


FIG. 19—COALING STATION, PHILADELPHIA AND READING R. R.

The following is the letter of Mr. Cummin referred to:

Long Island City, N. Y., Sept. 21, 1893.

Mr. J. E. Wallace, Supt. B. & B.:

Dear Sir—I have been looking up the coal storage and loading business, and the best method I have been able to find is the one put up by the C. W. Hunt Co. of New York. I send you with this one of their catalogues. The one in use by the Reading R. R. at Philadelphia is handling now 330 tons per day at a cost of $12.94, or a fraction less than four cents a ton. In addition to this, they load all the ashes in cars by the same conveyor at a cost of eight cents per ton. These figures come from the Master Mechanic at that station who has charge of the men employed there. The one in use on the Brooklyn Elevated works first-class. I see it in use every day and do not know of any other plan where coal and ashes can be handled as cheap as by this one.

J. H. CUMMIN,
Supt. B. & B., Long Island Ry.

DISCUSSION: SUBJECT—COALING STATIONS.

Mr. Travis approved of the report of the committee. The class recommended have given satisfaction in his section of the country (Illinois.)

Mr. Wallace said that the plans recommended refer to the handling of hard and soft coal and make no arrangements for taking care of screenings.

Mr. Pasco thought it would be well to have a provision to catch screenings and take them back to a car where hard coal is used.

Mr. Reid, Lake Shore & Mich. Southern Ry., stated that he has Kerr chutes with modification on his road, and that they put 5½ tons of coal into a tender in forty-five seconds. They have worked very satisfactorily. They have several eighty pocket chutes that are satisfactory. Repairs on chutes eleven years in use have been small.

REPORT: CREEPING OF RAILS IN RAILWAY TRACKS; ITS EFFECT ON BRIDGES, AND METHODS TO PREVENT INJURY TO THE BRIDGES.

On all swing or draw-bridges the rails are entirely separate and disconnected from the rails in the tracks on either side of the bridge and should be securely fastened to the bridge to keep them in their proper place, but on fixed spans of bridges.

Our opinion then is that no spikes should be driven in the slots of the rail or splices on any bridge to prevent them from creeping, but that they should be spiked to gauge only and left entirely free to creep or expand or contract as much as they would; neither do we think that any mechanical device or contrivance of any kind whatsoever should be placed at or near the end of any bridge to prevent the rails from creeping, as even if this could be done, it would only have a tendency to buckle the rail and cause a derailment of cars. A bridge is not intended to resist any end pressure, such as would be caused by the creeping of rails, and the effect it would have on a bridge would depend to a great extent on how securely the ties were fastened to the stringers. We have known the bents in a pile trestle to be pushed a foot out of plumb by the creeping of the rails. In this case the ties were securely bolted to the stringers and the stringers were also bolted to the caps and the rails were spiked to the slots. If the same state of affairs existed on an iron bridge, we can only say that the effects of the creeping rail would make itself visible at the weakest point. It might split the ties and get relief in that way, or it might slide the ties on the stringers, or if the ties were so securely fastened that they would not slide or split, it might, if the span was not very heavy, pull or push it off the abutment.

We have thus far stated what should not be done to prevent the creeping of the rails, and endeavored to give some hurried reasons therefor, and now we will say that the way that we would recommend for preventing the creeping of rails, would be to spike them securely through the slots into the grade ties on the bank and if it was found that that was not sufficient to hold them, we would have as many additional slots cut in the flanges of the rails as might be necessary, and if we found that the rails were running or creeping for a mile or two miles, we would have the additional slots cut in the rails for that entire distance, and if it was found necessary, we would have a slot cut for every tie so that every rail would be securely anchored by itself, which would prevent the tendency for buckling, which would be the case if an arbitrary attempt was made to stop the creeping at any one point, but under no circumstances would we ever allow a spike to be driven in the slot of a rail or splice on a bridge.

Creeping of rails has been known to crowd or shove a bridge of 154 feet span, three inches edgewise, in one season, and a case occurred on the L. S. & M. S. Ry. at Goshen, Indiana. The rail was spiked in a slot in the splice at the first tie on the abutment and said tie was shoved eighteen inches to the west in the space of six months. Rail creeping in double track railroads, we thing, is much greater, and it usually occurs in the expansion of the rails, working in the direction of the running trains, to a very great extent. We have found that at draw-bridges, it is necessary to hold the rails on the bridge firmly in their places and that all trouble came from the creeping of the rails on either side of the bridge, and that it is necessary, at times, to take out and cut off a rail that is shoved ahead by expansion of track on one side of a draw-bridge, and at draw-bridges it is frequently necessary to wedge back the rail to keep a proper clearance so the bridge is clear and in proper order to swing at all times.

Much more could be said or written on this subject, but we think it better to limit this article and not trespass on your time.

G. M. REID (Chairman), L. S. & M. S. Ry.,
J. B. MITCHELL, C., C., C. & St. L. Ry.,
Committee.

DISCUSSION: SUBJECT—CREEPING RAILS.

Mr. Pasco, Lehigh Valley Ry., called attention to the objection to cutting slots in rails for a mile.

Mr. Reid, Lake Shore & Mich. Southern Ry., stated that he had made no extensive experiements on that subject, but held that where it was done and the road well ballasted there was no objection to slotting rails.

Mr. Pasco gave experience of a track moving from expansion and did not think the cutting of slots would have prevented it.

Mr. Reid said that you can hold each rail from creeping and then you can hold the whole track. If a track is laid with proper shims for expansion on a bridge the rails can be held.

Mr. Pasco thought the subject should have been considered more with regard to the influence on bridges.

Mr. Shane, C., C., C. & St. L. Ry., stated that there is a rule on his road that no spikes shall be driven in slots on rails on a bridge.

Mr. Pasco said he objected to spiking in slots of the rail back of the bridge.

Mr. Reid, Lake Shore & Mich. Southern Ry., said that on his road there is a positive order that no spikes shall be placed in slots on a bridge so as to allow the rail to work freely over the bridge.

A member agreed with the committee's report on not spiking joints on bridges, but had had experience with a long bridge on which the rails of a single track travel in different directions; the north side travels east and the south side travels west. The track is straight over the bridge, but curves at each end. He put the question, "Why do rails travel so much?"

REPORT: GUARD RAILS ON BRIDGES—ADVANTAGES AND DISADVANTAGES—BEST KIND TO BE ADOPTED.

FIRST REPORT.

Guard rails in some form have, I believe, always been considered necessary on railway bridges and trestles for the preservation of the structure against derailed rolling stock. As is well known, a timber guard rail of some dimensions is common to all railroads. They not only furnish protection against derailed wheels as a guard rail, but are made to serve another purpose equally as important, viz: that of keeping the ties properly spaced and to prevent bunching. This is accomplished either by dapping or gaining the guard at the distances that ties are required to be spaced, to a depth of from one to two inches, letting the tie into the guard rail to that depth. The rail thus gained is laid upon the ties and securely bolted through tie and guard rail at least every fourth tie. Another practice is to omit the gaining and bolt through every tie. The former method is preferable, as it secures more rigidity to the floor system. A common dimension for these

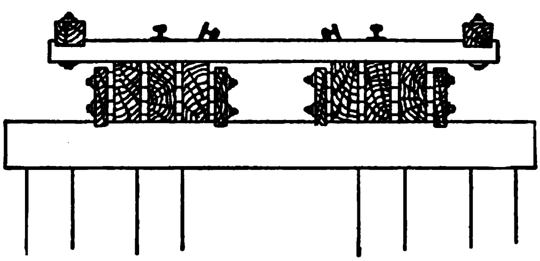


FIG. 20—GUARD RAILS ON BRIDGES.

wooden guard rails is 6x8 inches, worked the six-inch way, presenting a five-inch face to the derailed wheels when gained over the ties one inch. Wooden guard rails will be found far more efficient when shod with an angle iron or even an iron strap fastened to the upper inside corner of the guard rail facing main track rails. This is especially true where as small dimension timber is used as 6x8 inches. A very much better dimension is 8x8 inches or 10x10 inches, the latter dimension being preferable.

I submit a blue print of floor system (which has been adopted by our people) showing a guard rail composed of T-rails laid upon their sides the entire length of the structure inside of main track rails, as will be seen by reference to the plan. These rails present an inclined smooth surface to the main track rails, and are free from spikes, rail fastenings or any protuberance that would be likely to give a derailed wheel a hold upon the guard rail, thereby assisting it to climb the guard rail. These T-rails are laid eight inches from the main track rails at the base, and are carried a distance of thirty feet beyond the structure onto the bank on either side of the structure and there brought to a "frogpoint," or made to enter a "bull-nosed" casting made to receive the two rail sections. With this system of guard rails and Latimer re-railing bridge guards at the ends of the structures and the wooden guard rails of the dimensions mentioned placed twenty-four inches from the main track rails, I believe all will have been done in the interest of safety that can be accomplished with guard rails.

I can conceive of no disadvantage arising from the use of guard rails that might not be attributed to other members of the structure in their respective places.

O. J. TRAVIS,
E. J. & E. Ry.

REPORT: GUARD RAILS ON BRIDGES—ADVANTAGES AND DISADVANTAGES—BEST KIND TO BE ADOPTED.

SECOND REPORT.

The greatest advantage, in my estimation, obtained from guard rails, and which I think a matter of great importance, is their holding the ties in place and preventing them from "bunching" in the event of an accident on the structure. Another noticeable advantage is the finish they give to the deck of all bridges and trestles. To secure satisfactory results they should be sufficiently notched on ties and securely bolted down (on every third tie, for instance), to be able to resist the knocks and jars from derailed cars and still remain in their true position.

There is a disadvantage in having guard rails too large, and having them placed too near the rails. When too large they have been known to obstruct the transportation of special cars, such as the one appropriated to the use of the noted "Jumbo," and others not in general use. A great objection in having them too near the rails is that the wheels of a derailed truck will come in contact with them and in most instances cause a destructive wreck, whereas if guard rails were placed sixteen (16) inches or eighteen (18) inches from rails the same trucks would pass over the entire structure without any serious damage.

The best guard rail to be adopted, according to my knowledge, is an 8x8-inch 20-foot white, or good yellow pine, notched one inch on ties and bolted through every third tie, as I mentioned once before, and placed sixteen (16) inches from rail. A square piece of timber affords the advantage of having a good side up and a straight side for line. However, the size of guard rails must vary in accordance with height of rail on different roads.

JOSEPH M. STATEN, C. & O. Ry.

REPORT: GUARD RAILS ON BRIDGES—ADVANTAGES AND DISADVANTAGES—BEST KIND TO BE ADOPTED.

THIRD REPORT.

The subject of guard rails on bridges and trestles to an outsider is apparently a very simple one. To many their advantages and disadvantages are merely a matter of indifference, as they are wholly ignorant of their uses and importance, supposing that they are only ornaments, like jewels on the human body. Such remarks I have often heard from passengers on railway trains, who, to judge from their external appearance and intelligent conversation on general topics, one would suppose had more sense. And I am sorry to add that from the manner in which some of the guard rails on bridges and trestles are constructed by railroad men they do not seem to possess much more knowledge in that respect than the traveling public.

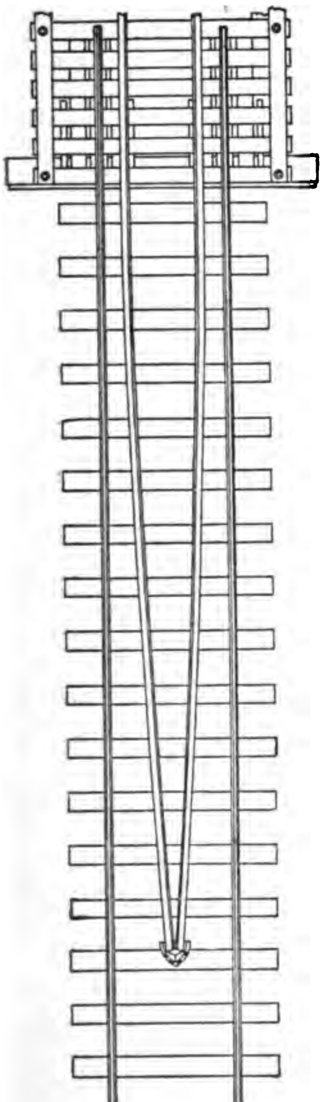


FIG. 21.—GUARD RAILS ON BRIDGES.

Nearly all track and bridge men with whom I have conversed admit the necessity of guard rails and maintain that they are often of vital importance, but the diversity of opinion expressed by men of practical experience in regard to the manner of construction demonstrates that we have not yet arived at the standard of perfection or the best to be adopted. I shall not take up the valuable time assigned to the convention for more important matters by enumerating all the divergent opinions of experts on this subject, but will simply give my own views, which, when compared with those of other members, may perhaps assist us to make some needed improvements in this line.

All bridges and trestles of importance should have Zee guard rails placed inside of main track rails, spaced about eight inches therefrom. These guard rails should be securely spiked to every tie, with angle splices on all joints bolted up in full, so that they may resist the severe strains that are often imposed upon them. Moreover, they should extend not less than sixty or seventy-five feet beyond the ends of each structure and there form a junction in center of main track, where a regular frog or point for that purpose should be placed to receive them. This frog or point to be securely fastened to the ties and have a bevel point, so that nothing hanging from a car may catch thereon. When constructed in a proper manner, guard rails are of an inestimable value, and have prevented many bad wrecks. But where they are put down merely for show, with a spike every eight or ten feet and no splices on the joints, they are useless and in fact a detriment. Guard rails are only of practical use in cases of derailment, and then they are generally subjected to the most severe strains. Consequently, if they are not constructed in the most substantial manner they are of no value whatever, but only an additional danger.

For wooden guard rails on the outside I use 7x8 sixteen-foot white oak, dropped into each tie one inch and bolted through every third tie with a $\frac{5}{8}$ bolt. These timbers are placed sixteen inches from the outside of main track rails; where snow plows are used it will be necessary to place them still farther.

Before concluding I will state one instance of the many which have come under my personal observation, proving very clearly the importance of guard rails. In this case a car left the track at a switch; every wheel was derailed. None of the trainmen knew anything of it, as it was nearly in the middle of the train; consequently the speed of the train was not reduced. They ran seven miles on a down grade before it was discovered, and in that space they passed three reverse curves of five and six degrees, and crossed over seven trestles, varying in length from 28 to 80 feet and one span of Howe truss bridge 114 feet long. And yet there was no material damage done, only breaking a lot of spikes and bolts, but the guard rails on every structure showed plainly that they had been put to a severe test and, no doubt, saved serious damage.

I have but little to say as to their disadvantages, only the expense of putting them on and maintaining them, and that cost is amply repaid if they only prevent a wreck once in five years, though my experience has demonstrated that they are of practical service much oftener than that.

QUINTINE M'NAB, C., C., C. & St. L. Ry.

DISCUSSION: SUBJECT—GUARD RAILS.

Mr. Wallace, Wabash Ry., stated that he had had a recent singular experience in regard to guard rails on a bridge. He was rebuilding a bridge, the train pulled out a draw-head, the draw-head dropped down through the ties, and if guard rails had been used there would have been a wreck. He believes in outside timber guard rails to keep the ties from bunching, and iron rails inside with re-railers at each end of bridge.

Mr. Heflin, B. & O. Ry., used 5x8 yellow pine guard rails and used iron rails inside. Knew of accidents where the cars were kept on the bridge only by the guard rails, therefore thinks that outside timber guard rails have use in preventing the bunching of ties.

Mr. O .J. Travis, Elgin, Joliet & Eastern Ry., thought that a guard rail only five inches high is not strong enough; guard rail mentioned by Mr. McGonagle is the proper size to use.

Mr. Markley stated that he has a T rail guard rail on the inside and connected at the ends of the bridge, but with a split switch. Had an escape from an accident in which the cars crossed over safely. He is satisfied that it was due to the inside rail that the accident was averted.

Mr. O. J. Travis said that the inside guard rail which he recommended is laid on its side and fastened by bolts through the web to the tie.

Mr. Olney, S. F. & W. Ry., asked whether anyone knew that a 5-inch guard rail had been crossed by a derailed wheel.

Mr. G. W. Andrews, B. & O. Ry., stated that within three months he had had a wheel jump over the 5-inch guard rail and then jump back again. The guard rail was 6 inch by 8 inch, dapped 1 inch. The guard rail was 8 inches from rail.

Mr. Olney, Savannah, Florida & Western Ry., held that 8-inch distance is too close; the wheel has not the space to get straightened out, but jumps the guard rail.

Mr. Heflin, B. & O. Ry., had never had a wheel jump the guard rail.

Mr. Wallace, Wabash Ry., assumed that reference is made to a guard rail for holding ties in position. He has on one bridge an 8x8 inch guard rail where there was an accident.

Mr. Olney believed it makes a difference which truck gets off the track. His road places guard rails 10½ inches from outside of rail.

Mr .O. J. Travis, Elgin, Joliet & Eastern Ry., said that guard rails should be placed according to the section of country in which the road is located. In northern countries allowances should be made with regard to snow plows.

Mr. Reid, L. S. & M. S. Ry., said he had known of cars running a long distance over a trestle where there were inside rails with re-railers. In each case it was visible where the wheel struck the point of the re-railer and was drawn into the line of the track.

Mr. Pasco, Lehigh Valley Ry., did not think it correct to build all floors to absolutely suit only snow plows. By spacing too far it leaves too much space. He prefers a lower guard rail placed closer to the rail, and thinks it would be better to recommend the adoption of a floor system that would be better able to ward off accidents and then make snow plows to clear the track.

Mr. Reid, L. S. & M. S. Ry., quoted several instances where snow plows were run very carelessly and recklessly, the snow plow reaching to within seven-eighths of an inch of the top of the rail.

Mr. McGonagle, D. & I. R. Ry., uses an 8x10-inch guard rail on a wide deck, dapped two inches on tie with lap joint at center of span which he thinks is important. Has known wrecked cars to pass over safely and two cars jumped the guard rail and fell free of the trestle. His opinion is that guard rails for holding ties in position should be far enough away from the rails to hold ties and should not be spaced with a view to holding wrecked cars. On a through bridge the width of the car is sufficient to strike the bridge before it strikes the guard rail. This should be provided for.

Mr. G. M. Reid, L. S. & M. S. Ry., always spaces guard rails so that they will be struck before the trusses are struck. Had an accident where a stone shifted on a car and struck a wooden bridge, broke two end posts, one main brace, and other rods, stirrup rod, etc., the stone was broken off and dropped down. The train hands did not know of the accident for three miles after passing the bridge.

REPORT: PLATFORMS—HEIGHT, DISTANCE FROM RAIL, MODE OF CONSTRUCTION, ETC.

The most important point to be considered in the construction of all passenger platforms is the safety of persons unacquainted with the surroundings, who, hurrying carelessly and oftimes in the dark, find a stumbling block which would be perfectly harmless to one familiar with the situation and surroundings. In our judgment the safest plan under all circumstances and conditions is a smooth floor built on a level with the top of rail; no steps after leaving the waiting-room door; no space between its edge and the moving wheels; or, in other words, joining close up to outside of rail. The principal and only objections to platforms constructed on this level are the extra height to coach steps and baggage car doors, which objections are more than counterbalanced by the safety rendered to passengers as compared to platforms constructed on the original or elevated plans.

At all small stations where the passenger and freight business are handled together or the same building is used for both, and situated on main line, we would recommend as the safest plan for passengers, with the least inconvenience to freight business, to have the depot building located twenty feet from the rail, with the floor of waiting-rooms, offices, etc., say five inches above level or top of rail.

Where elevated platforms are used at small stations on line of road the height should not exceed seven inches above top of rail to top of platform; two feet from outside of rail to edge of platform, with an easy incline at either end of platform. The platform for freight room at small stations should be on a level with car-floor, with an easy incline running parallel with the track to reach the level or main platform, as shown on accompanying plans. Where freight platforms are separate from passenger platform or located on sidings, the safety of passengers cuts no figure, convenience for handling freight being the only requirement. For handling ordinary freight the size of platform should be four feet from outside of rail and level with car floor, as freight passes both ways across it, and should be level if by itself, and with a pitch of

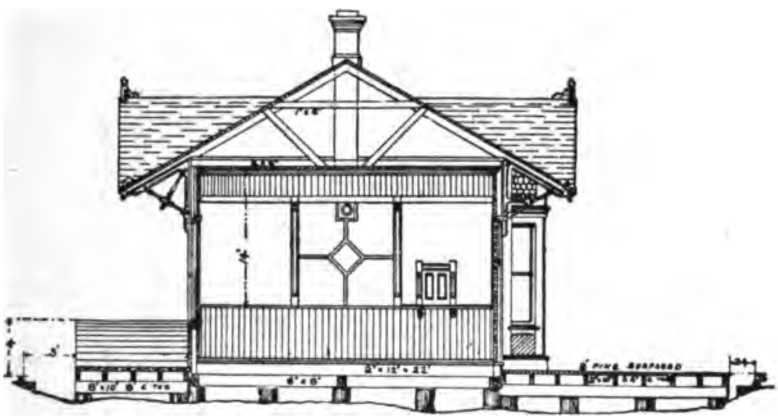


FIG. 22—STATION PLATFORM.

not more than two inches in six feet if connected with a depot. All special platforms for one particular class of freight should be constructed to suit the special requirements, as in case where freight passes only one way.

Mode or plan of construction:

For construction of passenger platforms 4x6-inch oak sleepers should be laid at right angles to the track, and as near as 24 inches from center to center as the cross ties will permit, extending to the rail and 3 inches below top of rail, which should be well tamped and filled in even with top surface of sleepers. Coarse sand and gravel are first-class filling, also cinders answer very well, which are always convenient and cheap. Floor of 3x10 inches by 16 feet, oak or yellow pine, surfaced and square edges, not dry enough to swell when wet, well nailed to the sleepers. The track should of course be put in good line and surface before starting. Between the rails the ties should be shimmed and floor laid flush

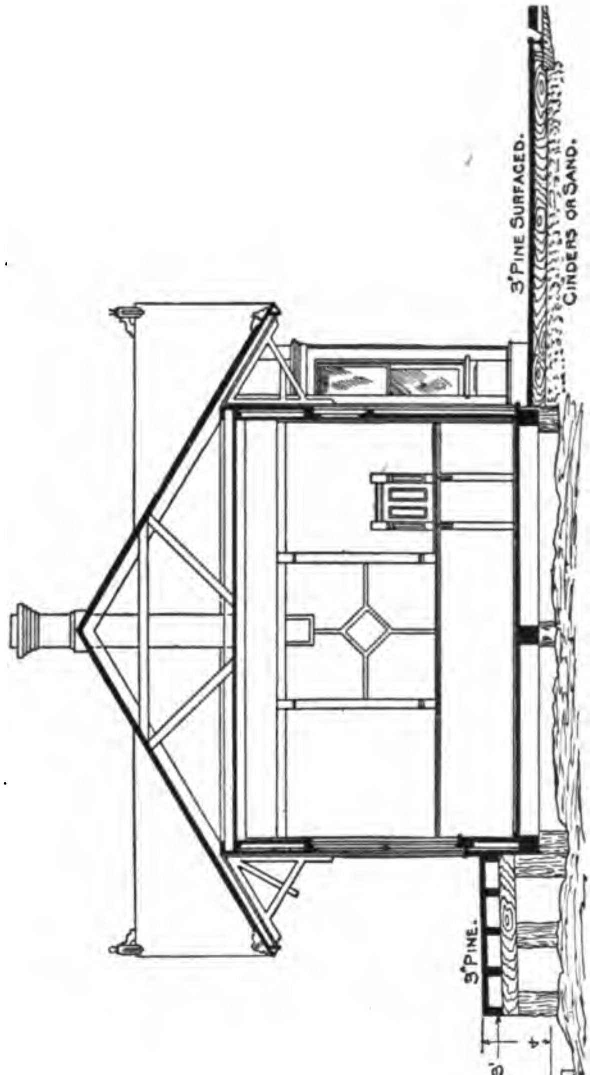


FIG. 23—STATION PLATFORM.

with top of rail, leaving a space of about 3 inches next to the rails for flange of wheels, which space should be filled within 1½ inches of the top.

Freight platforms should have posts of 12x12-inch oak or good sound pile ends, 8 feet apart each way, resting on rock or brick piers or foundations, keeping the posts clear of the ground to prevent decay. The posts should be cut square and of even height to receive the sills, with full and true bearing on top, the bottom end to take full and true bearing on stone or brick foundation, as case may be. Sills should be 10x10 inches by 15 feet, drift-bolted to posts, laid at right angles to track; or any good sound

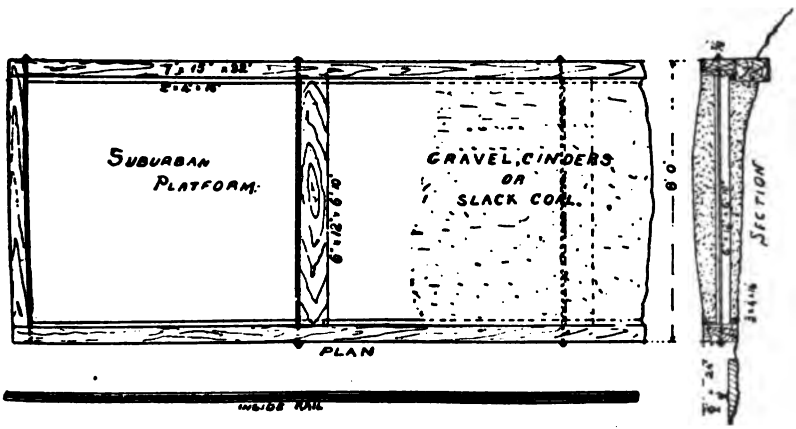


FIG. 24—STATION PLATFORM.

old bridge timbers could be utilized for sills in place of new timber, using 3x10-inch by 16 feet joist or two panels long, spacing same about 18 inches from center to center. The front joist, or one next to track, to be set flush with end of sill, with a 2x10x12-inch splice spiked across the joint inside of joist; the balance of the joist to be lapped by each other and nailed together and well bridged between the joists; a floor of 3x10 inches by 16 feet yellow pine or oak, surfaced and squared and laid at right angles to track, extending or projecting 2 inches beyond outside joist.

For all freight houses located at terminal stations or large cities where a large amount of freight business is handled we would recommend floors of granitoid, also for outside and transfer platforms.

As special platforms require special modes of construction each one would necessarily be governed by the requirements.

For suburban platforms where very little or no baggage is handled and where trucks are not used we would recommend cinder or gravel platform, made by filling in between two timbers set on edge with a tie bolt of about ¾ inch round iron about every 8 feet to keep timbers in position. Old bridge timbers may be utilized for this curbing, which makes a cheap and durable platform.

JAMES STANNARD, Wabash Ry.,
W. RANSOM, A., G. S. Ry.,
N. M. MARKLEY, C., C., C. & St. L. Ry.,
ROBERT OGLE, D. & R. G. Ry.,
Committee.

DISCUSSION: SUBJECT—PLATFORMS.

Mr. Cummin, Long Island Ry., spoke of the concrete platform that has been so satisfactorily used by the Long Island road. The cost is eighteen cents per square foot, the road supplying the cinders. It is his opinion that in having concrete laid it is important to have an inspector, his experience with contractors for concrete being that they are worse than plumbers.

Mr. W. G. Berg, Lehigh Valley Ry., stated that there were several features in the report of the committee which he would briefly call attention to, so that in the more exhaustive discussion of the subject, which would probably take place at the next convention, they could be properly considered. He was not ready to accept the apparent generality with which the committee decided in favor of low passenger platforms, running flush to the top of the rail, owing to the necessity of making the safety of passengers the first consideration. In the absence of a legal opinion on the subject, he considered that the introduction of a step in the platform did not indicate criminal neglect on the part of the company, nor could it be considered even as a defective design. Unless the steps of the cars were made to correspond with the very low platform, it would be a question whether passengers would not complain of too long a step. In the general recommendation of the committee to place high freight platforms four feet from rail, there should have been a distinction made whether the freight platform adjoined a pit in a warehouse, or faced on to a side track or a main track.

In the first cases mentioned the platform could be spaced closer, while most roads prefer a slightly greater distance opposite a running track. In regard to placing high freight platforms level with the car floors it would have been well to have given some distance, as the old standard of four feet from top of rail has had to be changed to allow for the swinging doors on refrigerator cars. He considered three feet ten inches to be the proper figure. He knew of roads that had to change platforms after the introduction of swinging doors on cars. The report did not make provision for the important case of a high platform, facing the track at combination depots. What distance to keep the face of the high platform from the track, so as not to imperil the lives of passengers, and yet keep the distance that freight has to be lifted or skidded across the low platform in front of the high platform, reduced to a minimum. No reference was made as to whether the planks on freight platforms should be laid tight or open. Attention might also have been called to the objectionable feature of closing in with planking the face of a high platform where it is close to a running track, as it gives no opportunity for a person caught between the platform and a train to crawl under the platform. It would also be desirable to make some recommendation as to the proper width of platforms.

Mr. Hanks, Flint & Pere Marquette Ry., thought it would be desirable to do away with all high platforms, if possible, by changing and extending the steps of the cars and by other means. He thought that all platforms should be kept down low.

Mr. Pasco, Lehigh Valley Ry., asked if any of the members had had any experience in keeping planks in place next to the rail.

Mr. Hanks said they never have any trouble in the winter season.

REPORT: BEST BRIDGES—WOOD, COMBINATION OR IRON.

In connection with this subject there are many things to be considered. The first and all important is absolute safety, or as nearly so as human ingenuity can make them. True economy must not be lost sight of. Localities and means at our command must be taken into consideration.

There are two elements to contend against (fire and water) that have caused greater loss of life and property than all other causes combined. The first can be guarded against by discarding wood to a greater or less extent. The danger from water may be overcome by providing sufficient water-way and a substructure of masonry on a good foundation.

There may be a day when time, the destroyer of all things, must be considered, but with bridges it is not yet, for owing to continually increased weight of rolling stock the poorest iron structure is not allowed to stand its natural life.

But let us consider this subject from a financial point. We will take a span 175 feet in length.

An iron bridge of this length, with forged eye bars of steel, with a unit strain of 20 per cent. in excess of the unit strain allowed for iron bars, and for all other members of the bridge iron or steel with the same unit strain as for iron; calculated on a basis of a load equal to Cooper's class A, will cost, erected ready for ties, about $8,000, or $45.70 per lineal foot, and should be so constructed that all its parts can be inspected and painted. With such a bridge as this all danger of fire and loose nuts is removed.

A combination of same length span, calculating on the same basis, may be built at a cost of 15 per cent. less, or $6,800, and by constructing the tensile member, as recommended above, for an iron span and for compression members using long-leafed unbled yellow pine of Georgia, or the Douglass fir, more commonly called Oregon pine, of Oregon and Washington, a first-class bridge may be secured that will last for twenty years, at a saving of $1,200 on the original cost, and computing that this $1,200 is worth 4 per cent. for twenty years, we have saved but $2,611.32, provided that we have been at no expense for repairs more than would be necessary on an iron span, namely, ties, painting, etc. By covering the chords, beams and stringers with galvanized iron or some other fire-proof covering they may be made almost first-proof and greater longevity secured.

A Howe truss can be built at a cost of 25 per cent. less than the cost of an iron span, or $6,000, thus saving $2,000, and by using such material as we have before mentioned, and covering all parts good with galvanized iron, after thoroughly painting, a comparatively safe bridge can be secured, good for twenty years, if properly cared for, at a saving of $4,381.95, computing the original saving of $2,000 at 4 per cent. Thus we find that although a wooden span may be constructed so that it will last twenty years, and we claim it can, yet with the difference in cost of that and an iron span compounded for the said twenty years, the life of the bridge, it will not net enough to reconstruct it, and as great a percentage of safety against fire is not secured with all the precaution that may be taken.

More rigidity is secured in an iron bridge than in either a wooden or combination, but this very rigidity may act to the detriment of the bridge, in that the iron will be more liable to crystallize than it would in a combination or Howe truss, but if a bridge is properly proportioned with a sufficient margin of safety, using about eight as a factor, this crystallization will probably not weaken the structure for many years. Your committee can quote no authority on the length of time an iron bridge constructed as before mentioned should stand, but we believe that if the members are so arranged that it can be kept painted and all rivets kept tignt and otherwise cared for properly, and calculating the rolling stock has reached its maximum weight, it can be maintained for seventy-five years. Generally speaking, of course there will be exceptions; for instance, one of your committee residing on the Pacific coast, finds from experience that dampness from the sea carries salt to a considerable extent, which is very destructive to iron and steel, but generally it is not to be contended against. Thus we conclude that, while a wooden bridge is safe, a combination is safer, and an iron bridge is safest, cheapest and best, if your company is able to afford it. The committee does not take into account any liabilities to accident from derailed trains, for in such cases the best as well as the poorest are liable to go down. Neither do we consider bad workmanship, for this should be guarded against at all times, in all kinds and classes of bridges, and all material used should be first-class, and never abused by pounding or rough handling.

Particular attention should be given to see that all connections in iron spans are compact and that the pins fit closely, that there may be no possible movement, else they will wear in time. One of this committee had occasion to break a connection a short time ago in a combination span that had been up about fifteen years, and it was found that the eye bar was worn about 1-32 of an inch, and also the pin about the same. The impression of t e bar was plainly discernible on the pin, so much so that when the bar was in position it was slack and would not tighten with a load, and had to be removed. On close inspection it was found that other members of the bridge were worn in the same manner, but it was not general. This was thought to be owing to the fact that the metal was a little softer in these worn members, or perhaps they did not fit closely on the pins, and had a better opportunity to wear.

This is objectionable, for it will be found that these worn members would not take the strain, and the load would be unequally distributed.

I would add, however, that the bridge referred to was not made in the manner recommended by your committee, namely, eye bars of forged steel.

As to the best method of reconstruction the committee, as in the foregoing part of the article, can say nothing that will interest or enlighten any member of the association. Modern iron bridges are so constructed that they may be raised with a traveler without the aid of upper false works. But many of us doubtless remember when we put up bents to support the superstructure, raised the different parts with a gin pole or mast, run them to their places on timber buggies and packed or connected them by hand. This plan, when there are but one or two spans to raise, and it will not pay to go to the expense of erecting a traveler, is commendable.

False work of all kinds is used to support the tracks and superstructures. Sometimes they are horse legs, simply posts set on the ground without sills, when the river bed will warrant it; again frame bents on mud sills, or cribbing are used, and often where the river bed is soft, piling is recommended, and especially the latter, where there is danger of a washout. All false work should be constructed of a sufficient width and strength to support the dead and rolling load, and care should be used to so arrange false work that it will not interfere with the members of the bridge, for if they come in contact it will be found expensive in making changes.

As to the reconstruction or the renewal of wood or combination spans it will be found economical to remove only such members as are defective, except in chords where spans would have to be supported by trestling. In such cases it would be better to renew the entire chord, for the expense of trestling the second time would be more than the cost of a new chord. As to stringers and ties we have found it necessary in wood and combination spans to renew them twice, and in some cases three times before the span gives out. In iron spans it will be found necessary to renew rivets that will get loose. These should be cut out and new ones driven, and sometimes the lateral rods will so corrode under the nuts, where the latter are used, that a wrench or blow will break them, necessitating new ones. Otherwise iron spans need but little renewal.

A. SHANE, C., C., C. & St. L. Ry.,
C. G. WORDEN, Southern California Ry.,
M. E. POTTER, C., C., C. & St. L. Ry.,
Committee.

REPORT: BEST METHOD OF ELEVATING TRACK FOR CURVES ON BRIDGES.

FIRST REPORT.

The question of the best mode of obtaining elevation of track on bridge structures located on curves, or with the end of span at front of curve, necessitating the graduation to be made on the bridge, is one involving a variety of opinions. Your committee has endeavored to evolve the best means of obtaining elevation, at the least cost, which is a very important point, and one of the first to be considered by railroad managers or engineers, when the question of a new structure or the renewal of an old one arises. There are a number of devises in use in gaining the desired elevation, some with good features and some otherwise. We have taken them up in detail and herewith submit them for your consideration.

Blue print No. 25 shows the old English style of elevation

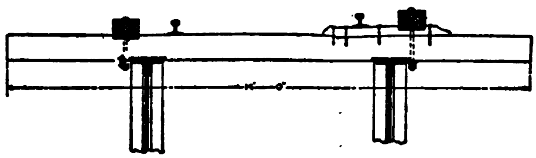


FIG. 25—ELEVATION BY BLOCK ON TIE.

by placing a block on the tie under the outer rail of such a thickness as to raise the rail to the required height. This plan is objectionable for several reasons, as follows: The rails are not on the same plane, and wear so irregularly that if it is desired to re-

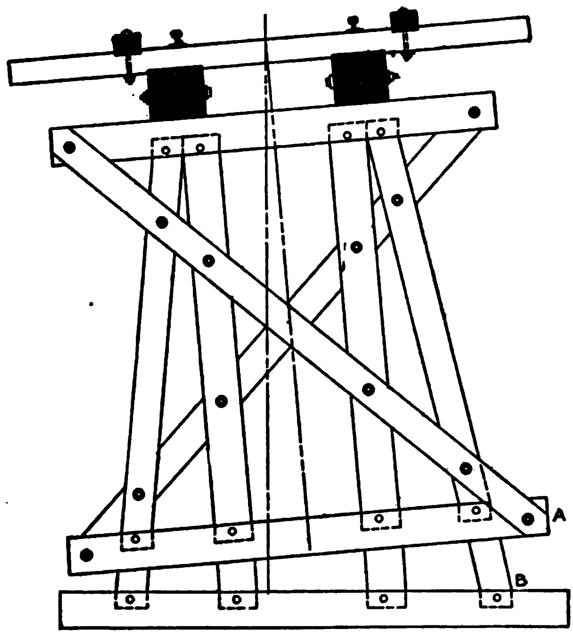


FIG. 26—ELEVATION BY RAISING END OF SILL A.
ELEVATION BY LENGTHENING POSTS B.

verse them they present sharp edges that are very injurious to wheels and tires; the bearing of the wheel on the inside rail comes on that portion of the thread not supported by the spokes, or body of the wheel, and prevents the flange from acting with full efficiency when the train is moving slowly; and in case of a derailment the elevation blocks are torn loose and split to pieces, increasing the liability of further damage to floor, and also the work of getting

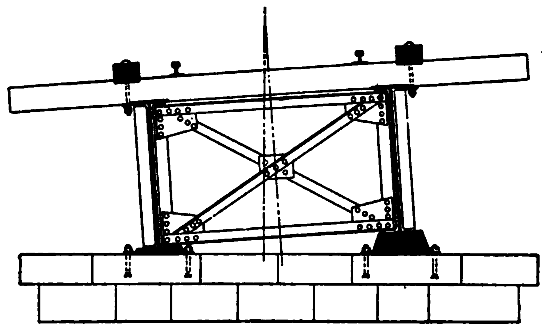


FIG. 27—ELEVATION BY RAISING OUTSIDE GIRDER.

the cars back on the rails. Print No. 26 shows the elevation by raising the outer end of the sill of trestle, as at A, and also by lengthening the post so as to allow the sill to lie level, as at B.

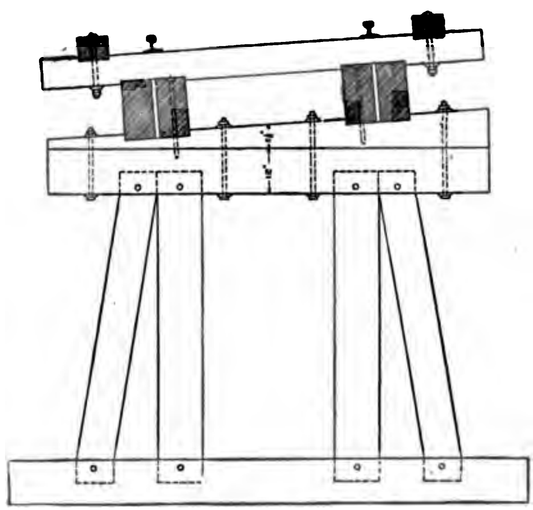


FIG. 28—ELEVATION BY CUSHION CAP.

Both these plans are objectionable, for the reason, first, if the elevation is sufficient to equalize the centrifugal force developed by a high speed passenger train it is too high for a slow moving freight train, and in consequence the load would not act through the axis of the trestle, but would reach the ground by gravity (as per the dotted line to the left of the center) and would thus throw most of the load on the posts under the inside rail, also causing the vertical posts to act as batter posts with the thrust in that direction opposed by one post only, and that in a very slight degree, so that the sway bracing alone would act against the racking of the bent, and it will be easily seen that the greater the elevation or the higher the trestle the greater will be the racking force exerted. This could be remedied by increasing the batter of the inclined posts on the inside of the curve, but this would involve framing several batters for one trestle, which is not desirable to the average bridgeman.

The same objection regarding centrifugal force developed by a high speed passenger train would hold in the case of sketch No. 27.

Here we find a pair of plate girders with the elevation gained by raising the outside girder to the required height. Under a train moving at a high rate of speed this plan would be a good

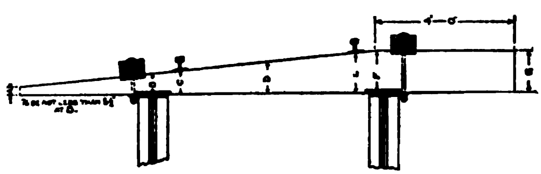


FIG. 29—TAPERED TIE FOR SIX DEGREE.

one, but as slow moving trains would also use it at a speed not sufficient to generate the force necessary to cause the load to reach the pier through the axis of the girder, it would go there by gravity and would subject the girder to a strain not provided for in its construction.

This mode of elevation is all right in principle, but we would not consider it good practice to use it unless there were separate tracks for fast and slow trains, so that the elevation could be regulated accordingly.

Another mode of elevation is seen in sketch No. 28. It is gained by means of placing a cushion cap on top of the main cap under the stringers, tapering to such a degree as to raise the outer rail to the point desired. This cap is generally dapped from 1 inch to 2 inches under the stringers, which is of great assistance to the drift bolt in holding the stringers in line. The principal objection to this mode is found in the fact that this dap under the stringers holds water, and the joint between the cushion cap and the main cap also holds water, being horizontal, and is the cause of early decay. For this reason it is not thought well of and is not used to any great degree.

Sketch No. 29 shows a very familiar plan for getting elevation by the use of tapered ties. This kind of ties answers very well on a trestle or truss bridge where the stringers are on the same plane, but on a long span of plate girders where there are several cover plates it frequently happens that to cut the thickness of several plates out of the tie removes so much of the timber as to weaken it at the small end and renders it dangerous in case of derailment. Somebody might ask, why not make the tie deep enough to leave all the timber you require at the small end after cutting the thickness of the cover plates out of the dap? In answer

TABLE OF TAPERED TIES FOR CURVES.

DEGREES.	A	B	C	D	E	F	G
1	6	6¾	6⅞	7⅜	7⅞	8 in.	8 in.
2	5	6½	6¾	7¾	8¾	9 in.	9 in.
3	4	6¼	6¾	8¼	9¾	10 in.	10 in.
4	4	7	7⅝	9⅝	11⅝	12 in.	12 in.
5	3	6½	7¼	9⅝	12	12½	12½
6	3	7⅛	8	10¼	13½	14	14

For sharper curves use elevation blocks.

we would say that a 14-foot tapered tie for getting the required elevation on a 6-degree curve would, as per sketch, require a tie 14 inches deep at the thick end, and oak timber of sufficient size to cut larger sizes from is not found plentifully in many sections of the country. Another objection to the use of the tapered tie and one that will carry considerable weight with the average railroad manager, especially on a system traversing a mountainous country, is this: The table of tapered ties shows six sizes of ties for six degrees of curvature. This could easily be arranged so that three sizes of ties would answer, but even then to keep on hand a supply of emergency ties would tie up three times the amount of money necessary in case a standard 8x10 inches or any other regular sized tie were used exclusively, and that this can be readily done it is our purpose to show further on. In our experience tapered ties are much more expensive than the regular sizes, from the fact that in computing the number of feet contained in them the size of the tie at its greatest section is taken and estimated as running its whole length. Millmen are able to govern this feature from the fact that a majority of them cannot saw tapered material.

Another method of obtaining elevation is seen on sketch 30. This is obtained by the use of an elevation block under the tie, and is used when the curvature is sharper than 6 degrees, and is not often required by roads traversing an open or prairie country. This plan is open to the same objections as a tapered tie in the case of a plate girder span having several thickening plates, as in cutting out the thickness of the cover plates at the low end of the ties they are weakened to such an extent as to render them unsafe in case

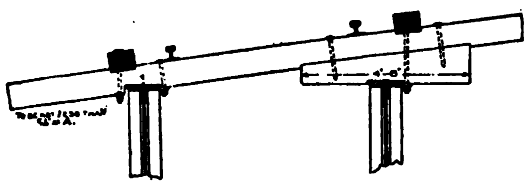


FIG. 30—ELEVATION BY BLOCK UNDER TIE.

of a derailment, or if not absolutely unsafe they generally split, starting at the shoulder of the dap and rendering their renewal imperative.

Print No. 31 shows the elevation built in the girder. This is a plan adopted as an experiment on the First Guest River crossing, Clinch Valley division of Norfolk & Western Railway, and while it is an excellent plan on short girder spans where there is not more than one cover plate, experience has shown that it is not a desirable plan to use on girders having four or more cover plates,

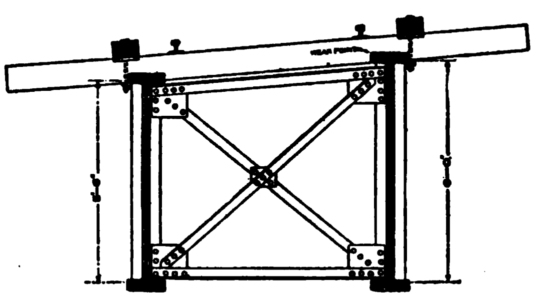


FIG 31—ELEVATION BUILT ON GIRDER.

as the daps over the center of the span are required to be cut to such a depth as to seriously weaken them and causing them to split under a derailment, with the fracture starting at the weak point shown on the print.

Another mode of elevation used and shown on print No. 32 is the cushion tie, which consists of a tapered stick about three inches thick at the thin end and of the same width as the tie or floor beam on which it is spiked or bolted. It possesses some merit during its life, which in my experience is very short, as it is open to several objections which all tend to curtail its usefulness. Being very light at the small end it is soon warped out of shape by the sun. The spikes split it; it forms a horizontal water joint, hastening decay, and in case of derailment it is generally torn to pieces, necessitating a thorough renewal.

In the opinion of your committee that method of obtaining elevation on bridges which combines the maximum of safety with

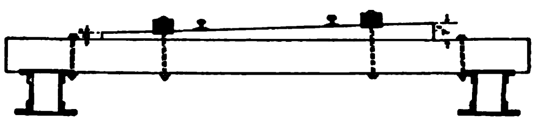


FIG. 32—ELEVATION BY CUSHION TIE.

the minimum of cost, is the best method, and if we can show that the desired end can be gained by the use of standard symmetrical ties, eliminating all tapered ties and also releasing the capital necessarily locked up in an emergency stock of the same, discarding surface elevation blocks and presenting a plane surface over which derailed trucks will roll with less danger of slewing than on the ground, throwing out cushion caps and ties and doing away with the consequent water joints, and causing all the loads to reach the bases of structures through their axes; then we consider that we have attained the object for which we were appointed. But before submitting the result of our labors we wish to call attention

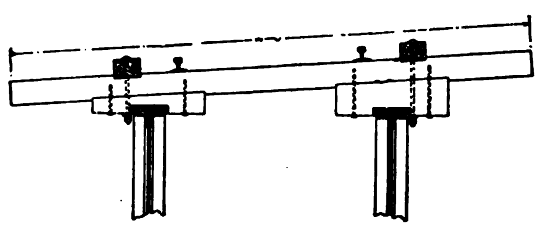


FIG. 33—ELEVATION BY BLOCK BENEATH TIE.

to the late plan of building iron or steel bridges with a solid floor of I beams or channels, obtuse angle Z bars, lap riveted to form a trough, covered with buckle plates made water tight at the joints, or covered with asphalt and gravel to attain the same end; and this floor carrying the standard stone ballast. If this were in general use the question of obtaining elevation would be solved and your committee would possibly not be in existence, but as this method is still in its infancy and present structures are those with which we have to deal, we will not give it any further consideration, but pass on to the matter in hand.

Print No. 33 shows a plan of gaining elevation on long girder spans, where there are several inches of cover plates. The advantage is seen in the fact that symmetrical ties can be used for any desired elevation. The daps are always of the same depth and if there are heavy cover plates the cutting out of the daps for them is done in the elevating blocks. These blocks can be made of any old material, of which there is generally a supply on hand,

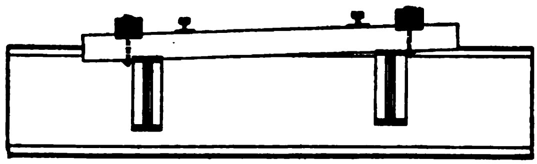


FIG. 34—ELEVATION BY RAISING OUTSIDE STRINGER.

although it is generally quite as economical to order the material new with the ties. These blocks can be fastened to the ties with either bolts, lag screws, or spikes, preferably with lag screws, as after they are once in place they require no further attention while bolts will lose their nuts and spikes will work loose, and are also a source of a great deal of trouble when a renewal of any part is required.

On any truss span where the stringers are on the same plane we would suggest elevating the outside stringer as shown on print

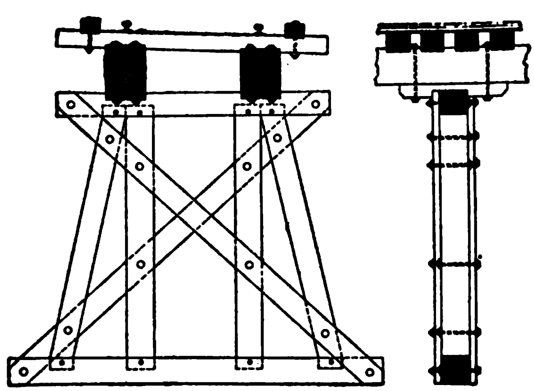


FIG. 35—ELEVATION BY INCREASING HEIGHT OF OUTSIDE CORBEL.

No. 34. This would obviate the necessity of using tapered ties, and as there would be no cover plates to cut out of the daps, the regular tie could be used with a regular sized dap, unless it were desired to cut out the camber in the ties, and in that case if the span should be very long, the cushion elevation block might become necessary. These would also answer in the case of existing trusses with iron floor systems, in which both stringers are on the same lateral plane, and also in trusses, either deck or trough, where the floor is supported on the chords.

Print No. 35 gives our suggestion for elevation on trestles. This shows the elevation gained by the use of a corbel under the

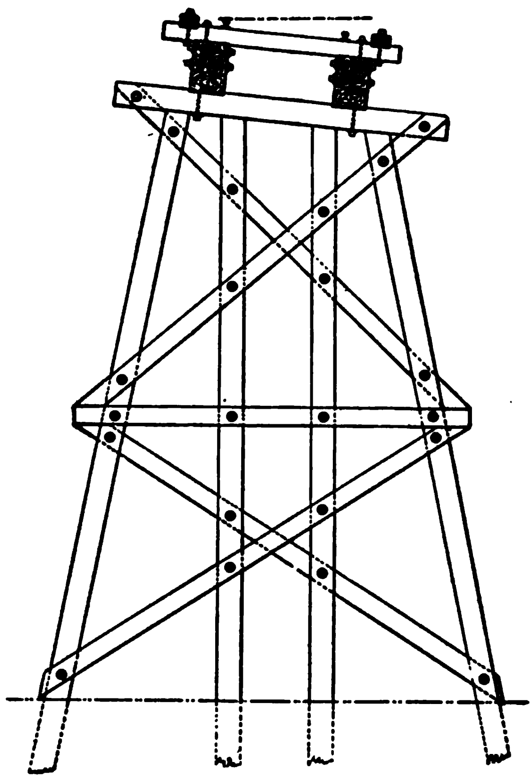


FIG. 36—PILE TRESTLE.

outer stringer, and if corbels are already in use it would only be necessary to increase the depth of those under the outer stringer.

H. E. GETTYS, Norfolk & Western Ry.,
S. F. PATTERSON, Concord & M. Ry.,
Committee.

REPORT: BEST METHOD OF ELEVATING TRACK FOR CURVES ON BRIDGES.

SECOND REPORT.

The following is the report of another member of the committee, Mr. G. W. Hinman, made in the form of a letter to the chairman of the committee on the subject of the best method of elevating track on curves upon bridge structures.

I herewith present three sketches of elevating tracks on bridges. Fig. 36 is a pile trestle, Fig. 37 is a frame trestle, and Fig. 38 is a 60-foot girder. After a long experience and trying every method of elevating tracks on bridges I have adopted these plans. It will be noted that the elevation on sketch Fig. 36 is put in by framing the cap on the piles; this leaves all the timber of the dif-

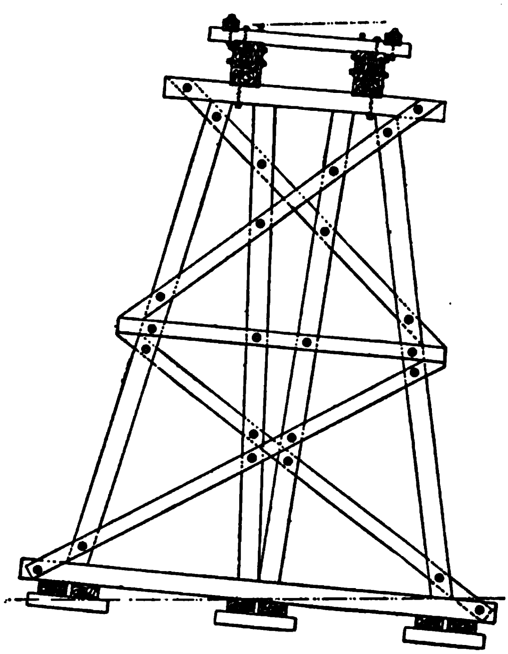


FIG. 37—FRAME TRESTLE.

ferent kinds to be framed the same size each. In the frame trestle Fig 37, the elevation is put in by elevating the bottom sill, thus leaving the several kinds of timber to be framed the same size each. The result is accomplished on girder, Fig 38, by building up with timber on top of girder to bring track to the required elevation. The elevation on the plans is for a six-degree curve, which, of course, is extreme.

In years past the speed over bridges where curves existed did not exceed twenty-five miles per hour and of course the elevation was ordinarily put in by using ties sawed tapering. Usually not over three inches of elevation was given at that speed, and so tapering ties answered very well; but at this time, with the fast speed that railroads are now using, it becomes necessary to put in more elevation. I use one inch for each degree of curve, up to six inches. I know of no better way than that shown in the sketches. I have a trestle 800 feet long, 50 feet high, on a grade of 4 feet per 100 with a ten-degree curve on it. I renewed it three years ago and built a trestle on the same plan as Fig. 37 and it has given me very

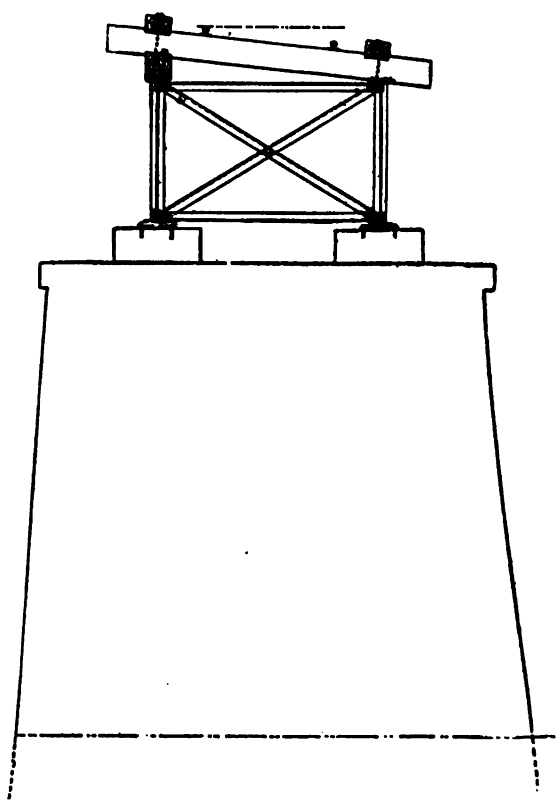


FIG. 38—SIXTY-FOOT GIRDER.

little trouble since. It will be noticed that the trestle bents stand in a directly perpendicular line with the load, which gives the trestle no unnecessary strain. I have a pile trestle 900 feet long, with a four-degree curve on it, built like Fig. 36, which is six years old and has given me no trouble. I cite these cases to show that elevation put in track according to these sketches works well in practice.

This method is much more convenient than using tapering ties, as any standard tie will go on any elevation. It is a very nice job to put elevation in track with tapering ties. For instance I have a trestle three miles long and on it is a three-degree curve 2,500 feet long; one inch elevation for each degree of curve elevates the track three inches; and running out sixty feet for each inch of elevation gives you a distance of 2,860 feet to use tapering ties. You must have at least four different sized ties, while if the result had been accomplished by framing the piles and putting the cap on at the proper elevation the same tie, or any standard bridge tie used on the road would fit the place. I will admit that the frame trestle looks rather "cobbled up," but when you come to look and understand that the elevation rarely is as great as in the sketch, usually about one-half, it is not so "cobbled" up as it looks. On the other hand, if you use tapering ties it will require a tie twenty inches wide to get the required elevation.

It must be borne in mind that we have to use this elevation for the speed that we are now running.

G. W. HINMAN, L. & N. R. R.

DISCUSSION: SUBJECT—BEST METHOD OF ELEVATING OUTER RAIL ON BRIDGES.

Mr. Pasco, Lehigh Valley Ry., thought it is desirable to use a block on top of the tie.

Mr. Olney, Savannah, Florida & Western Ry., stated that his road in cases where there are trestles, use double caps and where there are curves they make the elevation by placing blocks btween the caps.

Mr. Reid, Lake Shore & Mich. Southern Ry., made mention of a trestle with a twelve degree curve. The elevation was obtained by cutting the piles at the proper elevation; the caps were dapped and drifted on to the piles. This has been in use two years. The track is a side track, although there is no fast running.

Mr. Pasco thought the double cap is a good idea, especially for a side track trestle on piles, as in case a settlement takes place the proper grade can be easily established.

Mr. Hall, Ohio & Miss. Ry., asked Mr. Olney whether packing blocks were used between the caps.

Mr. Olney stated that they put blocks in only for elevation; in case of surfacing they use shims under the entire tie. Has no ice or snow to contend with.

Mr. Hanks, Flint & Pere Marquette Ry., had to elevate on iron bridges. Does not like to use bevel ties. Timber is now getting scarce. He objects to putting blocks on top, as the spikes split the blocks and then slide on top of ties. Lately he has been putting the blocks under the ties. Thus far this latter method has given good satisfaction.

Mr. Wallace, Wabash Ry., wished to know why in locating a bridge the elevation is not allowed for in constructing a bridge if a curve is to exist.

Mr. Pasco had had blocks for years on top of ties on twelve degree curves and over, and had never had a block split.

Mr. Olney, S. F. & W. Ry., said he sometimes takes the elevation out in the cap and not by shims; by dapping the lower stringer onto the cap.

Mr. Markley, on pine trestles or curves, makes the elevation entirely in the caps; in plate girders the same way, and brings the girders up by cast plates, so all the ties are of the same thickness. In using shims the sizes have to be regulated and cause much trouble.

Mr. Staten wished to know how girder bed-plate castings are set.

Mr. Markley said the girder is set up square and the elevation is then taken out by the cast bed-plates.

THE DUTIES AND KNOWLEDGE REQUIRED OF A SUPERINTENDENT OF BRIDGES AND BUILDINGS IN THE RAILWAY SERVICE.*

PAPER NO. 1.

The duties and knowledge required of a Superintendent of Bridges and Buildings in the railway service are so numerous and weighty that when I come to consider them I am appalled at the responsibility one occupying the position assumes. He has duties to employer and employe; to superior and subordinate; to the shipper and the traveling public. To his employers he owes eternal vigilance; ever guarding their interests to prevent injury to persons or loss of property in any way especially pertaining to his department, to guard against loss through viciousness, negligence or incompetency of self or subordinates; to warn his superiors of threatening danger, and in the absence of authority he must assume the responsibility and exert every effort to prevent it.

He should keep his superiors thoroughly posted as to the nature and condition of all structures and his work; he should carry out instructions when practicable and consistent, and when not so it becomes his duty to notify his superiors if possible.

* Papers written in competition for prize of $100 offered by The Railway Age. Paper No. 4 was awarded prize.

Should he find he cannot do this it then devolves upon him to exercise his judgment, advising them promptly of the action taken.

He should guard against irregularities, inequalities or injustice between man and man, employer and employe, and if any do occur he must use every effort to adjust them, for he is the medium through which the employe in his department should reach his employer.

In order that justice may be done to both, superiors must be correctly informed as to the true state of affairs; and should an employe have a grievance the official should not be afraid to espouse his cause and use every honorable means to have the grievance removed. I believe that great damage is done to employers and injustice to employes by misstatements made to superiors by officials in immediate charge. A great many labor troubles might be averted were employers correctly informed. As it becomes his duty to see that injustice is not done his employers, so it devolves upon him to guard the employe against imposition, to the extent of his authority and influence.

To the shippers and traveling public he owes a duty, the proper fulfilling of which inspires confidence as to the safety of structures on the road over which they are traveling or shipping.

It is the duty of the superintendent of bridges and buildings to personally inspect each and every structure on his division as often as his time will admit and occasion demand; to see that material is provided and on hand at the proper time, that his employer may not sustain loss on account of labor being unemployed for want of it; he should endeavor to have material moved promptly and should any delay occur en route it affords him no excuse for not unloading promptly at destination; he must take it into stock and render an account of its use; failing in this, he should accept a forcible reminder philosophically. When fences are taken care of by this department it is his duty to see that they are kept in good condition and as well the cattle guards at all road crossings, for great damage may be done by stock getting on the right of way.

He must see that his department is supplied with signals, and in hands of persons familiar with their use.

He should look well after water stations, see that they are in good condition and a plentiful supply of water on hand at all times; for great loss may be sustained through delays in consequence.

He must look after the platform and buildings; see that they are in good condition for the safety and convenience of patrons of the road, and care for in the interest of the company, look after round houses, turntables and coaling stations and see that interlocking and other devices (if there be any for the protection of road crossings) are kept in good condition; maintain sidewalks across right of way through towns and villages and see the shippers of stock have no cause to complain of neglected pens and broken down chutes. Mail cranes must be kept in working order lest the expected letter be delayed, the wrath of Uncle Sam be aroused and the railroad company be called to account.

Train order semaphores must not be neglected, and scales must be kept in a condition that correct weight may be assured.

He must see that correct account is kept of time made by employes subordinate to him, discriminating in favor of neither master or man, but see that justice is rendered unto both, that labor is profitably employed at all times, for great loss may be sustained through neglect of this.

Should he receive instructions from an official superior, but not immediately next to him, he should carry them out, informing his next superior of what has been done; should he be derelict in the discharge of any of these duties he should not take umbrage when his attention has been called to it.

He should assist in enforcing discipline, and he will find that a good example will ably assist him.

In order to perform these duties it is essential that he have a good common school education at least, and the better the more it will assist him in practical work. He must be able to read drawings correctly, make out bills of material and plan as well as execute; be well informed as to the principle of trusses, the nature and quality of all materials used, and their relative strength and value. He should understand the effect of an action of the elements and time upon all structures, both sub and super, and study the best method of protecting them.

He should be a good workman and a good judge of workmanship in wood, metal and stone, and be able to correctly estimate the cost; fancy ornamentation not essential, but work should be symmetrical.

He should be competent of doing and knowing when a good day's work is done; it is necessary to know what is required of a structure and how to bring about the best results and see that they are obtained.

He must have a thorough knowledge and a perfect control of himself and be capable of conveying an idea or imparting information, and it is important that he have force of character so that when he has instructions to give obedience may be insured.

He should understand human nature, for he has men of all kind and condition to deal with.

He should practice to his superiors courtesy and affability and to his inferior in rank kindness and condescension.

In order that he may acquire knowledge which will enable him to more faithfully discharge these duties, he should be an industrious, observant student in the school of experience.

A. SHANE, C., C., C. & St. L. Ry.

THE DUTIES AND KNOWLEDGE REQUIRED OF A SUPERINTENDENT OF BRIDGES AND BUILDINGS IN THE RAILWAY SERVICE.

PAPER NO. 2.

There is no more important factor in the railway service for the comfort, convenience and safety of the traveling public than that of the department of bridges and buildings. In the buildings can be found evidence of great care in the design and erection, and oftentimes lavish expenditures of money for the welfare and comfort of the passengers and employes. In the bridges are found means of traversing sections of the country that otherwise would be impassable, thus bringing distant cities within easy reach and creating a reciprocal trade of vast benefit to every citizen. By means of the many bridges, which in their design and construction are examples of unsurpassed engineering skill, railroad companies are enabled to run their trains at a continuous rate of speed which not only reduces the schedule time but avoids the unprofitable criticism of the public to insecure structures; it also enables them by the stability of their structure to guarantee to the public greater safety in travel. It is in the erection, care and maintenance of these valuable factors of the railway service that the superintendent of bridges and buildings is employed.

The duties of a superintendent of bridges and buildings on many of the railroads comprise in addition to the above the equipment and maintenance of the water stations, the erection and care of safety gates, train order and interlocking signals, piers, barges and other floating property. The supervision of this work necessitated the employment of a large number of mechanics of various trades, such as house carpenters, bridge carpenters, bridgemen for iron construction, blacksmiths, masons, bricklayers, painters, plumbers, laborers, etc. It may be asked, can there be found a man or men sufficiently versed in so many different trades as to so impress his men that in their superintendent they will recognize one who thoroughly understands the principles of their trade, as applied to the work under his supervision?

We can safely answer yes to this question in so far as it applies to the practical superintendent of bridges and buildings. It is not meant by this to say that he is sufficiently versed in all these trades as to be able to take the tools of a mason, smith or painter and do the mechanical part of the work, but he has that knowledge of the trades that enables him to know when they do their work in a good mechanical and economical manner.

He is in nearly all cases a thorough practical mechanic, having served a number of years as an apprentice at one of the building trades and devoted many hours to the study of architectural and mechanical drawing and the practical application of theoretic problems. He early recognized the fact that though all men have been declared "free and equal" it was necessary to maintain an equal standing with his fellows, to devote a considerable portion of his time not only to the studies applicable to his work but to the general affairs of men and their government.

An almost absolute essential for success in this position is that he should be a man upon whose word and promise reliance can be placed and who can be trusted for secrecy in confidential matters. A man of courage, character and strength, ever ready to obey the commands and execute the orders of his chief, and superintend with intelligence and authority the men under his supervision; generous but firm in his efforts to maintain discipline and have men in his employ understand that they are not considered simply machines, to be thrown aside at will, but as long as they continue to do that for which they are employed their rights and interests will be considered; a fair judge of human nature, capable of choosing competent men for his foremen, and possessing the faculty of having them feel responsible for their work and at the same time be subject to good discipline. With this and the keeping in close touch with his employes and gaining their good-will he will obtain from them better service than the man who endeavors to have them understand that they are simply hired for certain purposes only to be cast aside for the most trivial cause. He must possess sufficient knowledge of mathematics to enable him to correctly take out quantities and give reliable estimates from drawings submitted by his chief, and while a knowledge of algebra is not absolutely essential, he who is sufficiently versed in it to properly read and solve engineering formulas that are of daily use in the performance of his duties possesses a knowledge the benefits of which are incalculable. He should possess not only the ability to read and work by drawings of others, but a sufficient knowledge of the rules of design and proportions to enable him to make drawings when occasion calls for it, for with this knowledge he can more readily and intelligently explain the work to his subordinates; for no matter how correct the design, perfect the plan, or complete the drawing, it will not be a success unless he is able to properly explain to his men the different details of the same. With the ability to do this, he will not only achieve success in his work, but create among his subordinates a higher feeling of respect for himself. There is nothing that will cause one man to look up to another more quickly than the knowledge that he possesses abilities greater than his own, or nothing that will create greater scorn in the minds of subordinates than the belief that their knowledge of the way and manner of doing work is superior to that of the man to whom they are subordinate.

Construction is that part of the science of building that treats of the laws of pressure and the strength of materials. The art of building construction comprises the mechanical operations necessary to carry the design of the architect into practice, and the art of bridge erection consists of the practical application of the knowledge of construction to the design of the engineer. Being, as he is, the principal assistant to both engineer and architect in the practical application of their designs for this branch of the railway service, it is but just to say that to the practical superintendent of bridges and buildings a knowledge of this science is absolutely essential; in many cases he is left to use his own judgment as to the class of material to be used, the manner of construction submitted for his judgment and criticism, and very often the designs for the complete structure. To be thoroughly capable of performing these duties he should be conversant with the sound principles of construction, the laws of pressure and stability, without which his designs (if he is able to bring forth such) will either be totally inadequate for the work for which they are designed, or by the great waste of material and insecure construction become not only expensive but a menace to public safety. It is not intended to assert that he should posssess the technical education of the engineer, neither is it desired that he should be simply the practical boor, who does his work in a certain manner without understanding why, except that it is the way his father did and must therefore be right; but it is intended to assert that he should have a knowledge of the laws governing good construction, the theory of applied mechanics and be a fair draughtsman, which, with the knowledge acquired by hard work in the practical application of his own, as well as the ideas of others, and his ability to control men, will enable him to separate the useless from the valuable, practice economy in construction and maintenance, and exercise good judgment in the management and distribution of labor.

To more clearly show the various details with which it is essential he should be conversant, it will be necessary to briefly define some of the most important branches under his supervision, without intending to go into history of construction. This I will endeavor to do, by first taking up building construction in its most important details, followed by that of bridges and water stations.

The knowledge of designs and architecture necessary for success has been defined in the first part of this paper.. With this knowledge in commencing the building he will understand that the first thing to study will be the location (this is usually selected by his superior official) as regards firmness and stability of soil for foundation purposes. If it be of gravel, rock, firm sand or hard soil, it is only necessary to remove surface mould, excavate to a point below frost line and put in the footings, but if the soil be of soft clay, shifting sand, or moist ground where drainage is impracticable, there arises the necessity for some plan to overcome these difficulties. This is usually done either by concrete, corduroy of iron rails or timber, the driving of piles, by the inverted arch, or the ramming of sharp, clean sand into the moist soil.

The foundation walls, which are usually of stone, are laid upon the footings mentioned. This work is sometimes done by contract and at other times by the company's own men. If by contract, extra precautions are necessitated in the inspection of the work, to see that stone are properly laid, filling and backing placed in workmanlike manner; mortar duly proportioned as to cement and sand, all completed in accordance with the specifications. Unless this is done, work may be slighted in such manner as will render detection impossible at the time, but it may cause, and often has caused such failure of the superstructure as to make it unsafe for the purpose intended.

The superstructure is either of stone, brick or wood, and sometimes of iron, or a wood skeleton with sheet iron. Stone work may be rubble, quarry faced or cut. In either case due care must be exercised on the part of the superintendent to see that the workmen use good judgment in the placing of stone on proper bed, and in the judicious use of mortar.

If of cut stone, it should be seen that the bed of the stone is neither concave nor convex, but cut in such manner as to give an equal bearing throughout; if not, they will, where placed in position to bear much pressure, either shale off at points or break in half, thus not only disfiguring but endangering the entire structure. Of whatever quality or style of the work, too much caution cannot be exercised in the proper bonding of same, and to see that it consists of as much stone and as little mortar as possible.

Very often in the construction of buildings, the walls, instead of consisting entirely of stone, are of brick, either pressed, sand or red, and trimmed with stone of terra cotta molded into forms for belt courses, sills, lintels, quoins and exterior decorations of various sorts. Brick work, unlike stone, is more simple in construction and more easily bonded, and while it is possible to slight the workmanship, defects may be easily detected. The principal requisite for proper inspection in this work consists of the ability to distinguish the various grades of brick, a knowledge of their qualities for absorbing moisture, to see that proper bond is maintained, that the courses are horizontal, both longitudinally and transversely, that vertical joints recur perpendicularly over each other and that as few closures as possible are used. All walls that are to sustain the same floors and roof should be carried up as nearly simultaneously as possible, and under no condition should one wall be allowed to run more than scaffold high before all others of the same building are brought to the same height.

One of the most important factors in building is carpentry. It is divided into three sections: descriptive, constructive and mechanical. The first treats of framing every species of work by the rules of geometry, the fundamental principle of building construction. The second of the manner and practice of reducing and framing the timbers in accordance with the intention of the design. The third displays the relative strength of the timbers, and treats of the strains to which they are subjected in accordance with their disposition. As applied to building, the application of these principles commences with the laying out of the foundation, and continues throughout to the completion of the structure. As the work of the mason or bricklayer progresses, it becomes necessary for the carpenter to make and set the window and door frames, frame and place the joists, and have the roof timbers framed and ready for placing as soon as walls are completed. The joists of the ordinary building are usually of wood of sizes selected in accordance with the weight they are intended to carry, and to length of the span. In large buildings iron "I" beams are sometimes used with the intervening spaces filled with hollow brick. In places where they are to be subjected to heavy loads the beams are covered with buckle plates, riveted to top of beams. Where hollow brick are used, the usual custom is to place timbers on the top of beam, to which is fastened the finished flooring; where buckle plates are used the flooring consists of concrete, stone or brick paving. The roof, whether it be a shed, gable, hip or truss, is also comprised in the work of the carpenter, and necessitates a knowledge of the laws of pressure and stability; for no matter how solid the body of the building, an insecure roof will jeopardize the safety of the entire structure, but with proper care in the construction of the roof and the avoidance of oblique and lateral strains, weak walls may be firmly bound together.

A knowledge of framing is an absolute essential to the proper and economic practice of roof construction. No matter how difficult the framing or the number of members to the truss, he who has supervision over the same should possess the ability to frame the work on the ground, either by means of a scale drawing or steel square. The writer has seen many ridiculous mistakes made by men who otherwise were good workmen, in their attempts to get the lengths for a hip rafter. Understanding fully the principles of the common rafter, they could not see that raising the pitch at right angles with the plane line of the hip would give them the length. With the completion of the roof practically end the scientific laws governing the art of construction, and we are left to deal with the labor of the skillful workmen, such as the joiner, plasterer, stair builder, plumber, painter, cabinet maker, tile setter, etc.

The duties of the superintendent of bridges and buildings in this branch of the department consist chiefly in the general inspection and repair of the bridges, culverts and trestles, the rebuilding of the same when necessitated by the decay of timber, the washing out of freshets or through any other cause that may arise; the replacing of wood trestles or of insecure structures of the design of twenty-five or thirty years ago (which, by the general difference in weight of locomotives and cars of the present day, have become inadequate for the purpose intended) with bridges of modern design, capable of supporting any load that might be placed upon them. In doing work of this kind it must be borne in mind that (unlike the erection of bridges on a new line, where it is only necessary to raise false work, traveler, gin pole or derrick, for the placing of bridge, and without obstacles other than those arising through location), great care must be taken in properly supporting the tracks to avoid delay or stopping of trains.

In replacing old work with new on a line of railroad in operation, the first thing to be done is the adopting of some plan to avoid the delay to trains and at the same time economically erect the work. This must be governed in a great measure by the general conditions surrounding the work. Many methods may be and are used in this work, the most common being the erection of false work to support stringers for carrying track, as well as new structure, with the bents placed in such position as to permit the cutting of stringers to allow the floor beams of new work to be set in place. A method sometimes adopted and one to be commended where location will permit, especially in the replacing of timber trestles with iron, is the erection of false work alongside and parallel with the old bridge upon which is erected the new span. Under the bed plates timbers are placed in two layers, with small rollers between. On completion of the truss the old work is taken out and the new drawn to its position by means of blocks and tackle and crab. The writer has seen a number of bridges placed in this manner, one of them placed in position in seventeen minutes from the time the bridge seats were cleared of old work.

The remarks in reference to masonry on buildings are also applicable to bridges, with of course the consideration of the difference of the loads they are to carry, together with the necessity of erecting coffer dams, etc.

From the time steam was adopted as a motive power for railroads, the water supply for locomotives has occupied an important place in the affairs of the same. Its evolution has kept pace with the other branches of the service. From the filling of the small barrel by hand, we can trace it through various windings, until now water is taken by locomotives while under speed of forty miles an hour, and often without attracting the attention of the passengers to the decreased speed of trains. In the erection and maintenance of this branch of the railway service, we find another of the duties of the superintendent of bridges and buildings and one to which he is required to give close attention. In it many obstacles are often met with, such as the necessity of locating the station where the supply from natural sources are slight, thus necessitating the construction of a dam, the boring or sinking of wells, the conveying of water from a great distance by an expensive line of pipe over rough ground, and the erection of large storage tanks or reservoirs. At other places the supply is received from that of cities or townships and regulated by meter or the number of locomotives each day. In cases of this kind he is often compelled to design valves entirely different from the standard on other stations by reason of the strong pressure which will not admit of the working of the quick acting valves usually used, which by their action in closing cause a reaction of the water in supply pipes, thus damaging the water pipes of surrounding houses.

In these days of fast traveling the construction and maintenance of track tanks also occupies an important place in this branch of the service. A knowledge of the simpler problems of hydraulics and hydrostatics, combined with that acquired in the other branches of this department will ensure success in this branch of the railway service.

It is the aim of this article in endeavoring to show the knowledge requisite for the successful application of the duties of the "practical superintendent of bridges and buildings" to explain clearly and comprehensively the necessity of a knowledge of the fundamental principles of each branch of railway service that comes under his supervision. It might, and no doubt will be said, that to be thoroughly successful it is necessary that competent foremen be employed who are masters of their trade. This is a truth that will not be denied, and that it is a strong factor in success will be maintained, but unless he who has supervision over the whole is competent to judge when the work is economically and mechanically done, the best foreman to be found will not make it a success. What architect, in his massive buildings, or engineer in his magnificent structures, would have been successful in his efforts had he depended solely upon the practical man in charge of construction? We can safely answer not one.

The man who by close observation, hard study and devotion to business attains the degree of knowledge requisite to the successful performance of the duties herein mentioned, will not rest contented unless he continues to keep pace with the times, enriching his mind with valuable data that are the results of close application by earnest men devoted to certain engineering or mechanical specialties, and which are the fundamental principles upon which we can trace the progress of railways, from a rude beginning of comparatively few years ago to the splendid proportions of the present time. By these same principles the art of bridge design and construction has gradually developed from the time when stone and wood were the materials used, to the magnificent structures of steel and iron of the present day.

Unlike men of the earlier years of railroading, whose opportunities for acquiring knowledge were limited in many cases to what occurred under their own personal observation, having but few if any books relating to the branch of the railway service, or periodicals to publish every week all things of importance happening throughout the civilized world, the man of the present time has the advantages at a nominal cost of the excellent mechanical, engineering and architectural journals, that often contain in a single number articles worth the annual subscription, giving to the world papers by eminent men in their respective specialties, opening their columns to the criticism of all subjects, to any one desirous of the privilege, and which are, beyond peradventure, the fundamental basis that has inculcated scientific knowledge in the application of mechanical principles to the art of design and construction. At least one of these educational factors is the constant companion of the intelligent superintendent of to-day.

Another prime factor in the development of individual ideas and opinions is the various associations whose objects are the mutual advancement of their members, the inculcating of more scientific methods in the development of their respective arts, and the cultivating of feelings of friendship among men occupying similar positions in the affairs of men. This country is particularly rich in organizations of this kind, drawing as they do some of the brightest minds from the realms of art, science and business pursuits, who, in their desire for mutual advancement not only of their individual members but of mankind in general, bring forth from their combined knowledge fruits that benefit and enlighten the world. To none are the benefits so great as to the active member who follows closely the proceedings, digests the reports of the various committees and prepares himself to intelligently criticise the same. He who does this not only becomes more valuable to his employers, but at the same time increases in general knowledge, thus fitting himself for a higher station in life.

In this age of progress, in which the man of education is forging to the front in all vocations, it behooves all men who desire to advance with the times and their fellowmen to become a member of an association dealing with the practical and scientific applications of the principles of his branch of work. Such an organization is the Association of Railway Superintendents of Bridges and Buildings, and it is confidently believed that the time has now arrived when membership in it is one of the essentials to the "knowledge and duties of the practical superintendents of bridges and buildings."

GEO. W. ANDREWS, B. & O. Road.

THE DUTIES AND KNOWLEDGE REQUIRED OF A SUPERINTENDENT OF BRIDGES AND BUILDINGS IN THE RAILWAY SERVICE.

PAPER NO. 3.

The duties and knowledge required of a practical superintendent of bridges and buildings in the railway service, is a subject that comes home to every member of our association, and requires that he at least think of the important duties of his calling, even if he lacks the hardihood of trying for a prize, by writing his beliefs for the benefit of the others.

In my discussion of the subject I shall attempt to treat, first, of the duties of a railway superintendent of bridges and buildings; and, next, the knowledge required of him to properly discharge those duties.

The position that we are discussing is one of trust and responsibility, and the incumbent should be sober, industrious, clear-headed and of unflinching integrity. All perishable structures of the road are committed to his care, and only by unceasing care can he keep informed of their condition and needs.

The superintendent should be conscientious in the discharge of his duties; he should remember that his salary covers all time, and that his employers and the traveling public trust to his knowledge and integrity for the safety of their property and lives. It is very easy to make a superficial examination of a structure, and write a hurried report that: "Bridge No. 21 needs three cross ties, and a coat of paint." But to thoroughly examine bridge No. 21, learn all about it, and exactly what it requires to preserve its efficiency, is a laborious and trying undertaking, and will tax both the knowledge and integrity of the superintendent.

One of the first and most important duties of a superintendent of bridges and buildings is a thorough knowledge of the road and its weak points. A careful organization of the forces attached to his department, and constant study and endeavor to so move these forces that as little time as possible is lost in long journeys and delays for material. All of us know the many hours of labor almost wasted because the material for the needed work is not at hand. Look ahead and see that every stroke is applied to the weakest point.

The conditions of each road vary so greatly that no rule of organization can be laid down, but sound sense and careful study will build up an organization whose activity and economy will not only materially reduce the maintenance account, but will secure you the approval of every officer of the road.

Should the line contain many trestles and be liable to washouts, a supply of timber should be stored at available points, and in case of an accident to a structure the superintendent of bridges should be promptly on hand, and, if possible, personally see that the repairs are properly and expeditiously made. Apparently trust every foreman in your department; really see that your trust is justified.

If there is no engineer department to take charge of such matters the bridge superintendent shrould have on file in his office drawings of all structures in his department. And of the temporary structures duplicate bills of timber should be on hand to avoid any possibility of delay in ordering material for repairs.

Well disciplined bridge forces will always expect emergency calls, and if the superintendent has fulfilled his duty to them as a superior officer they will respond with the certainty and promptness of veteran troops; and just here it would be well to speak of the duty due the employes in his department. See that the men are well housed and fed, establish a scale of wages that will give everyone the incentive of securing advancement. Mercilessly weed out the incompetents and reward the active, intelligent workers. Extend to everyone unfailing courtesy and absolute justice, be an example of energy and efficiency, and every man worthy of the name will follow and back up your efforts at maintaining a high standard of excellence in your department.

Your watchmen are apt to get the idea that they are forgotten and have a soft place. Relieve them of this impression, for it is your duty to get detailed occurrences from them.

The knowledge that a railway superintendent of buildings and bridges should possess is so wide that, like the boy in the nursery rhyme, he should be: "both a soldier and a sailor, a tinker and a tailor," and almost everything else that one can think of. But perfection is rare now, so he should strive unceasingly to get what he can, and whatever he gets let him get it thoroughly. His duties will require the inspection and probably the repairing of foundations on which his structures rest; he should therefore be proficient in pile driving and coffer dam work; he should know something of the bearing powers of piles and various classes of foundations; he should know something of the value of cement, lime and concrete, and should have a fair idea of the proper handling of masonry in its different classes. It will fall to his lot, perhaps, to take down an old bridge pier, and if he is a wise, observant man he may save his company many dollars by taking down only the defective part, and grouting the remainder. So in defining the knowledge of a bridge and building superintendent you are apt to make of him a skilled engineer, by bringing him in conflict with the master mason.

There is one piece of knowedge he must have, and that is a thorough understanding of drawings and the capacity of carrying out the designs of any structure given him. He must be able to frame all wooden bridges and buildings and should be a fair draftsman himself; he must thoroughly understand the erection and adjustment of iron bridges; must know the duty of each member, and when it is carrying its proportion of load. Nothing is more unpardonable than the straining up of counters in ignorance of their use, or pulling and hauling at floor diagonals when the bridge has lost its camber. The bridge superintendent should have a very intimate acquaintance with rivets, how to drive and head them properly, and how to find and handle them if they become loose or the holes become elongated. Timber he will constantly handle; it is essential for him to know the various kinds, their relative merits and suitability to his purposes.

He should, by observation and study, cultivate his architectural tastes, to enable him to criticise plans for new buildings and to repair and remodel the existing ones under his care. He will be called upon to know something of painting, plastering, plumbing, tinning, etc., and should even be able to lay out station grounds in a neat and tasty manner.

Greatest of all, and above all, he should have that degree of knowledge that knows its own ignorance, and should have the courage and manliness, if called upon to do something beyond his powers, to speak out and say: "I do not know, but will try to inform myself." Then go to work and acquire the information. Don't jeopardize the lives and property of people by being afraid to admit your ignorance of a subject because it is remotely connected with your department.

M. F. CAHILL, Norfolk and Western Rd.

THE DUTIES AND KNOWLEDGE REQUIRED OF A SUPERINTENDENT OF BRIDGES AND BUILDINGS IN THE RAILWAY SERVICE.

PAPER NO. 4.

The duties of a practical superintendent of bridges and buildings are manifold, and on roads which are not part of a great system and not correspondingly equipped with a bridge or architecural engineer it becomes his duty to design permanent and temporary bridges and trestles. In such a case he would be required to have some knowledge of draughting and the strength of materials, as well as to be a pretty thorough mathematician, and in these "fin de siecle" days he would be expected to know the difference between the renaissance, old colonial, Queen Anne, and other styles of architecture, so as not to offend the aesthetic taste of his superiors. The writer has been engaged in the bridge and building business for the past twenty-three years, and has watched the development of railroad business in that time. Back in the sixties if a man was a good, practical mechanic, with a fair common school education and the faculty of handling bodies of men advantageously, he had all the requirements necessary for a superintendent of bridges and buildings; but in these days to make a practical superintendent, according to my ideas, would require a combination of a graduate engineer with a practical mechanic, and this combination is seldom found in a single individual. In a general sense, the requirements for a practical superintendent of bridges and buildings are as follows:

He should make a general examination of all bridges and trestles under his charge at least twice a year, separating them into three classes: the first class to consist of all new or otherwise good structures, the second class to consist of those which are beginning to show deterioration, but which are still safe for service, and the third class to include all those needing repairs or renewal. His time between general examinations should be devoted to this third class structures and other routine work.

He should keep a record of all the structures in his charge. His bridges should be numbered, and his record should contain the number of each one, the number of its spans, the style of structure, length of spans over all, clear span, height, from water to base of rail, depth of truss and number of tracks, and there should be a margin for writing in any information on the condition. This would enable him in case of flood or fire to at once order material for replacing, from any point where he might be at the time of the emergency.

He should also examine his buildings as often as convenient and see that they are kept in good repair, and that the surroundings are neat and tidy. He should see that each division force is kept supplied with the necessary outfit of tackle and tools for the quick and easy handling of heavy material, for use in emergencies occasioned by flood, fire or washout, or from any other cause.

He should arrange to locate his men convenient to their work, so that they would lose no time in getting to it. This feature does not generally receive the consideration it deserves, but it will make quite a difference in the cost of maintenance of way work.

The knowledge required of a superintendent of bridges and buildings is of such a varied nature and embraces portions of such a number of trades that to be thoroughly in touch with each of them would require him to be a living encyclopedia. The writer was at one time engaged on a road where, in addition to his regular duties, he was called on to do plumbing in stations where pipes had frozen up and bursted, build retaining walls, clear up wrecks, run the snow plow, and was ordered to build an ice house when there was no material on hand for the purpose and credit could not be obtained.

A man to be thoroughly capable of filling the position of superintendent of bridges and buildings on a railroad at the present time should be a practical mechanic, able to frame and erect bridges, trestles, and buildings from a set of plans. He should be able to judge of the quality of the different kinds of timber in general use on railroads, and its life under different conditions. He should have a sufficient knowledge of mathematics to enable him to figure the length of a batter post or the strength of a beam, and as much further as his capability will allow. He should also be sufficiently conversant with the erection of iron or steel structures to enable him to judge if such work is properly done. He should be able to operate a pile driver on land or water, and judge from the nature of the material in which he is driving whether it is best to drive sharp or blunt piles, or whether the best results are obtained by a slow masthead stroke or a short quick one.

He should have sufficient knowledge of masonry construction so that in these days of contract work, when there is no regular inspector for the purpose, he will be able to distinguish a header from a stretcher, whether a stone is properly bedded, or whether the mortar is of proper strength, and the cement fresh or air slacked. If in a part of the country where stone is difficult to obtain and cylinders are used he should know what constitutes the best ingredients for concrete, the proportion for mixing it and the best methods of applying it above or under water.

Last, but not least, he should be able to so handle and govern the men under him that in an emergency they will work as a unit without driving, and his moral character should be of such a nature that men following his example would develop into "that class" most prized by railroad managers.

H. E. GETTYS, Norfolk and Western Rd.

THE DUTIES AND KNOWLEDGE REQUIRED OF A SUPERINTENDENT OF BRIDGES AND BUILDINGS IN THE RAILWAY SERVICE.

PAPER NO. 5.

In attempting to write a letter defining the duties of a superintendent of the bridge and building department of a modern railway, and the requisite ability to perform these duties, I am amazed at the countless requirements and vast possibilities which such an office affords. The duties are many, but may be increased or diminished in direct proportion to the interest a man takes in the welfare of his company. He should feel, and teach those under him to feel, a personal interest in the success and prosperity of the company for which they work. The property entrusted to their care should be taken care of, and used as it would be were it their individual possession, and not wasted and destroyed as it so often is, as though it cost nothing. Economy in men's time, in the use of material, and in fact at all times and under all circumstances, should be constantly in mind. For as sure as "economy is wealth," so, too, is true economy success.

As wood occupies so prominent a place in this department, the superintendent of it should be a practical carpenter. In addition to this he should possess good ideas regarding the various other trades that come under his supervision; particularly stone cutting and stone and brick laying, as these are the foundations on which he builds.

He should have an intelligent idea of gas and steam fitting, plumbing, the setting up and operating of pumps and pumping machinery, boiler making, blacksmithing, painting, etc., and while having to depend largely on good foremen in the trades of which he does possess a practical knowledge, nevertheless he must have enough mechanical ability to be a judge of whether or not a job is done in a workmanlike manner.

That he should be a draughtsman is imperative. With this ability he can convey by a mere sketch ideas that would require a volume of writing, and without it he would have difficulty in "reading" a drawing intelligently, saying nothing of being unable to make plans and specifications when required to do so.

He should take counsel with his foremen and be ever ready to take advantage of their ideas if better than his own. It is his duty to keep abreast of the times to catch the advance ideas of the day and adopt them where practical. In a concise term, he should be a "progressive" man.

Owing to the fact that there are both theoretical and practical ways of reaching conclusions, and that both ways are not always harmonious, lest I should be guilty of the error of being too theoretical, I would set forth my conception of some of the more important duties of a superintendent of bridges and buildings by stating how I perform those duties as such an officer of the railroad company with which I am engaged.

As a starting point, I select the time for my annual inspection. During the month of April or May I make a thorough personal examination of everything coming under my supervision. I begin at the east end of the line and proceed westward, usually on a private hand car, closely inspect every bridge, building, platform, water station, turntable, coaling station, cattle guard, road crossing and whatever else I may have charge of; carefully noting in a suitable book the condition of each. If any repairs or renewal are needed, I make an estimate of what is wanted in the way of material, etc., and how soon the work should be done. Having finished my task, I am able to intelligently furnish my superior officers with a statement of what is wanted for the year in the way of material, and to plan the work for my men in a most satisfactory manner.

In buying material, I make it a point to have orders placed from thirty to sixty days in advance of the time at which I expect to do the work. It is sent direct to the site where it is to be used and unloaded there, thereby saving the cost of rehandling. In addition to this, by knowing just what you are going to use, you can save your company the expense of carrying a stock of material and supplies. I have followed this plan for the last eight years and find that it works well.

I do not wish to give the idea that I do not carry any stock at all, for I always have on hand, at a convenient place on each division, a small quantity of everything needed in case of accident. Very little of this is new, however, as I save all my good old timber for just such emergencies. Then in case of accident, I am able to cut and slash as the urgency of the case may require, with the knowledge that I am not willfully wasting new and costly timber; and at the same time I am able to build just as good a temporary structure as though I were using the best material to be had.

Another thing I make a practice of is grading the material. All second-hand stuff is kept out of new work and used for repairs or temporary structures only. In this way new wooden bridges made of strictly first-class timber will stand eight years or more without repairs, whereas if material is put into it just as it comes from the mill, inside of six years, and possibly as soon as four years after it is built, you will be called upon to remove decayed or sap-rotten sticks.

A historical record of all important structures is indispensable, and this is particularly so in the case of bridges. I have always kept such a record and can refer to it and give dimensions of all bridges, buildings, platforms, stock yards, etc.

In the detail description of bridges I show height, length of piling, kind and size of caps, stringers, ties and guard rails, length of spans, height and length of panels; clear height and width of roadway. Where masonry is used, nature of foundations; description of masonry; distance from foundation to top of rail, etc. Repairs are recorded and when bridge is worn out I know just what it consisted of and the service performed by its various parts.

The painting of iron structures receives particular attention, and the best of material has been selected. A record of the kind, quantity required and date painted, together with the name of the manufacturer and cost, is carefully kept.

I deem it a very important duty to frequently visit all work in progress; to see that proper material is being used; whether any additional material may be needed and that the men are not working at a disadvantage for the want of tools or supplies.

I always give my foremen written orders for important jobs and specify what material they are to use. Forgetfulness is then out of the question and mistakes are readily located. Nothing humiliates me more than to have a man criticise my work and say "I told you to do so and so," when in my heart I feel that I am right and he is wrong, through error or otherwise. "Black and white" was my safe retreat as a foreman, and as a superintendent I am often glad to have the "documents" produced.

The successful handling of men is a natural gift and one very much to be desired in a superintendent of bridges and buildings. They, through circumstances, must be more or less scattered, and at times their duties are arduous and exacting. To select men who will conscientiously carry out your instructions, whether they be to risk their lives in an emergency or merely to save valuable "odds and ends," is ability not given to all. Having made the proper selection of men, the preservation of their loyalty is to be guarded with scrupulous care. Treat them with all the courtesy that is due them; stand by them when attacked by any other department, whether it be the transportation department for necessarily holding a train or the general manager after part of their salary (for ours is a bread and butter department), and see that they have a fair chance to defend themselves. Finally while enforcing a rigid discipline remember the "golden rule" and treat them as you would have your superior officer treat you.

One word more and I am through. As home-staying lads have homely wits, it is the duty of every superintendent of bridges and buildings to join the International Association of Superintendents of Bridges and Buildings. Meet with us once a year and by striving to help the association along, receive a double portion as a reward.

JOHN H. MARKLEY, T., P. & W. Ry.

THE DUTIES AND KNOWLEDGE REQUIRED OF A SUPERINTENDENT OF BRIDGES AND BUILDINGS IN THE RAILWAY SERVICE.

PAPER NO. 6.

The duties required of a superintendent of bridges and buildings in the railway service are unquestionably of a more varied character than those required of other officials on railroads.

To begin with, he must be a man of sound judgment and conservative action, prolific in expedients in cases of emergency and able at all times to overcome obstacles that threaten the efficiency of his department. His title would seem to imply that it is his duty to oversee and direct the construction and repair of bridges and buildings on the territory assigned him, which is true; but it does not stop there by any means. His duty further requires that he personally direct the movements of large forces of men engaged in many different lines of mechanical employment, scattered frequently over large territory, with satisfaction to his superiors and with economical results to the company. It is his duty to see that good discipline is maintained in his department; that men are kept diligently employed during the hours prescribed; that men and material are moved promptly from point to point on his territory; that no time is lost by men not being fully advised as to the work they are expected to perform or for want of the material with which to do the work, as such delays would entail great loss to the company and tend to demoralize the working force.

It is his duty at frequent intervals to personally inspect every structure under his charge that he may know the exact condition of each and the ability of all traffic-carrying structures to withstand safely the service required of them.

It is his duty in case of extraordinary storms or floods to immediately place himself in close communication with his assistants along the line and direct their attention to places known to be dangerous at such times, with a view to extra protection for such dangerous places at the time and expeditious repairs should a break occur in the track, rendering suspension of traffic probable or necessary. It is his duty to repair all breaks in the track caused by flood, temporarily at least, leaving them in shape to be again filled when the flood subsides. It is in time of floods, fires, or other extraordinary contingencies that most is required of him; in fact, in all emergencies where traffic is interrupted his services are in demand, and to his sagacity and energetic movements is often entrusted the task of preparing the roadbed for the resumption of traffic, no matter what has been the cause of the interruption. It is his duty to provide the necessary tools and machinery, to know that they are in such good, safe working condition as will enable the men to do the greatest possible amount of work with the least expense. Tools and machinery enter largely into the economical prosecution of much of the work he has to do, and must be known to be equal to the work required, else the company may be mulcted for personal injuries caused by inadequate or faulty machinery or tools.

In addition to his responsibility for the care of bridges and buildings he is charged with the duty of maintaining water tanks, pumps and boilers, wells and reservoirs. It is his duty to provide water for locomotives as well as all other uses on the line; manifestly it is his duty to be conversant with the mechanism of the steam pump and strive to attain the best results from its use. He must also be acquainted with the construction of the steam boiler. A time comes to most men in the position of superintendent of bridges and buildings when he must take the matter of an unruly steam pump and boiler in hand himself and make them perform the service required of them. It is his duty to be able to cope with minor defects whioh are liable to take place under certain contingencies in this important item of machinery. Water supply, I dare say, is the cause of more worry and hard work for a superintendent of bridges and buildings than almost any other branch of the business he is engaged in. It is his duty to have all water pipes thoroughly protected against frost in winter, that there may be no delay to the business in this most busy season. Without water the wheels will stop, even though all else on the line be in perfect condition. The importance of a good water supply is therefore obvious.

His duties also require him to keep in order the train order signals. These, too, perform an important part in the safe operation of the road. Mail cranes are also to be taken into account and kept satisfactory to the railway mail service, while stock yards, sewers and sidewalks in cities and towns, underground culverts and cattle guards on the right of way, cinder and drain pits at engine houses, transfer and turntables, coal chutes, foundations for heavy tools and machines, all require his time and attention. Stock, wagon and track scales it is his duty to see to and keep in good honest working condition. It would be useless to tell any man conversant with the duties of this position the trouble that is caused by a track scale that refuses to honestly perform the duty required of it. The revenues of the company can be very seriously impaired, too, if the track scale does not properly perform its functions.

It is also the duty of the superintendent of bridges and buildings to provide station and office furniture, stoves and stovepipe, for all buildings on the line; to see that all heating apparatus, whether steam, hot air or hot water, is in perfect working order and sufficient for the needs of the various structures.

He must prepare plans and specifications for all masonry on the line, whether it be for bridges, buildings or other purposes, and superintend the construction of the same. He is required to keep all structures neatly painted, for the neat and tasty appearance as well as their preservation. Interlocking plants at railroad crossings and other points must be maintained by him to the satisfaction of the neighboring road and also of the railroad commissioners. Interlocking has become a very important feature in the railroad business and must have close attention, the safety of the traveling public depending a great deal on its perfect working condition, as also the expeditious handling of the company's business at railroad crossings and other busy centers.

And finally his duty requires him to keep a correct account of all materials and supplies furnished his department and render a strict account of the disposition of the same monthly.

These, then, are a part of the duties required. There are others imposed in times of emergencies or on extraordinary occasions which he is expected to be able to perform without hesitation. I think all will agree that his duties are voluminous. The knowledge required of him must of necessity be co-extensive with his duties; he must therefore possess good executive ability. On him devolves the task of planning and personally superintending the entire business of his department. He must have personal knowledge of all the details in the various branches of which his department is composed. It is not enough that he have perfect knowledge of carpentry; his knowledge must extend beyond any one line or trade; he must be at once a carpenter, a worker in iron, a plumber, a steam fitter, a brick and stone mason, an engineer and a draughtsman.

He should know something of the transportation business of the road and not encumber fast or busy trains unnecessarily with his materials, for the matter of handling bridge and building department materials is no inconsiderable item to the transportation department. His knowledge must in a measure extend to the rolling stock of the road, to the end that no defective car be allowed to go over the road with his materials, making a wreck possible in consequence of the breaking down of such car, thereby impeding traffic and causing loss to the company. In short, his mechanical knowledge must be of that manifold character that will enable him to personally know that in each of the various branches of mechanics coming under his supervision, as described in his duties, the work is done in a workmanlike, efficient and economical manner; and if not so done he must be able to quickly detect the deficiency and improve the service. His knowledge of accounts must be sufficient to enable him to keep the books of his department intelligently and to make estimates and statistical reports to his superiors when called for.

I have, I believe, enumerated duties and knowledge enough that are required of a superintendent of bridges and buildings in the railway service to convince the most skeptical that the assertion I started this article with is none too broad. A book might be written comprising the duties and knowledge required of him on special occasions if the memory of man could be made to hold them.

O. J. TRAVIS, E. J. & E. Road.

THE DUTIES AND KNOWLEDGE REQUIRED OF A SUPERINTENDENT OF BRIDGES AND BUILDINGS IN THE RAILWAY SERVICE.

PAPER NO. 7.

This subject is a prolific one and the discussion of it should interest every bridgeman throughout the land. The duties of the bridge superintendents are various, and the office properly and conscientiously filled is by no means a sinecure.

In the first place he should be a sober, energetic, kindly disposed man, conscientious in regard to the performance of his duties and fully competent of directing his employes and discriminating between duties performed and duties neglected. There is an opinion prevalent that anybody can be a railroader, but it is just as necessary to have good, reliable gentlemen in railroad work as any other avenue of business. When we remember how many lives are exposed to danger on our railroads we cannot be too careful nor try too hard to keep them in perfect order.

The bridge superintendent must understand how to direct work pertaining to his department, viz., erecting and repairing bridges, trestles, culverts, cattle guards, pump houses, water tanks, roundhouses, machine shops, coaling stations, turntables, track scales, mail cranes, all dwelling houses belonging to the company, ferry boats, wharves, stock pens, fencing, right of way and timbering tunnels. He should also look after the stone work and see that painting is done on bridges when necessary. Some roads have a construction department, which in a measure relieves the bridge superintendent of some of the above duties, but when that does not exist his duties require him to draw his own plans, make out bills and order all requisite materials.

He should inspect this work as often as possible and so carefully that nothing really needing attention would escape his notice. He, of course, must send his reports, bills, etc., to the higher authorities through the proper channels, according to the rules of the company for which he is working.

It is understood that where a man is employed by any company he is to work in the interest of that company. He must make every effort to make his work show off to advantage, economizing in every way consistent with the safety and durability of his work.

A bridge superintendent acquires his knowledge by experience as a subordinate. He should know when a building is safe, how long the material may last and what kind of material is best for each and every purpose. He must fully understand that old timbers and weak structures must not be allowed to stand too long. It will not do to run any such risks on bridges and trestles, for the most distressing wrecks have been caused by bridges giving way under trains. They are sometimes knocked down and sometimes wrecks occur in a most unexpected manner. On all roads in this emergency the bridge superintendent should know the quickest mode of erecting temporary false work, frame or pile, and avoid as much as possible the delaying of trains and transferring of passengers, the latter of which is not a coveted advertisement for any road.

He should be perfectly familiar with every part of his division, but the weakest points should be his special care. When the weak bridges and trestles have to be renewed the superintendent should make all arrangements for the work, and have everything in readiness so as to accomplish as much as possible between trains. He must know that the bridge or trestle is sufficiently bolted and braced to allow trains to pass over safely. This can be done without running any risks and in very temporary structures.

A practical superintendent knows that all frame and pile trestles are renewed on the same plan pretty much, but bridges vary according to spans, and each one requires a different false work.

It is often necessary for stone work to be rebuilt under bridges; in this event he must be prepared to support the bridge on a tower sufficient in strength to bear up trains during the repair work. In my own experience I have known of spans being trestled when a tower would have answered the same purpose and not have rendered the bridge so susceptible to washouts by filling the stream with trestle bents, thus converting them into regular drift catchers.

The superintendent of bridges should keep his foremen posted as to the cost of all material he uses. This will make them more economical and strive harder to keep the cost of his work down.

JOSEPH M. STATEN, C. & O. Ry.

CHAPTER III.*

1, REPORT: DEPRESSED CINDER-PITS—2, DISCUSSION: SUBJECT, DEPRESSED CINDER-PITS AND OTHER KINDS—3, REPORTS: BEST METHOD OF BRIDGE INSPECTION—4, DISCUSSION: SUBJECT, BEST METHOD OF BRIDGE INSPECTION—5, REPORT: MAINTENANCE OF PILE AND FRAME TRESTLE—6, PAPER: DESCRIBING METHOD OF RENEWING, METHOD OF INSPECTION, AND COST OF MAINTENANCE OF PILE BRIDGES —7, PAPER: MAINTENANCE OF PILE AND FRAME TRESTLES—8, DISCUSSION: SUBJECT, MAINTENANCE OF PILE AND FRAME TRESTLES—9, DISCUSSION: SUBJECT, FRAME TRESTLE—10, DISCUSSION: SUBJECT, ECONOMY OF PRESERVING BRIDGE TIMBER—11, REPORTS: BEST TRACK SCALE FOUNDATION—12, DISCUSSION: SUBJECT, BEST TRACK SCALE FOUNDATION.

REPORT: DEPRESSED CINDER-PITS.

Your committee appointed to report on "Depressed cinder-pits and other kinds" respectfully present the following information as to cinder-pit systems in use on American railroads, together with the conclusions and recommendations offered by the committee for your consideration.

A circular letter asking for information on the subject was sent to the members of your association, to a number of railroad officials in the engineering and motive power departments, and to the editors of railroad journals. Many answers were received, and the thanks of the committee and of the association are due to the contributors, some of whom furnished very detailed and valuable information, compiled in the appendix presented with this report.

From the previous experience of the members of your committee, and after examining the additional data collected, it was apparent, that it would be impossible to adopt or recommend standards for general practice throughout the country, as the choice of a cinder-pit system depends to such a large extent on local conditions. There are, however, a number of distinctive systems with individual characteristics in prominent use, so that

*Reports presented at Fourth Annual Convention held at Kansas City, Mo., October, 1894.

the existing practice can be classed and described under the following nine groups:

(a) DUMPING ON GROUND OR IN SHALLOW IRON TROUGH BETWEEN TRACK RAILS; ASHES SHOVELED OUT.

For dumping a limited amount of ashes at stations, water-tanks, or coaling platforms, where trains make a short stop on the main track, a large number of roads dump the front-end ashes directly on the ground between track rails. This is also done on new roads with the entire contents of the ashpan, until regular cinder-pits are built. The main objections are the limited amount of ashes that can be dumped, the necessity for prompt removal of same, and especially the damage done to the cross ties.

The ties are sometimes protected by old sheet-iron. An improved form in use is to place the rails on plank stringers, spiked on top of ties, and bend the old sheet-iron so as to form a trough between the plank stringers, thus giving a greater capacity and less liability for ashes to run against rails.

(b) DEPRESSED CLOSED PIT; ASHES SHOVELED OUT; ASH-CAR TRACK DEPRESSED, WHERE POSSIBLE.

This group practically represents the general style of cinder-pits, adopted almost universally throughout the country till within the last few years, and the present standard on a very large number of roads. On small roads it is still quite customary to blow out ashes on some side track, and to remove clinkers or draw fires on a regular engine pit in an engine house. The objections are the damage done to the engine house pits, and the expensive handling of the ashes.

The best practice for this group consists of having special cinder-pits, conveniently located in connection with an engine house or a coaling or water station, properly built so as to resist the heat, provided with a suitable water supply and efficient drainage, and the ash-car track located alongside of pit as conveniently as possible, so as to reduce cost of handling. While there are, no doubt, many conditions and localities warranting the use of depressed closed pits, as a rule the general objections to this class of pits will remain. The handling of ashes is expensive, rehandling being usually required, and the work is interrupted when engines are on the pit. Unless the pits are well built and efficiently protected against heat, the combined deterioration caused by heat, water, frost and shoveling, the vibratory action of passing engines, and the stopping up of drains, will destroy the pits or at least call for frequent extensive repairs, while the cost, if built very substantially, is practically equivalent to improved modern methods offering better economical results in operation. In flat country the drainage required for a deep pit depressed below the general level of the ground would be expensive or even impossible to obtain within practical limits.

The important distinctive features of the design of depressed closed pits are the foundations, side-walls, coping of side-walls, rail-fastenings, paving, water supply, drainage, protection of side-walls and paving from the heat, the relative location of the ash-car track to the dumping track, and the general layout.

(c) DEPRESSED CLOSED PIT; ASHES DUMPED INTO MOVABLE IRON BUCKETS, BASKETS OR HOPPER CARS IN PIT, HOISTED OUT BY CRANES.

This group is similar to the one just discussed, excepting that iron buckets, baskets, or hopper cars, in connection with cranes, are employed for removing the ashes from the pit to ash-cars, in place of shoveling by hand. As stated by Mr. H. M. Hall, it would seem that there is a very considerable saving in using the crane and bucket system in place of shoveling, and, in addition, it is more expeditious. It obviates to a large extent the objectionable features mentioned above in connection with depressed closed cinder-pits worked by hand. In regard to first cost the increased cost due to the buckets and cranes is probably offset to a large extent by the fact that the construction of the pit need not be very expensive, as the deteriorating influence of heat, water, and shoveling will not be serious. If ash-cars, with suitable protection against heat, are provided, then water need not be used in the pit at all, and drainage can be dispensed with. The feature of not being able to remove ashes, when engines are using the pit, is offset by the fact that the ashes are handled more expeditiously than by hand. The only questionable features would seem to be providing suitable power for working the crane, and the question whether the system is adapted to meet the demands of a very large cinder plant. The employing of the engine just cleared to transfer its ashes from pit to ash-car seems only feasible for a small plant, as otherwise the engine would not only be delayed itself, but would be holding others waiting to use the pit. The use of steam or other power is entirely dependent on local conditions, as it would not pay to introduce special power excepting for a large plant. The objection to multiplying cranes lengthwise of the pit in connection with a very large system, could be overcome by introducing an overhead traveling crane worked by power, or a moveable pillar crane running on a track alongside of pit.

(d) RAISED TRACK ABOVE GENERAL GROUND LEVEL, RAILS CARRIED ON LOW IRON PEDESTALS OR COLUMNS, PIT OPEN ON BOTH SIDES; ASHES SHOVELED OR DRAWN OUT SIDEWAYS UNDER RAILS—ASH-CAR TRACK DEPRESSED, WHERE POSSIBLE.

In this group the distinguishing feature is the raising of the cinder-pit track above the general level of the ground or neighboring tracks, suitable inclines or run-offs being provided at each end of the raised section. The location of these pits should be preferably on a special track, connected, however, at both ends with a running or important yard track. It is not practicable to locate these pits on fast-running tracks. The introduction of an ash-car track depressed below the floor of the pit will decrease the cost of handling ashes, and should be done wherever feasible. These pits need no drainage, and hence are admirably fitted for, and, in fact, absolutely necessary to adopt in level country, as for instance the Western prairie lands.

There are numerous methods in use for increasing the span between the iron pedestals or columns, by using extra rails under the running rail. The most practical method would seem to be that of using one inverted rail under the running rail or utilizing old bridge girders.

There are a large number of different designs for the cast iron pedestals. The feature of obtaining a solid foundation under the pedestals is in all cases very important, but more especially so where cast iron ties are used connecting the foot of the pedestals across the pit and cast in one piece. Some of the standard plans presented seem to be defective in this respect. In other designs the pedestals are anchored to solid foundations practically independent of each other. The utilization of old rails for the pedestals and iron tie across pit, as reported in use on the Union Pacific, Southern Pacific, and the St. Louis and San Francisco, as shown in Figs. 54, 55, and 56, is unique, cheap, and apparently very efficient.

As a rule, raised cinder-pits of this class are cheap to build and comparatively economically operated, more particularly, if an ash-car track well depressed below the floor of the pit can be introduced. The system has decided merits, especially, as above noted, in level country, where drainage of a depressed pit is hard to obtain or ground water is encountered.

(e) ELEVATED IRON TRESTLE, OPEN ON BOTH SIDES; ASHES DUMPED ON GROUND AND SHOVELED UP ON CARS.

This group of cinder-pits is represented by an elevated iron trestle of the Central Railroad of New Jersey, described below. Its chief merits are stated to be that the removal of ashes is entirely independent of the dumping, and does not have to be arranged for until sufficient ashes have accumulated to warrant the work train making a special job of the removal of the ashes, it being considered that the constant switching and manipulating to keep empty ash cars on hand and dispose of loaded ones, wasting the material frequently, is not as economical as to load and dispose of large amounts of ashes at one time and to good advantage.

(f) DEPRESSED PIT OPEN ON ONE SIDE AND BOTH TRACK RAILS CARRIED ON IRON PEDESTALS OR COLUMNS; ASHES SHOVELED OR DRAWN OUT SIDEWAYS UNDER RAIL ON OPEN SIDE OF PIT—ASH-CAR TRACK DEPRESSED.

The characteristic feature of this group is that the running track does not have to be raised above the general track or ground level and yet the objectionable features of depressed closed pits are practically eliminated by making the pit open on one side and introducing a depressed ash-car track located at or preferably considerably below the floor of the pit. This allows the work of removing ashes to be done even when engines are on the pit and with one handling, especially so if the ash-car track is conveniently placed.

The location of the pit is generally on a lead track to a turntable or on a special track connected at both ends with an important yard or running track. Double pits with one depressed ash-car track between them are used for larger plants. If a location can be selected alongside of a track on an embankment, the introduction of a depressed ash-car track and the drainage question are greatly simplified.

Relative to the methods adopted for increasing the span between column supports, the use of one inverted rail or of old bridge girders below the running rail seems to be the most practical. In regard to the supports cast iron chairs or columns of various designs are in use.

(g) DEPRESSED PIT OPEN ON ONE SIDE, ONE TRACK RAIL CARRIED ON WALL AND THE OTHER SUPPORTED ON IRON OR MASONRY COLUMNS; ASHES SHOVELED OR DRAWN OUT SIDEWAYS UNDER RAIL ON OPEN SIDE OF PIT—ASH-CAR TRACK DEPRESSED.

This group can be considered as containing some of the best standards for depressed cinder-pits, and the prominent list of railroads represented lends emphasis to this statement. It has all the advantages of the preceding group (f), with the additional feature, that, owing to the fact that one rail is supported on the side-wall of the pit, the track is very rigid, allowing the pit to be placed, if necessary, on fast running tracks and on curved tracks. It can be located with good advantage close to a main track, without spreading the tracks, and, if on the outside of an embankment, then the introduction of a deep depressed ash-car track and the disposal of the drainage are easily settled.

The objection that is sometimes made, to having one rail running on a solid wall and the other on a girder construction, is eliminated partly in some designs by introducing a timber coping on the wall and in other plans the rail over the wall is carried on an iron girder resting on the wall or on pedestals bedded in the wall, so that both rails are practically carried in the same manner.

The columns under the rail on the open side of pit are of various designs and, as a rule, of cast iron. The C., C., C. & St. L. R. R. uses old rails for columns, and the details of the connections to the girder on top and to the bedplate at the foot are exceedingly neat and simple, as shown in Fig. 69.

Attention should also be called to the sloping floor of the pit adopted by the Pennsylvania lines west of Pittsburg, Southwest system, as shown in Fig. 66, offering considerable advantage in shoveling. The several designs with deep depressed ash-car tracks are worthy of careful study and consideration, wherever local conditions will permit the adoption of similar systems.

(h) PITS WITH CHUTES UNDERNEATH FOR DELIVERY OF ASHES BY GRAVITY TO ASH-CARS.

This group is, in a general sense, simply an extension or improvement on the preceding one. The pits belonging to this group are practically the same as in group (g), excepting that iron chutes are introduced under the track pit, running out between the columns on the open side of it, and reaching over the top of an ash-car on the deep depressed ash-car track. Water is used to cool the ashes and wash them down the chute. The cinder plant of the Southern Pacific, shown in Fig. 74, is only one of this group reported to the committee as actually built, and it even has not yet been put into actual operation. While, therefore, iron chutes with water spray seem to be a natural improvement in the economical methods of handling ashes, results from actual practice are missing.

(i) MECHANICAL CONVEYOR SYSTEM REQUIRING POWER; ASHES DUMPED INTO HOPPERS UNDER TRACK AND THENCE CONVEYED BY BUCKET ELEVATOR OR TROUGH CONVEYOR TO OVERHEAD IRON CHUTES FOR DELIVERY TO ASH-CARS.

This group is clearly defined by the above heading. Mechanical ash and coal conveyors of different kinds are successfully in use in connection with stationary boilers at steam power plants, so that the application of this system on a large scale to locomotive cinder-pits seems to be a most natural conclusion and prophecy for the future. Unfortunately the plants actually built for locomotive ashes, so far as known to your committee, are limited to two different systems in use on the Philadelphia and Reading at Philadelphia, one of which has been apparently abandoned, while the other is reported to be working successfully.

A conveyor system, with independent power supply, is naturally only feasible at a very large cinder plant. Generally the aim seems to be to combine an ash-conveyor system with a coaling station, placing pits under the coaling track; but, if the engine is to be thoroughly cleaned, the time consumed is so much longer than the time required to take coal from overhead chutes, that this combination will not prove as practical in actual operation, where there is a big rush of engines, as would appear at first thought. Unless plenty of time can be spared to each engine, it will, therefore, prove preferable to make the ash-conveyor system and track independent of the coaling track.

In introducing a conveyor system there are two questions to settle. One is the first cost and the expense of operating and maintaining the conveying system. The other is, will the location of the plant and the necessary yard operations connected with it, as, keeping up the supply of empty ash-cars under the chute, running the machinery after dark, if engines have to be cleaned at night, unless ample pit storage is provided, etc., allow the system as a whole to be considered economical and practical, even if a saving in the actual cost of transferring ashes from pit to car is clearly demonstrated? In other words, the extra first cost of a conveyor plant; the possible rapid wear and tear of the machinery and iron parts, owing to the presence of destructive chemical agents in the ashes combined with the fine sharp grit; and perhaps the inconvenience of the yard operations connected with the plant, may go far to outweigh the advantage gained by the reduced cost of handling. As above stated, we have very little information on the questions affecting the life of a locomotive ash-conveyor plant, as the only one we know of in actual successful use has been in operation for only a year and a half. There is no doubt, however, that there are conditions and localities, especially where ground space is valuable, for which a conveyor plant of suitable design will be the correct solution of the problem.

GENERAL REMARKS AND CONCLUSIONS.

The proper study and design of cinder-pits is important for all roads, but more especially when a poor grade of coal is used, producing a very large amount of cinders and clinkers. Mr. William Forsyth (C., B. & Q. R. R.) states that "Coal in the West of fair average has 10 per cent. ash, and much of the coal used has 15 to 20 per cent. ash, by analysis. The total amount of the material in the ash-pit, which includes a considerable portion of carbon mixed up with the ash, probably averages 25 per cent. of the coal put in the fire-box, and, as each engine consumes six to eight tons of coal per day, it is readily seen it involves the handling of a very large amount of ashes." It is also well-known that Western coal gives a much heavier percentage of ash, and especially clinkers, than Eastern coals.

While the choice of an ash-pit design does not depend directly on the kind of coal used, it will have some bearing on the plan selected. On the New York, New Haven and Hartford, a distinction is made, as to whether soft or hard coal is used in the engines, the cinders from the latter necessitate a greater protection of tne side-walls from heat than with soft coal ashes. Otherwise the only difference reported to the committee would seem to be the size of the plant, dependent on the cinder producing qualities of the coal used, unless provision is made to take away the ashes practically as fast as they accumulate.

From the few figures quoted above some idea of the large amount of cinders to be handled on a road can be formed. It is apparent that the proper disposition of the cinder question should receive more consideration and cinder-pits should be given a legitimate position among the important auxiliary yard structures at terminals or division points. Their design should be studied accordingly, so as to insure the greatest practical economy in first cost, maintenance, and operation.

True economy in first cost does not mean the cheapest materials and design, as the questions of maintenance and especially the future operating expenses are far more important than a slight saving in first cost. In fact it is the heavy maintenance and operating expenses of the old style depressed closed pit or hole-in-the-ground system that has caused railroad officials within the last decade, or more strictly speaking within the last few years, to give considerable thought to curtailing the expenses connected with the disposal of locomotive cinders, even if the first cost of the plant has to be increased.

Timber, if used judiciously and properly protected, should not, under certain conditions, be considered bad practice. The very light brick or inferior rubble masonry walls, shown in many designs, as also the apparently inefficient foundations, are to be decidedly condemned. In designing foundations and walls the deteriorating influences of heat, water, frost, shoveling, and shocks from passing engines should be well considered. The use of old rails and bridge beams for girders and supports of open cinder-pits is to be highly recommended, provided the connections are simple and durable. A combination of several rails or girders requiring special castings, dependent on bolts to keep the parts in close contact, is not to be considered as efficient or economical in the long run. In regard to resisting heat and the disintegrating action of the destructive chemical elements in cinders, it can be stated, in general, that cast iron is preferable to wrought iron. Cast iron, however, unless suitable designed, is liable to crack easily from jars or unequal settlement of the foundation.

In regard to economies of operation the chief feature to consider is the handling of the material from pit to ash-car. The adoption of any particular style of cinder-pit is dependent mainly on local conditions. The best method, where feasible, is naturally to eliminate shoveling entirely by adopting a gravity system, requiring, however, a deep depressed ash-car track alongside the cinder-pit track. Where this is not possible, then the system with crane and bucket should receive careful consideration at all points where the conditions of the service warrant its adoption. The next step is to endeavor to have only one shoveling of the material. Any system requiring double handling should be condemned at once, unless absolutely necessitated by prevailing local conditions.

In the removal of the ashes from the pit to cars there are a number of minor points of economy that should receive brief mention. Open cinder-pits, in which the ashes can be scraped or shoveled out easily from under the pit direct to cars without an upward throw, are desirable. The standard design of the Pennsylvania lines west of Pittsburg, Southwest System, shown in Fig. 66, with the heavy sloping floor under the pit is commendable, as tending to throw the ashes out from under the pit and thus to assist the shovelers. A similar result is attained by the unique contrivance adopted at the Hornellsville shops of the New York, Lake Erie and Western, consisting of an improvised plow for clearing open iron cinder-pits, shown in Fig 75, copied from the American Engineer and Railroad Journal of October, 1894, which publication has a description of the plow on page 446. The cinder-pits, with deep ash-car track, depressed so as to bring the top of car below pit floor, offer very economical handling conditions. The suggestion of Mr. Wallis, Superintendent of Motive Power, Pennsylvania Railroad, to improve the East Tyrone cinder-pit system, shown in Fig. 72, by using scrapers operated by power to draw the cinders into the cars, is certainly interesting and indicative of the prevailing tendency to decrease the hand labor at cinder-pits.

Another opportunity for economy in operation is to be found in the ash-car service and the ultimate disposal of the ashes. A number of railroads use special cars for this purpose, made to dump easily, and protected to a certain extent against being damaged by the hot cinders, thereby insuring cheaper service and less damage to rolling stock. In regard to the supply of ash-cars, the length of the pit and size will establish the storage capacity of the plant, and local conditions will determine as to the advisability of removing ashes as fast as they are dumped or waiting until sufficient material has accumulated to warrant a work train or special gang of laborers being sent to load up the material. In the first instance the constant necessity of keeping empty cars at the pit may require considerable attention and the material will be frequently wasted in the vicinity in order to free the cars, whereas in the latter case the material is generally used to good advantage. In some cases the fire cleaners at the pit would be idle a large part of the time, unless required to load cinders. Where there are no special men kept at the pit, a certain amount of storage would seem desirable. As above stated, local conditions will generally determine which method to adopt.

The general layout of the pit and tracks should be such as to allow engines to make use of pit, if possible, without blocking other tracks, and the pit track should be connected at both ends with a running or yard track, so as to allow easy ingress and egress. The location of pits on a main track or fast running yard track is very bad practice. Where this has to be done every means should be adopted to insure the greatest possible stability of the structure, and guard rails and rerailing devices at ends of pit should be invariably used, so as to reduce the danger from having an open pit in the main track.

In regard to cost of construction of various cinder-pit systems the data reported to your committee show a wide range, which is due to the fact that the cost is dependent to such a large extent on local conditions and the nature of the foundations encountered. There is also considerable uncertainty in some of the figures, as to just what amount of work is included. In some cases the complete layout, including approach tracks, drainage, etc., is covered, while in other cases the cost given is only for the pit proper, exclusive of rails, ash-car track, etc.

The following cost of cinder-pits per foot effective pit length, compiled from the detail notes given in the appendix to this report, will prove valuable for brief reference:

Depressed closed pits (Groups "B")—Concord and Montreal, $11; A., T. & S. F., Fig. 40, $10; Northern Pacific, Fig. 41, $11.22 and $13.60; P., F. W. & C., Fig. 42, double pit, entire layout, $10; Southern Pacific, $4.33.

Raised open iron pits (Group "D")—L. S. & M. S., $10.87; N. Y., L. E. & W., Fig. 47, including ash-car track, $9.36 and $12.73, with double pit, $16.63, with difficult foundations, $25; C., N. O. & T. P., Fig. 48, all expenses, tracks, approaches, etc., $16.67; C., B. & Q., Fig. 49, including foundations, $12; K. C., F. S. & M., Fig. 50, exclusive rails, pit $6, ash-car track $6, total $12; Missouri Pacific, Figs. 51 and 52, exclusive rails, $3.95 and $3.67; A., T. & S. F., Fig. 53, including ash-car pit, track, switch, etc., $14.77; Union Pacific, Fig. 54, $4.42; Southern Pacific, Fig. 55, excluding rails, otherwise complete for single pit and ash-car track, $3.90; St. Louis and San Francisco, Fig. 56, iron work complete furnished in place, $2.46.

Elevated iron trestle (Group "E")—C. R. R. of N. J., Fig. 57, iron trestle $12.30, pile foundations, track work, masonry, and grading of approaches $13,41, total $25.71.

Depressed open iron pits (Group "F")—Illinois Central, special plan, complete layout, including ash-car track, etc., $42.23; Duluth and Iron Range, Fig. 61, complete, including expensive foundations, $28.57; C., R. I. & P., Fig. 63, $14; Chicago and Eastern Illinois, Fig. 62, $8.31.

Depressed open iron pits (Group "G")—Pennsylvania lines, west of Pittsburg, Southwest System, Fig. 66, exclusive tracks, $10; Illinois Central, Fig. 67, complete, $30 to $33.33; C., C., C. & St. L., Figs. 68 and 69, complete, $17.83; P., F. W. & C., Fig. 70, complete, $22.22; B. & O., Fig. 71, complete, exclusive ash-car track, $17.35; Penn. R. R., Fig. 72, total cost, including tracks, approaches, fire hydrants, stand-pipe, drainage complete, $42.09; Pittsburg & Western, about $25.

Relative cost of operation. The data presented to the committee are briefly as follows:

Depressed closed pit (Group "B")—C., R. I. & P., handling from pit to car without depressed ash-car track, 12 cents per cubic yard. P., F. W. & C., same, with well depressed ash-car track, 6 cents per cubic yard.

Crane and bucket system (Group "C")—B. & O. S. W., depressed open pits with crane and bucket system subsequently introduced, cost, at Washington, Ind., with crane and bucket, one-third of previous cost shoveling; at Cincinnati, cost with crane and bucket less than one-half previous cost shoveling, or cost with crane and bucket less than 6 cents per engine and previously with shoveling at least 12 cents per engine.

Raised open iron pits (Group "D")—N. Y., L. E. & W., cleaning engines and loading ashes on cars, exclusive hostlers, 30 and 32 cents per engine. C., N. O. & T. P., with well depressed ash-car track, handling from fire-box to car, 4½ cents per engine. Missouri Pacific, handling from pit to car, about $1 per car.

Depressed open iron pits (Groups "F" and "G")—C., R. I. & P., handling from pit to cars, 7½ cents per cubic yard. Penn. lines west of Pittsburg, Southwest System, cost per engine, including loading into car: ash-pit men, 13½ cents; hostler, 7 2-10 cents; total cost per engine, 20 7-10 cents. P., F. W. & C., handling from pit to car, $1.02 per car. B. & O., $1.50 per car, or about 5 cents per cubic yard. Penn. R. R., East Tyrone, cleaning and loading, 6 86-100 cents per cubic yard; average cinders per engine, 1.25 cubic yards; cost per engine, 8 58-100 cents.

Conveyor systems (Group "I")—P. & R., bucket conveyor at coaling and ash station, 9th and Wallace streets, Philadelphia, coal handled at 4 cents per ton and ashes at 8 cents per ton.

In regard to the various cinder-plant systems in use, the following general recommendations can be made:

Where it is absolutely necessary to dump ashes on the ground between rails, the ties should be protected by iron plates.

The old style closed depressed pit should not be used, unless local conditions absolutely require it. A depressed ash-car track alongside of pit is desirable.

The bucket and crane system, worked by the locomotive, is to be highly recommended for cheapness of operation at all points where the conditions of the service warrant its use. The introduction of a stationary engine or other power for running the crane will allow the system to be used to advantage at large cinder-plants and the multiplication of cranes along the pit to increase the capacity can be obviated by introducing an overhead traveling crane or a movable pillar crane on wheels alongside of pit.

Open pits raised above the general track level are, as a rule, cheap to construct and comparatively economical in operation, particularly if an ash-car track depressed below the floor of the pit can be introduced. This system has decided merits, especially in level country, where drainage of a depressed pit would be difficult to obtain. Hence its extensive use in Western sections of the country and also in large level division or terminal yards.

High iron dumping trestles offer a large storage capacity. The removal of the cinders is independent of the dumping operations and whenever undertaken will be done systematically and the material used to good advantage, which features may in some cases cause the adoption of this system.

Depressed pits open on one side, the ashes being shoveled or drawn out sideways under rail on open side of pit and loaded by hand into ash-cars on a depressed track located at or preferably considerably below the floor of pit, offer decided advantages and are recommended for use, wherever the local conditions will allow a depressed pit and ash-car track. This system represents the most advanced modern practice for depressed pits, and is being adopted as standard on a long list of prominent roads.

An extension of this system consists in the introduction of chutes under the cinder-pit track to load the ash-cars by gravity. A water spray playing on the upper end of the chute serves to cool the ashes, settle the dust, and allows the chute to be placed on a lighter grade. The system is just being introduced on several roads, so that data of actual operation and especially of the maintenance of the structure are not obtainable. It is to be considered, however, in general, as an improvement. It will certainly decrease the running operating expenses, and the chutes, if properly constructed, ought to give a reasonably long service.

Your committee has given considerable attention to the question of mechanical conveyor systems, and finds that a number of appliances of this class are in use for handling ashes at large stationary boiler plants for industrial establishments, but that there is only one conveyor plant in successful use for removing locomotive ashes, as far as known to your committee, namely, a bucket-conveying system on the Philadelphia and Reading at Philadelphia, which plant has been successfully operated for about a year and a half. Your committee is not willing to consider that mechanical conveyors will be the general solution of the cinder-pit question in the future; but it can be stated, that there are certain conditions and localities, especially where ground space is valuable, for which a conveyor plant of suitable design will prove very efficient.

WALTER G. BERG, Lehigh Valley Ry.,
GEO. W. ANDREWS, B. & O. Ry.,
R. M. PECK, Mo. Pac. Ry.,
ABEL S. MARKLEY, Pittsburg & W. Ry.,
Committee.

APPENDIX TO REPORT ON "DEPRESSED CINDER-PITS," GIVING DESCRIPTIONS OF CINDER-PIT SYSTEMS AND DATA COLLECTED BY THE COMMITTEE.

(a) DUMPING ON GROUND OR IN SHALLOW IRON TROUGH BETWEEN TRACK RAILS; ASHES SHOVELED OUT.

Mr. Walter G. Berg (Lehigh Valley) recommends the shallow wrought iron ashpit design, shown in Fig 39, for main track and for use on new roads, and states that the troughs should be made in short sections and placed loose between the track stringers, so that the track timbers can be tamped up or repaired by simply lifting out the light iron trough sections. Iron guard rails, as shown, or some rerailing device at each end of pit, will cause this style of pit to be the least objectionable for a main track, if a pit of some kind is demanded.

(b) DEPRESSED CLOSED PIT; ASHES SHOVELED OUT—ASH-CAR TRACK DEPRESSED, WHERE POSSIBLE.

Mr. S. F. Patterson (Concord and Montreal) reports a depressed closed cinder-pit, located on round-house track; built throughout of granite, 3 feet deep, 3 feet 10 inches wide, and 16 feet long in clear. Walls, 16-inch granite. Paving, 12-inch granite slabs 7 feet long, laid solid across pit. Rails fastened direct to granite coping. Pipe drain through wall. Cost about

$175, or $11 per foot effective length. Soft coal used. The watchman or someone around the round-house shovels the ashes out of pit, when necessary, and the work train crew load the ashes on their train for use as ballast or otherwise.

Mr. H. C. Draper (Chief Engineer, Chicago & Alton) states that his road uses mainly depressed closed cinder-pits, 3 feet 8 inches wide in clear, 3 feet 6 inches to 4 feet deep, and 40 feet long. Walls of hard burned brick, 20 to 30 inches thick, built on footing stone 3 feet wide. Paving, two courses of brick. Face of walls slightly battered. Drainage, sewer pipe at one or both ends. Rails fastened to oak stringers, 8 inches by 14 inches or 16 inches, strutted apart by 2-inch rods. Location, on engine house track. Soft coal used. Where feasible, the ash-car track alongside pit is depressed, preferably 4 feet. This kind of pit has not proven satisfactory, as the stringers burn out and the brick crumble from the heat. Several of them have been replaced in the last few years by cast iron open pits, similar to the C., B. & Q. R. R.

FIG. 39—PROPOSED DESIGN FOR SHALLOW MAIN TRACK PIT.

standard, described below under Group "D," and are giving good results.

Mr. Aaron S. Markley (Chicago and Eastern Illinois) reports depressed closed pits in use, located on round-house, 3 feet 10 inches wide in clear, 3 feet 6 inches deep, and from 32 to 78 feet long, built in some cases with stone and in others with brick. Rails spiked to 12x12-inch oak coping timbers. Ash-car track located alonside pit. Soft coal used. He also states that they use all iron cinder-pits at important points, where the ash output is large, described below under Group "F."

Mr. E. D. Hines (Norfolk and Western) reports that on the southwest division a depressed closed pit is used in a turn-table track, about 60 feet from the table, alongside of coaling platform; dimensions, 3 feet 6 inches wide, 3 feet 6 inches deep, and 30 feet long. Side walls, and paving, hard paving brick. Timber wall plate 8x12 inches, covered with heavy sheet iron. Tile drain from one end of pit. Ash-car track alongside pit, but ashes have to be handled twice.

Mr. A. G. Dailey (Superintendent of Tracks, Michigan Central) states that his road uses depressed closed cinder-pits, 2 feet 6 inches below base of rail, built of brick, and rail spiked to 10x14-inch timber coping. The length of pit varies from 30 to 50 feet. The longest pit is 90 feet long at Michigan City. The location of all pits is on a special track connected at both ends of pit with the track leading from the main track to turn-table. These brick pits need patching about once in two years, and rebuilding about once in ten years. Mr. Dailey states further that they have one timber pit at Grand Rapids, 30 feet long, made of timber faced with old frog plates fastened to the timber by driving 10-inch boat spikes through the old rivet holes. The plates are left 2 inches away from the timber and the space filled with cement. This timber pit has been in use five years and is in very good condition.

Mr. Onward Bates (Chicago, Milwaukee and St. Paul) reports depressed closed cinder-pits in use on his road, located in the main track at certain water stations, where it is desired to take water and dump front-end cinders simultaneously. These pits are 3 feet 7 inches wide in clear, 3 feet deep below base of rail, and from 11 feet 3 inches to 33 feet 9 inches long. Foundation under pit, 2-foot rubble masonry. Side walls, 17-inch brick. Bottom of pit, level crosswise; 1-inch layer of mortar on rubble foundation masonry. Rails spiked to 12x12-inch pine coping timbers, protected along face by special castings, 12 inches high, $\frac{3}{8}$ inch thick, and set out so as to leave about a 2-inch air space in front of timber. The rails are connected across pit by regular switch rods, spaced every 7 feet 6 inches. The principal peculiarity of this pit consists in iron gratings that are laid over the pit between the rails. These gratings are made in sections so as to be more readily handled. The gratings consist of $\frac{3}{4}$-inch gas pipes, spaced 2-inch centers, and fitted into $1\frac{3}{4}$-inch angles. Drainage of pit is not necessary, as special pits at division yards are built for receiving the clinkers and for drawing fires, described below under Group "F."

Mr. James Dun (Chief Engineer, Atchison, Topeka and Santa Fe) states that depressed closed pits, as shown in Fig. 40, are mostly used on his road, located on lead track to turn-table. Pits are 4 feet $2\frac{1}{2}$ inches wide in clear, 3 feet 6 inches deep below base of rail, and 30 feet long. Side walls 18 inches thick, built of common brick and faced all the way up with fire brick. Stone coping, 12 inches high, faced with fire brick, held to stone by $\frac{1}{4}$x12-inch iron plate in front of fire brick and bolted through the fire brick to back of coping stone with two $\frac{5}{8}$-inch bolts every 4 feet. Track rail is riveted to a $\frac{1}{2}$x12-inch iron plate and held by $\frac{7}{8}$-inch bolts running down through the coping stone to bottom of side wall, spaced about 6 feet. The foundation of side walls and bottom of pit is grouted concrete 1 foot thick. In the bottom of the pit there are three rows of fire brick set on edge along each side wall and end wall, and the middle of the pit is paved with stone. The floor of the pit is straight transversely, pitching toward one side wall, thus forming a gutter along the latter. Drainage through side wall at each end of pit with 5-inch drain pipes. Soft coal used. Cost of standard depressed closed pit $300, or $10 per lineal foot. They also have a standard open iron pit, described below under Group "D."

Mr. F. Ingalls (Northern Pacific) reports that there are two standards for cinder-pits on his road, one for a depressed closed pit, and one for an open pit on iron supports, described below under Group "F." The depressed closed pit standard, shown in Fig. 41, is 4 feet wide in clear, 3 feet to 3 feet 6 inches deep

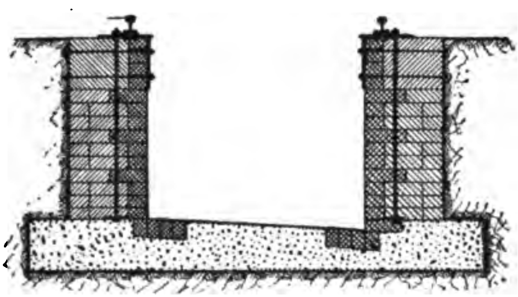


FIG. 40—ATCHISON, TOPEKA AND SANTA FE R. R.

below base of rail, and 60 feet long. Foundation is concrete. Side walls, 17-inch brick, with 8x12-inch white pine coping timbers, anchored to wall every 6 feet with ¾-inch bolts, 3 feet 7 inches long. The sides of pit are protected by cast iron plates, ½-inch thick, 18 inches wide, and 3 feet 3 inches long, which are hung on the timber coping by a 3-inch top flange and fastened with ½-inch spikes. This plate is set so as to leave a 1-inch air space between it and the brick wall. The bottom of pit is paved with common hard brick set on edge and bedded in an 8-inch layer of concrete. The paving dishes transversely, forming a gutter 2 inches deep along middle of pit. Pit drained from each end toward center, where an opening through side wall connects with a well designed covered catch basin, easily accessible for cleaning, from which a 6-inch pipe drain runs. Mr. Ingalls states that a pit with brick walls, as above described, at Fargo, Dak., has had to be rebuilt several times since 1883, but that a similar pit with stone walls built in 1883 at Jamestown, Dak., has never given any trouble. He also gives the cost of two pits built on a division of the road west of the Dakota division, as follows: One built in

1889, labor $250, material $423, total, $673, or $11.22 per foot pit; the other, built in 1890, labor $400, material $416, total $816, or $13.60 per foot pit.

Mr. F. S. Curtis (Chief Engineer, New York, New Haven and Hartford) states that depressed closed pits are used on his road, located on side tracks. Pits are 3 feet deep below base of

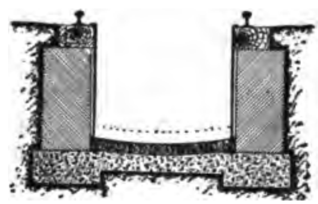


FIG. 41—NORTHERN PACIFIC R. R.

rail and 100 feet long. Side walls, stone 12 inches thick, with 12x12-inch coping stone. Rails fastened to coping stone with ordinary track spikes, driven into wooden plugs set in holes drilled in stone. Bottom of pit level transversely. Paving, brick. Drainage, pipe drain at ends. Where hard coal is used the face of the side walls and coping stone are protected by 1-inch cast iron plates, hung on coping stone. In all cases ashes have to be handled twice.

Mr. J. H. Markley (Toledo, Peoria and Western) reports that the P. & P. V. R. R. have at Peoria, Ill., a depressed closed ash-pit, located on a special track, 3 feet 10 inches deep, 3 feet 10 inches wide in clear, and about 68 feet long. Side walls 2 feet high, of paving brick, 4x5x12 inches, with no protection against heat. On top of side walls there are 22-inch old built iron floor beams, instead of wood or stone coping. The rail is fastened to the flanges of the beams with bolts and small shapes, that run up on the flange of the rail. The beams have three struts in the full length of the pit to keep them from spreading and only one brace frame in the center to keep the beams from canting. Right by the side of the pit there is a depressed track 6 feet deep and the same length as the pit, which makes it very convenient to shovel the cinders from pit to cars. It is a very convenient plant, but the brick work needs protection from the hot cinders, as an inspection of the pit showed bricks slacking away and mortar crumbling out of the joints.

Mr. N. W. Thompson (Pittsburg, Fort Wayne and Chicago) reports that his road has two depressed closed cinder-pits at Fort Wayne, Ind., with a depressed ash-car track between them, as shown in Fig. 42. The cinder-pits are each 100 feet long, spaced 20 feet centers, and are located on special tracks connected at both ends with the lead track to round-house. The depressed ash-car track has a dead end and is 6 feet 9 inches below the pit tracks. There is a stand-pipe alongside each pit, so that engines take waters while cinder are being dumped. The side walls of pits are built of hard burnt red brick, laid up in lime mortar with a small admixture of hydraulic cement. The walls are started on hard yellow clay foundations. The 10x10-inch oak coping is secured to the walls with ¾-inch anchor bolts every 4 feet, and protected with heavy galvanized iron. A 1½-inch hose connected with hydrants, conveniently located, serves to cool ashes. Drainage through 8-inch pipes at ends of pits, connecting with 12-inch sewer. Paving of pits, brick on edge. Soft coal used. Three gondolas loaded every twenty-four hours at a cost for labor of $4.50, or $1.50 per car. The cars are loaded to their full capacity and average about 25 cubic yards each, so that the cost of loading ashes is about 6 cents per cubic yard. The capacity of these two pits, each 100 feet long, is about 12 engines per hour. The cost of the entire layout is $2,000, or say $10 per foot effective pit length.

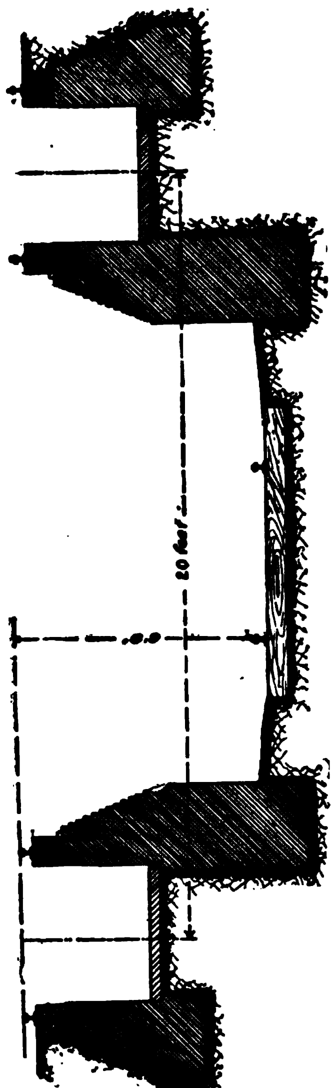


FIG. 42—PITTSBURG, FORT WAYNE AND CHICAGO R. R.

Mr. John D. Isaacs (Assistant Engineer M. of W., Southern Pacific) states that his road uses several systems for handling cinders. One is the ordinary depressed closed pit, 3 feet 11 inches wide in clear, 2 feet 6 inches deep, and from 20 to 40 feet long, located on a turntable track. Side walls, 13 inches brick, with suitable footing courses on outside of wall. Paving, brick on edge, level transversely. All brick laid in cement mortar. Coping 8x12-inch pine, anchored to side walls by ¾x30-inch bolts every 5 feet. Experiments are now being made with cement coping in place of wood. Drainage, where possible, by ordinary sewer pipe. The ashes have to be handled twice. The cost of a 30-foot pit is about $130, or $4.33 per foot effective pit length.

Mr. H. F. White (Chief Engineer, Burlington, Cedar Rapids and Northern) states that prior to 1893 the standard cinder-pit in use on his road was a depressed closed pit, 30 to 40 feet long, walled up with brick, lime stone or quartzite, but that it proved very expensive to maintain and operate owing to the damage done by heat and water. The open iron pit, described below under Group "D," is now the standard and is giving good results.

Mr. George J. Bishop (Chicago, Rock Island and Pacific) reports that prior to 1890 his road used a shallow iron depressed closed pit 22 inches deep, 5 feet 6 inches wide, and 32 feet long, stone foundation, end walls stone; rails supported on cast iron pedestals forming cast iron ties, spaced 3 feet centers, sides of pit lined with heavy sheet iron placed against outside of cast pedestals, and no drainage. With this plan the handling of ashes from pit to cars costs 12 cents per cubic yard. This plan has been discarded for a depresssed open iron pit, described below under Group "F," for which the cost of handling ashes is only 7½ cents per cubic yard.

Mr. Aug. Mordecai (Chief Engineer, New York, Lake Erie and Western) reports a depressed closed pit in use on his road for main track, 2 feet 10½ inches wide in clear, 3 feet 6 inches to 4 feet deep below base of rail, and 45 feet long, with masonry cross-walls every 15 feet to strengthen the side walls. The foundation is concrete. Side walls, common brick with fire brick facing. Coping, 8x16-inch oak, to which the running and guard rails are spiked. Bottom of pit, fire brick on edge, set in sand. The tops of intermediate cross-walls and of end walls are protected by cast iron plates. The coping timber is anchored to brick wall by ¾-inch bolts about every 6 feet. Paving dished toward center of pit. Drainage at end of pit, where a 2-foot sump with iron grating and 8-inch drain pipe is located.

Mr. Abel S. Markley (Pittsburg and Western) reports that his road, until 1890, used depressed pits with solid sides, but found they were too expensive to operate, and often engines were delayed by pit getting full and engines waiting to go over the pit until cleaned out. Additional men had to be kept to remove the ashes when engines were not on the pit. Dimensions of pit, 36 inches deep and 40 to 80 feet long. White oak coping 12x16 inches. Mr. Markley states that he would not recommend to any road this kind of a pit, where they have much business, but for a road that does not use it more than eight or ten times a day it would answer very well and would be better than none at all. Soft coal used. After 1890 a depressed pit with open sides was adopted with excellent results, as described below under Group "G."

Mr. Walter Katte (Chief Engineer, New York Central and Hudson River) states that his road has in New York City several closed depressed pits, with brick side walls, coped with timber anchored to wall, and pit lined with cast iron plates, the design being similar to that shown in Fig. 41, excepting that the bottom of pit is formed by cast iron plates. The pit is 3 feet 6 inches deep below base of rail, 3 feet 10 inches wide in clear, with intermediate cross-walls about every 8 feet. The pit at 47th street is 50 feet long, with concrete foundations, and the pits at 30th street and 72d street are 100 feet long, on timber and pile foundations.

(c) DEPRESSED CLOSED PIT; ASHES DUMPED INTO MOVABLE IRON BUCKETS, BASKETS OR HOPPER CARS IN PIT, HOISTED OUT BY CRANES.

Mr. H. M. Hall (Baltimore and Ohio Southwestern) reports that his road has cinder-pits with depressed ash-car track, described below under Group "G," but that their standard practice is the use of movable iron buckets placed in a depressed closed pit in connection with an iron crane for swinging the loaded buckets from pit to ash-cars. The pit is 4 feet wide in clear, 3 feet 5 inches deep below base of rail, and 40 feet long. Side walls, brick, 13 inches thick, with proper footing courses at bottom, and coped with 8x12-inch timbers. Paving, one layer of brick on edge, set on a layer of brick laid flat. The iron crane, shown in Fig. 44, is placed about 9 feet from the center of the pit. Buckets of tank iron, shown in Fig. 43, about 8 feet long and of proper dimensions to go in the pit and clear the firebox of engines, arranged with trap doors or openings in the bottom of bucket for dumping cinders, are placed in the pit in such a manner that a bucket will be under each end of the firebox of an engine on the pit. The cinders are scraped into the buckets and the same engine is used to hoist the loaded buckets out of the pit and dump the cinders on dump cars kept constantly on the ash-car track on the other side of the crane from the pit, so that there is no shoveling required. The cinders are dumped along the road for ballast. Mr. Hall states that there is a large saving in the use of the hoisting crane, and it is more expeditious than shoveling. The only force needed is the men who clean the fire box. The cost of handling cinders with buckets and crane at the depressed pit at Washington, Ind., described below under Group "G," is exactly one-third what it cost to shovel the ashes in the old way with the depressed pit. This is a fair and thorough test for comparison in cost, as the crane and bucket system is now used in the same depressed pit that was used for four years before the crane was set up. With the depressed pit operated by shoveling it required six men at $1.20 per day to do the same work now done by two men at the same wages. The cost of an iron bucket, as shown in Fig. 43, is $45.

Mr. Hall forwards following information furnished by Mr. J. G. Neuffer, General Master Mechanic, B. & O. S .W.: "We have been using cinder buckets in connection with cranes on

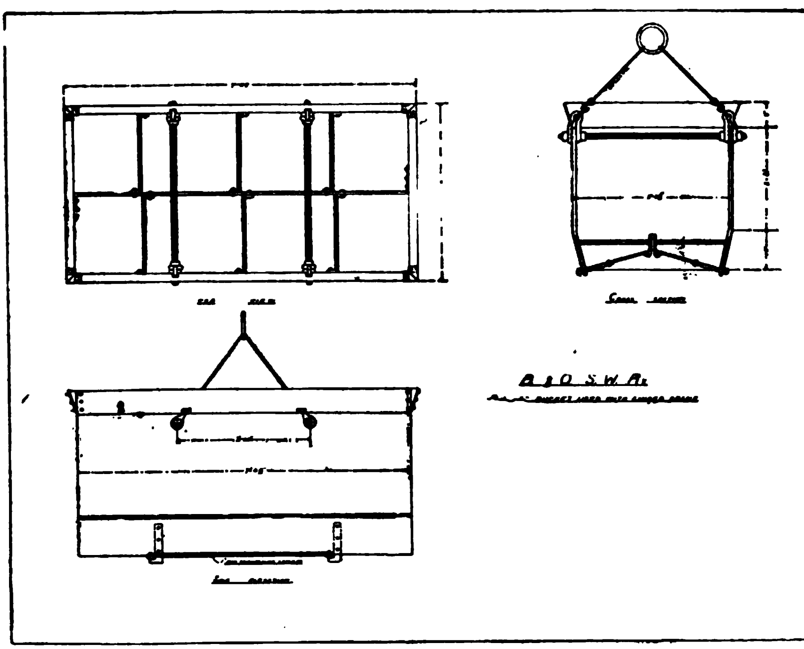


FIG. 43—BALTIMORE AND OHIO SOUTHWESTERN R. R.

Ohio division for five years. The life of a bucket is about two years, and two buckets are used with every crane. We have at Park street, Cincinnati, a crane with two buckets that we clean fires from an average of 50 engines in 24 hours. Before we used crane at Park street it required two men during the day and two men at night constantly to rake cinders out of ash pans and clean pit, and throw cinders from ground to car, but since we have put crane and bucket system in operation one man can do the work and often has time to spare to do other work. The cost of handling cinders from ash-pan before we used crane at Park street was $180 per month and very often we had to call in section men to assist in loading up the cinders that these pit men were not able to handle. The cost of handling the cinders now in connection with crane is $90 per month. The price of laborers here may look a little high, but in Cincinnati it is very difficult to get laborers to work for anything less than we are paying. This $90 per month includes every day. In operating the crane we always have a man that knocks out fire and who assists in dumping ashes and turning crane. If crane is in proper alignment two men can handle it very easily."

Mr. Wm. Smith (Superintendent of Motive Power, Chicago and Northwestern) states that his road has at Tracy, Minn., a pit in the bottom of which is a sheet iron box, which is raised out of the pit and dumped into a car standing on the side track by means of a crane and small gas engine. This arrangement is considered very favorably.

Mr. J. B. Pullen (Baltimore and Ohio Southwestern) writes as follows relative to the practice on his road: "Ash pits are generally located on a special track leading from the turn-table or engine house. We build them of uniform size, length inside 46½ feet, width inside 3 feet 11 inches, depth below base of rail 3 feet 6 inches. In this pit are placed two asn buckets of sheet iron. When cleaning engines of ashes, the buckets are placed about 5 feet each way from center of pit; after filling the buckets are attached to the hoisting chain of a revolving post crane (which is usually set at 9½ feet from center of ash pit and the same distance from the ash car track.) The locomotive moving along the track elevates the ash bucket, and by a hand lever attached to crane, the attendant swings ash bucket over the ash car and empties it. Our ash pits are built of hard burned brick—at present we are using paving 'seconds,' which we find excellent for the purpose. Pits are paved with the same and laid up in hydraulic cement. Close to the ash pit is placed a hydrant, with hose connected, to be used in wetting down cinders after removal from the engine. At the end of the ash pit a small catch basin is made (with double screens to prevent choking of drain) and a 6-inch drain carries off all surplus water. On top of the brick wall is placed a 7 inch x 15 inch oak timber, which serves as coping, and also to carry the rail which is spiked directly to it. The tracks are all on the same level. The coal used is the ordinary Ohio soft bituminous coal. The cost of ash pit lately built at Cincinnati was $94.45.

"The iron cinder crane deserves mention as showing the adaptation of old iron (which usually goes to the scrap pile) to the purpose. The mast of the crane consists of a Phoenix column (from old iron bridge scrap) usually 9 or 10 inches in diameter of

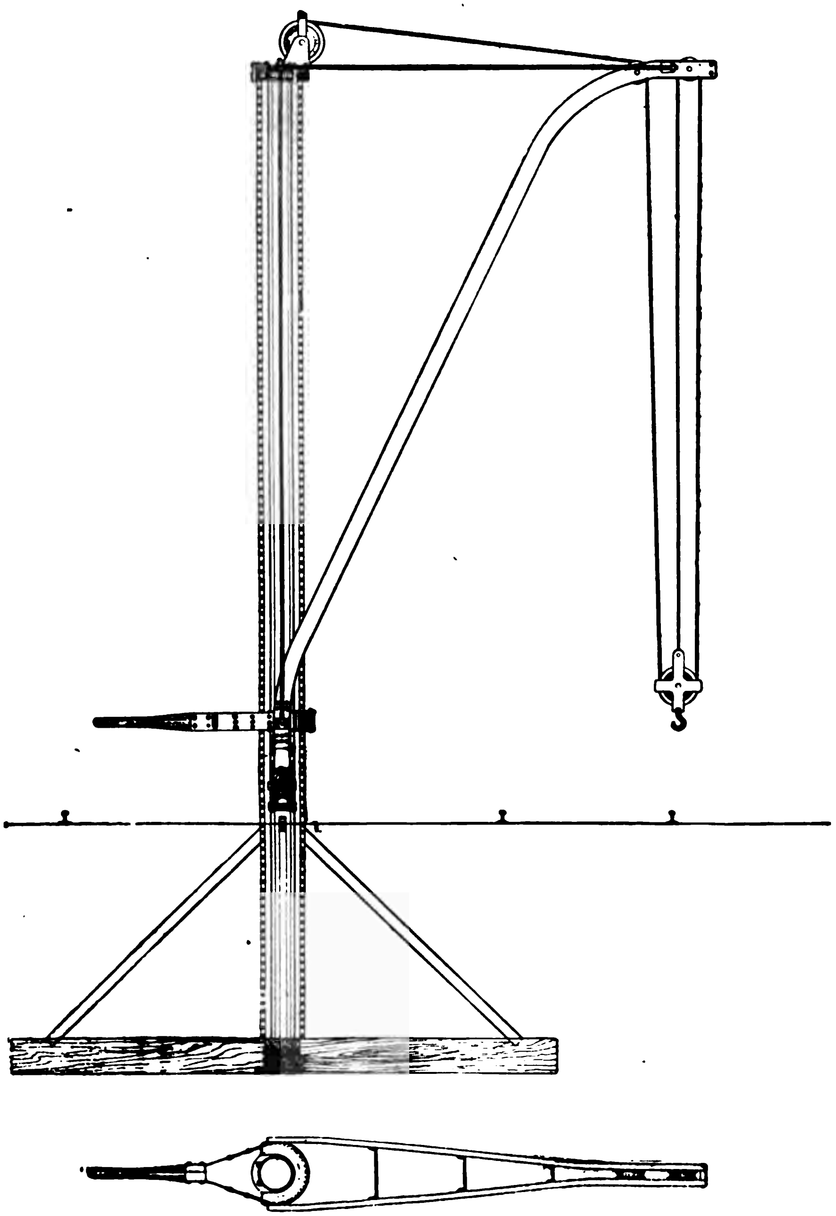


FIG. 41—BALTIMORE AND OHIO SOUTHWESTERN R. R.

4 segments; this is set in the ground 6 feet 4 inches below the base of rail, on a timber cross, with iron braces from timber to column, and the part below ground is surrounded and imbedded in a pyramidal concrete base or anchorage. The jib of crane (carrying ash buckets) is composed of two 6-inch channels curved at the top; these being connected with top of mast with round iron tie bars. Cranes of this kind have been in use for the past three years on the Ohio division of the Baltimore and Ohio Southwestern Railway and have given perfect satisfaction. The additional cost of operating the aforementioned cinder pits with crane and buckets, is nothing; by the old method of hand shoveling and hoisting we expended from $30 to $60 per month for section men's labor and labor of others not accounted for; by the present mode, section men are not needed, as ashes are deposited in buckets and are hoisted by the engine that has been cleaned. A very simple calculation will show the saving. The cost of a crane with anchorage recently built at Cincinnati was $546.26."

Mr. John D. Isaacs (Assistant Engineer M. of W., Southern Pacific) states that his road has experimented with buckets into which the ashes are raked and which are afterwards lifted by a derrick and dumped on cars. The derrick is worked by air from the engine, but the result as yet has not been satisfactory.

Mr. Herbert Wallis (Mechanical Superintendent, Grand Trunk) states his road uses a number of systems of removing ashes, but the one which gives the best satisfaction is that of raking into iron wire baskets placed in pits below the engine ash pans, which baskets are afterward raised by compressed air and dumped into cinder cars. The pit used is an ordinary one made of brick or stone, about 30 feet long and 2 feet 6 inches deep.

Mr. Edward Evans (M. M., Cincinnati, Washington and Baltimore) published in Engineering News of Aug. 30, 1890, an illustration and description of a bucket and crane system in use on his road for removing ashes. The crane, as shown in Fig. 45, copied from Engineering News, is a light wooden one. The system used is otherwise in general the same as reported above by Mr. H. M. Hall. The description published in Engineering News in connection with the illustration is as follows: A ½ inch hoisting chain is passed over the pulleys AAA, the farther end of which is attached to any locomotive. A ball bearing, B, is placed under the foot of the mast to enable it to revolve easily. The lower pulley, A, beneath the mast, is swiveled so as to follow the direction of the pull, whatever it may be. The bucket H is 8 feet long, and 3 inches less in width than the width of the ash pit. It is made of old tank iron, well braced, with two rods running across at the top of the bucket. Double rings, R, for hoisting are secured at the top of the bucket by two nuts at each end of these rods. Four hooks, I, attached to the central hoisting ring, K, engage with these rings. After the bucket is placed in the pit the hooks are detached at R, and the crane is swung to one side. There is a flaring flange, L, at the top of the bucket to keep the ashes from getting between the side of the bucket and the pit. The bucket has a drop bottom for its full length hinged at X, with a clasp at Y. An empty coal car is placed in a track to the left of the crane, the bucket raised, the crane swung around, the clasp at Y released and the ashes dumped at once; the whole operation,

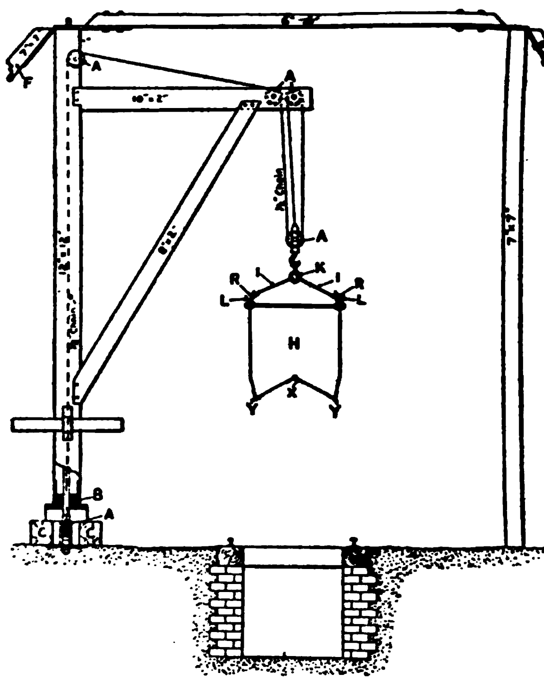


FIG. 45—CINCINNATI, WASHINGTON AND BALTIMORE R. R.

including return of the bucket to the pit, being performed in about four minutes. Water should be convenient and the ashes well wet down to prevent their setting fire to the car.

Mr. E. P. Lord (formerly Superintendent Motive Power, C., C., C. & St. L.) furnished the Railway Review with information and plans relative to the coaling station of the C., C., C. & St. L. R. R. at Wood street, Cincinnati, Ohio, published in the journal mentioned on May 6, 1893. In connection with the coaling of locomotives provision is made for handling ashes from locomotives. An ash pit 4 feet wide and 3 feet 6 inches deep, is placed under the coaling track, in which pit small iron hopper cars run on rails. The ashes from engines are dumped into these small cars and the loaded cars pushed to one end of the pit, where they are hoisted by a crane to an upper platform and the ashes dumped through iron chutes into the empty coal cars for use along the road. The power for running crane is a small steam hoisting engine required anyhow in connection with the coaling station. Mr. M. F. Potter (C., C., C. & St. L.) states that this pit is operated and works all right, but that the system is naturally not adapted for general use and that it is too expensive in construction for the slight advantage gained.

(d) RAISED TRACK ABOVE GENERAL GROUND LEVEL, RAILS CARRIED ON LOW IRON PEDESTALS OR COLUMNS, PIT OPEN ON BOTH SIDES; ASHES SHOVELED OR DRAWN OUT SIDEWAYS UNDER RAILS. ASH-CAR TRACK DEPRESSED, WHERE POSSIBLE.

Mr. S. W. McGee (Chicago and Grand Trunk) reports that the most approved ash-pit on his road is obtained by raising the dumping track about 4 feet above the prairie level, carrying the rails on cast iron columns, two to each bent, bents spaced 4 feet 6 inches centers. The columns in each bent are connected by wrought iron strap strut, 3x¾ inches, bolted to top of columns. The columns are bedded on 12-inch stone pedestals, 2 feet square, on rubble masonry foundations. The pit is 3 feet 2 inches deep below base of rail, and bottom is paved with brick on edge. Location of pit on special track, conected at both ends with lead track to turn-table.

Mr. H. E. Gettys (Norfolk and Western) reports that the raised open iron cinder-pit, shown in Fig. 46, is the standard on

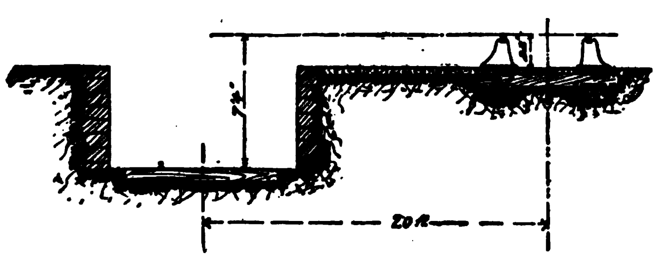


FIG. 46.—NORFOLK AND WESTERN R. R.

his road. The cast iron chairs are spaced 3 feet centers lengthwise of pits, the depth being 18 inches in clear under rail. The bottom of pit has a 4-inch concrete floor reaching to the edge of the retaining wall forming the pit for the depressed ash-car track, which is depressed, where possible, 5 feet below the floor of the pit. The bases of the iron chairs are bolted to 8x10-inch by 8 foot 6 inch timber cross ties, which are fastened with 1½-inch draft bolts to two sills, 8x10 inches, on each side of pit. All timber is covered by the concrete floor.

Mr. Geo. M. Reid (Lake Shore and Michigan Southern) reports that an open iron pit on his road at Westfield, N. Y., is very satisfactory. It is 110 feet long and cost $1,196, or $10.87 per foot run. Soft coal used. Ashes are shoveled into flat cars, if haul is short, and into gondolas, if to be hauled some distance on road. The track on the pit is carried on cast iron columns, one under each track rail, spaced 5 feet centers along pit. The bottom of pit is about 5 feet below top of rail. The characteristic feature in this design is the strengthening of the 65-pound track rail by two additional rails bolted to it, properly strapped and chocked by wrought iron splice bars and cast iron blocks suitably arranged along track rail at and between columns.

Mr. Aug. Mordecai (Chief Engineer, New York, Lake Erie and Western) reports the raised open pit, shown in Fig. 47, as standard on his road for use on sidings or special pit tracks, and recommends placing the iron stands upon stone foundations in place of upon wood, as shown on plan, and also places the ash-car track 3 feet closer to cinder-pit, so as to avoid double handling. The cast iron stands are spaced 3 feet centers. The pit is 18 inches deep below base of rail, the approach grades at each end being 100 feet long on 2-foot grade. The cost of pits varies largely according to local conditions and character of foundations. At Hornellsville, N. Y., 250-foot pit, cost $9.36 per lineal foot; at Salamanca, N. Y., 200-foot, $12.73; at Port Jervis, N. Y., double pit with two pit tracks, each 200 feet long, and a depressed track between them, $16.63; at Weehawken, N. J., with difficult foundations, $25. These prices include the ash-car tracks. The coal used is of uniform quality as regards amount of ash and no difference is made in pits, although anthracite coal makes more ash than bituminous. The cost of operation is as follows: At Port Jervis, the cost of cleaning ashes and loading into cars, exclusive hostlers, placing engines upon pits and taking them to the round house, is 32 cents per engine, with 90 engines every 24 hours; at Hornellsville, 30 cents per engine, with 57 engines every 24 hours.

Mr. J. T. Carpenter (Cincinnati, New Orleans and Texas Pacific) reports the raised open iron pit, shown in Fig. 48, as standard on his road. The pit is 24 inches deep below base of rail and 59 feet long, the cast iron stands being spaced 3 feet 4-inches centers. The approach inclines each side of pit are on 5-foot grade. Mr. Carpenter states: "My experience with cinder-pits

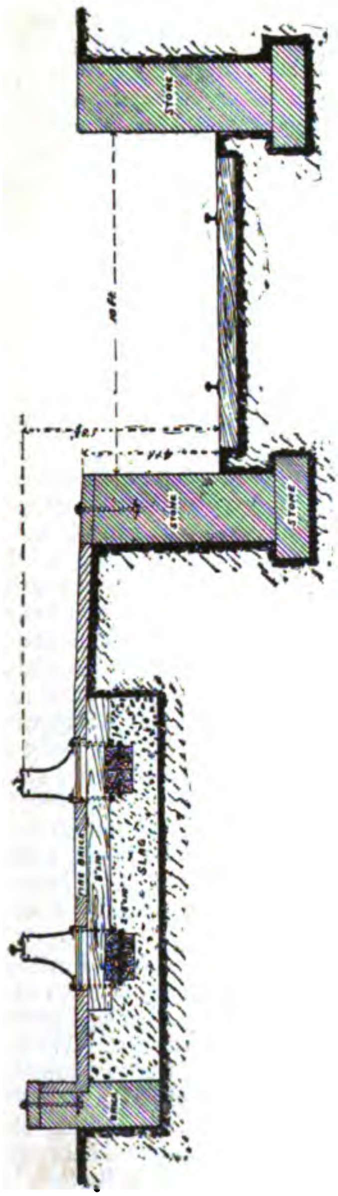


FIG. 47.—NEW YORK, LAKE ERIE AND WESTERN R. R.

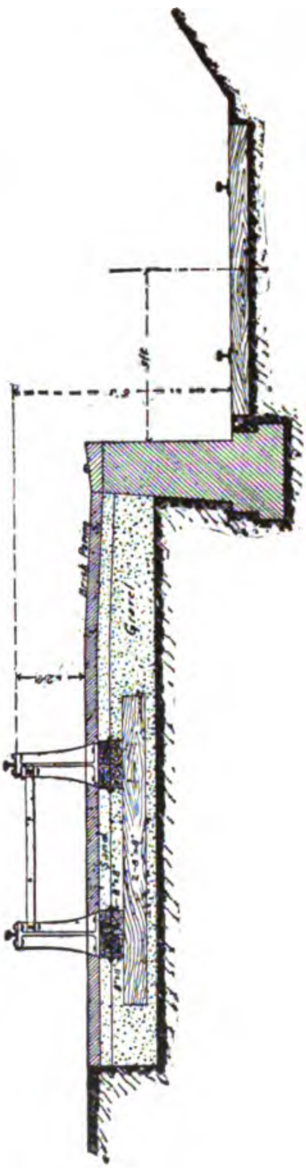


FIG. 48.—CINCINNATI, NEW ORLEANS AND TEXAS PACIFIC R. R.

has been limited, so far, to but three styles; first, the old style of a simple pit from which the cinders were thrown out of the pit by hand and then thrown into cars. The second one, like the first save the improvement of a depressed track at the side of the pit, which reduced the labor of handling the cinders fully one-half. The third, an elevated track for the engines, and a depressed track at the side of it for cars to be loaded with the cinders, which I consider such a great improvement over the two first mentiond as to leave them entirely out of the question, as by the use of this pit we have been able to reduce the cost of handling cinders from the fire-box to the car to at least four and a half cents per engine.

"The cost of standard pit, including all expenses, for cinder-pit, track approaches and ash-car track, is $983.85, or about $16.67 per foot effective pit length. This figure is high, as from unfortunate circumstances we were compelled to do most of the work in the midst of a very hard winter. The masonry of this pit is of good lime-stone, rubble work, and notwithstanding the large quantity of ashes coming from soft coal, which is used exclusively in this section of the country, so far shows no material defects from heat, as we have a water plug very close at hand with which to drench the ashes immediately after they are drawn from the fire-box. I would recommend, however, the use of good hard burnt brick, or fire brick, in the abutments of such a pit, especially in that part of them above the bottom line of the paving; also the use of a heavy iron chair of suitable pattern well embedded in the abutments to support the rails instead of the 8x12-inch timber shown on plan."

Mr. Walter Katte (Chief Engineer, New York Central and Hudson River) reports an open raised iron pit, 200 feet long, with depressed ash-car track, designed and built by him in 1885 at Frankfort, N. Y., on the West Shore Railroad, which is very similar to the design shown in Fig. 47. The cast iron pedestals, spaced 3 feet centers, are bolted to 8x10-inch by 8 foot 6 inch cross ties, bedded on two 8x10 inch longitudinal stringers under each rail. The pit is 18 inches deep below base of rail. Floor of pit, 4-inch layer of concrete. Ash-car track sunk about 6 feet below pit floor.

Mr. Wm. Forsyth (Mechanical Engineer, Chicago, Burlington and Quincy) states that the shallow raised open pit with cast rail chairs and ties, shown in Fig. 49, has been the standard on his road for about ten years, and is giving good results.. Within recent years more attention has been given to the economical handling of the ashes after being dumped in the pit, principally by the introduction of depressed ash-car tracks, facilitating the transferring of the ashes to special cinder dump cars. These cars are 34 feet long, arranged to dump sideways and built for the work expected of them, and have proved exceedingly useful. In very cold weather the wet cinders are liable to freeze, but during most of the year the cars dump freely. The principal advantage of the cast iron tie in this style of cinder-pit is that it requires very little additional material, and that, therefore, the pit can be made very long, enabling a large number of engines to be clinkered at once. When business is brisk, there may be 10 or 12 engines waiting to use the pit, and in winter steam falls rapidly, if they are not put in round house promptly. The pits are frequently made 200 feet long and several such introduced at important points. The cost, including foundations, is about $12 per foot run pit. The pit is about 4 feet 3 inches wide in clear at the top of the rail chair, and about 3 feet 6 inches wide at the bottom: the depth

FIG. 49—CHICAGO, BURLINGTON AND QUINCY R. R.

FIG. 49a.

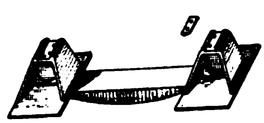


FIG. 49b.

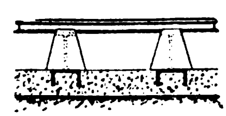


FIG. 49c.

is 1 foot in clear below base of rail. The foundations and side walls up to within about 7 inches of the floor level are of ordinary stone masonry, above which there is a layer of concrete. Each side wall is coped with two 6x10-inch oak stringers, on which the bed plates of the chairs rest. The iron ties are spaced 3 feet centers along the pit. The bed plates are 2 feet long and the uncovered length of 1 foot of the oak stringers is protected by wrought iron plates. The top of the iron tie is flush with the top of the bed plates and the floor of the pit. The rails are held in the chairs by clips and screwbolts. The first cast iron clinker-pit tie in this country was made at St. Joseph, Mo., being the joint invention of Mr. W. D. Rowley, Master Mechanic, and Mr. H. C. Fox, Patternmaker, Kansas City, St. Joseph and Council Bluffs Railroad.

Mr. H. C. Draper (Chief Engineer, Chicago and Alton) states that his road has within recent years adopted open pits with cast iron ties similar to the C., B. & Q. R. R. standard, described above, with very good results. The pits are made from 40 to 80 feet long, and located on a track leading to an engine house. Where possible, a depressed ash-car track is introduced 4 feet below the ash-pit track. Soft coal used.

Mr. L. K. Spafford (Kansas City, Fort Scott and Memphis) reports an open cast iron tie cinder-pit with depressed ash-car track, shown in Fig. 50, as the standard on his road. The pits are located on turn-table tracks. The cast iron ties rest on 12-inch by 12-inch stringers, bedded on concrete to prevent settlement, and protected from fire by concrete. The pits are usually about 60 feet long and cost, exclusive of rail or rail fastenings, $6 per foot run. The depressed ash-car track is 4 feet below the pit track and is built long enough to hold two cars, the pit being walled up at one end and on sides with rubble masonry. The cost of the depressed ash-car track, including excavation and masonry, but excluding track, is $350. The total cost excluding track, therefore, of the pit and ash-car track is about $12 per foot effective pit length. If a second pit is used in connection with the one ash-car track, the cost would be about $9 per foot effective pit length. The cinders are cooled in the pit by water from city water works or a water tank. The ash cars used are built specially for the service and are easily and quickly unloaded. Soft coal used. This system, for a cheap arrangement, reduces the cost of handling to a minimum.

Mr. R. M. Peck (Missouri Pacific) reports an open iron pit, shown in Figs. 51 and 52, as standard on his road, located on a special track raised above the general ground level. The running rail is assisted by an inverted steel rail below it to span the distance of 6 feet between rail chairs. The latter consist of a cast iron stand, weighing 173 pounds, under each running rail, the two stands being connected across the track by a cast iron channel tie, weighing 366 pounds. This cast iron tie is supported on and protects a 5x13-inch wooden tie, which is firmly spiked to a 5x12-inch oak or yellow pine stringer at each end. The pit is 20 inches deep below the base of the running rail. The bottom of the pit is filled with earth or cinders to the level of the top of the cast-iron ties. The end of pit is walled up with stone, brick, or timber, in which case the timber is protected by old boiler plates. The cost, exclusive of steel rails, is $3.95 per foot run pit. Where feasible, the ash-car track adjacent to pit is depressed 4 or 5 feet below the pit rail. The handling of cinders from pit to car costs about $1 per car.

Mr. J. R. Harvey (Missouri Pacific) reports the same standard and design in use on his division, as just described, with the

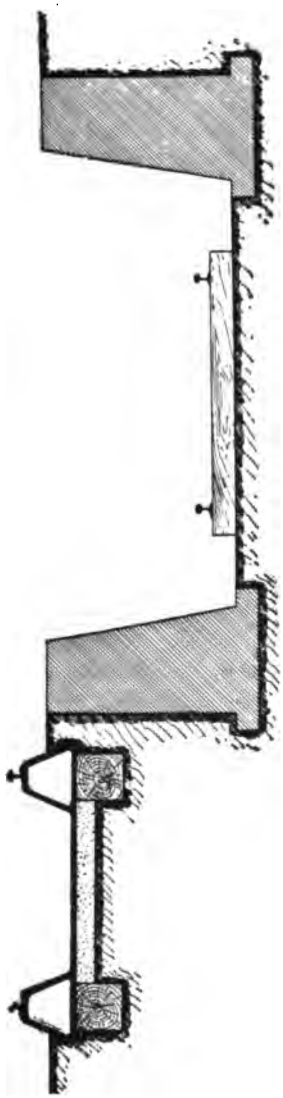


FIG. 50—KANSAS CITY, FORT SCOTT AND MEMPHIS R. R.

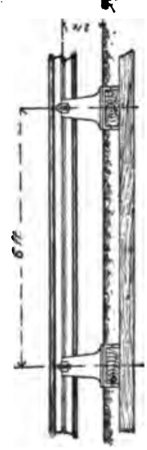


FIG. 51—MISSOURI PACIFIC R. R.

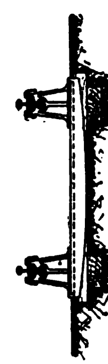


FIG. 52—MISSOURI PACIFIC R. R.

following additonal information: The timber used under cast iron ties and for stringers can be any good old material. Has had some in use five years without any trouble or expense for repairs. Wherever possible the ash-car tracks are depressed. No drainage is required, as the hot cinder absorbs all the water and the bottom of pit is above general level of ground. It is essential to make good run off at each end of raised pit track. The length of pits varies from 75 to 150 feet. The cinders are handled by the fire-cleaners. The cost of one set of castings, consisting of two stands and one tie, is $22.10. The cost of a 75-foot pit, exclusive rails, is for castings, $243.10; labor, $20; timber, $12; total, $275.10, or about $3.67 per foot run pit.

Mr. James Dun (Chief Engineer, Atchison, Topeka and Santa Fe) states that in addition to the depressed closed pit, described above under Group "B," his road has a standard open raised pit with cast iron tie, shown in Fig. 53. The cast iron tie and the two rail stands are made in one piece, which is bedded on three 5x8-inch oak ties, supported by concrete or rubble masonry walls. The iron ties are spaced 9-feet centers and each running rail is supported by two iron 7-inch "I" beams, 22 pounds per foot, properly spaced and bolted together every 3 feet by a cast block and bolts. The ash-car track is spaced 10-feet centers from the pit track. The pit track is raised 18 inches above the general ground level and the ash-car track is placed 3 feet 6 inches below the pit track. The bottom of pit is paved with brick on edge bedded in 4 inches of sand. The estimated cost for an 81-foot pit, including depressed ash-car pit, track work, switch, etc., is $1,196, or about $14.77 per lineal foot effective pit length.

Mr. A. H. King (Union Pacific)reports the raised open iron pit, shown in Fig. 54, as standard on his road. The 60-pound steel running rail is assisted by a second inverted steel rail below it to span 6 feet between the iron tie supports, which consist of old rails bent and riveted together with ¾-inch rivets, and fastened to the running rail and the inverted rail with ¾-inch "U" bolts and cast fillers. The old rails forming the iron tie are riveted to a ½x10-inch x 3-foot 3-inch wrought iron plate at each end, which plates are spiked, each with 12 ordinary track spikes to an 8x16-inch x 11-foot timber cross tie, bedded in the ground and well covered with cinders, rammed solid, which form the bottom of the pit. There is an ash-car track in a depressed pit alongside of ash-pit track, spaced about 13-feet centers, and depressed 4 feet 6 inches below the ash-pit track, which latter is raised 1 foot 6 inches above the general ground level. The depressed ash-car pit is 12 feet wide and walled in with brick, stone, or timber. A 60-foot cinder-pit built after this standard at Red Buttes, Wyo., cost $265.37, or $4.42 per lineal foot effective pit length.

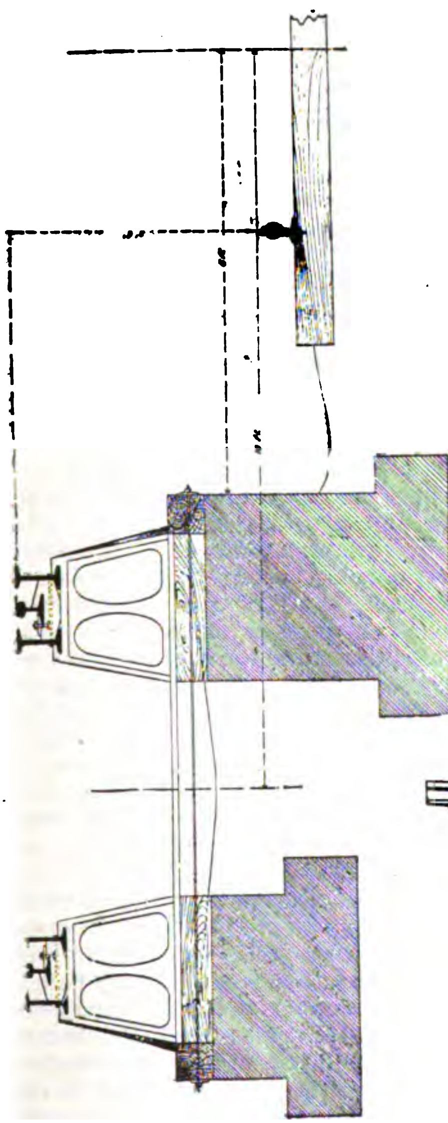


FIG. 53—ATCHISON, TOPEKA AND SANTA FE R. R.

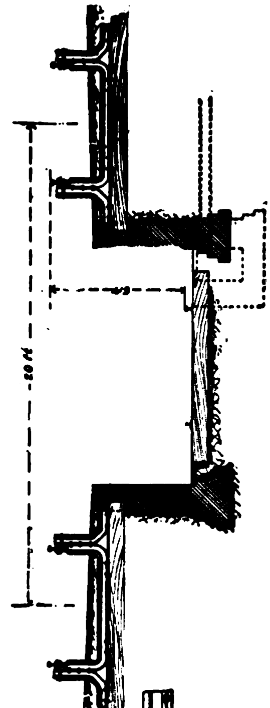


FIG. 55—SOUTHERN PACIFIC R. R.

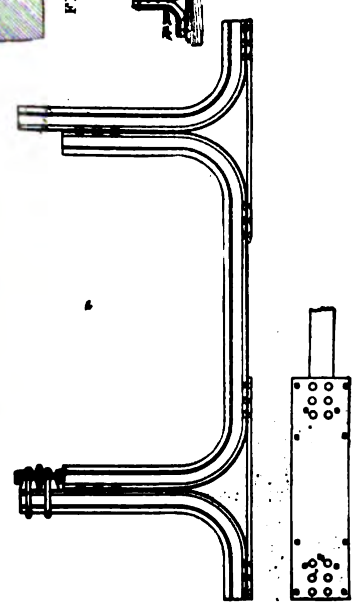


FIG. 54—UNION PACIFIC R. R.

Mr. John D. Isaacs (Assistant Engineer, M. of W. Southern Pacific) states that his company is now adopting as a standard the raised open iron cinder-pit with adjoining depressed ash-car track, as shown in Fig. 55. The running rail is double-riveted every eight inches to an inverted rail below it, spanning thus the 6 feet between the supports, which are made of bent rails, riveted together and to ½x6-inch x 3-foot wrought-iron bedplates, spiked to 8x10-inch x 9-foot redwood cross-ties. The bottom of pit is paved with brick on edge. An ash-car track is located along cinder-pit, spaced 10-feet centers, and depressed 6 feet below cinder-pit rail. The ash-car pit is walled in with brick walls and provided with a sump or catch-basin at the lower dead end of track, from which a 4-inch drain pipe runs. The cinder-pit is 77 feet long, raised 1 foot 6 inches above the general level of the ground, with run-offs 100 feet long at each end. The plan works very satisfactorily and economically. The cost of a single raised cinder-pit and of the ash-car track, excluding rails, but including all other material and labor, is about $300, or $3.90 per foot effective pit length.

Mr. G. W. Turner (St. Louis and San Francisco) reports the raised open iron pit, shown in Fig. 56, in use on his road. The running rail is strengthened by an inverted rail below it. Span between cast iron stands, 6 feet 6 inches centers. Depth 1 foot 8 inches below base of running rail. Base of cast stand, 14x15 inches, strapped with two 1-inch yoke-bolts to three old iron rails, about 7 feet long, running across the pit and forming thus an iron tie under the cast stands. These iron ties are placed on one or more timber stringers at each end according to the nature of the foundation material. The bottom of pit is earth or cinders. Each cast iron stand weighs 193 pounds. The abutments at ends of pit are made of stone; brick, or old timber, in which latter case the timber is protected by old sheet iron. The cost of the iron work furnished in place for one section, 6 feet 6 inches long, excluding the running rails, is $16, or $2.46 per foot run pit.

Mr. H. F. White (Chief Engineer, Burlington, Cedar Rapids and Northern) states that the latest standard of his road is an open raised iron pit, 40 feet long, built at Iowa Falls. The running rail is fastened with two ¾-inch bolts every 16 inches to the top flange of a 12-inch 32-pound "I" beam, spanning 10 feet between centers of cast columns. The beams are connected at top of columns by suitable iron spreaders. The cast columns are not connected together at base, but are each bolted with ¾-inch wedge bolts to 12-inch stone pedestals, 2 feet square, bedded on a gravel concrete foundation block, 3 feet deep, 4 feet wide, and 9 feet long across pit. The bottom of pit is paved with common brick laid flat in sand, sloping toward depressed ash-car track. The depth of cinder-pit is 2 feet 6 inches below top of rail. The ash-car track is spaced 15-feet centers from cinder-pit track and is about level with the floor of the pit. Western soft coal used.

(e) ELEVATED IRON TRESTLE, OPEN ON BOTH SIDES; ASHES DUMPED ON GROUND AND SHOVELED UP ON CARS.

Mr. T. H. Grant (Assistant Engineer, Central Railroad of New Jersey) gives the following information relative to the elevated iron cinder trestle, referred to above, designed and built under his supervision at Jersey City, N. J. The location is on soft ground requiring a pile foundation. The design shown in Fig. 57 consists of wrought iron trestle bents, 7 feet high above ground level, supported on stone pedestals on brick piers, bedded on a timber and pile foundation, 4 piles per bent. The rails are carried on deck girders, spanning 15 feet between bents, each girder consisting of two 15-inch "I" beams, 150 pounds per yard. Iron side brackets every 5 feet support a 2-inch plank walk each side of track. The posts are each built of two 8-inch channels, properly braced. Ash-car tracks are located each side of trestle, spaced 16-feet centers each way from trestle track. The iron trestle is 225 feet long, with filled approaches on 5 per cent. grades at each end. The ends of open pit are walled up with stone masonry, the face toward pit being protected by fire brick. This pit was built in 1892 and is giving good satisfaction. The cost of construction was for foundations under iron bents and for masonry and filling of approaches, $2,137; for iron work (225 feet at $12.30), $2,769; for track (750 feet), $880; making a total cost of $5,786, or $25.71 per foot run effective pit length.

Mr. Grant writes as follows:

"This engine ash-pit was designed to meet the conditions prevailing here, which are: The large number of engines to provide for; economy in loading the ashes and convenience in disposing of them.

"As to the features of the pit and its location and surroundings—the length permits it to be occupied by four engines at the same time, if necessary, and increases its capacity for holding ashes; the incline at each end allows engines to enter at one end and leave by the other, returning by a parallel track to the shop and turn-table tracks. The height (7 feet) gives ample storage room for ashes, and headroom underneath the sidewalks for the shovelers, also keeping the red hot cinders away from the track stringers; the parallel tracks adjoining on either side are for the dump cars to receive the ashes. There are hydrants with hose connections every few bents for wetting down the cinders. The dust is not troublesome.

"The main saving effected by this cinder-pit is due to its capacity, which allows the work train to come in after the loaded

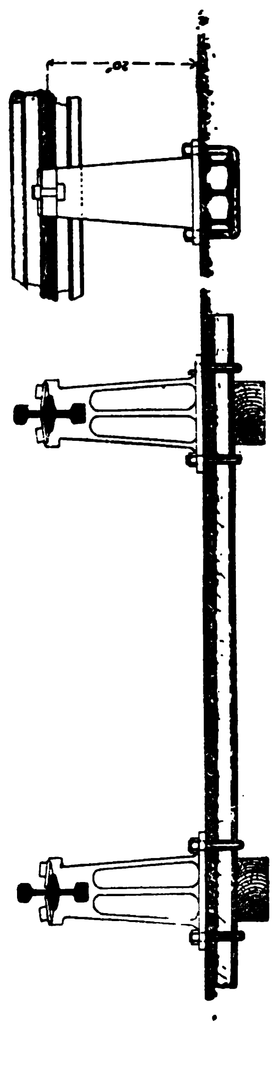


FIG. 56—ST. LOUIS AND SAN FRANCISCO R. R.

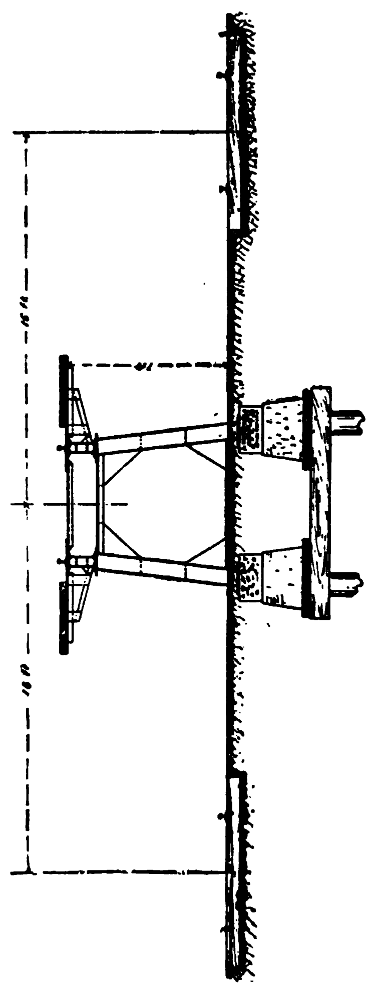


FIG. 57—CENTRAL RAILROAD OF NEW JERSEY.

cars at convenience, removing them to points where sidings and branches are being constructed, or filling is required. Engine cinders are valuable to this company for filling and ballast on the branches built over the salt meadows, on account of their lightness and cheapness. We have frequently done filling for tracks in this way from 10 cents to 15 cents per cubic yard."

(f) DEPRESSED PIT OPEN ON ONE SIDE AND BOTH TRACK RAILS CARRIED ON IRON PEDESTALS OR COLUMNS; ASHES SHOVELED OR DRAWN OUT SIDEWAYS UNDER RAIL ON OPEN SIDE OF PIT. ASH-CAR TRACK DEPRESSED.

Mr. J. H. Travis (Illinois Central) reports several styles of depressed cinder-pits in use on his road, but considers the standard, shown in Fig. 58, as the most economical and very satisfactory. The running rail, 75 pounds steel, is strengthened by an inverted old 60-pound rail, spanning 6 feet between centers of cast iron stands. The stands and tie across pit are cast in one piece, and are fastened to 12x12 inch stringers, bedded on 6x8 inch by 8 foot cross ties, spaced 24 inches centers. The floor of pit is brick on edge laid in a heavy layer of coarse sand. The pit is two feet deep below base of running rail. A depressed ash car track 6 feet below cinder-pit track, is spaced 14-feet centers from the cinder-pit track. The side of the ash car pit and the ends and closed side of the cinder-pit are walled up with timber. The cast iron ties at ends of cinder-pit are cast with a web between them across pit and wings on outside, so as to protect timber end-walls. The weight of one cast iron tie is 964 pounds.

Mr. Travis forwards, without comment, a similar plan for a cinder-pit, as just described, designed for use on his road, in which the cinder-pit track is raised 4 feet above and the ash car track is depressed 2 feet 6 inches below the floor of cinder-pit. The end walls and ash track pit walls are of brick. The length of the open cinder-pit is 60 feet. The construction is throughout of most durable materials and the estimated cost of the entire layout, including tracks leading up to cinder-pit and down into the ash-car pit, excepting only the drainage of the latter, is $2,534, or $42.23 per foot effective pit length.

Mr. J. S. Berry (St. Louis Southwestern) reports a depressed pit in use on his road and states it makes a very good and cheap pit. It has cast iron pedestals, spaced 7-feet centers, bolted with ¾-inch bolts through a cast iron bedplate to a 12x12 inch oak sill. This sill rests on and is drift bolted to timber stringers 7x15 inches by 28 feet, laid lengthwise throughout the foundation of pit, breaking joints. There is a timber wall at the ends of pit and on one side of it. All timbers are protected by old boiler iron.

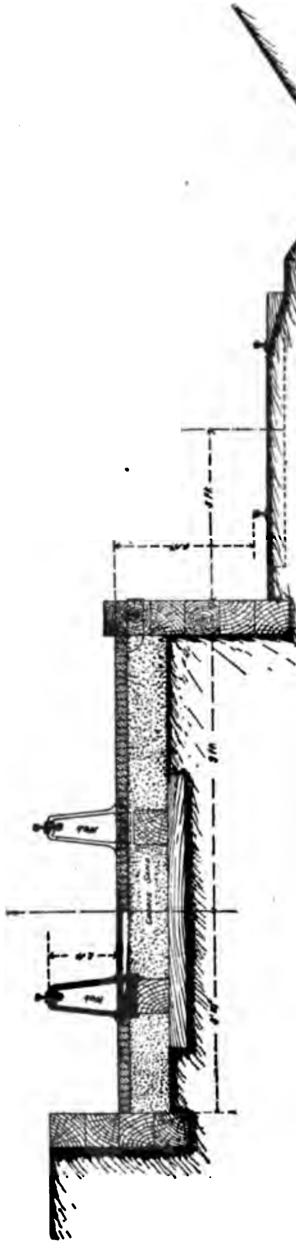


FIG. 58—ILLINOIS CENTRAL R. R.

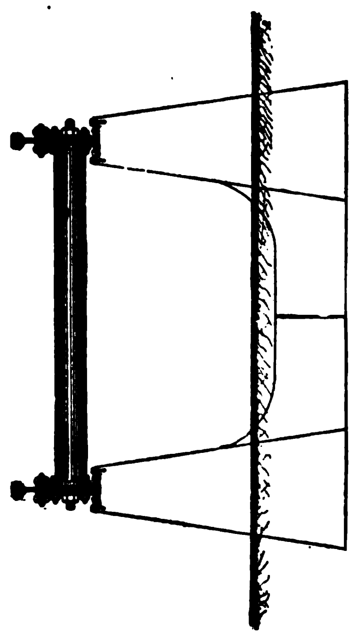


FIG. 59—CHICAGO, MILWAUKEE AND ST. PAUL R. R.

The cinder-pit is about three feet deep from base of rail to top of foundation stringers. One side of pit is open and an ash-car track is placed on this side of pit at about the level of the pit floor. The running rail is strengthened by an inverted rail below it. The inverted rail fits into the pedestals, and breaks joints on a pedestal. The top or running rail breaks joints at center of a panel. Rails fastened to pedestals with bolts and wrought iron washers.

Mr. H. F. White (Chief Engineer, Burlington, Cedar Rapids and Northern) states that in addition to the cinder-pit at Iowa Falls, described above under Group "D," his road has a depressed open iron cinder-pit with depressed ash-car track, that is very similar to the one at Iowa Falls, excepting that the panel spacing is 7 feet 6 inches centers, and the running rail is strengthened by an inverted rail. The rails are 60 pounds steel riveted together with ⅝ inch rivets, staggered every 3 inches. The ash-car track is spaced 15 feet centers from the cinder-pit track and depressed 4 feet below the latter. The cinder-pit is about 2 feet deep below top of running rail. A pit at Cedar Rapids is 75 feet long on timber and pile foundations owing to the soft ground. The pit at Burlington is 30 feet long with masonry foundations.

Mr. Onward Bates (Chicago, Milwaukee and St. Paul) reports the standard clinker pit, shown in Fig. 59, in use on his road, in addition to the cinder-pit for main tracks described above under Group "B."

These clinker pits are located on a turn-table lead track and are drained in any manner suitable to the locality, water being used to cool the ashes. The running rail, 75 pounds steel, is riveted to an iron girder, spanning 11-feet centers between pedestals, formed of two 10-inch wrought iron channels, riveted together, back to back, breaking joints with suitable splices. The girders are connected at panel points with 1¼-inch rods and 5-inch round cast iron strut. The girders are held with clip bolts to the cast iron pedestals. Each pedestal weighs 1,268 pounds, is very strongly designed, and reaches half way across pit, forming thus an iron tie, the two halves being bolted together at the center of the pit. The paving is brick and the retaining walls on one side of pit and at ends of pit are of stone. The pit is 3 feet deep below base of rail. An ash-car track is placed 12 feet centers from the cinder-pit track and about at the level of the pit floor.

Mr. J. E. Johnson (Toledo, St. Louis and Kansas City) reports the standard depressed iron cinder-pit, shown in Fig. 60, in use on his road, located on a turn-table lead track, and states it makes a very good pit. The cinder-pit is 3 feet deep below top of rail, and 30 feet long. A depressed ash-car track is located 13 feet centers from the cinder-pit track and as far below the floor of pit as feasible. The running rail is fastened with iron clips and

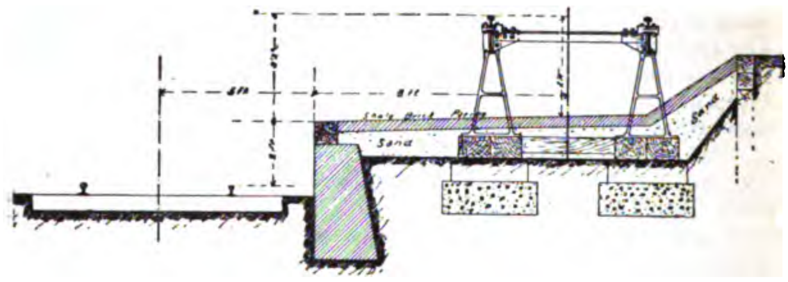


FIG. 60—TOLEDO, ST. LOUIS AND KANSAS CITY R. R.

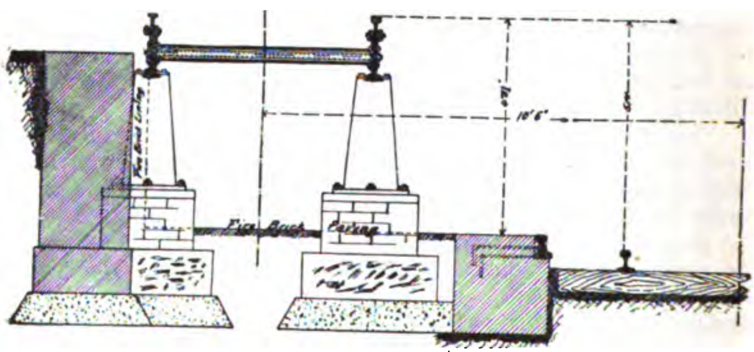


FIG. 61—DULUTH AND IRON RANGE R. R.

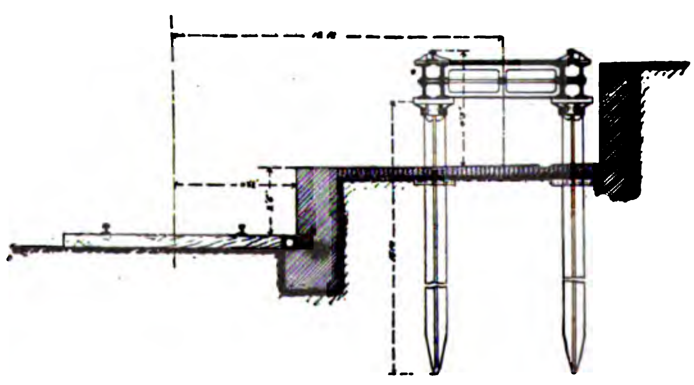


FIG. 62—CHICAGO AND EASTERN ILLINOIS R. R.

bolts to an 8-inch steel "I" beam, 27 pounds per foot, spanning 4 feet centers between cast-iron pedestals. Each of the latter is fastened with 8-inch lag screws to two 8-inch by 12-inch stringers, laid lengthwise of pit on a stone rubble masonry wall on bed of concrete. The stringers are tied together by a 6-inch x 8-inch tie about every 10 feet. The paving of pit is shale brick on edge, joints grouted with hot coal tar, bedded in sand. The iron girders are connected at each bent by an angle brace riveted to girders. Soft coal used.

Mr. W. A. McGonagle (Duluth and Iron Range) reports the depressed open iron pit, shown in Fig. 61, as the standard on his road, and states that this pit has given entire satisfaction and cost very little for maintenance. The pit is located on the round house track, and is 4 feet 8 inches deep below top of rail and 36 feet long. A pit built on this plan at Two Harbors, Minn., with very expensive foundations, however, cost, complete, $1,000, or $28.57 per foot effective pit length. Soft coal used. Water is used to cool the ashes. The 60 pounds steel running rail is riveted with ¾-inch rivets to a 12-inch "I" beam, 60 pounds per foot, spanning 9 feet between centers of cast pedestals. These girders are connected at each set of pedestals by a ⅞-inch tie rod and 4-inch round cast iron strut. The girders are fastened to top of pedestals with wrought iron clamps, held by ¾-inch set screws. The cast iron pedestals are 2 feet high, 1 foot 8 inches square at base, and are bedded on a 2-inch cast iron plate, 2 feet 1 inch square, fastened to the masonry below with four 1¼-inch x 2 foot anchor bolts. The foundation under plate is brick, on a 12-inch stone base, 3 feet square, bedded on a layer of concrete. The bottom of pit is brick, laid in fire-clay, on a bed of gravel well rammed and leveled with cement. A depressed ash-car track is located 10 feet centers from cinder-pit track at about the level of pit floor. The paving is confined at edge of pit by an iron rail anchored to stone wall. The closed side of pit and the ends of pit are walled up with a 2-foot rubble wall faced with fire brick.

Mr. F. Ingalls (Northern Pacific) reports, in addition to the deep closed pit described above under Group "B," a depressed open iron pit in use on his road, which is very similar to the plan shown in Fig. 61 just described. The running rail is 56 pounds steel, riveted to a 12-inch "I" beam, 40 pounds per foot, spanning 10 feet. The cast pedestals are 3 feet 6 inches high, making the pit nearly 5 feet deep. The ash-car track is depressed about 2 feet below the floor of the pit, and spaced 12 feet 6 inches centers from cinder-pit track. Each pedestal is anchored to a brick pier on a 15-inch stone base, 3 feet square. The paving of pit is hard burned brick in cement, held at outer edge of pit by a rail anchored to masonry wall of ash-car track pit. The end-walls and the closed side of cinder pit are walled up with 18-inch rubble masonry walls, faced with hard-burned brick in cement, coped with stone.

Mr. Aaron S. Markley (Chicago and Eastern Illinois) reports the depressed open iron cinder-pit, shown in Fig. 62, in use on his road at Danville Junction, Ill. The pit is 84 feet long, located on an important track and on a 10-degree curve. The running rail is held in cast iron chairs with tightening wedges to a girder spanning 8-feet centers, formed of two 15-inch "I" beams, properly cross connected with 1-inch tie rods and cast-iron box struts. The supports at panel points consist of two iron piles, star shaped, 9 inches outside measurements, ⅞ inch thickness of ribs, fitted at top with cast iron heads. The paving is firebrick on edge. The pit is 4 feet 3 inches deep below top of rail. The ash-car track is spaced 12-feet centers from the cinder-pit track and depressed 2 feet 6 inches below the floor of the cinder-pit. The walls are of stone. Mr. Markley states that this style of pit gives good satisfaction, but is naturally expensive, and only desirable where the work to be done is large. In a new pit he would increase the strength of the "I" beam girders. The cost of complete layout, including ash-car track, but exclusive track work, is $698, or $8.31 per foot effective pit length.

Mr. George J. Bishop (Chicago, Rock Island and Pacific) reports that since 1890, when the depressed closed pit standard, described above under Group "B," was discarded, his road has adopted a depressed open iron pit, shown in Fig. 63. The running rail is strengthened by three other rails, properly chocked with cast iron blocks, spliced and bolted together, the lowest rail being cut out immediately at the supports, the span being 7 feet 5 inches centers. The support under each rail at the panel point consists of an ordinary 12-inch cast iron pipe, 6 feet long, set with the bell down on two old rails, 8 feet long, laid across pit in an 18-inch bed of concrete. The top of pipe is provided with a suitably designed cast iron head. The columns are cross-connected at their top, and also below the paving of pit, with 1-inch tie rods, encased in 1½-inch pipes. The depth from top of rail to bottom of foundation is 9 feet. Concrete is put in around pipes and on top of foundation rails to within 3 feet 4 inches of top of rail. The paving of pit is vitrified brick, laid on edge. The end-walls and side-wall of pit are of stone. Ashes are cooled with water and drainage provided for surplus water. The pit is 3 feet deep, 11 feet wide, and 60 feet long. An ash-car track is located about 11 feet centers from the cinder-pit track and 2 feet below the pit floor. Soft coal used. The cost of construction is about $14 per foot run pit. The cost of handling ashes from pit to cars in this plan is 7½ cents per cubic yard, whereas with the closed pit standard without a depressed ash-car track, in use prior to 1890, the cost was 12 cents per cubic yard. Mr. Bishop recommends, as a modification of the present standard on his road, as shown in Fig. 63, the use of 4-foot pipes, set on castings 2 feet square, which would lessen the cost of masonry about 20 per cent., and would make depth of pit about 2 feet 8 inches.

Mr. William Smith (Superintendent Motive Power, Chicago and Northwestern) states that his road has a depressed open iron cinder-pit at Chicago avenue, Chicago, designed by Mr. John E. Blunt, Chief Engineer, which is about 4 feet 6 inches deep below top of rail and 54 feet long. The running rails are carried by box-

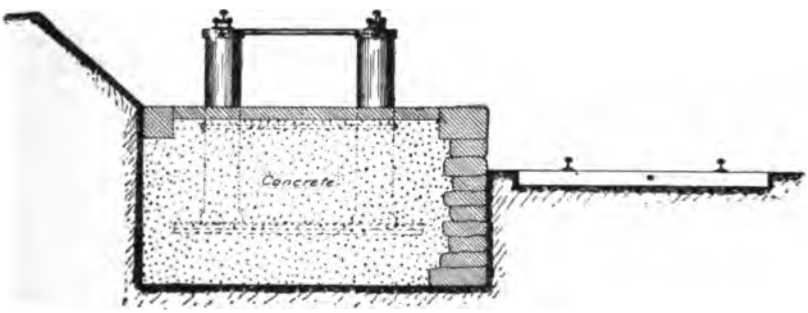


FIG. 63—CHICAGO, ROCK ISLAND AND PACIFIC R. R.

girders, spanning 7-feet centers, formed by two 12-inch channel irons turned toward each other, and cross-connected at panel points by a 9-inch "I" beam. The supports are 6-inch round cast iron columns, with suitable head and base, the latter bedded on a stone pedestal. A depressed ash-car track is located 13 feet centers from the cinder-pit track and at about the level of pit floor. At other points on the line this track is depressed as far as feasible below pit floor. Soft coal is used, and the dimensions of this pit are ample to take all the ashes from engines using a 48-stall round house, with one man left at the pit all the time to shovel away ashes.

(g) DEPRESSED PIT OPEN ON ONE SIDE, ONE TRACK RAIL CARRIED ON WALL AND THE OTHER SUPPORTED ON IRON OR MASONRY COLUMNS; ASHES SHOVELED OR DRAWN OUT SIDEWAYS UNDER RAIL ON OPEN SIDE OF PIT. ASH-CAR TRACK DEPRESSED.

Mr. C. W. Vandegrift (Chesapeake and Ohio) reports the depressed open pit, shown in Fig. 64, in use as standard on his road, and states it is a very efficient and economical design. It is 3 feet 6 inches deep below base of rail. An ash-car track is located 14-feet centers from the cinder-pit track and 1 foot below the floor of the pit. The running rail is fastened by ordinary track spikes, with a thread and nut on end, to the top flanges on top plate of old bridge girders or floor beams, the panel spacing being made to suit the old beams to be used. The girders are cross connected by a tie rod and pipe strut. One girder rests on the longitudinal brick side-wall of pit, the other is supported by brick piers, capped with stone. The walls adjoining ash-car track are of rubble masonry. Floor of pit is brick. The pit at Hinton, W. Va., is 150 feet long. Other pits on road are shorter. The location is on a turn-table lead track. The walls are spread at base to suit foundation material. Soft coal used. Water used for cooling cinders, drainage by a tile drain and never had any trouble with pipe stopping up. Cinders are loaded by the fire-cleaners, so that expense is not felt directly. Flat cars or the low side

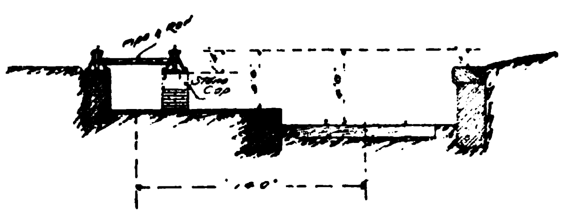


FIG. 64—CHESAPEAKE AND OHIO R. R.

gondolas are used as ash cars, and the cinders are hauled, sometimes, for long distances over road for use as ballast or top dressing, otherwise special small iron cars would be preferable, which could be loaded by gravity.

Mr. J. M. Staten (Chesapeake and Ohio) reports the same standard design, shown in Fig. 64, in use on his division and states that it offers a number of advantages. It allows iron beams taken from old bridges to be utilized, the alterations being all made at the company's shops.

Mr. H. M. Hall (Baltimore and Ohio Southwestern) reports the depressed open cinder-pit shown in Fig. 65, in use at Washington, Ind. It is 80 feet long and 3 feet deep below top of rail. One rail is spiked to the timber coping on the brick side wall, the other rail is riveted to an iron "I" beam and supported on a cast pedestal every 8-feet centers. The pedestals are bedded on brick piers capped with stone. An ash car track is placed along pit about 18 inches below the floor. This pit was designed for shoveling cinders from pit to ash car, but at important points the bucket and crane system, described under group "C," has been subsequently introduced with success, reducing the cost of handling to one-third of expense shoveling.

Mr. M. J. Becker (Chief Engineer, Pennsylvania Lines West of Pittsburg, Southwest System) states that the plan of cinder-pit,

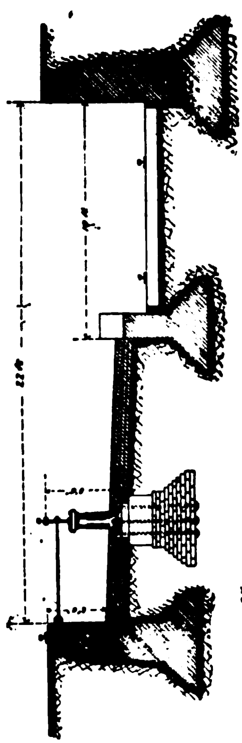


FIG. 65—BALTIMORE AND OHIO SOUTHWESTERN R. R.

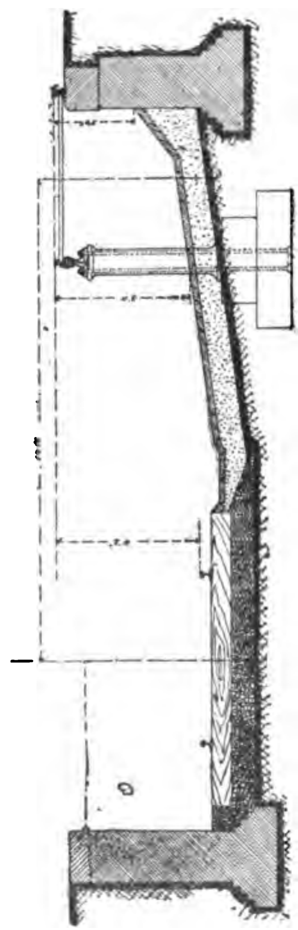


FIG. 66—PENNSYLVANIA LINES WEST OF PITTSBURG, SOUTHWEST SYSTEM.

built at Louisville, Ky., in 1886, shown in Fig. 66, represents the type of ash pit now in general use on the lines under his charge, and gives the following valuable data:

"The first pit of this type was built in Indianapolis in 1883, since which time all new pits built, or old ones remodeled, have been after this type, with the same general dimensions of cross-section, though the details as to the columns and stringers have been varied. The characteristic features of this pit consist (1) of a depressed track alongside of the pit for the cars into which the cinders are loaded; and (2) the pit itself is made open on the side next the depressed track, with the floor of the pit sloping toward the depressed track.

"The cinders are handled by shovels only, and loaded directly into flats or gondolas at the first handling. The men engaged in this work are outside of the track, and their work is not interrupted by the passage of engines over the pit. The pit is always located on the entrance track to engine house, and the length of pit varies at different points according to the number of engines to be served. The pit at Louisville is 70 feet long, and will serve two engines at one time by properly placing them over the pit. The lengths at the other points are as follows: Pitts-

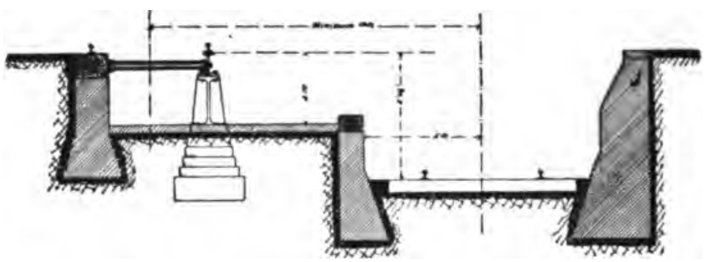


FIG. 67—ILLINOIS CENTRAL R. R.

burg, 100 feet; Dennison, 150 feet; Indianapolis, 115 feet; Logansport, 160 feet; and Columbus, Ohio, two parallel pits, each 170 feet long.

"In the pit at Louisville, and also at Columbus and Indianapolis, the rail over the pit wall rests on a continuous cut stone coping, while the rail over the open side is carried on cast iron columns and 8-inch steel I-beam girders; but at Pittsburg and Dennison the rails are carried on wood stringers, the open side being supported on columns, which at the former are cast iron, and in the latter are made of two track rails, bolted together base to base, and fitted with cast iron cap. Cars are kept on the depressed track at all times, and the pits are kept free from cinders by loading them into the cars as soon as they are cooled off. In this way wood stringers are found to be perfectly safe, and need no other protection than a sheet metal covering on the upper surface to protect them from live coals lodging on them.

"The coal used on these lines is entirely bituminous. I have had no experience with anthracite, but cannot see why the kind of coal should affect the dimensions of the pit, unless the ashes are allowed to accumulate and only removed at stated periods, in which case the relative amount of ash in the coal might affect the storage capacity required. But I would not regard that as good practice.

"The cost of ash pits built on this plan is about $10 per foot of pit, exclusive of cost of tracks.

"Relative cost of operating, the following data refer to cost of working the ash pit at Columbus, Ohio, for the first six months of 1894, namely:

"Length of pit, each track, 170 feet.

"Length of pit, both tracks, 340 feet.

"Number engines that can be cleaned at one time, 6.

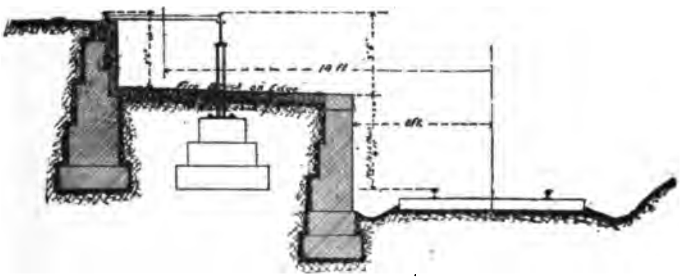


FIG. 68—CLEVELAND, CINCINNATI, CHICAGO AND ST. LOUIS R. R.

"Average time for cleaning one engine, 20 minutes.

"Maximum capacity in 24 hours, 432 engines.

"Average number handled per day during first six months of 1894, 85.

Cost per engine, including loading cinders into car; ash pit men, 13½ cents; hostler, 7 2-10 cents; total cost, 20 7-10 cents.

"Mr. S. P. Bush, Superintendent of Motive Power, advised me that the maximum economy is obtained when the actual number of engines handled is about 40 per cent. of the maximum theoretical capacity."

Mr. J. H. Travis (Illinois Central) reports that the depressed cinder-pit, shown in Fig. 67, with deep depressed ash car track, while not as cheap as the standard of his road, described above under group "F," still makes an excellent pit, although a little expensive. A 60-foot pit, with depressed ash car track, everything complete, would cost between $1,800 and $2,000, or between $30 and $33.33 per foot, effective pit length.

Mr. M. F. Potter (Cleveland, Cincinnati, Chicago and St. Louis) reports the depressed cinder-pit with depressed ash-car track, shown in Figs. 68 and 69, as the present standard of his road, adopted about two years ago, and states that it is the most substantial and best form of pit or method of handling cinders he knows of. In the standard plan, one rail is spiked to the oak timber coping on side wall, the other is riveted with $\frac{5}{8}$ inch rivets, one every 8 inches staggered, to top flange of 12-inch "I" beam stringer, spanning 8 feet 6 inches between centers of columns. The beams are usually taken from some old bridge. The rails are connected at panel points by an ordinary switch rod, riveted to web

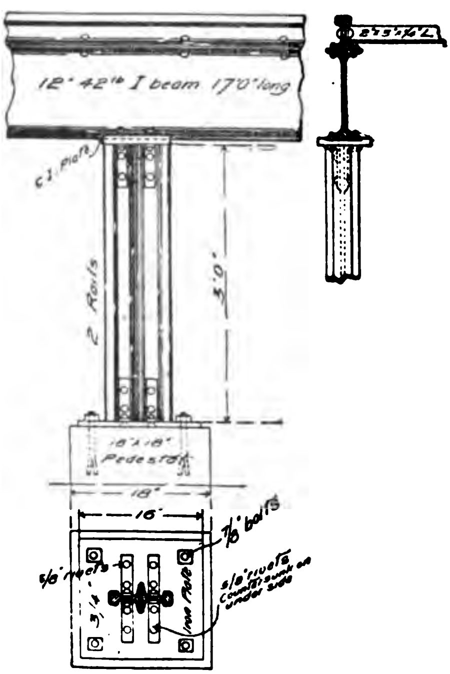


FIG. 69—CLEVELAND, CINCINNATI, CHICAGO AND ST. LOUIS R. R.

of rail on open side of pit, and fitted on to bottom flange of the other rail. The columns are made of two old rails fastened with angle straps and rivets at top to a plate under the iron stringer, and at bottom to a $\frac{3}{4}$ inchx16-inch square bedplate, which is anchored with $\frac{7}{8}$ inch anchor bolts to a stone pier foundation. The pit is 3 feet 2 inches deep below top of rail. The paving is fire brick on edge. An ash car track is spaced 14-feet centers from cinder-pit track and not less than 4 feet below the pit floor, where drainage will permit it, and preferably more. The standard plan shows brick walls with stone foundations. Mr. Potter states that

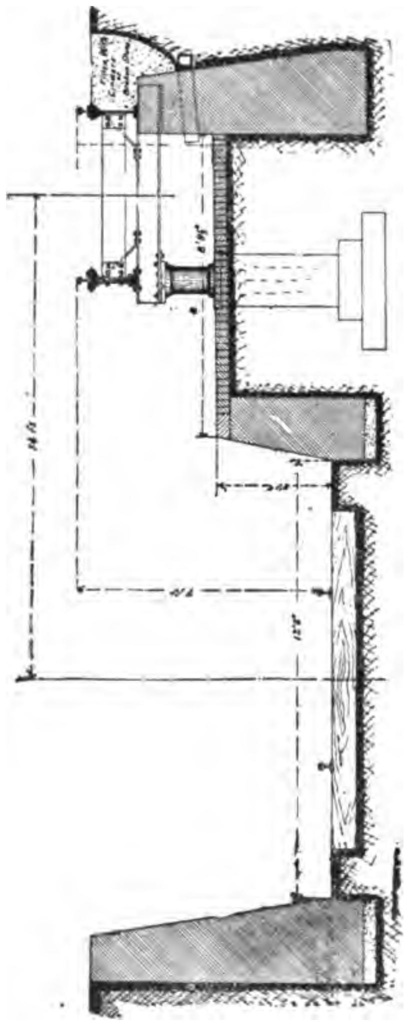


FIG. 70—PITTSBURG, FORT WAYNE AND CHICAGO R. R.

the dimensions of walls on plan have been found to be too small. He makes them heavier and puts no foundation under side-walls less than 4 feet wide and under column foundation none less than 4 feet square. Unless the foundation is good coarse gravel or rock bottom, he uses concrete, not less than 2 feet thick and 6 feet wide under walls and 6 feet square under columns. In this manner a very rigid and solid pit is obtained fit for any work and location in a main or side track. He has built a double pit at Springfield, each pit being 72 feet long, with depressed ash-car track between them. At other points has single pits, 72 and 84 feet long. A single pit 84 feet long, built complete as per plan, will cost about $1,500, or $17.83 per foot effective pit length. The handling of cinders is very cheap. Four men can shovel into cars as fast as two men can dump the cinders and clean engines with two engines on pit at the same time, and keep it up all day.

Mr. A. Shane, of the same railroad, reports the same standard cinder-pit in use and states that the walls, as shown on plan, are too light in practice, and should be started two feet thick at top.

Mr. N. W. Thompson (Pittsburg, Fort Wayne and Chicago) reports that, in addition to the depressed closed pit described above under group "B," his road has the depressed open cinder-pit, shown in Fig. 70, in use at their Sixteenth street engine house in Chicago, and he considers it the best and most elaborate system, giving good satisfaction and without any improvements to suggest. The pit is located on a special track, and is 180 feet long and 4 feet deep below top of rail. A depressed ash-car track is located 14-feet centers from the cinder-pit track and 3 feet below the floor of the pit. The running rails are 85 pounds steel, bolted to the top flanges of 15-inch "I" beams. The beam over the wall is a solid rolled beam, the other on the open side of pit, spanning 12 feet between centers of cast-iron columns, is built up of $\frac{3}{8}$ inch webplate and 4-inch x 4-inch x $\frac{3}{8}$ inch angles. These beams are connected by a 7-inch x $\frac{1}{2}$ inch tie plate, and are supported at the panel points by a box cross girder, made of two 8-inch "I" beams. One end of this girder is walled into the side-wall, the other end rests on a 9-inch round cast-iron column of 1 inch metal, with suitable cap and base, which latter is about 18 inches square and fits over a brick pier. The bottom of pit is brick on edge. All walls shown are of hard burnt brick, on stone or concrete foundations. All brickwork is laid up in lime-mortar, with a small admixture of hydraulic cement. Soft coal is used. One car of cinders is loaded up on an average every twenty-four hours, at a cost for labor of $1.02 per car. The capacity is about 18 engines per hour. The cost of the pit complete is $4,000, or $22.22 per foot, effective pit length.

Mr. George W. Andrews (Baltimore and Ohio) reports the depressed open cinder-pit, shown in Fig. 71, in use on his road at Benwood, West Virginia. The pit is 252 feet long and 7 feet 6 inches deep from base of rail. The running rails are 67 pounds steel. One rail is riveted every 3 feet 6 inches to a small wrought-iron plate, which is fastened to stone coping of side-wall with a $\frac{7}{8}$ inch x 18-inch anchor bolt. The other rail is bolted with $\frac{5}{8}$ inch bolts to the top flange of a 15-inch, 67 pounds, "I" beam, span-

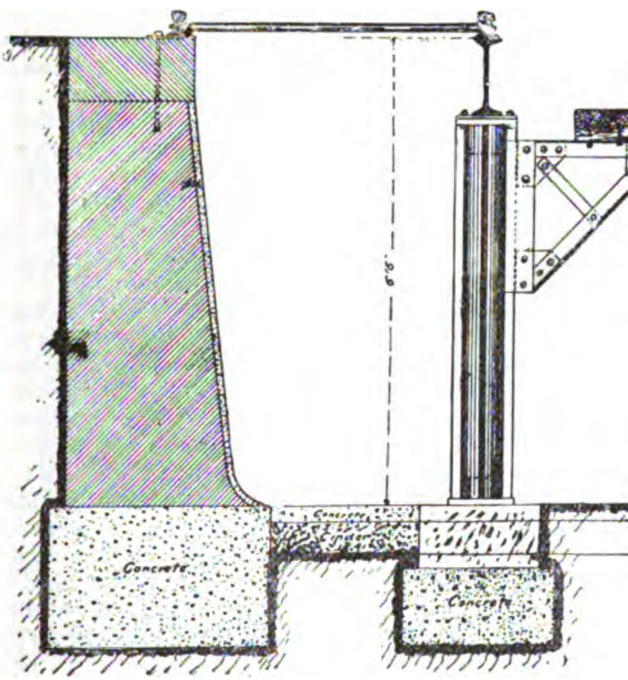


FIG. 71—BALTIMORE AND OHIO R. R.

ning 12 feet between centers of columns. The columns are 7 3-16-inches "Phoenix" columns, provided with suitable cast-iron head and base plates, the latter being fastened with $\frac{7}{8}$ inch anchor bolts to a 12-inch x 2-foot square pedestal stone, bedded on concrete. A side track, spaced about 14 feet centers from the cinder-pit track and at the level of the bottom of pit, serves as ash-car track. The cost of this cinder-pit, excluding the ash-car track, is as follows: Ironwork, $1,094.25; cement, $160; masonry, $2,936.41; rail, $182.99; total, $4,373.65, or about $17.35 per foot, effective pit length. The cost of loading ashes is about $1.50 per car of from 28 to 30 cubic yards. Plans are now being perfected to use chutes and aprons, so as to chute the ashes directly into the ash-cars, using water freely, which will effect a large saving in operating the plant.

Mr. G. B. Hazlehurst (General Superintendent Motive Power, Baltimore and Ohio) states as follows: "It is very difficult to adopt one standard for all locations, as there is generally enough variation to require some modification of any general standard plan. My idea is, that the track should be supported on iron rail joist and iron columns, the ashes should drop about 4 feet from the base of rail, there should be ample water connections for hose, say every 25 feet, so as to put out the ashes before they are loaded into cars; the cars should be run in on a sunken track, which should be sufficiently low in order that the ashes may be raked directly from where they are dropped, right over the side of a gondola car; in other words, the top of a gondola car should be about 6 inches below the platform on which the ashes are dropped, as this enables a man, with little exertion, to pull them, with a rake or hoe, right into a car. The pit should be made of sufficient length to meet the needs of the location."

Mr. Joseph T. Richards (Engineer M. of W., Pennsylvania R. R.) presents plan of depressed cinder-pit in use on his road at East Tyrone, Pa., shown in Figs. 72 and 73. The pit is 110 feet long and about 3 feet 6 inches deep below rail. The ash-car track is located 11 feet 7 inches centers from cinder-pit track and 8 feet below the floor of cinder-pit. The running rails are spiked to 12x12-inch oak stringers, covered with tank iron. One stringer is anchored to the masonry wall on back of pit and the other, spanning 8 feet, is supported on 8-inch round cast-iron columns, of ½ inch metal and 2 feet 4 inches long, with suitable cast-iron caps and base plate, the latter anchored with 1 inch stone bolts to the masonry foundations. The stringers are connected at each panel point by 1 inch tie rods, covered with cast-iron separators. The front of the heavy masonry retaining wall along ash-car track is stepped out at top. All the masonry is rubble work, excepting the coping courses. The floor of pit is paved with hard brick, set on end in cement. Mr. Richards forwards the following data relative to this pit from Mr. Wallis, Superintendent of Motive Power, P. R. R.:

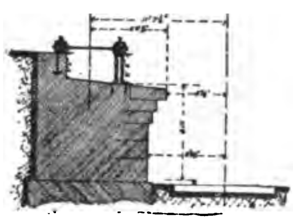


FIG. 72—PENNSYLVANIA R. R.

"We have two systems of removing ashes on the Tyrone division: 1. In which the ashes are dropped on the cross-ties and thrown from there to the side of the track. 2. In which the ashes are dropped on bottom of pit, the floor of which is on a level with the top of gondola car.

"This second method is in operation in East Tyrone yard. The arrangement of the depressed track on which ash car is loaded with reference to pit is shown on the plan. Semi-bituminous coal is used. Have had no experience with anthracite-coal ash-pits. The dimensions of cinder-pit are dependent on the number of engines required to be cleaned at one time. The ashes should be moved from the pit promptly, and not be permitted to stock up. We would make two changes to the ash pit shown on plan. First, the cast-iron columns should be 4 inches longer, so as to give the additional opening on the face. Second,

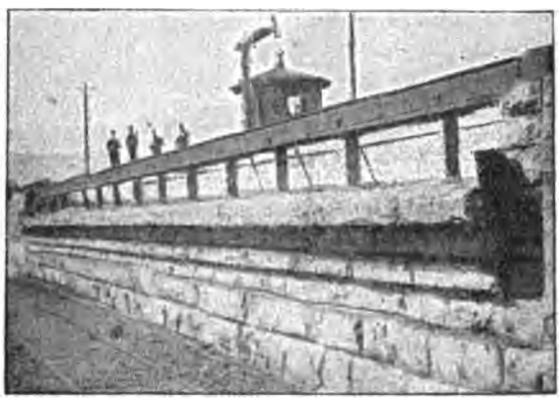


FIG. 73—PENNSYLVANIA R. R.

arrange the floor of the ash pit so that the car into which ashes are to be loaded would pass under the top coping of stone.

"We regard this pit as nearly perfect for the work required. The ashes are all sprinkled by water from hose attached to two hydrants placed along the pit. The water running over coping of pit and dropping down between ash-pit wall and depressed track to the creek, which is fortunately near.

"The total cost of this ash pit, including one 8-inch standpipe and two fire hydrants, 750 feet of 8-inch iron pipe, was $4,630.98, or $42.09 per lineal foot.

"Below is a record for four days at this pit:

"Number of engines cleaned, Aug. 25, 6 a. m., to Aug. 29, 6 a. m., 131 freight, 21 passenger engines.

"Amount of ashes cleaned and loaded, 191 cubic yards.

"Total cost of cleaning and loading, $13.10.

"Average number of cubic yards per engine, 1.25.

"Average cost [illegible] cubic yard, 6.86 cents.

"We estimate the number of engines that it would be possible to clean in 24 hours as 120.

"The arrangement, we think, could be much further improved, if scrapers were used, operated by power, to draw the cinder into the cars."

Mr. Abel S. Markley (Pittsburg and Western) reports that after 1890 his road found that the depressed cinder-pit, closed on both sides, was not the proper thing to use, and commenced looking out for other methods, and finally adopted the open side pit with a depressed track sunk 6 feet 6 inches below the main track rail; depth of pit 34 inches. Rail on open side supported by cast iron columns, set on stone pillars securely fastened, 4 feet centers, on which the 70-pound running rail is supported. This gives space enough from bottom of rail to bottom of the pit to allow a man to shovel across the pit without the use of any hoe or scraper. The distance outside to the retaining wall along depressed track is 6 feet 6 inches, allowing a man to stand in almost any position to shovel the ashes into the car. Dump cars are used at all pits, so the expense for unloading is practically nothing and the cost of loading has been decreased one half. With these pits in constant use for about four years, they find no reason to make a change of any kind and think them the best pit possible for all practical purposes, except at such places where the location suggests its own remedy or drainage is an impossibility. On the solid side of the pit the wall is coped with a cast iron coping, which makes the pit perfectly fire proof and almost everlasting. The cost is $25 per foot.

Mr. Channing M. Bolton (Chief Engineer, Southern Railway) states that the lastest cinder-pit design adopted for his road is a depressed open iron pit, 3 feet to 3 feet 6 inches deep, one rail being fastened to a cast iron coping plate on a 30-inch side wall, the other rail being bolted with clip bolts to the top of an 18-inch steel plate girder, spanning 15 feet and supported on steel built up columns, about 2 feet high, bolted to the foundation masonry. A depressed ash car track is located below the pit floor alongside pit.

(h) PITS WITH CHUTES UNDERNEATH FOR DELIVERY OF ASHES BY GRAVITY TO ASH CARS.

Mr. John D. Isaacs (Assistant Engineer, M. of W., Southern Pacific) reports a depressed cinder-pit, shown in Fig. 74, just completed at San Luis Obispo, Cal., designed by Mr. Wm. Hood, Chief Engineer, in which a series of iron chutes is introduced and the ashes, after being dumped into these chutes, are sluiced, under strong pressure from a spray pipe, by water jets, into cars on the adjoining depressed track. The pit is not yet in practical operation, but Mr. Isaacs states that from actual experiments made there is no doubt that it will work very successfully and economically. These iron chutes are 3 feet wide under the pit and 2 feet 5½ inches wide outside of it, 5 inches high, and about 10 feet long, reaching well over the car body, and are set on a fixed slope of 1 foot in 9 feet. There are six of them, making a solid length of 18 feet under the pit. The main water supply is brought in a 5-inch pipe, branching to 2-inch pipes leading to the back of each chute, where the 2-inch supply is connected with a 2-inch horizontal spray-pipe with closed ends. This horizontal piece of pipe has all along it ¼ inch holes, spaced 1¼ inches centres, with 1¼-inch long

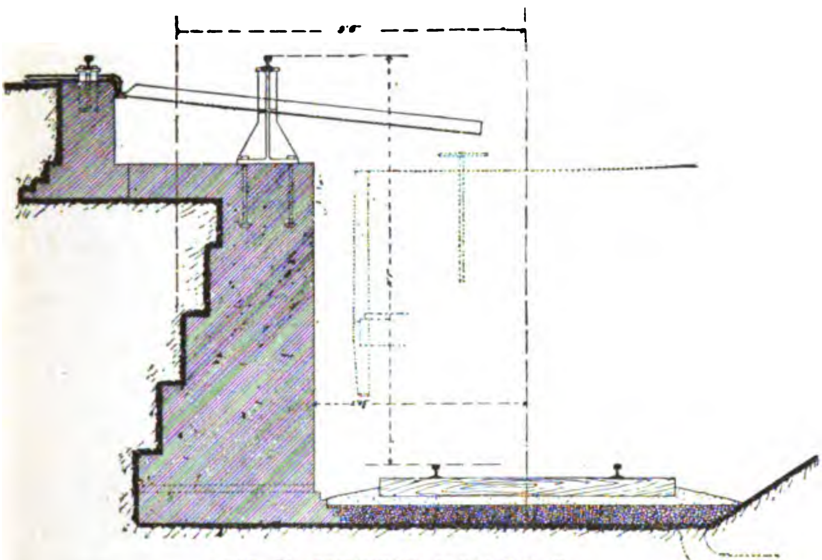


FIG. 74—SOUTHERN PACIFIC R. R.

nipples, inclined so that the water from each nipple sprays on the bottom sheet of the chute. The pit is about 3 feet deep below the top of rail, and about 40 feet long. An ash-car track is located 9 feet 6 inches centres along heavy brick retaining wall and set about 9 feet below the cinder-pit floor. The running rails are supported every 3 feet by cast-iron pedestals.

Mr. Geo. W. Andrews (Baltimore and Ohio) reports that arrangements are being made at the cinder plant of his road at Benwood, W. Va., described above under Group "G," to put in chutes with aprons underneath the pit track, so as to wash the ashes with water by gravity to the ash-cars standing on the depressed track adjoining pit, and it is expected that a large saving

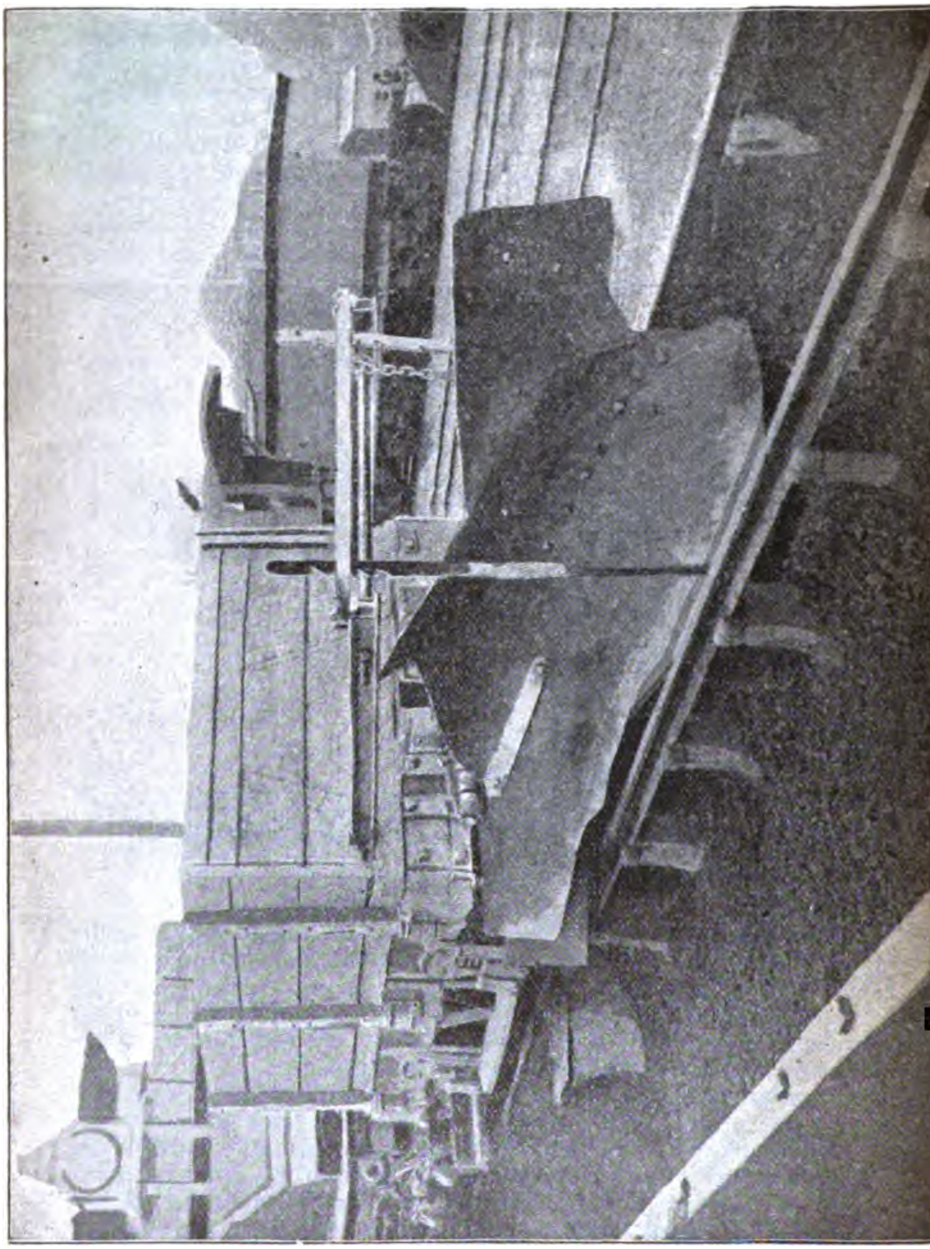


FIG. 70—PLOW FOR CLEARING CINDER-PITS, NEW YORK, LAKE ERIE AND WESTERN R. R.

in operation will be effected thereby. The chute will be similar to coal chutes and the apron will be hinged.

Mr. C. W. Vandegrift (Chesapeake and Ohio) states that it would be desirable to have a gravity cinder-pit. This could be facilitated by introducing small iron cinder dump cars. If grade of depressed track would be too heavy the cinder cars could be hauled out by a rope drawn by a stationary engine or a locomotive.

Mr. H. E. Gettys (Norfolk and Western) recommends a gravity system where the topographical conditions of the site permit it.

Mr. Walter Katte (Chief Engineer, New York Central and Hudson River) writes as follows: "I have had in my mind for some time past, and in fact have made rough sketches, which, however, I have not yet had time to have properly drawn, an improvement upon the pedestal or open pit system, to still further economize the cost of handling. Briefly, it is to run the depressed cinder track directly underneath the track on which the engine stands, in a walled pit just wide enough to admit the cars. The cars to be used to be built entirely of iron, and with hopper 'drop bottoms,' or some other similar 'self-dumping' device. The engines to be raked out, and, discharging their ashes, drop them directly down into these cars, thus avoiding all expense whatever for loading the cars for removal, and also if in cars of self-dumping type, all expense for dumping the same. Of course this system necessitates that the engine track shall approach from one end of the pit while the cinder track must approach from the other end. The respective relations of the gradients of the engine track, cinder track,and general yard grade would of course be adapted to the local conditions wherever it was applied. Normally, however, I should suggest that the gradients be equally divided; that is to say, that of the engine track ascending on the same angle that the cinder track descends, the general yard grade being a mean normal grade between the two. It would of course be possible to make both the cinder and the engine track approach from both ends by curving them at the end of the cinder-pits in opposite directions away from each other, but this would of course require a greater length of yard room for its construction."

(i) MECHANICAL CONVEYOR SYSTEM REQUIRING POWER; ASHES DUMPED INTO HOPPERS UNDER TRACK AND THENCE CONVEYED BY BUCKET ELEVATOR OR TROUGH CONVEYOR TO OVERHEAD IRON CHUTES FOR DELIVERY TO ASH CARS.

Mr. F. Ingalls (Northern Pacific) states that his road is putting up a coaling station with a conveyor system at Fargo, Dak., and he thinks, if it works well, that it will be connected with cinder-pit for elevating ashes, as he believes, that a conveyor system of some kind will be adopted for cinder-pits before many years.

The Philadelphia and Reading Railroad has a locomotive coaling station at Ninth and Wallace streets, Philadelphia, in which a bucket conveyor system is used to transfer ashes, that are dumped into an underground hopper, up to an elevated ash-bin, whence they are drawn by gravity through chutes into ash-cars, This plant is illustrated in Fig. 19, and Mr. J. H. Cummin states that "the C. W. Hunt Co.'s conveyor system at this coaling station is handling 330 tons of coal per day at a cost of a fraction less than four cents a ton, and in addition all the ashes are loaded in cars at a cost of eight cents per ton, which figures come from the master mechanic who has charge of the men employed at the coaling station." Mr. Cummin states further that a similar conveyor for coal on the Brooklyn Elevated Railroad, which he sees in use every day, works first-class, and that he does not know of any other plan where coal and ashes can be handled as cheaply as by this one. The unit figures for handling ashes given above, we have since been informed, covered the actual labor engaged in transferring the ashes and included also a small percentage for steam used, which was received from a large boiler in an adjacent shop.

This plant is illustrated in the Railway Age and Northwestern Railroader of July 21, 1893. There are two ash-pits under the tracks, each about 20 feet square and hopper shaped to a depth of about 7 feet, which hoppers are said to be ample to contain the ashes from night engines, so that the machinery does not have to be run after dark. The ash conveying system is entirely separate from the coaling system, separate conveyors and stationary engines being provided. The power required to run ash conveyor is very small, so that a vertical engine of about 10 horse-power is ample.

The Philadelphia and Reading Railroad has another locomotive coaling station near Lehigh avenue, at Port Richmond, Philadelphia, Pa., in which the Dodge conveyor or trough system for conveying coal is introduced. There is also an ash conveyor connected with sunken cinder-pits under the tracks, from which the ashes are carried by a trough conveyor up an incline to a large steel elevator pocket from which the ashes run by gravity through a chute into ash-cars. This plant is illustrated in Railroad Gazette, May 13, 1892. On making inquiries recently it appears that the ash conveyor feature of the plant, while constructed and used at first, was soon abandoned and is not operated at present.

Mr. Theodore Voorhees (First Vice President, Philadelphia and Reading), in response to an inquiry of your committee asking the reason for the apparent abandonment of the Lehigh avenue ash conveying plant, writes as follows: "I find there has been difficulty in the past in regard to moving the anthracite ashes by the conveyor at the Lehigh avenue coaling plant on account of the danger of fire, and an understanding that the ashes could not be wetted without causing deterioration to the plant from the presence of the sulphur, etc. We convey ashes at Ninth and Green streets by a 'Hunt' hoisting apparatus after wetting the same, and have so far had no trouble from the sulphur."

DISCUSSION: SUBJECT, DEPRESSED CINDER-PITS AND OTHER KINDS.

A Member.—I have some of the worst and some of the best. I have a pit 250 feet long. It is made of wood, wooden trusses, and the engine is run on the top of this. The car track is to one side, and the cinders are scraped by men into the cars. This so far as the shoveling is concerned is not very expensive business. It is one of the worst pits I now have. We are preparing and expect to make a chute that will drop the contents into a box, then we can get all the cinders washed out, at least the heavy cinders. If the water will not wash it out, it will be but very little trouble to scrape the cinders into the car. I think this the best pit we have.

Mr. Hall, Ohio & Miss. Ry.—We have on our road two or three kinds of cinder-pits. The first is the open pit. Simply dumping the ashes out and then shoveling them into the cars. Then we have the depressed cinder-pit, similar to those described by the committee. We are now using the crane system that the committee have described in their report. At Washington, Ind., we have in our general yard one of those depressed cinder-pits, I think as good a one as I have ever seen. Within the last year we have placed in that cinder-pit one of those cranes and buckets described by the committee. We had been using the open cinder-pit for thirty-six years. In using the depressed cinder-pits, it requires the constant service of four men, furnished by the machinery department, and two section men, making six men to take care of the cinders. Since putting in the crane and bucket system, two men do the work, do it readily and easily, so there is really only one-third of the expense connected with the crane system. It is one of the best cinder-pits that I have ever seen. I will speak about the power for removing the cinders. When the cinders are cleaned from the ash-pan, there is at the other end of the fire-box a chain which is coupled to the engine. The engine pulls out, thus hoisting the bucket. The engine then is detached, and goes into the roundhouse. The crane with the suspended bucket is swung around by the men, and the ashes dumped into the ash car. It requires but a short time to do this. The men that clean the fire-boxes are the only men required to operate this cinder-pit. It is the most economical manner of handling cinders I have seen.

Mr. Andrews.—In speaking of the power, the committee overlooked the use of pneumatic pressure when the crane is located near shops. We have in the last year put in a pneumatic crane which works more satisfactorily than any steam power that I have ever seen. This could be easily done at a very little expense.

Mr. Joseph M. Staten, Ches. & Ohio Ry.—It is necessary the buckets just hold what cinders you can get in them. I usually use one bucket, can use two.

Mr. Joseph Doll, C., C., C. & St. L. Ry.—We do not use any bucket but we use trucks. We run this truck right under the engine and run it ahead and load it into the cars. Those trucks are brought back and put into the pit. The cinders are put right into the truck and hoisted up and put into a chute.

Mr. Berg, Lehigh Valley Ry.—I would call attention to the crane and bucket system that the appendix of the report makes reference to. The C. & N. W. R. R. raise the buckets by a small gas engine. Also will mention that on the Grank Trunk they have iron wire baskets raised by compressed air. The superintendent of that road reports the system works satisfactorily. They also have experimented with the bucket and crane system on the Pacific railway, but the work was not satisfactory. I would presume that was because they tried to work the air from the engine. I think we would like to hear from Mr. Foreman. General opinion is frequently held that mechanical conveyors will be used in the future more or less, and the Philadelphia & Reading is the only road in the United States that we are able to get information from on this subject.

Mr. Foreman, Philadelphia & Reading Ry.—The cinders in the first place are dropped into the pit and conveyed to the elevator and the elevator conveys them to the pocket and then they are dropped into the car. This is satisfactory but very costly.

Mr. Markley.—Referring to what Mr. Hall said in regard to Washington, it looks to me that it would cause a delay, so many trains arrive in the evening at terminal stations, and if each engine would have to wait until the other pulls the bucket up and dumps the cinders into the car, there would be considerable delay and keep the engines out a long time.

Mr. Hall, Ohio & Miss. Ry.—In reference to that matter where the bucket is used there is no delay whatever. There is not sixty seconds delay in this matter. The engineer pulls ahead and hoists the bucket. It is then lowered and everything goes ahead. There is not two minutes delay from using the engine. It has given such perfect satisfaction that we are arranging to put them in every place where we have a cinder-pit. We have no station where the expense exceeds forty per cent of any other system ever tried.

Mr. J. T. Carpenter, C., N. O. & Tex. Pac. Ry.—Our cinders are dropped from the engine at seven feet from the nearest track to the elevator. A man can readily handle the cinders at that distance. It is not very much trouble to hoist the cinders. I have to depend upon the mechanical department. It costs about four and one-half cents to clean them. It strikes me that with a conveyor we would have complicated machinery, which would of course be expensive. This pit I speak of has run about two years, not five cents has been spent upon it. No repairs. This pit could be made more useful by being made longer.

Mr. Berg, Lehigh Valley Railway—I would like to call the attention of the association to information furnished by Mr. William Forsyth, C., B. & Q., who states that the ashes would be about twenty-five per cent. of the coal used in the engine in bulk. I would like to call attention to some remarks made by Mr. Hall to aid him in emphasizing the cheapness of the crane and bucket system. He has used the crane and bucket system for a number of years, at the same point where a depressed pit had been in use, and his opinions and deductions merit the most serious consideration. I think the crane and bucket system is shown to be the cheapest in the long run.

Mr. Doll, C., C., C. & St. L. Ry.—I take issue with this gentleman. What we use in Cincinnati depends on the ground we have. We have about four cars in a pit. The track is built over a pit. This pit holds four cars and two men shovel these cinders into these cars. The cars are then elevated and dumped. I find that it is the best arrangement for ashpits we have. Of course it depends upon the location of the ground.

Mr. Carpenter, C., N. O. & Texas Pac. Ry.—In regard to the style of ash-pit, would not the material figure in the kind of ash-pit used anywhere? There is not any road that has ground to spare, there are other kinds of pits that would be excluded on that ground. I would prefer a conveyor or the bucket system.

Mr. Berg, Lehigh Valley Railway—I wish to correct the impression of the gentlemen in regard to space for conveying system. The principal advantage of the mechanical conveying will be that it can be used at sites with very limited space. At Philadelphia, on the Philadelphia and Reading, the coaling station and ash-pit are located in the midst of the city and are very compact. Nothing has been said in our report as to cost of conveying system. But I can mention here that the coaling and ash-pit system on Philadelphia and Reading works very successfully. In investigating a conveying system, for ash-pit and the cost of conveying system for ash-pit services alone, I found that the machinery, consisting of the engine, the hopper under the track with valve, and the filling apparatus, would cost about $5,000. The necessary timber to make the chute to put the ashes into would probably cost $1,500, and the masonry would probably make the total cost from $7,000 to $7,500.

Mr. Berg, Lehigh Valley Railway—There is a hydro-pneumatic ash ejector, described and illustrated on page 602 of the December, 1893, issue of the American Engineer and Railroad Journal, in use on ocean steamers, the principle of which might be utilized to remove ashes out of a deep pit where a suitable water pressure and subsequent drainage is obtainable.

In the committee's report on "Depressed Cinder Pits," presented at the last convention, the gravity cinder chutes of the Southern Pacific Railway at San Luis Obispo, Cal., were described on page 54 of the "Proceedings of the Fourth Convention." (Fig. 74, page 173 of this volume.) These chutes were at that time not in actual operation. Since then they have been put in use and Mr. William Hood, chief engineer, Southern Pacific Railway, wrote on December 13, 1894, that these chutes are working most successfully. He states further that "the engines are handled as usual by hostlers, who clean out the engine ashpans in the usual maner. Generally they clean several engines before washing out the ash-pit chutes, leaving the ashes accumulating until the chutes are about full. The hostler, at any time he finds convenient, then washes out the accumulated ashes from the chutes into the dump car, which stands on the dropped track. If each 2-inch valve at the upper end of the pockets is opened full and at once shut, the ashes will have been moved into the dump car from the chute served by that particular valve during the process. The water pressure is about 80 pounds. There is very little water used and the hostlers do the work of handling the valves along with their other duties."

It would also seem desirable to record that the Southern Pacific Railway has introduced at Oakland, Cal., during the past year, automatic buckets for handling cinders, which, according to my informant, "save one-half the labor required originally for shoveling."

Mr. Markley—It is not desirable to allow the ashes to remain in the pit while three or four engines are run through. Where the pits are built of stone, the intense heat that accumulates from these ashes is very liable to injure the stone, and will in a very short time cause them to deteriorate and burst from the heat and cold water together. We have had that experience where we had erected them of sand-stone. Where the stones get extremely hot and then have cold water poured on them, they will eventually crumble to pieces. We always clean the ashes after each engine, turning a hose into the ash-pan and extinguishing nearly all the fire in the ashes. As to that particular part of the report, quoting from the chief engineer of the Southern Pacific Railway as to their practice, I think there is a defect in that they allow several lots of ashes to accumulate before they sluice them down the chute into the dump car.

Mr. McNab—If you tried sluicing ashes down into a car in cold weather, they would freeze. It would never do in the neighborhood of Chicago.

Mr. Peck, Mo. Pac. Ry.—I would like to know if the trouble from stone being damaged by heat cannot be overcome by lining with brick, and if so, if it would not be economical?

Mr. Berg, Lehigh Valley Railway—It can with good fire brick; but I question whether any character of brick would stand heat and cold together. I consider the lining of pits with fire brick would prolong the life of the pit, but I personally doubt whether it is practical railroading, because fire brick come very high; at least in the Eastern section of the country. And then the men in the pit shoveling will damage the brick.

Mr. Eggleston, Chicago & E. Ry.—Within the last two years we put in an elevated ash pit, with hard brick, and then a coat of cement. It is standing there to-day, as good as ever. We turn half a dozen engines in there at a time. I do not think sluicing would do in the North; it would freeze.

Mr. Berg—I would like to call on Mr. Heflin to say why the proposed cinder pits with water sluices were not put in on his road in West Virginia. Any physical reasons why they were not put in?

Mr. Heflin, B. & O. Ry.—I do not know really the reason why it was not put in; I ordered the iron for the sluice chutes and received it, but pending the time to do the work, the iron was ordered away, and the work is just as it was this time last year; but I would say that I do not see how the heat could affect the stone, if the sluice chute is put in in the manner we proposed to do it, as it would be impossible for the ashes to come in contact with the stone. Whether this sluice pit will be finished in the future, I am unable to say.

Mr. Markley—Another thing to be taken into consideration is the value of the water. In Chicago and other places, where we get water from the water works, we are obliged to pay eight and ten cents for it, and it would be a question whether the value of the water would overcome the advantages of the pit.

Mr. Berg—I would quote from a letter received from an official of the Southern Pacific that by opening a 2-inch valve once full and then turning it right off again, the amount of water that would pass through—there being a valve for every four feet run of the chute—will clean the entire contents of the chute.

So it cannot take very much water—water pressure force of eighty pounds.

REPORT: BEST METHOD OF BRIDGE INSPECTION.

This important method should commence at the drawing table. The chief draughtsman prepares plans, and with this the bridge inspection should begin. All plans should be thoroughly investigated in order to ascertain if all members have ample material in them, so as to bear up under any strains which may come in contact with them. The connections of a bridge constitute a very significant feature to be provided for. To enable us to have a thoroughly good bridge, complete strain sheets, detail drawings and specifications in general should be accurately calculated before the bridge work is started. At this point an expert is required who fully understands the situation, and should be inspector as well as engineer, to see that proper material is used, and mode of construction is carried out to the letter by the bridge company or contractors. When bridges are being erected, an inspector should be on hand as much as is practicable, and he should be a man who has sufficient experience in construction to make him a competent judge of contruction work. Who can better direct or understand a piece of work than the man who has done it himself. He must also be familiar with the plans and see that the structures are put up in accordance therewith. When this mode is complied with it is hardly necessary to experiment with the work, as some companies do, by putting a train of locomotives on the bridge to try to break it down, and if they fail so to do pronounce it all right, and accept it for general use. This kind of a test, no doubt, has caused injuries to the structure that were not observed at the time, but caused trouble and expense at some future time.

The bridge inspector should be well acquainted with all bridges and trestles on his division. He should know the age of each and every one, as well as the dimensions and other details. Inspector should make his tour of inspection as often as it may be deemed necessary, that inference being drawn from age and strength of the structures. It is well for him to be accompanied by three or four bridge carpenters, with tools, so that any small repairs may be executed at once. Such little affairs are sometimes overlooked until they become positively dangerous, because they were of such small moment at first.

All parts of either bridge or trestle should be examined minutely to see if they are getting unsound or reaching the average life of timber. All important members should be bored or sounded with a hammer to ascertain if there is still enough firm, strong timber remaining to insure its safety. To properly inspect an iron bridge it is necessary to climb over and under it, examining all rivets and closely observing connections to see if they are holding as they should. When the structure has been accurately inspected, it is then important for an inspector to remain on it while a heavy train passes over it at full speed. If there are any weak parts he can detect them more quickly in this way, than any other. In my judgment, all railroad companies would receive better bridge inspection by employing competent bridge men for this work, who are known to be fully capable, and whose integrity and loyalty to the company's interest can be relied on, instead of instituting a standard method of bridge inspection.

J. M. STATEN, C. & O. R. R.

REPORT: BEST METHOD OF BRIDGE INSPECTION.

I make my inspection of all trestles and bridges on a light hand-car, propelled by four men; the car equipped for convenience to ride, and with suitable tools for the inspection, also tools that are required to make repairs to trestles or bridges, if any are found in an unsafe condition.

I have made inspections on a velocipede propelled by myself, but found that making them on a hand-car was much better, for the reasons above mentioned, for often I have found a trestle or bridge that needed attention at once, and made repairs upon them sufficiently to carry all trains, until the bridgemen of that division reached them. Some of the repairs that are made to the trestles and bridges, on the inspection trip, have perhaps avoided some serious accident, and for this reason the difference in the cost of inspecting on a velocipede and on a hand-car, cannot be considered.

A stop is made at each trestle or bridge, special attention is paid to the smaller openings. All of the timbers or piling that appear to be defective are tested with a steel bar $\frac{3}{4}$ inch in diameter by about 5 feet long. This bar has a ball on one end, and a diamond point on the other. The ball end is used for sounding all of the timbers and piling that are out of the ground. It is applied to the timbers and piling that are not badly decayed or sap rotten; if so, the pointed end of the bar is used, as sounding is not needed. I also use a brace and small bit to bore into places of the wooden spans and frame structures that are more liable to decay than others, and which I do not wish to prod up with the bar.

Sills, sub-sills and posts of frame structures that are under the ground, the earth is removed with a pick and shovel, so that those timbers can be thoroughly examined and tested with the bar.

Iron bridges, girders, etc., the adjustments are closely inspected, the rivets that appear to be loose tested with a light hand-hammer, and to see if all parts have an equal strain. Bridge seats, piers, and abutments are examined very closely.

The inspector of bridges should be a practical bridgeman, one who knows how long a trestle or bridge can be carried; to be able to judge of the qualities of the different kinds of material used in construction, and its life under all conditions. Experience has much to do with being a good bridge inspector, as he can do the work in most cases by sounding the timbers and piling that are out of the ground.

The notes of the inspection I take upon a book, which is a copy of the bridge and trestle record, with a blank page sufficient for all notes to be taken. This book contains all the information regarding the trestles or bridges, such as length of panels, number and kind of bents, height of structure, clear span, etc. Also the date when driven and rebuilt. With this information it enables me to inspect more closely the bridges that are the oldest, but under no circumstances are new structures slighted, as often the bents or dumps are found washing or scouring, of which notes are also taken.

After I have completed my inspection, a copy of same is made and sent to each foreman of their respective divisions. The list mentions all the work to be done on each bridge and the amount of material required. Special remark is made upon bridges that need immediate attention.

In conclusion I will say that the inspection upon all bridges must be made very closely—nothing slighted.

In my experience I have learned that the timbers in use for some time are deceiving to the eye. Timber that appears to be sound, after testing it with the bit, was found very rotten, with but a hard shell on the outside; and again, timber that looked rotten was found to be sound and good for long service yet. The inspector, above all, must know where to look for the defective places in the bridge, or places that are more liable than others to become so; and those places are usually the hardest to get at. This method of inspecting bridges has been the most successful in my experience.

J. S. BERRY,
St. Louis S. W. Ry. Co.

PAPER: BEST METHOD OF BRIDGE INSPECTION.

In my opinion the best method of bridge inspection is as follows:

PIN-CONNECTED SPANS.

1. Look over pins and see that they are not bent and fit perfectly.

2. See that all connecting members also fit perfectly.

3. See that all rivets at all connections and intersections are tight and not corroded, and at all other points where they are used, as well.

4. Examine turn-buckle connections on counter-rods, for when not properly adjusted they are liable to strip.

5. Inspect painting.

6. Examine iron for defects.

7. Inspect ties and rail fastenings.

8. Examine masonry or substructure, especially for some time after it is built, to see if there is any undue settling.

RIVETED SPANS.

1. Inspect rivets at all connections and intersections; as a usual thing loose rivets show a stain of rust.

2. Examine iron for defects.

3. Inspect painting.

4. Inspect ties and rail fastenings.

5. Examine masonry or substructure.

PLATE GIRDERS.

1. Inspect rivets at lateral and brace connections.

2. Examine iron for defects.

3. Inspect painting.

4. Examine ties and rail fastenings.

5. Examine masonry or substructure.

HOWE TRUSS SPANS.

1. Examine camber.

2. See if the top and bottom chords are in line.

3. Take off the nuts on top and bottom main rods and see whether the threads fit the rods perfectly. I once saw a bridge that broke down on account of thread in nut stripping, the nut being too loose. I would, however, only advise this done once, and that just after completion.

4. See that the main rods have the proper tension.

5. See that all main and counter braces are in position.

6. Inspect timbers for defects.

7. Examine rail connections.

8. Examine masonry or substructure.

FRAME BENTS AND TRESTLES.

1. Inspect ties and rail fastenings.

2. Inspect stringers and see that they have a fair bearing; observe knots, checks, and decays.

3. Examine caps for breaks and decays; also note bearing of caps on piling.

4. Examine frame bents closely—posts usually give way at the bottom.

5. Examine the sills.

6. When inspecting piles I dig the dirt away from around the piles about 18 or 20 inches in depth, and if sap-rotted I remove all decayed parts so that I can see at a glance how much sound timber remains.

7. Inspect superstructure for straw, grass, leaves, and other matter carried there by birds for nests, which largely increase danger by fire.

8. In inspecting the trestles and pile bents I have a field book in which I make a sketch of each bridge, and mark each defective part; and when a certain percentage of defective parts are not safe, I mark structure for rebuilding. I mark all members of the bridge or trestle that have been inspected, and have to be replaced in less than six months with a certain mark that indicates the fact; less than one year with another mark; over one year and less than eighteen months with still another mark which indicates the fact.

After pile or trestle bridges have been built four or five years, the timbers begin to decay and require constant watching and repairs, in order to make them last the required time (7 to 11 years). The life of a bridge depends largely upon location and traffic. Bridges on the eastern part of line west of the Missouri River, where the physical features of the country are comparatively low and wet, and traffic is heavy, have to be rebuilt from one to four years sooner than those near the mountains where the altitude is higher. In inspecting rivets, I use a light hammer; timbers, a small octagon steel bar, ⅝ inch diameter, four feet long, one end sharpened to a point, the other made like a pinch bar. At members I sometimes bore with a half-inch bit.

My division is divided into six districts ranging from 140 to 220 miles in length, with a division foreman on each division, who is held responsible for the good condition of bridges and structures. The bridges are inspected by the foreman each month while he is working over his district with his men, and if not able to get over the entire district, he takes a velocipede car and runs over such part as he has been unable to work over. It generally takes him from five to eight days, and I don't consider it economy for any road to have the foreman away from his gang that length of time, and would recommend a bridge inspector for all divisions over 500 miles long, especially where in that distance he may have 45,000 feet of trestle structure, as is the fact in my territory.

A foreman, in my opinion, should be with his gang and see that the work is properly done. In case he is away, and there should be a burn-out, wash-out, or derailment, where repairs must be made quick, he may be 150 miles away, and considerable time would be lost on account of men not having the experience, and not being properly governed to make the necessary repairs.

I make it a point, if possible, to be at all accidents or blockades. Once each year I inspect about one-half of the bridges and structures on my division, and those that are to be rebuilt I make a complete bill of material of each bridge, showing length of piles and height of frame bents required. I number each bent in each bridge, commencing at the east end, 1, 2, 3, etc. I take the foreman and three men with me on a hand-car, and give each bridge a very thorough inspection, decide what repairs are necessary for the year, or immediate present; and then give my views on the work, also as to the best method to economically perform it. Our present mode of inspection costs about nine cents per mile, or one mill per lineal foot of bridge per month. In my opinion, particular care should be observed in inspection and maintenance of all structures, in order to secure safety without regard to the practice of fictitious economy. G. J. BISHOP,

C., R. I. & P. Ry. lines west of Mo. River.

REPORT: BEST METHOD OF BRIDGE INSPECTION.

Bridge inspection on a road doing a large business or running heavy rolling stock and motive power, is an important function of railroad work, and it demands both care and skill and an earnest application of the inspector's best judgment. In my inspection of bridges, which is done twice each year, I use a light hand-car, with four bridge men to propel it and to remove it from the track to avoid passing trains. The tools used are two crank augers, four feet six inches long, with a twelve-inch pad and a half-inch bore; two octagon steel bars, with a sharp diamond point and an oval head three and one-half inches diameter, and shaped similar to the face of a shoe-maker's hammer. These tools are for wooden structures. For riveted work I use light hammers for tapping rivets. Also light cold chisels for starting rust scale. I also take the division foreman with me on trips of examination, as he is entirely familiar with the structures on his own territory. In the examination of wooden structures we use the auger, the sounding bar and the pointed bars to remove sap rot at the ground line of pile work. I find that timber standing vertical, or nearly so, lasts much better than timber in a horizontal position. Also that all wood lasts much longer in a cold, clayey soil than in a sandy loam soil which is dry and warm. Also that oak pile grown in a light up-land soil is much more liable to red rot, and decays more quickly than lowland or swamp oak. I have one pile trestle built April, 1878, which will come out next season (i. e., 1895).

There are a number of Howe truss bridges on the line of the L. S. & M. S. Ry., built from 1887 back to 1872, all covered and in a fair state of preservation. In inspecting these we see that the chord bolts are kept up snug; then the lateral rods are properly adjusted, and this is followed by an adjustment of the truss rods until the counter braces have a firm bearing on the angle blocks; and when this is done the wheel wrench work is stopped. I use a good stiff floor in Howe truss bridges, with a 12x12 track stringer, and the floor beams two feet C to C, and in many cases less. This insures a firm, steady rail for passing trains and engines. All Howe truss bridges are white-washed inside and outside each third year; and when they were built the timber was carefully inspected and none but the very best allowed to go into the work. We have been transporting engines over our road of eighty-four (84) tons weight, while sixty-one (61) tons is the greatest weight in our own motive power.

In the line of iron bridges we have the lattice or riveted truss, the Post truss and the Pratt truss, and both steel and iron plate girders. Also a few I beam girders. In inspecting these we test the rivets and examine all pin and rivet connections; all splice plates, stiffening all angle iron connections, both for loose rivets and for rust. Also for rust scale under the paint, and at connection of track stringer to floor beams, as that is one of the most prolific sources for loose rivets in a pin connected bridge. In a pin connected bridge in plate girders the lateral connections, the splice plates, and stiffening plates are liable to have loose rivets that need a renewal.

The painting of iron work is a very important problem, and all thick paints, or paints of a syrupy nature, should be avoided, as they scale up from the iron, and rust underneath builds up in a thick scale enlarging year by year until the iron is badly eaten into and very much injured. I have seen large flakes of rust scale with three heavy coats of paint on it, and the oxidation underneath the paint exceeded an eighth of an inch in thickness.

In matters of bridge inspection I have found that men versed in the construction of bridge work were much the best men to assist in inspection; viz.: A man used to driving piles, framing and erecting the pile trestle, makes the best man to assist in the inspection of it. The same may be said of frame bent work; and the men accustomed to erect it.

Also as to iron bridges; the men trained to erect or raise the bridge and skilled in field riveting on such work, other things being equal, are much the best men to assist in inspection. All iron bridges which are being built at the present time are planned and the strains are all worked over and corrected ere work is commenced upon them. And elaborate blue prints with all the details are made, which, with proper care in watching the manufacture, will assure the turning out of good work. But in all cases, the more a man knows about the erection and construction of a structure of this kind, the better able he becomes for its inspection. In other words, "Practice makes perfect." All iron material for bridge construction should have careful chemical tests made during its transformation from ore to metal.

G. M. REID, Chairman.
L. S. & M. S. R. R.

DISCUSSION: SUBJECT—BEST METHODS FOR BRIDGE INSPECTION.

Mr. Reid, Lake Shore and Michigan Southern Railway—There are four members that have written on this subject, but there is still a great deal left to be said. We have been quite brief in our articles; we believe that brevity is the soul of humor. We need light on the different classes of timber. Need light as to the effect of exposure, as to the lasting quality and kinds used. With the common tamarack we get good effect, but I would like to hear from any member of this association who can give us some light on this subject.

Mr. Andrews, B. & O. Ry.—I will endeavor to state the system that the B. & O. R. R. Company has in use. On the division which I am located on we have a bridge inspector for every fifty miles. His sole duty is inspection of bridges. After his inspection he reports to me, giving the number of bridges that he has examined, together with condition, written on blanks furnished for that purpose, and with general remarks. In cases where a bridge needs immediate attention, it is his duty to call on the section men, or if a bridge gang is near, to get them to go and do the work. If it does not need immediate attention he reports to me and I give the attention. On the first of each week from the reports furnished by the bridge inspector I go over the report, which is then sent to our chief engineer, who considers the needs, files the report, and gives the order to work in accordance with the general tone of the report. We find this system works with very little friction and with most excellent results. It keeps us posted as to the condition of our bridges all the time. We make semi-annual inspections, the supervisor and engineer, that is supposed to be their duty. The inspection is made very thorough and systematic. By this system we are able to keep our bridges in better condition than where some section man gives his opinion.

Mr. Bishop, C., R. I. & P. Ry.—We have about 1,000 miles of road, 75,000 feet timber trestles and iron bridges on my division. It is divided at the present time into five districts from 175 to 230 miles in length. The foreman is supposed to go over those bridges once a month, and in case he cannot go he is supposed to send a competent man in his place. The foreman is supposed to inspect each one as they go over every section, and oftentimes they find two and three stringers that need attention. We are compelled to send our bridge man with a foreman to repair those bridges. The pile and trestle bridges were all built by contract in the year 1887, 800 miles. At the present time the bridges are giving out very rapidly. I find that our piles cut in summer give out sooner than the winter cut piles. It seems to me they last several years longer. The piles, stringers, and caps of pine give out sooner in the eastern part of the country than in the western part. Bridges, 6x16 stringers, three of them packed together, commence to decay at four years. We drive four piles to the bent, 22 feet—sometimes have to drive five piles, and sometimes six.

Mr. J. L. White, Texas Midland Railway—I would ask Mr. Bishop if he has no bridge inspector but the foreman.

Mr. Bishop—No, sir.

Mr. White—The question of bridge inspectors on railroads is a very important thing. I have been on railroads a great many years, and in many instances where there have been wrecks and accidents it was owing to the fact that there were no inspectors. I hope and trust that our superintendents of bridges and buildings will advocate to have inspectors on all roads where possible. I wil state further that I do not think, or rather consider, it an additional expense to any railway company to have bridge inspectors.

Mr. McGonagle, D. & I. R. Ry.—We make two inspections each year—spring and fall. On that trip I take with me the general foreman of bridges. We make a careful investigation of each bridge. The foreman takes a copy of the same notes that I make, he then has all the information necessary to start in on his work as soon as the inspection is completed. It is my custom, after returning, to furnish him with all the materials necessary for the work, and he of course knows where to place it. We give a great deal of time to making reports, that is, for the regular semi-annual inspection. For ordinary inspection during the year I cultivate pleasant relationship with the roadmasters. I find it pays. In any ordinary case of bridges needing attention on any of them it is reported very promptly, and we have good opportunity to repair it before any serious damage is done. In inspecting the foundation of a bridge the first thing we look for is moisture, expecting to find decay where there is moisture. When we have piles in water we have a better class of timber. We determine particularly how much sap and how much rot we have to depend upon. We can form a very good idea how long such a pile will last, and if we have any doubts about its lasting until the next inspection we attend to it at once. I am a firm believer in not using timber until it is worn out. I will take out the stringer if we have any doubts about it, and replace it with a good one and use that piece for a culvert. We can get just as good results out of that stick in another place, besides the taking it out removes the danger to our structure. The ties are one of the first things to receive attention. First look to see if they need respiking. We use a very rigid foundation with very little trouble. The caps being of white pine are very durable, and our results from that are pretty well known. We are very rigid in our inspection of timber, and that is one of our greatest points in getting good results.

Mr. White, Texas Midland Railway—I do not think it is proper for the superintendent of bridges and buildings to depend upon any roadmaster for the safety of his bridges. I do not think it is the thing for a roadmaster to have to report the condition of bridges. I think a foreman of any road ought to be compelled to go over his road once a month and report to the general foreman or superintendent of bridges, or have a bridge inspector to report direct to the head of the department.

Mr. Cummin, Long Island Railway—Mr. McGonagle intended to convey to the members of this association that he depended upon his foreman (general foreman) for information outside of his two semi-annual inspections. Now I disagree with our friend White, and fully agree with Mr. McGonagle. It is well to have the good will of the roadmasters, as well as the other officials of the road, so that we can work in harmony. It seems to me these two departments should work together more than any two departments in the railroad system. I am on very friendly terms with our chief engineer. I notice very many things traveling over the road, and lose no time in seeing him and giving him the necessary information. The chief engineer does the same thing in my department. If he is traveling and sees anything that needs attention he reports to me. Not in a fault-finding manner, but that things may be kept in better order. That was the idea that Mr. McGonagle intended to convey to this association.

Mr. McGonagle, D. & I. R. Ry.—I said to cultivate pleasant relations with our roadmasters. He assists me in finding defective places in our road, and he trusts me. I walk a great deal, and see a great many defective places, and as Mr. Cummin has said, I believe that railroad departments should work in harmony. I see no reason why a roadmaster should not keep me posted, except where we make our annual (semi-annual) inspection. My foreman travels over the road very nearly every day, sees the bridges in a general way, and talks with the general section hands; any serious defect is reported by letter. I consider it essential that the two departments should work together in harmony.

Mr. White, Texas Midland Railway—I do not wish to say for a moment that there should be no friendly relations between the roadmasters and superintendent of bridges and buildings. I am on the best terms with the roadmasters always. But what I had reference to was that these men are not capable of sending out telegrams, etc., to say what should be done with a bridge that needs attention. My idea is this, I did not want the roadmaster to order the bridge department, or the bridge department to order the roadmaster.

Mr. Staten, Chesapeake and Ohio Railway—I think myself it is always best to maintain friendly relations with the roadmasters and section foremen and even the section men. It is often of great value to us. We have an inspector for bridges. Mr. Wallace makes semi-annual inspections over the road. I would sometimes take a hand-car and take him over the road. We use piles. Very little frame trestlework—4,000 feet on our 365 miles of road. Our entire bridges, 7¾ miles, nearly all iron work on good masonry. Mr. Wallace, the inspector, would make his semi-annual report, it would then reach me with the necessary work to be done, and it would devolve upon me to do the work. We use augers, are very particular about our rivets, do not allow any loose rivets. All are replaced. Look very carefully after all the rivets. We have been very successful. Never had an accident on our road. Have been connected with this road for about fifteen years. Never had an accident from broken stringer because we watch them very closely. In addition to this, I will say that there is scarcely a day but that I am on one or more of the structures. If I am not able to go over all my structures inside of a month, I have a man whom I have drilled in the business who can report the condition of things. Every three months I take a personal inspection.

Mr. Reid, Lake Shore and Michigan Southern Railway—I make what I term semi-annual inspection, taking forty to sixty days in the spring and about sixty days in the fall. My fall inspection covers every structure on the road; it is done closely and carefully. We believe in the old adage, "A stitch in time saves nine." It is poor policy to keep in poor timber; this can be used in making culverts. We are all the time watching the timber. I pack my stringers with iron key, 14 inches long. They are very easy to use. They cost fifteen cents each. Have used them over twenty years. Our standard length of trestle work is 15 feet on centers. I use 30 feet stringer timber. Three pieces under each rail. Our caps are white oak. On our branch road we have all on tangent, white pine ties, each 8x8 and 9 feet long. Use on those a ribbon 6x8 dapped, giving me 5x8 as guard rail. The ties are spaced 12 inches centers and dapped ½ inch. We pay a great deal of attention to iron rust on bridges. We have 166 iron structures. Have at one time taken 1 barrel of iron rust. The constant dripping of engines causes a great deal of rust. I advise about three coats of paint. Now I know that I have ten good foremen; would not be afraid to put them to work anywhere where the work is on iron bridges. I have good men that will put up an iron bridge in as thorough a manner as it is possible to be done. I have a foreman go over the ground four times a year and he makes a very accurate report to me. If I think it is necessary work needing my attention I go over it with him, if it is slight work he goes and does it. We have had no accident on our road for 23½ years, and I was in the midst of that, before I had any connection with the road. We handled 8,000,000 people last year; did not hurt one of them. We give a careful and analytical inspection on rust scale.

Mr. Bishop, Chicago, Rock Island and Pacific Railway—We issue a circular on our system giving permission to call on my foreman where anything is found wrong, merely to give them notice that such a bridge is out of order. Oftentimes broken stringers are found. The foreman gets the word quicker than if the report goes through my office. In case anything needs attention after the foreman has been notified, the roadmaster notifies me. The committee report mentions my method of inspection.

Mr. Reid, Lake Shore and Michigan Southern Railway—In regard to the roadmaster; the roadmaster on our road has very little to do with our bridges. I feel like Mr. McGonagle; I want to be on friendly relations with the roadmasters. The bridge department are very willing to accept their help, and it is oftentimes very valuable. I believe those feelings of friendship between the railroad organizations and their officials are very essential. It serves to keep the road in better permanent condition, and is very much better than to be without them.

REPORT: MAINTENANCE OF PILE AND FRAME TRESTLE.

We have sent out a circular letter to all the principal railroads in the United States asking them to forward us a blue print of their standard plans for pile and trestle bridges; many of them have cheerfully complied with our request and we submit the drawing herewith as a part of our report. Quite a number have replied to our letter and regret that they have no standard plans to send, while others have been so busy and so short of help that they have been unable to prepare plans in time for the convention.

Two members of your committee have prepared articles which are attached to the formal report and we would recommend that the discussion of the subject be arranged under the following heads:

STANDARD SIZES OF MATERIALS FOR PILE AND
Compiled for the Association of Railway Superintendents of Bridges and

NAME OF ROAD.	Piling.			Length of span (feet and inches)	Stringers.		
	Size. (in.)	Kind.	Weight of hammer. (lbs.)		No. under each rail.	Size. (ft. in.)	Timber.
L. V. R. R	....	....	....	12	2	9 x 16	So. pine....
C. & N. W	10 S.	W. oak .... Cedar	2,200 2,800	16	2	10 x 14	W. pine ....
T., P. & W	10 S.	W. oak	2,800	14	3	6 x 16	Fir........
C., N. O. & T. P	10 S.	W. oak........	2,700	15	2 3	8 x 16 6 x 16	So. pine ....
C. & E. I	10 S.	W. or B. oak...	2,800	13	2	9 x 16	" ....
B., S. & T	....	....	....	15	2	8 x 16	" ....
Tex. Mid	10 S.	W. oak	2,600	14	3	6 x 14	" ....
C., R. I. & P	8 S.	"	3,140	16	4	7 x 16	Fir........
St. J. & G. I	10 S.	"	2,200	16	2	8 x 16	" ....
N. & W	....	....	....	12 16	2 3	8 x 16 8 x 16	So. pine ....
Wabash	10 S.	W. oak........	2,800	15	3	7 x 16	" ....
L & N	10 S.	W. oak, cedar..	2,800	13	[illegible]	8 x 16	" ....
D., S. S. & A	10 S.	Pine	2,800	16	2	12 x 14	W. pine ....
L. S. & M. S	10 S.	Oak...........	2,800	15	3	7 x 14	Pine........
Penna Co	14 L.	"	2,800	12	2	8 x 16	Oak........
B. & O. S. W	10 S.	"	2,800	15	3	7 x 16	Pine........
C., M. & St. P	....	....	....	16	3	8 x 16	Fir.........
St. P. & D	10 S.	Pine	2,400	12	2	8 x 16	Pine........
Gt. Northern	10 S.	"	....	12	2	7 x 14	" ....
D., M. & N	10 S.	"	2,800	15 9	3	9 x 16	" ....
D. & I. R	10 S.	"	2,800	12	3	8 x 16	Fir ....
Mo. Pac	12 S.	Cypress oak...	....	14	3	7 x 15	Pine........
Nor. Pac	10 S.	Pine...........	....	15 6	3	8 x 16	" ....
K. C., F. S. & M	20 L.	W. oak	2,700	16	3	7 x 16	Fir ....
W., B. & Ter	10 S.	Oak...........	3,200	15 9	3	8 x 16	Pine........
P., F. W. & C	16 L.	"	2,600	12	2	8 x 18	Oak........
Tex. Div. Frisco	10 S.	"	2,600	15	2	10 x 15	" ....
E., J. & E	10 S.	"	2,300	16	3	8 x 16	Pine........
W. & L. E	10 S.	"	2,800	16	4	6 x 16	" ....
Mex. Nat	12 S.	Pine...........	2,600	15	2	6 x 15	" ....

TRESTLE BRIDGES IN USE ON AMERICAN RAILROADS.

Buildings by W. A. McGonagle and J. H. Markley, Committee, October, 1894.

Ties.			Guard Rails.			Drift Bolts.		Packing blocks. (in.)	Style of Framing.	
Size. (in.)	Length (ft.)	Dist. Centres. (in.)	Size. (in.)	Length (ft.)	Splice.	Head	Point.		Mortise and tennon.	Drift bolts.
8 x 8	10	14	8 x 8	16	Half .	No	Chisel.	1 x 4	No.	Yes.
6 x 8	12	14	8 x 8	16	"	"	"	3 x 4	"	"
6 x 8	9	16	6 x 6	18	"	Yes.	"	1 x 4 x 6	"	"
6 x 8	9	14	5 x 8	22	"	"	No.	1 x 3	"	"
6 x 8	9	12	5 x 6	16	"	No	Chisel.	1 x 4	"	"
7 x 8	9	15	7 x 8	16	"	"	No.	2 x 4	Yes.	No.
6 x 8	9	16	6 x 8	14	Butt..	"	"	2 x 4	No.	Yes.
6 x 8	10	16	5 x 10	16	Half..	"	"	1½ x 4	Yes.	No.
6 x 8	12	16	7 x 8	32	Butt..	Yes.	"	3 x 4	No.	Yes.
8 x 10	14	15	6 x 8	24	Half..	No.	"	1½ x 4	Yes.	No.
7 x 7	12	14	5 x 8	16	"	Yes.	"	1½ x 3	No.	Yes.
6 x 8	9	18	5 x 9	16	"	"	Yes.	¾ x 3	Yes.	No.
8 x 8	12	16	6 x 8	16	Butt..	No.	No.	4 x 4	No.	Yes.
7 x 8	12	12	6 x 8	16	Half..	Yes.	Yes.	Keys.	"	"
7 x 8	10	14	8 x 8	16	"	"	No.	"	Yes.	No.
6 x 8	10	14	7 x 10	20	"	No.	"	1½ x 5	"	"
8 x 8	12	12	5 x 8	16	"	Yes.	Yes.	3 x 4	No.	Yes.
6 x 8	12	14	8 x 10	24	"	No.	"	None.	"	"
6 x 8	12	14	5 x 8	14	"	Yes.	"	1 x 2½	Yes.	No.
6 x 8	12	14	8 x 10	16	"	No.	No.	½ x 4	No.	Yes.
6 x 8	12	12	8 x 10	16	"	"	Yes.	2 x 3 x 7	"	"
7 x 8	10	14	6 x 8	16	"	Yes.	No.	2 x 3½	"	"
8 x 8	12	13	10 x 12	16	"	"	Yes.	1½ x 3½	"	"
6 x 8	10	16	6 x 8	32	"	"	No.	2 x 3	Yes.	No.
8 x 8	9	16	6 x 8	30	"	"	Yes.	1 x 3	No.	Yes.
7 x 8	10	14	8 x 8	18	"	"	No.	2 x 4	Yes.	No.
6 x 8	9	14	5 x 8	16	"	No.	"	⅞ x 3½	No.	Yes.
6 x 8	10	14	6 x 8	16	"	Yes.	Yes.	2 x 2	"	"
6 x 8	9	12	6 x 8	16	"	No.	No.	Keys.	Yes.	No.
6 x 8	8	18	....	....	....	"	"	1 x 4	No.	Yes.

1. Piling—Size and kind of timber. Best weight of hammer to use in driving.
2. Length of Span.
3. Stringers—Number, size, and best timber.
4. Ties—Size, length, and distance centers.
5. Guard Rails—Size, length, and framing design.
6. Drift Bolts and Packing Bolts.
7. Cast Washers and Packing Blocks.
8. Best Method of Framing Trestles.
9. Economy of Preserving Bridge Timber and Best Methods.

Your committee have given their individual opinions on some of the above heads, and earnestly hope to receive further light on the subject from the experience of the many members of the association whose long years of active service in the care of pile and trestle bridges, render them well qualified to speak with authority on this most important branch of maintenance of way.

WILLIAM A. M'GONAGLE, D. & I. R. Ry.,
JOHN H. MARKLEY, P. & W. Ry.,
Committee.

PAPER: DESCRIBING METHOD OF RENEWING, METHOD OF INSPECTION, AND COST OF MAINTENANCE OF PILE BRIDGES.

FIRST—RENEWING PILE BRIDGES.

To begin with, I get good white or burr oak piling cut while the sap is down (this is very essential). I order my piling from the annual inspection, usually allowing a few extra in case of breakage, etc. I distribute them with the pile driver crew going out and drive returning. I very seldom sharpen my piling to a point, generally leave them about 6 inches square on the ends, and always select the large piling for the center ones. In framing my piling I always "top" the center piling in my 4-pile bent about 4 inches above where they are eventually to be framed and spread them, so that at least one-half or the full head of the piling is directly under the stringer, as shown by the plans. By doing this I have no fears of my caps breaking and it adds to the bracing of the bents. I select all of the best material out of my stock for the new work and use the other grades for repairs and miscellaneous work, and in this way my bridge repair expense is very light. After I get my new bridge in all of the old one is removed and that which is worthless is piled up and burned; the other is loaded and taken to the yards to be used for repairs or any other temporary work.

SECOND—METHOD OF INSPECTION.

This is the most important branch of the work that comes under this department and the inspection should be made in the presence of the head of the department. I take three of my best bridgemen with me on a light hand car. My tools consist of two $\frac{7}{8}$ inch octagon steel bars 4 feet long, two shovels, an ax and tape line. I take the shovels along to clean the dirt and gravel off of the top and around the end caps. It is sometimes necessary to dig down by the side of piling that are in sandy soil to discover dry rot, which always take place a few inches below the surface. On this trip I inspect everything that comes under my department and keep a record in an ordinary blank book of everything that it will take to make repairs or renewals as the case may be. This gives me an intelligent idea of what is needed and I order my material accordingly. I find it saves carrying a large stock of expensive timber; however, I always carry some stock to have in case of an accident. This system, too, I find is a very economical way to handle men. I know what there is to be done, and when I send a gang of men to a place I know what men are necessary. I give them written orders or a copy of my inspection for everything that is to be done in that vicinity, from the largest job down to the repairs of a door latch. This, too, does away with a great deal of the extra transporting of men in running here and there, sometimes taking a whole day to do what could have been done in an hour while the men were at the point. I don't care how close an inspection is taken, there is always some small detail that will be overlooked. Therefore I instruct my foreman to make all necessary repairs; as I am a firm believer in the old adage, "A stitch in time saves nine." I keep all of my records of inspection so when it becomes necessary to renew bridges that I have once renewed, I can refer to them and get a copy of the former bill of material used.

THIRD—COST OF MAINTENANCE.

This is something I have not kept a very good record of. So far as material is concerned, there is very little new that goes into the repairs of old bridges on my line. About all the expense chargeable to this line is labor. I would estimate this not to exceed 5 per cent. of the original cost of the structure. If the bridges were properly credited with all of the good, old timber and scrap iron that is taken from them, it would more than over-balance the expense of maintenance.

J. H. MARKLEY,
Toledo, Peoria and Western Ry.

PAPER: MAINTENANCE OF PILE AND FRAME TRESTLES.

It has been stated by a competent medical authority that the only way to reform a wayward child is to begin with his grandfather. Following a similar practice, it is the opinion of the writer that the most important item in the maintenance of bridges is the quality of the materials and workmanship in the original structure. Much needless expense in the maintenance of pile and framed trestle bridges could be avoided if the original structure were intelligently designed, honestly built, and the workmanship capably inspected.

As superintendent of bridges and buildings we are often called upon to assume charge of structures of which we have no knowledge of their internal character or the stability of their foundations and it is here that I want to make the point that in my opinion no pile or framed trestle bridge should be constructed without a complete record of pile driving and a complete plan and certificate of inspection being furnished to the superintendent of bridges and buildings or even more radical, the superintendent of bridges and buildings should have charge of all new work which is to come under his supervision after the completion of the road. It is only in this way that we can intelligently and economically plan to keep our structures in proper and safe condition.

The design of a pile or framed trestle bridge has a considerable effect upon the cost of its maintenance. It is the practice of civil engineers in designing a pile or framed trestle bridge, to plan a structure that no power on earth can loosen or tear apart without destroying the timber. For this purpose they design drift bolts with large heads which they drive into the timber, crushing the fibres on the upper surface of the stick and making a depression in the surface which is an invitation for the inevitable decay which occurs from the accumulation of rain water in these cavities. When we want to reline a stringer we find it anything but a pleasant task to raise the stick far enough above the cap to allow us to cut off the old drift bolt, much less pleasant is it to try to drive the old drift bolt through the stick and loosen it in this way, and I cannot approve of the method of digging out the head of the drift bolt in order to allow the bolt to be drawn out except in case of renewals.

I believe in building our bridges so that they can be readily and economically taken apart, relined, or renewed, and for this reason I use drift bolts with chisel points, but no heads, and by using augers of smaller diameter than the bolt, I find that sufficient head is formed in driving to answer all purposes.

We have the greatest respect for our chief engineers, but want them to get some experience in maintenance, and we have no doubt that their theories of construction will be radically changed.

The foundation of a pile or frame trestle bridge is the most important part of the structure both in design and workmanship. It is here that we want quality of material and workmanship and the most careful inspection. It is too often the case that the inspector of pile driving is one of the poorest paid men on the engineer's corps and being incompetent for regular work with the corps is thought to be good enough for an inspector of pile driving. I once knew of an inspector of pile driving who when watching the downward course of a pile after the first blow, ordered the contractor to cease driving, as the next blow would surely drive the pile below grade. It is hardly necessary to state that this man was not in my employ, and I state the fact simply to show the kind of work that is turned over to us in many cases and which we are expected to maintain economically.

I require the foreman of pile drivers to keep a complete record of each pile driven as follows:

Date. Bridge number. Bent number. Pile number. Length of pile in leads. Weight of hammer. Height of fall at last blow. Penetration at last blow. Depth of pile in ground. Length of cut off. Remarks.

I find that it pays to keep these records especially when we come to renew these same structures, when it is an easy matter to make out a bill of piling that we know is correct. It is my practice where the ground is uncertain or unknown to drive the outside pile of each bent and thus ascertain the required length of piles and in maintenance work this can be done without any disturbance to the existing structure by driving the pile just outside the guard rail.

In order to complete the pile driving, I remove a sufficient number of ties to permit the track piles to be driven, drive these and then cut off close to the level of top of tie, the deck of the bridge is then raised by shimming between the caps and stringers until there is sufficient room to slip in the new caps, the piles are then cut off and new caps placed in position and drift bolted; the sway braces are then spiked on with boat spikes after which the old deck is moved forward span by span until the old superstructure rests upon the new foundation. During this time we renew any stringers that may be required and after bolting same in position we renew the ties and guard rails.

There is no good reason for delaying a regular train during the progress of this work if a temporary spur track is built near the structure, and this should always be done when the bridge is at any considerable distance from a regular side track.

Length of span exerts a considerable influence upon the cost of maintenance of pile and framed trestle bridges. The writer is of the opinion that where very heavy loads are to be provided for it is economical to use a length of span not to exceed twelve feet centers. I have arrived at this conclusion after a number of years' experience with spans of different lengths on a road running some of the heaviest locomotives in America. The Duluth and Iron Range R. R. has a maximum grade of 137 feet per mile descending into the terminal at Two Harbors. Over this road we haul twenty-five loads of iron ore, each car weighing thirty-eight tons loaded and this train is pulled by a twelve-wheel locomotive weighing 119 tons, with sixty-nine tons on drivers. I state these facts to show the possible reason why I am in favor of short spans and while I am satisfied that they are the proper length for the Duluth and Iron Range Railroad, I am willing to admit that longer spans would be preferable on railroads owning lighter rolling stock.

The selection of timber materially affects the cost of maintenance of pile and trestle bridges. As far as possible native timber should be selected and the proper season for cutting same be determined after which experiments as to proper locations for different kinds of timber in different parts of the structure determined. For example, we find in our country that Norway pine piling makes the best available pile to drive well and lasts from six to eight years, while white pine piles have been in service eleven years and many of them are still in good condition. But white pine will not stand driving nearly so well as Norway pine and it is difficult to obtain as firm a foundation with them. We find that Norway pine makes an excellent post in a trestle, but a very poor cap sill or stringer, and for this reason we always specify white pine for horizontal members and either white or Norway pine for vertical members in all trestles.

Since the reduced freight rates on Washington fir have made it possible to secure this timber at a reasonable price, we have adopted it as standard for bridge stringers and have excellent results from its use.

Liberality in the management of the road is a prime factor in the cost of maintenance of pile and trestle bridges. Many a superintendent of bridges and buildings is hampered in his management of the repairs of bridges by insufficient or antiquated plant, and also by the necessity of holding down the cost of maintenance in order to permit the management to show a good comparison sheet, and while this latter principle is always desirable, yet there comes a time in the life of all bridges when comparisons are out of the question and the work must be done.

On taking charge of the bridge and building department of the Duluth and Iron Range Railroad, I received the following statement from the principal officer of the road:

"I have all the money that is necessary to place the bridges of this road in absolutely safe condition and will take no excuse for the failure of any structure on the road." It is hardly necessary to add that we have had no bridge accidents, and that there would be fewer accidents elsewhere if the same policy was pursued.

The standard pile bridge of the Duluth and Iron Range Railroad consists of bents of five piles each of Norway or white pine piling, not less than twelve inches in diameter under bark at mid length and peeled before driving. Bents are spaced twelve feet centers and outside piles are driven or drawn in at the top to make a batter of approximately one inch to the foot.

White pine caps 12x14—14 feet long are placed on these piles and fastened to each pile with one drift bolt 1 inch by 24 inches long, with chisel point, but no head. The bents are sway braced with Norway or white pine braces 3 inches by 12 inches—fastened to each pile with three boatspikes ⅝ inch by 7 inches. Stringers under each rail consist of three pieces of Washington fir 8 inches by 16 inches—24 feet long breaking joints and fastened to caps with drift bolts ¾ inch by 24 inches long, chisel pointed, but with no heads.

Track stringers are packed with machine bolts ¾ inch by 32 inches long under head and cast iron packing blocks 2½ inches by 3 inches by 7 inches.

In addition to track stringers we have two outside or jack stringers 8 inches by 16 inches—12 feet long in each span and fastened to caps same as track stringers. Bridge ties are of white pine on tangents and white oak on curves and are 6 inches by 8 inches—12 feet long and surfaced on one side and placed twelve inches apart centers. Guard rails are white pine 8 inches by 10 inches—12 feet long notched down two inches over ties, placed with middle of stick over bent and halved together in center of span, they are bolted three bolts to each rail with machine bolts ¾ inch by 33 inches long, passing through tie and outside stringer, with two cast washers to each bolt. Furring strips 2 inches by 6 inches—4 feet long—are nailed to piles of end bents to receive the end planks which are four in number on each end, 4 inches by 12 inches—12 to 16 feet long—and fastened to furring strips and piles with boat spikes ½ inch by 10 inches. Each bridge is furnished with two number boards on which is painted the number of the bridge. We number our bridges first with the mile number and then add a letter indicating the number of the bridge on that mile, thus 10 C indicates the third bridge on the tenth mile from Duluth. When we letter bridges on a branch line, we prefix a letter to the mile number, thus X 5 B indicates the second bridge on the fifth mile on the Western Mesaba branch. The advantage of this system of numbering is that everybody connected with the road knows where to go in case of a fire or wreck, and the signs are a valuable auxiliary to the mile posts.

WILLIAM A. McGONAGLE,
Duluth and Iron Range R. R.

DISCUSSION: SUBJECT—MAINTENANCE OF PILE AND FRAME TRESTLE.

Mr. McGonagle, D. & I. R. Ry.—I would like to hear from everybody on the subject of piling—the size of piling to use, the kind of timber, the best weight of hammer. I will state the kind of piling I use. I use piles of Norway pine. The specifications are usually about 12 inches in diameter. Norway pine lasts from six to eight years. Have white pine that has been used eleven years and is still in good condition. Hammer 2,800 pounds. We find it necessary to use the follower in using soft pine piling.

Mr. Bishop, C., R. I. & P. Ry.—We use piles 14 inches at the butt and 8 inches at the tip. I do not think the piles are large enough. I should recommend 18 or 20 inches at the butt and 10 inches at the tip. We have a 3,100 pound hammer; should recommend 2,800 pound hammer. We use white oak.

Mr. White, Texas Midland Railway—On our road we use piling 10 inches at the small end and nothing said about the large end. Use white oak piles; I think it is the best piling we can get; 6x8 ties, 9 feet. The stringers, by the way, are of long leaf yellow pine. We use a 2,600 pound hammer, but would prefer 2,800 pound.

Mr. Hall, Ohio and Mississippi Railway—On the Mississippi division of the B. & S. W., which I have charge of as superintendent, use white oak piles 12 inches at the small end and not less than 14 at the butt and not to exceed 16 inches. Use a 2,600 pound hammer, 35 inches from the bottom of the hammer to the tip. We find the heavy hammer answers a better purpose than the light hammer. We drive four piles to the bent up to 22 feet, 22 and over five piles, 30 to 40 we drive six piles to the bent.

Mr. White, Texas Midland Railway—We have four piles to the bent up to 16 feet, over that we drive five. Up to 35 and over we drive six. We are obliged to use some cypress pine.

Mr. J. H. Markley, T., P. & W. Ry.—In reference to size of piling, we use 30 feet long, 10 inches at the small end and not over 18 inches at the large end. For piling shorter than that, 12 inches at the small end. Four piles to the bent, for a train running from forty to forty-five miles an hour I put in five piles to the bent. Use 2,800 pound hammer, and I like it very much. Prior to that we used the 2,600 pound hammer and found it rather light. The hammer is concave just a little. I notice that a great many prefer the square face hammer.

Mr. Hall, Ohio and Mississippi Railway—I will say in addition to what I have said that we use pile drivers by which we are able to drive piles very successfully. Prefer concave hammer. Have just finished up this year's work by driving 6,538 feet; allowing $5 a day for piledriver, and $25 for the use of the locomotive, the cost was from 3 to 4.136 cents per foot.

Mr. Noon, Duluth, South Shore and Atlantic Railway—I have very little to say. We use some cedar, oak, white pine, red pine and tamarack. We find the cedar piles are the most lasting ones we use. We have some cedar piles driven seventeen years ago that are sound yet. White Norway pine lasts from five to six years. The red Norway is considered pretty good for piling; 2,800 pound hammer with 2,000 pound follower sharpened in the shape of a tea cup, concave at the bottom. Our piles in use are about nine inches at the tip and sixteen inches at the butt end.

Mr. A. S. Markley, Chicago and Eastern Illinois Railway—Our company prefer oak piles, thirty feet and under, thirteen inches in the center and eight inches at the small end. Hammer, 2,800 pounds. Four piles to the bent except for a very sharp curve. Estimate of cost, four cents to four and one-half cents for labor, including the engine and fireman. Usually last from ten to fourteen years.

Mr. Thompson, P., F. W. & C. Ry.—We use white oak exclusively. Our specifications are fourteen inches in diameter, four piles to the bent, which is found to be sufficient in all cases on our road; 2,600 pound hammer. We estimate six cents per foot. Our road is a very busy road and it sometimes runs above that.

Mr. Soisson—Do you sharpen your pile?

Answer—We do not sharpen our piles. Do not consider it necessary.

Mr. Soisson—I have noticed where the piling was sharpened it would cut the ground better. The pile that is not sharpened is easily controlled. We use white oak, ten inches at the top; do not consider the butt end at all.

Mr. Ryan, K. C., Ft. S. & M. Ry.—We use 12 by 12 and find that the wedge piling can be driven, but there is not one single point or place in my 532 bridges that I could drive the square pile, not one. We use a 2,800 pound hammer.

Mr. O. J. Travis, E., J. & E. Ry.—Our road use 8 by 16 three-ply stringers, sixteen feet long. Use oak. Four piles to the bent, sash braces and sway braces; 2,600 pound hammer. We drive piles as long as they will go. Size of pile, eighteen inches at the butt end and ten inches at the tip. Smooth hammer.

Mr. Berg, Lehigh Valley Railway—We use Norway spruce, Canadian spruce, yellow pine, eight inches at the small end and fifteen inches at the butt. New work is done by contractors. Very little work is done by railway pile drivers on the track.

Mr. Riney, C. & N. W. Ry.—On our road we drive five piles to the bent in some instances. Four to the bent usually. No figures on the cost; 2,800 pound hammer, concave. Square piling.

Mr. Davis, Birmingham, Sheffield and Tenn. Riv. Ry.—We have no piles on our road at all.

Mr. Vandergrift, Chesapeake and Ohio Railway—We have no pile driving on our road. Use them only in case of a washout. Use anything we can get hold of from a fence rail up. White oak, from West Virginia and Kentucky; sometimes use old Virginia pine; anything we can get we use. Never keep a supply on hand.

Mr. Hinman, Louisville and Nashville Railway—My experience is ten inches at the small end, and it should not take less than sixteen to eighteen inches at the large end. In my experience of driving piles that size is best. We have used four piles to the bent except in the case of floods, then we use from five to six piles. For ordinary work I deem four piles sufficient. We use 3,300 pound hammer. Have four different weights, 2,800, 2,400, and 3,300 pounds, concave at the bottom about one inch. On an average we drive about twenty-four piles, some days forty, some days even sixty. We built a three-mile trestle last year, using 5,500 piles, twenty-two a day, at a cost of about $40 per day. We never allow our piles made of cedar driven in by heavy blows; it injures or cripples them. We are very careful in regard to our pile driving. We have everything of the most modern improvements. Would recommend a large hammer with short blow.

Mr. Spafford, K. C., Ft. Scott & Memphis Ry.—We use oak entirely; our specifications are sixteen to twenty inches at the large end, and use friction engine for driving, and in the last few years we have driven the outside piles on the batter; 2,400 pound hammer. Estimate, eight cents per lineal foot to drive the piles. We use four piles to the bent, where it is sixteen feet or more above the ground we drive five. Length of standard span, sixteen feet from center to center.

Mr. Cummin, Long Island Railway—On our main line we use Nova Scotia pine, twelve to fourteen inches butt, eight inches at the tip. Four piles to the bent; 2,600 pound hammer.

Mr. Stannard, Wabash Railway—We use oak piles, ten inches at the top, fourteen to eighteen inches at the butt. We have four piles in all trestles, running thirty feet and over that; over forty to forty-five we use five; over fifty-four to sixty feet we use six piles; 2,300 pound hammer, friction engine, and our drivers drive twenty-one feet over the ties. Our braces are put on with bolts entirely. The cost is about $2; that is, up to thirty feet; very small expense over that for additional feet. Very little difference in driving. In soft places we have to drive deeper. We do not sharpen our piles for soft ground; in hard ground we sharpen them.

Mr. Carpenter, C., N. O. & Texas Pac. Ry.—I have very little to say on the subject of piles, as we use very few piles. What we do use are confined to our iron viaducts. We usually keep on hand a supply of piles so we have them in case of a washout. Our specifications are ten inches at the small end, with bark taken off;

we do not consider the butt end or center; have a friction engine, hammer between 2,600 and 2,800 pounds, with slight concave face, probably one-half to three-quarters of an inch. We have driver, could drive piles on a batter three and one-half inches to a foot, for use in driving our outside piles. Have four piles to the bent. When from six to eight feet above the ground, we use three piles. We have never been able to estimate the lasting quality, as our piles are driven into moving ground. I am not prepared to say how many piles we can drive in one day. We point all of our piles. We recently had opportunity to drive piles through soapstone; did not have very much success in it.

Mr. O. H. Andrews, St. Jo., G. I. & K. C. Ry.—On our road we use 3,600 pound hammer, square face, friction engine. Our specification is ten inches at the small end and fourteen inches at the butt end. We drive them on general principles with sixteen feet in the ground. We drive sometimes piles on batter one and one-half inches to a foot. We use from four to six piles, as occasion may warrant.

Mr. Bradley, St. L. & San Francisco Ry.—We use friction engine, 2,600 pound hammer, oak piles not less than ten inches under the bark in diameter. We have four piles to the bent as a rule. Above thirty feet we use five piles; forty and upward we put in six. We have our outside piles on a batter of two to three inches, high trestle two inches. Use the best white oak we can get. We can get no material that will stand driving except white oak. We penetrate, when we can, four feet, sometimes six. Very little of the 456 miles which I have can be penetrated ten feet, and the cost on an average is about two cents for driving. That is the cost of the crew and the engine. We sharpen our piles according to circumstances.

Mr. Reid, Lake Shore and Michigan Southern Railway—My experience in the last few years has been very limited in pile driving. I have two drivers on the road, one is a revolving driver, no friction. Our piling runs from 7 feet to 40 feet in height above the ground. In 1887 I drove 150,000 feet of piles. The cost of driving, including the sharpening, and occasionally we had to cut a pile off with an ax or saw, was $0.0632 per lineal foot. We drove when over twenty foot, five piles to the bent. The specifications, ten inches at the top and fourteen inches and upward at the butt. I drove on the Kalamazoo that fall in November a five pile bent trestle 498 feet long. Our piles were all oak. The longest pile in the trestle was thirty-five feet. The chutes were twenty-two feet; the leader would take the pile thirty-nine feet above the track on ordinary grade. The hammer was cast 2,365 pounds, four feet eight inches long. I find the long hammer strikes a better blow than the short hammer. I find that it is more expensive driving piles on our main line than it is on our branch roads.

Mr. White, Texas Midland Railway—I will state something about pile driving in my experience. In 1889-90-91 I drove piles for U. P. Denver & Gulf R. R., paying $25 per day for locomotive, crew, fuel, etc., and $150 to the Colo. Midland R. R. for the pile driver. Had a very poor locomotive, will state they hung me up many a time. I averaged from 3 to 6¼ cents per foot, with that $25 and cost of the pile driver, that making all the expense for the crew, wear and tear, steam hose, etc., 6¼ cents a lineal foot.

DISCUSSION: SUBJECT—FRAME TRESTLE.

Mr. McGonagle, Duluth & Iron Range Railway—I will state that we have not a mortise and tenon. If there is any good reason for using a mortise and tenon I would like to know it. Wish members to state why they use it.

Mr. Hall, Ohio and Mississippi Railway—We use the mortise and tenon standard trestle with two draw pins through the tenon, making the tenon the full width and we have made them of six-inch timber. I find it makes a much more rigid trestle than any other I have used. The drift bolt used is probably the cheapest for ordinary work. I would always recommend it for that purpose. But for a permanent structure, especially where it is used under heavy loads of fast moving trains, I would always use the mortise and tenon. It makes a rigid structure. Have never found any difficulty with the mortise and tenon except on the bottoms of the posts. Have to provide for drainage by boring through sill, unless the sills are under the water. I have never found any difficulty to give drainage.

Mr. Markley—We have a number of bridges sixty-five feet high, none of which have the mortise and tenon. The advantage of not having the tenon, we get full bearing of the post to the sill. You cannot get any bearing whatever on any of the tenon, because you are deprived of one-third of the value of the timber. This has a tendency to stiffen the bent. If it is well braced, there is no danger of their getting out of the way.

Mr. Hall, Ohio and Mississippi Railway—I have a little experience. Will speak of a structure we have had in use for the past twenty-six years. It is from Riverside to Bedford. In this structure the chief engineer consented to use the drift bolt. I have had more trouble to keep those trestles in proper shape than all the trestles on the balance of the system.

Mr. Reid, Lake Shore and Michigan Southern Railway—On the line of our bridge department we have but one frame trestle on the entire line. On French Creek, twenty-eight to thirty-two feet high, four piers under each bent and pine trestle, 12x12, framed with mortise and tenon, all dapped one-half inch in the sill and cap and the double drift pin through the cap with the head of each post and two dowel pins three-quarters inch. This trestle is tied horizontally and longitudinally, 4x12 ties on the batter longitudinally, and on all posts horizontally, the bracing runs out to the end of the cap to the foot of this tie, and from the tie to the sill, which brace is 3x12 pine plank, each bolted in cap and in post.

Mr. Hall, Ohio and Mississippi Railway—In reference to drift bolts I notice there has been nothing said about spiking trestles. We use spikes from three-eighths to one-half inch, two to four spikes on either side in the piles.

Mr. Reid, Lake Shore and Michigan Southern Railway—I did not say anything about the preservation of this trestle. This trestle was built in the winter of 1887 and 1888. It is in good condition and has been free from expense except the taking up of bolts. Ten dollars would cover that expense up to the present time.

Mr. Carpenter, C., N. O. & Texas Pac. Ry.—We have some frame trestles on our line, posts 12x12, caps 12x12; some 12x14. Our original plan was for the mortise and tenon, but we have abandoned that. We have 3x8 sway braces that are bolted to each end of the cap and to each end of the batter post. We have not as yet had experience to see what the results will be. We have endeavored to use the lag screw, but it was not successfully done. We use guard rails on our trestle also.

Mr. Reid, Lake Shore and Michigan Southern Railway—I would say that I have used about forty tons of lag screws in the last seven years. Our experience in certain places has been very successful if properly put in. They are three-quarters inch in diameter, ten and one-half inches long, have used them for guard timbers quite extensively. I bore with a three-quarter inch auger through the ribbon and then bore into the tie with a one-half inch auger. We are going to use the lag screw quite extensively. They prevent the moving of ties.

Mr. Bradley, St. L. & S. F. Ry.—We use 12x12 posts, 10x12 caps, and oak, 10x12, for batter posts dapped one inch in sill and cap and drifted. We use another trestle 12x14 cap, 12x12 posts, 10x14 batter, braced in the same manner, all of oak. We use braces bolted to every post, also to each end of cap and sill.

DISCUSSION: SUBJECT—ECONOMY OF PRESERVING BRIDGE TIMBER.

Mr. Hinman, Louisville and Nashville Railway—The best method I have found in preserving bridge timber is to use creosote oil on the places where they come in contact with any other wood, and to cover them with iron. I know of no better method than this. We have used coal tar, but do not find it beneficial. In many instances where we used coal tar the timber burned up, but with the creosote oil it is different. The covering of the stringers with iron I deem the best plan I know of. Creosoted timber is as hard after several years' service as it was when it was put in. Speaking of covering with iron, if put on right and with sufficient room left for the expansion and contraction of the iron, it is usually satisfactory. I think it pays to creosote.

Mr. Cummin—Do you put it on with a brush?

Mr. Hinman—Three applications with a brush.

Mr. Berg, Lehigh Valley Railway—I wish to state on the Lehigh Valley system we are very particular to apply with the brush what we call creosote residuum on all joints and all places where timber adjoins timber in a frame structure. This creosote residuum as we use it is a thick tarry matter that remains in the creosote establishment. It is not like tar, owing to the large amount of boiling it has had over and over again in the process. The objectionable features in the coal tar have been eliminated. If we did not use this creosote residuum (we would certainly recommend every one to use this creosote residuum), I would use the ordinary creosote, which is probably as good but more costly. In the process of burnettizing, I will mention for frame structures, which are not exposed to flowing water, I consider that the burnettizing is probably as good as creosote. It is cheaper. I will state that to give some value to my opinion I was superintendent of the Lehigh Valley Railroad creosoting works for five years. I have had occasion to investigate the subject for about the last ten years very thoroughly. The reason I mention burnettizing is because it is cheaper. In the West there are a number of burnettizing works. I consider the burnettizing all right if not exposed to flowing water. The burnettizing process consists simply in introducing chloride of zinc into the lumber, water is the vehicle which conveys the metallic salt. Creosote on the contrary is not affected by water whatever. It is the thick tarry substance that remains in the lumber. I will call attention to the value of preserving timber in frame structures. The expense, of course, has to be considered. There is one part in the structure that I have made it a rule to have preserved, I refer to the horizontal caps and sills. These are hard to replace and to maintain, when they rot out. The vertical pieces like the posts need not be taken out in repairing, but an additional one can be put in. The horizontal pieces are very expensive to repair, and the extra cost of preserving these is very small, because the timber does not amount up very fast. I do not recommend preserving the stringers or the ties, but I do recommend, very sincerely and earnestly, the preserving of the horizontal caps and sills in a frame structure. If a company can work for the future, preservation of much of their lumber is desirable.

Q.—What is the cost of 1,000 feet lumber creosoted?

A.—If the lumber is not used in the water and not subject to the attack of the sea worm, probably ten pounds per cubic foot is an ample specification, and that would cost from $10 to $12 per thousand feet. If the timber is not exempt from the work of the sea worm, specifications of from 12 to 18 pounds per cubic foot depending whether the locality is South or North. In the South the sea worm works very rapidly. This will cost from $14 to $20 per M feet. It might be interesting to add the cost of creosoting piles. Piling should generally have from 10 to 16 pounds per cubic foot. This will cost, taking the average piling, for piers and docks, from 10 to 16 cents per lineal foot pile.

Mr. Cummin asks Mr. Berg whether he has ever used horizontal lumber that was creosoted thoroughly.

Mr. Berg—I had one dock on the Lehigh Valley Railroad in which all the timber, even including the floor planks, was creosoted.

A member was interested to know how creosoted timber stands as regards strength of untreated timber.

Mr. Berg—I have never tested the difference. I have no direct data.

Mr. McGonagle asks the question as to additional life on account of being creosoted.

Mr. Berg—I think the best answer to that is we have an authenticated report in England, in which a certain engineer or railroad man, who when a young man was inspector of a dock in England and inspected the piling in the piers. When he was about 40 years old he was sent to inspect the same work, and then I think when years later he had become president of one of the large railroad companies, the report was made again, finding the creosote timber as good as when he had inspected it as a young man, with the exception of the timbers that had been cut into by the sway bracing, storms, or vessels driven against them. The rest of the piles were as perfect as when he inspected the timber when a young man. There is no reason why creosoted timber in this country should not show as good results as in England. The tendency in this country is to make money, and unless the contractor of creosote is honest the results will not be as good as in England. Another thing we have to consider is whether it is a question of rot or of the timber being attacked by the sea worm.

Mr. Cummin, Long Island Railway—How much would it take to put in stringers that were thoroughly creosoted? I have known them to snap short off. We use them for piling, but never use them as stringers on that account.

Mr. Berg—I do not think the quantity of the creosote used had any bearing on the question of the strength of the timber. I take exception to Mr. Cummin that the preserving of the timber takes away the strength. I wish to modify that by saying that it seems possible that it takes away the strength for cross strain. The reason that the quantity of creosote has no bearing on the strength is because the danger, if any is done to the timber, is in the steaming or endeavoring to extract the sap from it. This is the preparation for the preserving of the timber, that is done in the same manner for the coal tar, burnettizing process, and wood creosoting or any other different process. It is what is called the desiccating of the sap to make room for the preserving fluid that hurts the timber.

Mr. Cummin, Long Island Railway—We have some creosote piles that were driven fourteen years ago this summer. To all appearances they are just as sound and good to-day as when they were driven.

Mr. Berg, Lehigh Valley Railway—I will state that on a trestle across the Newark bay, creosote piling were driven by the Central Railroad of New Jersey, and were left in for fourteen years, in actual service under the bridge. About four years ago the piles were taken out and the creosote timber was perfect. The sea worm is the same, except in some places the action of the worm is much quicker. On the gulf coast it would be riddled in a short time. In the north it takes eight to ten years before the structure has to be thrown out on account of the piles being eaten by the worms.

Mr. Hinman, Louisville and Nashville Railway—We use nothing but creosote piles, but the sea worm injures them so quickly that we have to get sewer pipes for use as covering.

Mr. Berg—I would like to ask Mr. Hinman whether the creosote oil used in preserving of these timber piles was the oil of coal tar?

Mr. Hinman—I suppose we have the best used.

Mr. Berg—I will state for information that I believe the oil used at the Southern Creosote works is wood creosote and not recognized as the best.

Mr. Reid, Lake Shore and Michigan Southern Railway—I would ask Mr. Hinman if he had any piles on which the Tilmany process is used, namely sulphide of copper. It has been used in Pensacola bay quite successfully. When put into the timber properly, as it has been done in a number of cases to get the sea worm out, it has done almost exclusively.

Mr. Mallard, Southern Pacific Railway—We are using creosote piles. At Morgan City we have a bridge about 1,700 feet long, with very long piling—some 135 feet, spliced. We have the piles examined every year by a diver. The part that is under water is perfectly solid. So far, I have known of only two piles that show the least signs of decay; the decay seems to be where the sap had been shattered loose from the heart by the hammer. I think the L. & N. have some piles that are 17 and 18 years old.

Mr. Markley—I would like to ask the cost of creosote, per lineal foot of piling?

Mr. Mallard, Southern Pacific Railway—It depends entirely on the amount of creosote. It runs all the way from $22 to $26 per 1,000 feet board measure. I think piling cost $27 to $30. We have our own works at Houston and of course get ours cheaper. On pile trestles of 15-foot centers we make a floor of creosoted 10x12, then 8 inches of gravel on top of that, making a continuous roadbed. The L. & N. started the use of creosoted timber about 19 years ago. I think about three years ago they examined some of the trestle; found them perfectly sound after 15 or 16 years. In response to an inquiry as to use of stringers on 15-foot openings and covering with gravel, Mr. Mallard stated it rendered traveling easier and reduced the danger from fire, gives a continuous roadbed and is estimated to last 25 years.

Mr. Stannard, Wabash Railway—It will require a great deal of time when you come to renew them; it will cost as much as not using gravel; of course, it reduces danger from fire. The K. C., F. S. & M. use a 2-inch plank between the tie and stringer, filled in between with gravel, using 2x6 spiked to tie, to prevent the gravel from running out to prevent danger from fire.

Mr. Markley—In coming over the Illinois Central, I noticed some of these openings and could not understand the advantage; it would seem that the timber would rot if not protected. In our country we have to commence renewing bridges when they are five or six years old.

Mr. Mallard, Southern Pacific Railway—We will leave the solution of these questions to future generations. The gentleman overlooks the fact that on portions of our road we have openings every 100 to 200 feet. They have the old French system of giving one man so much water. Every man has to have his water under his own control—for raising rice. By this continuous roadbed you have smooth riding track.

Mr. Berg, Lehigh Valley Railway—When the creosoted timber is used, I presume it is perfectly proper to let the maintenance question remain for future generations, as mentioned by Mr. Mallard.

Mr. Cummin, Long Island Railway—I simply want to say that there is a gentleman here who is not a member, but I think can give us some very valuable information—Mr. Colburn of the Atlantic system of the Southern Pacific.

Mr. Colburn, Southern Pacific Railway—The first creosoted work that I put in in this section about twenty years ago is still in. Mr. Mallard has mentioned that we have a good sample of the class of work which we call a ballast deck. Our object in putting this in specially is to make a continuous track and prevent the bob or jump at the end of each little opening. There are no bridges in the section of swamp country on which the approaches can be kept up without continuous work. We have a great number of continuous decks, which we use from here to El Paso. I suppose that our percentage of creosoted timber, New Orleans to El Paso, is about 35. The economy is being demonstrated to-day by the amount of timber we use each year. The first work done in this section of the country was on the New Orleans & Mobile, now the L. & N. R. R. The first work was in 1876, twenty miles from New Orleans; the piles under the bridge are to-day the same as when the work was done. I have never yet taken out, in something over eight years, a stick of creosoted timber on account of rot. I have seen a few rotten creosoted timbers, but I considered same due to defects. If it commences to rot before you treat, it will not stop. We use it also in piling piers altogether in this country.

REPORT: BEST TRACK SCALE FOUNDATION.

MAJORITY REPORT.

Track-scale foundations like all other foundations designed to carry or support heavy loads, should manifestly be of the most substantial character; proper drainage is one of the primary objects to be taken cognizance of in putting in the pit, and this is often a very difficult matter in railroad yards, from the fact tnat track-scale tracks are usually surrounded by other tracks, precluding the possibility of adequate drainage, and making the pit a receptacle for surface water from adjoining tracks.

It is the opinion of a majority of your committee, after the pit is fully excavated a well-rammed bed of concrete composed of proper proportions of sand cement and broken stone eight inches deep be laid the full size of the pit, and on top of this four inches of a floor composed of cement and sand properly proportioned, all laid with a pitch toward the drainage point sufficient to permit the water to flow freely toward that point, and in this four-inch floor, troughs or corrugations should be provided to allow the water to pass off under the scale frame sills, corrugations to run lengthwise of the pit, all these troughs or corrugations to lead to the drainage point where a sewer pipe should be laid in on a level with the top

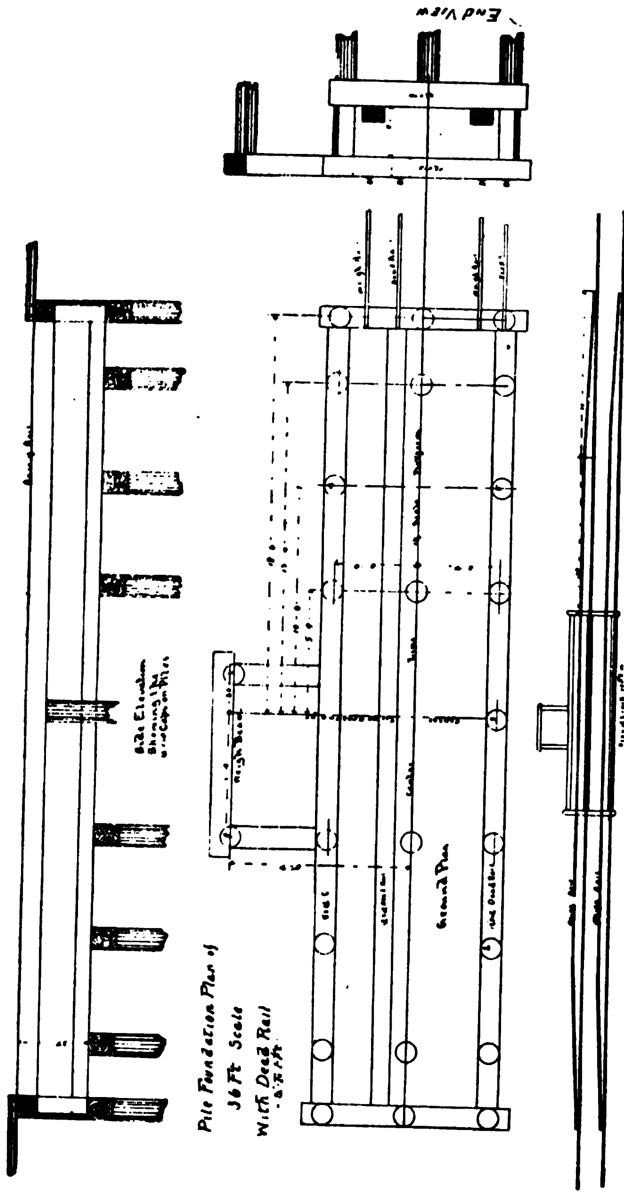


FIG. 76—PILE FOUNDATION PLAN OF 36-FOOT SCALE WITH DEAD RAIL.

of the concrete floor and this pipe connected to the tile or drain pipe outside of the pit.

On this concrete floor the masonry should be laid, of good dimension stone laid in good quality of domestic cement. The practice of using rubble masonry for track-scale foundations is in the opinion of your committee not good practice, the mortar in the multiplicity of joints in such masonry crumbles in a short time, and thus disturbs the equilibrium of the masonry and throws the scale frame out of level and causes no end of trouble.

A scale foundation put in on above lines, your committee believes, will give eminent satisfaction and would be the best to be adopted.

C. E. BRADLEY, St. L. & San F. Ry.,
T. M. STRAIN, Wabash Ry.,
Committee.

REPORT: BEST TRACK SCALE FOUNDATION.

MINORITY REPORT.

While a minority of your committee will not attempt to gainsay the fact that the majority have prescribed a good track scale foundation, it is still the belief of a minority of your committee that a stone foundation for track-scales is neither economical nor desirable. It is the experience of your committee that track-scales are moved more frequently to suit the exigencies of yards in which they are placed than any other structure which the Bridge and Building Departments have to maintain, and for this reason, if none of greater importance could be urged, your committee would recommend a pile foundation for this purpose.

Piles of a sufficient number to receive the bearings of the scale members and also to form the supports for a curb entirely around the outside of the scale pit proper and to support the "dead-rail" timbers or sills, sided up with oak plank on the outside of the piles to prevent the dirt from entering the pit, and the piles driven as long as they will go a particle, is, in the opinion of your committee, the best track-scale foundation to be adopted. The character of the location as regards drainage does not enter as it does where stone is used, for the matter of getting bottom is only gauged by the length of pile used; the scale is more easily accessible for repairs, there are no joints to settle and throw the scale out of level, and if the scale has to be moved to another location no very great expense is incurred in such removal. The expense of this foundation is very small compared with that of a stone foundation, and it is the opinion of your committee the pile foundation will be found the best track-scale foundation to be adopted.

O. J. TRAVIS, E., J & E. Ry.,
Committee.

DISCUSSION: SUBJECT—THE BEST SCALE FOUNDATION.

Mr. Doll, C., C., C. & St. L. Ry.—For some of the scales I drive piles, concrete about 2 feet up to 4 feet on top of the piles.

Mr. Reid, Lake Shore and Michigan Southern Railway—I think where it is admissible a concrete foundation should be used, getting below the frost line.

Mr. O. J. Travis—The committee on scale foundation has submitted two reports; in this report is to be found my view on the subject. I favor the pile foundation track scale. Track scales are more frequently moved from place to place than any other structure which we have to-day.

Mr. Markley—We find that stone shatters if used for scales.

Mr. Berg, Lehigh Valley Railway—I will state that I do not consider that the pile foundation is always reliable, as I put in a track scale in a marshy, salt swamp at Jersey City, watched the pile driving carefully, and yet the foundation moved in a short time.

Mr. McGonagle, D. & I. R. Ry.—I have had considerable experience in scale foundation, both in pile and masonry. It is necessary in our country to drive a very firm foundation, on account of frost, and in constructing our scale we always drive first a pile foundation, and then lay a course of large stone and build on this a very durable foundation. The experience we have had is that the masonry foundation is far superior to the pile foundation, especially where it comes through the structure. It is very expensive matter to get at the caps and sills. To prevent the shattering of the walls use oak timbers placed longitudinally.

Mr. Carpenter, C., N. O. & Texas Pac. Ry.—We have scale foundation on stone for 36 to 42 feet scale on tracks joined with about seven feet between the two made twenty-two years ago. We drive piles as long as they will go. A 42-foot scale I built this last summer, a year ago, and the other one about eight or nine years ago; we never have any trouble with them. Farther down we have some foundation built on good clay ground; by being careful to get a good start at the bottom we have never had any trouble. Some of our pile track scales are built of very heavy foundations; on this scale we were continually repairing them as long as we used them.

Mr. White, Texas Midland Railway—As regards track foundation for scales, I think the locality determines it somewhat. The fact is that we live in two countries. We do not have to build below the frost because we do not have any frost. Have a number of track scales foundations built of stone.

Mr. McGonagle, D. & I. R. Ry.—We have very deep frost in our section. In regard to drainage in our country, will say that it is very hilly, and our scales are so situated that it is not at all difficult to drain a sub foundation. We use vitrified sewer pipes.

Mr. Reid, Lake Shore and Michigan Southern Railway—I would remark that on the Lake Shore road on some of the scales we use oak caps and various other kinds of caps. On one of our scales we have 350 cars across this scale in twenty-four hours. It has been in use six years. We have one foundation that is paved and grouted; the drainage is perfect. You can keep the water out of those scales, if a trifle higher than the surrounding road. Our standard cars carry from thirty to thirty-five tons of ore continually.

Mr. Patterson—What kind of scale do you use?

Mr. Reid—We use Fairbanks'.

Mr. Heflin, B. & O. Ry.—I do not suppose that any one will dispute that a good stone foundation is the best for track scales. I know of one that was put in 35 years ago, still good yet; has never had any repairs. Of course, it depends somewhat on the earth you have. Never have had any trouble about a foundation in my section.

Mr. Mallard, Southern Pacific Railway—What are you going to put under your stone foundation; dig down three feet, in my section of the country, and you get a well.

Mr. Markley—We have on the line of our road some twelve or fifteen track scales. There is not one of these twelve or fifteen that has a stone foundation. We have in all cases driven pile foundation. We find it cheaper to drive piling than to have a stone foundation from the fact that stone is liable to shatter. We drive 21 piling under each scale, using timber of course for the superstructure.

Mr. Peck, Mo. Pac. Ry.—My experience is that concrete foundation for scales is better than either stone or piling. The advantage of concrete foundation is that when you dig a trench you can fill it in very readily, and there is no possibility of water coming through, while with a stone foundation this is not the case. It is true it requires some time for concrete foundation to set and get strong; where we build stone-work and want a good foundation, we almost always place concrete under it.

Mr. Markley—I do not know why that portion of the committee that made the minority report should condemn the use of stone. In some sections they can get stone; in others it is not to be had. I have put in a number of scale foundations and have used stone and brick, and in one instance drove 40-foot piles with grillage. I have built quite a number of scale foundations of rubble work; they are good to this day. As far as condemning stone, I think it is the most economical where it can be obtained in suitable sizes. The Cincinnati Southern put in a large track scale with very large stone. They concluded to remodel the yard, which necessitated moving the scales. They took a derrick car and moved the foundation, except the pit, which they filled up. If a stone foundation is put in substantially and solidly it will certainly last well.

Mr. McNab—In soggy ground, where you have to drive piles to get a foundation, 25 to 40 feet, concrete will not do. Everything depends on the soil.

Mr. Peck, Mo. Pac. Ry.—No matter how soft the material, if piling will hold, concrete will also hold, and the solidity of the foundation depends upon the size and thickness of the walls. Where the foundation is very soft, the area of the walls should be increased, so as to secure the necessary strength to prevent them from going down, or straining.

Mr. Markley—Of course, concrete is used very largely in place of timber foundations. Have put some in at $2.35 per yard —the cheapest it was ever done; masonry, $4.50 per yard. An 85 cubic yard job cost us $175 for the stone.

Mr. Mallard, Southern Pacific Railway—We drive piles here, the whole ground is thoroughly saturated, sometimes at a depth of 18 inches it is almost a lake. In lots of places where the piles are too short the buildings have gone down; 30-foot piles will not carry, and in all new buildings 50-foot piles are being used. The custom-house in New Orleans is a sample; it was put in on mud-sills and one end has gone down about 20 inches more than the other. I think the foundation should depend upon the locality in which it is put in. If you have a wet country, soft soil, you certainly have to use piles.

Mr. White, Texas Midland Railway—I have never used concrete for scale foundations, but I like it from the simple fact that I have put in quite a lot of machinery in railroad machine shops, such as shears and heavy machinery. In very soft bottom where I can get sufficient surface of gravel, I use 4x12 or 6x12. We have some foundations that have been in for fifteen, sixteen, eighteen, and twenty years, and the master mechanic informs me that they have never stirred; just as level as when they were put in. I do not see why concrete would not be very good for scale foundations as well as for machinery, as it stands the vibration.

Mr. Damon, Louisville, Nashville & St. Louis Railway—I have put in scales in Tennessee and in Maine. In one instance I used piling, and in the other concrete. In Arkansas, in one instance, I used piling, and in the other concrete; in Maine I did not use piling; used timber foundation. I think in all cases you have to adapt yourself to the situation; whether it requires a pile 5 feet long or 25 feet.

Mr. Mallard—I would like to ask Mr. White if any of these foundations were in Texas?

Mr. White, Texas Midland Railway—Yes, sir. Part of this work that I put in twenty-two or twenty-three years ago was in very soft ground: not more than half the length of the machine shop from there it was hard. I used a very wide foundation for concrete in one case; in the other did not use anything at all. In Texarkana I drove piling, a cluster of piles, then used concrete as Mr. Peck speaks of. For turn-table pits and walls I drive piling, fill the intervening space with concrete, cut off the piles, and fill right up to the top.

Mr. Markley—Was there not some danger of the piles rotting?

Mr. White, Texas Midland Railway—No, sir; the piles are completely covered with concrete. We all know it is at the surface of the ground that the pile rots—as the seamen say, between wind and water. We invariably cut our piles off below the surface. Have never known piles to rot when cut off this way and covered with concrete.

Mr. Mallard, Southern Pacific Railway—It depends a great deal on the character of the country you have to deal with; if you go out in this arid country, where the soil is dry, the piling would rot in the ground.

Mr. Kelleher, New Orleans & N. E. Ry.—I have had a great many scale foundations; and it is all owing to the nature of the soil as to what you use. I have often laid them in brick, and found no settlement whatever. It is entirely owing to the nature of the soil.

Mr. Hanks, Flint and Pere Marquette Railway—I consider a stone foundation, if properly constructed, covered with Portland cement and properly drained, is the best. I would like to say for the information of the members that the F. & P. M. road have a scale tester; they keep it in a car with the weights; with this car they can raise the scales two feet and a half very readily, and with the use of blocks this will allow you to take your scales apart, clean them up, brush them off, and, if you please, paint them, and lower them again. It saves a great deal of expense, by having a test car that we can ship from one point on the road to another; let the weigh master test the scales and report the weights to the tester. The tester does not have to go with the car, unless work is necessary.

Mr. A. McNab—This summer we have built four scale foundations; three of them were built out of rather soft stone, sandstone, and the other out of hard-heads. Up in our country, in the spring of the year, the sun melting the snow and it freezing again at night, affects the stone, not at the bottom, but at the top, causing it to crumble. We have been getting hard stone for all scale foundations that we have put in for the past years. In fact, none of these scales have lasted four years. In putting them in, I think the climate, weather, and the material that you use have a deal to do with the kind of foundation.

Mr. Austin, Boston and Maine Railway—I think you should adapt yourself to the soil. I put in a scale eight years ago, driving piling. Where the stone is either Rockport or Quincy granite, which freezing does not seem to hurt, it makes a good foundation; in soft material, I drive piling, cutting them off about four feet from the surface, where the salt water strikes them, through marshy, murky stuff, then use granite and top off with hard-burned brick. Some put in there eight years ago have never had anything done on them.

CHAPTER IV.*

1, REPORT: STRENGTH OF BRIDGE AND TRESTLE TIMBERS—2, REPORT: SAND DRYERS, ELEVATORS AND METHODS OF SUPPLYING SAND TO ENGINES, INCLUDING BUILDINGS—3, DISCUSSION: SUBJECT, SAND DRYERS, ELEVATORS AND METHODS OF SUPPLYING SAND TO ENGINES, INCLUDING BUILDINGS—4, REPORT BEST METHOD OF SPANNING OPENINGS TOO LARGE FOR BOX CULVERTS, AND IN EMBANKMENTS TOO LOW FOR ARCH CULVERTS—5, DISCUSSION: SUBJECT, BEST METHOD OF SPANNING OPENINGS TOO LARGE FOR BOX CULVERTS AND IN EMBANKMENTS TOO LOW FOR ARCH CULVERTS—6, REPORT: PUMPS AND BOILERS FOR WATER STATIONS—7, DISCUSSION: PUMPS AND BOILERS—7, REPORTS: METHODS AND SPECIAL APPLIANCES FOR BUILDING TEMPORARY TRESTLES OVER WASHOUTS AND BURNOUTS—8, DISCUSSION: SUBJECT, METHODS AND SPECIAL APPLIANCES FOR BUILDING TEMPORARY TRESTLES OVER WASHOUTS AND BURNOUTS—9, REPORTS: BEST METHOD OF ERECTING PLATE GIRDER BRIDGES—PAPER: SUBJECT, PLATE GIRDERS ACROSS THE WISCONSIN RIVER—10, DISCUSSION: SUBJECT, BEST METHOD OF ERECTING PLATE GIRDER BRIDGES—11, PAPER: SUBJECT, REPLACING A TIMBER TRESTLE BY A RIVETED DECK GIRDER BRIDGE.

REPORT: STRENGTH OF BRIDGE AND TRESTLE TIMBERS.

Your committee appointed to report on "Strength of Bridge and Trestle Timbers, with special reference to Southern Yellow Pine, White Pine, Fir, and Oak," desire to present herewith, as part of their report, the very valuable data compiled by the chairman of the committee, relative to tests of the principal American bridge and trestle timbers and the recommendations of the leading authorities on the subject of strength of timber during the last twenty-five years, embodied in the appendix to this report and tabulated for easy reference in the accompanying tables I. to IV.

---

* Reports presented at Fifth Annual Convention, held at New Orleans, La., October, 1895.

The uncertainty of our knowledge relative to the strength of timber is clearly demonstrated after a perusal of this information, and emphasizes, better than long dissertations on the subject, the necessity for more extensive, thorough, and reliable series of tests, conducted on a truly scientific basis, approximating, as nearly as possible, actual conditions encountered in practice.

The wide range of values recommended by the various recognized authorities is to be regretted, especially so when undue influence has been attributed by them in their deductions to isolated tests of small size specimens, not only limited in number, but especially defective in not having noted and recorded properly the exact species of each specimen tested, its origin, condition, quality, degree of seasoning, method of testing, etc.

The fact has been proved beyond dispute that small size specimen tests give much larger average results than full size tests, owing to the greater freedom of small selected tests pieces from blemishes and imperfections and their being, as a rule, comparatively drier and better seasoned than full size sticks. The exact increase, as shown by tests and by statements of different authorities, is from ten to over one hundred per cent.

Great credit is due to such investigators and experimenters as Professors G. Lanza, J. B. Johnson, H. T. Bovey, C. B. Wing, and Messrs. Onward Bates, W. H. Finley, C. B. Talbot, and others, for their experimental work and agitation in favor of full size tests. Professors G. Lanza, R. H. Thurston, and William H. Burr have contributed valuable treatises on the subject of strength of timber. The extensive series of small and full size United States Government tests, conducted in 1880 to 1882, at the Watertown arsenal, under Col. T. T. S. Laidley, and more recently the very elaborate and thorough timber tests being conducted by the United States Forestry Division under Dr. B. E. Fernow, chief, and Professor J. B. Johnson, of Washington University, St. Louis, afford us to-day, in connection with the work of the above mentioned experimenters, our most reliable data from a practical standpoint.

The test data at hand and the summary criticisms of leading authorities seem to indicate the general correctness of the following conclusions:

1. Of all structural materials used for bridges and trestles timber is the most variable as to the properties and strength of different pieces classed as belonging to the same species, hence impossible to establish close and reliable limits of strength for each species.

2. The various names applied to one and the same species in different parts of the country lead to great confusion in classifying or applying results of tests.

3. Variations in strength are generally directly proportional to the density or weight of timber.

4. As a rule, a reduction of moisture is accompanied by an increase in strength; in other words, seasoned lumber is stronger than green lumber.

5. Structures should be in general designed for the strength of green or moderately seasoned lumber of average quality and not for a high grade of well-seasoned material.

6. Age or use do not destroy the strength of timber, unless decay or season-checking takes place.

7. Timber, unlike materials of a more homogeneous nature, as iron and steel, has no well defined limit of elasticity. As a rule, it can be strained very near to the breaking point without serious injury, which accounts for the continuous use of many timber structures with the material strained far beyond the usually accepted safe limits. On the other hand, sudden and frequently inexplicable failures of individual sticks at very low limits are liable to occur.

8. Knots, even when sound and tight, are one of the most objectionable features of timber, both for beams and struts. The full size tests of every experimenter have demonstrated, not only that beams break at knots, but that invariably timber struts will fail at a knot or owing to the proximity of a knot, by reducing the effective area of the stick and causing curly and cross-grained fibers, thus exploding the old practical view that sound and tight knots are not detrimental to timber in compression.

9. Excepting in top logs of a tree or very small and young timber, the heart-wood is, as a rule, not as strong as the material farther away from the heart. This becomes more generally apparent, in practice, in large sticks with considerable heart-wood cut from old trees in which the heart has begun to decay or been wind-shaken. Beams cut from such material frequently season-check along middle of beam and fail by longitudinal shearing.

10. Top logs are not as strong as butt logs, provided the latter have sound timber.

11. The results of compression tests are more uniform and vary less for one species of timber than any other kind of test; hence, if only one kind of test can be made, it would seem that a compressive test will furnish the most reliable comparative results.

12. Long timber columns generally fail by lateral deflection or "buckling" when the length exceeds the least cross-sectional dimension of the stick by twenty, in other words, the column is longer than twenty diameters. In practice the unit stress for all columns over fifteen diameters should be reduced in accordance with the various rules and formulae established for long columns.

13. Uneven end-bearings and eccentric loading of columns produce more serious disturbances than usually assumed.

14. The tests of full-size, long, compound columns, composed of several sticks bolted and fastened together at intervals, show essentially the same ultimate unit resistance for the compound column as each component stick would have if considered as a column by itself.

15. More attention should be given in practice to the proper proportioning of bearing areas; in other words, the compressive bearing resistance of timber with and across grain, especially the latter, owing to the tendency of an excessive crushing stress across grain to indent the timber, thereby destroying the fiber and increasing the liability to speedy decay, especially when exposed to the weather and the continual working produced by moving loads.

The aim of your committee has been to examine the conflicting test data at hand, attributing the proper degree of importance to the various results and recommendations, and then to establish a set of units that can be accepted as fair average values, as far as known to-day, for the ordinary quality of each species of timber and corresponding to the usual conditions and sizes of timbers encountered in practice. The difficulties of executing such a task successfully cannot be overrated, owing to the meagerness and frequently the indefiniteness of the available test data, and especially the great range of physical properties in different sticks of the same general species, not only due to the locality where it is grown, but also to the condition of the timber as regards the percentage of moisture, degree of seasoning, physical characteristics, grain, texture, proportion of hard and soft fibers, presence of knots, etc., all of which affect the question of strength.

Your committee recommends, upon the basis of the test data at hand at the present time, the average units for the ultimate breaking stresses of the principal timbers used in bridge and trestle constructions shown in the accompanying table.

In addition to the units given in the table, attention should be called to the latest formulae for long timber columns, mentioned more particularly in the Appendix to this report, which formulae are based upon the results of the more recent full-size timber column tests, and hence should be considered more valuable than the older formulae derived from a limited number of small-size tests. These new formulae are Professor Burr's App. I.; Professor Ely's, App. J.; Professor Stanwood's, App. K.; and A. L. Johnson's App. V.; while C. Shaler Smith's formulae will be better understood after examining the explanatory notes contained in App. L.

Attention should also be called to the necessity of examining the resistance of a beam to longitudinal shearing along the neutral axis, as beams under transverse loading frequently fail by longitudinal shearing in place of transverse rupture.

In addition to the ultimate breaking unit stress the designer of a timber structure has to establish the safe allowable unit stress for the species of timber to be used. This will vary for each particular class of structures and individual conditions. The selection of the proper "factor of safety" is largely a question of personal judgment and experience, and offers the best opportunity for the display of analytical and practical ability on the part of the designer. It is difficult to give specific rules. The following are some of the controlling questions to be considered:

The class of structure, whether temporary or permanent, and the nature of the loading, whether dead or live. If live, then whether the application of the load is accompanied by severe dynamic shocks and pounding of the structure. Whether the assumed loading for calculations is the absolute maximum rarely to be applied in practice, or a possibility that may frequently take place. Prolonged heavy, steady loading, and also alternate tensile and compressive stresses in the same piece, will call for lower averages. Information as to whether the assumed breaking stresses are based on full-size or small-size tests, or only on interpolated values averaged from tests of similar species of timber, is valuable, in order to attribute the proper degree of importance to recommended average values. The class of timber to be used, and its condition and quality. Finally, the particular kind of strain the stick is to be subjected to, and its position in the structure with regard to its importance and the possible damage that might be caused by its failure.

In order to present something definite on this subject, your committee presents the accompanying table, showing the average safe allowable working unit stresses for the principal bridge and trestle timbers, prepared to meet the average conditions existing in railroad timber structures, the units being based upon the ultimate breaking unit stresses recommended by your committee and the following factors of safety, viz.:

Tension, with and across grain	10
Compression, with grain	5
Compression, across grain	4
Transverse, extreme fiber stress	6
Transverse, modulus of elasticity	2
Shearing, with and across grain	4

In conclusion, your committee desires to emphasize the importance and great value to the railroad companies of the country of the experimental work on the strength of American timbers being conducted by the Forestry Division of the United States Department of Agriculture, and to suggest that the American Association of Railway Superintendents of Bridges and Buildings endorse this view by official action, and lend its aid in every way possible to encourage the vigorous continuance of this series of government tests, which bids fair to become the most reliable and useful work on the subject of strength of American timbers ever undertaken. With additional and reliable information on this subject, far-reaching economies in the designing of timber structures can be introduced, resulting not only in a great pecuniary saving to the railroad companies, but also offering a partial check to the enormous consumption of timber and the gradual diminution of our structural timber supply.

WALTER G. BERG, Chairman, Lehigh Valley Ry.,
J. H. CUMMIN, Long Island Ry.,
JOHN FOREMAN, Phil. & Reading Ry.,
H. L. FRY, C., F. & Y. V. Ry.,
Committee.

AVERAGE ULTIMATE BREAKING UNIT STRESSES, IN POUNDS, PER SQUARE INCH.

RECOMMENDED BY THE COMMITTEE ON "STRENGTH OF BRIDGE AND TRESTLE TIMBERS."

ASSOCIATION OF RAILWAY SUPERINTENDENTS OF BRIDGES AND BUILDINGS.
FIFTH ANNUAL CONVENTION, NEW ORLEANS, OCTOBER, 1895.

KIND OF TIMBER.	Tension.		Compression.			Transverse.		Shearing.	
			With Grain.						
	With Grain.	Across Grain.	End bearing.	Columns under 15 diams.	Across Grain.	Extreme fiber stress.	Modulus of Elasticity.	With Grain.	Across. Grain.
White oak	10,000	2,000	7,000	4,500	2,000	6,000	1,100,000	800	4,000
White pine	7,000	500	5,500	3,500	800	4,000	1,000,000	400	2,000
Southern, Long-Leaf, or Georgia yellow pine	12,000	600	8,000	5,000	1,400	7,000	1,700,000	600	5,000
Douglas, Oregon, and { yellow fir	12,000	....	8,000	6,000	1,200	6,500	1,400,000	600	....
Washington fir or pine { red fir	10,000	....	....	....	....	5,000	....	....	....
Northern or Short-Leaf yellow pine	9,000	500	6,000	4,000	1,000	6,000	1,200,000	400	4,000
Red pine	9,000	500	6,000	4,000	800	5,000	1,200,000	....	....
Norway pine	8,000	....	6,000	4,000	800	4,000	1,200,000	....	....
Canadian (Ottawa) white pine	10,000	....	....	5,000	....	....	....	350	....
Canadian (Ontario) red pine	10,000	....	....	5,000	....	5,000	1,400,000	400	....
Spruce and Eastern fir	8,000	500	6,000	4,000	700	4,000	1,200,000	400	3,000
Hemlock	6,000	....	....	4,000	600	3,500	900,000	350	2,500
Cypress	6,000	....	6,000	4,000	700	5,000	900,000	....	....
Cedar	8,000	....	6,000	4,000	700	5,000	700,000	....	1,500
Chestnut	9,000	....	....	5,000	900	5,000	1,000,000	600	1,500
California redwood	7,000	....	....	4,000	800	4,500	700,000	400	....
California spruce	....	....	....	4,000	....	5,000	1,200,000	....	....

AVERAGE SAFE ALLOWABLE WORKING UNIT STRESSES, IN POUNDS, PER SQUARE INCH.

RECOMMENDED BY THE COMMITTEE ON "STRENGTH OF BRIDGE AND TRESTLE TIMBERS."

ASSOCIATION OF RAILWAY SUPERINTENDENTS OF BRIDGES AND BUILDINGS.
FIFTH ANNUAL CONVENTION, NEW ORLEANS, OCTOBER, 1895.

KIND OF TIMBER.	TENSION.		COMPRESSION.			TRANSVERSE.		SHEARING.	
			With Grain.						
	With Grain.	Across Grain.	End bearing.	Columns under 15 diams.	Across Grain.	Extreme fiber stress.	Modulus of elasticity.	With Grain.	Across-Grain.
FACTOR OF SAFETY.	Ten.	Ten.	Five.	Five.	Four.	Six.	Two.	Four.	Four.
White oak	1,000	200	1,400	900	500	1,000	550,000	200	1,000
White pine	700	50	1,100	700	200	700	500,000	100	500
Southern, Long-Leaf, or Georgia yellow pine	1,200	60	1,600	1,000	350	1,200	850,000	150	1,250
Douglas, Oregon, and Washington fir or pine { yellow fir	1,200	....	1,600	1 200	300	1,100	700,000	150	....
Douglas, Oregon, and Washington fir or pine { red fir	1,000	....	....	....	....	800	....	....	....
Northern or Short-Leaf yellow pine	900	50	1,200	800	250	1,000	600,000	100	1,000
Red pine	900	50	1,200	800	200	800	600,000	....	....
Norway pine	800	....	1,200	800	200	700	600,000	....	....
Canadian (Ottawa) white pine	1,000	....	....	1,000	....	....	....	100	....
Canadian (Ontario) red pine	1,000	....	....	1,000	....	800	700,000	100	....
Spruce and Eastern fir	800	50	1,200	800	200	700	600,000	100	750
Hemlock	600	....	....	800	150	600	450,000	100	600
Cypress	600	....	1,200	800	200	800	450,000	....	....
Cedar	800	....	1,200	800	200	800	350,000	....	400
Chestnut	900	....	....	1,000	250	800	500,000	150	400
California redwood	700	....	....	800	200	750	350,000	100	....
California spruce	....	....	....	800	....	800	600,000	....	....

STRENGTH OF BRIDGE

TABLE 1.—

ULTIMATE BREAKING STRESS, IN

COMPILED FOR THE FIFTH ANNUAL CONVENTION OF THE ASSOCIATION OF

	AUTHORITY	Appendix reference.	DESCRIPTION.	Tension. With Grain. Limits.	Tension. With Grain. Av.	Tension. Across Grain. Lim.	Tension. Across Grain. Av
Recommended Values.	W. J. M. Rankine	A	Red oak		10,250		
			English oak	10,000-19,800			
	Chas. H. Haswell	A	Oak				2,300
			White oak		16,500		
			Live oak		16,380		
			Canadian white oak				
			Red oak		10,250		
			Pennsylvania oak, seasoned		2[illegible],333		
	John C. Trautwine	A	Oak				2,300
			White oak		10,000		
			Live oak		10,000		
			Basket, black, and red oak		10,000		
	Robert H. Thurston	A	Oak				
			White oak		10,000		
			Live oak		10,000		
			Canadian oak				
	Louis DeC. Berg	A	White oak		11,000		2,300
			Red oak		8,000		
			Live oak		11,000		
			Canadian oak		7,500		
	F. E. Kiauer	A	White oak		16,000		
	Malverd A. Howe	A	White oak		10,000		
			Live oak		10,000		
	William Kent	A	Oak				
	A. L. Johnson	W	White oak		10,000		
Results of Small Size Tests.	U. S. Ordnance Depar't, Capt. T. J. Rodman	B. i.	White oak, well seasoned	13,333-25,222			
	Thomas Laslett	B. b.	White oak		7,021		
			Baltimore oak		8,832		
	R. G. Hatfield	B. a.	Oaks, average				
			White oak		19,500		
			Canadian oak				
			Live oak				
	U. S. 10th Census	B. h.	White oak				
			White, post, iron, red, and black oak				
			Scrub and basket oak				
			Chestnut and live oak				
			Pin oak				
	Robert H. Thurston	B. c.	White oak		13,210		
			Live oak		10,310		
	St. Louis Bridge	B. d.	White oak, blocks				
			White oak, round columns				
			Black oak, blocks				
			Black oak, round columns				
	U. S. Ordnance Depar't, Watertown Arsenal	B. f.	White oak	12,670-22,703	17,410		
			Red oak	7,600-12,183	10,124		
			Yellow oak	20,260-20,520	20,390		
Results of Full Size Tests.	G. Lanza	D. c.	White oak, 36 beams				
		G. a.	White oak, 10 posts and blocks				
		G. a.	White oak, 18 old posts				
	D. Kirkaldy & Son	E. b.	White oak, 5 beams, 5 feet span				
			White oak, 5 beams, 11 feet span				
			White oak, 5 posts, about 6 diams				
			White oak, 5 posts, about 11 diams				
			White oak, 5 posts, about 23 diams				

AND TRESTLE TIMBERS.

OAK.

POUNDS, PER SQUARE INCH.

RAILWAY SUPERINTENDENTS OF BRIDGES AND BUILDINGS, OCTOBER, 1895, BY WALTER G. BERG.

Compression.					Transverse.				Shearing.			
With Grain.		Across Grain.			Extreme Fiber Stress.		Modulus of Elasticity.		With Grain.		Across Grain.	
Limits.	Av.	Limits.	Indentation.	Av.	Limits.	Av.	Limits.	Av.	Limits.	Av.	Lim.	Av.
	6,600					10,600		2,150,000				
	10,000				10,000-13,600		1,200,000-1,750,000			2,800		4,000
				2,800				1,710,000		780		4,032
	7,500					10,800						
	6,850					11,520						
	5,982					10,512						
						9,720						
5,000- 7,000	6,000						1,000,000-2,000,000	1,500,000	400-700			
						10,800						4,425
						10,800						8,480
						15,300						
										780		4,000
5,500- 8,000						11,000						
8,000-10,000						12,000						
						10,000						
	7,200			2,400		7,200		900,000		800		4,400
	6,000					6,500		1,200,000		750		
	6,850			4,500		7,300				700		8,500
	6,000					7,000						
3,150- 7,000						5,670		1,240,000		780		4,400
	7,000		1-10 in.	1,600				1,500,000		850		4,400
	7,000		1-10 "	1,600				1,500,000				
							974,000-2,283,000					
	4,000		3 pr ct.	1,200		6,000		1,100,000		800		
4,691-10,058					8,460-17,340							
	6,964					10,900		1,330,000				
	5,891					9,800		1,770,000				
						8,550		1,114,560				
6,531- 9,775	8,000		1-20 in.	2,650		11,700		1,339,200	1,076-1,474	1,250		
						10,600		1,929,312				
	11,100		1-20 "	6,800								
			1-100 "	1,600								
5,810- 9,070			1-10 "	4,000	7,010-18,360		879,000-2,103,000					
	7,000		1-10 "	4,000								
	6,000		1-10 "	4,200								
	7,500		1-10 "	4,500								
	6,500		1-10 "	3,000								
	7,140					9,840		1,620,000				
	10,410					11,280		1,851,428				
3,200- 3,778	3,505	1,300-2,200		1,750								
6,000-12,200	7,812											
		1,600-2,000		1,800								
5,400- 6,980	6,101											
	7,192		1-20 "	2,850						842		
										803		
					3,535- 7,834	5,863	744,774-1,777,500	1,131,100				
3,132- 4,450	3,470											
2,943- 6,147	3,957											
						6,890						
						8,550						
	3,285											
	3,418											
	2,891											

STRENGTH OF BRIDGE

TABLE 2.—

ULTIMATE BREAKING STRESS, IN

COMPILED FOR THE FIFTH ANNUAL CONVENTION OF THE ASSOCIATION OF

	AUTHORITY.	Appendix reference.	DESCRIPTION.	Tension.			
				With Grain.		Across Grain.	
				Limits.	Av.	Lim.	Av.
Recommended Values.	Chas. H. Haswell	A	White pine		11,800		550
	John C. Trautwine	A	White pine		10,000		550
	Robert H. Thurston	A	White pine	3,000–7,500			
	Louis DeC. Berg	A	White pine		9,000		550
	F. E. Kidder	A	White pine		7,000		
	Malverd A. Howe	A	White pine		10,000		
	H. T. Bovey	M	Canadian (Ottawa) white pine				
	A. L. Johnson	W	White pine		7.000		
	W. M. Patton	A	White pine		7,000		
Results of Small Size Tests.	U. S. Ordnance Depar't, Capt. T. J. Rodman	B. i.	White pine, well seasoned	11,433–11,960			
	R. G. Hatfield	B. a.	White pine		12,000		
	U. S. 10th Census	B. h.	White pine				
	Robert H. Thurston	B. c.	White pine		6,880		
	St. Louis Bridge	B. d.	White pine, blocks				
			White pine, columns				
	F. E. Kidder	B. e.	White pine				
	U. S. Ordnance Depar't,	B. f.	White pine	5,300–11,299	8,916		
	Watertown Arsenal	Q	White pine, resistance to keys tearing out				
	H. T. Bovey	M	Canadian (Ottawa) white pine	8,503–14,273	11,396		
Results of Full Size Tests.	H. T. Bovey	M. I.	Canadian (Ottawa) white pine, 15 beams				
		M. II.	Canadian (Ottawa) white pine, 68 posts				
	U. S. Ordnance Depar't,	H. a.	White pine, posts, under 32 dia.				
	Watertown Arsenal		White pine, posts 32–62 diams				
	G. Lanza	D. d.	White pine, 37 beams				
			Western white pine, kiln dried, 8 beams				
	Onward Bates	R. a.	White pine, new and old, 30 b'ms				
		R. b.	White pine, new, 14 beams				
	W. H. Finley	S	White pine, 31 years in use, 12 beams.				
			White pine, new, 2 beams				

AND TRESTLE TIMBERS.

WHITE PINE.

POUNDS, PER SQUARE INCH.

Railway Superintendents of Bridges and Buildings, October, 1895, by Walter G. Berg.

Compression.					Tranverse.				Shearing.			
With Grain.		Across Grain.			Extreme Fiber Stress.		Modulus of Elasticity.		With Grain.		Across Grain.	
Limits.	Av.	Lim.	Indentation.	Av.	Limits.	Av.	Limits.	Av.	Lim.	Av.	Lim.	Av.
....	5,775	....	....	550	....	9,000	....	1,830,000	....	490	....	....
5,000-7,000	6,000	....	....	....	....	8,100	....	1,600,000	250-500	....	....	2,480
3,000-6,000	....	....	....	....	....	....	....	1,000,000	....	490	....	....
....	5,500	....	....	700	....	4,000	....	850,000	....	450	....	2,500
2,800-4,500	....	....	....	....	....	4,320	....	1,073,000	....	490	....	2,480
....	5,400	....	1-10 in.	600	....	....	....	1,750,000	....	325	....	2,480
....	5,000	....	....	....	....	....	....	....	....	....	....	....
....	3,500	....	3 pr ct.	440	....	4,400	....	870,000	....	300	....	....
....	9,500	....	....	....	....	9,000	....	....	....	482	....	2,480
5,017-5,775	....	....	....	....	6,798-7,092	....	....	....	....	....	....	....
5,579-7,502	6,650	....	1-20 in.	800	....	9,000	....	1,252,800	433-530	480	....	....
3,750-5,600	5,400	....	1-100 " 1-10 "	600 1,200	5,610-11,530	....	868,000-1,478,000	....	....	....	....	....
....	9,590	....	....	....	....	5,280	....	883,636	....	....	....	....
3,083-3,694	3,261	555-722	....	611	....	....	....	....	....	....	....	....
3,580-3,900	3,727	....	....	....	....	....	....	....	....	....	....	....
....	....	....	....	....	7,578-9,440	8,297	1,251,252-1,461,728	1,388,497	....	....	....	....
....	5,617	....	1-20 "	1,045	....	....	....	....	....	370	....	....
....	....	....	....	....	....	....	....	....	236-611	421	....	....
....	....	....	....	....	....	....	....	....	273-382	....	....	....
....	....	....	....	....	2,500-4,986	3,388	433,250-1,184,240	754,265	....	....	....	....
....	3,843	....	....	....	....	....	....	....	....	....	....	....
1,687-3,700	2,414	....	....	....	....	....	....	....	....	....	....	....
1,000-2,000	....	....	....	....	....	....	....	....	....	....	....	....
....	....	....	....	....	2,456-7,251	4,451	727,200-1,565,000	1,122,000	....	....	....	....
....	....	....	....	....	....	5,482	....	1,183,087	....	....	....	....
....	....	....	....	....	2,350-5,376	3,872	712,500-1,480,900	1,098,000	....	....	....	....
....	....	....	....	....	2,160-5,131	3,694	....	....	....	....	....	....
....	....	....	....	....	5,139-10,616	7,051	715,000-1,900,000	1,208,250	....	....	....	....
....	....	....	....	....	....	5,402	....	982,500	....	....	....	....

STRENGTH OF BRIDGE

TABLE 3.—SOUTHERN YELLOW PINE, LONG-LEAF YELLOW

ULTIMATE BREAKING STRESS, IN

COMPILED FOR THE FIFTH ANNUAL CONVENTION OF THE ASSOCIATION OF RAIL-

	Authority.	Appendix reference.	Description.	Tension. With Grain. Limits.	Tension. With Grain. Av.	Tension. Across Grain. Lim.	Tension. Across Grain. Av.
Recommended Values.	W. J. M. Rankine	A	Yellow pine				
	Chas H. Haswell	A	Pitch pine				550
			Yellow pine		13,000		550
			Virginia pine		19,200		550
			Georgia pine				550
	John C. Trautwine	A	Yellow pine		10,000		550
			Georgia yellow pine				
			Pitch pine		10,000		
	Robert H. Thurston	A	Yellow pine	5,000-12,000			
			Pitch pine	8,000-10,000			
	Louis DeC. Berg	A.	Yellow pine		9,000		
			Georgia yellow pine		12,000		
			Pitch pine		10,000		
	F. E. Kidder	A	Yellow pine		16,000		
	Malverd A. Howe	A	Southern yellow pine		10,000		
	G. Lanza	D. b.	Yellow pine				
	A. L. Johnson	W	Long-leaf pine		12,000		
	W. M. Patton	A	Yellow pine		20,700		
Results of Small Size Tests.	U. S. Ordnance Depar't, Capt. T. J. Rodman	B. i.	Yellow pine, well seasoned	12,600-19,200			
	Thomas Laslett	B. b.	Pitch pine		4,666		
	R. G. Hatfield	B. a.	Georgia pine		16,000		
			Pitch pine				
	U. S. 10th Census	B. h.	Long-leaf Georgia pine				
	Robert H. Thurston	B. c.	Yellow pine		20,700		
	St Louis Bridge	B. d.	Yellow pine, blocks				
			Yellow pine, columns.				
	F. E. Kidder	B. e.	Yellow pine				
	U. S. Ordnance Depar't,	B. f.	Yellow pine	12,066-17,922	15,478		
	Watertown Arsenal	Q.	Yellow pine, resistance to keys tear'g out				
	U. S. Forestry Departm't, Bulletin No. 8	C	Long-leaf pine, from Alabama	4,170-31,890	16,029		
Results of Full Size Tests.	U. S. Forestry Departm't, Bulletin No. 8	C	Long-leaf pine, from Alabama				
	G. Lanza	D. b.	Yellow pine, 51 beams				
		G. a.	Yellow pine, 18 posts and blocks				
	U. S. Ordnance Depar't,	H. a.	Yellow pine, posts under 22 diams				
	Watertown Arsenal	H. a.	Yellow pine, posts 22 to 62 diams				
		H. c.	Yellow pine, straight grain, well seasoned, 12 posts				
			Yellow pine, very slow growth, 3 posts				
			Yellow pine, very green and wet, 3 posts.				

AND TRESTLE TIMBERS.

PINE, GEORGIA YELLOW PINE, AND SOUTHERN PITCH PINE.

POUNDS, PER SQUARE INCH.

WAY SUPERINTENDENTS OF BRIDGES AND BUILDINGS, OCTOBER, 1895, BY WALTER G. BERG.

Compression.					Transverse.				Shearing.			
With Grain.		Across Grain.			Extreme Fiber Stress.		Modulus of Elasticity.		With Grain.		Across Grain.	
Limits.	Av.	Limits.	Indentation.	Av.	Limits.	Av.	Limits.	Av.	Lim.	Av.	Lim.	Av.
...	5,400	...	...	...	...	...	...	...	...	...	...	...
...	8,947	...	...	550	...	9,864	...	2,480,000	...	510	...	...
...	...	...	...	550	...	9,360	...	...	...	...	...	...
...	8,200	...	...	550	...	...	...	...	...	...	...	...
...	...	...	...	550	...	14,400	...	...	...	...	...	...
...	...	...	...	...	...	9,000	...	1,600,000	...	...	4,340-5,785	...
...	...	...	...	...	...	15,300	...	...	...	...	...	5,735
...	...	...	...	...	...	9,900	...	...	...	...	...	5,058
6,500-10,000	...	...	...	...	...	7,000	...	1,600,000	...	510	...	...
...	...	...	...	...	...	8,000	...	1,900,000	...	...	...	...
...	5,400	...	...	...	...	6,000	...	1,100,000	...	...	...	4,800
...	7,400	...	...	1,850	...	7,200	...	1,200,000	...	500	...	5,700
...	8,900	...	...	...	...	6,600	...	1,225,000	...	510	...	5,000
4,400-6,000	...	...	...	...	...	6,750	...	1,780,000	...	510	...	5,700
...	8,500	...	1-10in	1,800	...	...	...	1,600,000	...	325	...	5,700
...	...	...	...	...	...	5,000	...	...	...	...	...	...
...	5,000	...	3 p.c.	645	...	7,750	...	1,440,000	...	500	...	...
...	11,500	...	...	...	...	15,000	...	...	...	848	...	5,735
7,836-8,350	...	...	...	...	8,796-11,676	9,972	...	...	...	...	...	...
...	6,462	...	...	...	...	11,900	...	1,900,000	...	...	...	...
8,170-11,508	9,500	...	1-20in	2,250	9,000-21,168	15,300	...	2,468,800	713-934	840	...	...
...	...	...	...	...	...	9,792	...	1,225,152	...	...	...	...
4,010-10,600	8,500	...	1-100 1-10 "	1,300 2,609	9,220-21,060	...	879,000-2,878,000	...	...	...	...	...
...	11,950	...	...	...	...	16,740	...	3,534,727	...	...	...	...
4,500-4,917	4,722	1,000-1,222	...	1,092	...	...	...	...	...	...	...	...
4,650-4,820	4,735	...	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	12,280-14,654	13,048	1,707,282-1,926,160	1,821,680	...	...	...	...
...	...	...	1-20 "	1,900	...	...	...	...	...	352	...	...
...	...	...	...	...	...	...	...	...	337-720	512	...	...
4,567-9,850	7,228	584-2,094	15p.c.	1,517	...	...	...	...	464-1,299	852	...	...
...	...	...	...	...	4,268-16,200	12,250	842,000-3,117,870	2,069,650	...	...	...	...
...	...	...	...	...	3,963-11,360	7,486	1,162,467-2,886,096	1,757,900	...	...	...	...
3,604-5,452	4,544	...	...	...	...	...	...	...	...	...	...	...
3,430-5,677	4,442	...	...	...	...	...	...	...	...	...	...	...
1,700-3,500	...	...	...	...	...	...	...	...	...	...	...	...
5,593-8,644	7,386	...	...	...	...	...	...	...	...	...	...	...
7,820-10,250	9,339	...	...	...	...	...	...	...	...	...	...	...
2,795-3,180	3,015	...	...	...	...	...	...	...	...	...	...	...

STRENGTH OF BRIDGE

TABLE 4.—DOUGLAS, OREGON, WASHINGTON,

ULTIMATE BREAKING STRESS, IN

COMPILED FOR THE FIFTH ANNUAL CONVENTION OF THE ASSOCIATION OF RAILWAY SUPER-

	AUTHORITY	Appendix reference.	DESCRIPTION.	Tension. With Grain. Limits.	Tension. With Grain. Av.	Tension. Across Grain. Lim.	Tension. Across Grain. Av.
RECOMMENDED VALUES.	Robert H. Thurston	A	Oregon pine	9,000-14,000			
			California spruce	12,000-14,000			
	F. E. Kidder	A	Oregon pine		13,800		
			Oregon spruce				
	H. T. Bovey	M	Douglas fir				
			Douglas fir, specially selected				
			Douglas fir, ordinary first qual.				
	Arthur Brown, Southern Pacific Ry	O. b.	Pacific Northwest (Douglas) fir		15,900		
	A. L. Johnson	W	Douglas fir				
RESULTS OF SMALL SIZE TESTS.	U. S. Ordnance Depar't, Capt. T. J. Rodman	B. i.	Oregon yellow fir	13,633-16,333			
			Oregon red fir		12,867		
			Oregon white fir		14,533		
	U. S. 10th Census	B. h.	Red and yellow Douglas fir				
	W. B. Wright	O. d.	Red fir		10,872		
			Yellow fir		11,550		
	Oregon & California R.R.	O. e.	Douglas fir		16,600		
			Oregon sugar pine		11,000		
	Robert H. Thurston	O. c.	Oregon pine				
			California spruce				
	U. S. Ordnance Depar't, Watertown Arsenal	B. f.	Oregon pine		13,810		
			Oregon spruce		16,160		
	A. T. Bovey	M. III	Douglas fir, 71 tests	2,485-13,856	11,612		
		M. IV	Douglas fir				
	John D. Isaacs, Southern Pacific Ry	T	Douglas fir		15,900		
RESULTS OF FULL SIZE TESTS.	Onward Bates	B. c.	Douglas fir, 12 beams				
			Douglas fir, 10 beams (omitting 2 bad sticks)				
	A. T. Bovey	M. I.	Douglas fir, specially selected, 4 beams				
		M. I.	Douglas fir, ordinary first quality, 15 beams				
		M. II.	Douglas fir, 122 posts				
		M. I.	British Colum. spruce, 3 beams				
		M. II.	British Colum. spruce, 69 posts				
	C. B. Talbot, Northern Pacific R. R	N. a.	Wash'n yel. fir, 5 small beams				
		N. e.	Washington fir, hard, fine grain, 1 small beam				
			Washington pine, fine grain, 1 small beam				
	A. J. Hart, Chic., Mil. & St. Paul R.R.	N. b.	Washington yellow fir, green, 4 beams				
			Washington yellow fir, 6 years seasoned, 2 beams				
	A. J. Hart & C. B. Talbot	N. c.	Washington fir, 9 beams				
	S. Kedzie Smith	N. d.	Washington yellow fir, close grain, 2 beams				
			Washington red fir, 8 beams				
		O. a.	Washington yellow and red fir, 19 beams				
	State of Washington Chapter, American Inst. Architects	N. f.	Douglas fir, 11 beams				
			Washington yel. fir, 13 beams				
			Washington red fir, 11 beams				
			Average of all tests				
	Charles B. Wing	U	Douglas fir, ordinary No. 1, merchantable, 10 beams				
			Douglas fir, ordinary No. 1, Merchantable, 10 small beams				

AND TRESTLE TIMBERS.
AND CALIFORNIA FIR, PINE, AND SPRUCE.
POUNDS, PER SQUARE INCH.

INTENDENTS OF BRIDGES AND BUILDINGS, OCTOBER, 1895, BY WALTER G. BERG.

Compression. With grain. Limits.	Compression. With grain. Av.	Compression. Across Grain. Lim.	Compression. Across Grain. Indentation.	Compression. Across Grain. Av.	Transverse. Extreme Fiber Stress. Limits.	Transverse. Extreme Fiber Stress. Av.	Transverse. Modulus of Elasticity. Limits.	Transverse. Modulus of Elasticity. Av.	Shearing. With Grain. Lim.	Shearing. With Grain. Av.	Shearing. Across Grain. Lim.	Shearing. Across Grain. Av.
9,200-11,500						11,071						
9,200-12,800						12,228						
										840		
										310		
	6,000									400		
						9,000		2,000,000				
						6,000		1,430,000				
	6,000					13,630		1,272,000		600		
	4,400		3 per ct.	500		6,600		1,380,000				
7,488-9,217					7,740-10,944							
	7,083					6,728						
	6,644					4,194						
4,880-9,300					8,220-17,920		1,308,000-2,579,000					
	6,099					15,894						
	6,132					15,080						
	3,085		2-100 in.	1,000		8,658			515-833	689		
	3,391		4-100 "	1,000		8,370						
9,200-11,500						11,071						
9,200-12,800						12,228						
	8,597		1-20 "	1,150		17,228				786		
	5,772		1-20 "	695						311		
									377-411	408		
	6,000							1,272,000		600		
					3,597-7,544	5,791						
					5,268-7,544	6,214						
					8,020-10,441	9,054	1,934,500-2,178,100	2,036,529				
					4,027-8,882	6,081	926,500-1,770,563	1,431,209				
	5,974											
					4,614-5,906	5,120	1,011,450-1,528,499	1,208,633				
	3,617											
					6,890-9,720	7,847						
						9,720						
						5,116						
					6,143-7,982	7,323						
					5,935-6,088	6,020						
					5,263-7,561	6,278						
					7,500-8,160	7,830						
					4,255-6,138	5,186						
					3,530-8,160	5,420						
						5,979						
						7,402						
						5,186						
						6,359						
					5,580-7,951	6,482						
					6,438-12,056	9,257						

APPENDIX A.

EXPLANATORY OF TABLES, SHOWING STRENGTH OF BRIDGE AND TRESTLE TIMBERS. TABLES 1 TO 4.

These tables were compiled to show all the information available in regard to the strength of the principal American bridge and trestle timbers. The literature consulted covers the period since 1875 to date, and the endeavor has been to take into consideration all important test results or recommendations of eminent engineering authorities during that time.

Unless otherwise stated, the timbers mentioned are invariably to be considered as American. Considerable trouble is caused in a compilation of this kind to classify the results properly, owing to the different and also the indefinite names used by the various authors and engineers in describing the species of wood tested or referred to.

The explanatory data for the small-size tests, mentioned in the tables, are recorded in Appendix "B," while the full-size and very valuable tests are given in considerable detail in special articles under various headings of the Appendix.

The average values for strength of timbers recommended by different authorities, as given in the tables, are of interest as showing the results of the studies and researches of these parties. While a great many of the unit values given are merely the work of compilation from the best available data and in many cases clearly copied from previous publications, still a great many of the results are from individual experience or unpublished tests. At any rate, each author has carefully sifted the information at his command, correcting and adjusting it according to his best ability.

Below will be found a few notes in regard to the professional standing of the authors consulted.

Prof. W. J. M. Rankine, the celebrated English engineering authority and experimenter on strength of timber, author of "Applied Mechanics," "Manual of Engineering," etc.

Prof. Robert H. Thurston, Cornell University, Ithaca, N. Y. (formerly Stevens Institute of Technology, Hoboken, N. J.), author of "Materials of Engineering," "Materials of Construction," and numerous technical books; writer and experimenter on strength of timber.

John C. Trautwine, civil engineer, author of "Trautwine's Civil Engineer's Pocket-Book;" writer and experimenter on strength of timber.

F. E. Kidder, civil engineer and architect, Denver, Col., author of "Kidder's Architects and Builders' Pocket-Book;" writer and experimenter on strength of timber.

Louis De C. Berg, architect, New York City, member American Society Civil Engineers, author of "Safe Building."

A. L. Johnson, civil engineer, in charge of U. S. Forestry Division physical timber tests under the direction of Prof. J. B. Johnson, Washington University, St. Louis, Mo.

Prof. Malverd A. Howe, Rose Polytechnic Institute, Terre Haute, Ind.

Prof. Gaetano Lanza, Massachusetts Institute of Technology, Boston, Mass., well-known writer and experimenter on the strength of timber, author of "Applied Mechanics."

William Kent, mechanical engineer, New York City, author of "Kent's Mechanical Engineer's Pocket-Book," associate editor of Engineering News; well known writer and compiler of experimental statistics.

Prof. Wm. H. Burr, Columbia College, New York City, author of "The Elasticity and Resistance of the Materials of Engineering."

R. G. Hatfield, architect, New York City, author of "Transverse Strains" (1877), and "American House Carpenter;" experimenter on strength of timber.

Thomas Laslett, English writer and experimenter on strength of timber, author of "Timber and Timber Trees" (1875).

Col. T. T. S. Laidley, in charge U. S. Ordnance Department timber tests, Watertown arsenal, 1880 and 1881, (Ex. Doc. No. 12, 47th Congress, 1st session, and Ex. Doc. No. 1, 47th Congress, 2d session).

Capt. T. J. Rodman, in charge U. S. Army Department timber tests, published in the "Ordnance Manual."

T. P. Sharples, in charge of American timber tests for tenth census, 1880, published in Vol. IX., on the "Forests of North America;" also in tests of materials, U. S. Ordnance Department, 1883, Ex. Doc. No. 5, 48th Congress, 1st session, summary, page 568.

Prof. Henry T. Bovey, McGill University, Montreal, Canada, writer and experimenter on strength of Canadian timbers.

Charles H. Haswell, author of Haswell's "Mechanics and Engineers' Pocket-Book."

W. M. Patton, professor of civil engineering in Virginia, and author of a "Treatise on Civil Engineering."

Continuation of the Appendix to the report on Strength of Bridge and Trestle Timbers is printed seperately in back of book where the detailed results of various valuable series of timber tests are treated under the following heads:

Appendix B—Record of Timber Tests, with Small Specimens.

Appendix C—U. S. Forestry Division Tests of Long-leaf Pine, Including Tables of "Range of Mechanical Properties of Long-leaf

Pine." "Notes and Characteristics of Southern Timber Pines."

Appendix D—Professor Lanza's Full-sized Transverse Tests.
Appendix E—Miscellaneous Full-sized Tests.
Appendix F—Longitudinal Shearing Under Transverse Strain.
Appendix G—Professor Lanza's Full-sized Tests of Timber Columns.
Appendix H—U. S. Government Full-sized Tests of Timber Columns.
Appendix I—Professor Burr's Formulas for Timber Columns.
Appendix J—Professor Ely's Formulas for Timber Columns.
Appendix K—Professor Stanwood's Formulas for Timber Columns.
Appendix L—C. Shaler Smith's Formulas for Timber Columns.
Appendix M—Professor Bovey's Full-sized Tests of Canadian Douglas Fir, Red Pine, White Pine, and Spruce.
Appendix N—Report of Washington State Chapter, American Institute of Architects, on Strength of State of Washington Timbers.
Appendix O—Miscellaneous Tests of the Northwest and Pacific Coast Timbers.
Appendix P—Professor Soule's Tests of California Redwood.
Appendix Q—United States Government Watertown Arsenal Tests of the Shearing Strength of Timber with the Grain Resisting the Pulling Out of Pins and Keys.
Appendix R—Transverse Tests of Full-sized Old and New Bridge Stringers Made for the Chicago Milwaukee and St. Paul Railway, Under the Direction of Mr. Onward Bates.
Appendix S—Comparative Transverse Tests of Full-size Old and New White Pine Bridge Stringers, Made by Mr. W. H. Finley, for the Chicago and Northwestern Railway.
Appendix T—Tests of Douglas Fir and California Redwood, Made for the Southern Pacific Railway by Mr. John D. Isaacs.
Appendix U—Professor Wing's Full-size Transverse Tests of Douglas Fir.
Appendix V—Mr. A. L. Johnson's Formula for Timber Columns.
Appendix W—Mr. A. L. Johnson's Recommendations for Unit Values.
Also diagram of ultimate breaking weight of yellow pine columns and other valuable notes and information.

REPORT: SAND DRIERS, ELEVATORS AND METHOD OF SUPPLYING SAND TO ENGINES, INCLUDING BUILDINGS.

On April 20, 1895, a circular letter was sent out to many members of this association, civil engineers, superintendents of motive power and machinery, and editors of railroad journals. Many of them responded to them by letters, and others by both letters and blue prints, for which the thanks of the association and the committee are due, for the assistance rendered it in making its report. Some of these blue prints contain a large amount of detailed information which will be instructive to those that desire to avail themselves of their contents.

It was quite apparent that it would be impossible for your committee to recommend any standard plant for general purposes throughout the country. The amount of sand used at any given point will largely depend on the character of the plant that should be erected and amount to invest, but the committee has no hesitancy in recommending that wherever the amount of sand used justifies the establishment of a sand drying plant, no railroad company can afford to do without an elevated dry-sand hopper, so sand can be taken same as water. The additional expense will not exceed one hundred dollars. To supply engines with sand with buckets, as is done in many cases, requiring one to two men in addition to engine man, is dispensed with, thus saving the expense of two men which consumes in sanding each engine from eight to ten minutes' time. The saving in this direction is apparent on an investment of one hundred dollars, as well as the liability of the men dropping sand on guides, etc., of the engine when supplying sand to same with buckets, which at times is unavoidable. With the elevated hopper one man can do the work of three men. At places where the expense of elevating the sand machinery is not justified, the man that attends to drying the sand with a windlass and self-dumping bucket can elevate sand at leisure times, sufficient to supply twenty-five to thirty engines per day. In connection with this work, if engine supply of waste and oil is close, he can also attend to these supplies.

The Chicago and Eastern Illinois R. R. has similar arrangements to the above referred to at Momence Junction, Ill., which is handled in this manner by one man at a dollar and twenty-five cents per day, the entire plant costing complete less than four hundred and seventy-five dollars, including wet-sand bin, with a capacity of twenty carloads of sand. In all cases in cold country the green-sand bin should be large enough to hold the entire winter supply where it is possible, in order to save the expense of unloading frozen sand from cars. The hopper should be of sufficient capacity that when filled will supply the demand during the night.

At terminals where a large quantity of sand is consumed, and where air and steam are utilized for other purposes as well, the former can be used for elevating the sand much cheaper than by elevator. The greater part of this expense will be the air supply requiring no other machinery to maintain. In the use of air all pipes so used should be under cover, and any moisture that accumulates in the air pipes while not in use can be eliminated by running the air through them before sand is started. The committee is not in possession of sufficient data to recommend drying sand by steam radiation, though there are a number of them in use. Blue prints are submitted to this convention, describing that method of sand drying for your information. The objections the committee has to offer for its use for this purpose, being in its natural form is in itself damp, whether the dampness from the sand and steam would not deter the sand from drying as readily as it should, more particularly where dried in large quantities, the steam and wet sand causing and containing moisture which could not pass off readily in the open atmosphere without first passing through at least part of the sand. Where steam is used for this purpose, the boiler supplying it should be located as near the sand dryer as possible, that the steam passing through the coils may be as dry as possible, thus reducing the dampness to a minimum.

Another objection is the cost of maintenance, which in the committee's opinion, would far exceed that of the ordinary stove that is used for that purpose. The repairs on the former must be done with skilled labor, while the latter can be repaired with common labor. One ordinary sand drying-stove will in ten hours dry enough sand for fifty to fifty-five engines, as much as is usually required at one terminal of ordinary sized road in that length of time, or twenty-four hours. The character of the building should be fire-proof in every particular, and so located that sand can be taken in connection with coal, water, and oil on the same track, either going to or coming from the engine-house where possible. A large per cent. of labor can be saved where green sand track can be elevated. By this means gravitation can be used, which will reduce the cost to the minimum.

SAND PLANT OF THE PITTSBURG, FORT WAYNE & CHICAGO RAILWAY AT FORT WAYNE, IND

Frame building, 22x30. Elevated 11 feet 8 inches above main track. Two bins for green sand, 12 feet 6 inches by 9 feet. Immediately opposite these bins are two sand-drying stoves, and opposite stoves are hoppers for dry sand. Building is so arranged with elevated coal track on one side to unload green sand into bin from car and track on opposite side for engines to take sand from. Dry sand hopper 5 feet wide, 30 feet long, and 4 feet high, floor of which inclines towards outlet spout to engine. Floor of green sand and drying sand department are on same elevation from which dry sand is shovelled into dry sand hopper, thus dispensing with the expense of elevating dry sand by machinery. (Fig. 77.)

SAND PLANT OF THE PENNSYLVANIA COMPANY, SIXTEENTH STREET, CHICAGO, ILL.

Building located on level with main track, 32 feet long, 14 feet wide, built of brick, with stone foundation. Truss over main building of iron and covered with slate. Tower for elevator 29 feet and 2 inches above foundation, 15 feet 8½ inches of upper section of iron, in which dry-sand hopper and upper elevator attachment are located. Sixteen and one-half feet of one end of this building used for storing green sand, and remainder used for drying stove

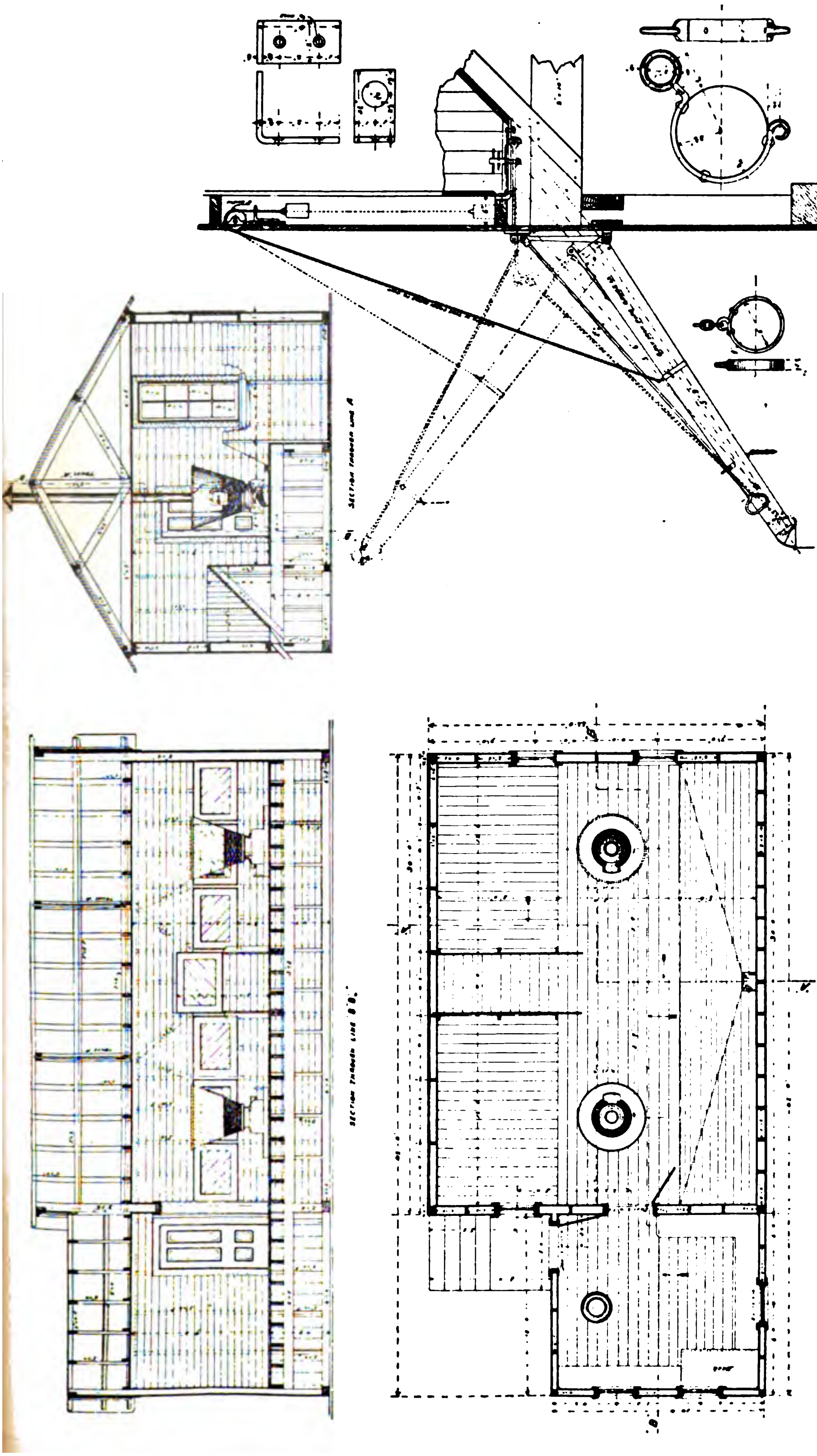


FIG. 77.—SAND PLANT OF THE PITTSBURG, FORT WAYNE AND CHICAGO R. R. AT FT. WAYNE, IND.

and hoisting engine. The hoisting engine being run by compressed air supplied by Westinghouse compressor located 300 feet away, which also furnishes air for coal hoist and pressure for oil tank. Elevator located near sand-drying stove, where dry sand is shovelled direct from floor around stove to boot of elevator. Elevator shafts 24 feet on centers. Hopper for dry sand 4 inches high, 7 feet wide at top, 6 feet 3 inches long, bottom of which is inclined towards outlet spout at an angle of 35 degrees. In both of the above plants sand is taken in the same manner as water, with number 22 galvanized iron spout 6 inches in diameter at the butt and 4 inches in diameter at the outer end, 5 feet 9 inches long. Sand valve operated by lever which is nearly same length as spout to which it is looped at the outer end. By this means spout and lever is raised and lowered at the same time by chain and weight attachments.

Mr. N. W. Thompson, superintendent B. & B., P., F. W. & C. Railway, reports as follows: Blue prints showing this system in use on his road. "At Fort Wayne the sand house is located at the coaling yard, which is elevated on natural ground 11 feet 8 inches above main track rail. The sand is shovelled from cars into wet sand bins through doors at the back of the building, from there it is shovelled into the drying hopper, which is nothing more nor less than a heavy wire surrounding a so-called No. 1 common stove heated with bituminous coal, the sand as it dries falls upon the floor and is shovelled into a hopper, to which is attached a movable spout which supplies the sand direct to the engine sand boxes, as shown by blue print.

"At Chicago the arangement is somewhat different, as the tracks are all on the same level. The sand is shovelled into wet sand bin, as is done at Fort Wayne, thence to the drying stove, the dry sand being shovelled into a hopper, and by means of a conveyor is elevated to another bin from which a movable spout leads to sand box of engine, as at Fort Wayne. The power to run conveyor is taken from a small (about ¾ horse power) engine, operated by compressed air drawn from storage track, also shown on blue print. The air storage tanks are kept supplied from Westinghouse compressor located in our electric light plant about one block away. As to the cost of these sand-drying plants and of operating them I am unable to give the figures, not having access to the same." (Fig. 78.)

SAND PLANT OF PITTSBURG AND WESTERN RAILROAD. AT PAINESVILLE, OHIO.

Sand loaded in cars run on elevated track sixteen feet above main track from where sand is shovelled into green sand hopper. Under the center of this hopper drying stove is located, using six-

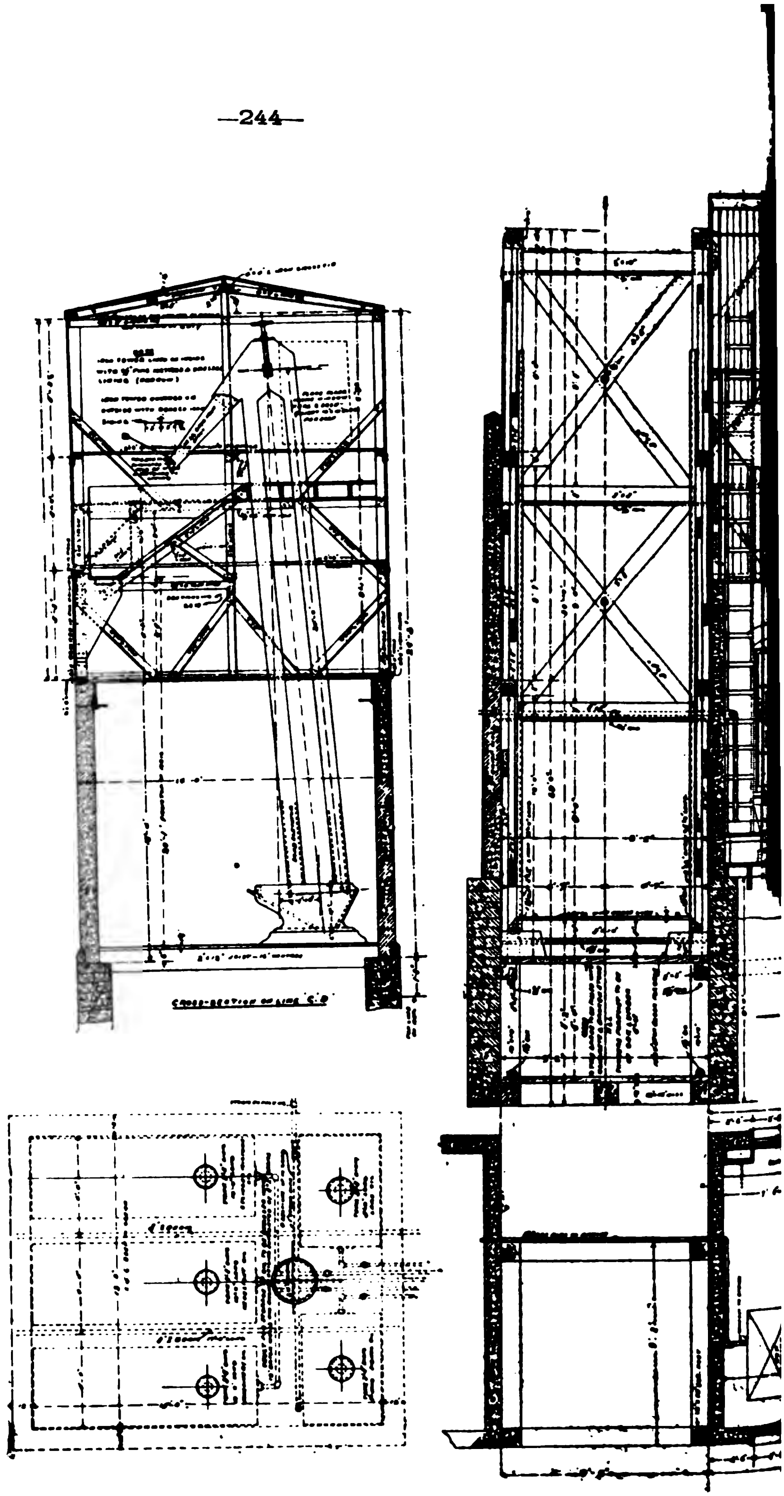
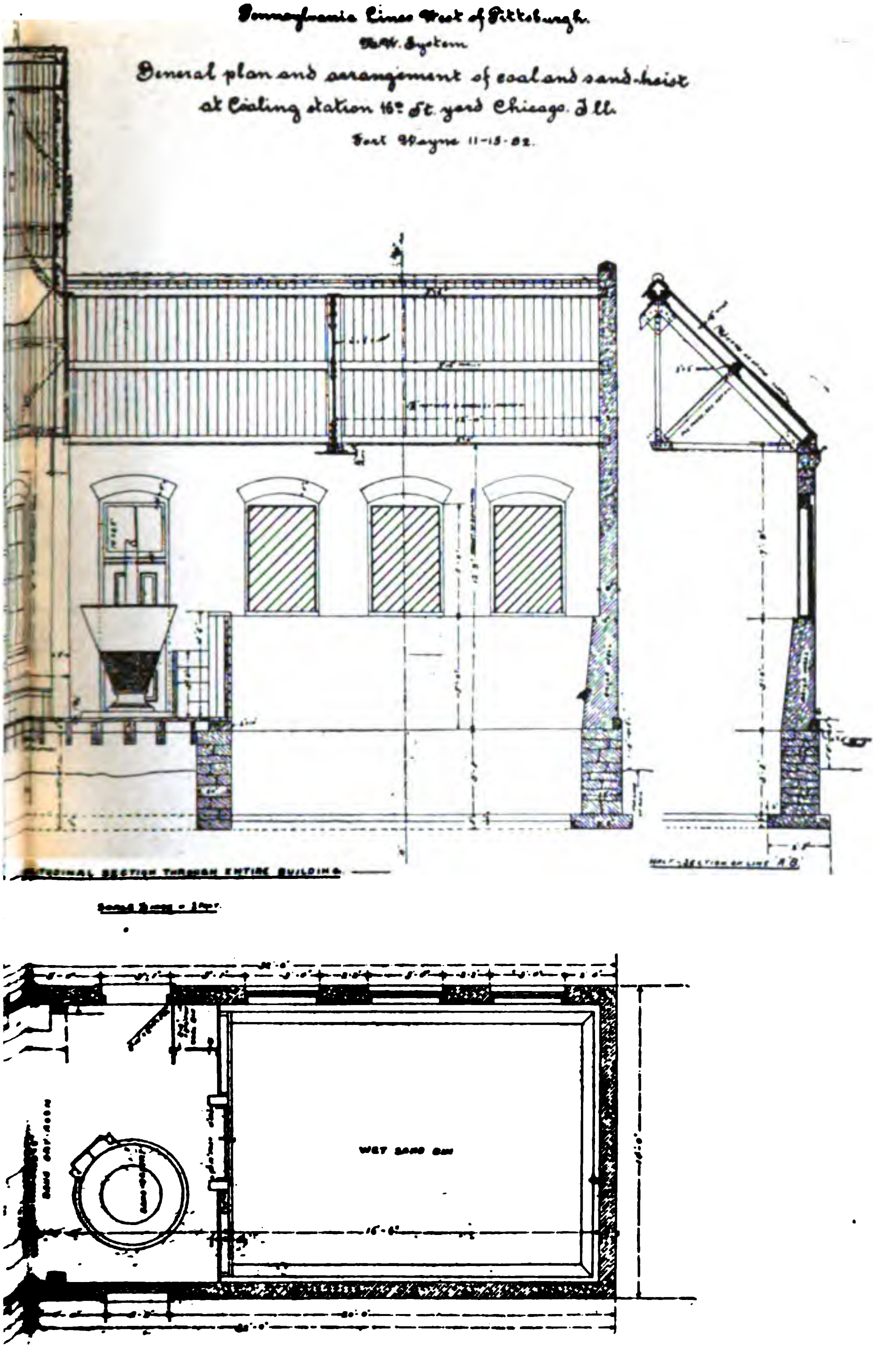


FIG. 78—SAND PLANT, PENNSYLVANIA LINES EAST O



ITTSBURG, AT SIXTEENTH STREET YARD, CHICAGO, ILL.

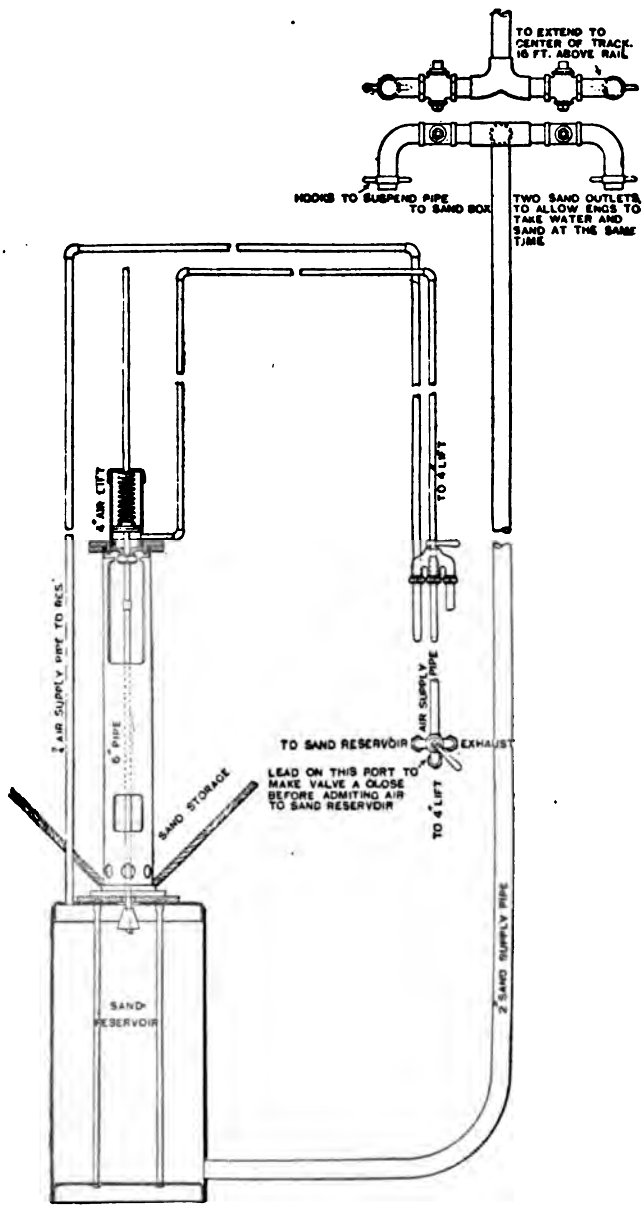
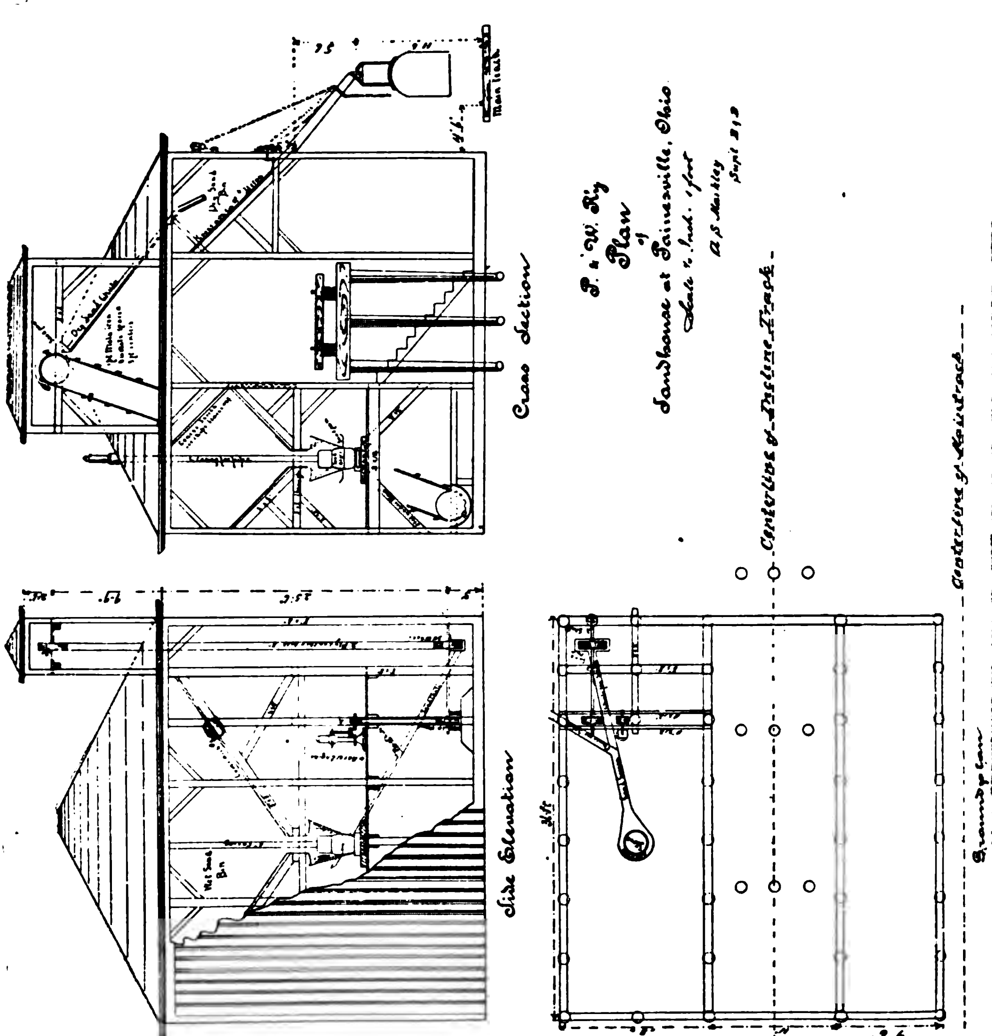


FIG. 79—SAND PLANT AT WEST PHILADELPHIA.


Cross Section
Side Elevation
P. & W. Ry
Plan
of
Sandhouse at Painesville, Ohio
Centerline of Incline Track
Centerline of Main track
Ground plan

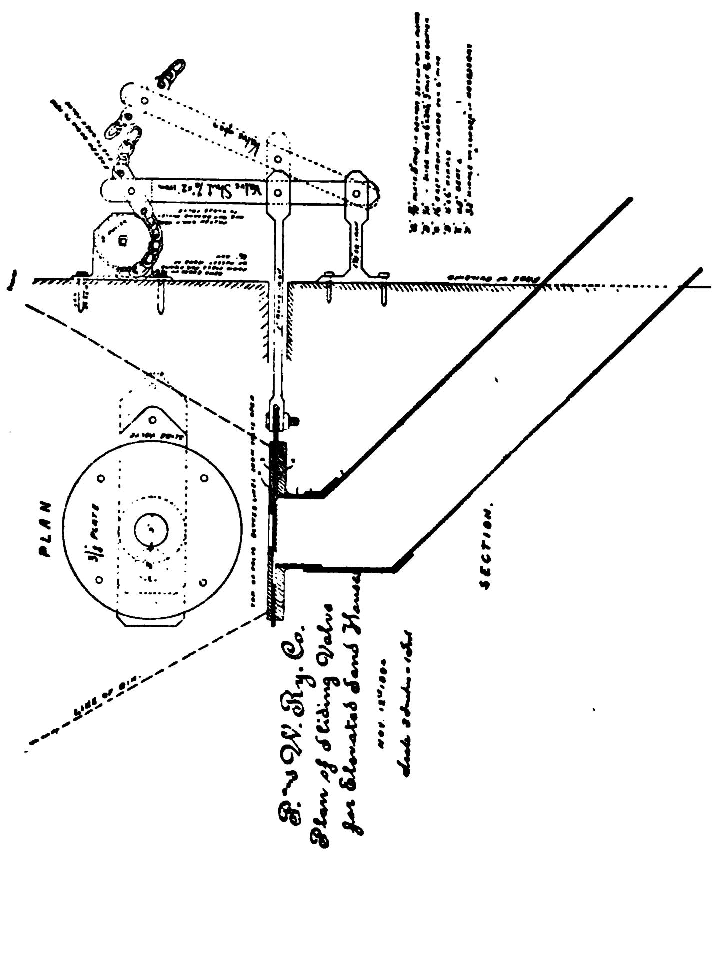


FIG. 80 (CONTINUED)—SAND PLANT, P. AND W. R. R., PAINESVILLE, OHIO.

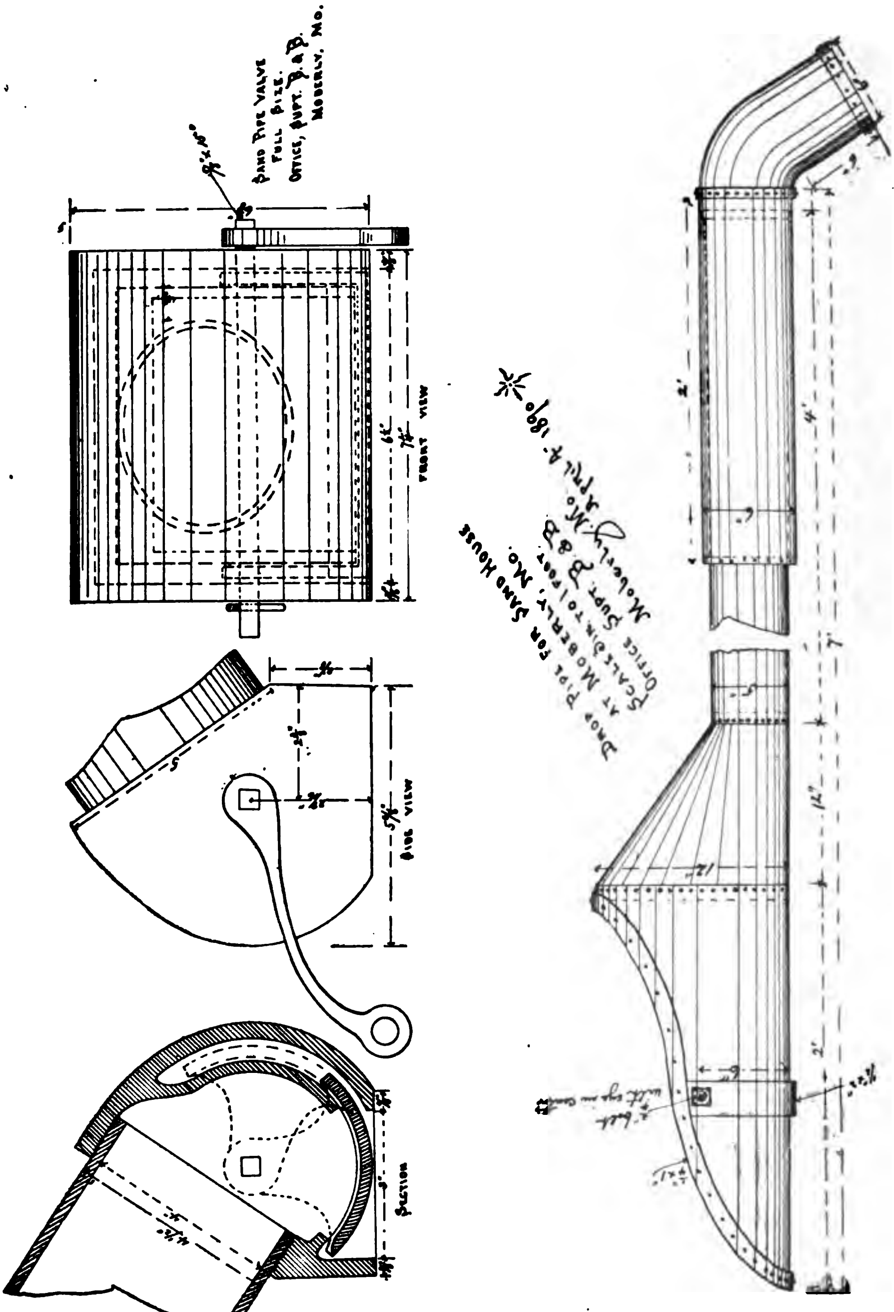


FIG. 81—SAND PLANT, WABASH R. R., AT MOBERLY, MO.

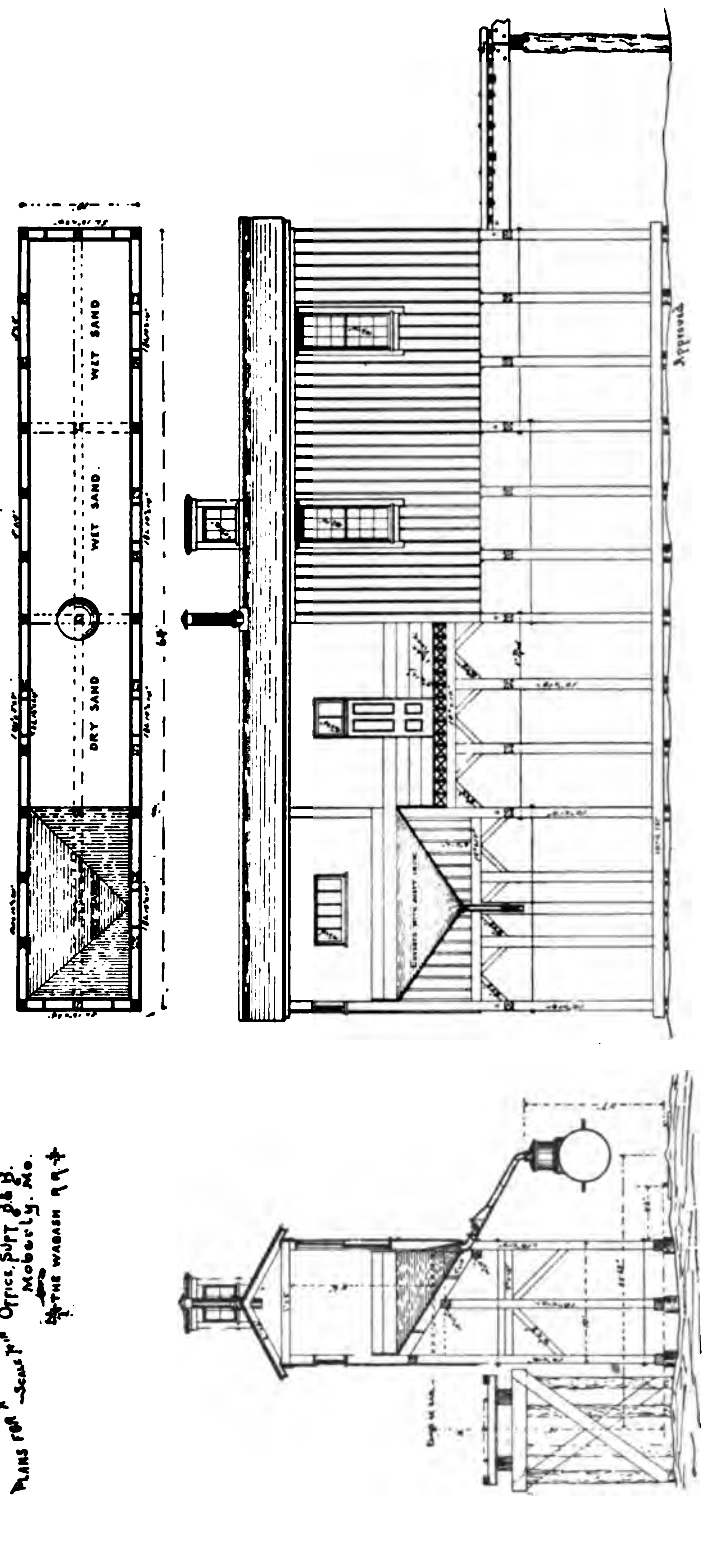


FIG. 81 (CONTINUED)—SAND PLANT, WABASH R. R., AT MOBERLY, MO.

inch gas pipe for smoke-stack, around which sand is thrown, and runs by gravity from this hopper into top of sand drying stove. After sand is dried, it is run by gravity to boot of elevator through spout, in the bottom of which is fine screen through which sand passes, in connection with which is a diverging spout which carries off coarse screening to outside of building. Elevator belt made of eight-inch two-ply rubber belting, riveted to which is one pint malleable iron buckets, three feet centers, run by four horse-power upright engine connected with six-inch belt to main shaft of elevator. Driving-pulley on engine twelve inches, on main shaft, twenty-four inches; upper and lower elevator pulley, thirty-inch diameter. Center to center of elevator shafts, thirty-five feet three inches. Dry sand bin from which engines take sand located on opposite side of elevated track, sand being elevated over elevated track. Building occupied by this plant, of frame and under cover, adjoining coal dump on the end. Building, thirty-six feet long, thirty-four feet wide, through center of which elevated track passes. Valve for dry sand bin, of cast-iron siding wrought plate, eight inches wide, twenty inches long, with three-inch hole for outlet of sand into outlet spout of engine. (Fig. 80.)

SAND PLANT LOCATED AT MOBERLY, MO., ON THE WABASH RAILROAD.

Attached letter from Mr. James Stannard, superintendent B. & B. of that road, fully explains the design and operating of the plant, together with the cost of handling same:

"Elevated sand house which is located on elevated coal track at end of chutes. Cars of green sand are placed on end of elevated coal chute tracks and unloaded with shovels from cars into sand house. Our mode of drying is by use of large cast furnace, somewhat in shape of a stove, with a hopper made of heavy wire netting. Hopper is kept filled with green sand which is passed in at top by use of shovels. We use coal for fuel in above furnace. Sand screen is placed between sand dryer and dry sand bin, through which dry sand is passed from sand dryer to bin. Sand bin is made in shape of hopper with valve located at lowest point, from which sand is passed through spout to sand dome on engine, on the same principle as water is taken from water tank. Capacity of dry sand hopper, about two carloads or twenty-four cubic yards. Time required for sanding engine, about two minutes. Capacity of green sand storage as per blue print is about seven carloads or eighty-four cubic yards. Man in charge of coal chute also has charge of sand drying. Cost per yard for handling and drying sand, about twenty-five cents per cubic yard. Size of building as shown on plan, ten by sixty-four feet; height from floor line to roof, sixteen feet. This plan has been adopted as our standard on Wabash line, and I consider same a very convenient, economical method of handling sand, there being no waste in handling." (Fig. 81.)

SAND PLANT C., B. & Q. RAILROAD, WESTERN AVENUE, CHICAGO, ILL.

Mr. G. W. Rhodes, superintendent motive power of that road, in letter attached to committee, fully explains the operation of this plant, together with some practical experience he has had with sand-drying plants and their operation. Mr. Rhodes gives his reason from experience he has had in this direction which is certainly good evidence by which to be guided.

"Yours of the 27th ult. received, and we take pleasure in forwarding you to-day by Adams Express, two blue prints showing the sand tower and sanding device as in use on the C., B. & Q. You will observe that the sand is hoisted by an elevator, our buckets are secured to a leather belting—we formerly used a link belt, but it did not prove as satisfactory as the leather belting. The elevator can be operated by hand or by power. At our principal shops we operate it with power. A feature of the device is that the engines are sanded up from a spout when they are coaled and watered. We have experimented with various methods for drying sand, such as steam pipes, large, flat pans with steam introduced, ordinary stoves with an outside sheet-iron casting. We find in practice, however, that there is nothing as good as the large cast-iron stove as shown on sheet 1150, encased with wire netting. The advantage in using the wire netting is that as the moisture is driven off from the sand by the heat; it escapes at once through the netting into the atmosphere, and the sand is dried very much quicker, consequently, than if it was enveloped in a sheet-iron casing. I am not sure that our tower is the most economical device. We find, however, that it is very convenient, as at many points we are able to elevate sufficient sand during the day to supply the want at night without having to maintain any machinery in operation. At one of our shops we elevate sand by air; the air being supplied by a couple of Westinghouse pumps. Other railroads, we understand, also elevate sand with air. Our experience, however, is that this is a very wasteful method. The coal consumed to furnish sufficient air for the work is very large and is produced quite expensively. A much less amount of steam and consequently a less consumption of coal to run a small engine which will operate an elevator as shown on the drawing." (Figs. 82 and 83.)

SAND PLANT OF ATCHISON, TOPEKA AND SANTA FE RAILROAD, LA JUNTA, COL.

Steam sand dryer and air elevator, elevating the dry sand direct from sand drum into engine sand box. In a letter from Mr. Drury, general foreman, in reply to one from committee in refer-

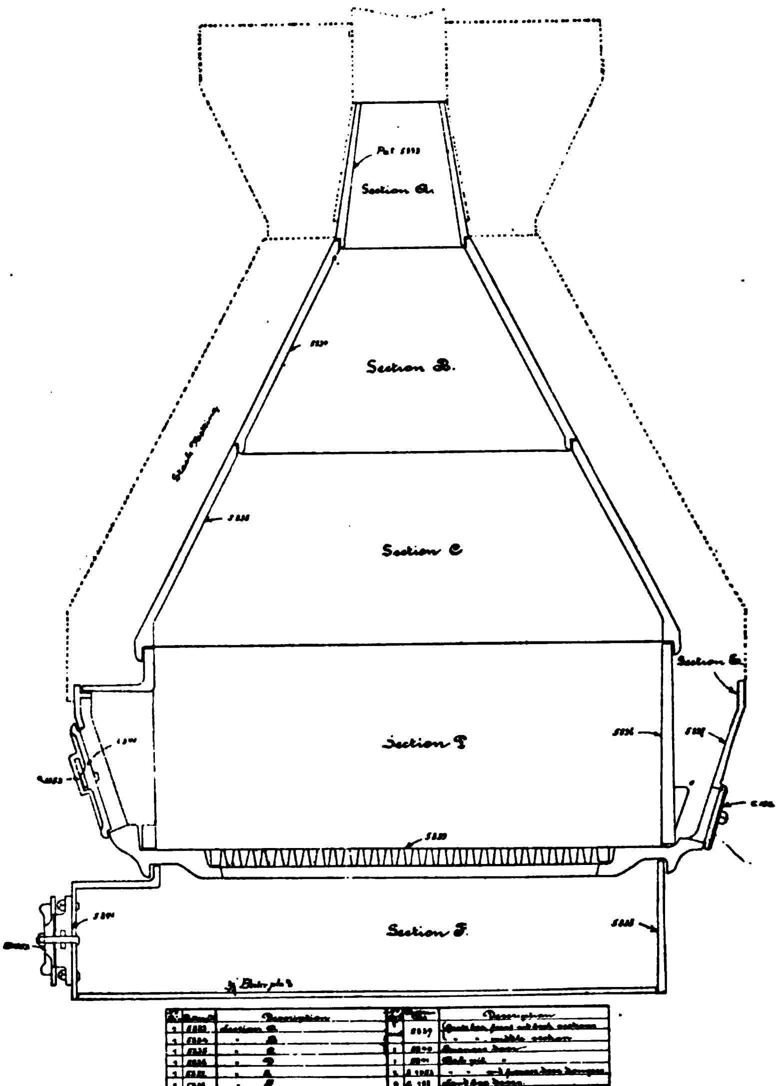


FIG. 82—SAND DRYER, C. B. AND Q. R. R., AT AURORA.

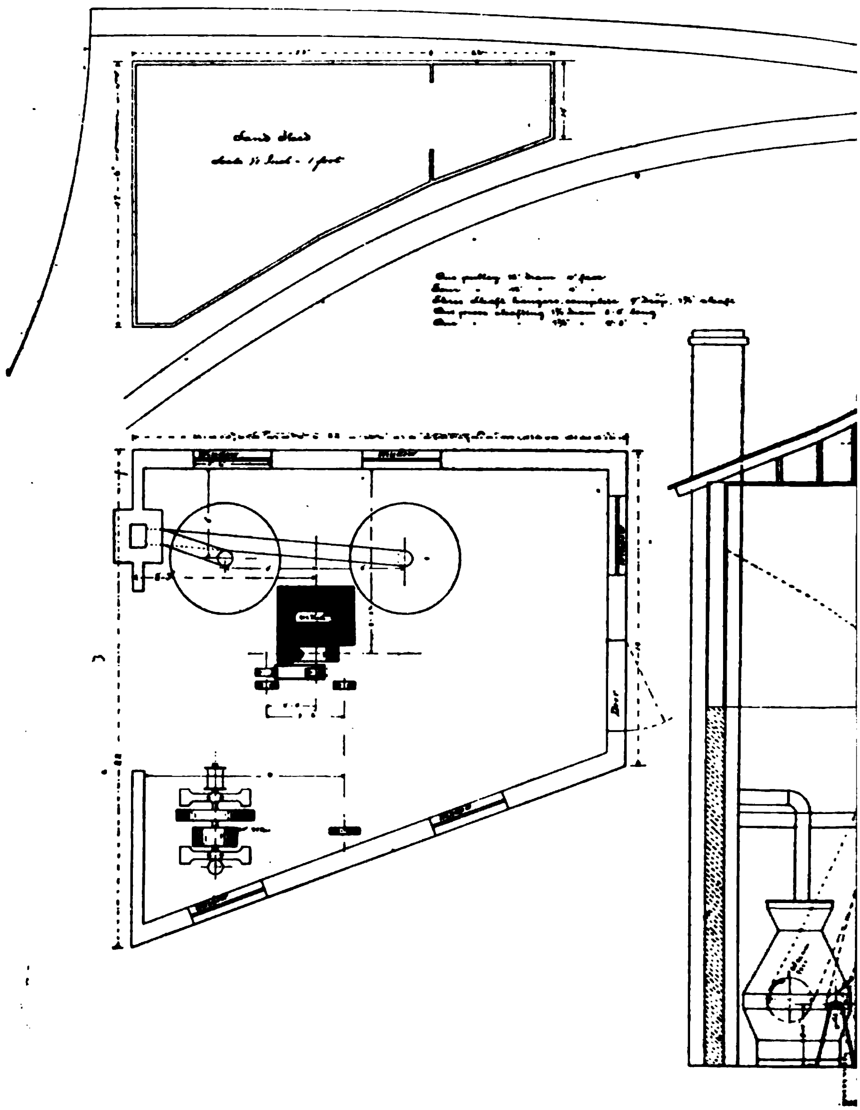
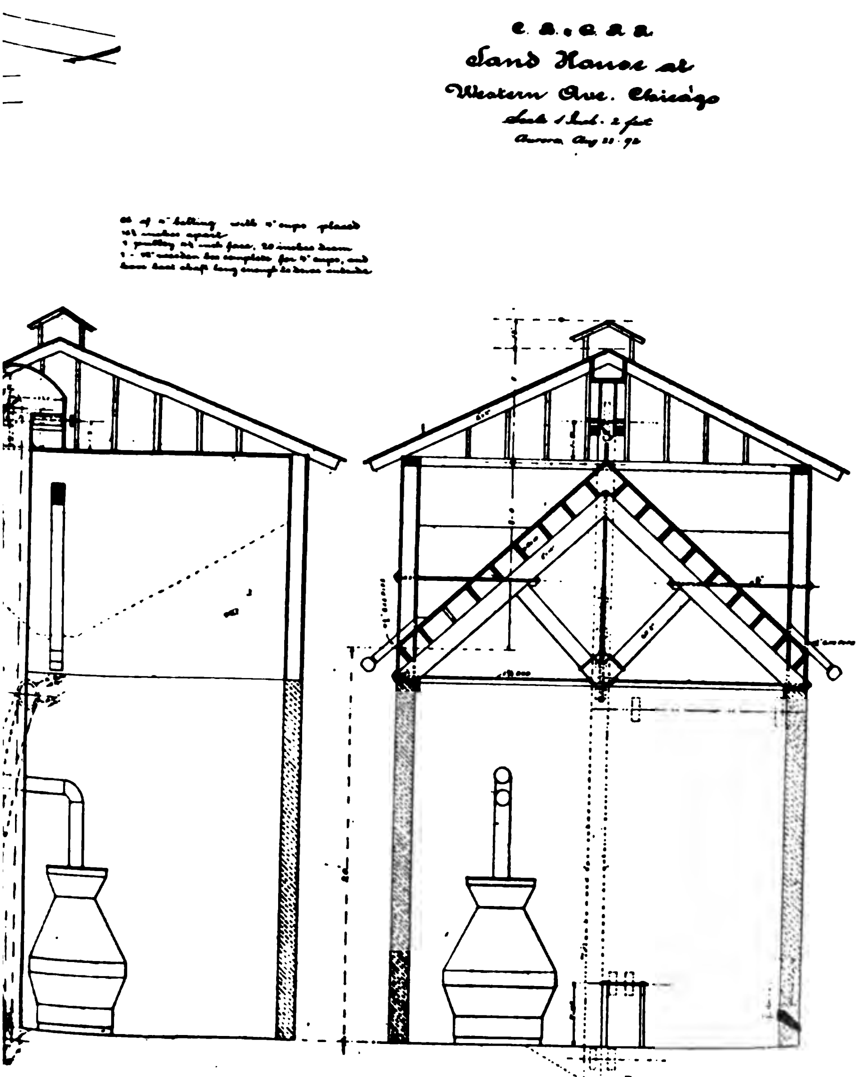


FIG. 83—SAND PLANT, C. B. AND Q. R



L, AT WESTERN AVENUE, CHICAGO, ILL.

ence to delivery sand pipe being exposed to the water, regarding dampness that might in all probability interfere with the free flow of sand, as follows:

"In reply to your favor of the 27th inst., relative to sand device, please refer to my typewritten letter accompanying blue print of the same I sent you some time ago. By that you will see that the air is admitted to top of drum. The small pipe at the bottom

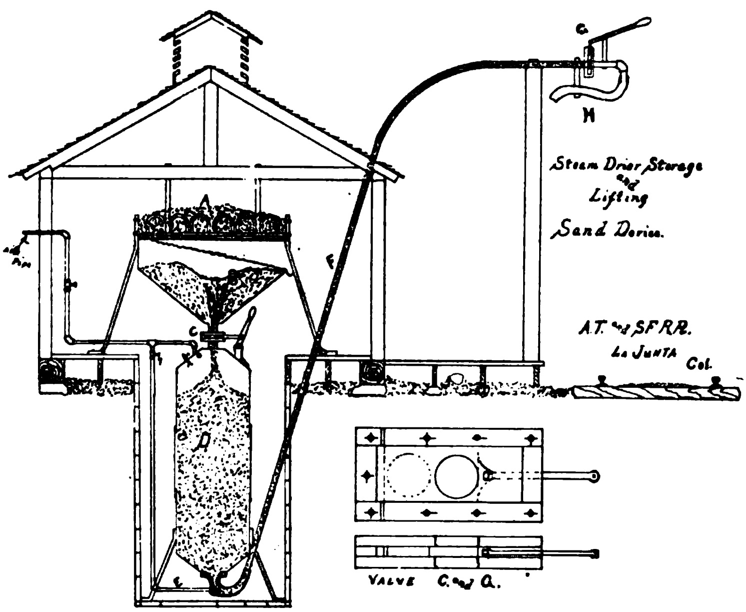


FIG. 84—SAND DRIER AND LIFTING DEVICE, A., T. AND S. F. R. R.

is used in case of two-inch pipe stopping up, as will be explained in letter referred to in regard to experience of trouble by sand becoming hardened—due to moisture. In the compressed air I had some difficulty, but overcame this by placing a siphon a short distance from the drum, in air line. This collected all the moisture, and before each application of air to drum I have my hostler open pet cock on siphon to allow any collection of dampness to escape. I find by doing this, and arranging to shut off air after application, I have no further trouble. In conclusion I would say that the sand device has got the capacity of ten cubic feet per minute. Hoping this will be of some interest to you and your committee."

Following is explanation:

(A) represents square drying box, in which are suspended coils, or loops of steam pipe at sufficient incline to insure proper drainage. The bottom of the box is of two and one-half by two and one-half mesh netting, trussed and suspended, admitting of a slight lateral motion to precipitate the dry sand, which, in falling, passes through an intervening screen of four by four mesh netting, set at an angle to carry off coarse gravel, the dry sand falling into hopper (B).

(D) is round storage drum of pressure strength, set in a pit cased with plank, and large enough to admit passing around it.

(C) is valve connecting (B) and (D).

(F) is the delivering pipe. (G) the valve controlling flow of sand into engine box. To charge drum for operation, open release valve (X), on top of drum, relieving drum of pressure, then open slide valve (C), and fill drum with sand. Close (C) and (X), and open valve in air pipe. If sand does not flow freely at first, open valve at (Y), which admits air into (E). This acts as a primer or persuader, but is seldom used. (H) is a piece of hose, flexible, to lead sand into box of engine. With eighty pounds pressure, and a two-inch pipe, this device will deliver ten cubic feet of sand per minute. With the exception of drum (D), valve (C) and (G), and pipe fittings, are all made of old material. Large sketch of valve (C) and (G) annexed. (Fig. 84.)

SAND PLANT OF DELAWARE, LACKAWANNA AND WESTERN RAILROAD, EAST BUFFALO, N. Y.

Steam and drying bin six feet wide at top, ten feet long, with vertical sides extending eighteen inches down from top. Below this, sides incline at an angle of forty-five degrees to bottom, leaving twelve inches flat surface on bottom, with necessary opening for dry sand to pass through, detail of which is not brought out in plan. Three sets of one and a quarter gas pipe along each side and bottom of hopper, as well as through center of same, nine feet six inches long, with return bends, making 100 pipes on sides and bottom, and thirty-one in center, making a total of 131 in all. Underneath sand drying hopper is suspended galvanized iron hopper, the top of which is full length of dryer, and twelve inches wide, reduced to twelve inches square at bottom. The hopper sheet is on the two ends only in which are placed screens for screening sand, leaving a space of about three inches between the screens and sides of hopper on the bottom, through which sand passes, leaving gravel to pass over the screen. Two outlet spouts are provided, one for gravel, which is diverted outside of the building, and

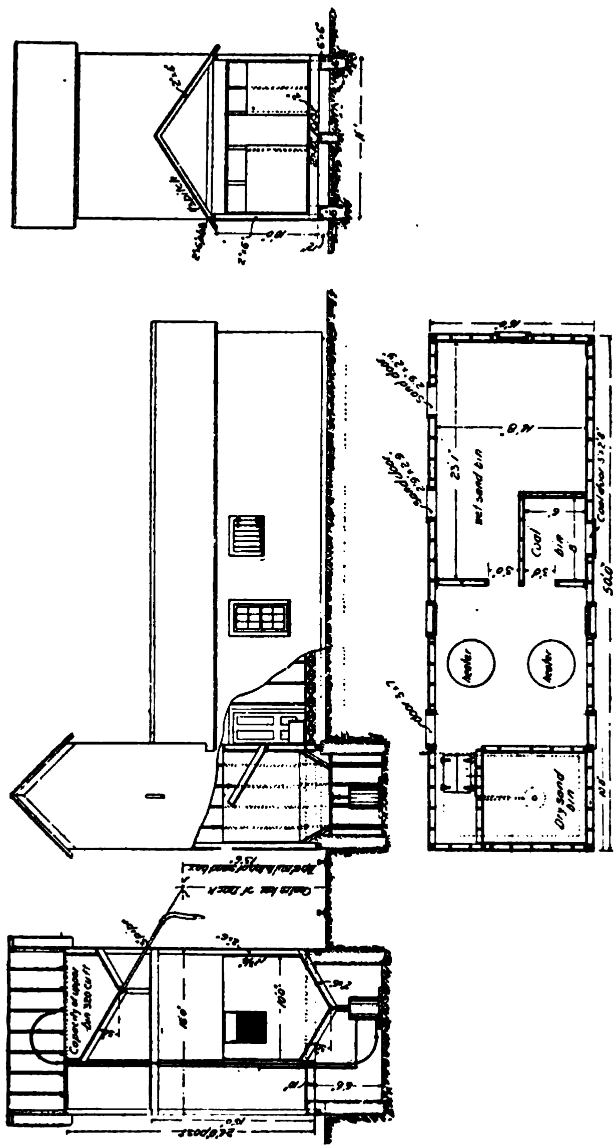


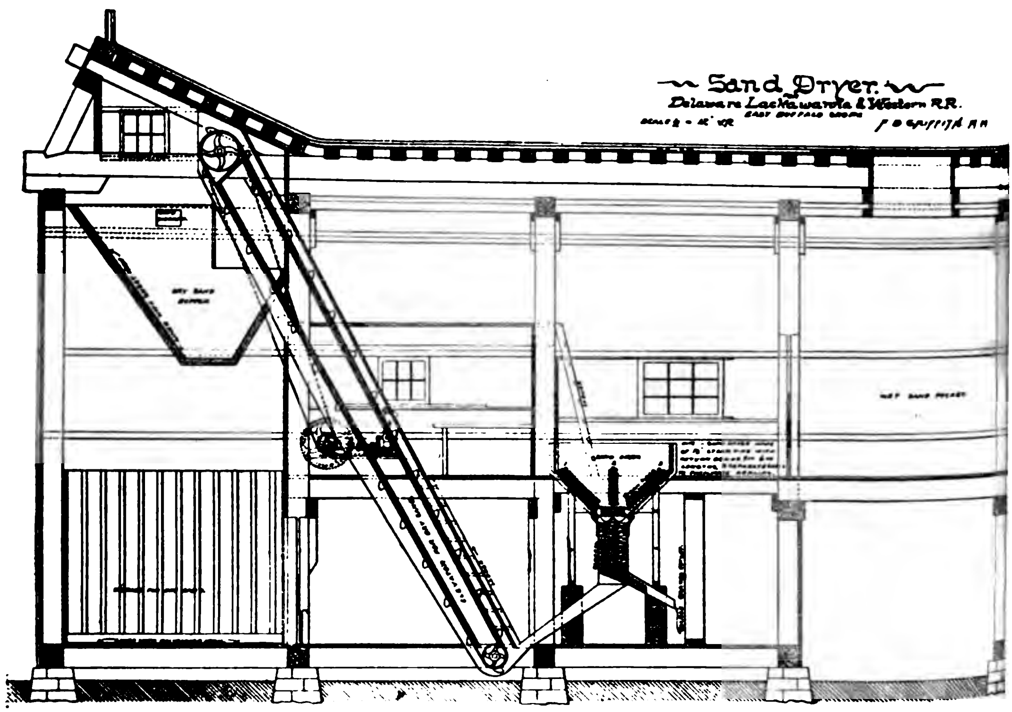
FIG. 85—SAND PLANT, A. T. AND S. F. R. R.

another one for sand run by gravity to boot of elevator, where it is elevated into sand hopper, from which engines are supplied. The entire plant is eighteen feet wide, sixty-two feet long, twenty-five feet in length of which is used for green sand, twelve feet for sand drier, and the remainder for elevator and hopper, as well as dry sand storage bin, which is located underneath the hopper. Track elevated twenty-seven feet, where cars loaded with green sand are run and unloaded from drop-bottom cars through doors provided for that purpose in center of track. The bottom of green sand bin being elevated eleven feet above the track or ground surface, or sixteen feet below base of rail of elevated tracks. Top of sand drier hopper elevated eighteen inches above green sand bin floor. The outlet valve in bottom of dry sand hopper is entirely different from any of the others submitted, being cone-shaped, run to a point in a vertical position, and is inserted into the outlet spout inside the bin when desired to stop the flow of sand, and is operated by lever attachments inside, and from the top of the bin, with suspended chain on outside, in easy reach of engine man. Outlet spout three-inch galvanized iron, telescope pattern, suspended by weight attachment at outer end. (Fig. 86.)

SAND PLANT OF MISSOURI PACIFIC RAILROAD.

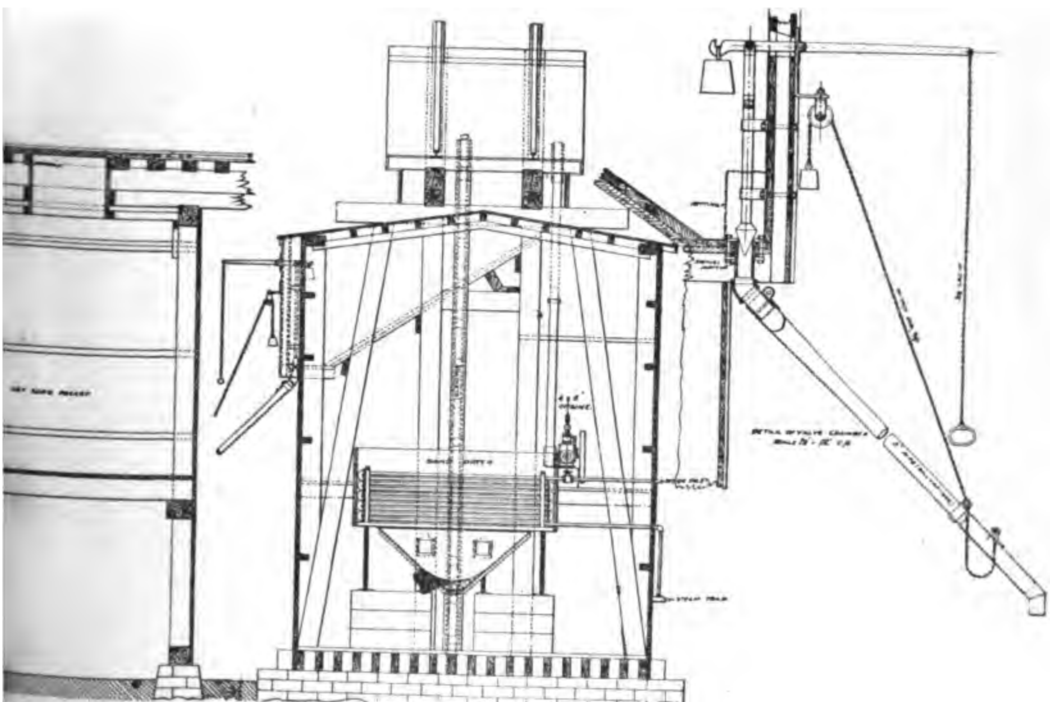
Sand drying house, 28 by 34 feet. Sand, after being dried in stove and furnace, is placed in round storage drum-pressure strength, which is located near drier or furnace, the top of which is on level with the floor of sand house and encased with brick walls. The air is applied in top of drum from compressor; the sand supply pipe from drum to sand bin is also connected to top of air drum and extends to bottom of same. Air being supplied to top of sand in drum, forces sand from drum to dry sand bin, which is located on opposite side of track, from which engines take sand in same manner as they do water. Mr. Peck says, on inquiry from the committee, that so far as his information goes they have never had any trouble with air pipe stopping up with sand, or accumulation of moisture in them. Men who operate these conveyors and elevators say they give the best of satisfaction in every particular. Mr. R. M. Peck, superintendent B. & B., reports as follows:

"In reference to handling sand, drying same, and delivering it to engines, will state that we use two methods of drying sand, one by stove and the other by furnace. Enclosed to you blue print of drawing of furnace. The stove we use is Clark's patent. Also enclose blue print of sand-drying house in use. We are using two methods of delivering sand to our elevated bins, which we built in connection with our coal chute and elevated track, from which we can spout sand into the barrel of our engines. At some of our stations we switch our sand cars up on our elevated tracks and shovel the sand from the cars to the bin. At other points we



Sand Plant, D. L. &

FIG. 86—SAND PLANT, D., L. &



E., at East Buffalo, N. Y.

. R. R. AT EAST BUFFALO, N. Y.

elevate the sand into the bin by means of compressed air. Blue prints of bins, air pipes and tubes also enclosed. We use the ordinary wire screen. At some points on our line the sand is hauled by teams and delivered at the dryer. At other points it is delivered in car-load lots, and unloaded with shovels. We have no conveyor in use. Our air compressors are run by steam power. The average cost of sand delivered in our dry sand bin is about 55 cents per cubic yard."

SAND DRYING PLANT, M., K. & T. RY., OF TEXAS, DENISON, TEXAS.

Mr. C. T. McElvaney, M. M. of this road, kindly furnished the following information:

By means of this plant one man working ten hours per day is enabled to dry and store ready for use 500 cubic yards of sand per month. The plant has been in use for three years, and has cost practically nothing for repairs. The building consists of a sand shed 68 feet long, 19 feet 6 inches wide, 11 feet 5 inches high to the eaves, having at one end a drying house 12 feet by 19 feet 6 inches, and 27 feet 8 inches high to the eaves. Fig. 88 shows a plan of the drying house and a portion of the sand shed. Fig. 89 is a transverse section through the drying house. A small engine is located in one corner, and operates the conveyor and elevator. A steam dryer 17 feet 6 inches long is placed in the shed adjacent to the house, and both the dryer and engines take steam from a boiler plant located about 400 feet away. The sand to be dried is shovelled into the dryer (A), where the steam-heating coils soon take the moisture out of it. As it dries it falls through a trough at the bottom of the dryer, from whence it is carried to the conveyor (B) into the boot (C) of the chain elevator (D). From thence the sand is coveyed up to the small iron tank, from which it is allowed to flow through a spout (E) into the revolving screen (F). This screen is 42 inches long, 10 inches in diameter at the small end and 27 inches in diameter at the large end, and is composed of netting having 4 meshes per inch and made of wire No. 12, A. W. G. The fine sand passes through the screen and falls into the tank (G), while the coarse material goes through a spout (L) to the outside of the building. From the tank (G) the screened sand is carried by the elevator (I) to the top of the building, where it is discharged through the spout (J) into the storage bin (KK). These bins have spouts somewhat similar to those of an ordinary water tank, and swing into position so as to deliver the sand into the locomotive sand box. The fireman, by means of a lever, operates the valve of an air cylinder, by which the sand valve is controlled. An accidental waste of sand is prevented by so arranging the mechanism that the valves have to be held open and as soon as the operator lets go they close automatically. In Figs. 90 and 91

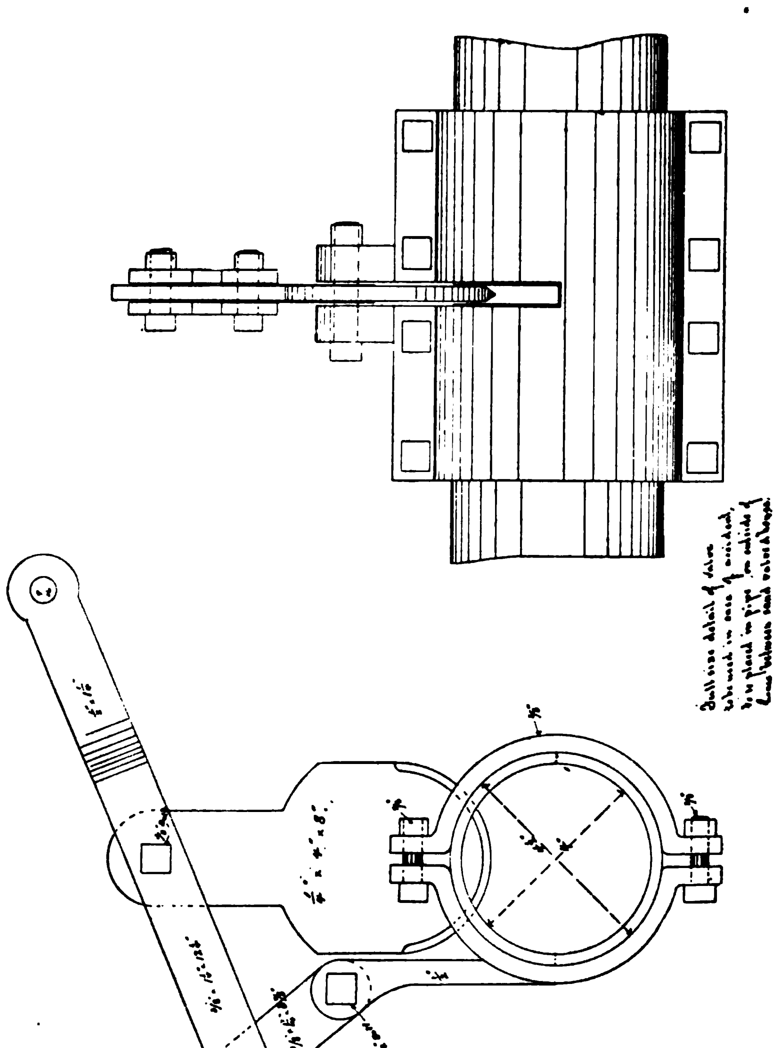


FIG. 87—SHUT-OFF VALVE IN SAND PIPE OF SAND PLANT, M., K. AND T. R. R.

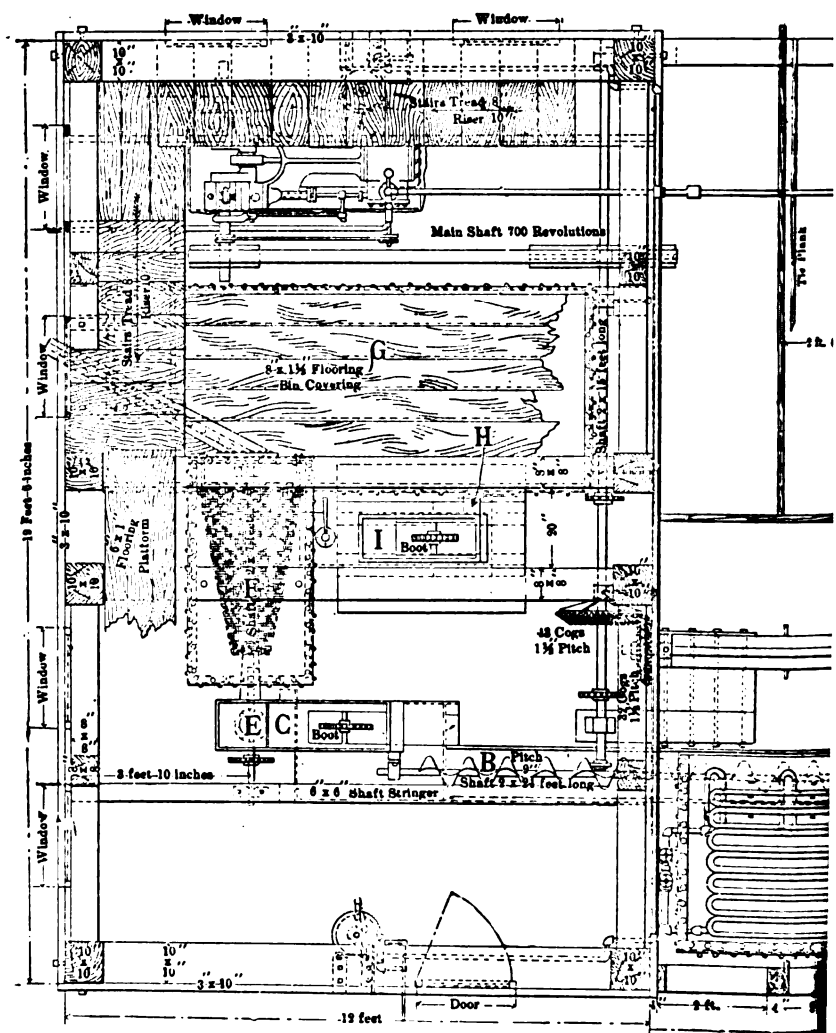
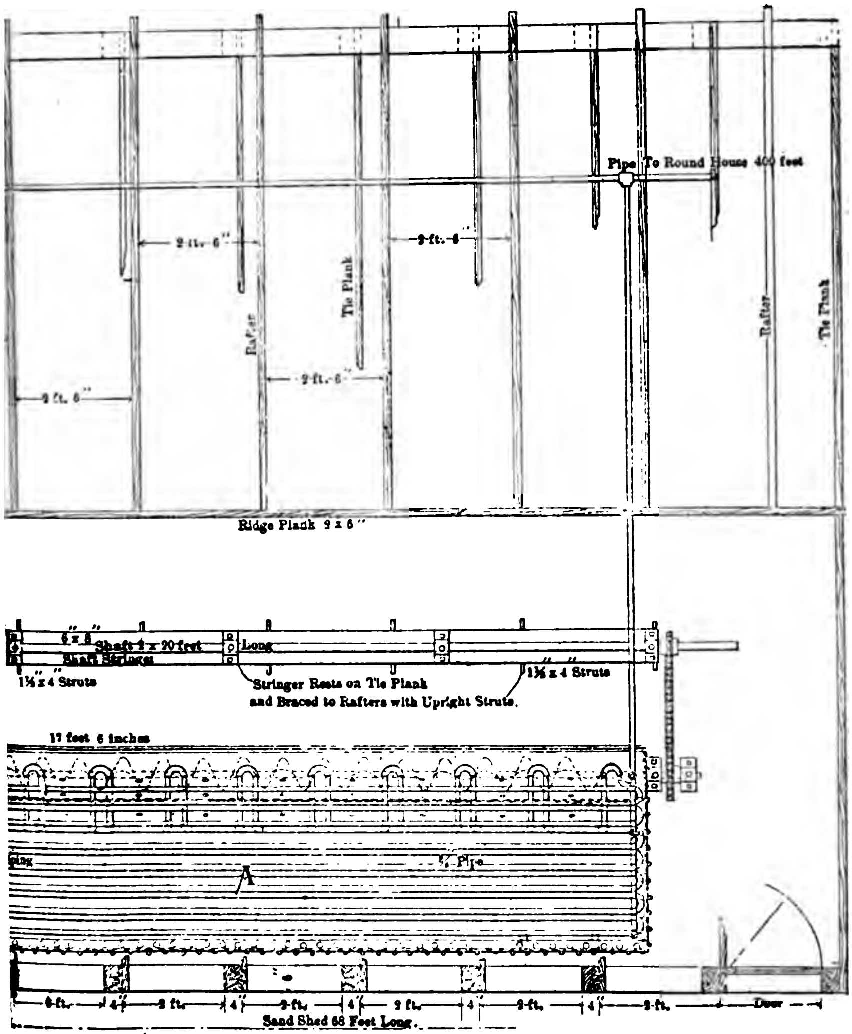


FIG. 88—SAND PLANT, M., K.



I. R. R., AT DENNISON, TEXAS.

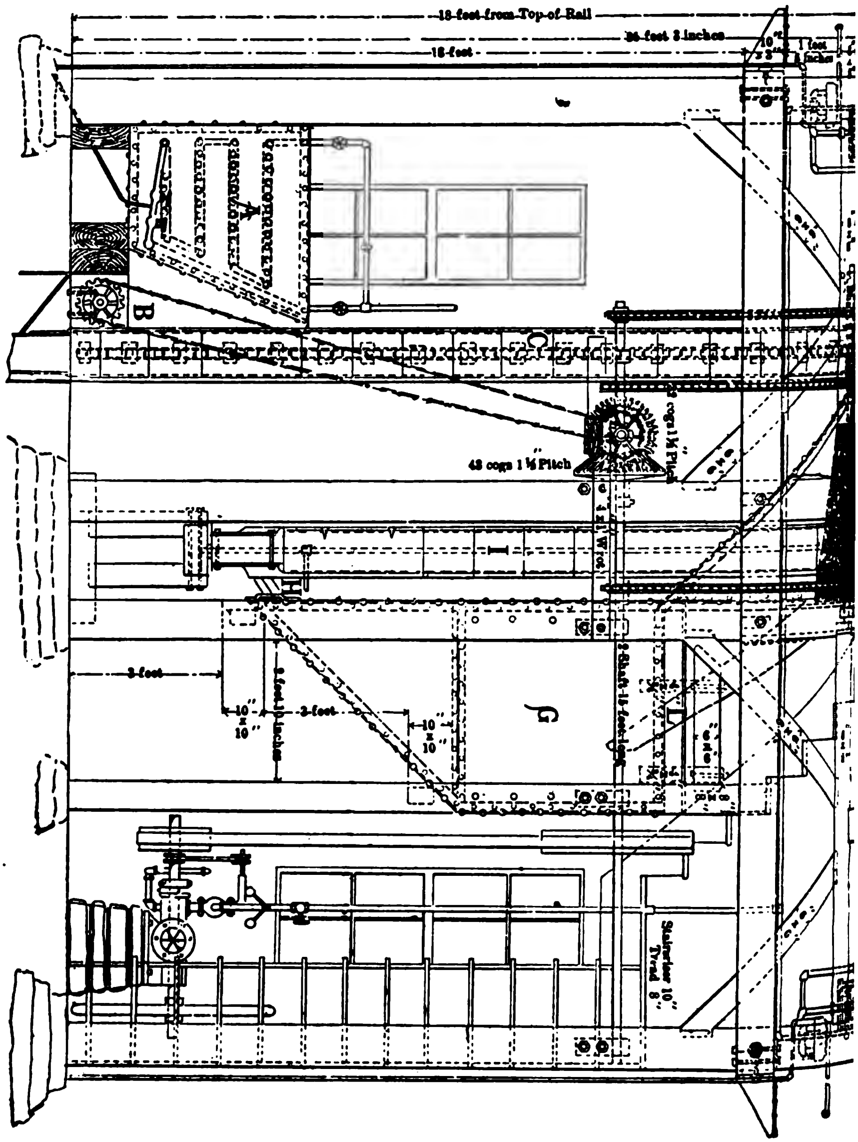
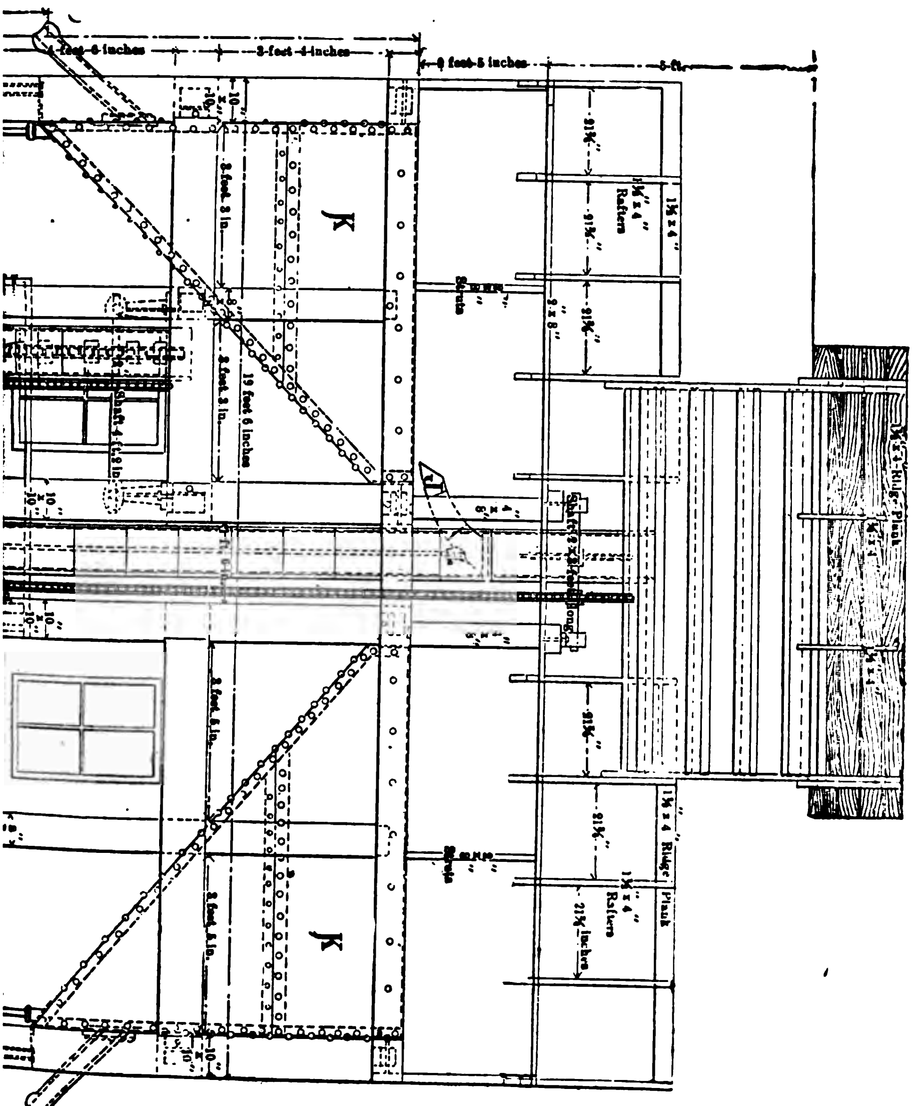


FIG. 89—SAND PLANT, M., I.



T. R. R., DENNISON, TEXAS.

we show a view of the air cylinder and controlling valve employed to operate the sand valve. The latter are slide valves, and travel over a hard wood seat secured to the inside of the bins (KK). The valve is quite large and has a port 4 inches in diameter. The size of the valve and the possibility of having considerable pressure on it when the bins are full, make the air cylinder a great convenience. Our drawing shows only the fixed portion of the sand spout. A study of the drawing shows that the plant has been constructed in a substantial manner, and that all hand labor has been avoided except that of shovelling the sand into the dryer. The building is placed with one side of it to the main track and the other the roundhouse track, and engines can receive sand from either side. Before the erection of this plant four large sand stoves were kept going night and day to supply the demand, and the cost of drying the sand and delivering it to the engines was much greater by the old method. In this connection, beg to say that one man at a dollar and a half per day attends to the entire operation of the plant and unloads the sand used from cars into the sand house. We dry sand for an average of forty engines every twenty-four hours, which is about 75 per cent. of its capacity. Cost of sand house would be about $1,200. We convey steam about 400 feet through a 1½-inch pipe. Should one desire to put in the dryer without the elevator, a small upright boiler 30x60 would furnish an abundance of steam and be far more economical than sand stoves. Four to five tons of coal per month dries all the sand we use.

SAND PLANT OF N. Y., L. E. & W. AT HORNELLSVILLE, N. Y.

The total length of the whole building of this plant is seventy feet, forty feet being utilized for the storage of green sand, as shown in the left hand of the engraving of the elevation and plan. It consists merely of a large covered building, with doors opening between the uprights, placed at a height of six feet above the sills, and through which the sand is unloaded from the cars. The main building at the right is devoted entirely to the drying, elevating, and storage of the sand, ready for delivery to locomotives. The sand is brought in from the storage shed by means of a trolley, from which is suspended a hopper-shaped bucket holding about 400 pounds of sand. This is filled, and brought to the dryer, where it is raised by means of an air hoist to an elevation above the dryer, and put upon a track running over the latter, and to which the bucket can be run to any desired point over the dryer, and dump. The dryer is so designed that no sand which is not thoroughly dried can pass out through the half-inch slot that runs along the entire length of this lowest extremity. This is accomplished by means of a convex shield that is placed directly over the lowest steam pipe, and extends out to within three-fourths of an inch of

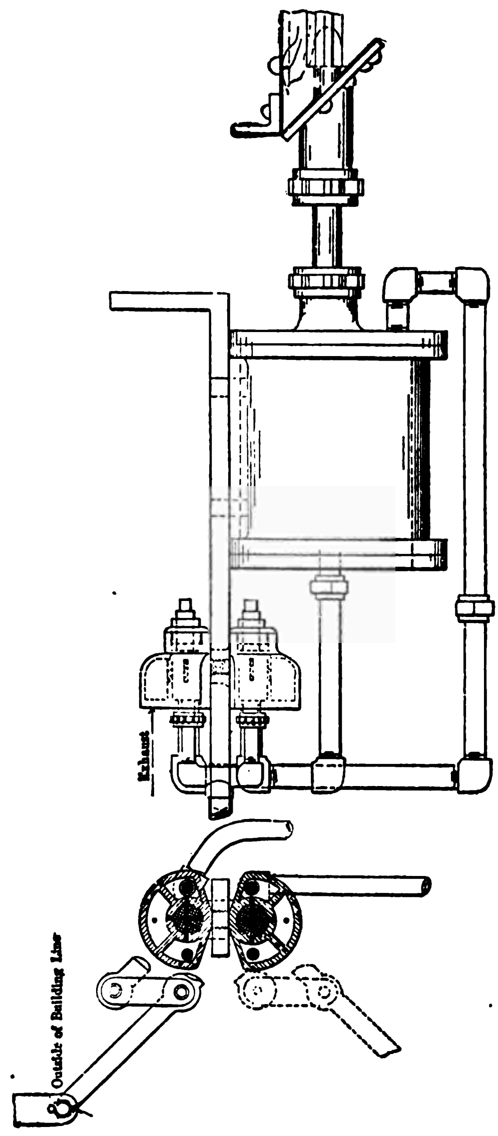
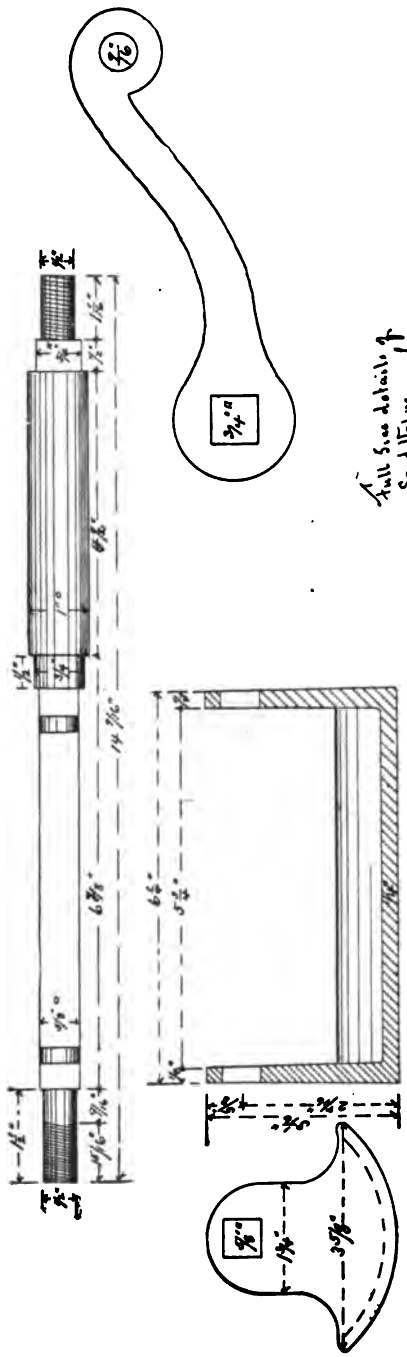


FIG. 90—SAND PLANT, M. K. AND T. R. R., AT DENNISON, TEXAS.



Full Size details of Sand Valve.

FIG. 91—SAND PLANT, M. K. AND T. R. R., AT DENNISON, TEXAS.

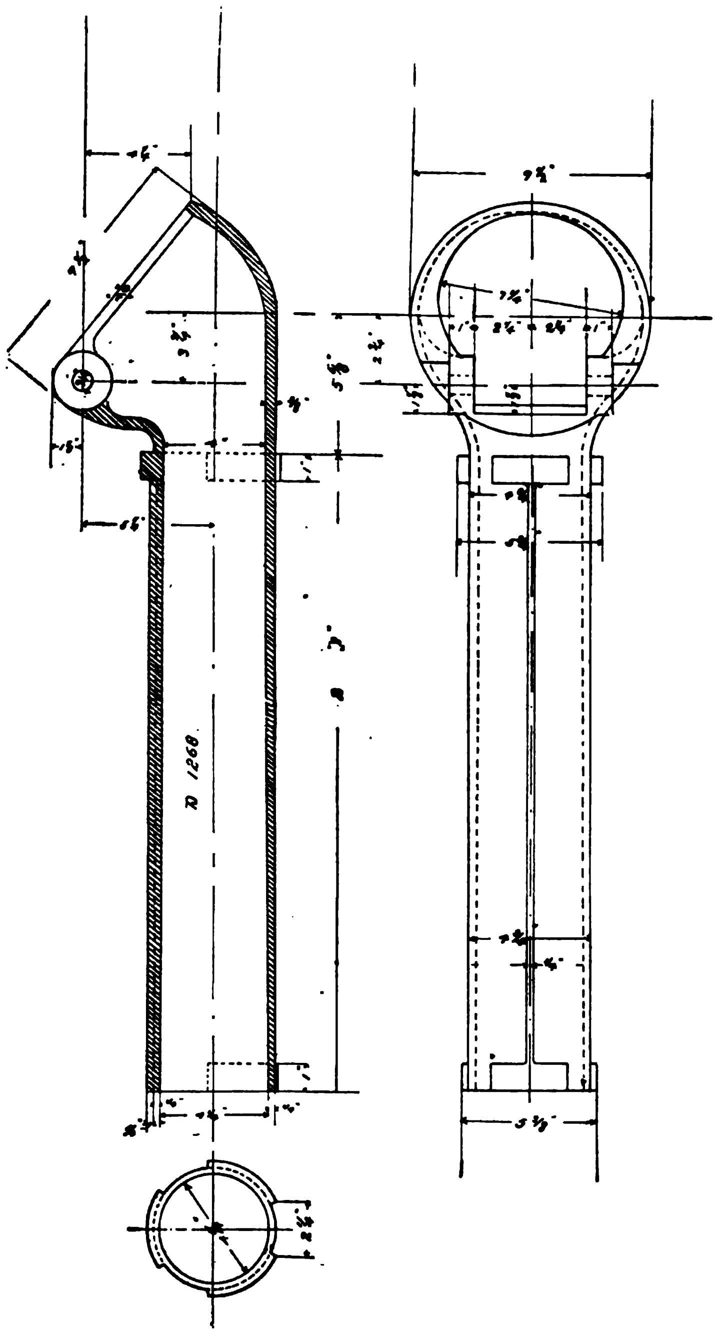


FIG. 92—SAND PLANT, N. Y., L. E. AND W. R. R.

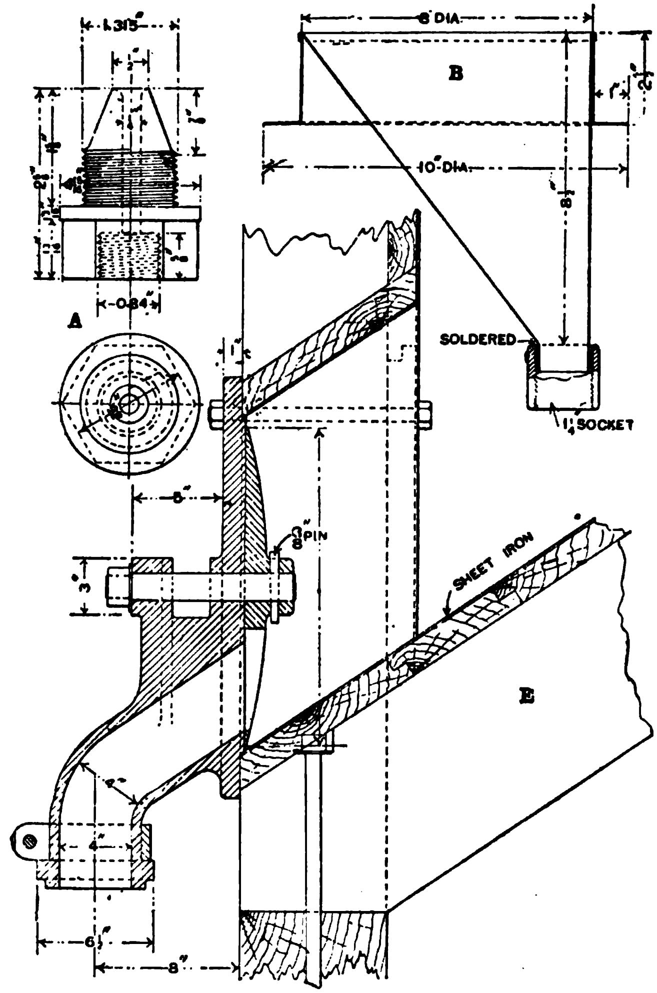


FIG. 93—SAND PLANT, HORNELLSVILLE, N. Y.

the sloping sides, where it retards the flow of the wet sand until it is dried sufficiently to run over this shield. The drying is accomplished by means of a number of rows of steam pipe that run the entire length of the drying bin, and furnishes ample heat to thoroughly dry the sand. Steam is furnished by a locomotive form of boiler, whose location is indicated by the dotted lines in the lower right hand corner, at one end of the elevation. It also provides the steam for an eight-inch Westinghouse air pump, which in turn provides the compressed air for elevating the dried sand. When the dried sand runs down through the slot, it first passes through a fine screen which is stretched over the sloping channel, and is then carried by gravity down into the mouth of a funnel, whence it passes directly into a blast pipe, and is blown by the current of air coming from the air pipe into the storage bins above. In order that the amount of sand elevated may be regulated in proportion to that required, the portion below the bins is divided by two sections, each having its own independent hopper and pipe. This also enables one of the pipes to be shut down, for repairs, without stopping the whole plant, or disturbing either of the others. When this is done, the air pressure is increased in the two remaining sections, and nearly as much work is done with the two at such times as with the three when working under the normal pressure of twenty-five pounds per square inch, showing that the actual capacity of the plant is considerably above that at which it is rated, which is an average of fourteen tons of sand per day dried, and elevated to the storage bins, or enough to supply from sixty to seventy locomotives. The storage bin, into which the dry sand is elevated, is of sufficient height so it will flow into the sand box of the locomotive by gravity. The upper elevation of the building shows the line of rails running alongside the building, with the height of the top of the sand boxes of several of the classes of locomotives which are in use upon the road, a spout like that ordinarily used for water enables the fireman to take on sand in exactly the same way that he usually takes water. Referring to the details of the sand bins, as shown in Figs. 92 to 100, they will require but a brief explanation. In Fig. 94 is a side and end elevation, with a plan and cross section of a three-fold dryer. The dryer is twenty feet long, and occupies half the length of the drying portion of the building. The sand, after being thoroughly dried by the heat of the steam pipes as already described, drops through the slot in the bottom, and running down the incline, flows into the funnel (B) through the strainer netting (C). This latter is made of wire with six meshes to the inch, and is readily taken out for cleaning. The funnel (B) is made of galvanized iron, and is of the dimensions given in Fig. 93. The action of the air blast will be easily understood by referring to the end elevation in Fig. 94. The sand flows

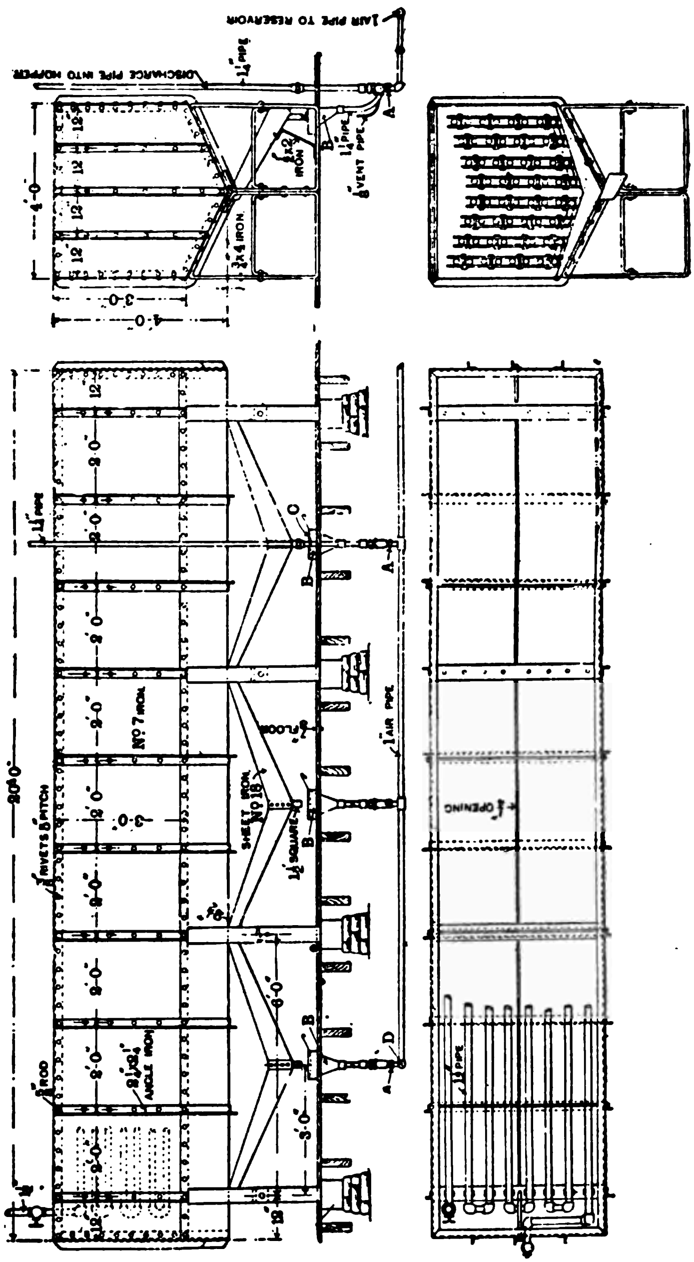


FIG. 94—SAND PLANT, HORNELLSVILLE, N. Y.

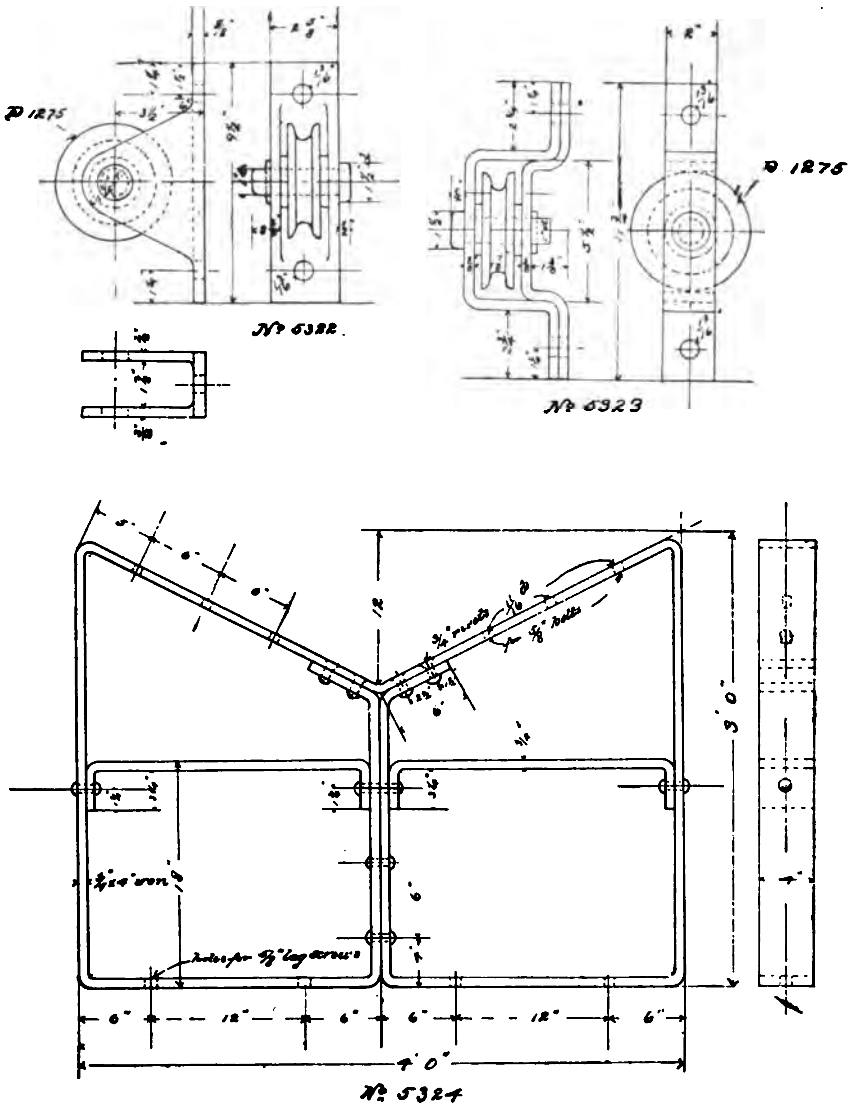


FIG. 95—SAND PLANT, N. Y., L. E. AND W. R. R.

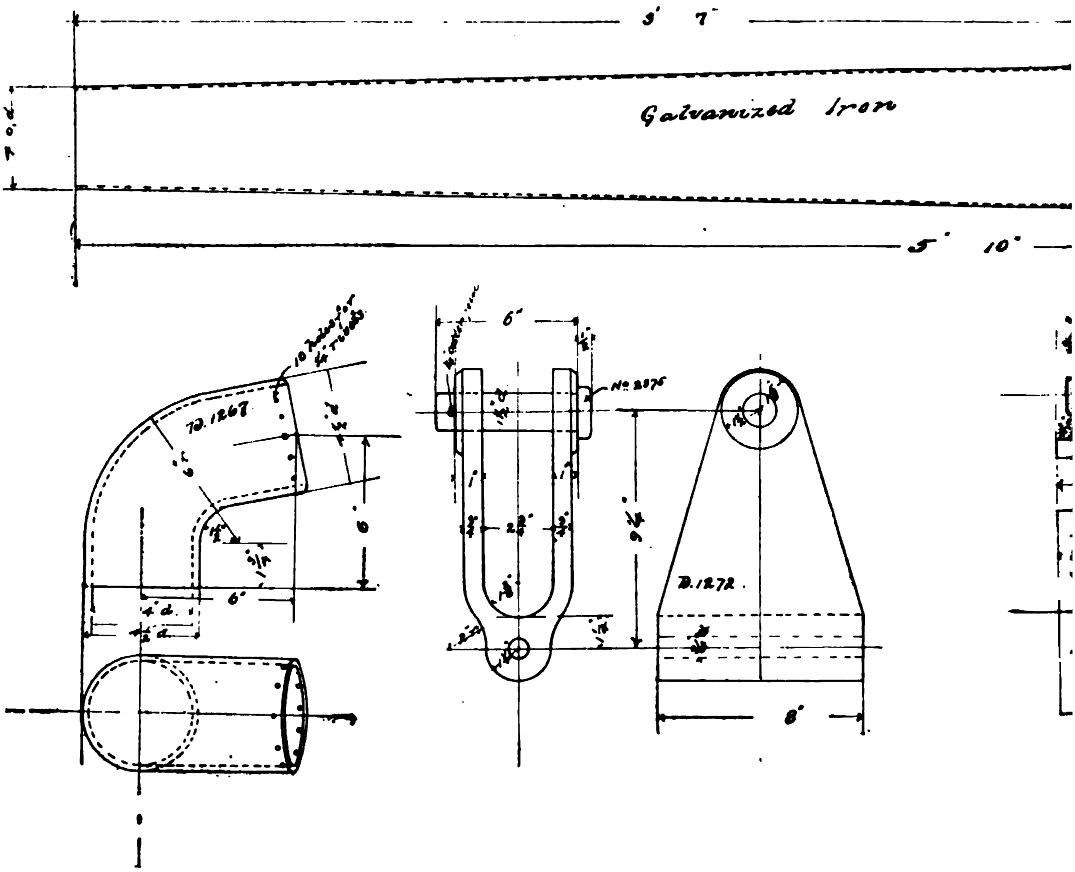
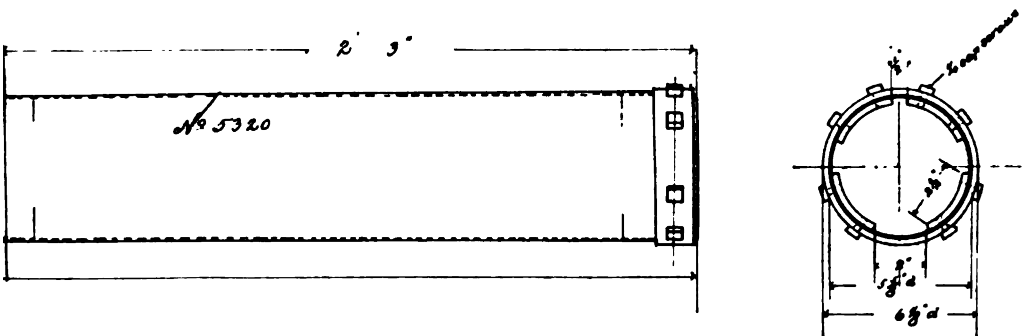
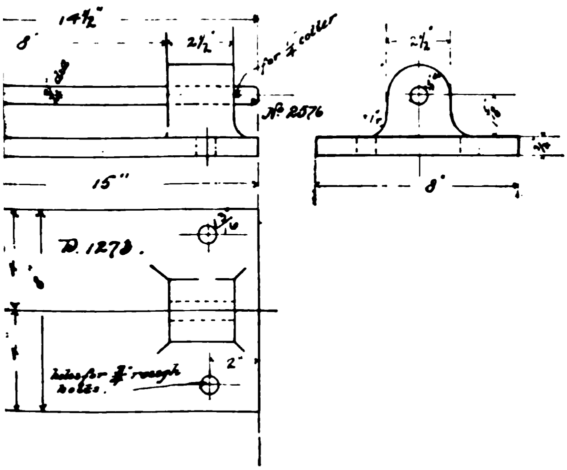
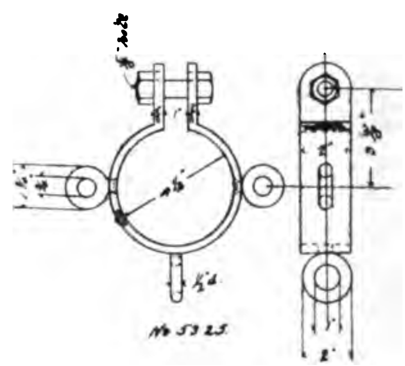
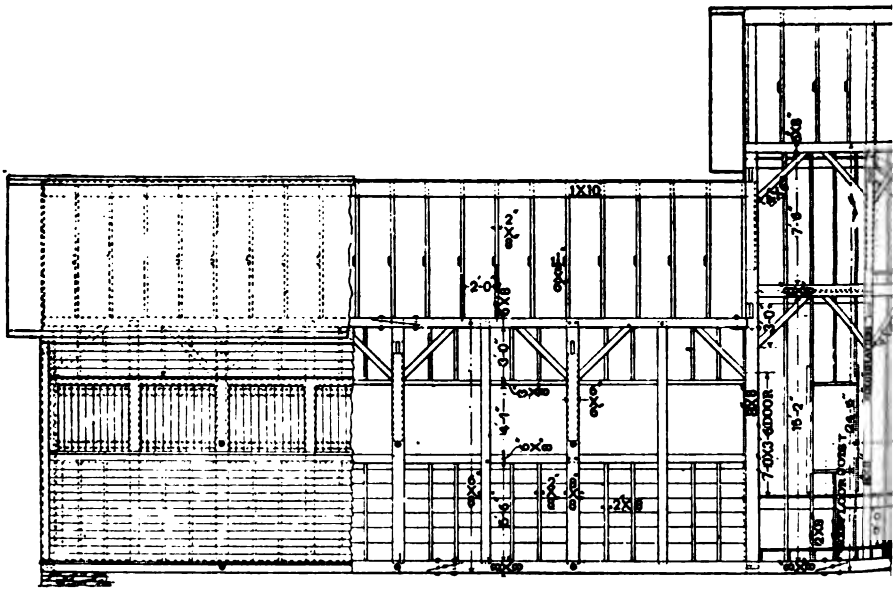


FIG. 96—SAND PLAN


2' 3"
No 5320
6⅝"d


14½"
8"
2½"
No 2576
15"
8"
D. 1278.
2"


No 5325
2"



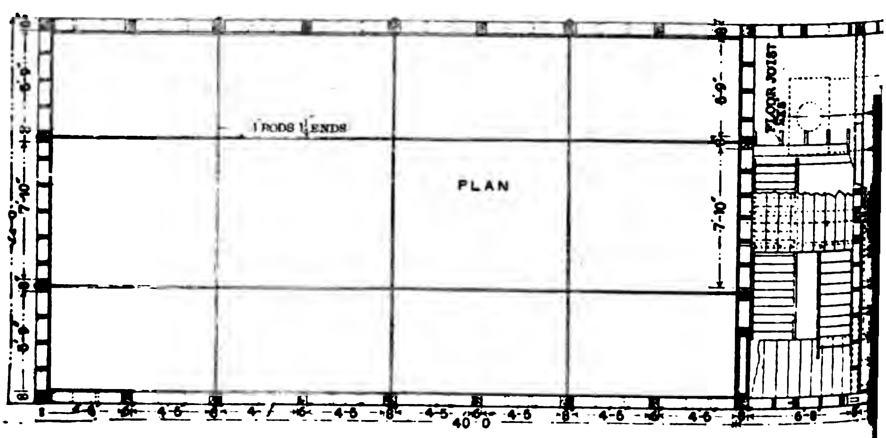
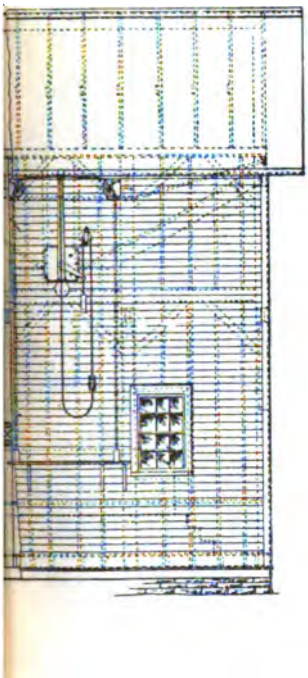
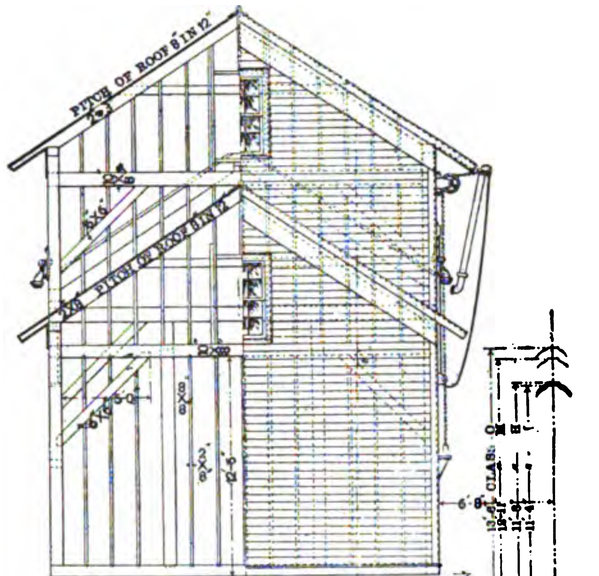
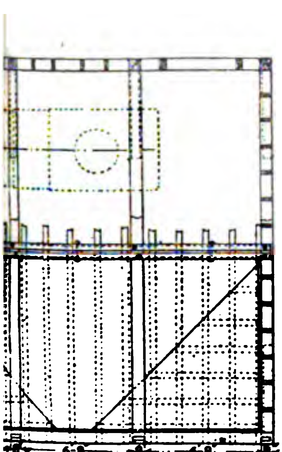


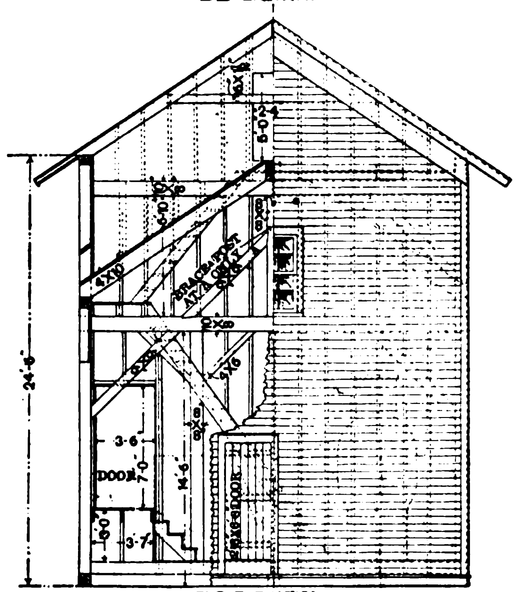
FIG. 97—SAND





END ELEVATION





END ELEVATION

I. Y., L. E. AND W. R. R.

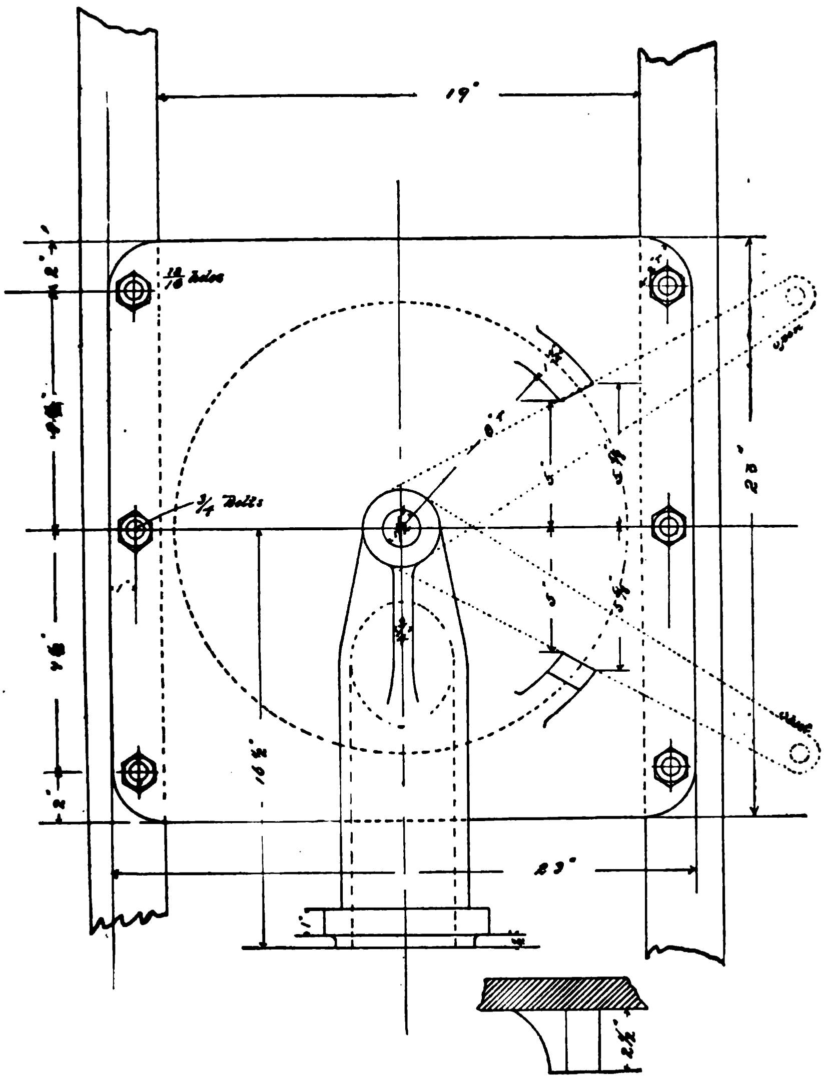


FIG. 98—SAND PLANT, N. Y., L. E. AND W. R. R.

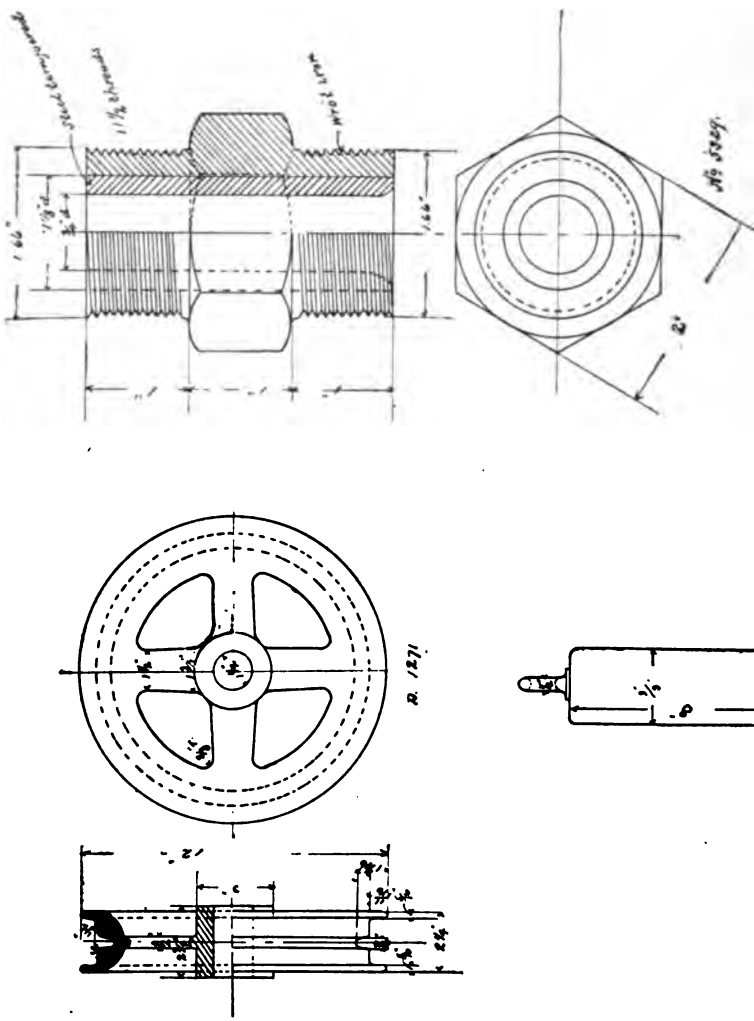


FIG. 89—SAND PLANT, N. Y., L. E. AND W. R. R.

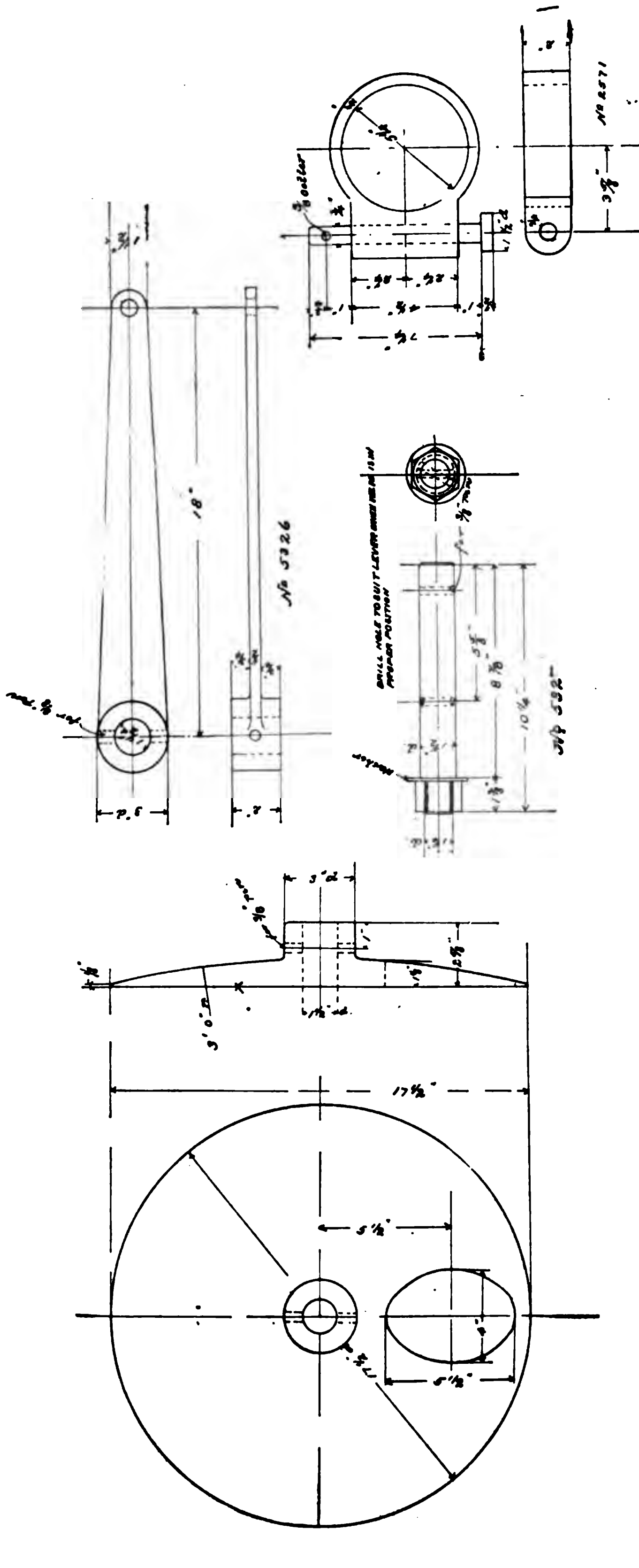


FIG. 100—SAND PLANT, N. Y., L. E. AND W. R. R.

out of the bottom of the funnel (B) and through the curved pipe into a "T" in the bottom of which the air nozzle (A) is screwed, here it meets the air blast, and is carried up the one and one-fourth inch discharge pipe to the hopper above. The section (E), in Fig. 93, is drawn through the outlet from the storage bin. The section shows the disc valve open for the flow of sand, but a pull upon the lever attached to the stem of the same in the opening shown in the casting on the outside of the building, will give the valve a quarter turn, and shut off the flow of sand. All working parts are readily accessible for repairs, and their dimensions are fully given on the engraving.

A plant similar to the above referred to is located at Huntington, Ind., on the Chicago and Erie R. R., excepting the sand is dried by stoves instead of steam.

The following report is from W. O. Eggleston, master carpenter of C. & E. R. R.:

"The sand is unloaded from the cars to storage bin by hand, at a cost of a dollar and twenty-five cents per car. It is then wheeled to the dryer, which is a large stove made for the purpose, with a "V" shaped hopper around it to hold the sand, which is dried by heat; as it dries it falls to the floor around dryer. It is then shovelled into the hopper with a wire screen over it, and as it falls through the screen it is elevated to the delivery bin above, ready for use. From there it is run through spout to sand box on engine as shown on print. Besides the unloading of sand from cars, there is only one man employed to operate the work; this man works twelve hours per day at twelve and one-half cents per hour. The hostler takes sand the same as they do water. Instead of the boiler being located in the sand house, as shown on print, it is in the round-house, and furnishes power for some small machinery used there. This boiler furnishes steam also to elevate the sand, sand house being about 300 feet from the roundhouse, through two eight-inch air pumps and a thirty-inch reservoir, this air passes through a two-inch pipe to the elevator, where is reduces to one-eighth of an inch just at the mouth of pipe to receiving bin, and is a success in all respects, as you see the cost of all labor is nominal; the man that dries the sand furnishes it for about seventy engines in twenty-four hours. Add to it the cost of the proportion of furnishing the power to elevate the sand and unloading it from the cars, places the cost of sand at about three cents per engine. The first cost of outfit was $1,600.

SAND PLANT, C., M. & ST. P. RAILROAD, LOCATED AT WEST MILWAUKEE, WIS.

Building of brick, with iron trusses and slate roof—ninety feet long, twenty feet wide, in which all machinery, etc., is contained for drying and storing green and dry sand. The former in space

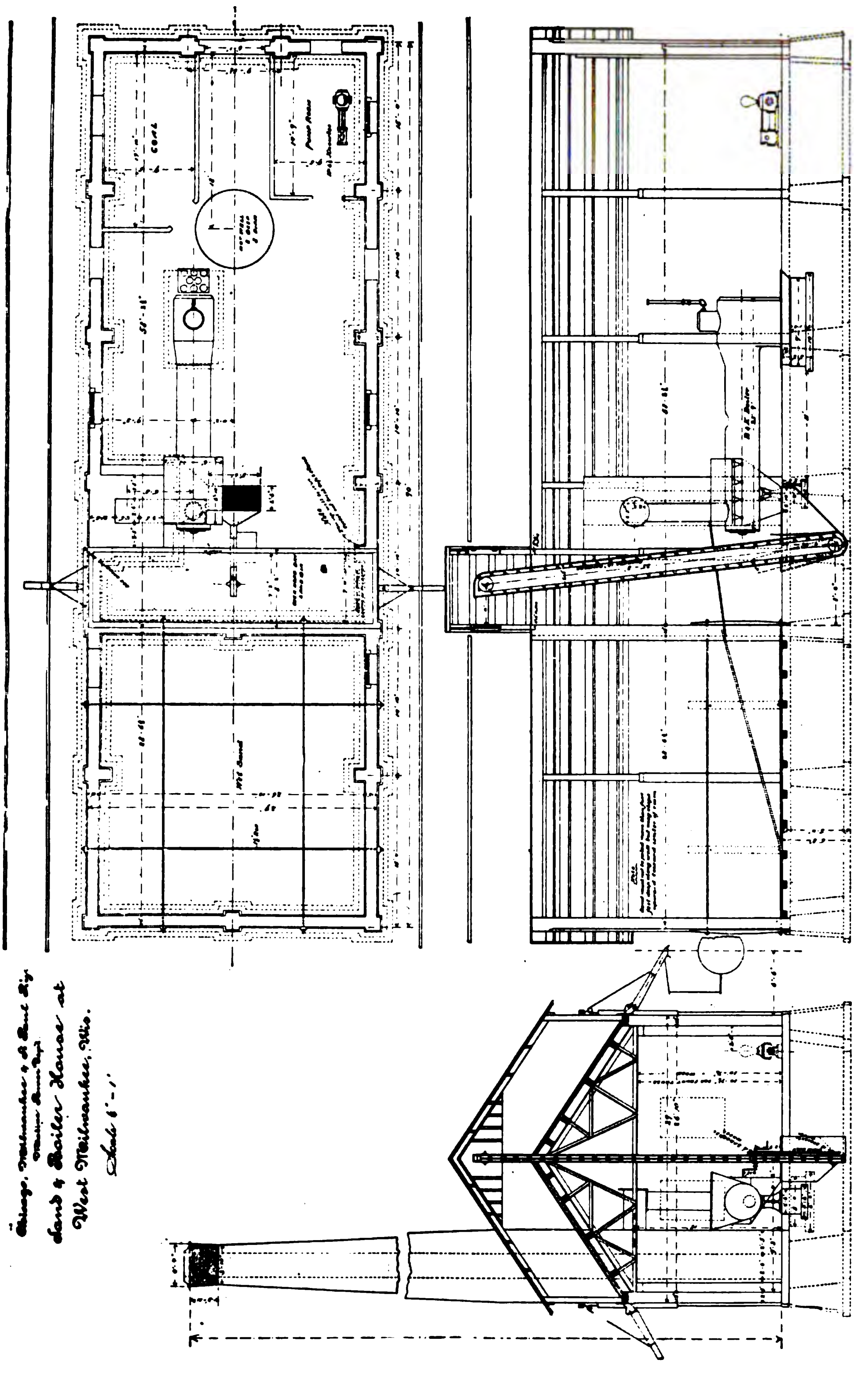


FIG. 101—SAND PLANT, C., M. AND ST. P. R. R. WEST MILWAUKEE, WIS.

twenty-eight and one-half by twenty-nine feet, the latter in center twenty-nine feet by seven feet four inches, which is elevated to a height sufficient for elevators to convey dry sand to bins for that purpose by link belting and buckets. Fifty-eight feet by twenty-nine feet is used for machinery for drying sand, pump room, and coal bin for engine, and pump; sand hopper, six feet wide, six feet, ten inches long, attached to front end of locomotive boiler, which also furnishes steam for sand elevator engine and other purposes, through which steam coils are run. This together with the heat from the boiler dries the sand. And as sand is dried it is conveyed by gravity to boot of elevator, from where it is elevated to a dry sand bin, of which there are two at some places, one on each side of the building, so sand can be taken on either side at the same time, or built single, if so desired. The elevator being run by steam or hand power, in connection with the drying of sand, is also a pump by which water is pumped for locomotives, all of which can be accomplished by the same man who attends to the drying of the sand. Onward Bates, engineer and superintendent of B. & B., of C., M. & St. P. R. R., reports as follows:

"Replying to your circular letter of April 20, 1895, asking, in behalf of the American International Association of Railway Superintendents of Bridges and Buildings, for information concerning various methods of drying sand for locomotive use, our practice is limited to two systems—the coal stove, with sand hopper attachments, and the steam dryer described below. The first system is one which we employ at intermediate stations and at certain division points. The wet sand is stored in bins out of doors or is unloaded directly into the sand house, which is usually a small frame building. The wet sand is handled with shovels and wheelbarrows and the dry sand is handled with shovels and buckets. The drying arrangement is simply a hopper attached to an ordinary cast-iron, soft-coal stove and the sand is dried by the means of the heat radiated from the upper part of the fire-pot and from the section of cast-iron stove-pipe between the top of the stove and the top of the hopper. As the sand becomes sufficiently dry it passes through the apertures in the base of the hopper and is screened into bins through screens usually made of locomotive stack netting. Sand sent to the sand-house in cars is unloaded by shovelling. The cost of operating this dryer is dependent upon the amount of sand used, and whether the men operating the dryer have other business to attend to. There is only one station on this company's line where the amount of sand used is sufficient to require the constant attention of the man operating the dryer and at that station it is estimated that the cost is about eight cents for each locomotive. Our standard steam system of drying is employed at division points where we have constructed a combined boiler and sand-house in connection with the round-house and other buildings incident to a division station. It consists of a hopper attached to the front end of a stationary boiler. The wet sand is stored sometimes outside the sand-house, either exposed or under sheds, and sometimes in the round-house proper. It is usually supplied to the hopper by wheelbarrows, but in one instance we have the wet sand unloaded into the bin, from which it is conveyed to the dryer by steam power. The operation of drying is by means of steam coils in the hopper mentioned and in addition to whatever heat may be radiated from the boiler itself. After being dried the sand is screened into a pit below the dryer, and is elevated to a sand-bin in the upper part of the building, from which it is conveyed to the locomotive through a spout on the outside of the building, operated in very much the same way as a water tank. The power used to elevate the dry sand into the bins is sometimes steam and sometimes hand. The latter is not very satisfactory. Under this system the sand is always unloaded by hand, but when the sand house is built, adjoining the elevated track of the coal chute, we have arranged to unload the cars from the elevated track. There are certain modifications of the above two systems which are immaterial. One of which is in operation at certain stations to supply the sand to locomotives by means of a crane and bucket, the latter having an outlet and valve in the bottom. This is considered more economical than using buckets where there are many engines requiring the sand, and in the line of equipment it may be said to stand as an intermediate between a stove equipment with buckets to handle the dry sand and the boiler equipment with an elevator and elevated bins. I send you, under separate cover, copies of such drawings as we have, which will be of assistance to you in this report." (Fig. 101.)

SAND PLANT, DULUTH AND IRON RANGE RAILROAD, LOCATED AT TWO HARBORS, MINN.

Mr. W. A. McGonagle, Supt. B. & B., reports as follows:

"I enclose plan of our present sand-house and dryer. This system is operated by receiving the sand on flat cars, shovelling same into the bins on ground floor, screening the sand and allowing it to run into the dryer, which in this case is a sheet-iron hopper, with stove inside, and then elevating the dry sand to high bins above by crane and bucket operated by hand. The sand is thence conveyed by a spout to the dome on engine, and it requires but a moment or two to take a supply of sand. The plant is operated by one man by day and another one at night, the wages in each case being $1.50 per day. The building is covered outside with corrugated iron, and the master mechanic reports that it operates successfully. I am now preparing plans for a new and much larger plant, in which the sand will be dumped from a hopper-bottom car into a pocket, and will run over screens into a screen dryer and from thence be elevated by an air blast to the pocket above. This will eliminate all labor of shovelling, and the cost of operation, on account of the limited amount of compressed air used, will be very much less than at present." (Fig. 103.)

SAND PLANT, CHICAGO, ROCK ISLAND AND PACIFIC RAILROAD.

Built adjoining an elevated coal-dump track, on which sand in cars is run to an elevation sufficient for engines to take sand in same manner water is taken; sand dried by a common stove for that purpose. Building for sand-house purposes, 9 feet wide, 33 feet long, elevated, with floor of same 4 feet above top of rail on elevated track. Dry sand hopper, with flat bottom, located at one end, drying-room in center, green sand in opposite end. With this arrangement the necessity of elevating sand by machinery is dispensed with, making it very cheaply constructed and economical for handling sand at small stations or terminals. Spouts through which sand is supplied to engines are of telescope pattern, hung on weights, admitting of sand being given to engines of various heights. Mr. George J. Bishop, general foreman B. & B., reports as follows:

"We have a large sand dryer, built like a stove, with a sheet-iron funnel fastened to dryer, that will hold about one and one-half yards of sand. The sand is dried in the heat of the fire. The engines are filled by buckets, and also by telescope drop-pipe, from the elevated sand-house, built on coal-chute incline. The elevated sand-house is made to hold about three cars of green sand. The sand dryer is filled by hand, with a scoop shovel. The dry sand is shovelled into a bin built for that purpose, made to hold a car of dry sand, for filling engines. The drying apparatuses are very crude affairs, and cost $39.50 each. They will dry an average of about 40 bushels of sand per day with one stove. The cost of labor, $1.25 per day. The sand boxes on our engines hold about seven bushels of sand each. It is hard to determine the exact cost per engine, as the man who does the sanding is not working at it continually; in fact, I do not think he devotes more than one-third of his time to it—filling up the hopper and sifting the dry sand—and the balance of his time we utilize for other purposes. I think that one cent per bushel, or seven cents per engine, will be a liberal estimate." (Fig. 102.)

SAND PLANT, C., C., C. & ST. L. R. R., BELLEFONTAINE, OHIO.

Green-sand bin fifteen by twenty-one feet, half of which extends under elevated coal-dump track. By this arrangement sand can be unloaded from drop bottom cars through door in roof of house for that purpose, or shovelled from cars standing on main track. Capacity seventy-five yards, stoves, sand drying, and ele-

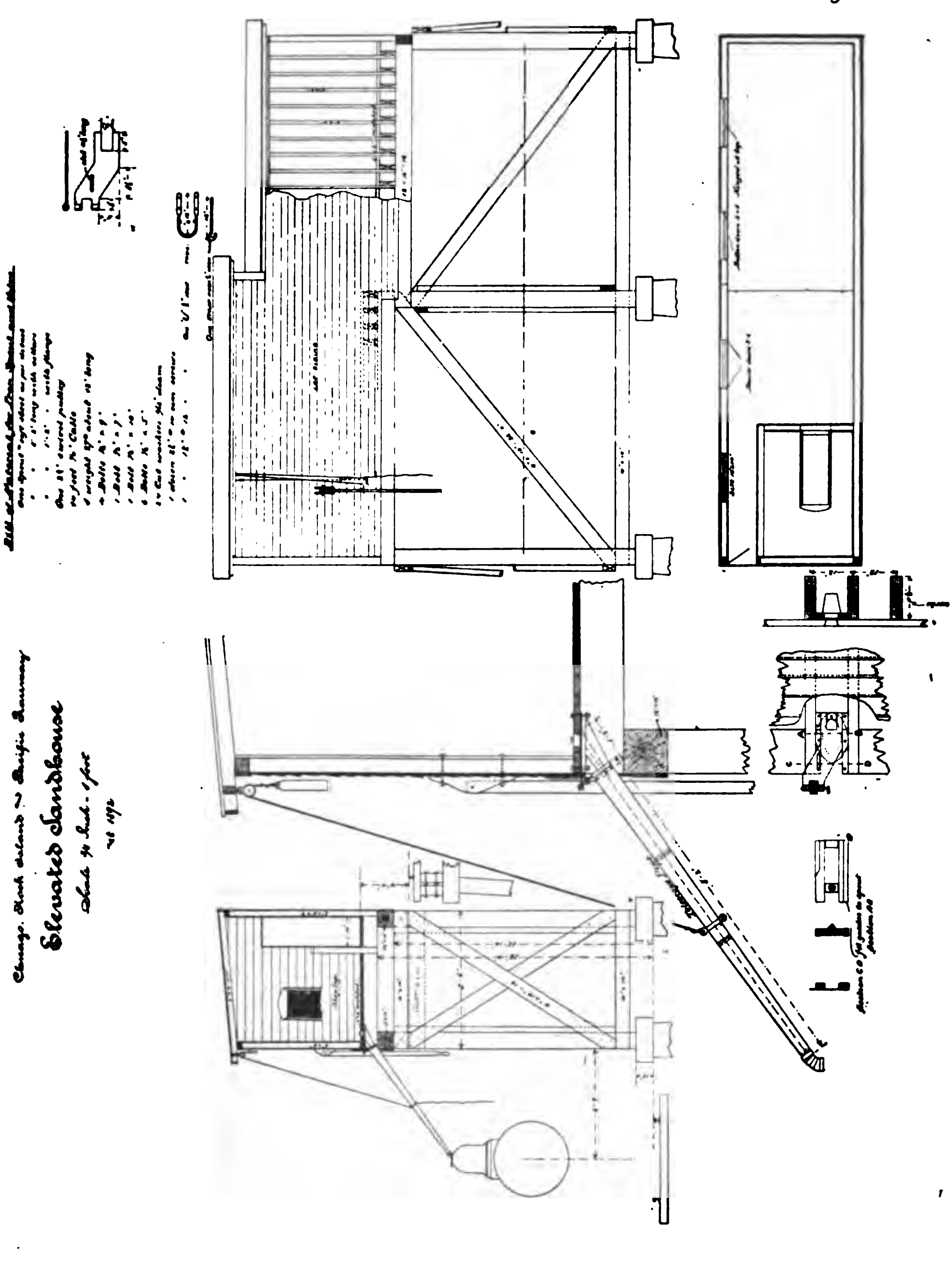


FIG. 102—SAND PLANT, C., R. I. AND P. R. R.

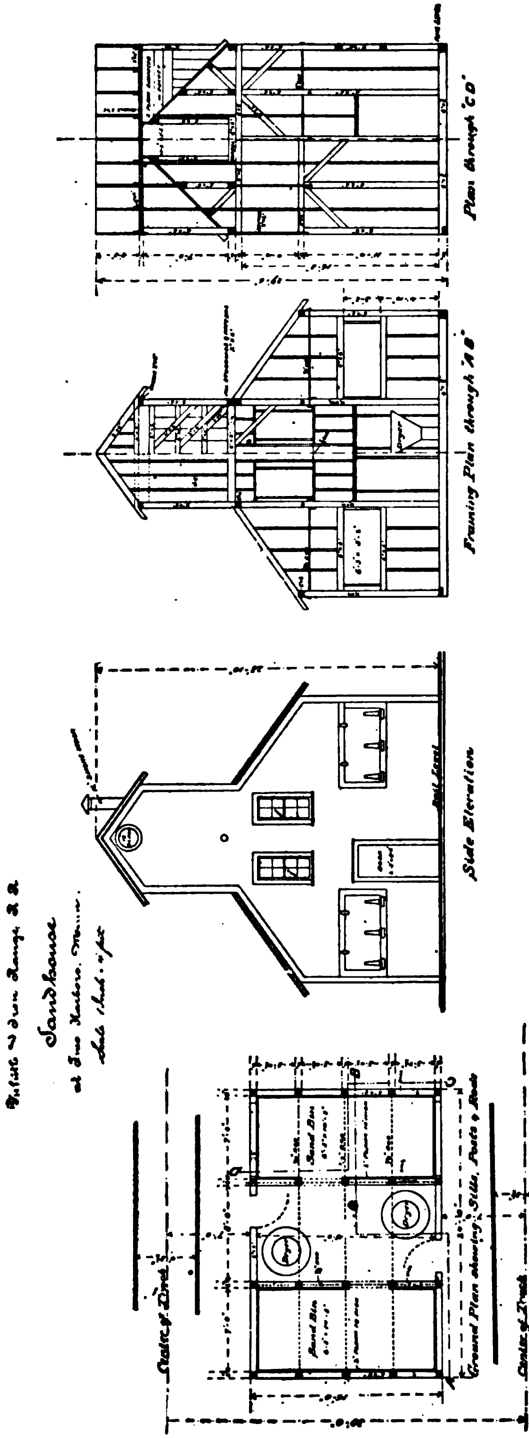


FIG. 103—SAND HOUSE, DULUTH AND IRON RANGE R. R., TWO HARBORS, MINN.

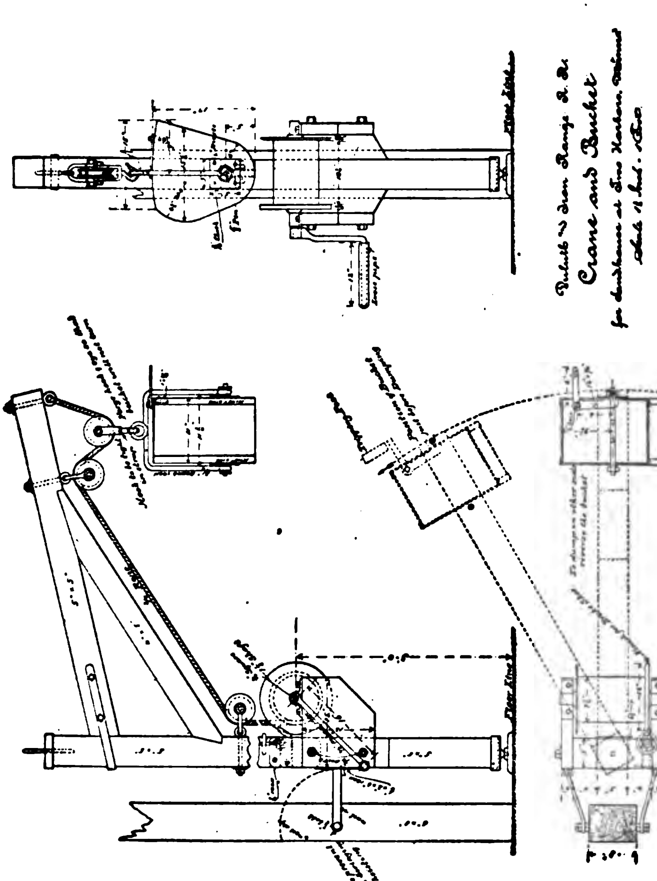


FIG. 103 (CONTINUED)—SAND HOUSE, DULUTH AND IRON RANGE R. R., TWO HARBORS, MINN.

vator room nine feet ten inches wide, eighteen feet long, thirty-one feet high. All built of wood, with four-ply gravel roof and adjoining coaling station. Elevator of link belting operated by hand. Has dry-sand hopper where sand is elevated and taken by engines the same as water. Mr. A. Shane, superintendent of B. & B., reports as follows:

"I hand herewith blue print of standard sand-dryer and elevator. Cost of building, $250; sand elevator, $62; dryer, $10; concrete floor, $27.50; total, $349.50. Storage capacity, seventy-five yards. Drying capacity, twenty yards per day, at a cost of six cents per yard." (Fig. 104.)

SAND PLANT, ST. LOUIS AND SOUTHEASTERN, TEXARKANA, TEXAS.

Building of frame, twenty by thirty feet. Green-sand bin ten by thirty, two dry-sand bins eleven by ten feet each, between which are located drying stoves. The building elevated to sufficient height that green sand is shovelled from cars into bin on level with dry-sand bin. Floor of dry-sand bin on level with running board of engine, extending three feet outside of building and next to engine, to which apron with hinge attachment is secured, used to walk on while sanding engines. Outlet spout of hopper elevated sufficient height above platform for sand bucket to stand under while being filled from sand bin by gravity. With this arrangement one man can sand engines very easily, which is a labor-saving device. J. S. Berry, assistant superintendent B. & B., reports as follows: "Replying to your favor of July 22d, I will say that I am not prepared to give you the information I would like on the subject. I am figuring on a sand-house dryer and elevator, by which the sand is to be dried by steam and elevated into the hopper by compressed air, with slide and spout attachment for delivering the sand into the sand box of the engine. I have not the plan far enough along to give you an idea of what it will be, but if I get them completed by the time your report will be ready, I will send you a blue print. Under separate cover I mail you to-day a blue print of our present sand house and dryer, as good as any I have seen in this country. All the work, of course, is done by hand. You will notice outside stairway where sand is taken up by a bucket, and at the top of landing a door which is lowered down on to the running board of the engine, the sand carried across and put in the sand box of the engine." (Fig. 105.)

SAND PLANT OF LEHIGH VALLEY RAILROAD, SAYRE, PENNSYLVANIA.

Sand dried is located over entrance to the round-house. Green sand, after being screened, is elevated to the steam drier by link belting elevator operated by steam. Steampipe is used, con-

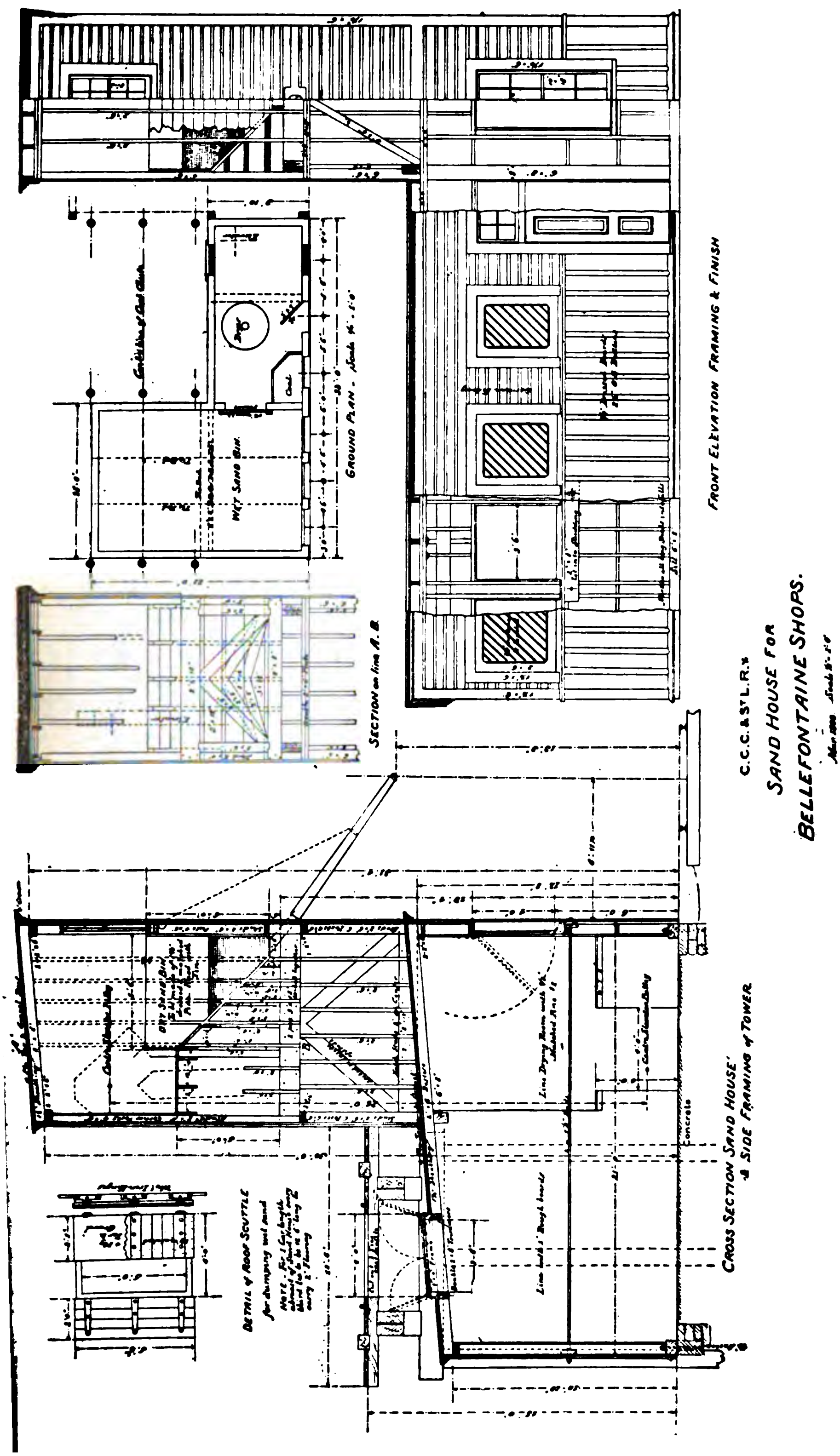


FIG. 104—SAND PLANT, C. C. C. AND ST. L. R. R., AT BELLEFONTAINE SHOPS, OHIO.

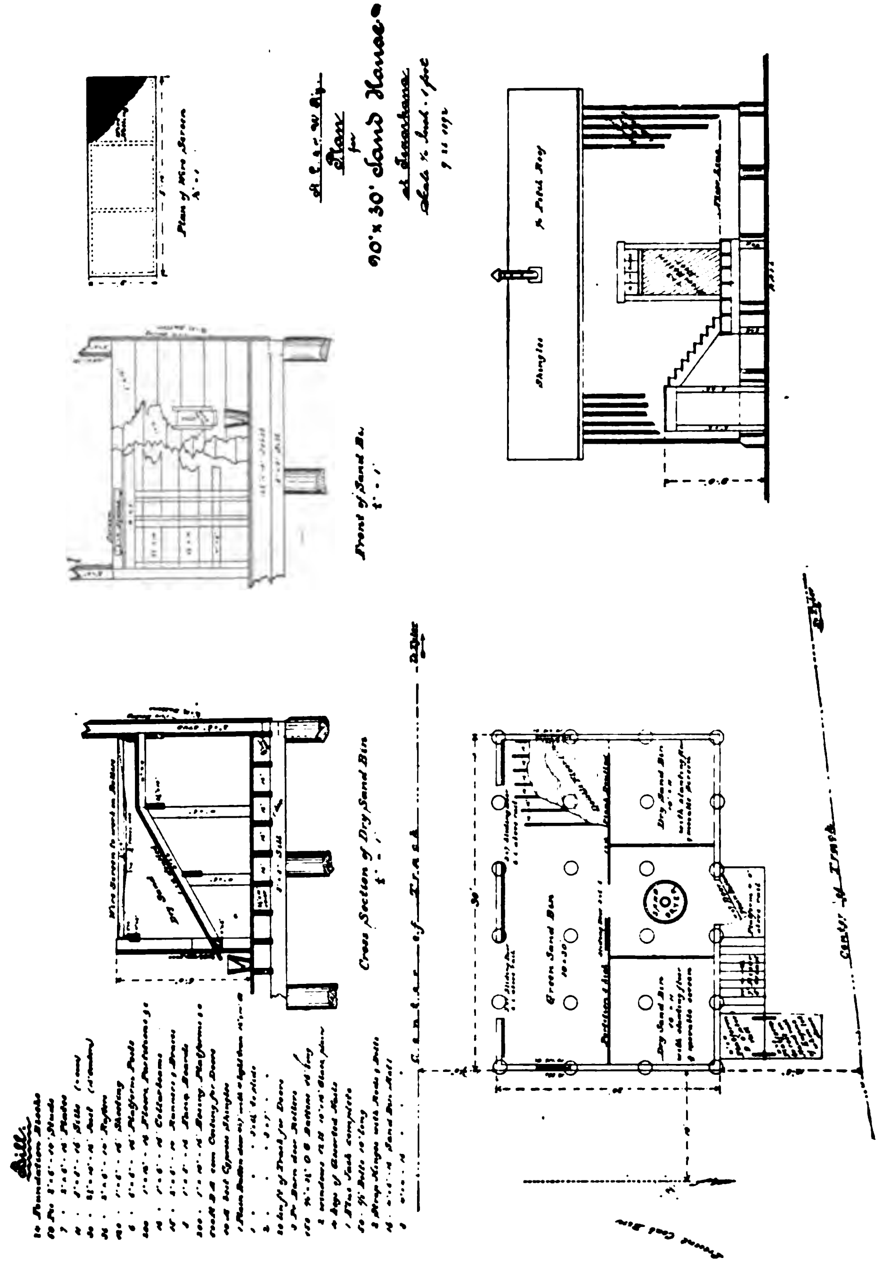


FIG. 105—SAND PLANT, ST. L. AND S. W. R. R., TEXARKANA, TEXAS.

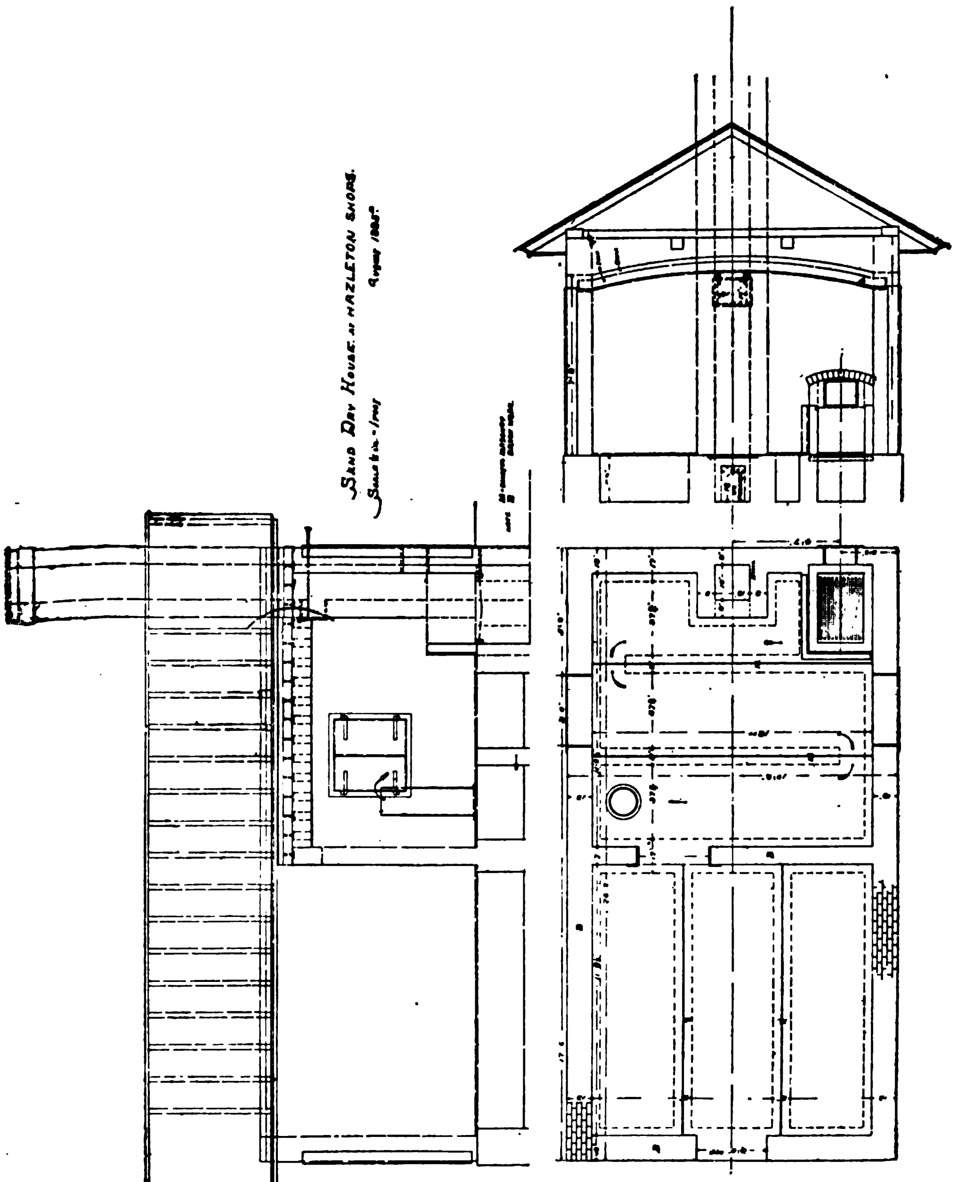


FIG. 108—SAND PLANT, LEHIGH VALLEY R. R., AT HAZLETON, PA.

sisting of three sections of twenty-five double lines of one inch gaspipe, with double manifold connections at each end, and quarter turn at the angle. The horizontal section eight feet long, vertical section two and one-half feet long. Underneath the horizontal sections gravel grate is located. Sand, after being dried, passes through this grate to dry-sand slide, which is inclined sufficient for dry sand to pass off readily to dry-sand hopper, from where engines are supplied by a flexible pipe, with valve direct to the sand box of engine.

AARON S. MARKLEY, C. & E. I. Ry.,
H. A. HANSON, C., C., C. & St. L. Ry.,
A. J. KELLEY, K. C. Belt Ry.,
J. O. THORN, C., B. & Q. Ry.,
Committee.

DISCUSSION: SUBJECT—SAND DRYERS, ELEVATORS, AND METHODS OF SUPPLYING SAND TO ENGINES, INCLUDING BUILDINGS.

Mr. Shane, C., C., C. & St. L. Ry.—Unfortunately, this subject, I think, does not interest us as much as a whole as perhaps a few individuals. Perhaps a large majority of our members have nothing to do with sand dryers, except to erect them. Now, on our system we erect them, and once the building is in position, we have nothing whatever to do with it. The motive power department maintain it and it is immaterial to us how it operates, whether it is successful, economical, or not; it is erected and off our hands. I believe this is the case with the majority of the gentlemen; there may be a few who have to maintain them.

Mr. Markley, Chicago and Eastern Illinois Ry.—The drying of the sand is for the company by which we are employed, and if we can get any good ideas by which we can help our master mechanics, it is our duty, as we are all working for the same company, and the money that pays us comes from the same pocket. While I have not myself anything to do with the construction, I have been called on by our motive department for ideas as to what would be the best arrangement at our principal points, and I suppose other members will be asked the same question.

Mr. Millener, B. & O. S.-W. Ry.—I have seen a great many sand dryers, but nothing that would compare with those we have on the B. & O. road at Washington, Ind., designed by Mr. Hall. The building is of brick, immediately at the end of our coal chute incline. At the end of it we have a large shed to store the sand before it is dried. We fill this shed in the fall of the year, by hauling sand and throwing it in. The intention at first was to run the

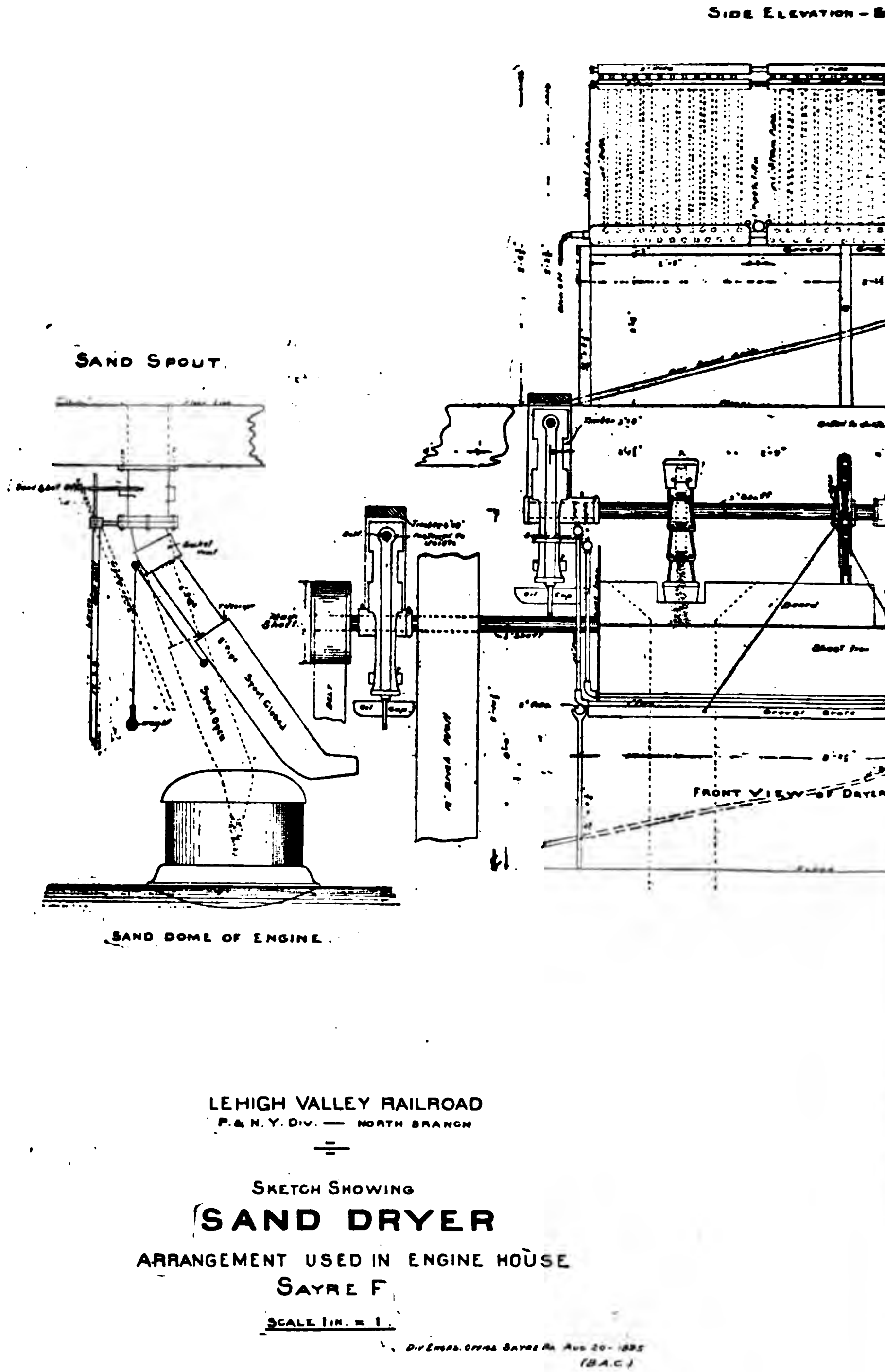
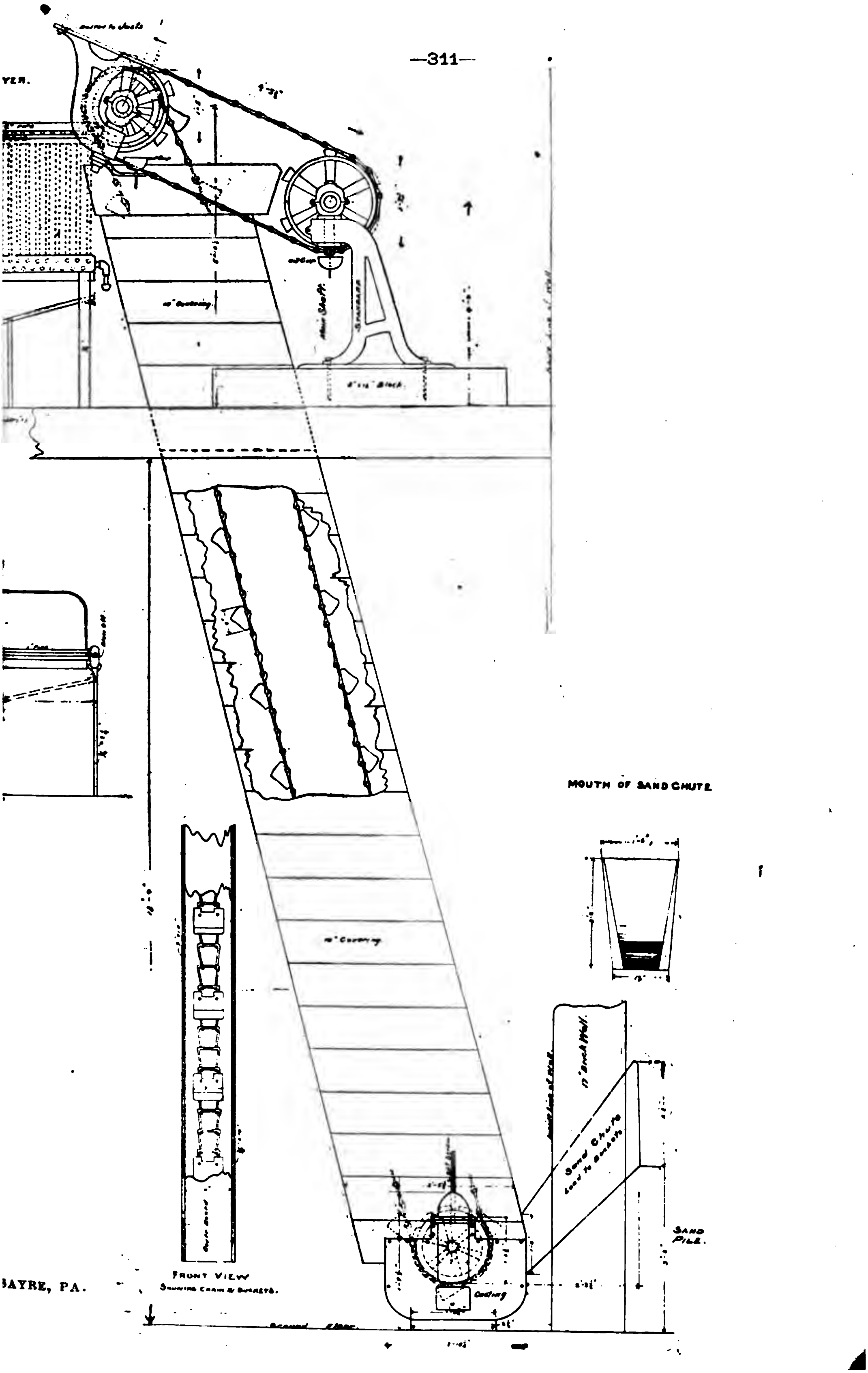


FIG 107—SAND PLANT, LEHIGH VALLEY, R.


YER.
Main Shaft
10" Covering
MOUTH OF SAND CHUTE
FRONT VIEW
Showing Chain & Buckets
11" Brick Wall
Sand Chute
SAND PILE.
Casting
Ground Floor

SAYRE, PA.

sand into dump cars and dump it from them into the shed. The sand is put into this brick building and dried in a large stove, which is made with a hopper of sheet-iron and wire. The sand is dried in there thoroughly and then run into two bins with hopper shaped bottoms. The sand is run into a chute operated by the upper gearing of the elevator, into hopper bottom bins, from which it is run into engines—by a 4 in. sand spout, similar to those used in a water tank. One man does all the work of elevating the sand; the fireman, when the engine takes sand, moving the lever and letting it into the dome.

Mr. Heflin, B. & O. Ry.—I have three or four houses on my line in which we dry sand. While they are made of different material, some of brick, others of wood, they are all constructed upon the same principle. We have a bin about 18 ft. wide, 36 ft. long; at the end are a couple of rooms for storage of the wet sand. In the center room we have a coil of steam pipe; at the other end is a room for dry sand. The sand is thrown first into the room for storage, then shoveled on to the steam pipes, then when dry it is shoveled through a screen which is erected across the building, then shoveled into the room for dry sand. The fireman runs the engine up beside the building, conveying the sand to the sandbox by buckets. All our new sand houses are arranged in this way. We have been looking for some means by which we might handle the sand from the sand house to the engine in a better way, for instance, a spout as was mentioned.

Mr. Kelleher, New Orleans and N. E. Ry.—I would like to ask the gentleman if the sand drying process is under his charge.

Mr. Heflin—No, sir; I construct the building, the motive power department dries the sand.

Mr. Kelleher—I think the remarks of Mr. Shane were very pertinent, and that when we have erected these buildings our part of the work is done.

Mr. Millener—Let me state for the information of the gentlemen one thing which Mr. Heflin has not stated. Mr. Heflin and I have the honor of being connected with the same company; we have to build, and maintain the sand dryers; the machinery department dries the sand.

Mr. Wallace, Wabash Ry.—I would like to ask a question of the gentleman in regard to this drying of sand, whether these buildings are constructed by the methods of the bridge and building department, or the chief engineer's department, and the drying process is suggested by the B. and B. department, or if we of the B. and B. department are taking items from other departments. But the question is this: Now if we erect a sand dryer, we arrange the elevating of it and other portions of it; that would belong to the B. and B. department, provided it is included in this work. It seems to me, as Mr. Shane has said, that it is a thing that concerns very few of us. Very probably we are furnished with a plan of these buildings to erect same as a depot; possibly we are asked as to the best handling of it; we know but very little about it, and I think the percentage of the members of this association concerned in this sand drying business would not amount to two per cent.

Mr. White, Texas Midland Ry.—I have no recollection in all my experience of but once having to invent or erect a sand dryer on my own responsibility. I do not mean the building, but the dryer; then it was new work. There was no machinery department there and the whole responsibility was left to me. I erected just a common sand dryer, using one end of the building for wet sand, the stove in the middle, simply made of boiler iron, and the screen before the dried sand at the other end. It seemed to answer the purpose very well, but I paid no attention to it after it was built; merely did this as an accommodation.

Mr. Peck, Mo. Pac. Ry.—We use the Plock sand drying stove on the Mo. Pac., and I believe it does very well. They have made some improvements on the stove in the last few years. We usually dry our sand at the most convenient point to secure it. We elevate the sand at our coal chute, shoveling into a bin, the same as we shovel our coal into coal-bins—elevated sufficiently to enable the engineers and firemen when they run to the coal chute to take sand at the same time, or immediately after or before with coal, without unnecessary detention. The spout is raised so it reaches the sand dome of the engine the same as water-spouts reach the tank—delivered into the spout by a valve, so that it makes a very quick method of delivering sand. We have experimented considerably with different methods, but have not found anything that was very satisfactory; in fact, we have come to the conclusion that this sand drying stove is the best method. I think the stove should be entirely of cast-iron—sheet-iron is too easily warped with heat and causes extraordinary expenses on account of repairs. Even the pipes should be cast; at least for some considerable distance from the stove. I have charge of the erection; the sand drying is under our master mechanics.

Mr. Stannard, Wabash Ry.—Our method is the same as Mr. Peck's.

Mr. Berg, Lehigh Valley Ry.—I would like to refer to the more extensive use that is being made daily of compressed air in moving sand in connection with supplying sand to locomotives. It is quite marked, and a large number of novel devices and expensive plants have been adopted within the last few years. I have recently heard of a novel construction on the Chicago and Northwestern Railway, I believe either in Chicago or right close to it. The idea for taking sand is similar to that for taking water; in other words, it is a sand standpipe. The sand house is located conveniently several hundred feet away, and the dry sand moved by compressed air to this standpipe with a horizontal pipe swung out over the track. This is certainly a novel construction, and indicates the general trend in the matter of moving sand for locomotive supply, especially where compressed air is easily obtainable.

I believe thoroughly in all these improved methods, that is, where there is a plant of sufficient size to warrant a regular force of men to be engaged in the business; but for a small plant with intermittent service, where the crew of an engine has ample time to get off and load the sand, I am a very strong advocate of the good, old-fashioned, cast-iron, sand-dry stove, which can be so located that it does not require a special man to look after it, as one man can look after other duties in the same neighborhood, such as attending to a coaling station, oil house, roundhouse, etc., and attend to the sand stove at the same time also. I think that the introduction of complicated and expensive sand-drying appliances is possibly in some cases a fad adopted by railroad officials but not warranted if the small output of sand is considered. In other words, I thoroughly believe in improvements and labor-saving devices, but deprecate the introduction and duplication of expensive plants, even in a modified form, at small stations. For these, I still believe, as I said before, in the good, old-fashioned, sand-drying stove.

Mr. Riney, Chicago and Northwestern Ry.—We have in use the old-fashioned, cast-iron, sand-drying stove. We were talking of getting a new device, but I do not know that we shall get it. We take care of some ninety engines in twenty-four hours with the appliance we now have.

Mr. Garvey, Iowa Central Ry.—We have got a sand-dryer and pump, and are going to fill up the sand-dryer, and load the sand on the cars run up to our coal-chutes, just the same as coal, and we have arranged to fix two of our coal pockets for sand tanks, putting up a spout, and when engines take coal, they will take sand at the same time.

Mr. James Stannard, Wabash Ry.—We use an elevated sand house which is located on elevated coal track at end of chutes. Cars of green sand are placed on end of elevated coal-chute tracks and unloaded with shovels from cars into the sand house. Our mode of drying is by use of large, cast furnace, somewhat in shape of a stove with a hopper made of heavy wire netting. Hopper is kept filled with green sand, which is passed in at top by use of shovels. We use coal for fuel in above furnace. Sand screen is placed between sand dryer and dry sand bin, through which dry sand is passed from sand dryer to bin. Sand-bin is made in shape of hopper with valve located at lowest point, from which sand is passed through spout to sand dome on engine, on the same principle as water is taken from water-tank. Capacity of dry sand-hopper, about two carloads of twenty-four cubic yards. Time required for sanding engine, about two minutes. Capacity of green sand storage as per blue-print, is about seven carloads or eighty-four cubic yards. Man in charge of coal chute also has charge of sand drying. Cost per yard for handling and drying sand, about twenty-five cents per cubic yard. I consider same a very convenient, economical method of handling sand, there being no waste in handling.

Mr. Rogers—We have a plant at Stony Island for drying sand and elevating it into a small tank. It is used for drying sand, and pumping air through an air chamber, and getting water for washing out in the roundhouse, and the apparatus is equipped with a hopper and a sand bin alongside the boiler and the sand is thrown up and run down into a reservoir, and under this there is an air tank which blows the dry sand up into the tank outside, contiguous to the track where the engines come from the roundhouse, and it is run into the engine from that tank the same as water.

Mr. Eggleston, Chicago and Erie Ry.—We have two on the Chicago and Erie; one is referred to and illustrated in the committee report, and is a success. Since that time, we have put in one at Chicago and it can be seen in operation any day. Engines coming out of the house take sand the same as water. The work is all handled by the man in charge of the engines. The sand is put into the dryer and then carried up by air pressure. This plant is located at 49th street, Chicago.

REPORT: BEST METHOD OF SPANNING OPENINGS TOO LARGE FOR BOX CULVERTS, AND IN EMBANKMENTS TOO LOW FOR ARCH CULVERTS.

The proper method of constructing an opening on this plan: First, excavate for walls to secure a permanent and solid foundation, or where permanent foundation for wall is difficult to obtain, would recommend driving piling and put in concrete to depth of about three feet for foundation of wall. Walls to be made of good quality rubble stone, laid in good cement mortar, composed of two parts good, clean sharp sand, and one part Louisville cement. Walls to be built to proper height, made true and level on top or last course to receive old rails which are laid close together, with a rod passing through each end to hold them in place, using any kind of old track rails that have sufficient length of good rail to span the opening, and use old "I" beams or channel bar at either end of culvert to hold ballast in place. Rails and channel bar should

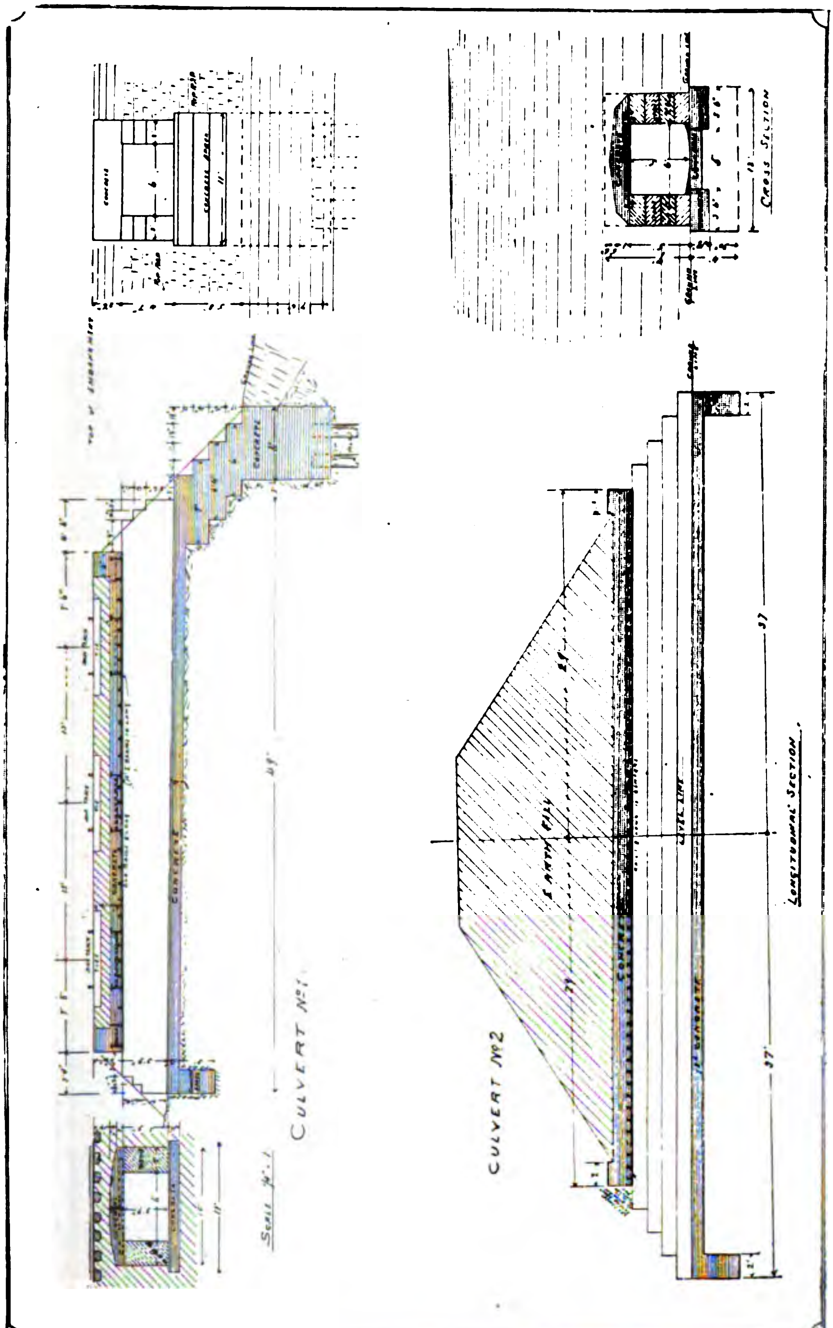


FIG. 108—BALLAST FLOOR CULVERT BRIDGE.

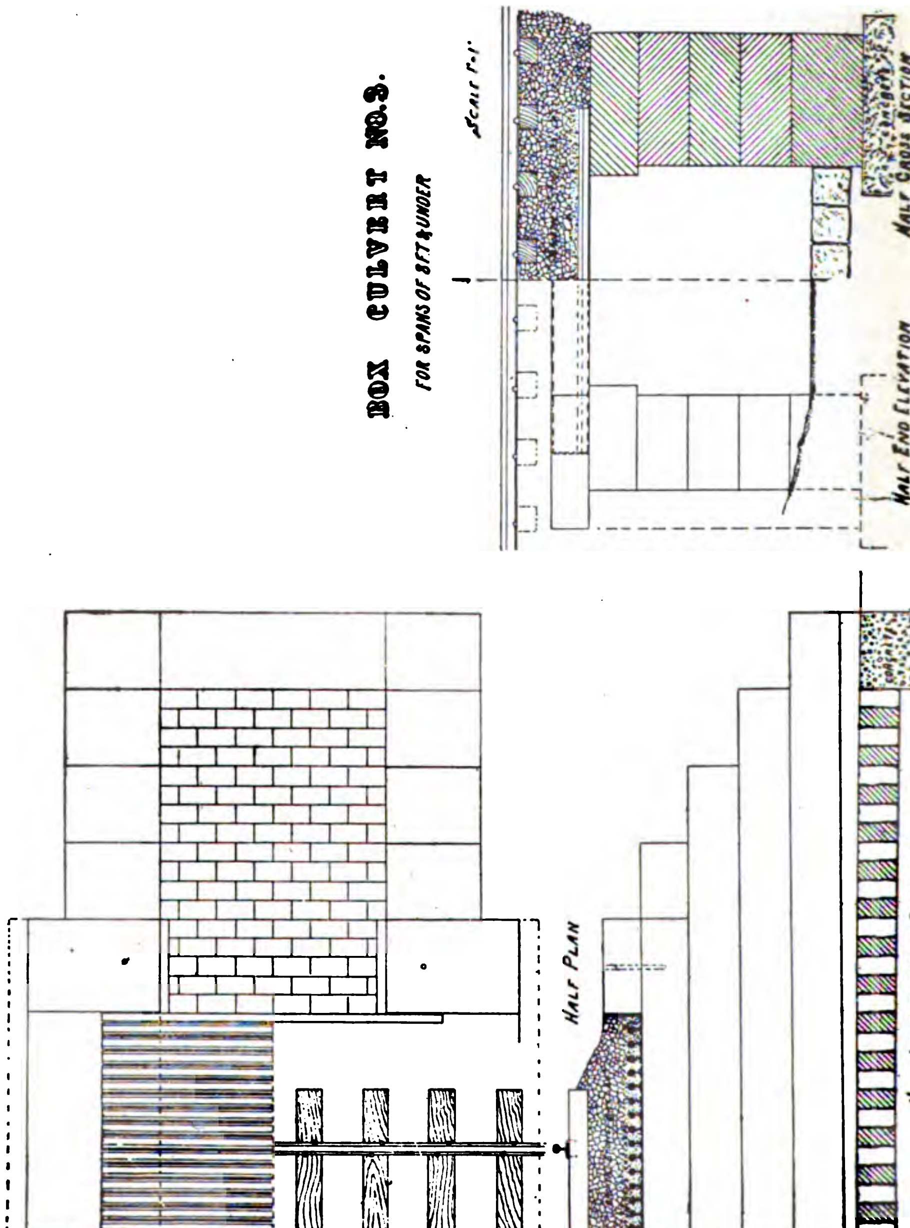


FIG. 108 (CONTINUED)—BALLAST FLOOR CULVERT BRIDGE.

receive a coating of coal tar to prevent rust. The retaining, or wing walls, should be built higher than main walls on which rails are placed as shown on plan, and the first piece of rock in retaining wall, above level of top of main wall, should be securely anchored or doweled to wall underneath same to resist pressure of embankment against the "I" beam. The rails should be covered with concrete to a depth of four to twelve inches, owing to length of opening. Concrete to be made highest in center, in order to give drainage and add strength, and place about twelve to eighteen inches of ballast above concrete to bed ties in. The bottom, or water-way, of culvert should be floored with concrete to a depth of twelve inches, or paved with flat stone laid in cement mortar. Great care should be taken to extend floor or pavement on down stream side far enough to prevent wash.

This plan of culvert has been adopted and is in use on the Missouri Pacific system, also the Kansas City, Fort Scott and Memphis Railway and other Western roads. They are used for all openings up to twelve feet in the clear. For all openings eight feet span and over "I" beams should be used under track rails to increase strength, as shown on plan.

For the class of openings referred to, this plan of culvert is considered practically the cheapest and best of anything in use.

We, your committee, deem it unnecessary to make further explanation relative to subject in question, as the accompanying blue prints show everything in detail.

JAS. STANNARD, Wabash Ry.,
L. K. SPAFFORD, K. C., Ft. S. & Memphis Ry.,
O. H. ANDREWS, St. Jo. & G. I. & K. C. Ry.,
F. W. TANNER, Missouri Pacific Ry.,
Committee.

DISCUSSION: SUBJECT—BEST METHOD OF SPANNING OPENINGS TOO LARGE FOR BOX CULVERTS AND IN EMBANKMENTS TOO LOW FOR ARCH CULVERTS.

Mr. Peck, Mo. Pac. Ry.—Would state that our method of bridging such openings is to build stone walls with necessary foundations of stone or concrete, raise the walls to proper height and use old rail, discarded rails from the track, to span the openings, placing the rails from eight to twelve inches apart, according to the width of the opening. The space intervening is filled in with concrete, after being planked. We use concrete walls on the side, level up with the base of rail, fill, and after leveling off pack with cinders to a depth of eighteen or twenty inches, and place our ties the same as on ordinary roadbed.

Mr. Aaron S. Markley, Chicago and Eastern Ill. Ry.—Would not that make a place to retain the water, or do you provide for draining the water?

Mr. Peck—In answer to that would say that our retaining walls are not solid at the end—there is plenty of room to admit of the water passing out. We use three parts of sand to one of cement; very often use American cement.

Mr. Middaugh, Seattle, Lake Shore and Eastern Ry.—I would like to ask Mr. Peck if he has tried large iron pipe in cases of this kind, and how it would compare in cost with the plan he speaks of. Seems to me it would probably be very much cheaper.

Mr. Peck, Mo. Pac. Ry.—We usually use this plan where pipe is not practicable in openings from six to twelve feet. Four foot pipe is as large as we ever think of using, and where that will not do we have a great many openings where two pipes are used, but it is troublesome on account of debris filling them up and blocking the waterways. I find it important to leave all the opening possible on account of the liability of corn stalks and other debris stopping the passage of the water.

Mr. Eggleston—Why not double two old 12-inch eye-beams on masonry and put your floor system on that?

Mr. Peck—We frequently use eye-beams because we most always have some that can be got without trouble. We use them where we would otherwise use old rail.

Mr. Eggleston—Do you truss this rail any?

Mr. Peck—Not at all.

Mr. White, Texas Midland Ry.—All this talk that I have heard strikes me as being applicable to old established roads. I would like to get some views on new work. I am unfortunately connected with new work. We cannot use old rail for the simple fact that we are just starting new. I would like to get the ideas of some of the members in regard to temporary openings for new roads, three, four, or five years, and would be very much obliged for the information.

Mr. Mallard—The Southern Pacific use a system, I think, somewhere near El Paso, where they have irrigation ditches; water very nearly up to the rail; they use channel iron about twelve inches, riveted up, and on the top place a six by twelve, to which the rail is spiked. I am not prepared to give the cost of this.

Mr. Eggleston, Chicago and Erie Ry.—On permanent work and through girders there is a floor system that is made for the purpose. You can get your rail within 12 inches of the base of your bridge for permanent work.

Mr. Markley—You refer to the buckle plates, do you not?

Mr. Eggleston—Yes, sir.

Mr. Markley—I would like to ask Mr. Eggleston what he uses on the Erie where there is not room enough for iron pipe.

Mr. Eggleston, Chicago and Erie Ry.—When we cannot put in iron pipe, we use a through or deck girder or truss bridge. We can put in three foot pipe without danger of its becoming stopped up with wood and debris because we keep our right of way clean.

Mr. Markley—We keep our right of way clean, but it comes from the woods.

Mr. Berg, Lehigh Valley Ry.—In answer to the question of Mr. White, what to do in new work, temporary new work, four or five years, I should say use any kind of trestle, if properly constructed, and I believe this is what you might call standard practice. It allows the work to be rushed forward to complete the railroad and then whenever you find the finances allow, masonry and iron construction can be built much cheaper on account of the facility with which material can be brought to the site of the culvert. In regard to the use of the old rails spoken of, I am an advocate of their use in a simple form, by which I mean when used without too much shop work to be done on them, and without elaborate castings and yokes.

Mr. White—For small openings that we have, what is the most economical?

Mr. Eggelston—I like Mr. Mallard's idea of using channel iron.

Mr. White, Texas Midland Ry.—The information I want is where we have no channel iron; we have no such things as old rails.

Mr. Staten, Ches. and Ohio Ry.—I would recommend making a box of good timber and cross-ties, and put them in wherever they can be used; this will last several years. These boxes you can have made and unloaded and set in the track wherever you prefer.

Mr. Berg, Lehigh Valley Ry.—I think Mr. Staten in speaking of box culverts is getting off the subject. I think that trestles are the proper form for temporary construction; you can make your span wider than is required so that when the time comes for permanent work, it can be built right in. That is where another advantage of the trestle comes in.

Mr. Millener, B. & O. S.-W. Ry.—We are building a little piece of new work at the present time, where the fill ranges from six inches to eight or ten feet. We are using in these wide places pieces of old floor beams or stringers that came out of other bridges. We have taken a great many old iron bridges out and have a good many of the eye-beams from nine to fifteen inches in width, which we are utilizing for these wide openings.

Mr. Peck, Mo. Pac. Ry.—For the benefit of Mr. White would state that our standard box culvert is built with wooden walls and covered with a big flat stone.

Mr. Berg—I would like to ask Mr. White what the covering is of the box culvert he refers to.

Mr. White, Texas Midland Ry.—We make our box culverts for twelve feet openings of old stringers. As a little information for the members, would say that in this Southern country, Mr. Peck and the balance of us in Texas and Missouri, use the slabs of Bodak, which will last forever. We cover over the stringers with these shavings and then a covering of dirt, and have no further trouble with it.

Mr. Berg—Then I understand, Mr. White, where you have an opening too large for a single box culvert, such as is generally understood to be covered over with stone, and too low for arched culvert, that you adopt a system of double, triple, or quadruple timber boxes.

Mr. White—That is the idea.

Mr. Stannard—How do you take care of your drift wood?

Mr. Eggleston—My idea of this is to get in your masonry, steel girders, make it permanent, and your management will never regret it.

Mr. White, Texas Midland Ry.—Different points in the country have different usages. We have to use timber for the simple fact that we have not the rock; you have to use rock, perhaps, because you have not the timber. Another thing, our management will not go to the expense of getting us rock or girders; all this comes after we are an old established road. I am working for a new road where these things cannot be afforded.

Mr. Eggleston, Chicago and Erie Ry.—We have wood in the north, but do not use it; wooden bridges have to be renewed every five to ten years, while iron and masonry will last forever.

Mr. Milliner, B. & O. S.-W. Ry.—Stone is a scarce article with us, but we have lots of cedar. Where we have low culverts and additional openings are necessary, we simply make double or triple culverts—that is, where we cannot bridge over. We put in a course of timber, one on top of the other, and make the openings wide enough and a number of them.

Mr. Eggleston, Chicago and Erie Ry.—The condition of the roadbed and bridges is an advertisement for the road. The best of your people will ride on the hind end of the sleeper, and if they see poor structures will make comments. If you have first-class bridges and maintain them all the way through, it will advertise your road all over America.

Mr. Berg, Lehigh Valley Ry.—I agree with Mr. Eggleston as to the value of first-class structures, but think that a good roadbed throughout, a solid road, is more desirable, if you can have it in place of bridges. On any road a solid roadbed without bridges is certainly preferable to bridges. This being so, I think that in our discussion we have lost sight of the practical value of the structure recommended by the committee, viz., continuity of roadbed; another advantage is in having ordinary track forces attend to the track at this point, and not having another bridge on your right of way. It saves labor for the bridge department, and it certainly is an improvement in railroading.

Mr. Mallard, Southern Pac. Ry.—On these ballast openings, we have a depth of only 25 inches, track tie 7 inches, use 8 inches of gravel, and 13 pieces creosoted 10x12, laid on piles for 16 foot openings.

Mr. Berg, Lehigh Valley Ry.—Another advantage of the solid, continuous roadbed, as shown in the plan recommended by the committee, or similar to that plan, is that you avoid the jump that invariably takes place in going on to regular track off a trestle, which point Mr. Mallard brought out yesterday as one of the advantages of the solid deck being adopted in his section of the country.

Mr. Eggleston—I would like to ask Mr. Mallard where he does away with the jerk on marshy ground; if you put a solid roadbed on the trestle, where are you going to relieve the shock right at the end of the trestle?

Mr. Mallard—We do not get any shock. We have eight or ten inches of gravel under the ties; continuous roadbed running off the trestle.

Mr. Berg—There is no doubt that the shock is removed by the under layer of ballast, which amounts to a cushion, and while that cushion does not have the earth underneath it, but solid timber, the ballast still acts as a cushion, and relieves the shock to some extent; there is also more mass opposed to the shock, which reduces the effect of the blow.

REPORT: PUMPS AND BOILERS FOR WATER STATIONS.

THE STEAM PUMP.

This is something that is manufactured by outside firms, therefore your committee will not recommend any particular make. Either the duplex or single acting pump (with rubber packing always in water end). The location and service the pump is to perform has all to do with the size that should be used. A new idea has lately been introduced in connecting the exhaust pipe from the pump to the suction pipe with a Y connection running towards the pump. It is done for two purposes: one to assist the suction and the other to heat the water in winter time to prevent freezing. When connected this way it is necessary to have two exhausts, one as just described and the other either in stack or out.

At a point on the T. P. & W. I have a 6x4x6 duplex pump that forces the water 4,000 feet and raises it 90 feet through a 4-inch discharge pipe, with 60 pounds of steam pressure, and throws 3,500 gallons of water per hour.

BOILERS.

Your committee did not solicit for any great number of plans, in fact only in one case did we go outside of what the members of the committee are using, and can speak from practical experience of what we have. We have plans for two boilers and submit them as a part of our report and invite the attention of every member to inspect them, as no doubt they are something new to a great many. But all of them are practical and the most simple ones to construct are the cheapest and give good results. The great word of economy that we are brought face to face with nowadays causes us to enter into the simple construction of our water service boilers. The fuel that is almost universally used is coal screenings of the very finest kind, and which answers all purposes where you have boilers (such as we submit) to burn it.

1. We have the T. P. & W. vertical boiler 36 inches in diameter by 84 inches in height, with twenty-eight 3-inch submerged flues. It is somewhat different in construction from the average pump boiler; it has no solid mud ring or solid ring around the fire door. In this respect it is constructed just like a locomotive boiler around the door. At the bottom or water leg the inside sheet is bent out on an O G form and the two sheets are riveted together. One very important point I wish to call the members' attention to and that is to keep the grates up plenty high enough so the fire will not heat the boiler below the water line. The boiler cost $175 complete. There are many who still cling to the old idea that the pump boiler must have as many 2-inch flues as you can possibly get in. If any of the members of this association have that idea all they have to do is to build a boiler such as this committee recommends and they will have no other in the future.

2. We have the C. & E. I. vertical boiler. The plan is for a 48-inch x 10-foot. They also make a 36-inch of the same plan. The 36-inch cost $130 trimming and base, complete $159. The 48-inch cost $206 trimming and base, complete $235. This pattern of boiler has been in use fourteen years. One boiler ran eleven years without removing; it was then taken out to have a patch put on around mud ring. The fuel used is soft coal and they are good

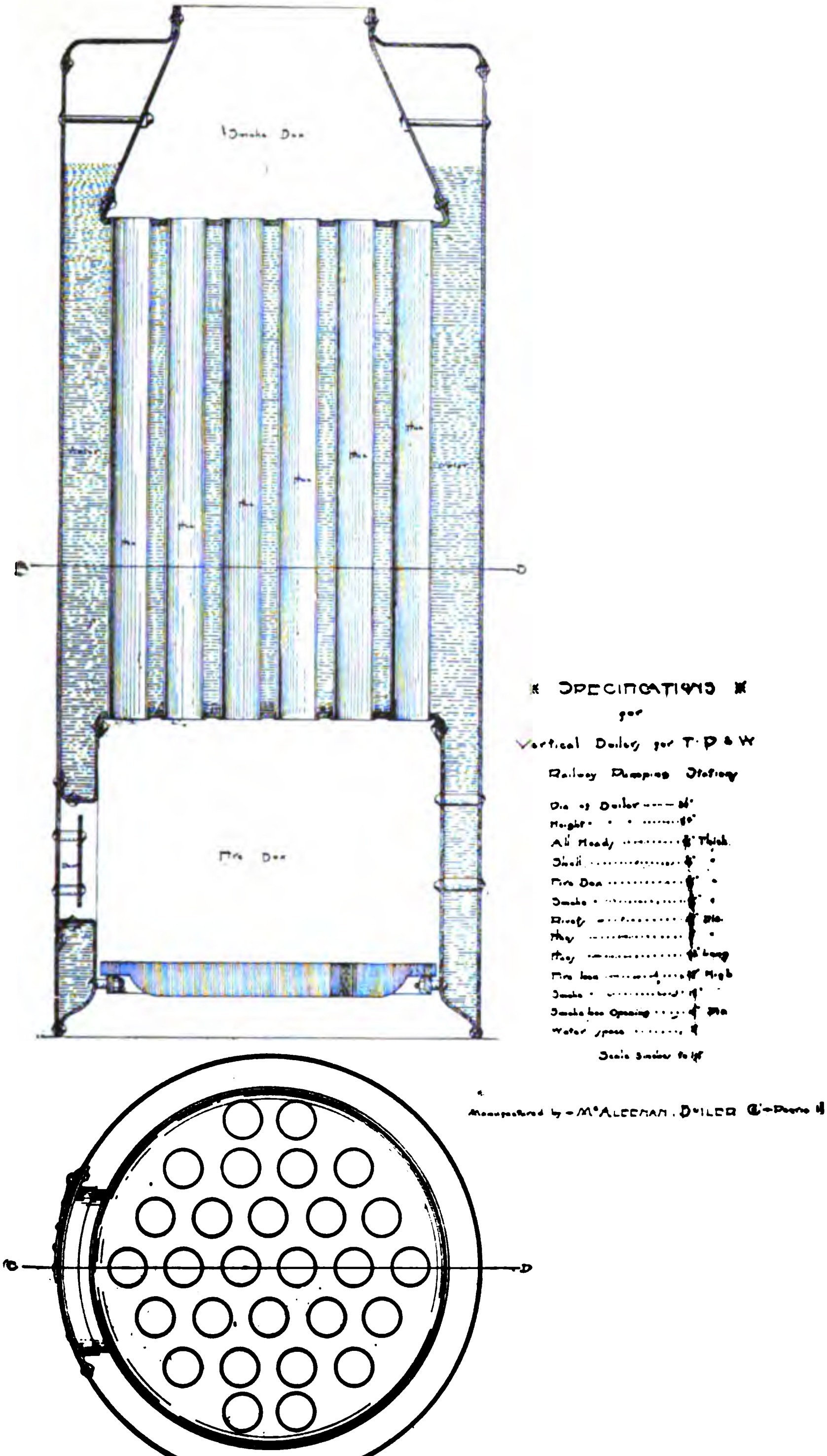


FIG. 109--VERTICAL BOILER, T. P. AND W. R. R.

steamers, raise steam in 45 minutes from cold water. Dimensions of material top head, crown sheet, and fire-box ⅜ inch, balance 5-16 inch. Your committee has canvassed the boiler subject pretty thoroughly and agree on recommending either of the two plans submitted; and a cut of them to be inserted in the proceedings of our fifth annual meeting.

J. H. MARKLEY, T. P. & W. Ry.
O. J. TRAVIS, E. J. & E. Ry.
A. SHANE, C., C., C. & St. L. Ry.
G. W. MARKLEY, C., C., C. & St. L. Ry.

DISCUSSION: SUBJECT—PUMPS AND BOILERS.

Mr. Aaron S. Markley, Chicago and Eastern Illinois Ry.—On our line we use nothing but Worthington Duplex pumps, 7 inch suction, 6 inch discharge; while we have a lot of other pumps, they have been left over from long ago. The size is 8x12x12, manufactured by Fairbanks, Morse & Co.; the manufacturers have their own number, consequently the size of the pump can only be given by the dimensions. We connect all of our exhaust pipes into the suction pipes, thereby, of course, preventing freezing in winter time. In making this connection, we use a cast-iron "Y," sufficiently large, of course, to receive the exhaust pipe. This is located 16 feet from the pipes; we have tried them closer, but it will suck air, and cause the pump to jerk. In connection with this, we now use a second discharge pipe, in case we want to turn it out direct, either in the stack, or the roof of the building. The dimensions of our pumps are: Surface, 8 inch water end, 10 inch steam end, 12 inch stroke, 7 inch suction pipe, 6 inch discharge, with a capacity of 18,000 to 20,000 gallons an hour; Cook, 8 inch steam cylinder, 36 inch stroke, 5¾ inch working barrel; Downey double-acting pump, 8 inch steam end, 24 inch stroke, 4¾ inch water valve. A description of our building is submitted by the committee on this subject.

Mr. S. S. Millener, B. & O. S.-W. Ry.—I would like to ask if any of the members are using compressed air for pumping water. Our management has bought an air compressor, but I have never used one of them myself, and do not know of anyone that does. I understand that the air compressor is three-fourths of a mile from the well, air is taken down into the well in a two-inch pipe, and the water is forced back through a three or four inch pipe.

Mr. R. C. Heflin, B. & O. Ry.—We recently put in one on my division; it was manufactured by a man by the name of Reef, of Roanoke; has been in five months and has given entire satis-

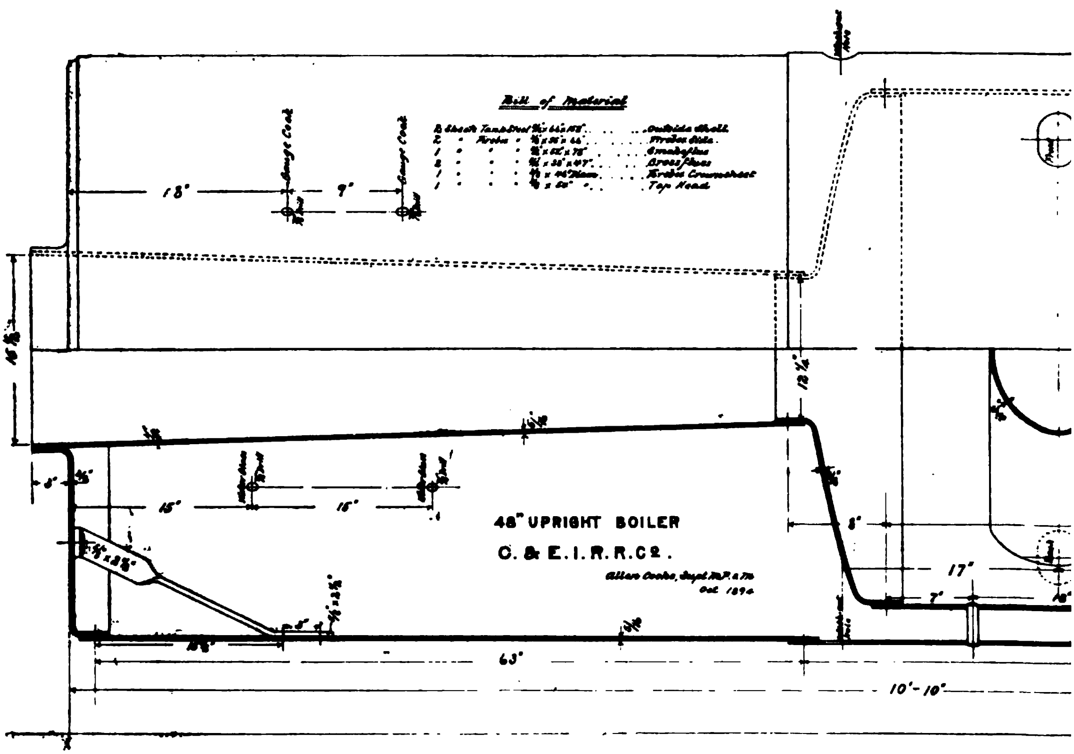
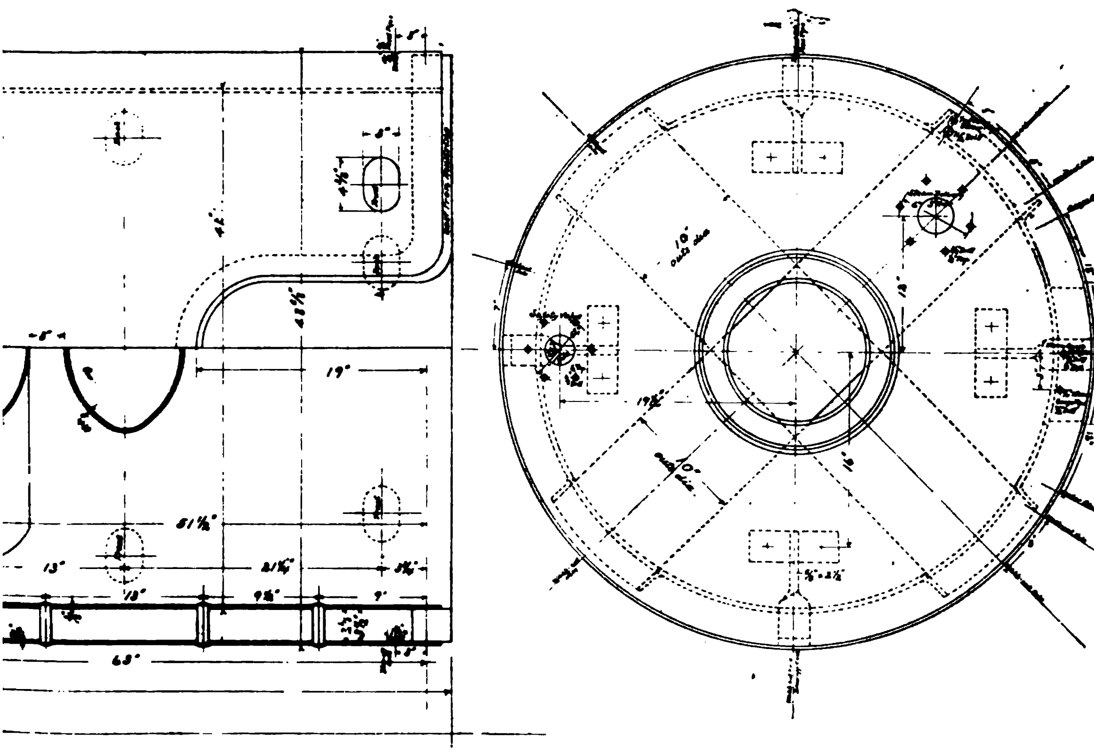


FIG. 110—UPRIGH



BOILER, C. AND E. I. R. R.

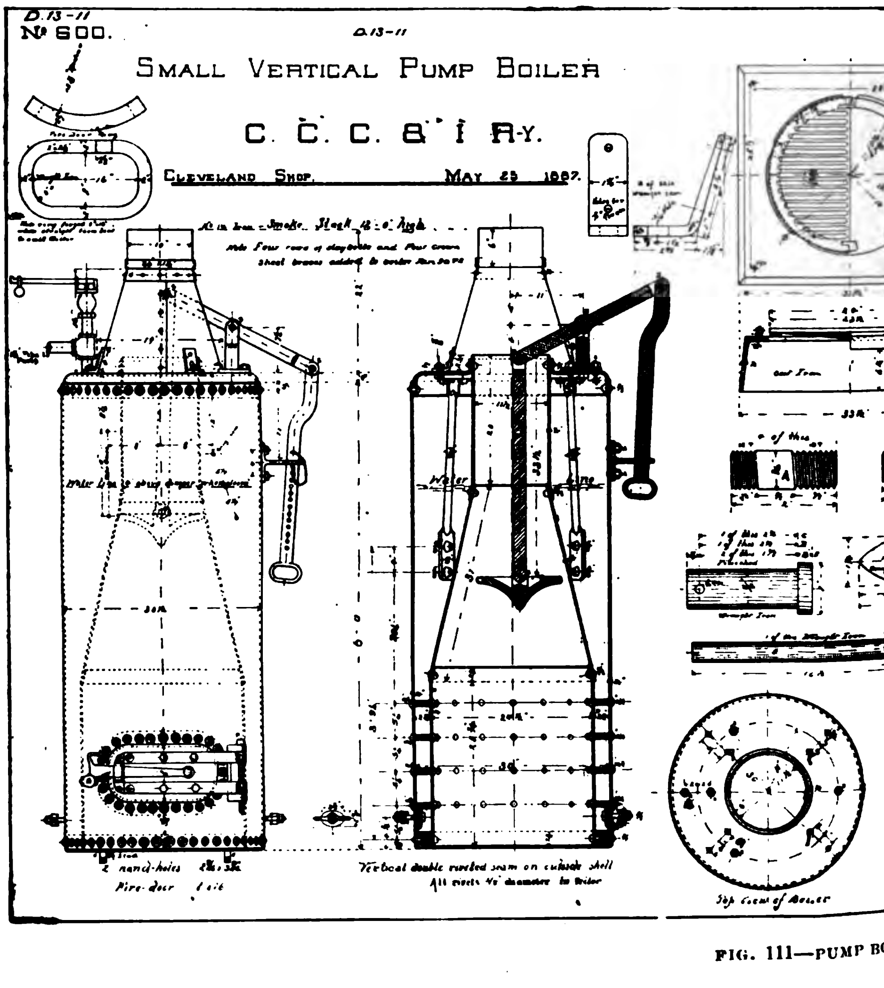
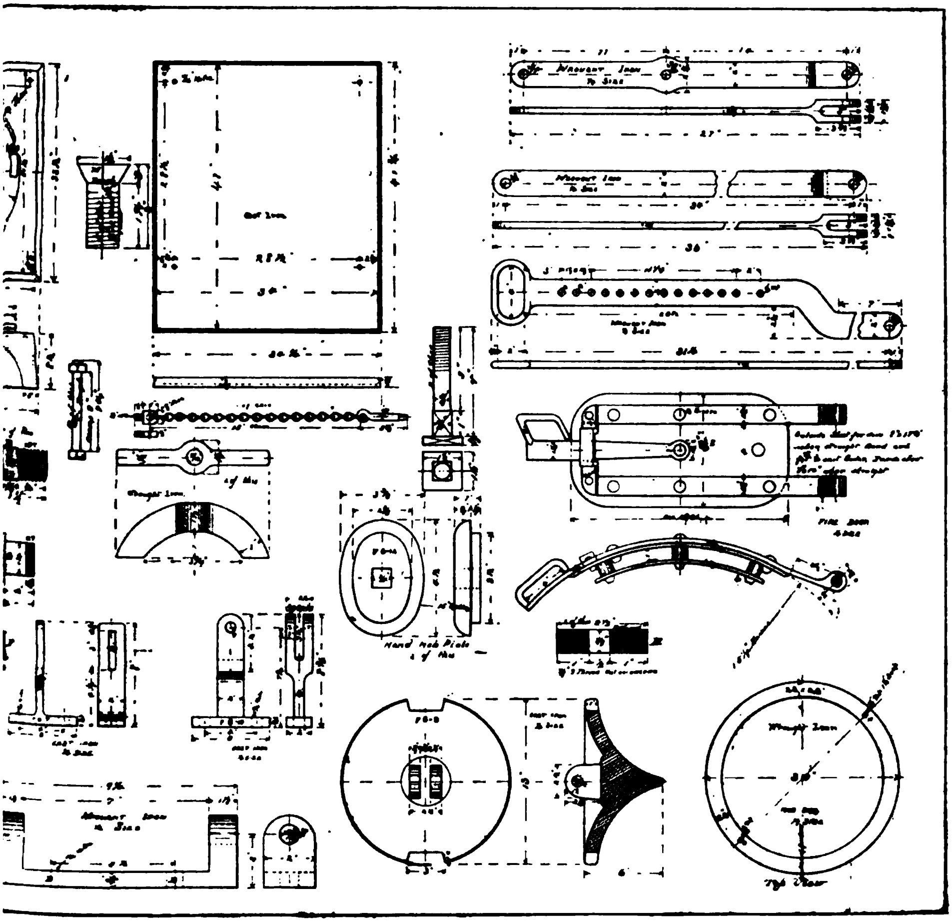


FIG. 111—PUMP BOI



ER, C., C., C. AND I. R. R.

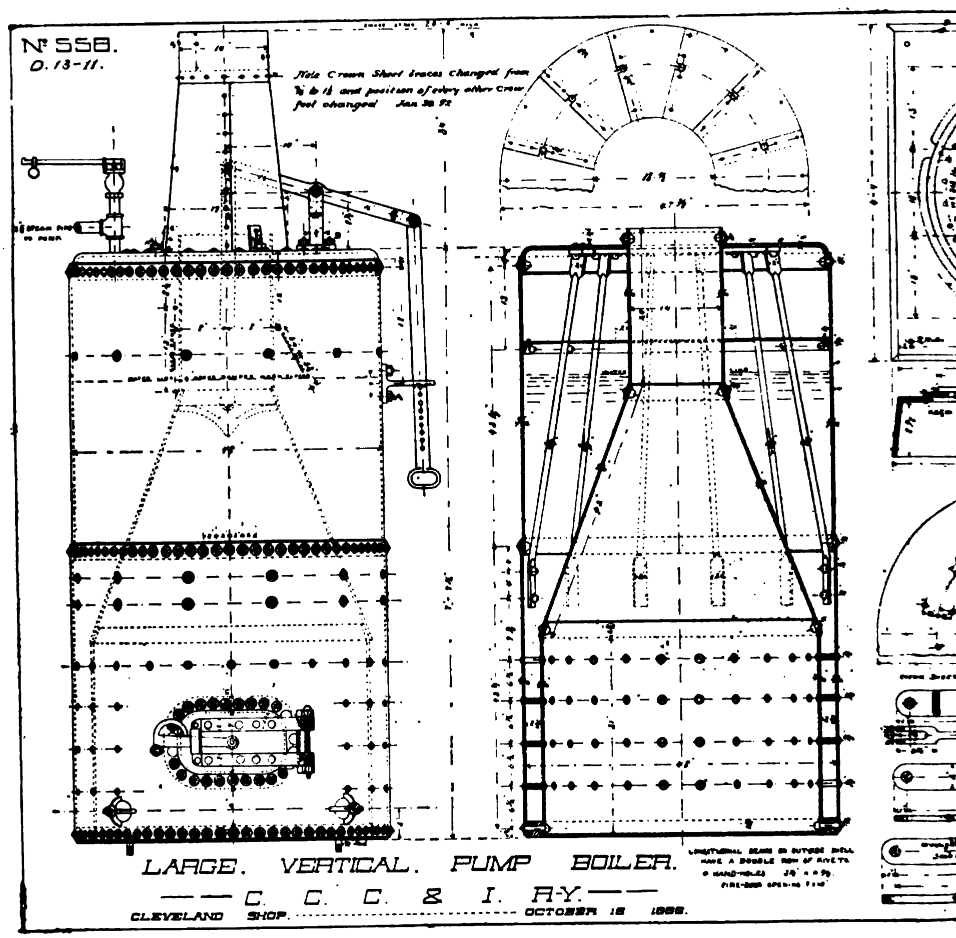
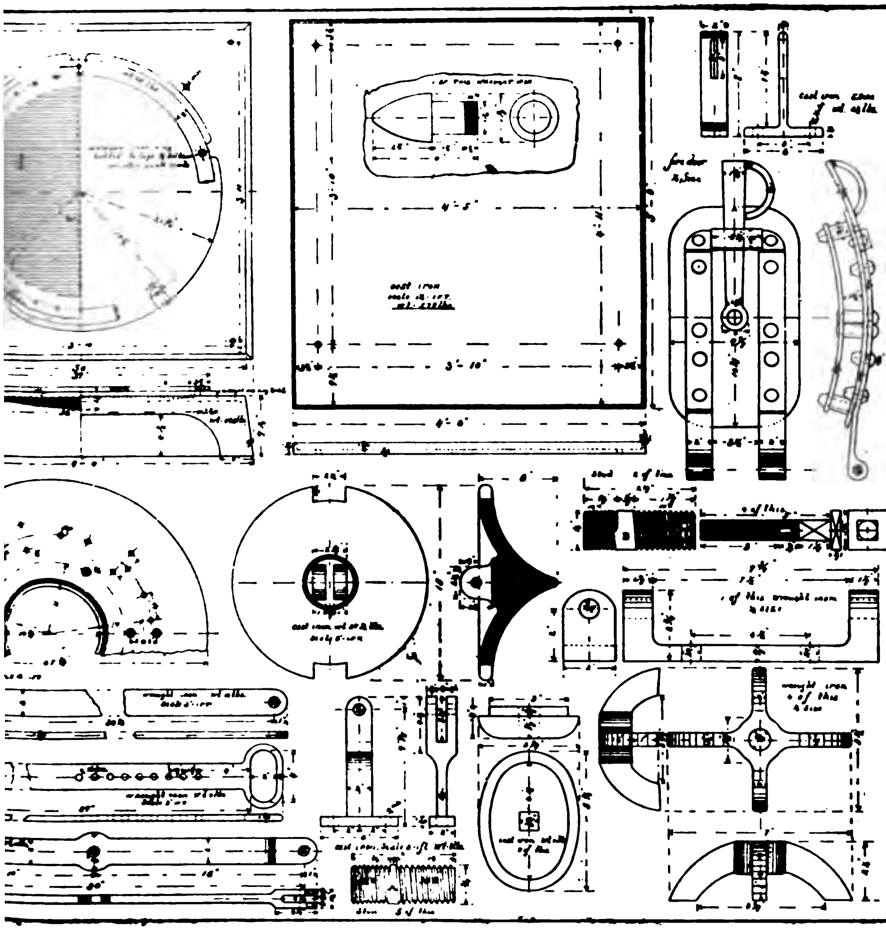


FIG. 112—PUMP BOILER



', C., C. AND I. R. R.

faction; put in at a station that had formerly been furnished with water by a pump; since we put it in have had no trouble. In a 12 foot fall, we have raised water about fifty feet. They are the best thing, where you can get the fall, that I ever saw, for the work. The pump, or ram rather, will lift the water thirty feet for every foot of fall that it has to drive pipe. In those that we use the drive pipe is four inches, discharge pipe to tub is two inches. Will state in connection with this that about one-sixth of the water that is used to run the ram is conveyed to the tub, the other, by oscillation and reaction, five-sixths, is lost. The expense of keeping them in repair is, so far as I can learn, very little; these people guarantee to keep them in repair for five dollars a year. The only repairs necessary are a valve in the cylinder air chamber. As to pumps, have a variety, Knowles, small Erie, Blake, Cameron, but the pump that gives the most satisfaction is the special No. 9 Blake pump, which I am using altogether in ordering new pumps. The others have been in service a number of years, have been taking out three or four a year; have thirty-nine water stations, at most of which I have two pumps. The boilers we use are from twenty-three to forty-eight inches diameter, outside measurement, twenty-three, twenty-six and thirty-six inch grate bars. Some of these boilers have submerged flues, others not. The thirty-six inch boilers have twenty-three inch grates, and, ordinarily, will run one of our No. 9 pumps without any strain of the boiler; but the new boilers that we get, for emergency, in future, are forty-six or forty-eight inch boilers, that will run two No. 9 pumps very nicely if we do not have too much lift; and this is a thing that we do not have a great deal of, except in two places, where we have a great deal, nearly the capacity of the pump, thirty-three feet.

Mr. Markley—Mr. Heflin says that five-sixths of the water is lost; do I understand that it is gone entirely, or it is returned to the tank?

Mr. Heflin—No, sir, it is not; if you can raise a dam, say six feet, you can carry the water 180 feet, a certain quantity; you lose five-sixths of the water from which you gain your power.

Mr. M. M. Garvey—In Iowa we are trying to get rid of our old windmills and put in pumps and boilers. We adapt ourselves to the occasion when we can, and use boilers. We consider them a good deal cheaper than to depend on the wind. On our road one man has got two boilers to look after, and we are now getting so we are having very good satisfaction, except in places where we have been trying to use city water taken from a long distance under the ground, and that we could not use in the boilers. We tried two or three places and had to give it up. For the past two years we have had no rain in Iowa until this year. We are now in good shape, and have got our pumps located at places where there is no difficulty. We use the duplex pump.

President—We ought to have some information on this question of duplex pumps. There is a difference of opinion between manufacturer and superintendents as to which is the most economical. I would like to have an expression of opinion from quite a number of our members.

Mr. Rogers—We have a good many, but they are all old.

Mr. Thompson, P., Ft. W. & C. Ry.—I could not tell anything about the duplex. We use the single and it gives very good satisfaction.

Mr. Rogers, in answer to Mr. Markley as to the quantity of water pumped per hour, stated that they pumped twelve thousand gallons.

Mr. Stannard, Wabash Ry.—We use single pumps and find they give very good satisfaction. There is one thing about it, we turn our exhaust into the suction pipe, which we find is a good thing.

Mr. Aaron S. Markley, C. & E. I. Ry.—During the past year we have connected nearly all of our exhaust-pipes from the pump into the suction pipe sixteen feet from the pump with a Y connection, the Y, of course, leading toward the pump so the force of the exhaust will aid the pump in lifting the water. We find from a number of tests made, that this increases the temperature of the water from six to eight degrees, thus preventing the water from freezing in the tanks, and saves fuel in locomotives. In putting these exhausts into the suction-pipe, care should be taken that all joints are air-tight, and valve-stems, if any, are well packed to prevent leaking air. We have them on both duplex and single acting pumps, both of which give good satisfaction connected in this manner. In making these connections, we arrange them so the exhaust can be turned out in the open air if so desired, or into the suction-pipe.

Mr. J. H. Markley, Toledo, Peoria and Western Ry.—We are using the duplex, the Worthington, and the Knowles single pump. We like the duplex every time. The Knowles takes from seventy-five to eighty pounds of steam pressure, and the Worthington from forty to forty-five pounds with the same result.

Mr. Markley—What effect has it on the water running into the discharge?

Mr. Stannard—It heats the water and warms the cylinder.

Mr. Markley—In that case you would have to drain your discharge pipe every night.

Mr. Stannard—Yes.

Mr. Markley—What arrangement is there for keeping the water from running back?

Mr. Stannard—The water pipes through the tank, and the exhaust-pipes through the discharge.

Mr. Markley—It looks to me that that would create a back pressure on the pump.

REPORT: METHODS AND SPECIAL APPLIANCES FOR BUILDING TEMPORARY TRESTLES OVER WASHOUTS AND BURNOUTS.

When a washout or burnout occurs, the first information necessary is the definite location of break in the track. The next question for consideration is the kind of structure which has washed or burned out; whether it be a trestle or truss bridge, length of the structure, depth of the opening, characteristics of the stream; as to whether there is likely to be water, mud, or sand to contend with. The superintendent of bridges should have the above information on file in his office, in order to enable him to determine to a great extent what kind and manner of temporary work will best meet the requirements.

If depth is not too great, opening may be cribbed up with ties; if very deep, it may be that temporary foundation for frame bents can be secured, but if bottom is soft and there is much water and current swift, frame bents or cribbing cannot be maintained, it may then be necessary to drive piles.

These questions being disposed of, the next thing is to determine what debris is in the way of constructing the temporary structure. Is there a lot of cars in the washout, or an engine and cars? And if so, where is the wrecking outfit? How soon can it be brought to the washout, and how long will it require to clear the stream of the wreckage?

The necessary material for such temporary work, consisting of piles, stringers, caps, ties, sway-braces, plank, bolts, spikes, nails, etc., should always be stored at some convenient point on the line where it can be readily loaded on cars for such emergencies. The superintendent of the road should also have the necessary track ties where they can be loaded without delay.

The conductor's report in case of a wreck, in a washout or burnout, should be full and complete. The following form, now in use on the New York, Lake Erie and Western Railway, and some other lines, is copied from a paper read by Superintendent W. L. Deer, of the N. Y., L. E. & Western road, before the New York Railroad Club, and seems to embrace about all the information required:

............Station..........189..
To........Supt. Time sent.......m. Time received.....m.
Train No.......... Conductor............
Engine............ Engineer.............
A. Time and place of accident. (State if on main or side track,

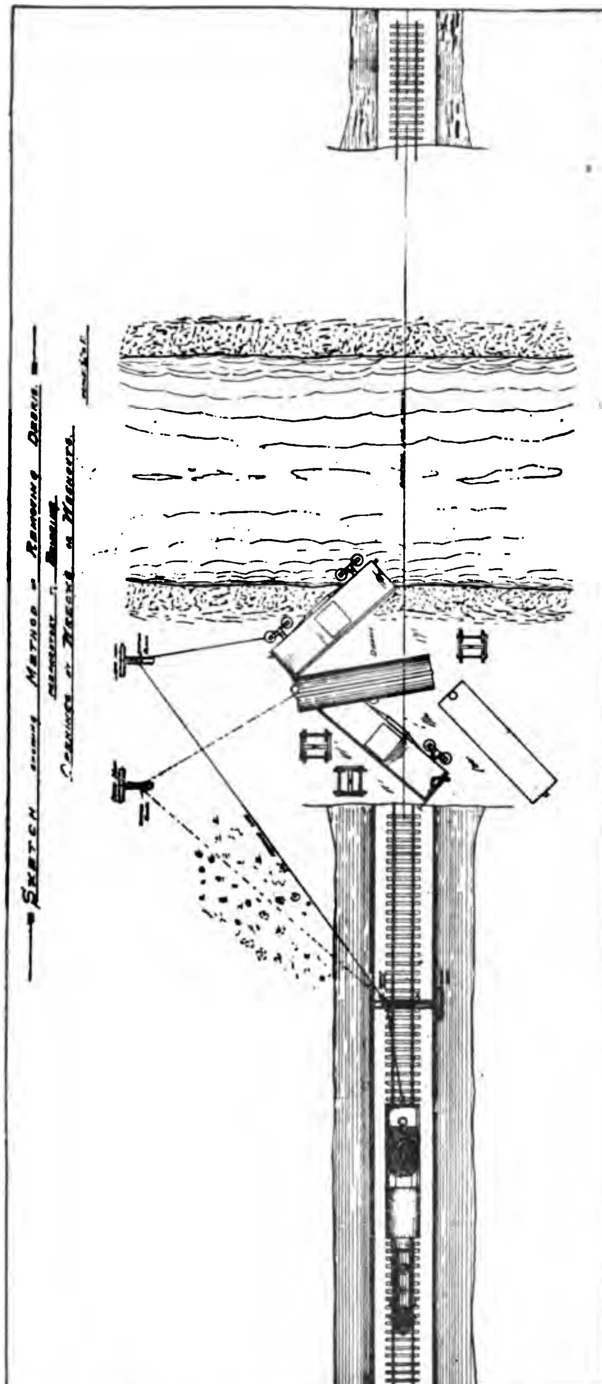


FIG. 113—SKETCH SHOWING METHOD OF REMOVING DEBRIS AT WRECKS OR WASHOUTS.

company or individual siding, at frog or switch, in fill, cut, or on level) ....

....

B. What caused it? ....

C. Were any persons injured, and to what extent? Give name, age, residence, and occupation, and what was done with the persons ....

....

D. Which track is obstructed, and which clear?................

E. Which track can be opened first, and how soon?.............

F. What crossing-switches or sidings, east and west of obstruction, can be used to pass trains around?.......................

....

G. How long will it take to get track clear so trains can pass?....

H. Will the derrick-car be required, and which way should it be headed to work to advantage?..........................

....

I. How much force is wanted to clear the obstruction?..........

J. Is the track damaged, and to what extent? Have track-men been notified? ....

K. Is engine off track or damaged? ....

L. What position is engine in?............................

M. What position are cars in? ....

N. How many cars broken and off track, loaded? (Give numbers, initials, and kind)..

....

....

O. How many cars broken and off track, empty? (Give numbers, initials, and kind)..

P. How many cars and kinds are wanted to transfer freight in?

....

Q. What does lading cars consist of? What amount of damage to lading? ....

....

R. How many cars next engine? ....

S. How many behind cars wrecked? ....

T. How many car trucks needed? Give numbers of cars under which needed..

....

U. Can passengers be comfortably transferred around wreck?..

....

V. How long will it take to transfer passenger train?...........

W. What was the speed of the train?........................

X. What was the state of the weather?......................

Y. What trains, east or west, are stopped by the obstruction?.....

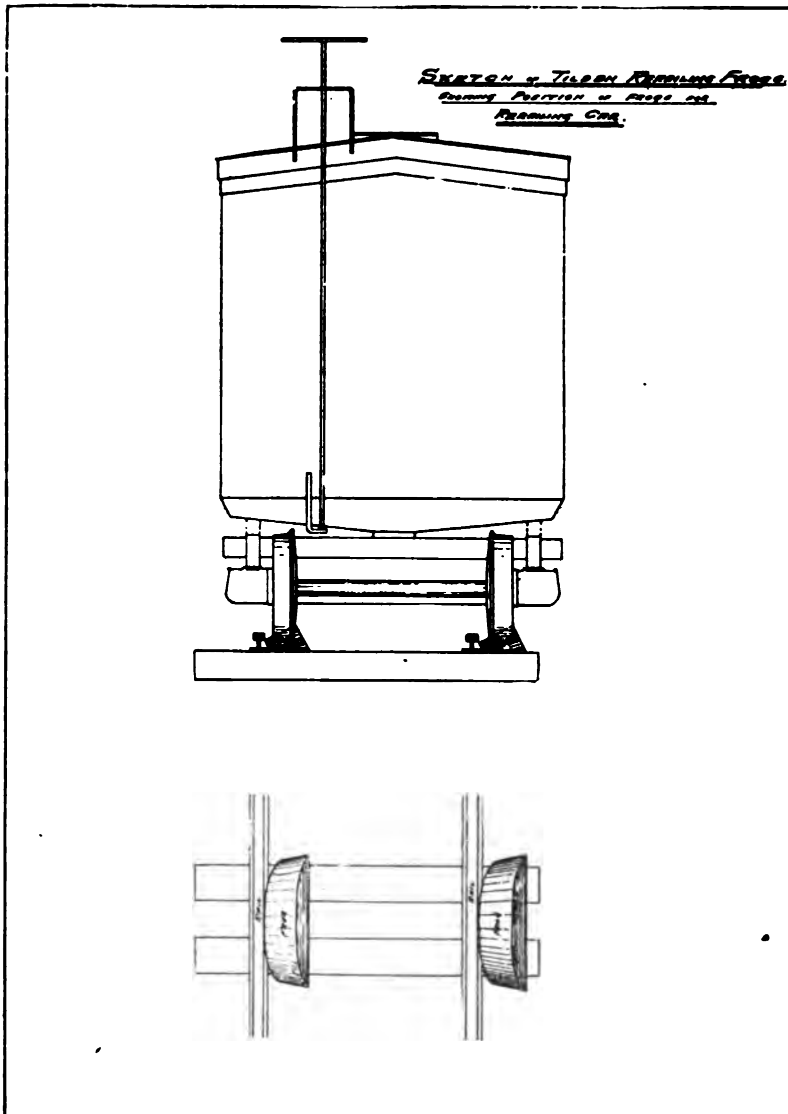


FIG. 114—SKETCH OF TILDEN RERAILING FROGS, POSITION OF FROGS FOR RERAILING CAR.

Z. Remarks ....
....
Signature...............................

This information secured, the wrecking train and outfit is of the first importance, as no other work can be done until the wreck is cleared, or at least sufficient debris cleared away to enable the bridge gang to locate the temporary structure.

The wrecking train should consist of an engine, truck-car, tool-cars, and derrick-car.

The tool car provided for this purpose should be large and roomy—not less than nine feet, ten inches wide, and forty-four feet long—with seats enough for fifteen men. The balance of the room, arranged in the most convenient manner to store the tools. Hooks properly arranged along the sides of the car, the proper height from the floor to hang snatch-blocks, blocks and falls, hauling line, including any other tools which can be stored in this manner; for other tools, racks, boxes, and lockers should be arranged. A special place should be provided for hydraulic jacks, where they can be stored in an upright position.

After properly locating the seats for the men, and storing the tools, there will not be room enough left for a cooking outfit, which will have to be provided for in another car, yet there will be room enough for the men to eat their meals, which can be delivered to them from the most convenient boarding-house in lunch baskets or buckets.

The men can occupy this car on the road to a wreck. The car will require a heating stove, firmly anchored to the floor, to heat it during inclement or cold weather.

This car should be equipped with the following tools and wrecking devices:

Hydraulic jacks.—Five, from ten to thirty tons capacity, as follows: One ten-ton, two twenty-ton, and two thirty-ton. (The Dudgeon jacks are considered equal to any other in the market, and are built from fourteen to twenty-four and thirty inches in height.)

Screw jacks.—Twelve, six twelve-inch, three eighteen-inch, and three twenty-four inches in height.

Manilla rope.—Two pieces, each 600 feet long, by two and one-half inches in diameter, two pieces 600 feet long two inches in diameter, two pieces 125 feet long, three inches in diameter, with link spliced into one end of each of them, with hook on other end of one rope, the other to have about eight feet of best one-inch crane chain, with ring in one end and hook in the other; the ropes to be properly spliced into the ring of the chain, which must be

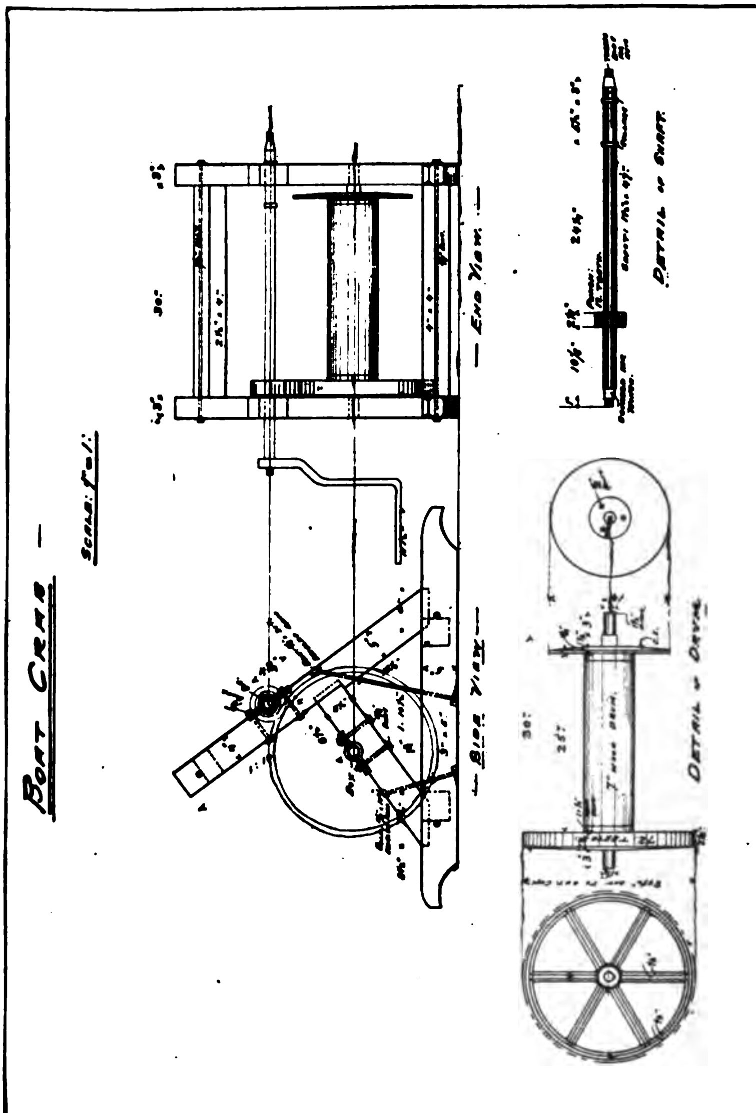


FIG. 115—BOAT CRAB.

provided with thimbles to keep ring from cutting the rope. The hooks on the chains are very useful on account of convenience in making hitches. Six slings, of best manilla rope, as follows: Two one and one-half-inch, two two and one-half-inch, two three inches in diameter; one of each size should be six feet long, the other one and one-half-inch eight feet long, and the remainder twelve feet long.

A one and one-fourth-inch plow steel wire rope, which has safe working capacity of about twelve tons, may be used to better advantage than a two-and one-half-inch manilla rope. The snatch-blocks, however, will require a larger sheave than for manilla rope, as sheaves for the wire rope should not be less than twenty-two inches in diameter at bottom of groove. In addition to above line, there will also be required enough rope for equipping blocks and falls.

Blocks and falls.—Four sets of the following sizes, one for one inch line, one for one and one-fourth-inch, one for one and one-half-inch, and one set for two-inch line. All blocks having double sheaves of proper size to fit the line. Blocks with steel shells and iron sheaves are generally used for heavy work, such as turning over engines, and moving them into a position to be elevated to the level of track.

Blocks.—Two iron snatch-blocks for three-inch manilla rope, two for two and one-half-inch, two for two-inch, two for one and one-half-inch, and one extra set of double blocks for two-inch line, one provided with becket.

Chains.—Six best charcoal iron crane chains, three three-fourths inch, and three one inch; the one inch chain to have a ring on the end four inches clear diameter, made of one and three-fourths-inch iron, and the three-fourths inch chain a like ring made of one and one-half-inch iron, each chain to have a hook on the other end; two of the large chains should be sixteen feet long, and the other twelve feet, the three-fourths inch chains should be from eight to twelve feet long.

Switch ropes.—Two one and one-fourth-inch plow steel wire switch ropes, one forty-five feet long, the other eighty feet long, each with link in one end and hook in the other.

Hooks.—Six double hooks, made of two-inch iron.

Links.—Six links, from eighteen to thirty inches in length, made of one and one-half-inch iron.

Wrenches.—Car should be supplied with wrenches of various sizes, including at least twelve monkey wrenches varying from twelve to thirty inches in length.

Steel bars.—Eight steel bars, varying in length from four to seven feet, shorter bars to be made of one and one-fourth, and others of one and one-half-inch octagon steel.

Re-railing frogs.—Three pair of most approved design. (The B. E. Tilden frog, illustrated on print 114, is considered equal to any in use; there are other designs, however, which are very good.)

Hand crab.—One boat crab, as illustrated on print 115, will be found to be a very useful and convenient device for bridge gangs at a wreck. (It is the same design as used on board a vessel.) I have not found any of the modern designs which work any better than this one.

Wrecking crew.—The crew of a wrecking train should consist of fifteen men, including a wrecking boss, all of whom should have had some experience in this line of work; at least six of these men should be familiar with the use of hydraulic jacks, and all kinds of rigging. Two at least should understand how to splice ropes, make hitches and knots of the various kinds, such as timber, cat's-paw, Blackwell and half-hitch, single and double bow-lines, hand and flat knots; they should also understand how to coil lines in a neat and perfect manner. One of the best in this line should be selected and put in charge of wrecking cars when at the shop, or wherever they are kept, whose duty it should be to see that all rigging is in perfect order for emergencies, and in case a rope, chain, block, jack, or any other tool, has been broken or damaged at the last wreck, have it repaired or replaced. This man should be a good mechanic, and understand how to handle and repair hydraulic jacks and keep them in perfect order.

In case any of the ropes have been placed in the cars wet or dirty, they should be washed off, thoroughly dried, neatly coiled, and placed in their location in the car. All wrenches should be cleaned off, oiled, after which they should be wiped with waste, all surplus oil removed, and put in their place, as there should be a particular location in the car for each of the tools, and each of them placed there, to the end that any of the wrecking crew may go to the car, and pick up any tool at once.

The man in charge of the car should have a complete list of all tools which belong in the car, and should proceed, immediately after the wreck is cleared, to check up his tools, and in case any are missing, report them to the proper superior officer to be replaced. One member of this crew should be a competent, careful engineer, who is capable of handling the engines on the wrecking car.

The superintendent should look after the commissary for the wrecking crew. If they are not provided with a regular commissary car, their meals should be furnished to them at the work.

The wrecking crews on the Missouri Pacific Railway are in charge of the division master mechanics. On some lines they are in charge of the division superintendents, and on others, in charge of the road department.

It is my opinion that the master mechanics should have charge of the wrecking crews.

The derrick car for a wrecking train should be equipped with all necessary lines, blocks, rigging, etc. One of the latest and most approved designs for a car of this kind is shown on print No. 116, which gives position of steam wrecker, or derrick car, picking up a wreck.

The capacity of the car referred to is thirty-five tons, and it is manufactured at Bay City, Michigan, by the Industrial Works. The following is a general description of the car as given by Mr. Deer: "The body of the car is constructed throughout of steel beams and channels. Main sills, six in number, four of which run from end to end of the car, are of I beams fifteen inches deep, fifty pounds per foot. Shorter sills are of twelve-inch I beams, forty-two pounds per foot. Intermediate sills of twelve-inch I beams, forty pounds per foot, and these, with the longitudinal sills, joined by plates and angles, are thoroughly riveted together. End sills are of white oak ten by fifteen inches, bolted to one-half by fifteen-inch plates, which are securely riveted by angles to the longitudinal sills. Frames so constructed give an entire length to the car body of thirty-seven feet six inches, and a width of ten feet four inches. The floor is of tongued and grooved white oak, laid in widths not exceeding four inches, with each plank fastened by four bolts to the longitudinal sills. The car body is further strengthened by four truss rods, two of which are inverted and one and three-fourths inches in diameter, with two-inch turn buckle ends, the lower rods being one and one-half inches in diameter, with one and three-fourths turn buckle ends. The forward or crane end of the car is suspended from two equalizing frames, one on either side, which, in turn, rest upon the two front trucks; this arrangement distributing the weight and wheel base over a surface twelve feet long, and at the same time, accommodating itself to all curves, and allowing a speed otherwise impracticable. These equalizing frames are each constructed of two fifteen-inch steel I beams, fifty pounds per foot, and nine feet six inches long, boxed with forged connections to trucks.

The boiler is of flange steel, is fifty-two inches in diameter, and eight feet high. It has an upper combustion chamber. Power for hoisting and slewing the crane is derived from a pair of reversible engines whose cylinders are nine by twelve inches. A train of gearing from the engine shaft works three spools, the rope from one of which leads to a single sheave block attached to the crane jib for light and rapid lifts; another to a powerfully geared block on jib for heaviest work; while the third and smallest is used for raising and lowering the jib as may be necessary in transportation. The engine is connected also with a system of gearing for slewing

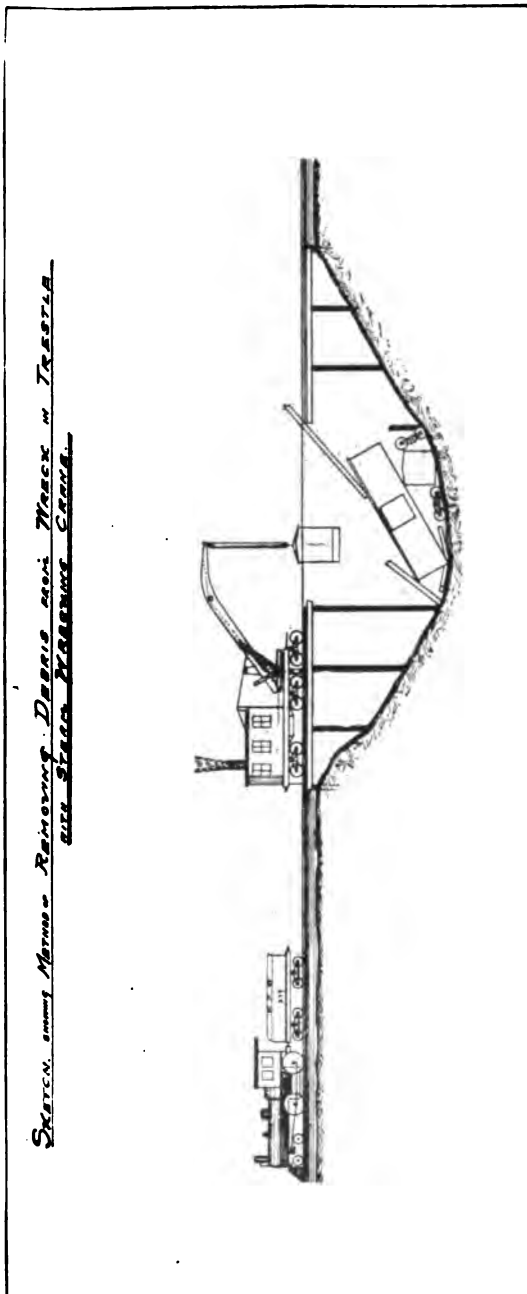


FIG. 116—SKETCH SHOWING METHOD OF REMOVING DEBRIS FROM WRECK IN TRESTLE WITH STEAM WRECKING CRANE.

the jib in either direction twenty-two and one-half degrees from the center of the track. All gearing is constructed of steel, and for the latter purpose is supplied with a device which securely locks the jib in any position during the process of lifting, this device also being most important for safety in handling the heaviest loads. The center-post of mast supporting the jib of the crane is constructed of a Phoenix segmental wrought column, with an inside diameter of fourteen and one-half inches, and re-enforced at its base with encircling castings binding the whole together, and producing a section showing an outside diameter of some thirty-three inches, and possessing the greatest strength. It has a circular opening in its center for the passage of the hoisting rope. The jib of this is constructed throughout of steel, and designed to have an effective radius of twenty-two feet from the center of the crane post to the center of the hoisting block. The main members of this jib are constituted of two beams with a depth of thirty inches at the base, and fifteen inches at the extremity. The webs of these beams are one-half inch plates running from end to end, with double three by three and one-half-inch angles for the flanges. and further re-enforced by a top and bottom five-eighths by seven-eighths inch plate. These two beams are connected by distance pieces, and partially covered by one-fourth inch plates bolted to the top and bottom flanges, making portions of the jib a box section. The webs of these beams are also strengthened by "T" irons riveted to their sides.

The jib is mounted upon four wrought "V" struts, two on either side, the forward of these being in compression, and the rear in tension when lifting, the bending movement due to the load being applied to the mast at a point about three feet above the deck of the car. By withdrawing the lower retaining pin from the back struts, the jib may be swung on the upper pin in the forward struts until it reaches a horizontal position, and one suitable for travelling. Replacing the pin in the upper hole of the rear struts holds the jib in this position. The jib, while being made tapering, is also constructed with a curved extremity, allowing material of large proportion to be raised to the full height of the jib, obviously a great advantage.

In case a derrick is not to be had, other methods may be adopted, one of which is to apply the torch to the wrecked debris, and burn it out. This may be done in extreme cases with good results, but it requires time, and after the wood is burned the iron is left to be either picked up with a derrick or hauled out of the way with lines and crabs, or locomotive and lines. The quickest method to adopt is to use a locomotive and hauling lines, which is illustrated by print No. 113. If this method be adopted, the necessary snatch-blocks may be anchored to what are usually termed "dead men," properly planted in the ground; or anchored to trees if any be found convenient. The anchor usually adopted is the "dead man," which consists of a piece of timber about ten by twelve inches by ten feet in length, set horizontally in a trench about five feet deep, and parallel to the center line of main track, and of sufficient distance from the wreck to haul out cars, trucks, etc., far enough to clear the site of temporary work. Commencing at the center of the trench already dug, dig another at right angles to it, and about ten feet long, and slope it from the bottom of original trench to surface of ground toward the wreck. Pass a good one inch chain around the center of the timber, of sufficient length to lead up to the top of the ground. To this chain attach a snatch-block. Another anchor of the same kind should be placed in the ground near the track, to lead the line in the proper direction so it can be attached to road engines as illustrated in print No. 113.

To raise an engine, the first work or consideration will be to place the engine on its wheels; the next move will be to place it in proper line with the track which it is proposed to land it on. Every wrecking master has his own methods of arriving at the object desired. Hydraulic jacks are important tools for this purpose; hauling lines may also be used to good advantage in the same manner as illustrated by print No. 113. The method of elevating an engine by hydraulic jacks alone is a slow process; particularly is this the case when the height to be raised is great. Where the conditions are favorable a track can be built down an embankment, the engine placed on the rails, and hauled up the incline with one or more engines, by using a one and one-fourth-inch steel wire switch rope to connect the live engine with the dead one.

In case the conditions are such as to make this method impracticable hydraulic jacks with a sufficient amount of blocking will be required. Blocking cut from sound old timber is the best, and should be cut into lengths from two to four feet, and of various sizes.

In case the location is on soft earth, a lot of blocking timbers should be cut from eight to twelve feet long, to make footings in the mud. The best size for this purpose will be seven by fifteen, or eight by sixteen, old stringers.

A lot of hard wood wedges about five inches wide, thirty inches in length, and three and one-half inches thick at the large end, are very convenient for use when changing jacks.

After the wreck is cleared away the bridge force can proceed with the construction of the temporary trestle. The material is at hand, on the cars, ready for the work.

Let us suppose, in this case, that it is necessary to drive piles, as the water is deep, and the bottom soft. The pile car is switched

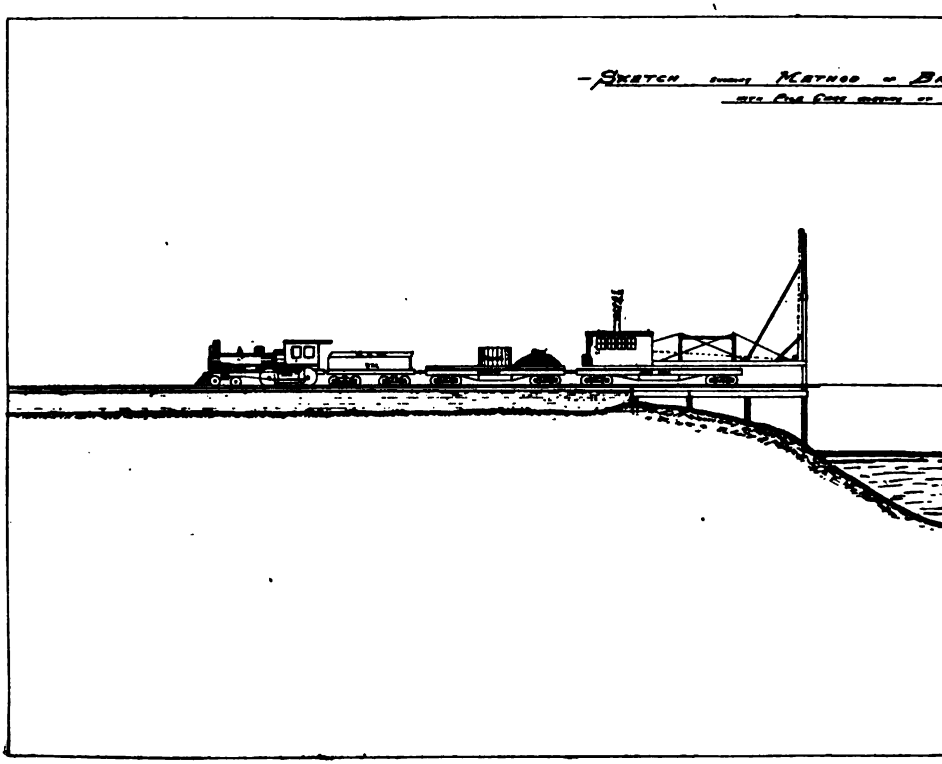
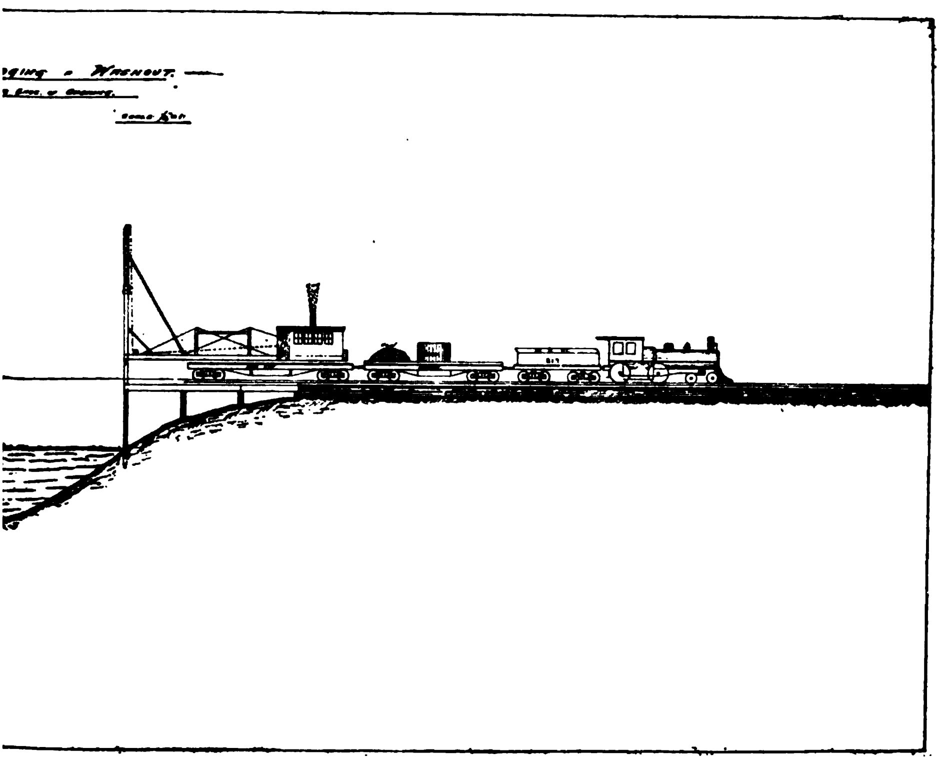


FIG. 117—SKETCH SHOWING M



HOD OF BRIDGING WASHOUT.

into place, illustrated by print No. 117. The car represented in the cut is one used by the Missouri Pacific Railway, has a clear reach of sixteen feet, which enables the use of a sixteen-foot panel, and so arranged that it will reach on either side of the track fourteen feet from the center. The deck of the driver proper is fifty-five feet two inches long; the leads are forty feet high, and twenty and three-fourths inches clear between, are faced with eight-inch steel channels, and hang on hinges which enable them to be raised from a horizontal to a perpendicular position, and fastened in place, ready for service in eight minutes. Car is equipped with a three-thousand pound hammer, all the necessary ropes and tools, consisting of two one and three-fourths-inch best manilla hammer lines, two one and one-fourth-inch pile lines, with seven feet best half-inch crane chain, with ring in one end and hook in the other, line being spliced to ring of chain, and properly protected with steel thimble. Chain is used on account of liability of rope slipping, and is also much more convenient for making hitches for raising piles. The hammer and pile lines run over different sheaves and are connected to separate drums of the engine, which is situated back in the cab. The sheaves at the top of the leads over which these lines are run, are nicely turned out, and made to fit the rope in perfect manner, as are the sheaves at the bottom of the leads; from these sheaves to the engine's drums the lines run over pulleys which protect them from chafing or damage by coming in contact with rough or sharp surfaces.

The engines of these cars are of the Mundy design, equipped with double drums twenty-two inches in diameter, and with double cylinders seven and one-fourth by ten inches; these engines have best approved friction gear, with link motion, and can be reversed or stopped in an instant, are strong, and free from accident.

The boiler is built of special design, extra heavy, forty-five inches in diameter, seventy-two inches high, with one hundred and twenty flues two inches in diameter; it being necessary on account of the limited height of the cab to keep the boiler down to seventy-two inches in height. A small amount of coal is stored in the cab; the principal supply, however, is carried by the convoy car, which is also provided with a water tank of two thousand gallons capacity.

This convoy is provided with a complete outfit of tools; consisting of one twenty-ton hydraulic jack, one-half dozen screw jacks, two snatch-blocks for two-inch line, two for one and one-half line, one set of block and falls for one inch line, one for one and one-fourth and one for one and one-half-inch line, six hundred feet of one and three-fourths-inch rope, one hand-crab, chains, wrenches, steel bars, pinch bars, adzes, spikes, nails, hauling lines, six sets of carpenter's tools and a limited number of framing tools, axes, etc.

The crew for this car for ordinary work consists of a foreman, engineer, and seven men, but for emergencies of this kind should have a crew consisting of twenty-four men, one-third good laborers, and the remainder bridge-men. This crew will drive five bents, four piles to each bent, cut them off, cap, place stringers, ties, and spike the track on them in ten hours.

The piles for the work, having been sawed off square at the butts, small ends pointed, closely trimmed, all projecting knots removed and pile rings fitted so that the first slight stroke of the hammer will drive them tightly on the butt of the pile, the road engine pulls the pile car back to where they are lying, where the pile will be picked up and taken out to be driven.

After piles have been driven and properly sawed off, caps, twelve by fourteen inches by fourteen feet long, will be raised into place with the pile lines; as soon as they are landed four men will climb upon them, each with an auger, and bore four holes through the cap (one over the center of each pile); others of the gang will have the necessary drift bolts (which should be seven-eighths of an inch round iron twenty-four inches long) together with a spike maul to drive them ready to hand to the men on the cap.

The stringers, six of them, eight by sixteen inches by thirty-two feet long (any other length can be used) are next hoisted into position with the pile line, and outside stringers drift-bolted to the caps; these in place, the ties (seven by eight inches by ten feet) are placed, and every third tie spiked to the outside stringer. The rails of the track are then extended ahead, firmly spiked into place, pile car moved ahead to drive another bent. This process will be repeated until the structure is finished. While the pile car is driving a bent, a portion of the gang will be at work placing the material for the next panel, where it can be readily reached by the car. In making changes from driving to sawing off piles, placing caps, stringers, and ties, it may be necessary to move the pile car back out of the way for a few minutes.

In case wash-outs or burn-outs should cover very wide openings in the track, and the importance of completing the repairs be great, every effort should be made to relieve the road from loss on account of detention of traffic. The only way to effect this is to increase the number of men and use two pile cars, one on each side of the stream, as indicated on print No. 117.

In case water is deep, it may be found convenient to employ the use of pontoons, which can be readily built of old pieces of pine or cypress timber, such as seven by fifteen inches or eight by sixteen inches, stringers sixteen to twenty feet long, packed side by side, from five to eight feet wide, with plank deck spiked crosswise on it after it is placed in the water. Such pontoons can be built to carry three or four men, can be anchored at any point re-

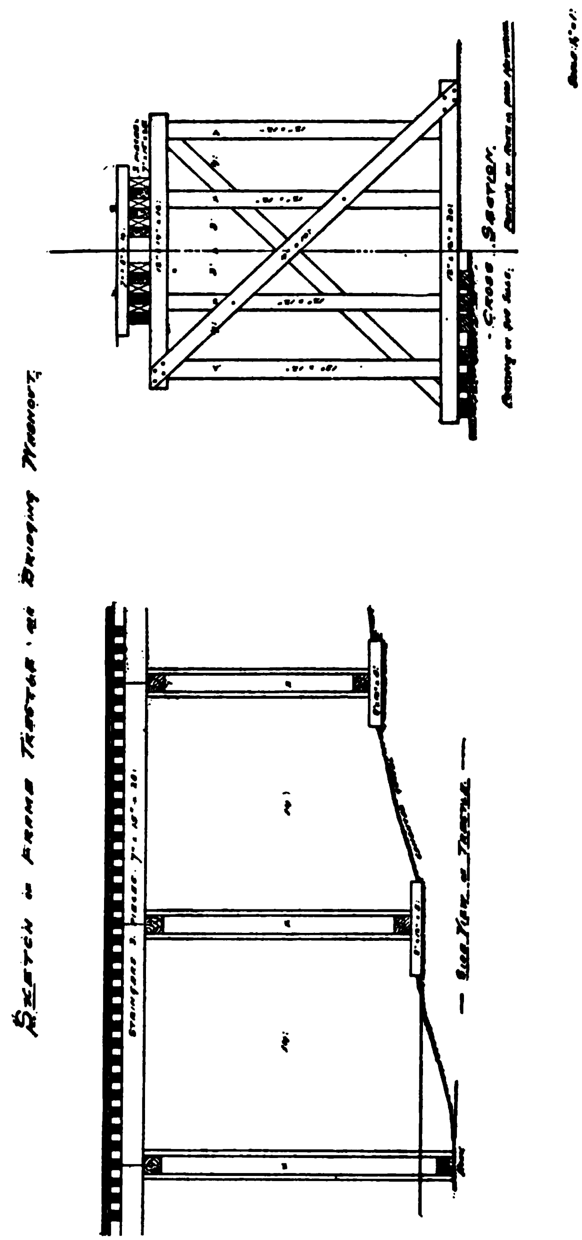


FIG. 118—SKETCH OF FRAME TRESTLE FOR BRIDGING WASHOUT.

quired in the stream, and moved to the various positions with pike poles I have often found these pontoons to be very serviceable, as men on them can guide piles to proper location, spike sway-braces to the piles immediately above the water, as well as greatly assist in handling the bracing.

Where frame bents can be used I have found riprap stone of valuable assistance in securing a foundation, placing it where the bents are to be located, and, after a sufficient quantity has been placed, level it off and sills of the bent placed thereon. I have known bents located on foundations of this kind to remain in place several months without showing any signs of settling. Where frame bents, such as are represented in print No. 118, can be set without liability of settling, they can be constructed very much cheaper than any other kind and put in place much quicker than piles. They require to be well braced, however. I advocate the use of four by ten plank for the bracing, which is spiked to sill, posts, and cap with one-half inch boat spikes eight inches long.

There is another method of using frame bents where the bottom of the stream is comparatively solid and particularly where a rock bottom is found; this is to use twelve by twelve posts placed separately and of such length as will meet the requirements of an uneven or irregular bottom.

These bents can be framed together by securing the exact height where each post is to be located, after which cut the post to the required length, place them the proper distance apart, drift-bolt cap to the top ends, after which, spike a four by ten plank horizontally across the posts at a distance from the bottom, which will bring the plank level with the water surface when the bent is raised in place, after this spike a diagonal brace from the top of the four by ten plank across the posts and one end of the cap. This done, the bent is raised in place. After raising the bent, spike a four by ten plank on the other side of posts opposite the one spiked before raising the bent, also spike on another diagonal brace running in opposite direction to one on the other side.

This is not a quick process, but can be adopted where other methods cannot be used to advantage. In case such a bent should settle to one side, add two more braces, and level up on cap.

If frame bents are used, the question of raising them must also be considered. A single mast or gin pole with four guy lines, one set of blocks and falls, can be used to good advantage. The mast should be located near the center line of the track, and of the proper height for the work, two of the guy lines anchored near the track, the other two on the other side of the wash-out. The guy lines should be of the best plow steel wire rope, three-quarters of an inch in diameter, two of them two hundred and twenty-five feet, the other two, two hundred feet long. Before raising the mast, the

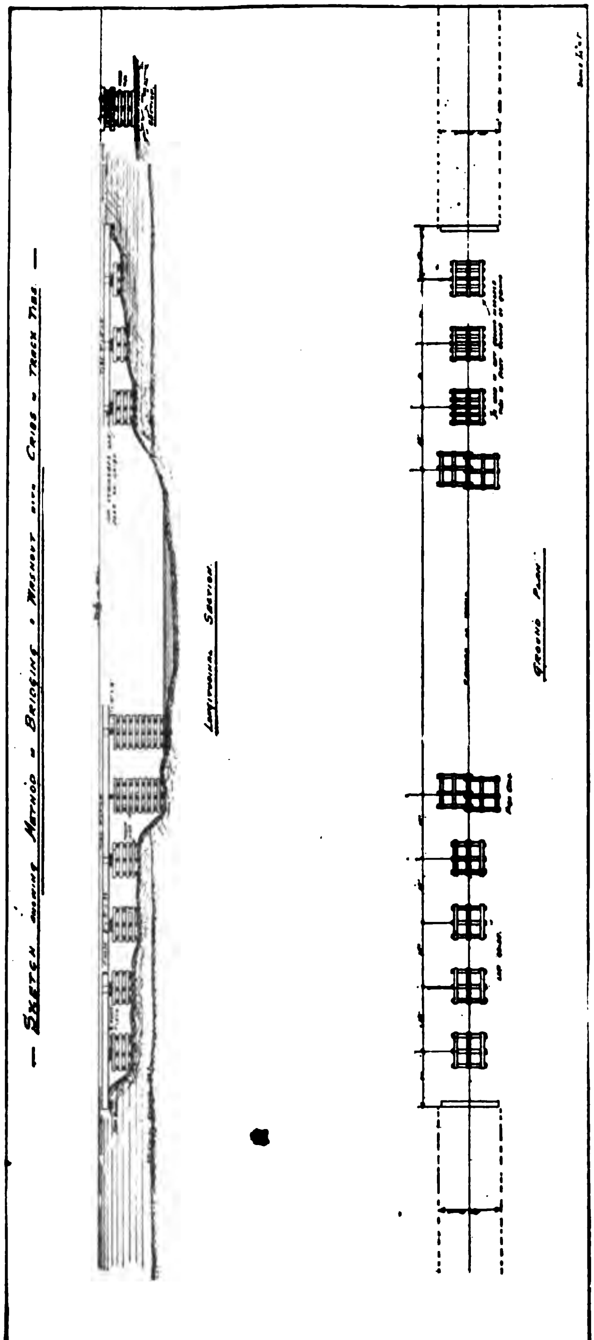


FIG. 119—SKETCH SHOWING METHOD OF BRIDGING A WASHOUT WITH CRIBS OF TRACK TIES.

upper fall block should be hooked in the ring provided near the top of the mast, the hook securely lashed with marlin to prevent it from being unhooked. After the mast is properly guyed into position, and the end of fall line fastened to the crab, which has been properly located and anchored, fasten a one and one-quarter-inch line, having a double bow line in the center to hook the lower fall block into, to each end of cap of bent, and raise bent to a perpendicular position, adjust properly, brace longitudinally, after which other bents can be raised without changing location of mast, and this process continued until all bents are raised.

I may add here, that in constructing temporary trestles the stringers are usually placed on the caps without packing them together as in permanent work, and great care should be taken to see that the stringers do not move endwise, and pass off the cap at one end, which might result in a serious accident, provided temporary work is left in place for any considerable length of time.

Another method of bridging a wash-out is by the use of cribbing, constructed of ordinary hewn track ties. The method of building such cribbing is illustrated by print No. 119.

This is ordinarily considered a rude method of constructing temporary work, and is often built by men of little experience in constructing any kind of work, and is liable on this account to give trouble. But where cribs are built in a proper manner there is no reason why they should not be perfectly safe. The crib should be brought up as nearly level as possible, care being taken to select ties of the same thickness for the same course of the crib. In case the height is such that double cribs are necessary, the cribs should be capped with twelve by fourteen inches by fourteen feet long caps, using ties and stringers as in other temporary work, and securing them in the same manner. For cribs six to eight feet high, single cribs can be employed. For higher work I have found the method as illustrated on Print No. 119 to admit of speedy construction, work better, and stand firmer, with less swaying than double cribs built separately. In building such cribbing, it is some times necessary, in case bottom is very soft, to lay a complete floor of ties for footing of the crib.

This method of bridging a wash-out is the most expeditious, as a large number of cribs can be built at the same time, and, in this way, enable a large force of men to work at comparatively good advantage.

Referring again to the use of engines and pile-driving machinery, more particularly to a comparison of the designs of machines, will state that I have not found anything in this line which excels the best designs of friction-gear engines.

There are two or three good designs of steam drivers, one in particular, which is manufactured by the Vulcan Iron Works of Chicago. I recall one of these which has been in use for a number of years, and works quite satisfactorily, but to say that it excels the best friction-gear engine is quite another question. We are quite satisfied with friction-gear engines, at the same time we will be glad to adopt anything that may be discovered which will perform the work more expeditiously, or show any improvement worthy of consideration. The steam hammer is, I think, better adapted to use on docks or floating drivers.

R. M. PECK,
Mo. Pac. Ry.

REPORT: METHODS AND SPECIAL APPLIANCES USED FOR BUILDING TEMPORARY TRESTLES OVER WASHOUTS AND BURNOUTS.

First. Conditions governing physical features of the country on different railroads cause methods of repairing washouts to vary according to the locality. Some parts of the country are subject to cloudbursts, while others more to high water from rains and ice, which also of necessity causes different arrangements in the organization of the bridge and building department. On some roads the bridge and building and roadway departments come under the engineering department. On some roads the roadway comes under the superintendent of the operating department, and the bridge and building department comes under the general superintendent. The reason for this is, that the superintendent of bridges and buildings, as a rule, can handle more territory than is allowed a division superintendent. Where the roadway and the bridge and building departments come under the same head, their relations are closer and therefore they can work in harmony, giving better results. The bridge and building department must have the assistance of the roadway and the transportation departments; the roadway in loading material and helping to make repairs; and the transportation department in furnishing cars for material and forwarding the same promptly to their destination, and also furnishing work trains, etc., as it is very important that traffic be delayed as little as possible on account of washouts and burnouts, and preparations should be made with this end in view, that any emergency may be met and promptly overcome.

Second. There should be material yards located at division and junction points where there are large bodies of men and where there are likely to be plenty of cars, so material can be loaded rapidly. The amount of bridge material that is carried in stock at these places should be governed by the number of lineal feet of bridges on that division of road which is subject to washouts and burnouts. There should be one principal material yard, and that should be located at some prominent division point nearest to the point material is received, where there should always be kept on hand a large supply of all kinds of bridge material. At the smaller yards there should be kept from five to fifteen panels of sub and superstructure, and some old bridge material, such as stringers, twelve by twelves, and bridge ties, and also from five to fifteen panels of standard bridge hardware.

Third. During heavy storms section foremen should patrol their tracks and, as a rule, discover washouts. If discovered by a section foreman, he should notify the chief dispatcher and roadmaster. The chief dispatcher or roadmaster should notify the bridge foreman and also superintendent of bridges and buildings and the head of his department of break, giving details in full to the best of his knowledge. If only a small break, it can be repaired by the roadmaster and his men. If it is a bridge of a few panels, or a small fill, it can be repaired by the bridge foreman, with the assistance of the section men.

All roadmasters at division points where material is located should have blue prints showing the material it takes for from one to thirty panels of bridge deck, and should also have a blue print showing material required for frame bents from eight feet up to fifty feet in height. This is to save long messages and chance of mistakes in transmitting.

In extraordinary washouts it is necessary to have material loaded at from three to five points, for usually there is not enough carried at one point, and in most all cases it is necessary to call on the roadway department to assist in loading.

Fourth. The superintendent of bridges and buildings in selecting foremen should make it a point to employ the best men possible, men who have had experience and display good judgment. They should be good all-round bridge and building men, which takes years of experience, and should be competent to do all classes of work in their department. They should be furnished with a complete list of plans of pile and trestle bridges, and should have blue prints showing bill of material for from one to thirty panel of bridge deck complete. They should also have a bill of material for frame bents from eight feet up to fifty in height, showing sway braces and longitudinal and sash girts, and they should have the same for pile bents. They should have a blue print for framing bents, showing length of sills and distance between mortices and length of plumb and batter posts, so it will not be necessary for them to do any figuring in case of a rush. The superintendent should see that his foreman understands thoroughly how to make repairs with the material he has on hand, as the telegraph wires often go down and they cannot get instructions. The line may be washed out at a number of places, and the superintendent of bridges and buildings unable to get around on account of being busy at other points, when the foremen should understand that they are to act without instructions and use their own judgment.

The superintendent, supervisor, or general foreman of bridges and buildings should be a thorough mechanic, competent not only to instruct, but to do in detail any work he has in charge, and he should have a thorough experience in repairing washouts and burnouts.

Fifth. There are many different classes of washouts. In some instances embankments are washed out; in others, the fills are badly side washed, oftentimes from thirty to four hundred feet in length and from five to twenty feet in depth. Some fills are completely washed out, with large holes scooped out, and water two to twenty-five feet deep and in some places thirty to four hundred feet long. Pipes and arches are sometimes washed out with more or less of the embankment.

Bridges sometimes have the ends washed out; some have a few bents crippled only, and others are totally gone, with from sixteen to four hundred feet of dump at each end of the bridge, and water running through the full length of the break. There are instances also where the track and bridges are washed out for miles. This is sometimes caused by insufficient water way, ice, or drift, but the majority of cases are caused by cloud bursts or extraordinary rains and cannot be prevented.

Sixth. The best special appliance for making repairs to washouts is a first-class extension pile driver, with the latest improvements, with a twenty-foot extension, on a flat car with wrought iron Bay City, Michigan, turn-table, with improved center and special turning gear and fastenings, these latter not furnished by them. It should turn completely around, and drive at any angle from the car or at either end of the car, and should drive twenty-six and one-half feet at right angles from the center of the track, so that it will make no difference how it is located or in what direction headed; it will always be ready for work. It should be fitted with a double drum friction engine, and should turn by friction, air, or by hand.

The repairing of washouts is governed by the kind of break and the appliances on hand for such work. On some roads repairs are made of large washouts of fills and bridges, where water from five to thirty feet has to be contended with, and not having a good extension pile driver it is necessary to crib. Where the work should be done in one day it takes two or three; besides there is a waste of material and labor caused by putting in temporary work when permanent work could have been put in in less time, and in any event the crib is unsafe on account of unevenness of ground; while with a pile driver the bridge is permanently rebuilt and men are ready for other work. Oftentimes it is not necessary to drive a bridge in washouts where temporary frame bents can be put in, as it will be filled in again when convenient. In such places it is not necessary to use new material. There is no road but has more or less old material, and in such places all old material should be used. The principal object where cribbing must be done in water is to get material to sink the crib. Rock or rails are mostly used; but if none are convenient, it is necessary to have sacks to be filled with sand or dirt.

Seventh. In case of washouts the superintendent should have a complete detailed report as soon as possible, giving the location and extent of the different breaks, and if water is to be contended with, so that material can be ordered for temporary or permanent work, as necessary or advisable, old material being always ordered for temporary and new for permanent work. In case temporary work has to be put in where permanent work goes afterward, due care should be taken that the temporary work may not interfere with the permanent work.

In making repairs across streams where water is from ten to thirty feet in depth the following organization is recommended: First. Unload enough material to start work. Second. Start a gang of men framing ties and one end of stringers and sizing both ends, sizing the end not framed back thirty inches. Third Start pile driver to driving. Fourth. Have foreman and ten men in front. By the time the pile driver has a bent of piles driven the foreman has his staging up and height on the piles, and at the last blow of the pile-driver hammer the straight edge is put on and two men to each pile start sawing them off. While the men are sawing off the piling the driver has run back for a cap. When the piles are sawed off the pile driver lowers the cap to position and starts for stringers for one side. The stringers are lowered to position and the driver goes back for the other side. While the pile driver is gone men place stringers and finish drift bolting the cap. The other stringers are then lowered to position and the pile driver starts for a panel of bridge ties. As soon as bridge ties are lowered the driver goes back for two thirty-foot rails. These are placed on ties and the driver goes for a pile. Note, it is necessary to use two rails twenty feet long and two ten feet for temporary work. Thirty-foot rails do not always work to good advantage on fourteen and sixteen foot spans; they are either too short or too long, as the rails should project over the bridge. While it is gone the track is spiked, bolted, gauged, and lined up. At this point there is generally a few minutes' delay of driver waiting for men to get through. Then the driver starts driving the next bent. While driving this, two of the men in front are sawing off the ends of the stringers, getting ready for the next panel, and two of the men are detailed to bore and bolt up the stringers, so as to keep everything

FIG. 120—PILE BRIDGE OVER ARKANSAS RIVER, DODGE CITY.
(Exhibit "A"—Mr. Bishop's report.)

safe, and so it goes until the gap is crossed. I wish to state that of the ten men that work in front of the pile driver each man has his part to look after. While the pile driver is driving the next bent, one man should see that angle bars, track bolts, drift bolts, and tools are ready for the next bent. Two men sawing off stringers, five men putting up ledger boards and staging, putting on sway braces and bolting up same. The other two men are back boring and bolting up the chord. They should have turn buckles to pull bents square with the track and to pull the piles into place. All caps are bored out on the dump for sway brace bolts, and the gang there should do all the unloading, framing of material and piling same after framed for the pile driver to pick up. A foreman and nine men can do this and keep material prepared for a day and a night gang; note, one man should be detailed from this gang to file cross-cut saws for the pile driver and the two bridge gangs. There is no reason why, with proper management, they cannot drive and complete six to ten panels of bridge work every ten hours, and at night three to five panels of permanent work. As the night gang have to do all the changing and coaling-up on their own time, there will necessarily be considerable loss of time to them and slower work on account of the darkness. If night work is done it will be necessary to have an extra engine tank for water for pile driver and locomotive. The locomotive should be arranged to take water from the pile-driver tank to avoid running for water from 6 a. m to 7 p. m., or from 7 p. m. to 7 a. m.

In temporary work, where only three piles are driven to the bent, better results can be secured and fewer men are required.

There are roads that have bad washouts where it is necessary to crib in deep water, though they have a road driver that has an extension of six to eight feet. The writer recommends that they have two or three pieces of timber twenty-four by twenty-four inches by fifty feet, Oregon fir, and use them as stringers, projecting them over the cap ten feet or more and laying bridge ties and track thereon. The driver can be run out on them for driving a stringers can be readily moved forward to drive the next.

There are several different ways of making repairs to embankments badly side washed. One is to dig down the remaining embankment and bring up the part washed to a level It is necessary sometimes to make a long run-off, so that grade will not be too steep, as the fill cut down is often six or eight feet below grade. Another way is to build around the break what is called a shoofly. This is very often done, but it is not advisable except in extreme cases, as the cars are likely to run off the track, or the train to break in two parts on account of sharp curves and steep grades.

The following is recommended as the best way to make such

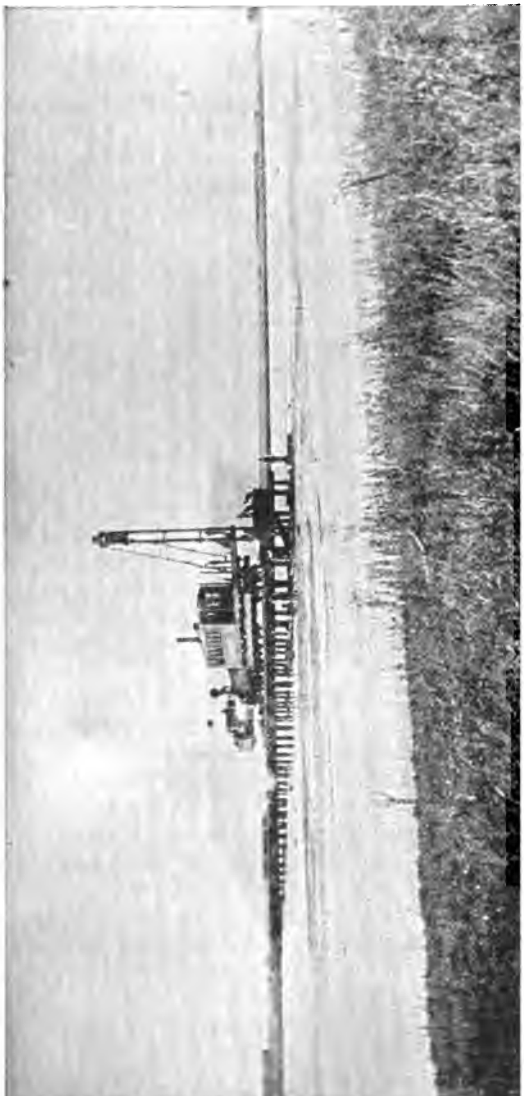


FIG. 121—PILE BRIDGE OVER ARKANSAS RIVER, DODGE CITY.
(Exhibit "B"—Mr. Bishop's report.)

repairs: Where embankments are half washed out and only ten feet deep lay one sill six by sixteen by ten feet longitudinal with track; set plumb posts on that, put caps on plumb posts, dig out bank and project caps through and place stringers under outside rail, resting on caps. The stringers carry the track on one side and the embankment on the other. Where the washout is eighteen feet deep set up a plumb and a batter post on sills and sway brace the plumb and batter posts to the cap. By putting in this temporary trestle work the track is up to grade, regular trains can be pulled, which cannot be done where embankment is cut down or shoofly is put in, and it can be filled by work train or steam shovel. If by steam shovel and side plow only a few section men will be required to handle the dirt; on the other hand, if shoofly is put in and filling is done with the steam shovel, it is necessary to scrape dirt off on one side and keep raising track up and throwing in line to get it back on its old centers and grade. This will require a large force of men and will cause a waste of material and delay of shovel unless they have other work in the vicinity. It is the same with embankment cut down, as a large number of men are required for raising and putting dirt under the track to bring it up to grade.

In large washouts, where road beds and bridges are washed out for miles, it is necessary to organize a track-laying outfit to work in conjunction with the bridge department. And it is often necessary to haul bridge material on wagons several miles ahead of the track to rebuild and repair bridges so they will be ready for the track-laying gang.

Burnouts are treated in a general way similar to washouts; but, as a rule, there is no water to contend with, and driving can be started at one end and frame bents at the other.

Rapid repairs of washouts depend to a great extent on the number of men and conveniences for doing the work.

There should be boarding trains at all large washouts, or other arrangements made for the men to get their meals regularly. This should be looked after by the head of the bridge and building or roadway department, or by some one detailed by him.

All bridge gangs should have outfit cars, one bunk, one tool, and one material car, so as to be ready to move upon short notice.

I submit herewith exhibits of work.

Exhibit "A," showing pile driver driving an outside pile having one already driven. Bridge eight feet high. (Fig. 120.)

Exhibit "B," showing ties just lowered on stringers and pile driver starting back for rails. (Fig. 121.)

Exhibit "C," showing pile driver at washout driving a nineteen-panel bridge three hundred and four feet long in from fourteen to seventeen feet of water, bridge fourteen feet above water.

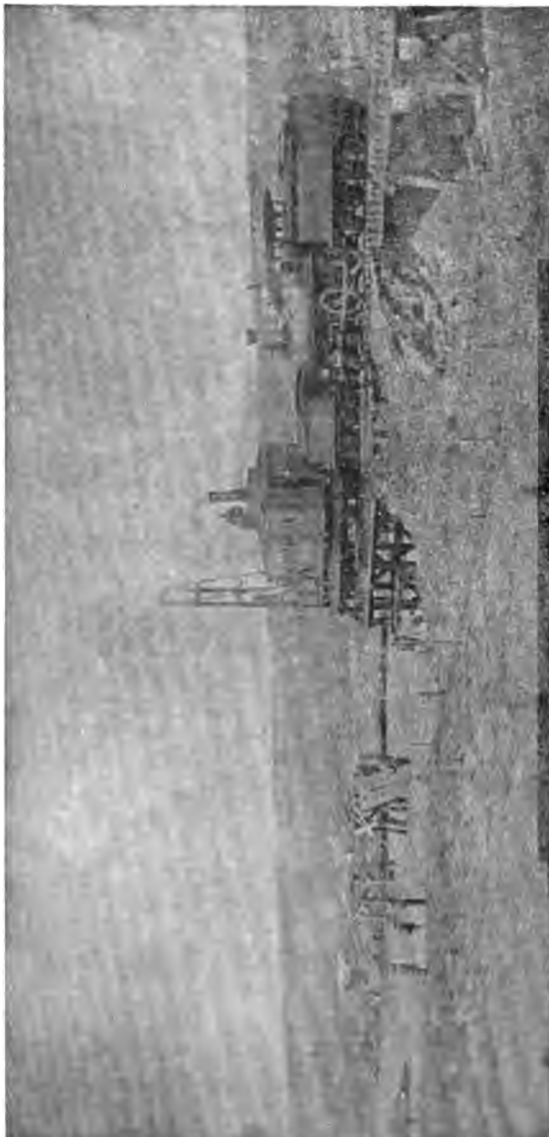


FIG. 122—PILE BRIDGE OVER ARKANSAS RIVER, DODGE CITY.
(Exhibit "C"—Mr. Bishop's report.)

Sixty feet east of the bridge this exhibit shows a washout in fill one hundred feet long and twelve feet deep. (Fig. 122.)

Exhibit "D," showing methods of repairing side-washed embankments. (Fig. 123.)

This method should not be used where embankments are over fourteen feet high without three ties fourteen feet long to each panel blocked up under the ends to support the track, and the soil then should be cement, gravel, or clay. It may be necessary in some instances to put in an extra plumb post to support the cap.

GEO. J. BISHOP, C., R. I. & P. Ry.

APPENDIX.

ORGANIZATION OF BRIDGE AND PILE DRIVER OUTFITS.

Each bridge gang should have a bunk car, tool car, and flat car. On the material car should be carried one panel of bridge deck, a large assortment of 1, 2, and 3 inch lumber, and staging for cutting off piles for not less than 4 to 6 bents. Under the tool and material cars should be boots for carrying tools and supplies.

In the tool car should be carried 6 to 10 panel of bridge bolts, 50 drift bolts, and a large assortment of spikes and nails and the following tools:

1 hand car.
1 push car.
1 velocipede car.
4 timber dollies.
1 track dollie.
1 hydraulic jack, 10 tons.
4 double-acting telescopic screw jacks 14 inches high. Ball's patent.
1 screw jack 8 inches high.
2 track jacks, Barrett No. 1.
1 medium size grind stone.
1 track gauge.
4 track chisels.
2 shackle bars for $\frac{7}{8}$-inch bolts.
3 claw bars. Verona pattern.
6 octagon steel pinch bars, $1\frac{1}{4}$ in. x 5 ft. 4 in.
5 spike mauls.
2 8-inch double face hammers.
2 14-lb. double face hammers.
3 chopping axes, $4\frac{1}{2}$ lbs. each.
3 clay picks.
12 maul handles.
6 sledge handles.
6 ax handles.
6 pick handles.

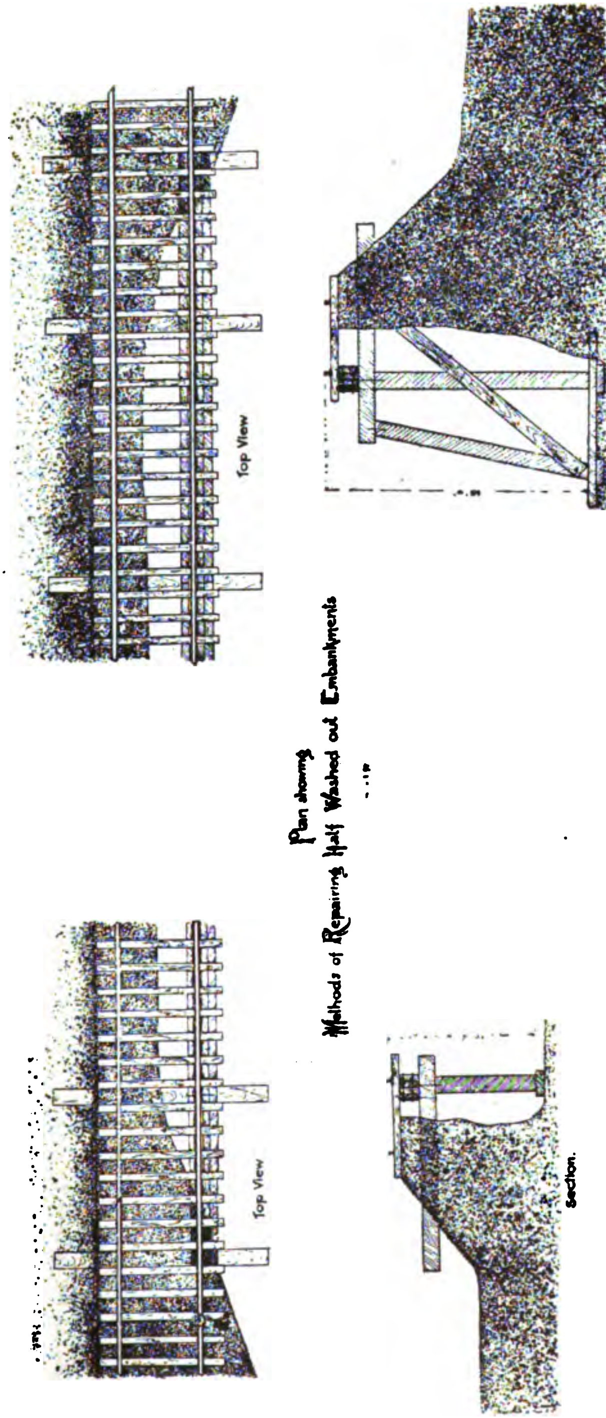


FIG. 123—PLAN SHOWING METHODS OF REPAIRING HALF WASHED OUT EMBANKMENTS.
(Exhibit "D"—Mr. Bishop's report.)

2 long handled shovels.

6 short handled shovels, No. 2.

2 lumberman's cant hooks without end spikes.

2 post holes diggers, Eureka patent.

3 chisel bars 3½ inches wide, 1 inch thick, and 6 feet long.

2 15-inch monkey wrenches.

2 track wrenches.

4 S. wrenches 2 ft. long for two kinds of ¾-inch nuts, jaws 1 15-16 and 1 9-16 inches.

2 1-inch bridge augers with cranks.

6 ⅞-inch bridge augers with cranks.

2 ⅝-inch bridge augers with cranks.

7 cross-cut saws, 5 ft. long, with climax handles. "V" tooth ¾ of an inch from point to point. H. Disston's patent.

6 8-inch flat mill files.

1 large size garden rake.

1 boring machine with 3 augers; one 1 inch, one 1½, and one 2 inch.

2 ⅝-inch chain spider, turn buckle 36 inches long, 2 ⅝-inch chains 8 feet long attached to turn buckle, with grab hooks on the ends.

1 ½-inch cable chain 14 ft. long, grab hook each end.

6 ½-inch cable chains 7 ft. long, grab hook one end, ¾-inch ring ½-inch in diameter at other end.

2 clamp bolts 1⅜ inches, 36 inches long, threads cut 20 inches, 2 nuts each.

2 clamp bolts 1⅜ inches, 44 inches long, thread cut 20 inches, 2 nuts each.

4 cranks to fit nuts on clamp bolts.

8 wrought washers 5x5½ inches, 1½ inch hole.

4 staging hooks 5 ft. long, hooks 8½ and 12 inches.

3 pike poles 16 ft. long, 1¾ inches one end, with ferule; other end 1¼ inches, select yellow pine.

2 16-foot poles 1¼x1½ inches select pine, S. 4 S.

6 straight edges 16 ft. long, 1¼ inches thick, and 10 inches wide, full length, select pine.

2 10-inch double blocks, Hartz' patent steel.

2 8-inch double blocks, Hartz' patent.

1 10-inch snatch block, Hartz' patent.

2 hand lines 50 ft. long, ¾ inch rope.

100 ft. of 1½ inch rope.

250 ft. of 1 inch rope.

150 ft. of ¾ inch rope.

6 lantern frames.

6 white globes.

3 red globes.

6 red flags.

12 green flags.

12 track tropedoes.

4 2-gallon oil cans, 2 gallons coal oil, 2 gallons black oil, 2 gallons signal oil.

1 1-quart oiler with short spout.

2 water pails.

1 broom.

1 water keg.

1 wash basin.

1 dipper.

3 torches.

1 No. 3 Merrill's saw set for single tooth cross-cut saw.

1 $\frac{5}{8}$ octagon steel drift 16 inches long.

1 $\frac{5}{8}$-inch octagon steel drift 24 inches long.

Pile driver outfit organized and supplied with tools, etc., as follows:

Train crew: Conductor, 2 brakemen, 1 engineer, 1 fireman.

Pile driver crew: 1 foreman, 1 engineer and 6 men.

1 engine.

1 caboose.

1 bunk car.

1 tool car.

1 flat material car.

1 flat car 3 ft. high and 30 ft. long, to go under extension of pile driver.

1 20-ft. extension pile driver.

1 pile driver water tank with connections for road engine.

Description of pile driver as follows:

Length of flat car, 32 ft. 4 in.

Width of flat car, 9 ft. 10 in.

Length of flat car, including draw heads, 33 ft. 6 in.

Size of axles, $5\frac{1}{4}$x9.

Size of journal brasses the same.

Distance from center of turn table to ends of car, 16 ft. 2 in.

Length of pile driver over all when leads are raised, 61 ft.

Width of pile driver over all, 10 ft. 2 in.

Length of engine room, 26 ft. 10 in.

Height of engine room from floor, 7 ft. 9 in.

Length of platform outside of engine room, 18 ft. 4 in.

Length of angle to nose of driver, 16 ft. 10 in.

Height from top of rail to top of head block on leads, 36 ft.

Length of leads, 35 ft.

Size of leads, 7x9 oak.

Size and length of channel iron on leads, $2\frac{1}{2}$ in. x 7 in. x 32 ft.

Distance between leads, $20\frac{1}{2}$ in.

Diameter and width of pulley on 20½x2⅞.
Weight of pile driver, 86,600.
Weight of pile driver on rear trucks, 41,600.
Weight of pile driver on front trucks, about 45,000.
Weight of pile driver with leads raised, about 48,000.
Weight of hammer, 2,800.

1 friction pile driver engine, Lidgerwod Mfg. Co., No. 72, 30 horse power.

Boiler 42 in. diameter, 96 in. high, 48 ft. of the top swelled out to 48 in. diameter.

Driver should have solid wrought iron turn-table 10 feet in diameter, and should turn completely around. It should be capable of driving 20 feet ahead of the track and 26½ feet at right angles from center of track. It should be fitted to turn by friction, air, or hand. Duplicate parts should be carried for whatever is likely to break or give way; also a complete outfit of tools, as follows:

2 15 ton hydraulic jacks.
4 telescopic, double acting screw jacks 14 inches high. Ball's patent.
3 track jacks, Barrett's No. 1.
1 grind stone, medium size.
2 shackle bars for ⅞ inch bolts.
4 claw bars. Verona pattern.
6 octagon steel pinch bars, 1¼ inch x 5 feet 4 inches.
1 track gauge.
4 spike mauls.
2 8-lb. double face hammers.
2 14-lb. double face hammers.
4 clay picks.
4 chopping axes, 4½ lbs.
12 spike maul handles.
6 sledge handles.
6 clay pick handles.
12 ax handles.
2 long handle shovels.
6 short handle shovels.
6 lumberman's patent cant hooks.
2 15-inch monkey wrenches.
4 S. wrenches 2 feet long for two kinds of ¾ inch nuts, jaws 1 5-16 and 1 9-16 inches.
2 track wrenches.
2 1-inch bridge augers.
6 ⅞-inch bridge augers.
2 ⅝-inch bridge augers.
4 5-feet cross-cut saws, "V" tooth ¾ inch from point to point, with climax handles. H. Disston & Sons' patent.

6 8-inch flat files.

2 clamp bolts $1\frac{3}{8}$x36 inch threads cut 20 inches, 2 nuts each.

2 clamp bolts $1\frac{3}{8}$x40 inches, threads cut 20 inches, 2 nuts each.

2 clamp bolts $1\frac{3}{8}$x44 inches, threads cut 20 inches, 2 nuts each.

6 cranks to fit nuts on clamp bolts.

12 wrought washers 5x5 inches, $\frac{1}{2}$ inch thick, with $1\frac{1}{2}$ inch hole.

4 pile clamps 6x10x16 pine. S. 4 S.

2 $\frac{5}{8}$-inch chain spider turn buckles 36 inches long, with two $\frac{5}{8}$ inch chains 8 feet long attached to each turn buckle, with grab hook on one end.

2 1-inch cable chains 16 feet long, grab hook on each end.

4 $\frac{3}{4}$-inch cable chains 16 feet long, with grab hook on each end.

1 $\frac{3}{4}$-inch cable chain 18 feet long and grab hook each end.

1 $\frac{5}{8}$-inch cable chain 14 feet long, grab hook each end.

2 $\frac{5}{8}$-inch cable chains 8 feet long, grab hook each end.

2 $\frac{5}{8}$-inch cable chains 4 feet long, grab hook each end.

2 20-inch wooden double blocks with large ring.

2 16-inch Hartz' steel double blocks with rings.

2 12-inch Hartz' steel double blocks with hooks.

2 8-inch Hartz' steel double blocks with hooks.

2 12-inch Hartz' steel single blocks with hooks.

2 8-inch Hartz' steel single blocks with hooks.

4 18-inch Hartz' steel snatch blocks with rings.

2 14-inch Hartz' steel snatch blocks with hooks.

2 12-inch Hartz' steel snatch blocks with hooks.

2 10-inch Hartz' steel snatch blocks with hooks.

1 bale of 2-inch manilla rope.

1 bale of $1\frac{1}{2}$-inch manilla rope.

1 bale of $1\frac{1}{4}$-inch manilla rope.

400 feet of 1-inch manilla rope.

400 feet of $\frac{3}{4}$-inch manilla rope.

24 toggle blocks 4x6 inches x 4 feet oak. S. 4 S.

2 toggle irons, top front, for repairs of pile driver leads.

2 toggle irons, bottom front, for repairs of pile driver leads.

2 toggle irons, bottom back, for repairs of pile driver leads.

4 pike poles 16 feet long, large end $1\frac{3}{4}$ with ferule; the other $1\frac{1}{4}$, common select yellow pine.

10 18-foot poles $1\frac{1}{4}$x2, S. 4 S. Second clear pine.

12 straight edges 16 feet long, $1\frac{1}{4}$ inch thick, 10 inches wide, full length. Second clear pine.

6 pile rings, 12 in. inside diameter.

10 pile rings, 14 in. inside diameter.

16 pile rings, 15 in. inside diameter.

20 pile rings, 16 in. inside diameter.

25 pile rings, 18 in. inside diameter.
4 staging hooks 5 feet long, hooks $8\frac{1}{2}$ and 12 inches.
2 kegs of 10-inch boat spikes.
2 kegs of track spikes.
2 kegs special track bolts with loose nuts.
2 kegs 60-penny nails.
1 keg 30-penny nails.
1 keg 10-penny nails.
2 steel rails $4\frac{1}{4}$ in. high, 20 ft. long.
2 steel rails $4\frac{1}{4}$ in. high, 10 ft. long.
1 marlin pin.
1 car coupling 20 ft. long.
6 lantern frames.
6 white globes.
3 red globes.
6 torches.
1 locomotive headlight.
1 Lucigen lamp with hand compressor and fifty feet of hose, 1,000 candle power, made by Industrial Light Co., New York.
12 red flags.
12 green flags.
2 water kegs.
2 dippers.
2 wash basins.
24 track torpedoes.
12 fusees.
1 No. 3 Merrill cross-cut saw set.
1 octagon steel drift $\frac{5}{8}$x24.
1 octagon steel drift $\frac{5}{8}$x16.

List of tools for pile driver engine:

1 $1\frac{3}{4}$-lb. hammer.
1 $1\frac{1}{4}$ ball pien hammer.
1 15-inch Stillson wrench.
1 15-inch monkey wrench, Coe's patent.
1 10-inch monkey wrench, Coe's patent.
1 small steel wrench for eccentric bolts $\frac{5}{8}$ and $\frac{3}{4}$ jaws.
1 small "S" wrench, $\frac{3}{4}$ and 1 inch jaws.
1 cold chisel $\frac{3}{4}$x8 inches.
1 cold chisel 1x8 inches.
1 pair pipe tongs, $\frac{3}{8}$ to 1 inch pipe.
1 pair pipe tongs, 1 to 2 inch pipe.
1 key punch.
1 packer ratchet.
4 drills, $\frac{1}{2}$, $\frac{5}{8}$, $\frac{3}{4}$ and $\frac{7}{8}$ inch.
1 half round file, 16 inch.

1 flat mill bastard file, 16 inch.
3 lbs. sheet lead.
3 lbs. sheet rubber, $\frac{1}{8}$ inch thick.
3 lbs. sheet rubber, $\frac{1}{4}$ inch thick.
2 lbs. asbestos packing, $\frac{5}{8}$ inch round.
1 ball candle wicking, $\frac{1}{4}$ pound.
12 gauge glasses.
12 lubricator glasses.
24 hand hole gaskets, $3\frac{3}{4}$x$4\frac{3}{4}$.
2 1-quart oilers.
1 tallow pot.
15 lbs. tallow.
5 gallons coal oil in can.
3 gallons black oil in can.
3 gallons engine oil in can.
3 gallons signal oil in can.
1 coal pick.
1 ash hoe.
1 fire hook.
1 scoop shovel.
100 feet of 1-inch steam hose.
$\frac{1}{2}$ dozen 3-inch hose clamps.
$\frac{1}{2}$ dozen $1\frac{1}{4}$-inch hose clamps.
200 feet bell cord.
12 pinion keys.
1 steel key drift 16 inches long.
5 lbs. waste.

DISCUSSION: SUBJECT—METHODS AND SPECIAL APPLIANCES FOR BUILDING TEMPORARY TRESTLES OVER WASHOUTS AND BURNOUTS.

Mr. Noon, Duluth, South Shore and Atlantic Ry.—We have had very little experience in this line, but I might say that we keep a stock of timber on hand for work of this kind, as a protection and safeguard to ourselves. We also keep a certain quantity of timber on hand for rebuilding bridges burned. In case of a burnout, I look at my records and ascertain the length and height of the bridge, and what material is necessary to rebuild it, and, prepared with that information, I can the more easily attend to it. I get my timber loaded by men most convenient and gather men and material at the burnout as soon as possible. I arrange to have the section men clear away all rubbish by the time I arrive to start work. I first arrange my men in crews, with a foreman, each foreman to have a distinct section of work to do. The first crew to unload the timber at the most convenient place, and so that we can get at any kind of timber we may want first, and with a push-car will supply us at the bridge as it is wanted. The second crew I start in to make the foundation; if on burnt piles, by cutting them off and putting sills on, or it may be on mud blocks and sills. The third crew, to frame and put together bents ready for raising. The fourth crew to do the raising and bracing. The fifth crew, on top, to put on stringers and ties. We use a 12x12x16 stringer, using the side nearest to 12 in. in depth to save all framing, putting five sticks in one panel and six in the next, and so on, letting the ends pass each other over the caps, then an 8x8x12 tie, using the side nearest to 8 in., so as to save all framing; the only tool work to be done is the squaring off of the posts and a few bolt holes. To keep the ties spaced we use 1 in. strips, the length of the space we want the ties to be, and that nailed to the top of the stringer between the ties. The top crew will lay the rail down as fast as the work advances, and allow the push-car to unload as near the front as possible. I endeavor to equalize the crews as much as I can, by changing off where I see it is necessary and would be to advantage.

Mr. J. O. Olmstead, Central Vermont Ry.—We have got quite a number of wooden bridges. We have been fortunate during last year not to have any burned out, but when we do have any burned out, the first thing we do is to start our wrecking gang. They go to a wreck, clean the rubbish out of the way and get everything in readiness for the bridgemen, and my first business is to see that the timber is loaded ready for service. We use 10x10 for posts, and we have lengths up to forty feet. We carry some in stock for trestles and openings 100 feet. We use 4x12 for sills, raise one post at a time, and brace them, tack on a straight edge and cut off top ends, and put a cap on. We use for stringers, 8x16, with a joint on every other cap. We use a bracing, 3x8, most of the time. Where we have a burnout not over twenty feet in height, we prefer round timber for posts that we can saw off quickly. These we can handle better.

Mr. Eggleston, Chicago and Erie Ry.—We carry a supply of lumber on hand for this purpose, 12x12 and 12x16x24; and for stringers 12x16. We put on our stringers, and when run out to the end of stringer, put on another. We always do our trestling that way.

Mr. J. H. Travis, Illinois Central Ry.—We had a burn-down a little over a year ago. Two of our truss spans, 150 feet each, burned up over the Iowa River, 75 feet deep; it was quite a little place to go to. We keep the main supply yard, containing all ordinary material, in Chicago, but we have a road market and can always get a sufficient supply to repair 200 or 300 feet of fire or washouts at any time. The system on the Illinois Central is a little different, perhaps, to what it is on other roads. The ordinary repair work on the Illinois Central is under the superintendent. The supervisor of bridges and buildings reports to and receives instructions from the division superintendent, and all ordinary repairs are taken care of by him. In case of fire or washout the Chicago office is immediately notified and we start men, tools, and material from Chicago, and I go myself, no matter to what portion of the road it is, so as to be there if I can be of any assistance. The first thing that we establish on the road is a good commissary. That is one of the most important things. Men without tools and tools with men without something to eat, are out of place to go to either washout or to fires. One is as important as the other. We generally provide for a working commissary and take care of our men. If there is work requiring more than twenty-four hours to accomplish, we divide the force into two gangs, working the first as near as we can in daylight. For instance, if we have a week or two weeks' work, we try to get a gang on before daylight in the morning and work them till noon; then we relieve that gang and put on another and work them until nine or ten o'clock at night, allowing all hands then (at whatever point we have reached), to rest on their oars until the next morning a little before daylight. We use in construction, piles and frame bents, fourteen feet centers, 12x14 in., 8x16, four panels, twenty-eight feet long, probably yellow Southern pine. I find that ties like these are quite as long-lived and give as good service as the oak. The ties are only six inches apart and fourteen inches centers. We have very few derailments and when we have, the ties are not cut up much. The last pile-driver that we constructed, to be used in case of emergency, will reach out twenty-six feet from center to center, or nearly that. Our standard opening is fourteen feet. If we have a fire where it is possible to drive piling, we do it, reaching out twenty-six feet and putting on eight stringers and driving a bent between that, making it nearly thirteen feet. If it is possible to get good bonfires they are a good thing. I keep about three or four carloads of cord wood (or rubbish) cut up into cord wood lengths, where it is easy to load into cars. Where you have to work at night, I find that a bonfire with resin is the best to work with, particularly if you have a side hill. You can work to better advantage and the glare does not affect you.

Mr. A. S. Markley, Chicago and Eastern Illinois Ry.—In driving piles at washouts, or where water is deep and current strong, it is necessary to have a platform near the edge of the water, where the height of the bridge is ten feet or over above the water, for men to stand on, landing the point of the pile where it is to be driven. To provide for this platform, we use two pieces 3x12, double the length of the openings we are driving; this allows them to extend far enough ahead of the last bent driven to be in easy reach of the next bent to drive. These pieces are suspended from above with lines and back ends anchored down by pieces spiked across the piles on top of the 3x12, as well as nailing to the piles to keep them from swaying. Two pieces of three-inch plank laid crossways of these 3x12, form the scaffold from which the men can work, to set the piles, and if necessary to sway-brace the bents. These pieces are shifted ahead as fast as the driving progresses.

Mr. J. H. Travis, Illinois Central Ry.—As to the manner of sawing off piles: In all our drivers we have a scaffold; it is a part of the driver itself, and it slides back on rollers on the side of the car. When ready to drive piles you extend your stringer out, whether it is a 14 or a 16 foot driver. The scaffolding is supported at the outer end by chains to the leads. There is a regular scaffolding hook, made to drop down over stringers. As soon as piles are ready to saw off, there is nothing to do but to drop the hook down for the scaffolding and commence your work. This scaffolding is never taken off the driver. It is with the piledriver at all times. In regard to the amount of tools that are carried on the piledriver for emergency cases: I have never yet seen too many tools with a bridge gang or on a piledriver. An emergency is where you need the tools, and a great many of them. You can very easily destroy 500 feet of line in one or two piles. There may be a surplus of flags, but I have seen times when flags were very useful in cases of pinched fingers and cracked feet. In the majority of cases we use the old-fashioned Howe truss-bridge dogs. You are all familiar with them. They are made generally of 7-8 inch material, to draw the joint of the Howe truss-bridge together, and they are generally long enough so you can drive in the side of the pile and slide a 2x6 inch each way to guide your pile scaffold. There is motion enough so that a man can get out ten feet. You can take off one and push it ahead. If you have two, or even four bents, and take dogs off after you until you are through, and if the regular dog that you were using is not long enough, make a leg four or four and one-half inches, and put your plank through that. If it is twenty-six feet, instead of using 2x6, you can use 4x8, and make twenty-six feet long, and hang to driver and have a sufficient stay.

A Member—When you swing up a pile, there is a general pressure against it, if the water is ten or twelve feet deep, or more.

Mr. J. H. Travis, Illinois Central Ry.—Your piles must be pulled in position, and before you can get your piles high enough up you will have not more than eighteen inches or two feet, and your plank would be about sixteen feet long, and there would be ample room for going backwards and forwards. I drove piles in thirty-five feet of water on the Grand River. Had no trouble there. I think where you have got only twenty-five feet and are going to drive forty feet, I would just as soon swing the leads and drop the pile out. You can soon catch the point where you want to drop your pile, and I would not want any one at the bottom of it.

Mr. Bishop, Chicago, Rock Island and Pacific Ry.—In regard to burnouts or washouts, the first thing is to ascertain the extent of the burnout or washout; its location, and its nature, so as to make repairs accordingly, as in some cases there are different methods in making repairs to same. I have about 500 miles of my territory that is located in Eastern Colorado, and Western and Central Kansas, that are subject to cloudbursts from about the middle of May until September. Early on the morning of July 3d, 1893, I had a very large washout in Western Kansas that took over five days to repair. In the meantime, our trains had to run over other roads, that took them about twelve hours longer to reach their destinations. I had nine distinct washouts, all within eleven miles; five bridges washed out, and four places in the embankment that were from 100 to 350 feet in length, and from sixteen feet to forty-five feet in depth, and I had water to contend with in five of them from ten feet to thirty feet. It was necessary, before trains could cross, to repair and construct 1,680 feet of pile and trestle bridges. My organization was for day and night work. In this washout I had my piledriver caught at a station about the center of the washout, and it was necessary to borrow a piledriver from another division. At the last bridge that we were driving, and the last pile of the bridge, which was within two feet of being driven, we broke the piston-rod; and that bridge let me get into the station where my piledriver was. So you can see the importance of carrying duplicate parts of piledriver engine, in case of an emergency of this kind. August 3d, 1896, in Eastern Colorado, I had a side wash twenty-eight feet high, one hundred feet long, where it was necessary to drive one pile to a bent and cap same, and place four stringers under one rail. It was necessary, in addition to track ties, to use five switch ties 7x9x14 to 16 feet long, to support the track, running the ties out on the embankment, and making a floor of trackties, four feet wide, on the same plan as shown for methods of repairing side-wash embankments. (Fig. 123.) It was a success. The soil was a sandy loam, and the stream is very rapid when water is up. In the spring of 1888, across a deep ravine, I had falsework in a bridge that we were about to put iron on, and the masonry was in. The span was sixty feet. During the night we had a very heavy rain, which weakened the structure, and a freight train, during the night, ran across this bridge, ditching fourteen cars and a tank; the engine got across. The banks were very steep and very muddy. We were forty-eight hours cleaning out the wreck to do three hours' work, to get the temporary work in place so trains could cross. In that instance I used up over 1,000 feet of one and one-half inch rope, and broke about six single and double blocks. On my bridge and piledriver outfits, I carry a large supply of tools of all descriptions, on account of being so far from the storehouse, which carries generally a very small supply, and then in case of emergency we have the tools on hand. For instance, take Eastern Colorado and Western Kansas. When we have a washout and the line is blocked, we have to make repairs, and that promptly, for after we get 175 miles west from the Missouri River, the company has no parallel lines, and it is necessary to go a roundabout way over some other road. Another thing is, that we have not the markets here, as you have in the East, to draw supplies from, in case of breakdowns. At washouts where there was deep water, I have seen staging break down by some accident and drop all the tools that were on it into the stream. Also, men that work nights lose more or less tools, such as lanterns, bars, wrenches, saws, etc., and when the washout is repaired, I always find there is a large shortage of tools.

REPORT: BEST METHOD OF ERECTING PLATE GIRDER BRIDGES.

We, as superintendents of bridges and buildings, and committee appointed to write of this subject, know how essential it is to have girders erected as cheaply, with as little delay to traffic as possible. I will first discuss the manner of erecting girders on new roads, with which I have had a good deal of experience: I erected four 51, two 44, and one 69 foot deck plate girders on a new road where track was being laid. Girders arrived before track had reached the bridge site, were unloaded on scaffold, level with floor of car. I then had them riveted up complete, framed ties and guard rails all ready to put on, then put up temporary trestle to enable them when they reached bridge site to push over cars of rails and ties sufficient to give them employment for at least one day after this. I then loaded girders on flat cars, ran them out over opening, set jacks under them, took the weight, pulled cars under them, took away false work, then slacked them down to the proper place. In doing work after this method it affords an elegant opportunity for good riveting, and the track force experience no delay whatever with their work. This is a very economical way, as it requires no engine, traveler, or rigging, only four jacks to handle girders.

On main line, or where traffic is to be contended with, it is impossible to adopt any regular plan by which to put in new girders, but you have to be governed by location and surrounding circumstances. I erected several girders on main line where trains were running regularly, in the following manner: I received a 70 foot deck plate girder for an opening where abutments had been extended for double track. Siding was near bridge. I did not unload girders, but backed them up on cars, riveted them up complete, had cars pushed out on main line opposite the place for which they were intended, took the weight, had cars pulled out, slacked girders down on two greased rails, pushed them out over crib of blocking clear of main line, and lowered them down into proper place with jacks. This was done very successfully and cheaply, requiring no false work or rigging, only four jacks, as in the case mentioned above. This work was done with regular road force of eight men.

Thirdly, I erected a deck plate girder on double track, both main lines. Girders were 50 foot each and were made the same as two single track girders, and askew. Not having room on side of bridge to put them together, I was forced to do this at the end of the opening. Being at a place where I could get one track for six hours, I greased the rails, pulled the girders out to proper place, took off rails and deck, cut down piling, slacked girders down into proper position with jacks. Both girders were put in place complete, on same plan, without any delay to trains. Expense of labor, $212.

Fourthly, I put in a double track through plate girder span, 65 feet long. This was a very heavy span, three girders, center 8 ft. 2 in. high, two outside ones 6 ft. high. The span was askew, and, consequently, more difficult to erect. Only one track was in use, which was on piling, the grade being ready for the other track. To avoid blocking the main line while unloading, I cut the track, ran cars off on new grade, put up two bents of trestle, laid stringers across with rails on them and then pulled girders off cars endwise on their flat across the opening with crabs. They were then set up with jacks and riveted in floor system for one track then in use. Old structure was then taken out and girders pulled into position with crabs. Having accomplished this I then unloaded the other girder after the same plan and finished it up complete for the other track. Twelve men did this at a cost of $560 for labor.

The last girder which I shall mention was a 53 foot three-track through plate girder. Stone work was built for five tracks, but only two were being used, and they were on piling. I unloaded all girders from cars down on abutments, riveted them up for two tracks then in use, and put ties on both spans complete and ready for rails. These were pulled into position in the same manner as those referred to above. Girder for third track was then adjusted and the whole job was executed by fourteen men at a cost of $384 for labor.

When bridge companies put in girders they almost invariably block the track and delay trains, I think, unnecessarily. This, in most instances, is attributable to their not getting everything ready in advance. In this lies the secret of erecting girders successfully and economically. No man can hold onto a good reputation as a bridge man on the Chesapeake and Ohio Railway if he stops the "yellow cars." J. M. STATEN, C. & O. Ry.

REPORT: BEST METHOD OF ERECTING PLATE GIRDER BRIDGES.

Being a member of your committee on the best method of erecting plate girder bridges, and not being able to meet with the committee, I hand you a plan of what I consider one of the best methods of erecting plate girder bridges.

First, erect false work (A) at each end of the span, placing the top of it on a level with the top of the pedestal rock, on the piers, then place two railroad bars of track iron on top of the false work (A) at each end, and let them run across the false work and pedestal rock. Then lower your girders down onto these railroad bars and place your girders in the same position they should be when in the bridge, and put in your struts and lateral bracing, rivet them up, and put on your ties and guard-rail, and finish up the span complete. When this is done, remove the old bridge, and shove the new bridge into place. This is very easily done when the railroad bars are well oiled, and you will find that the girders move very easily.

Note the post (B) placed at the opposite end of the pier. Build a platform near this post, to set your winch on, then make your tackle fast to the post and the girder, and pull your girder into place.

This is for girders sixty feet long and upwards. Girders from thirty to fifty feet may be pinched into place with pinch bars.

The best method to unload the girders from the cars is to put up a timber bent at each end of the bridge, and use a winch and tackle to lift the girders off the cars and lower them down onto the false work. Should you have two wrecking cars handy, you can use them to unload the girders with, but the timber bent is the cheapest, and usually the safest. (Fig. 124.)

G. W. HINMAN,
L. & N. R. R.

PAPER: PLATE GIRDERS ACROSS THE WISCONSIN RIVER.

During the erection of the twelve plate girder spans over the Wisconsin River, at Merrimac, Wis., the number of trains that

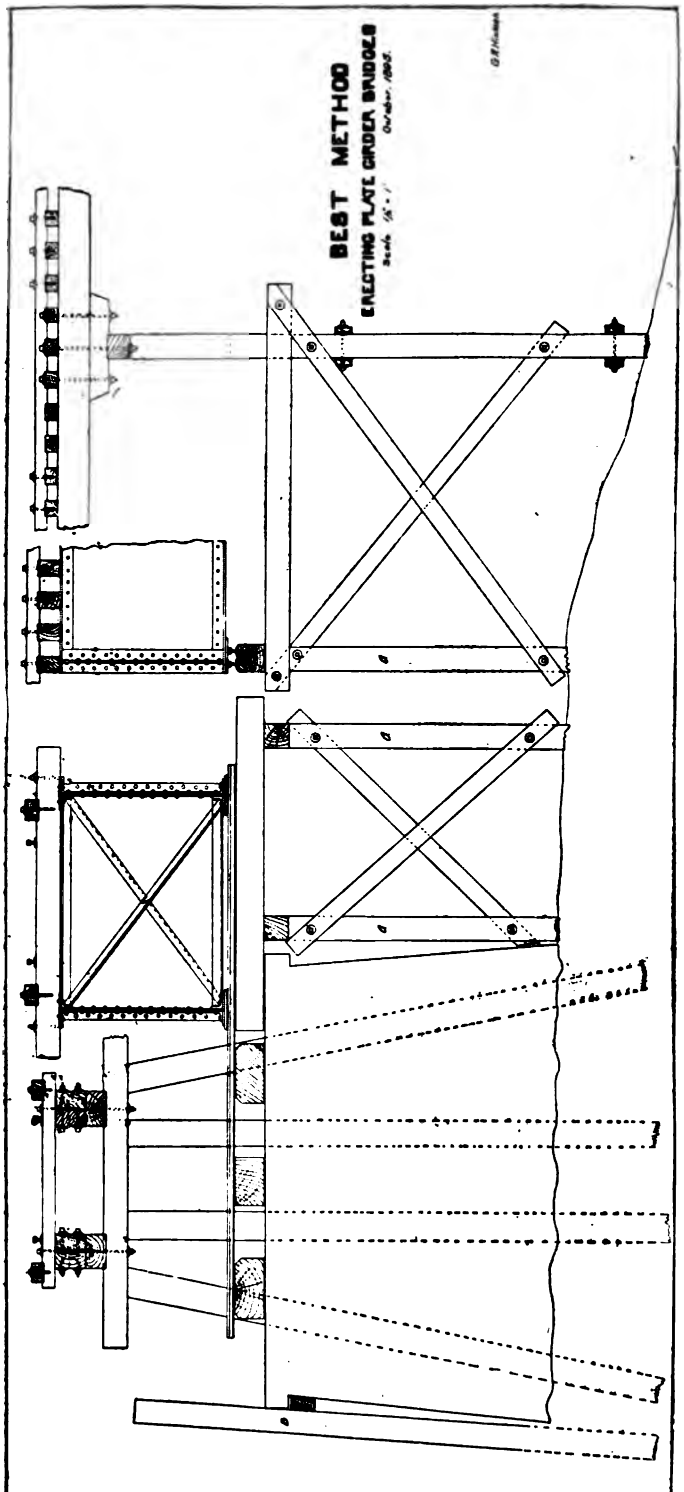


FIG. 124.—BEST METHOD ERECTING PLATE GIRDER BRIDGES.
(Mr. Hinman's report.)

crossed the bridge daily between 7 a. m. and 6 p. m. was eighteen. Work was begun unloading the falsework the last week in September, 1895, and on October 3, 4 and 5 three spans of falsework on both sides of the bridge were raised. On October 5 the iron crew lowered the first girder on to the falsework, and by October 7 the remaining girders and connections for all three spans had been lowered, and the floor beams, laterals, and stringers put in place. On October 9 the first set of girders was moved on to their permanent position. To allow of this shift, the running of trains was so arranged that the time between 2 and 4 p. m. was left free from trains. In making the shift the first thing done was to remove the ties from the old bridge. A block and tackle was then hitched to the old span, and it was slid bodily out on to the falsework, by means of a hoisting engine. The time occupied in doing this was three minutes. The hitches were then changed to the new girder span, blocking meanwhile being placed on the towers to provide for the less depth of the girder span. The new span was then slid into place in about five minutes. The old span was moved about fourteen feet, and the new span about fifteen feet, from their original positions. Before starting to move the new span, the ties had been placed so that all that remained to be done was to put the rails into place. The procedure with the remaining spans was exactly similar, and the following statement shows the time occupied in placing each new span complete:

No. span.	Hrs.	Mins.	No. span.	Hrs.	Mins.
1	2	30	7	1	10
2	2	00	8	1	30
3	2	05	9	1	40
4	1	15	10	1	30
5	2	00	11	1	40
6	1	45	12	1	30

Only one train was delayed, and that during the change of the first span, when the men were new to the work, and over-careful.

When the three new spans had been set, the next task was to remove the old spans, so as to get at the falsework to move it to a new position. Two long pine timbers were placed on timber horses transversely across the car, with their ends overhanging on each side of the bridge. By means of block and tackle, operated by a hoisting engine, also on the car, two bents of the falsework on each side of the bridge were picked up, and the cars moved along the bridge to the points where the bents were to be set again. Everything possible was handled by a locomotive, hoisting engines, and a wrecking car. The first span was set in place October 9, and the last, October 31.

M. RINEY,
C. & N. W. Ry.

DISCUSSION: SUBJECT—BEST METHOD OF ERECTING PLATE GIRDER BRIDGES.

Mr. Eggleston, Chicago & Erie Ry.—I have had considerable of that kind of work to do since 1890; we take our girders anywhere from 17 to 45 feet in length, set them to one side on temporary bents, rivet them and put the floor system in complete, and then get the use of the track, pulling them in in forty to fifty minutes, may be an hour and a half, according to the length of the bridge. We have put in some 82 ft. through girders in almost the same way; have them unloaded and fitted up alongside, take out your girder and shove them over. I have never had a bridge yet that took more than an hour and thirty-five minutes to put in, 82 ft. girders.

Mr. Reid, Lake Shore and Mich. So. Ry.—About a year ago I had two girders to put in, 33 ft. 10 in. long; put in the girder on the south track first; riveted the girders altogether, hitched the engine on to the girders and pulled them right up just where we wanted them, took out the false work and let it right down on the masonry; had no trouble. One of these girders I hauled a mile, doing the work the same day—held the track one hour and thirty minutes. I put in girders 82 ft. 6 in., had them all riveted up and hauled them out; had no trouble of any kind.

Mr. Aaron S. Markley, Chicago and Eastern Illinois Ry.—It is very difficult to outline any certain method to follow in erecting plate girders. There are many different things to be taken into consideration in reference to height, etc. It is almost impossible to decide on anything definite until the location is known. The most practical way, in my estimation, is to erect them on the side of the track; by so doing, a much better job of riveting can be made, and more quickly done. In addition, it takes but little time to slip in place by laying down a couple of rails, and oiling them, and when everything is ready, to slide them in, which is a very short job.

Mr. Riney, Chicago and Northwestern Ry.—The location is always the most important matter to determine in connection with a matter of this kind. Where the traffic is pretty heavy, we generally handle our work on the outside. Last year, we removed eleven or twelve lattices, and replaced with twelve through floor girder spans in six weeks, and handled on an average eighteen trains in ten hours. There the work was handled from the outside, and temporary trestle work built. The length of the girder will determine, of course, the handling. A heavy girder is better to be handled from the outside; if for truss work, on the ground of safety, if it is high. If it is a floor system, I would always advise to work it from the outside and bottom, when seventy-five feet or less; for over fifty feet, I would advise building each side of the trestle work.

Mr. Hinman, Louisville and Nashville Ry.—I submitted a drawing with my report as to the "Best Method of Erecting Plate Girder Bridges," at our last meeting; that was, by rebuilding them on the outside, and shoving them in place. I know of no better way than this, and no quicker or cheaper way. This is my knowledge and practice. It is very quickly and easily done, and you can get at, and do all of your rivet work, and finish up the bridge complete, except the track rails. The girders can be pulled in place by the use of a tackle and crab. Much depends upon the place where you have to put the girder in. Short girders, say from thirty to sixty feet long, can be erected in the same way, and shoved into place with pinch-bars.

Mr. Markley—I would say that the Detroit Bridge company built two girders, and in lowering the girders, they were swung right on jibbooms. That is the easiest way I can see, and it struck me as being a very good way, very cheap and very quick.

Mr. McNabb—How long were the girders?

Mr. Markley—Fifty feet.

PAPER: REPLACING A TIMBER TRESTLE BY A RIVETED DECK GIRDER BRIDGE.

I send some photographic views (Figs. 125 and 126) of a riveted deck girder bridge, 710 feet long, and 56 feet high; consisting of seven 80-feet, one 60-feet, and three 30-feet sections, that I have recently erected for the Southern California Railway Company. This bridge is across the Arroyo Seco, on the main line of the Southern California Railway, between San Bernardino and Los Angeles. On this division we have twenty-two trains between 7 o'clock a. m. and 6 o'clock p. m.

Previous to the erection of this structure, the company had imported men from the East to place their iron and steel bridges; this one, however, has been done by men in the regular employ of the company, and at a price so much less than bids received for this one, that I feel some pride in placing these before the association, thinking at the same time that they may give some new ideas to the members of the association who may hereafter have occasion to erect a similar one. The management had some hesitancy in having this work done here, as they thought it impossible to secure the men competent to do the work, all of our bridges except two being of wood, and 95 per cent. of them pile and timber trestles. After looking over my estimates, and finding a difference in their favor between that and the contractor's, they concluded to do the work with their regular employes.

I had at first intended to lower these girders into place with

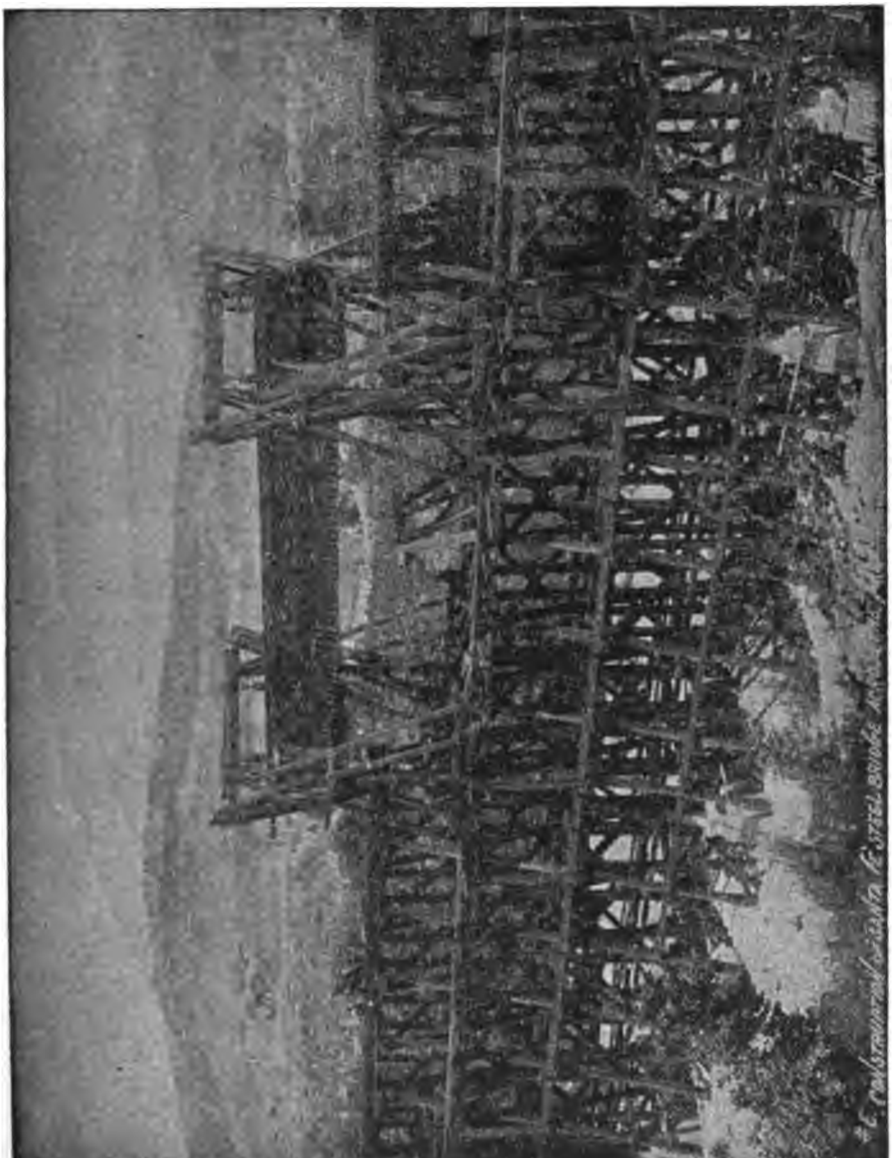


FIG. 125—REBUILDING ARROYO SECO RIVER TRESTLE BRIDGE, SOUTHERN CALIFORNIA R. R.

hydraulic jacks. However, owing to the situation, I found it necessary to have some conveniences for setting the pedestal stone and posts in bents, so I concluded to use two travelers with suitable tackle instead. While the excavations were going on, I put in my falsework (the original bridge consisted of 525 feet of timber trestle, and two—105 feet over all—overhead Howe truss spans, altogether 735 feet) by trestling the two spans, and cutting out a section twelve inches long of the posts of trestle part, and introducing an intermediate cap, a distance of twelve feet below the rail to form lookouts for track for travelers. In this way, my falsework was very inexpensive, and gave me a chance to place everything from the top, using one traveler for placing the pedestal stones the entire length, and placing the posts on return trip. After the posts were placed, another traveler was erected, in order to carry both ends of the girders.

The only suitable place for an unloading and erecting yard was 2,000 feet south of the Arroyo; consequently, everything had to be sent out on push-cars that distance, except the girders, which were loaded on trucks and moved with a locomotive. The girders were riveted together on the skids, the ties, tie-plates, guard-rail, and rail placed on them, then loaded on the trucks ready to be sent out. When they were spotted over their place, jacks were put under each end, and they were raised clear of the trucks; then the tackle was hitched to them, a strain taken, the trucks run out, jacks released, and they swung clear. Owing to the height, the stringers, ties, and guard-rail of the old bridge had to be taken on deck. The bents were let down on the intermediate caps, then the girders were lowered into place by means of the lines. We were enabled to swing the girders either way, so that when they were within six six inches of their seat, we inserted a small, pointed bar at each end which guided them into place.

In placing the first girder, we of course took advantage of the longest time between trains, two hours and fifteen minutes; we consumed all that, and seven minutes of train No. 1's time. The men, sixteen, were all new; only one of the lot had had any previous experience, and they were a little timid, for the weight of these eighty feet girders, with ties, etc., is forty-seven tons. The next day, however, the second eighty-foot girder was placed in one hour and thirty-eight minutes, and when we placed the one shown in the photgraph, it was done in fifty-eight minutes, from the time it was spotted until the girder was in place and bolts in, or one hour and eighteen minutes from the time it left the spur, until the attending locomotive passed over it.

The cost of placing these eleven girders, together with the riveting, unloading steel, loading on trucks, engine attendance, etc., was $1,255.49, or $1.7683 per lin. foot.

FIG. 126—NEW TRESTLE BRIDGE, ARROYO SECO RIVER, SOUTHERN CALIFORNIA R. R.

The cost of placing the four rocker, and three tower bents was $570.04, or $0.8003 per lin. foot.

The total cost of superstructure, including falsework and traveler, was $2,248.85, or $3.1674 per lin. foot.

Riveting girder, drove 8,026, cost $0.05024 per rivet.

Riveting bents, drove 480, cost $0.1066 per rivet.

Riveting girders to posts 264, cost $0.1458 per rivet.

Total rivets drove 8,770, cost $0.0573 per rivet.

C. G. WORDEN,
Southern California Railway.

CHAPTER V.*

1, REPORT: DIFFERENT METHODS OF NUMBERING BRIDGES—SHOULD ALL WATERWAYS BE NUMBERED?—2, PAPERS: NUMBERING OF BRIDGES—3, DISCUSSION: SUBJECT, DIFFERENT METHODS OF NUMBERING BRIDGES—SHOULD ALL WATERWAYS BE NUMBERED?—4, REPORT: DRAWBRIDGE ENDS, METHODS OF LOCKING; AND INCLUDING LOCKING OF TURN TABLES—5, DISCUSSION: SUBJECT, DRAWBRIDGE ENDS, METHODS OF LOCKING; AND INCLUDING LOCKING OF TURN TABLES—6, REPORT: PROTECTION OF TRESTLES FROM FIRE, INCLUDING METHODS OF CONSTRUCTION—7, DISCUSSION: SUBJECT, PROTECTION OF TRESTLES FROM FIRE, INCLUDING METHODS OF CONSTRUCTION—8, REPORT: LOCAL STATIONS FOR SMALL TOWNS AND VILLAGES, GIVING PLANS OF BUILDINGS AND PLATFORMS—9, DISCUSSION: SUBJECT, LOCAL STATIONS FOR SMALL TOWNS AND VILLAGES, GIVING PLANS OF BUILDINGS AND PLATFORMS—10, REPORT: TANKS, SIZE, STYLE AND DETAILS OF CONSTRUCTION, INCLUDING FROST-PROOF PROTECTION TO TANK AND PIPES—11, DISCUSSION: SUBJECT, TANKS, SIZE, STYLE AND DETAILS OF CONSTRUCTION, INCLUDING FROST-PROOF PROTECTION TO TANK AND PIPES—12, REPORTS: BEST AND UNIFORM SYSTEM OF REPORT BLANKS FOR BRIDGE AND BUILDING DEPARTMENT—13, REPORT: THE MECHANICAL ACTION AND RESULTANT EFFECTS OF MOTIVE POWER AT HIGH SPEEDS ON BRIDGES—14, REPORT: BEST AND MOST ECONOMICAL RAILWAY TRACK PILE-DRIVER—15, DISCUSSION: SUBJECT, BEST AND MOST ECONOMICAL RAILWAY TRACK PILE-DRIVER—16, REPORT: SPAN LIMITS FOR DIFFERENT CLASSES OF IRON BRIDGES AND COMPARATIVE MERITS OF PLATE-GIRDERS AND LATTICE-BRIDGES FOR SPANS FROM 50 TO 110 FEET —17, PAPER: LOCAL STATIONS.

REPORT: DIFFERENT METHODS OF NUMBERING BRIDGES—SHOULD ALL WATERWAYS BE NUMBERED?

The art of successfully managing the Department of Bridges and Buildings can only be acquired by a thorough education. Those of us who have not had the advantage of a college education

*Reports presented at the Sixth Annual Convention at Chicago, Ill., October, 1896.

must be content with a practical one, and as it is impossible to rehearse our lessons, but as we are pressed on by rush of business from one to another, it behooves us to put ourselves in a position to refer to our past from time to time as occasion may require, and not only freshen our memories, but furnish beyond doubt reliable data.

This can only be done by the aid of a thorough and systematic record of all work, both great and small, not omitting the slightest detail. Until one begins to inquire into such matters, he little dreams to what extent we have become remiss in this respect.

We quote from bulletin No. 12 of the division of forestry of the United States Department of Agriculture, in treating upon the economical designing of timbers in trestles. Mr. A. L. Johnson says: "Table 1 gives the different species now employed in various parts of these structures, and a mean estimate of the length of life of each. These separate estimates, however, were very erratic, in many cases being little better than a guess, so that the mean given in the table is by no means reliable. This lack of information is scarcely less remarkable than it is fortunate. Although railroad companies have been using timber for more than fifty years, no accurate, classified knowledge exists as to its length of life. This could be easily obtained if each member in a trestle was given a number, as is done in iron structures. Thus we find that practical men have been using timber for fifty years, and yet, when called upon, could give no reliable information as to its longevity. This is not from a lack of knowledge, but is owing to the fact that no records had been kept.

As with timbers, so with each and every other material used in the construction of water-ways of every dimension. We should keep a record of the cost of all such material, and the labor performed on each structure, date of construction or renewals of whatever nature and extent. A knowledge of these things is a component part of a practical education, and once acquired should be perpetuated. We cannot expect to retain this knowledge and be always ready without a moment's warning to answer any question that may be asked, or decide upon any point at issue, or give any information wanted, except approximately, which will not at all times be satisfactory.

In an article on substitutes for a college training, the Rev. Charles H. Parkhurst, D. D., says: "I studied Greek faithfully when I was in college, and read considerable of Homer, but I do not suppose I could read a line of him to-day without a grammar and dictionary. If anybody says I ought to be ashamed of it, all I can say in reply is that I am not ashamed of it at all. When a traveller comes to a river, he looks about to find a bridge by which he can cross it, and when he gets to the other side of the bridge he leaves it for the next man without its ever occurring to him to take it along with him. So when a mountaineer is scaling the sharp spur, and finds a ladder spiked in for the convenience of climbers, he puts his foot upon it, scrambles up over it, and then leaves it behind him, never expecting to encounter any one who is so much of a fool as to rebuke him for not having trummeled the ladder up with him, and for not having capped the summit with all his mountaineering paraphernalia. What I mean by this is that Greek, Latin, physics, and mathematics are primarily not the goal of pursuit, but the bridges, ladders, and other apparatus for locomotion by which the goal is to be reached. So that whether we do or do not knew how to read Plato and Livy six years after we are out of college, or how to analyze Homer and calculate ellipses, we are still at the apex if we are possessed of the mental keenness and vigor which it is the special office of those studies to produce." And farther on he says: "Problems tumble easily apart in the field, that refuse to give up their secret in the study, or even in the closet. Reality is what educates us, and reality never comes so close to us with all its powers of discipline as when we encounter it in action."

Then let our records be our grammar and dictionary to practical work, and their correctness a source of reliable data, and if not a guide our successors can follow, they will at least serve as a beacon to protect them from the breakers. We should also keep a record of our work, that we may be able to give an account of our stewardship. Show where all the money has been expended in detail, and not deal in generalities, for that is no longer satisfactory to officials of railroads, and if there should be an occasional official satisfied, the superintendent of bridges and buildings should not be. In order to keep such a system of accounts, it is necessary to be able to designate each structure in some manner. This may be done by describing structure and location, by naming, or lettering. The general practice, however, seems to be numbers.

Your committee has inquired as to the methods adopted by different roads, a few of which we submit as a part of the report.

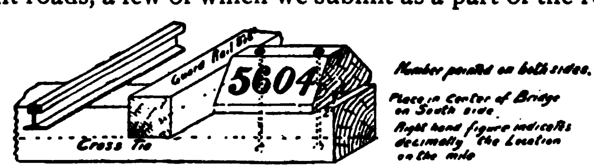


FIG. 127—BRIDGE NUMBER, CHESAPEAKE AND OHIO R. R.

Mr. J. M. Staten, of the C. & O., furnishes us with tracing No. 5,046, and writes: "We only put numbers on openings ten feet and over. Never number anything like box or arch culverts, no matter what their length may be. You will observe that number blocks have numbers on each side, which is the same from each direction. Ten bridges may be on the one mile, and if one of these should be dispensed with it will not affect the remainder, or if a new opening be created on the mile, the fraction of a mile numbers it. This is a big advantage over the old conventional way of numbering. Don't know the actual cost of number blocks, but they are very inexpensive. I must emphatically denounce numbering all waterways. This seems utterly useless to me. All railroads are endeavoring to fill up all openings less than ten feet by using old iron and scraps of steel rails, and ballasting over them so they are then looked after by the section men."

Mr. F. E. Shall, assistant engineer L. V. R. R., furnishes us with blue print No. 44, and says: "The method adopted (although not yet carried out), is as follows: The bridges are to be numbered in accordance with the mile on which they are located. For instance, the bridges located between the first and second mile posts, the first would be No. 1, the second No. 1A, the third No. 1B, and so on. The bridges between mile posts 50 and 51 to be 50A, 50B, 50C, etc. For box and arch culverts, it is our intention to use the same numbering, but to place a cipher in front of the number. The bridges on branches are to be numbered in the same manner, but to have the first letter of the name of the division placed in front of the number. Through bridges are numbered on the end post, while deck bridges are numbered on a sign post made of three-inch oak plank. A copy of the post I send you herewith."

The Chicago and Erie Railroad Co. furnishes us blue print 34, showing structure number, and 35 and 36, copies of bridge sheets. This road has a number plate of $\frac{1}{8}$ steel tank plate, old material, 7x12 inches, with a $5\frac{1}{2}$ block figure on posts of $\frac{3}{4}$ or $\frac{7}{8}$ iron rods. Number plates painted black, with white figure. Drill a hole in parapet 4 feet from end of this and set number with cement on pile trestle. They set it in bulk heads; at overhead bridges they set a post and put number plates on it. Truss bridges are numbered by painting number on both posts. On through girder, they paint the number on end girder. The numbers on through bridges are on engineer's side on both ends of the bridge. The numbers for deck bridges have figures on both sides, and only one number for a bridge. These number plates cost $38\frac{1}{2}$ cents each in position. They also keep a record of all bridges, showing the number of the mile post, description of structure, length, foundation, date of construction, name of stream, if any, if box and pipe water-ways showing size, kind and location by mile posts and $\frac{1}{4}$ mile; but their small openings are not numbered.

The Elgin, Joliet and Eastern number all openings consecutively on an oak board 2x12x18 inches with a white ground and black figure, the figure being 3x3 inches. On of these boards is fastened to the cap at each end of trestle with lag screws, and always on the engineer's side. This style, while not so artistic as some methods, is considered by those people to be the most economical, and its simplicity recommends it. As these numbers were put on by contractors, the original cost cannot be given. The road has been built for eight years, and not a single number has been renewed.

Tracings No. 24 and No. 243 show number plate used in the entire system of C., C., C. & St. L. This road numbers all structures of every kind consecutively. They keep a record of all bridges and culverts as shown on bridge sheet No. 1, and open an account with each structure, recording all material that enters into its construction, describing the same, giving date and extent of all repairs, and cost of labor.

There are a number of other methods used for numbering structures, and a diversity of opinions as to whether all openings should be numbered. The majority of roads number consecutively, some using the affix letter where the same stream crosses more than one track. For instance, structure No. 28 is on the main track; on the next track to the main the same structure would be 28A, and if there be another track over the same stream at the same point, it would be 28B, etc.

There are a few roads that pay but little attention to the numbeing of structures, being content to make a general charge of expense to bridges and culverts. But should this method be satisfactory to the company, it should not be to the superintendent of bridges and buildings, for a systematic numbering of structures and records will serve him at a time when he will most need it, in furnishing valuable data as to the durability of material, cost of construction; refreshing his memory; and to himself and successor it will be found a source of valuable information.

The committee that made a report October, 1895, on "Methods and Special Appliances for Building Temporary Trestles over a Washout or Burnout," recommends, first, when a washout or burnout occurs, the first information necessary is the definite location of break in the track. The next question for consideration is the kind of structure which is washed or burned out, whether it be a trestle or truss bridge, length of structure, depth of opening, characteristics of stream, as to whether there is likely to be water, mud, or sand to contend with. The superintendent of bridges and buildings should have the above information on file in his office, in order to enable him to determine, to a great extent, what kind and manner of temporary work will best meet this requirement. This being done, simply wiring number of structure, and reference to those records will give all required information.

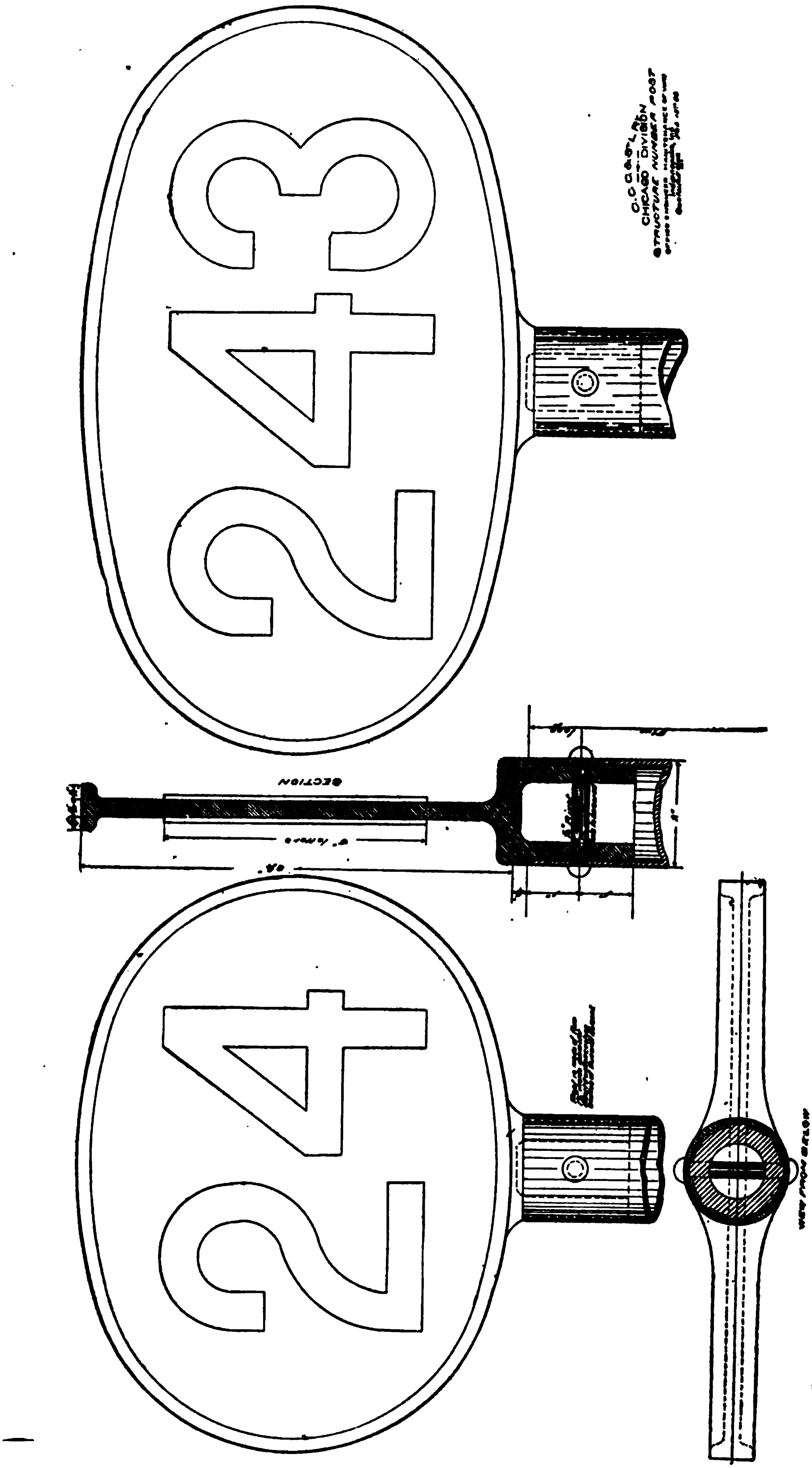


FIG. 128—BRIDGE NUMBER, C., C., C. AND ST. L. R. R.

Your committee, in selecting sheet No. 1 of the C., C., C. & St. L., has purposely taken one that has not been posted up since 1891. This we have done to show the advantage of keeping a complete official record in addition to the bridge sheet. By referring to the sheet you will notice the first structure, 499, is a trestle 42 feet long. By referring to the books we find that in 1894 the opening was filled up at a cost of $54, and the structure abandoned. In such cases the number is taken off. The next structure on the sheet is a combination truss built in 1882, and is 128 feet 4 inches long. By referring to the books we find that this structure was rebuilt in January and February, 1896. The cost of masonry was $11,412.62, including excavating; contract price for girder No. 139,220 at $18, $2,505.96; false work, $316.20; labor, dismantling old bridge, raising track to new grade, unloading and putting in two 75-foot girders, $812.28; total, $15,047.06; and this structure now consists of two 75-foot girders, with a clear span of 70 feet each.

The next structure to which we will call your attention is No. 513. Sheet shows this to be a wood box 24x36. Reference to the book shows that it was reconstructed in 1893, and is now a 48-inch cast pipe 48 feet long, with masonry at each end, at a cost of $831.28.

We would further call your attention to the fact that location of structure is shown between mile posts, and also stations. The difference between it and sheet of Chicago and Erie R. R. is that they show fraction of a mile, and not the station. We failed to state, the cost of C., C., C. & St. L. structure numbers complete is 27½ cents, and as numbers are on both sides, only one is placed at the approach of each structure, on engineer's side, six feet from the rail.

We have endeavored to show the necessity of keeping a record, and the advantage it affords in refreshing our memories, enabling us to account for all our expenditures, and furnish reliable data as to the longevity of all material, and that to do this it is absolutely necessary to be able to designate each structure, and by including every kind of structure a more general knowledge can be had.

Your committee recommends consecutiveness and simplicity of numbering, for by that method the number itself becomes an index to your book. Be careful in keeping records correct, for they will be your guide, and that of your successor, and you will not have to depend on a treacherous memory to retain knowledge gained by a lifetime of practical work.

We are told that Franklin kept a book in which he wrote down his faults. If he wasted half an hour of time, or a shilling of money, or said anything he had better not have said, he wrote it down in his book. He carried that book in his pocket all his life, and he studied it as a boy at school studies a hard lesson. By it he learned three things—first, to do the right thing; next, to do it at the right time; and last of all, to do it in the right way.

If Franklin could not trust his memory to correct the mistakes of his life, can we be expected to retain all the transactions incident to a business life, although it is a part of our education, a work that is not finished while we live?

A. SHANE, C., C., C. & St. L. Ry.,
W. O. EGGLESTON, Chicago & Erie Ry.,
O. J. TRAVIS, Elgin, Joliet & Eastern Ry.,
Committee.

PAPER: NUMBERING BRIDGES.

The Boston and Maine Railroad system is composed of a group of what were formerly independent companies. It is made up of ten divisions which, generally speaking, follow the lines of the original organizations. The maintenance is directly in charge of the various division superintendents, who report in regard to such matters to the assistant general manager. It is the intention of the management to make the division superintendents responsible for everything, from one end of his division to the other. New construction is in the hands of the chief engineer. The supervisors of bridges and buildings are appointed by, and report to the division superintendent. In the maintenance of these structures, the different divisions are as independent of one another as they were before the various leases and agreements brought them under one management, except that a few large tools, like car piledrivers, derrick-cars, pumps, steam shovels, etc., are occasionally transferred as the work demands, and at rare intervals a crew of special workmen, with their boarding car, is sent from one division to another to do an unusual piece of work.

This condition of affairs raised the question whether the bridges should be numbered consecutively over the whole system, beginning with unity somewhere and bringing up somewhere else with a figure between 2,000 and 3,000, or be numbered by beginning with unity on each division. The former method seemed to have two objections: First, after reaching four figures, the numbers are awkward to put on a post, and are not so easily read from a passing train. Second, it was thought that it would be unpleasant to the men of the division to have their numbers succeed those on some other division. The lines mostly radiate from Boston like the spokes of a wheel, so that there is but slight geographical reason for locating the starting point on any particular division. We consequently made lists some years ago, starting each division with unity and numbering consecutively through its main line and branches. Other roads were acquired by lease, and the same system was applied to them, and all went smoothly until the management found it convenient to step over the lines of the original organization and enlarge some divisions by detaching from others. This mixed us up badly, so that now on one division we have three sets of numbers, making it necessary to name the branch as well as the number in corresponding about a particular bridge. I think the system of affixing letters is confusing and clumsy, and have reached the conclusion that consecutive numbering for the whole system is the best method, starting each division on an even hundred perhaps, to isolate them somewhat.

When a bridge is abolished by filling, or otherwise, its number is dropped out and no trouble arises, but when bridges are inserted where none existed before, we give them fractional numbers or attach letters to the adjacent number. The abolition of grade crossings, which is a very active industry in New England at present, necessitates a large number of these insertions. Our number schedules, in consequence, are getting badly demoralized. The only remedy that I can see is to renumber occasionally.

As to putting the numbers on the structures, we have three methods in use. First, a board, or cast plate, attached to the end of through bridges, or to the guard timber of deck-bridges; second, a board about 12x16 inches, attached to a post, set near the bridge; third, a plank post, six inches wide, with the figures one above the other. I prefer the latter. Its only objection is that the figures are in vertical, or Chinese order. Strangers may not know what they mean, but the road men have no difficulty. The post admits of figures on both sides, takes but little lumber and is durable. The post and board are objectionable, as the figures can be put only on one side, and they are being continually used for shotgun targets by boys, so that their life is very short. On lines where they are used, we continually find many numbers partially or wholly gone. Where a board or iron plate is attached to the timbers of deck bridges, it is impossible to see it from a train unless it is placed in such a position that the snow-plow is pretty sure to demolish it. I would recommend putting boards on the end posts of through bridges at each end, and on the stringers of overhead bridges, well to one side of the track, to get them away from the engine smoke, and would paint these white, with black figures. The plank posts I would paint a light brown or buff, with black figures to prevent confusion with the more important whistle and other track signs, the figures in all cases to be five inches high.

As to the proper minimum limit on which to put numbers, opinions may well differ. Most commissions fix ten feet clear span as the minimum to be reported, but a bridge of eight or nine feet clear is quite a structure; it must be maintained by the bridge crew, and I think should be numbered. We have generally adopted six feet clear as the dividing line, but I think if we were intending to change from this that I would advise, as the result of my experience, extending downward to four feet at least. I would number all arches, but would not include stone box culverts, pipes, etc. I think that all overhead bridges, whether maintained by the railroad or not, should be numbered with the rest.

For the use of the various general and division officers, we make lists of each division, of which the following is an abstract:

Number.	Name.	Location.	Kind.	Clear opening.	Dat .	Remarks.
209	South canal...............	S., No. Lawrence.	Pl. Gir. deck...	60-0	1887	
210	Merrimack river..........	So., "	Iron pin deck ..	524-3	1893	6 spans.
211	No. canal......	So., "	Pl. Gir. deck...	95-3	1886	2 spans.
212	Lowell street....	. m. N., N. "	Framed trestle.	71-4	1892	Overhead.

The former custom on all of our lines was to designate the bridges by names and as far as practical convenience in maintenance on the ground is concerned, it is just as good, in my opinion, as numbering, and in fact I know most of the bridges on the system far better by name than by number, but when it comes to books and records, numbers are almost indispensable. We keep the original names, as far as possible, on all lists and records.

I think it preferable to locate from depots, rather than from mile-posts, as the lists tell us then how to best reach the structure, and we have a better idea where it is, than if referred to mile-posts, unless we attach to our bridge record an index of mile-posts referred to the stations.

Our regular office records are kept in note-books, convenient to carry in the field. They contain full measurements and descriptions sufficient for a full knowledge of a structure and sufficient for computing its strain-sheet; notes as to the physical condition of superstructure and substructure, the computed strains in the principal parts, its distance from nearest station, reference to plans on file, date of building, etc. This record also contains, in consecutive order, all small openings, all crossings, highway, private, farm, etc., all box culverts, sizes and condition, and all matters on which reports have to be made by the engineer department to State or government commissions. This record is made in pencil, for convenience in recording changes. They are not bulky. A common pocket field-book will cover about seventy-five miles.

I believe in addition to this that the central office should also keep books, giving a page or more to each bridge, on which is regularly recorded the reports of the periodical inspections of the structures. In this way we would have a continuous record of any changes that occur in the condition of the bridge, of the repairs made on it, and a check on the inspector himself. I regret to have to say that this is not in vogue on our road.

The supervisor on each division, or principal foreman, should carry with him, at all times, a small book, giving for each bridge the date of building, last renewal of ties, date of painting, if iron, clear span, etc., for his own information and for that of his superior officers when they are out with him on the line.

I believe, with the committee, that a simple system of numbering is the best, and would also extend this principle to the records. A complicated system of bookkeeping is not necessary. If attempted, it will probably be neglected after a short time, fall behindhand, and be finally dropped. It has certainly been found unnecessary on the roads where I have been employed, to keep a book account with each bridge to show the cost of repairs on it. The ability to state from the ledger just how much expense has been put on each individual bridge from year to year may look very enticing, but it means a great deal of clerical work, and, in my opinion, will not yield an adequate return.

J. P. SNOW,
Boston and Maine Ry.

PAPER: NUMBERING BRIDGES.

We number according to mileage. Thus, the first bridge in second mile would read 2A, the second one 2B, and so on; the prime advantage in this system of numbering is that though a new bridge will or may be placed, it will not affect the number of the others; it also has its advantage in giving the exact distance of bridge from either terminal. The blue-print attached is a photographic copy of a large print we have for office use, the small one for pocket use.

The signs are on a 4x4 wooden post at end of bridge, and consist of an iron plate 18 inches by 13½x¼ inches thick, painted white, with a black border and letters. I think it essential that all waterways should be numbered, both large and small; the system of numbering nothing under ten feet, as in use by a number of roads, seems to me to be wrong, as you well know that many of the washouts are small openings, and where they are without numbers they are often without records, which often gives trouble that might have been avoiding by numbering.

GEORGE W. ANDREWS, B. & O. Ry.

DISCUSSION: SUBJECT—DIFFERENT METHODS OF NUMBERING BRIDGES, AND SHOULD ALL WATERWAYS BE NUMBERED.

Mr. W. G. Berg, Lehigh Valley Ry.—This question seems to have been divided by the report of the committee into two questions, one as to how to number and the other whether all openings should be numbered. In regard to the first question, how to number bridges, the committee report is in favor of consecutiveness, that is, numbering the bridges from one end of the line to the other with consecutive numbers. The committee report also mentions the mileage system of notation, in use on a number of roads, namely, using the mile number, with a suitable letter or prefix to distinguish each particular structure on each individual mile which is intended to be covered. I think, therefore, that in any discussion that may now take place, it would be desirable for the members to express themselves in regard to their opinion as to the preference for one or the other of these systems of numbering, namely, the consecutive system or the mileage system. The other question that the committee report on is, as to whether all openings should be numbered, or whether only a specific kind of openings, such as bridges and larger openings, should be numbered, while closed culverts would not be considered. This is also a matter for discussion and opinion. After having outlined what I think the direction of the discussion should be, I will give you my individual views. In regard to numbering structures, I am a strong advocate of the mileage system, numbering each structure with the number of the mile it is on, with a letter or prefix to distinguish each structure itself. Sometimes a system can easily be arranged so as to distinguish between the closed openings or an open opening. Bridges can be distinguished by a suitable letter or designation to be added. The reasons I have for preferring the mileage system of notation are, that any one on the railroad, without being the specialist in charge of the bridges, can know at a glance that if something has to be done at Bridge 55 A or B, it is located on the fifty-fifth mile, whether he is a train-hand, a depot agent, roadmaster, or superintendent. The objection I have to the consecutive system is, that it is only the man in charge, or the men who have particularly to do with work on the bridges or openings, who know and understand the numbers without having to hunt up a reference list. They probably carry a list with them, or know them, but no one else does. A further advantage that I see in the numbering by mileage is, that if a structure is removed by filling in the opening, it causes less disturbance in the system than if the consecutive system was made use of. In other words, I believe that if for a certain number of years, say ten or twenty, a road has been using a consecutive system of notation, and one-half or one-third of their structures have been abandoned or filled in, some day or other one of the officers of the road will call for a revision, so as to have the numbers run consecutively again, and then the road will be confronted with a complication in its accounts, and in speaking of a structure it will always have to be referred to as number so and so, "new" or "old" system. We find that feature in New York City on our piers, where the city has had the piers renumbered within recent years. On the other hand, in the mileage system, if a structure is filled in, it simply drops that particular letter on that mile, and it is less confusing than if there were a whole lot of numbers in a consecutive system to be dropped. I will mention in addition that the committee's report covers the question of the style, make, and cost of the sign-boards or bridge number boards, so that feature also would be correct to discuss.

Mr. O. H. Andrews, St. J. & G. I. & K. C. Ry.—Our system of numbering is the old-fashioned way, placing number of mile on the tie in the middle of the bridge, with date of the bridge. I have been considerably interested in this subject, and I am hardly satisfied with the way we are numbering. I am holding a system of numbers now, waiting to see if we cannot find something better.

President—Do you place the number on the tie?

Mr. Andrews—Yes, midway on the bridge.

President—Is the tie beveled on both sides?

Mr. Andrews—It is twelve inches outside of the guard-rail and fixed right in.

Mr. Bates, C., M. & St. P. Ry.—Our bridges are numbered consecutively on each division, with an initial letter for each division. Bridges are given even numbers and culverts odd numbers. Thus: number A—262 is a bridge, and number A—119 is a culvert. We have no openings in our track, except for waterways or under crossings. We do not use open cattle guards, and every open span exceeding six feet in length is known on our books as a bridge. Every opening which is covered by ballast is known as a culvert, except certain small culverts near the rails, which are designated as drain boxes, and are maintained by the road department. We make no attempt to number these drain boxes. When we fill a bridge, its number is dropped from our books. When we fill a bridge, leaving a culvert under the embankment, the culvert takes the bridge number. I think there is no question but that the system of numbering bridges and culverts by miles and decimals of miles is the best, and I do not see any necessity for making a distinction between bridges and culverts in giving them numbers. We have considered on our road the question of changing our numbers to the decimal system, and concluded that the advantages gained would not pay us for the cost of the change. Such a change would involve the numbers on more than 16,000 bridges and culverts and the advantage gained would be slight. The number boards for our bridges are of pine 2 inches by 12 inches, with the top diamond pointed, and the division letter and bridge number stenciled in black, on a white background on both sides of the board. The number board is spiked on the end of a cap for pile and trestle-bridges, and for other bridges is put in the most convenient place, where it can be readily seen from a passing train. Our culvert boards have black letters and figures on a white background, and are made of pine and nailed opposite the culvert on a fence post or telegraph pole, and in some instances, on a stake driven in the ground for the purpose.

Mr. A. McNab, Chicago and W. Mich. Ry.—I am following up the system of numbering by mileage. We adopted the system five years ago, and the longer we use it the better we like it. We number by miles and decimals, painting the number on a 4x14 inch oak post, placed near the end of bridge. Every 500 feet we also have station numbers. Should a washout occur on the track, or at any culvert, or trouble of any kind, the section men report it between such and such station numbers, so that we know just the exact location of the trouble. Our culverts are not numbered. We have a great many bridges on our main line across Indiana and Michigan. We have a little book showing every bridge on the road, so that if anything occurs we know what station we want to go to in a minute's time. I must say that I am very much in favor of the mileage system in numbering bridges.

Mr. J. H. Travis, Illinois Central Ry.—In regard to our method of numbering bridges, I would say that we have adopted a mile number which has been in existence on some roads twelve or fourteen years. We are now renumbering all bridges on our line. We number our bridges and culverts consecutively, no matter what the character of the culvert may be, concrete, pipe, stone, or wood. We also have a division letter, the same as is used for stations and baggage numbers, designating the division, beginning with the letter A. The bridge on that division is marked A, the mile number and fraction of a mile. The shape of the numbering tie is a half of a regular standard 6x8 tie, cut in a triangular shape at the end, about two and one-half feet. We number consecutively from New Orleans to Chicago, 912 miles. The posts are beveled and the face is large enough to get on three and one-half inch letters, but I believe that is hardly large enough. Five-inch figuring would be better. The culverts are numbered with 6x6 cypress, set in the ground. Each division having this letter is properly designated so that in case a report comes to Chicago from a division away off 2,000 miles, you can get the number of the division and the number of the bridge at once. The location of the bridge is designated by the letter. It is used officially and also on all papers pertaining to the passenger and baggage departments; every person is familiar with it and I do not think any difficulty is experienced. I think it would be a disadvantage to have the work of numbering bridges separate and distinct from the road department. On most of the roads, the B. and B. department is under the control of the chief engineer, and we are only subheads of that department. The road department and the bridge department are identical. As a general thing, the bridge foreman takes care of culverts, and it is just as necessary to have the numbers consecutive on culverts as well as bridges, as the reports sometimes come from the section foreman. It is just as easy to report by mile on culverts as on bridges. I believe that the mile number is the most economical and the most satisfactory. In this connection we find it very advantageous to cultivate a good relationship and feeling with all the train crews—engineers, firemen, conductors, brakemen, etc., as a report from them sometimes saves us a good deal of trouble, as well as gives us valuable information. If they report something wrong at a certain bridge or culvert, and the correct number is not given, it does not take long to find out what the record number is.

Mr. C. P. Austin, Boston and Maine Ry.—Our bridges are numbered consecutively on each division, which, in one sense of the word, is about the same as we have heard is the practice on other roads. I use a mile post 6x6 about six feet away from the track and ten or fifteen from the bridge, and a board 12x18 painted in white with six-inch black figures. I have 267 bridges. Everything from six feet and upwards I look after; everything below six feet the track department takes care of, and those I do not have anything to do with. The section men look out for the waterways and culverts. I have a carefully prepared list of bridges which I carry with me.

Mr. Austin then gave some minute details in reference to the modus operandi of numbering bridges on his road, beginning at the Boston terminal, and the clerical methods in which the records are kept. In the way he explained, no difficulty was experienced in locating any number at a moment's notice. Everything was familiar to everybody having anything to do with the bridges on his division.

Mr. J. H. Cummin, Long Island Ry.—Our system is that of numbering consecutively. The bridges are numbered running from 1 to 300, though we do not have so many as that; our arches or culverts begin with No. 300, the overhead bridges begin with No. 500, and so on. The numbers on the bridges are made of enameled iron with a six-inch figure, the body being blue and the number white, the plate screwed on the tie. From some of the remarks made here, I should judge that the mileage system was the best on most roads, but whether it would answer in all cases, for instance, on the Long Island, I am not prepared to say. I might illustrate this by the following: Our late member, Mr. Reed, and I made a little trip last February over the Long Island. We had a four-mile trestle on the road and he was anxious to see it. We got on at Long Island City, and took a seat in the rear end of the train, and started out. We went over the trestle and stopped at different stations. Finally, I told him it was about time we got out. He got out, looked around, and then said, "Why, Cummin, we are at Long Island City, where we started from." I explained to him that we had been sitting in the rear car all the time and had gone around a loop. We have got two of these on the road, and I do not know how the mileage system would work on these loops.

Mr. W. S. Danes, Wabash Ry.—We number all our bridges consecutively on the eastern division of the Wabash, using pine boards twenty-two inches long and beveled. One of these is placed outside of the guard-rail near the middle of the bridge. The body is black and the letters are painted white. Culverts we do not number. We are filling a good many bridges, using pipes. I think that culverts should be numbered or designated by some post with the number on it, so that in case of washouts it could be located.

Mr. Eggleston, Chicago and Erie Ry.—We are numbering all our bridges by the mileage system—miles, half miles, and quarters. We have a full description of each bridge, giving length, kind, date of construction, etc., and this is kept in the office in the form of a blue-print, and each division foreman, division engineer, superintendent, and other general officers have a copy. If any trouble arises at any of the bridges, they can look at their sheet, and see what kind of a bridge it is, and where it is located. There is no trouble in locating a bridge. We use a steel plate number, as mentioned in the report. I think the mileage system good and very satisfactory on the whole.

Mr. A. J. Kelley, K. C. Belt Ry. Co.—Our road has not any system of numbering, as we have no bridges. We use street numbers, that is, street names; but if I were on a road where there were bridges, I should prefer the mileage system of numbering them. I think it is decidedly the best.

Mr. Aaron S. Markley, Chicago and Eastern Illinois Ry.—About five years ago, we changed the entire system of numbering bridges. Formerly they were numbered consecutively. We adopted the mileage system, using tenths of a mile. If a bridge was 16.1 miles from the end, it would be numbered 161, and so on. All the bridges are recorded in the office of the chief engineer, and bound in book form, the numbers being given and the general description. On branch lines we prefix letters ahead of the number, same as used by transportation department in numbering stations. We have not yet decided as to the style of number we wish to put on except on through bridges, on which we paint the number on batter post. All waterways are numbered. The bridge department is under the chief engineer, and we are obliged to keep track of and look after them, and are held responsible for them.

Mr. N. M. Markley, C., C., C. & St. L. Ry.—We number consecutively everything from east to west, and the different divisions separately, using a cast-iron plate. On trestles they are placed on a cap.

Mr. Berg, Lehigh Valley Ry.—I would like to ask Mr. N. M. Markley a question. He says they number bridges consecutively. Mr. Markley, I presume, quoted the practice of his road. I would like to bring out more definitely Mr. Markley's individual opinion on the question, as to whether he is in favor of the mileage or the consecutive system, if he had a free hand; in other words, if he were taking hold of a new road.

Mr. Markley—I am in favor of the mileage system. I forgot to state that all small openings, I mean pipe openings, are not sealed up. The iron pipe is placed in a box and set in the ground.

Mr. Noon, Duluth, South Shore and A. Ry.—We use consecutive numbers on our road for bridges. No box culverts are numbered, but all openings. We use two-inch pine, nine inches square, painted black letters on white boards, placed on the side of the bridge facing the engineer. I do not know but what I prefer this instead of the mileage system. We have a great many reports from farmers, section men, and trainmen, and we have no difficulty in locating the place. Of course a new man might experience a little difficulty, but section hands are not changed very often.

Mr. Olmstead, Central Vermont Ry.—We use on our system for numbering a board ten inches wide and sixteen inches long. This is set up about eight feet from the track on a post, and back about twelve feet from the bridge, except on through bridges, where the number is placed on the end of the bridge. The numbers are put on the posts, one on either side of the track, and we number everything over six feet consecutively; everything under six feet is taken care of by the road department. I believe that the mileage system of numbering is far better than what we have.

Mr. Stannard, Wabash Ry.—Our bridges are numbered consecutively, omitting numbers on stone and iron-pipe culverts. I am partial to the consecutive system of numbering, as structures are more easily located. We use a bridge book which gives a description of each bridge or trestle.

Mr. Thompson, P., Ft. W. & C. Ry.—We number all openings, no matter how small, but only put signs at openings over twenty-four inches in width. Our sign is of cast-iron, about ten inches wide, with a seven-inch figure, and long enough for figures needed, either one, two or three. When we put in a new opening, we use the number of the last structure, with a letter following, as 50 A, 50 B, 50 C, etc. We sometimes get into confusion at that. Mr. Thompson cited a case in point where confusion had ensued. I think I would favor a system of numbering from mile-post, giving the first opening beyond a mile-post the number of the post, say 40, and the next one 40 A, etc. Think this would be most convenient in locating a structure in case of trouble, as all employes are familiar with the location of mile-posts. Mr. Stannard says everybody knows where a bridge is—brakemen, section men, train dispatchers, etc., but even then it is sometimes difficult for them to locate it. We have a blue-print in the dispatcher's office, showing location, but usually in case of trouble at a bridge the blue-print has got into the wrong drawer and cannot be found, so they have to inquire for the information.

Mr. Large, Erie and Pittsburg Ry.—Our system is practically the same as that of Mr. Thompson, so far as mileage numbers are concerned. I do not know that that would work very well where I am, from the fact that one of the lines is made up of two roads, and the mile-posts begin at both ends, and it would be a little difficult to number consistently in that case. On a line running right straight along, it seems to me it would be a very good way to number by the mileage system.

Mr. McGonagle, D. & I. R. Ry.—We number all openings, regardless of size, first with a mile number and then with a letter, indicating the number of the bridge on that particular mile. Number 10 C would be the third bridge on mile ten from Duluth. In the case of branch roads, the general freight agent has selected one of the closing letters of the alphabet as a prefix. The letter "V" indicates the Vega branch, which is a branch to one of the iron mines. On that road we have some small bridges. These bridges would be numbered V, then with the mile number, and then with a letter indicating the number of the bridge on that mile. The Western Mesaba branch has a letter "X" prefixed to it. In this way, we have a very clear and comprehensive method of numbering bridges, and any employe knows as soon as he hears of a bridge being burned or injured, the exact location. For instance, a work train being ordered out suddenly to go to bridge 14 A, the conductor knows exactly where to go, and there is no delay whatever. It is a very simple way of numbering the bridges on a road that has a limited number of openings.

Mr. Garvey, Iowa Central Ry.—I want to say that I have talked with our chief engineer in regard to the matter of numbering bridges. We talked about the new method. We have a book that describes everything—culverts, cattle-guards, crossings and overhead bridges. We talked the matter over of getting up a new book, and he is in favor of the mileage system of numbering, and if the engineers on other roads, together with the superintendents of bridges and buildings, are of the same opinion as this, I do not believe we shall have any trouble in adopting that plan.

REPORT: DRAWBRIDGE ENDS, METHODS OF LOCKING; AND INCLUDING LOCKING OF TURNTABLES.

There are three things absolutely required for the safe operation of a railroad draw or more properly swing-bridge. They are:

1. A device that will raise the ends so as to take up the sag due to changes of temperature.

2. A device for connecting the track rails at each end, which should be one in which the swing-bridge rails are long enough to extend over its ends and find a solid bearing on the fixed structure at either end of the swing-bridge.

3. Where a swing-bridge is not heavy enough to stay in line by its own weight, it should be provided with a latch that will hold it so.

Raising the ends of a swing-bridge is accomplished in a variety of ways—by rollers with wedge-shaped bearings, by swinging rollers, by wedges, and by screws, all of which act at the ends. Another method is to raise each arm of the bridge from the center. Of the last four, we present a number of examples of bridges that are in actual use, and request that the association take up each one separately and discuss its good and bad features. Without venturing an opinion as to the best methods of lifting the ends, we would call attention to the fact, that in bridges turned by hand, where wedges are used, they do not really raise the ends, but serve only to give them a firm bearing. As they become loose with every considerable fall of the thermometer and have to be adjusted constantly, too much reliance has to be placed in the carefulness of the bridge tender to look after it.

A recent writer on this subject says: "A swing-bridge, wherein no proper provision is made for raising the ends, is a dangerous structure at all times," and we would add that a railroad swing-bridge is equally as dangerous a structure wherein no provision is made for securely connecting the rails with those on the fixed structure at each end.

C. C. MALLARD,
Southern Pacific Ry.

Responses to Mr. Mallard's circular, requesting answers to the following questions:

1. What devices do you use for securing track rails at the ends of drawbridges?

2. What devices do you use for raising ends of drawbridges when they are closed?

3. What devices do you use for locking drawbridges?

4. Do you use wedges, screws, or other devices under the ends of turn-tables to relieve the jar when locomotives go on or off them?

REPLIES.

1. The rail rests on a wrought plate; upon the plates are riveted clamps which hold the rail in position; the plates are securely spiked to end cross timber of drawbridge; to prevent creeping, expansion joints are introduced about three hundred feet on each side of draw-bridge.

2. There is only one drawbridge in use on this system; this is constructed so that ends are lifted by means of screws at the center; when the bridge is in place, the action is the same as two independent spans, and the pinholes in toggle bars being oblong relieve them from any weight when the ends of bridge are lowered to the support on the masonry.

3. The bridge is locked with a pin more as a guide for lowering; this kind of construction needs no locking, as its weight will keep it in place.

4. We use no wedges or other device on the ends of turn-tables to relieve the shock from locomotives moving on or off; the rail on the table is about one-half inch higher than off the table, to allow for the deflection; we have no trouble with our turn-tables.

CHARLES E. WEBSTER,
Chief Engineer Lehigh Valley Ry.

---

1. We use split rails at the ends of drawbridges, rails from the movable span, lapping on those on the fixed span, one set of rails being lifted above the others when bridge is to be opened.

I enclose blue-print showing arrangement used at our Beardstown draw, which will illustrate this. No special device other than that shown is needed to hold the rails in position. At points where draw-bridges are interlocked, the rails are locked down by bolts to prevent clear signal being given while the rails are elevated.

2. We have only five draw spans on the C., B. & Q. proper. At four of these the ends are raised by cams under the end posts of the truss or girder. These cams are operated by the same engine that swings the draw at points where draw is swung by power. At two of the five bridges, we use hand power, and at one of these we have no lifting arrangement at all, but the end of the span (which is a one hundred and seventeen-foot through girder) rests on rollers, the axis of the rollers being parallel with the track.

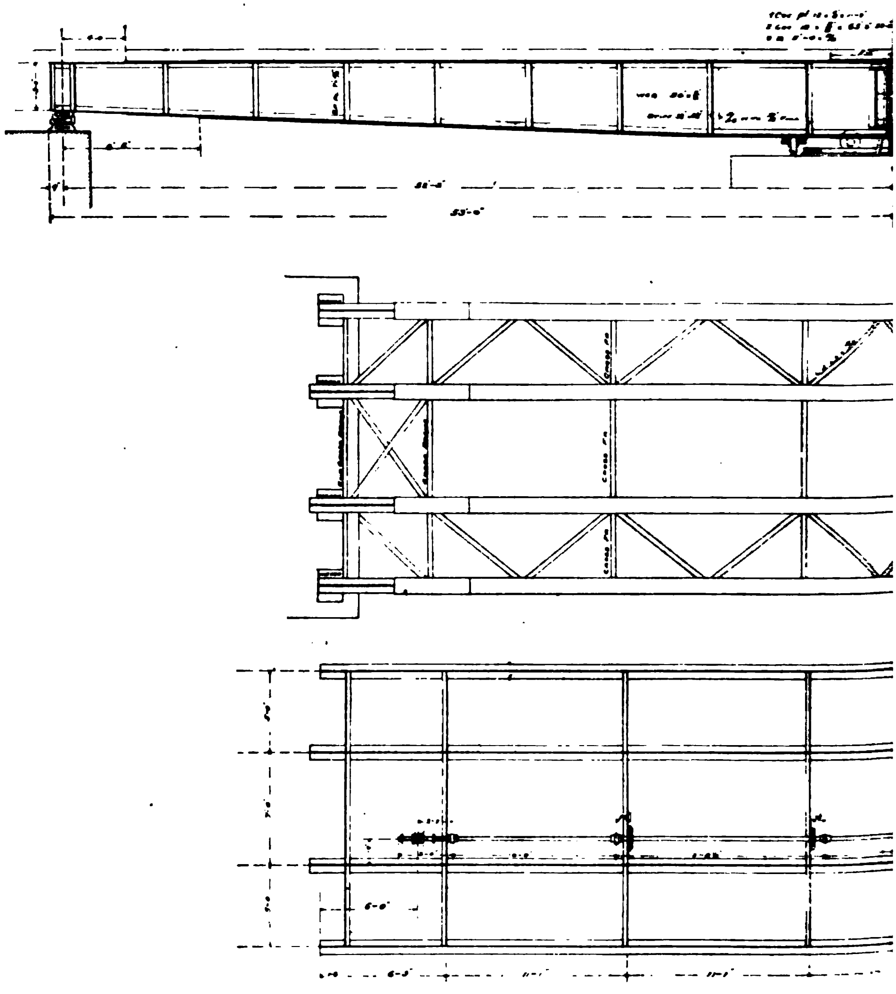
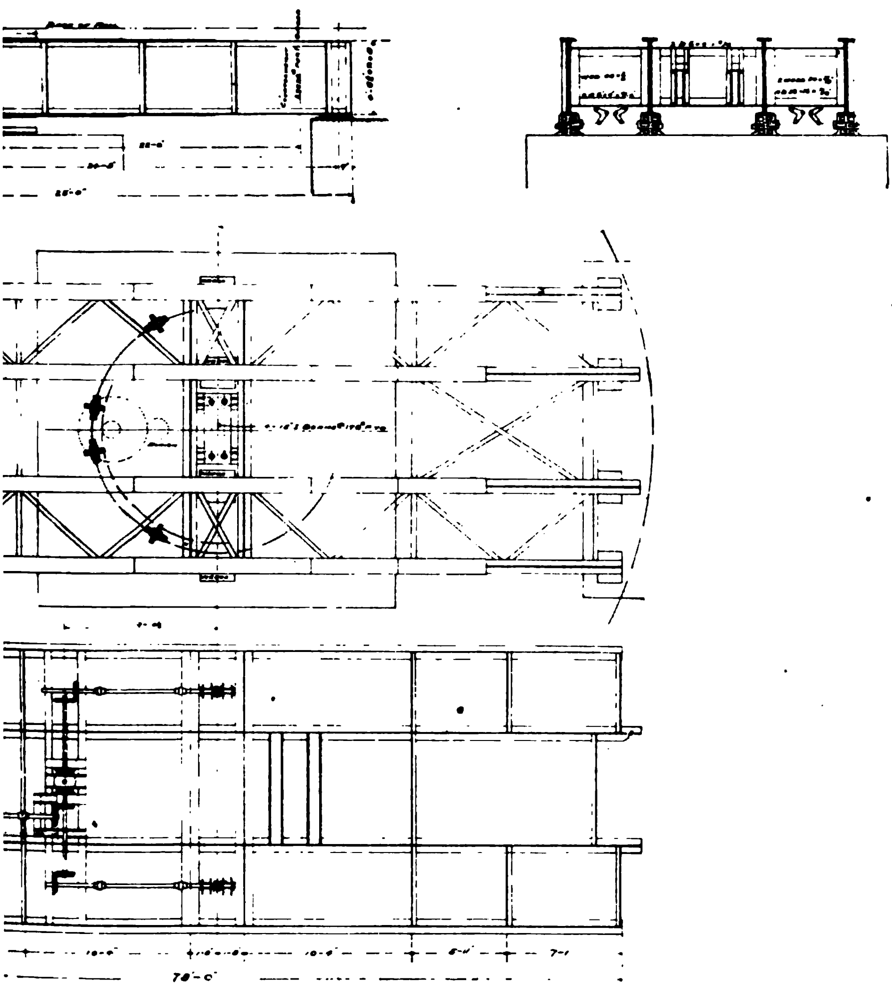


FIG. 129—DRAWBRIDGE NO. 46, LONG



D R. R. GENERAL PLAN OF BRIDGE.

There is very slight clearance between the rollers and the bed plates of the spans, and the action is similar to that of a turn-table.

3. At interlocked drawbridges, we use a standard drawbridge lock, furnished by the Union Switch and Signal Company or the National Switch and Signal Company. At some other points, we have an ordinary bolt which is operated from the center of the draw span. These bolts are principally of use to hold the bridge in place until the ends are raised, and the rails are lowered; with the span raised on cams and the rails lapping, no additional lock is needed.

4. We do not use wedges, screws or other devices under the ends of turn-tables. We have discussed this somewhat in cases where we have continuous track across the table and extended for some distance on either side and trains of cars are switched over the table, but have as yet taken no steps towards accomplishing anything in this direction.

E. J. BLAKE,
Chief Engineer C., B. & Q. Ry.

---

1. We use a wrought-iron bed plate fastened to a heavy cross tie, or wall plate, of oak, and hold the end of track rail by bolts and lugs.

2. We raise the ends of drawbridges, either with screws or by running them on rollers, or by lifting the ends of the bridge with a toggle-jointed arrangement at the center, and lowering again when the bridge is closed.

3. We lock drawbridges, either with latches, or with bolts operated by springs, or by raising the ends and lowering them over the rollers on the abutments, which rollers also act as expansion rollers.

4. We do not use wedges, screws, or other devices under the ends of turn-tables to relieve the jar. We usually weight one end of the table so that it has a bearing when the locomotive goes on, and in going off at the other end it comes to a bearing without shock, because it tilts over as soon as the engine has passed the balancing point.

ONWARD BATES,
C., M. & St. P. Ry.

I have but one drawbridge on my division, and that is a short one, being but 140 feet long, and although I have had considerable experience in the past with such bridges, yet none of them are of modern pattern.

For heavy, long spans I favor the screw. I have never known a wedge or eccentric to work perfectly satisfactory.

On the span on our road, the locking device is a wrought bolt, 1¼x4, operated by a common wagon spring, and works automatically when closing. It is fastened under the ties. A mortise casting is imbedded in the masonry at the center, and the face of pier lined with a wrought plate. The bolt strikes this plate, and slides as the draw closes, until the bridge is in position, when the bolt shoots, and the span is held securely in position. To open the span, a chain is run from this bolt to the center of bridge, where it is drawn back with a crank, and held until the draw moves off its bearing, which is a ten-inch roller under each corner, which the bridge rolls on to as it swings into position.

The rails are seated in a grooved chair, and are held more firmly with a knuckled strut between the rails, which can be lifted out by catching it at the center, and raising up, or connecting same with a rod, and working on the principle of an eccentric.

When I say that, with the exception of renewing one spring, there has not been a dollar expended on this span, for lifting or locking it in twelve years, you will conclude that that is recommendation enough for use on a small bridge.

Our arrangements cannot be classed as modern ones, and they have nothing but their simplicity, effectiveness, and durability to recommend them.

A. SHANE,
C., C., C. & St. L. Ry.

Mr. J. H. Cummin sent very carefully prepared tracings (Figs. 129, 130, 131, 132), showing the locking and lifting devices of the Main street drawbridge, No. 46, of the Long Island Railroad, built by the Pencoyd Bridge and Construction Company in 1890, with the following information: The bridge has been used continuously since erection, as a single track bridge, and has given good satisfaction. It is operated by one man, and the time required to open and close bridge, including setting of signals, is five minutes and forty seconds, divided as follows: Setting signals, fifteen seconds; lifting rail and drawing wedges, one minute; opening bridge, one minute and forty-five seconds; closing bridge, one minute and thirty-five seconds; setting wedges and lowering rail, thirty-five seconds; setting signals, thirty seconds. This time is for using slow gear for turning, as two men are required to operate on fast gear.

Mr. George W. Andrews writes that in answer to the fourth question, with reference to ends of turn-tables, the B. & O. R. R. depend entirely on the pony wheels at ends of table, and that no wedge arrangement is in use on any of them.

Mr. G. J. Bishop, of the Rock Island Ry., writes in answer to the fourth question: "We do not use wedges or screws under the

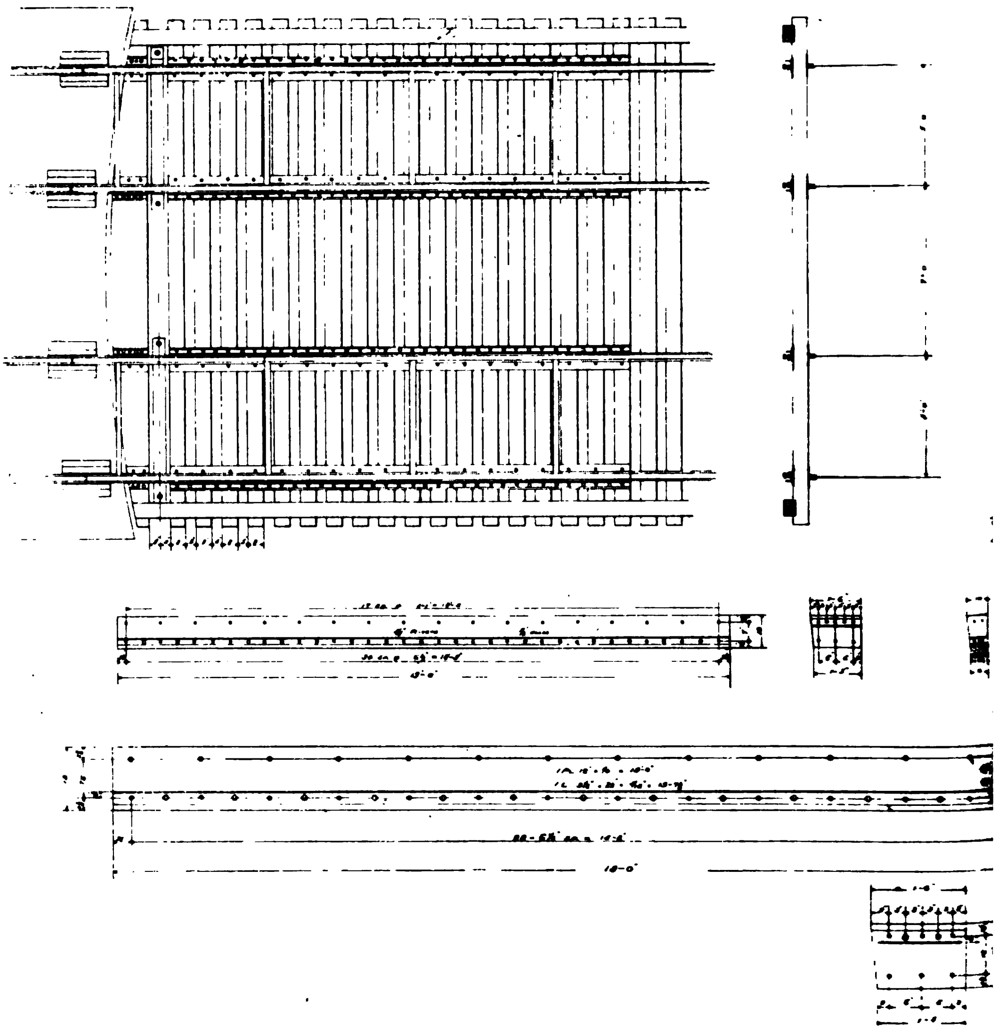
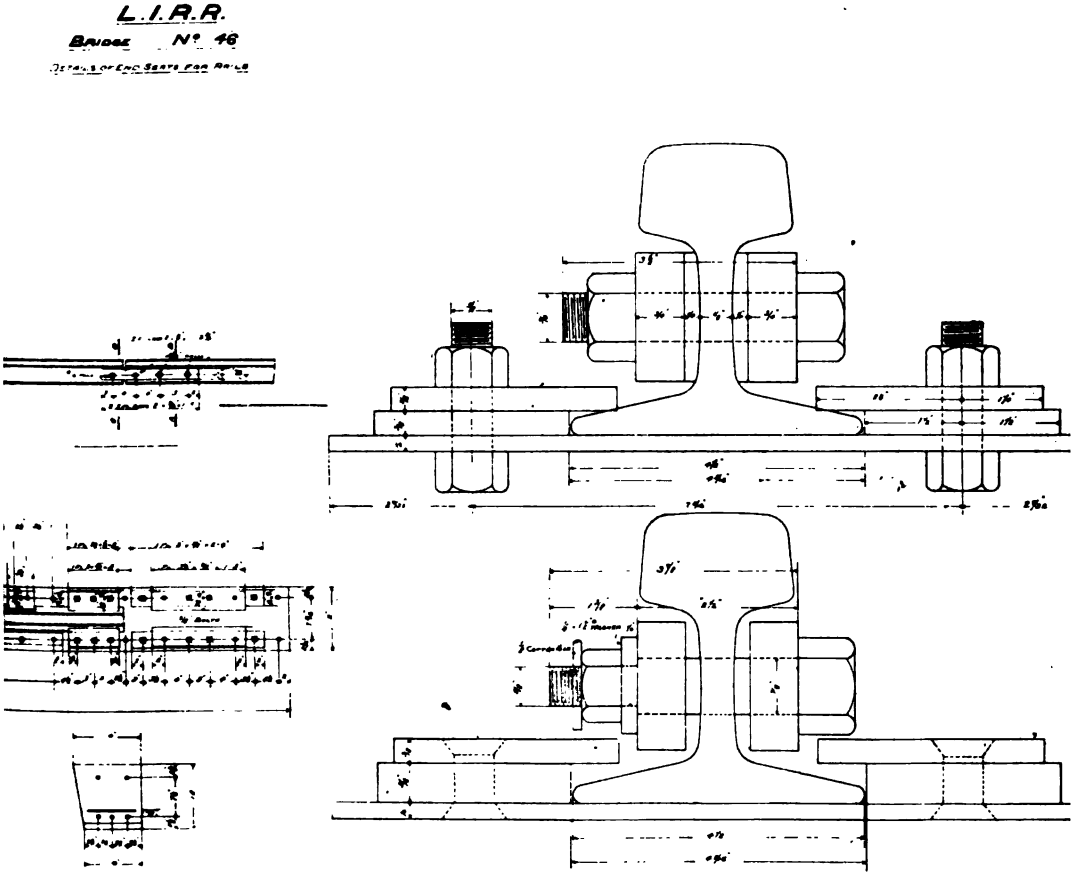


FIG. 130—DRAWBRIDGE NO. 46, LONG



AND R. R. DETAILS OF END SEATS FOR RAILS.

ends of our turn-tables to relieve the jar. Our fastening for turn-tables is generally a latch thrown with a lever. The latch is about one and a half inches thick by four inches wide, and runs in a socket, which is set in the coping of the turn-table."

Mr. James Brady, of the Rock Island Ry., writes that no wedges, screws, or cushions of any kind are used on their turn-tables, to relieve the jar of engines going on or off of turn-tables.

Mr. T. H. Perry, chief engineer, Lake Erie and Western Railroad, kindly furnishes the information that they do not use any wedges, screws, or other devices, on the ends of turn-tables to relieve the jar, when the locomotives go on or off the tables. The end wheels of the turn-table resist the jar.

DISCUSSION: SUBJECT — DRAWBRIDGE ENDS; METHODS OF LOCKING; AND INCLUDING LOCKING OF TURNTABLES.

Mr. Stannard, Wabash Ry.—I have a drawing furnished by Mr. Danes, of the Wabash road, showing device for locking turn-table in use on his road, by which a turn-table can be locked before coming to a dead standstill.

Mr. Danes, Wabash Ry.—The drawing referred to represents a new turn-table that was recently put in. It has a new kind of a fastening, that works with a shaft, with the leverage working at the sides. It works and fastens between the two rails, so that a man operating it is not in risk of getting hurt. It is a great deal better than the old fastener. This is the first turn-table of this kind that we have put in on the road, and it is entirely satisfactory.

Mr. Cummin, Long Island Ry.—I would like some information as to whether any roads have on their tables a device to loosen or lessen the jar of the engine, when it strikes the table in going on or off.

Mr. Danes—I do not know of any such device, but it seems to me that could be overcome.

Mr. Cummin—It seems to be the only turn-table is one that can be brought to a dead stop before the man locks it.

Mr. Danes—The table has got to be brought to a stop, and the man has got to be pretty careful.

Mr. Cummin—Where you have a fastening with a table that can be used to bring the table to a stop, you are bound to have the table out of order all the time. I have had considerable experience in that way.

Mr. A. S. Markley, Chicago and Eastern Illinois Ry.—About a year ago, when at New Orleans, I saw a good fastening operated with a lever on the side of the engine, which seemed to work well. We have but one drawbridge on our line. We have one on the Wabash River that has never been locked, and one on the Calumet River. They are operated from the engine on top.

Mr. Berg, Lehigh Valley Ry.—In answer to Mr. Cummin, I will say that I do not know of any special device, but have always heard that the introduction of ties or timber for the foundations of the circular rail of a turn-table, is generallly indorsed, because they are more elastic. In other words, the placing of a circular rail of a turn-table on a stone coping direct, has been quoted as bad practice, for the reason that it increases the shock to the turn-table. I know of no special device to reduce the jar of the engine in going on or off the turn-table.

Mr. Bates, C., M. & St. P. Ry.—I am reminded at this moment of a circular letter that was sent to me some years ago by a man who is now one of our most distinguished engineers, asking for copies of the plans in the office where I was employed. His letter stated that he wanted not only examples of our good bridges, but especially wished for drawings of our bad ones as well, because, as he ingeniously stated, he could perhaps learn more from the contemplation of our failures than our successes. I am in a better position to advise you what to avoid than what to adopt. At a later date, when I have carried out some ideas on the subject, which are not yet developed, I may have a drawbridge latch which I can recommend. At the present time, with twenty-five drawbridges, there is not one which I consider entirely satisfactory with regard to the end-locking apparatus. Probably the best of the lot is a spring bolt which shoots in place when the bridge is closed. The objection to this is that the fastening receives a violent shock when the bolt is shot in place before the bridge is at rest, and in practice this shock usually occurs. We have one bridge where the ends of the bridge are lifted up and dropped down on rollers, which act as expansion rollers as well as a lock to hold the bridge in place sideways. I have not furnished any plans of these appliances, because it seems to me there is no place in our publication for plans unless they can be recommended for adoption.

Mr. Riney, C. & N.-W. Ry.—We use the old method of latch or the tie plate and key on turn-tables, and the old-fashioned methods on drawbridges.

Mr. McIntyre, Erie Ry.—We have drawbridges with mitred joints. The joints are two feet long and the neck of the rail is

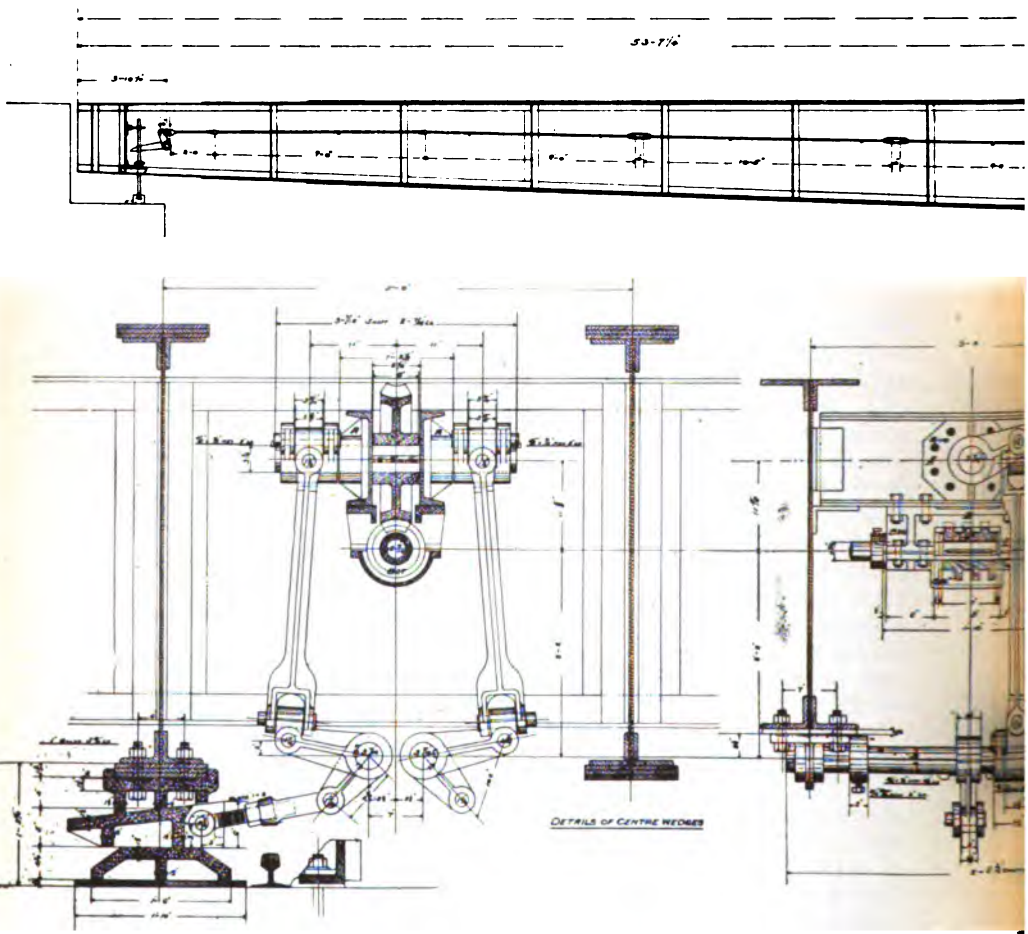
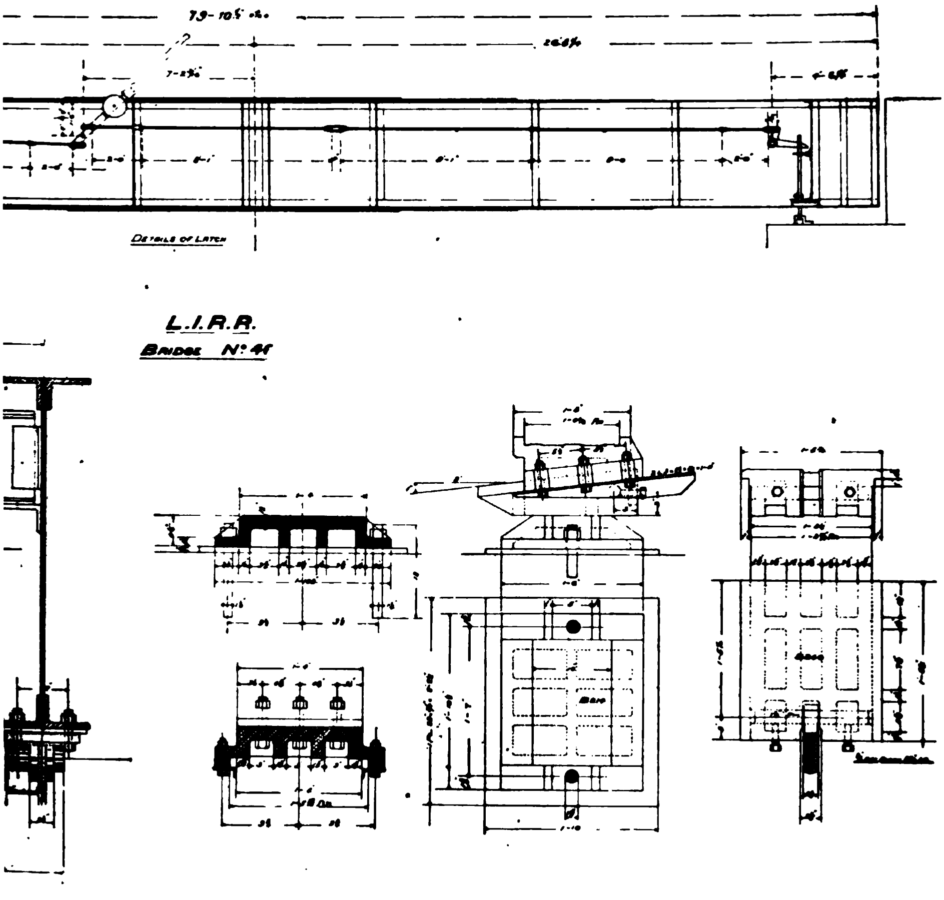


FIG. 131—DRAWBRIDGE NO. 46, LONG ISLAND R. R.



TAILS OF LATCH AND CENTER WEDGES.

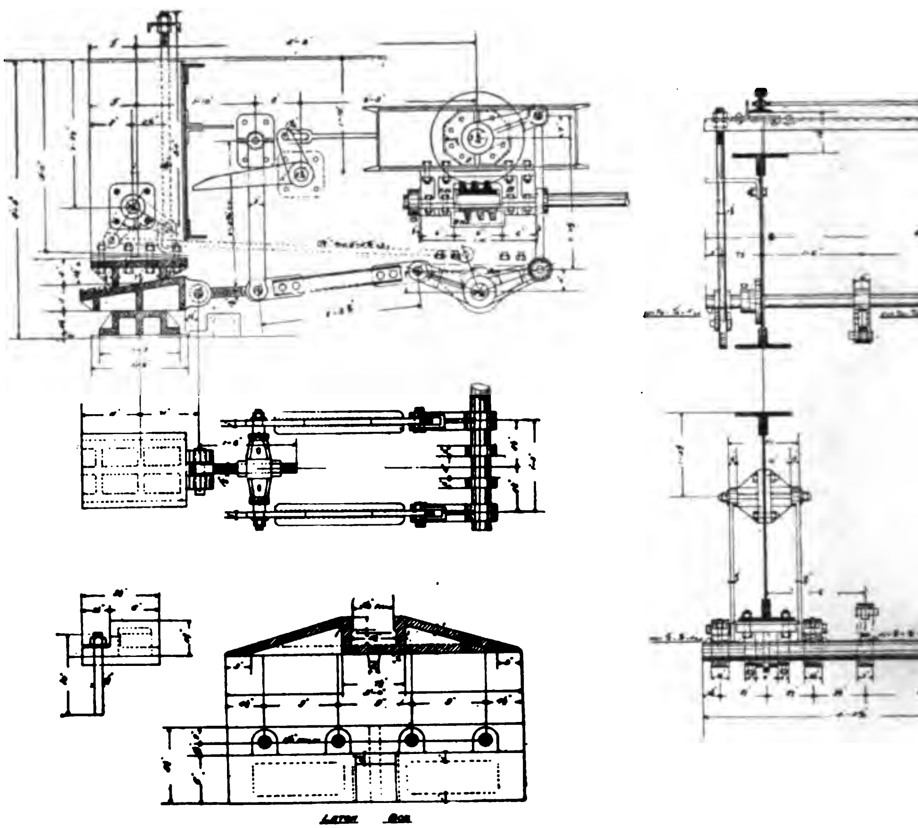
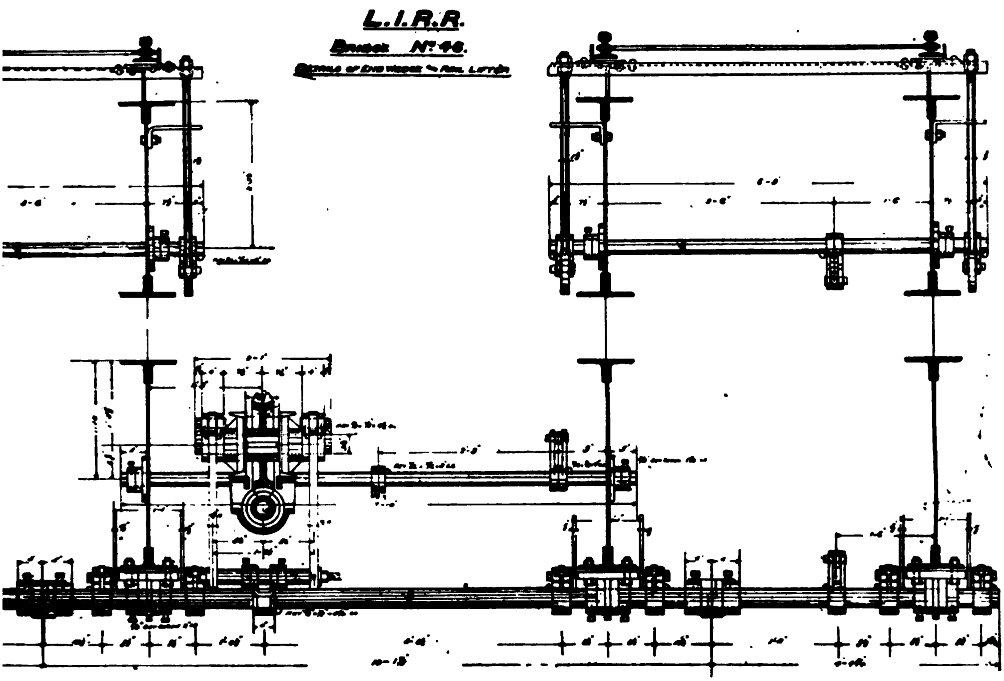


FIG. 132—DRAWBRIDGE NO 46, LONG ISLAN



R. R. DETAILS OF END WEDGE AND RAIL LIFTER.

filled out to the outside, but the track there does not last over two years. On all our turn-tables we have a latch. To overcome the jar on them, we have on some of them stone, but the most satisfactory way is timber under circular rail.

Mr. J. H. Markley, Toledo, Peoria and Western Ry.—As far as the locking apparatus is concerned, it works very satisfactorily. When you want to open the draw there are four sets of rollers, one on each corner. They raise on a cast-iron pedestal, and when you come to close them they roll against the shoulder on the outside of the pedestal. I have had a great deal of trouble with rollers at the end of bridges. I use now nothing but stub ends, and they have to be renewed about every three years. I have been thinking some of using the mitre joint, but have been afraid of expansion and contraction. If the mitre joint can be used satisfactorily, I will adopt it.

Mr. Large, Erie and Pittsburg Ry.—As far as turn-tables are concerned, we use a bolted frame in through the ties with a bolt and a slot in it. We make it so that the levers run out and push the table. Our men are admonished to be careful. This bolt makes a very secure fastening.

President—I would like to ask if any one has turn-tables operated by steam or electric power, and the locking device connected with the same motive power?

Mr. N. M. Markley, C., C., C. & St. L. Ry.—We use a latch to hold it in place after the engines are released from turning it around. The rim would catch and throw it around when anything would hold it.

Mr. Thompson, P., Ft. W. & C. Ry.—At Fort Wayne, we have a one hundred foot turn-table worked by steam engine at the car shops. Lock is between the rails, the old style. The engineer works the whole thing. We have had very little trouble for five or six years. They hardly ever disturb the curbing or get off the track.

Mr. Stannard, Wabash Ry.—The laws of Missouri require us to keep our turn-tables locked when not in use. We use a latch, keeping our tables locked all the time. I think possibly that is the best arrangement for locking.

Mr. Eggleston, Chicago and Erie Ry.—We have two drawbridges on our line, one at Hammond. That bridge is not open more than once or twice a year, and we have no special device attached to it. At Spencerville, we have a draw sixty-eight feet long. We have a special device there furnished by the Union Switch and Signal Company, with three levers attached at the center of the bridge. These levers are interlocking, similar to interlocking crossing levers. The first lever will drop one signal to danger; that releases lever No. 2, and that lever will drop signal on opposite end and that releases lever No. 3 that locks the bridge at the ends. The bridge tender then raises the ends of the rails and opens draw. This is a very satisfactory arrangement, as we have connected with this a signal protection. This arrangement can be seen in the Union Switch and Signal Company's catalogue.

Mr. Berg, Lehigh Valley Ry.—I wish to call attention to a serial article on "Drawbridges and Details of Drawbridges" that has just commenced in the Engineering Record. The first issue was October 17, 1896. This series of articles bids fair to be one of the best and most practical treatises on drawbridges that we have. It is written by Mr. Charles H. Wright of the Edgemoor Bridge Works, Wilmington, Delaware. I understand the articles are advance sheets from a forthcoming book on the subject. I think the details are going to be very elaborately described and illustrated, so that members seeking information on this subject will be able to get it.

Mr. Cummin, Long Island Ry.—I have been listening for some device that would be better than what is now in use, but so far the only satisfactory one that we have, I think, is the slide-bar. We use slide-bar, and the table has to be brought to a full stop before they can slide the bar in. When they turn an engine, they have to bring the table to a full stop before they can slide, because we do not allow over one-sixteenth inch play. The table is brought to a full stop before the bar is slid in.

Mr. Garvey, Iowa Central Ry.—I agree with Mr. Cummin that we must have a device that the table must come to a full stop before being locked. I have tried different methods, but we are now using the old-fashioned way, a key between the rails. We have one bridge with a locking device of the Phoenix Bridge Company's manufacture, and this is set down into cast-iron chairs. The engineer raises the ends of the rails up three inches before he starts to turn.

Mr. Eggleston, Chicago and Erie Ry.—We use the same device as Mr. Cummin. We are a little more liberal, we allow a quarter-inch play. Table has got to come to a full stop before being locked. I think that is the only way a table can be taken care of.

REPORT: PROTECTION OF TRESTLES FROM FIRE, INCLUDING METHODS OF CONSTRUCTION.

I herewith hand you a tracing of a trestle-bridge, Fig. 133, which shows the iron covering of the parts of the trestle that are most liable to take fire from passing engines. You will note I have covered the caps and rail joists with iron, these members being the ones that usually catch fire. I use No. 20, B. G., galvanized iron, twenty-five inches wide for caps, and bend the edges down on an angle of forty-five degrees. This iron for the cap is made of two pieces twenty-five inches wide and seven feet nine inches long, spliced in the center, lapping six inches, using flat-head, soft iron, tinned rivets, five-sixteenths of an inch in diameter, three-eighths of an inch long, placed in the center of lap two and one-half inches apart. The rail joists are covered in the same way. You will note that on the tracing I have three stringers, 7x14, in each chord. This requires iron thirty-three inches wide to cover them. The iron ought to turn down at least five inches on each edge of the rail joists. It will use up one-half inch in turning the iron down. You want to order your iron eleven inches wider than the timber you wish to cover. The splicing is the same as on the caps. The iron for covering the rail joists should not be less than ten feet long, and should be riveted in sections of three sheets each, and the sections lapped six inches when laid on the rail joists, and not riveted together, to allow for expansion. The anchor bolts that go through the ties, rail joists, and bolsters and the tie dowels will keep the iron in place.

Trestle-bridges covered, as described above, cannot take fire from passing engines. Occasionally a tie may be set on fire, but it cannot communicate with the rail joists, and, consequently, no serious damage results from it. Neither is there any danger from fire caused by cinders dropping from ashpans of passing locomotives lodging on the caps. The iron is turned down over the corner of the side of the cap and rail joist on an angle of forty-five degrees, and anything that falls upon either when it slides off, is bound to fall clear of everything connected with the trestle.

Trestle-bridges, when some portions of them are on dry ground for a part of the year, should have the sod and grass cleaned away from the bents a distance of at least three feet, as cinders are liable to fall from a passing engine and set the grass or sod on fire, which would communicate to the bents and burn the trestle.

Trestles, in some parts of the South, are protected from fire by fitting a plank between the ties and closing the ends by fitting a board between the ties and nailing it fast to the bottom plank, and filling the space between the ties with gravel, and covering the tops of the ties at least half an inch. I think this a very good protection from fire if the spaces are kept full of gravel or sand, the gravel being best as it is not so liable to be lost out by the cracks between the ties and the plank. About the only objection I can see, is in renewing the ties which wear out first, as they generally require two sets of ties to one of rail joists, and in this case the gravel would have to be renewed, but the cost is small.

G. W. HINMAN,
L. & N. R. R.

DISCUSSION: SUBJECT—PROTECTION OF TRESTLES FROM FIRE, INCLUDING METHODS OF CONSTRUCTION.

Mr. Eggleston, Chicago and Erie Ry.—We cover our stringers with No. 22 galvanized iron and protect two or three inches on the side opening. That is the only protection we have on the Erie.

Mr. Cummin, Long Island Ry.—The only protection we have is a balf barrel of water certain distances apart. We have never had any trestle burned.

Mr. Thompson, P., Ft. W. & W. Ry.—We use 8x18 oak stringers, 7x10 oak ties, and 12x13x14 oak cap. We scarcely ever have fires.

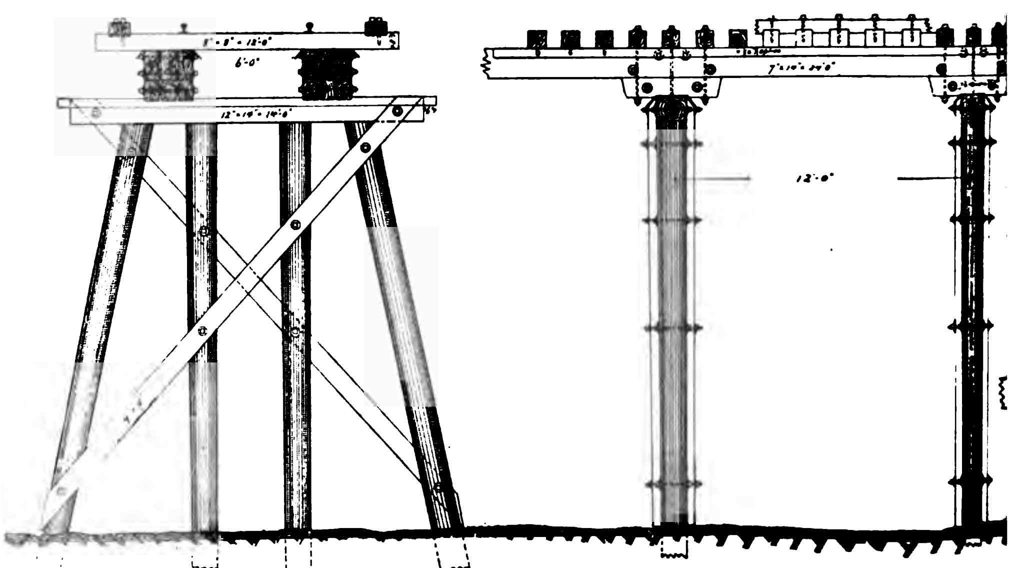
Mr. Danes, Wabash Ry.—We do not have any extra protection. We generally cover the stringers with No. 16 galvanized iron, lapping it over the girder, and at the trestles we have half barrels some distance apart, filled with water. We have no trouble with fires at bridges.

Mr. Noon, Duluth, South Shore and A. Ry.—We have no protection except water-barrels filled. If required, we use an engine tank fitted with a pipe, or have a special engine if occasion should require it.

Mr. Bates, C., M. & St. P. Ry.—We depend on the track department. Bridge men only get over the road at irregular intervals, while the track men see the bridges every day. It is the duty of the track men also to clear away the grass, weeds, and rubbish that is liable to catch fire from sparks and set fire to pile and other wooden bridges. Track men also keep water-barrels filled with water on all long bridges. We usually put salt in these water-barrels to keep the water from freezing, and keep a bucket in the bottom of each barrel for use in putting out fires. On our Western lines, particularly in Minnesota and Dakota, we are especially liable to have our pile bridges burned, because it is the custom to burn the straw after threshing in the fall of the year, and prairie fires are common. It is remarkable that we have never had a train accident due to the burning of a bridge, and the carefulness and vigilance of our track men are very apparent in the few cases of damage to our wooden structures by fire.

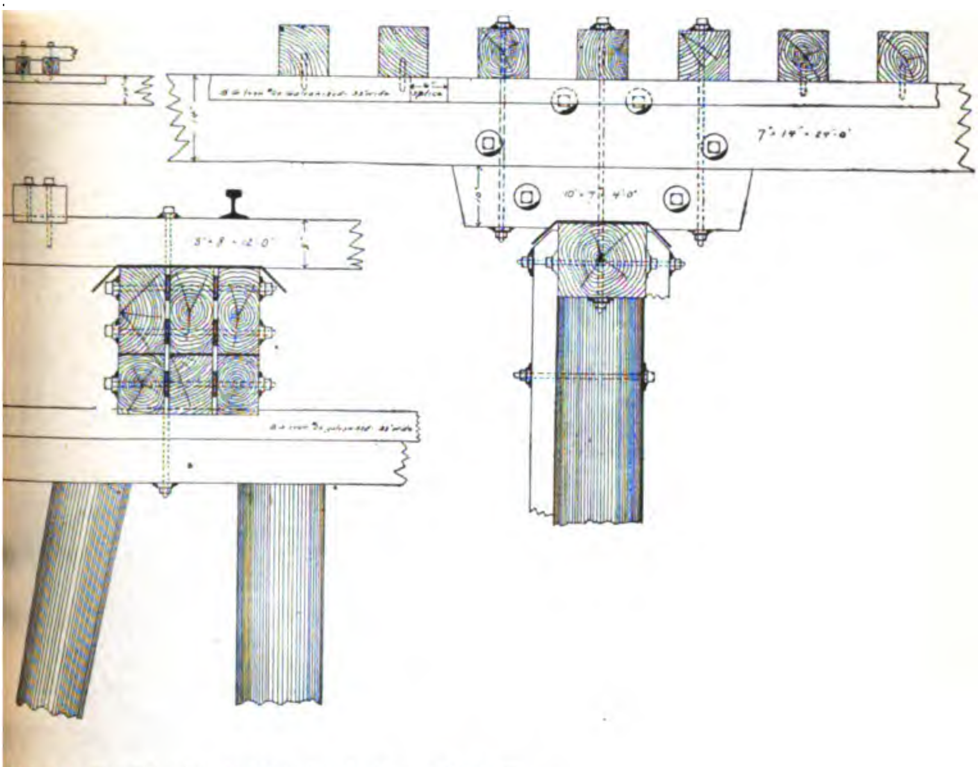
Mr. N. M. Markley, C., C., C. & St. L. Ry.—On long trestles we have a barrel filled with water.

Mr. Nutting, O. R. & C. Ry.—The only protection that



METHOD OF COVERING TRESTLE BRIDG
WITH
IRON
TO PREVENT FIRE AND DECAY.

FIG. 133—DESIGN SUBMITTED BY MR. G. W. HINMAN



VING METHOD OF PROTECTING TRESTLE FROM FIRE.

we use at this time of the year is, that we clean up thoroughly around trestles and burn up everything that is liable to take fire from sparks. At a few of our large trestles, which are more liable to catch fire, we keep watchmen to see to the water-barrels, as an additional precaution.

Mr. Berg, Lehigh Valley Ry.—The question of the protection of trestles from fire, I think, could be subdivided into two divisions; one, the method of construction; the other, the means and appliances to fight a fire, in case a fire should take place. In regard to the methods of construction, it seems to me the more substantially or fire-proof a structure can be made, the better it would be. One method that is adopted on some roads for a timber trestle is building a solid floor and covering it with gravel; in other words, a so-called gravel-top trestle. It is a method that should be mentioned as probably a very feasible one to prevent a trestle from taking fire, and it is used very extensively. Another method, that is used for the same purpose, is to cover the ties between the guard-rail and the rails proper, and then between the rails again with sheet-iron or galvanized sheet-iron. This method I do not think favorably of. Unless it is well maintained, it will, after a number of years, show holes and it will buckle up in places and cost considerable for renewals, and, unless it is kept in good repair, it does not protect properly. It has also the further disadvantage that in case of a fire it is very difficult to get down to the structure below to get at the fire. It also interferes with the proper inspection of the trestle by track-walkers from above. I think it is an objectionable method of construction. The method of protection of the vital parts of the trestle, that is, the stringers and caps, as outlined by Mr. Hinman in his report, seems to me to be preferable. It protects the important parts of the trestle, and the fire, as he remarks in his report, might spread to the ties, but they could be readily replaced. An individual tie could be burned badly and yet the rails would carry the trains over. In regard to a further method of protection from fire, such as has been mentioned by a number of members, namely, cleaning away weeds and other matter around the base of the trestle, that is a very good precautionary protection. There is another point that should be mentioned; that is, the necessity and desirability of having gang-planks on the outside of a trestle. I believe there are lots of trestles that are not built this way, and in case of fire it is very difficult to get down to the trestle in a hurry. This gang-plank is also of advantage in regard to inspections, and it also is desirable to allow men getting caught on a trestle to get out of the way of trains, instead of clinging on to the edge of the caps, as they often have to do. Another feature is the building of ladders, or nailing of small strips on the outside posts of the trestle, at intervals, so that in case of fire it can be got at from below more quickly. In regard to means for fighting a fire, I think railroad companies should give more attention to equipping their locomotives with fire hose or ordinary washing-out hose, fitted up so as to be used as a fire hose. We had a fire recently on our road, in one of our yards, and out of a large number of switch engines there were only two at the time in the yard that were equipped in that way and that could be used to put out a fire. It was a freight car that started to burn. That brought home to me the desirability of having all locomotives equipped so that in the event of its being necessary, a locomotive could run out on a trestle where there was a fire and extinguish it. The great point in stopping a fire after it has started is, as all the members know, to get at it quickly and stop it soon after the start. For this purpose I think water-barrels placed along the trestle at frequent intervals are especially desirable, but there should always be buckets in connection with the barrels, preferably on the inside and kept wet, unless made of metal. From the limited experience I have had or heard of on the roads I have been connected with, in regard to chemical fire extinguishers, I have come to the conclusion that whenever a fire breaks out the chemical fire extinguisher is generally found to be out of order. It does not act. I have yet to learn of a fire on a railroad structure where they worked successfully. I will not say it is always the fault of the extinguisher, as generally such apparatus is allowed to deteriorate, not having the proper inspection.

Mr. Bishop, Chicago, Rock Island and Pacific Ry.—We take no special precautions against fire. We keep weeds and grass cleared away from each side of the trestle for about ten feet.

REPORT: LOCAL STATIONS FOR SMALL TOWNS AND VILLAGES, GIVING PLANS OF BUILDINGS AND PLATFORMS.

The committee issued the following circular letter of inquiry to all the members of the association:

At the last meeting of the association, held in New Orleans, the undersigned were appointed a committee to report on the subject of "Local Stations for Small Towns and Villages," giving plans of buildings and platforms. We believe that this subject is of vital interest to every member of our association, as it is from the station and its surroundings that the stranger gets his first impressions of a town or village, and first impressions, as you know, are usually lasting. In looking over the reports of our proceedings, we find that they are becoming more interesting and valuable every year, and if our association is to grow, this certainly should continue. We think that you will agree with us that this depends entirely upon the committees appointed and the assistance they receive from the members; and in view of this we ask you to assist us in making our report one in which we can all take pride, and one that will be of great value to our members by helping them in one of the most important branches of our work.

This you can do by sending to the chairman, or any member of the committee, plans of such stations on your road as you think are appropriate. If you can possibly send tracings, please do so, as it will save considerable expense and they will be returned; but if not, send blue prints and tracings will be made. In accordance with a resolution passed at the last meeting, all reports have to be in the secretary's possession thirty days before the meeting; we, therefore, ask that you will kindly send plans, etc., as soon as possible, so that the committee can make a full and complete report on the subject assigned them.

J. H. CUMMIN, L. I. R. R.,
N. M. MARKLEY, C., C., C. & St. L. Ry.,
J. H. MARKLEY, T. P. & W. R. R.,
C. G. WORDEN, S. Cal. Ry. Co.

A number of the members responded by sending plans, and the committee have had tracings made of them and now present them for your consideration.

PLAN NO. 1 (FIG. 134).

Represents a frame, combination depot 21 feet by 54 feet on the Buffalo division of the Lehigh Valley R. R., with waiting-room, office, and freight room and 8 feet of overhang of roof entirely around building.

PLAN NO. 2 (FIG. 135).

Passenger station on the Missouri Pacific R. R., 17 feet by 49 feet, with two waiting rooms; ticket office 9 feet by 10 feet.

PLAN NO. 3 (FIG. 136).

Passenger station on the Missouri Pacific R. R., 26 feet by 82 feet, with two waiting rooms 17 feet 8 inches by23 feet 10 inches each; office 11x15 feet; baggage and express rooms, toilet rooms with ventilating flues in the chimney are provided for each waiting room. The roof has 8 feet overhang.

PLAN NO. 4 (FIG. 137).

Combination station on Duluth and Winnipeg R. R., 24 feet by 88 feet, with two waiting rooms, office, and large freight room.

PLAN NO. 5 (FIG. 138).

Combination station on Chicago and Eastern Illinois R. R., 16 feet by 40 feet, with waiting room 11 feet 2 inches by 15 feet;

office and freight room. This station cost $500, which includes outside W. C. and coal house. Waiting room is ceiled with hard pine and all sash hung with weights. Telegraph table, shelves, etc., of quartered oak.

PLAN NO. 6 (FIG. 139).

Track elevation and floor plan of passenger station on Illinois Central R. R., 20 feet by 76 feet, with two waiting rooms, baggage and freight room. A special feature of the plan is a vestibule adjoining the office for trainmen's use while getting orders.

PLAN NO. 7 (FIG. 140).

Combination depot on Union Pacific R. R., 20 feet by 50 feet, with waiting room, office, and freight room; also sleeping room for agent 8 feet by 8 feet. Floor plan shows arrangement for outside toilet rooms and coal house.

PLAN NO. 8 (FIG. 141).

Passenger station on the Southern California R. R., with freight house and shed adjoining. The two buildings are connected at the roof, giving a cool passage way between, where seats are stationed. This arrangement is made for the comfort of the passengers, as in this climate a stove is needed only a few days in the year. The open shed at the end of the freight house is for the convenience of fruit packers in packing and shipping their stock. The location of the ticket office, giving both an outside and inside door, makes it convenient for agent to transact business with the public.

PLAN NO. 9 (FIG 142).

Frame passenger station 16 feet by 26 feet on the Elgin, Joliet and Eastern R. R., showing elevation, section, and floor plan. Platform 16 feet wide and 200 feet long.

PLAN NO. 10 (FIGS. 143-144).

Gives elevation and floor plan of combination depot on the same road, 28 feet by 64 feet 6 inches.

PLANS NO. 11 AND NO. 12 (FIGS. 145-146).

Combination depots on the L. E. & St. Louis R. R., one 18 feet by 50 feet and the other 18 feet by 48 feet. Passenger platform 16 inches above the rail and 3 feet from outside of rail to edge of platform.

PLAN NO. 13 (FIG. 147).

Passenger station at Colorado Springs on the U. P. D. & G. R. R., showing elevations and floor plan. The waiting rooms are conveniently arranged with toilet rooms to each and 10 feet by 10 feet baggage room in rear of station.

PLAN NO. 14 (FIG. 148).

Standard combination No. 2 on the Chesapeake and Ohio R. R., showing front and end elevation, section, floor plan, and general lay-out of platforms. Frame depot with brick foundation and platform on brick piers with 6x8-inch sleepers, 4x8-inch stringers, and 2-inch plank.

PLAN NO. 15 (FIG. 149).

Frame passenger station on the Pennsylvania line, west of Pittsburg, 21 feet by 70 feet; showing front and east elevation and floor plan. The elevations show a neat and tasty design and the floor plan is well arranged for the convenience and comfort of passengers, giving two waiting rooms and large toilet rooms for both sexes, with baggage room 12 feet by 20 feet.

PLANS NO. 16 AND NO. 17 (FIGS. 150-151-152).

Showing elevations and plans of two brick and stone stations on the C., C., C. & St. L. R. R., one at South Side, Ohio, the other at Home City, Ohio. These stations are designed entirely different from the general run of railroad depots and present a beautiful and attractive appearance, and with the general lay-out of the floor plans, will attract attention at once. For a village station it would be difficult to improve on them.

PLANS NO. 18 AND NO. 19 (FIGS. 153-154).

Give elevations and floor plans; a frame station at Richmond, Ky., on the Louisville and Nashville R. R. Station is 75 feet long by 32 deep feet at the deepest portion. The elevations show a great deal of taste and care in design, and the floor plan is well laid out. There is one peculiarity in this plan, inasmuch as it has three waiting rooms, one each for men and women and one for colored people, which makes it quite different from those in other sections of the country. The rooms are large and airy and the entire plant convenient for station agent's duties. The building is covered with slate. The platforms are built 6 inches above the top of rail and 4 feet 6 inches from center of track to edge of platform.

PLAN NO. 20 (FIG. 155).

Plan of modified depot No. 1 as used on the Chicago, R. I. & Pacific R. R. Frame building 22 feet by 65 feet by 12 feet high; shingle roof, one waiting-room, office, two living rooms, and freight room. This class of depot is used at small villages and costs as follows: Foundation, \$107.60; depot, \$1,195; painting, \$128.61; platform, \$130.67; total cost, \$1,561.38. Platforms in front and at ends of depot 2-inch plank; the balance along track is two stringers set on edge, 8 feet out to out, ¾ inch rod and cast washers every 8 feet filled in with cinders and well rolled. Two-inch wood platform costs 10 cents per square foot.

PLAN NO. 21 (FIG. 156).

Shows brick and stone depot 26 feet by 88 feet on the same road. Slate roof, two waiting rooms, express and baggage rooms, and two toilet rooms. This style of station is used in towns of 3,000 to 5,000 population and costs $7,500, using a vitrified brick platform, stone curbing costing about 5 cents per square foot on the flat and 7¼ cents on edge, curbing 4½ inches thick, 30 inches deep, 25 cents per lineal foot. The ground is excavated the necessary depth, well rolled with 2,200-pound roller, then filled with 4 inches of sand. The sand is leveled off with straight edge, the brick then laid and rolled with the same weight roller. Joints well broomed with sand for one week after platform is laid. This platform gives good satisfaction.

PLAN NO. 22 (FIG. 157).

Frame combination depot at King's Creek, Ohio, on the N. Y., L. E. & W. R. R. Building 16 feet by 40 feet, with slate roof, and costs $1,200.

PLAN NO. 23 (FIG. 158).

Frame passenger station on the same road 21 feet by 43 feet, with two waiting rooms and commodious office. The elevations present a neat appearance and the cost of the building with slate roof is $1,300.

PLAN NO. 24 (FIG. 159).

Gives elevations and floor plans of a fourth-class frame station on the Philadelphia and Reading R. R. These stations were designed by our esteemed member, Mr. John Foreman, twenty-seven years ago, and have been in constant use, with very little repairs, since that time. They are conveniently arranged for business, at the same time giving the agent a comfortable home of six rooms.

PLAN NO. 25 (FIG. 160).

Shows plan and elevations of a frame combination station at South Ottumwa on the Wabash R. R. The building is 20 feet by 58 feet, with bay on each side. The elevations present a neat appearance and an octagon tower extends above the ridge of roof. It is ceiled inside with long leaf yellow pine and finished in hard oil. The agent can get to any part of the building direct from his office. The section shown gives a good idea of the inside finish and trim. The cost of building, including platform, is $1,659.85.

PLAN NO. 26 (FIG. 161).

Shows elevations and ground plan of a frame combination depot on the Wabash road of larger size. The building is 22 feet by 150 feet with several breaks. The elevations are drawn with a great deal of taste and command attention, the roof being surmounted by a neat tower. The floor plan is well arranged, giving a large amount of room for the different purposes for which they are intended. The waiting rooms are provided with toilet rooms and the agent's office is up to all requirements. Separate rooms are given for baggage and express, and the building as a whole is fitted for the business of a large town. The inside finish is yellow pine finished in hard oil and the cost of building, without platforms, is $3,554.27.

PLAN NO. 27 (FIG. 162).

Gives elevations, section and floor plan of a small standard, combination depot on the Wabash R. R., 16 feet by 56 feet, showing the construction of the platforms, which are made of old bridge timbers. This depot has the same inside finish as the others and cost, without platforms, $1,095.45.

PLAN NO. 28 (FIG. 163).

Elevations and plan of a small passenger station on the Boston and Maine R. R., at Seabrook. There is but one waiting room, but convenient toilet rooms are provided, together with a baggage room.

PLAN NO. 29 (FIGS. 164-165).

Elevations and plan on the same road at Walnut Hill, Mass., of somewhat similar design as No. 28.

PLAN NO. 30 (FIG. 166).

Elevations and plan of similar design at Sunapee, N. H.

PLAN NO. 31 (FIG. 167).

Floor plan and photograph of frame station at West Manchester, Mass. The arrangement is good and it is evident that the building is in an exposed situation by the number of radiators necessary to keep it warm.

PLAN NO. 32 (FIG. 168).

Front elevation of brick and stone station being erected at Manchester, Mass., by the Boston and Maine R. R.

PLANS NO. 33 AND NO. 34 (FIGS. 169-170-171-172).

Show front and rear elevations and floor plans of two stone stations on the Southern Pacific R. R., at San Carlos and Los Guilucos. These plans are worthy of the attention of every member of the association, as the designs are about perfect, not only in the effect of the elevations but also the arrangements for the comfort of the public.

PLAN NO. 35 (FIGS 173-174).

Gives elevations, section, floor plan, with section showing stationery cases and closets in agent's office of a frame passenger station on the Toledo, Peoria and Western R. R., 20 feet by 60 feet 10 inches, with two waiting rooms and office; also showing construction of platforms.

PLANS NO. 36 AND NO. 37 (FIGS. 175-176-177-178)

Show elevations, floor plans, and sections of two frame combination depots on the same road; one 18 feet by 54 feet and the other 14 feet by 38 feet 4 inches, giving interior details and also construction of platforms.

PLAN NO. 38 (FIGS. 179-180-181-182),

Elevations, floor plan, and section of brick depot at Glen Cove, Long Island. The outside finished with washed brick laid in red mortar. Rubbed bluestone sills and trimmings; tile roof, with copper gutters and leaders. The under side of overhang of roof and the interior of building finished with narrow yellow pine on which is one coat of wood-filler and two coats of spar varnish. The platforms are concrete, running entirely around the building and 400 feet along the track. On each end of the passenger platform is a raised baggage platform 13 feet by 26 feet, level with the car floor. These baggage platforms are built at all stations on this road to facilitate the handling of baggage and express, which is very heavy during the summer months. The cost of this station, with platforms complete, was $9,736.64.

PLAN NO. 39 (FIGS. 183-184-185-186).

Brick station at Oakdale, L. I. A two-story structure, with living rooms for the agent. Inside finish three coats plaster painted a light terra-cotta color. The platforms at this station are wood; 3x8-inch yellow pine stringers resting on chestnut posts set 3 feet in the ground and 6 feet centers. The stringers are laid 3 feet centers and 1½-inch to 2-inch yellow pine used for planking. High baggage platforms are placed at each end.

The committee feel that in the above list of stations the members of the association have had placed before them lists that will repay them if they are carefully studied, but at the same time we regret that the members sending in plans did not go into the style and construction of platforms and also the cost of the buildings sent in. We have no doubt, however, that this part can be fully brought out in the discussions of this report. Respectfully submitted.

J. H. CUMMIN, Long Island Ry.,
N. M. MARKLEY, C., C., C. & St. L. Ry.,
J. H. MARKLEY, T., P. & W. Ry.,
C. G. WORDEN, So. California Ry.,
Committee.

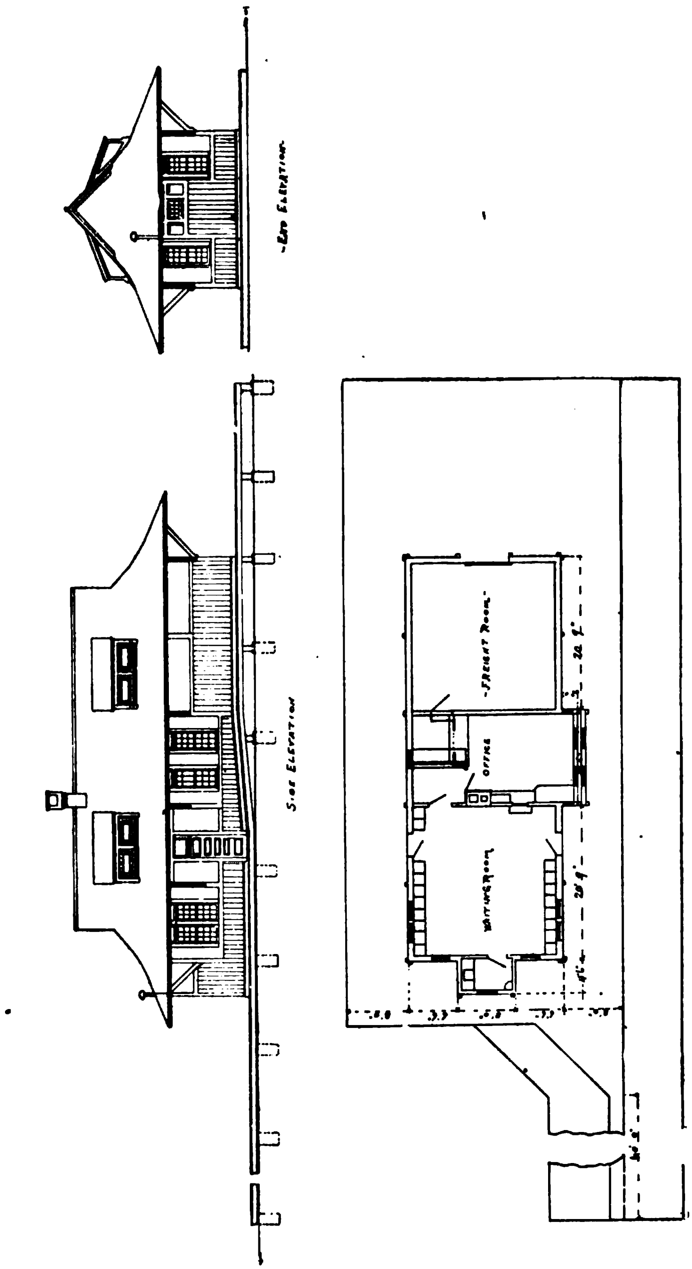


FIG. 134—LOCAL COMBINATION DEPOT, BUFFALO DIVISION, LEHIGH VALLEY R. R. (PLAN NO. 1.)

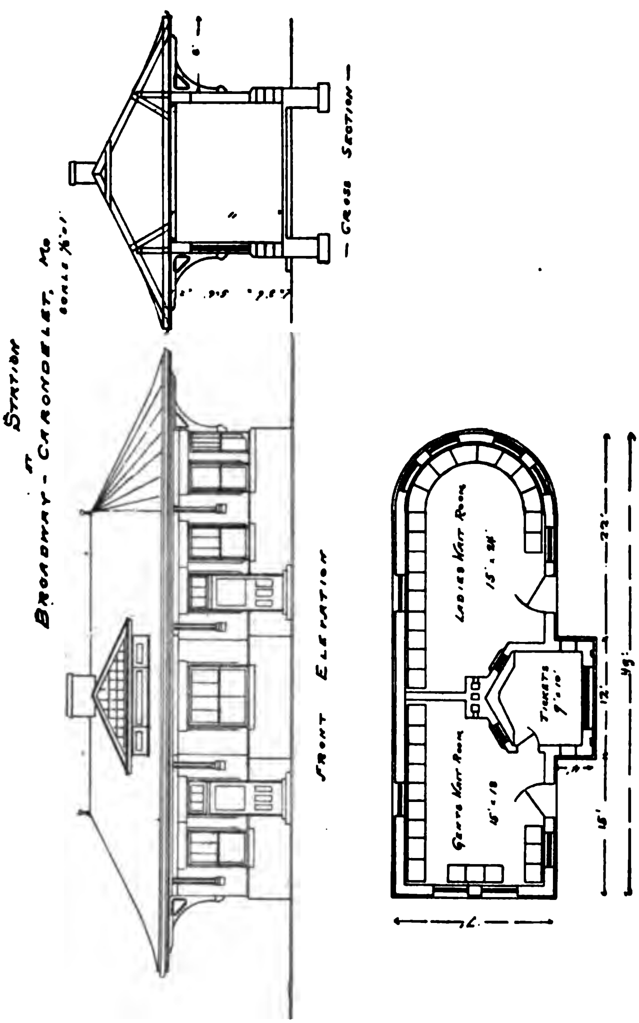


FIG. 135—LOCAL PASSENGER DEPOT AT CARONDELET, MO., MISSOURI PACIFIC R. R. (PLAN NO. 2.)

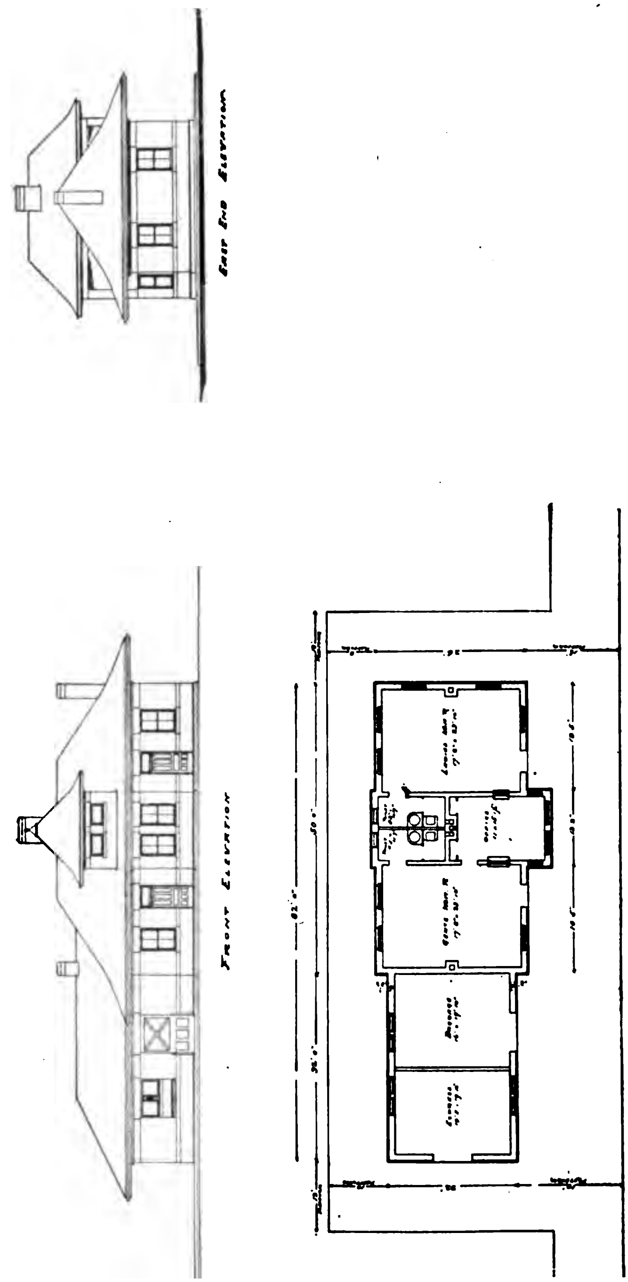


FIG. 136—LOCAL PASSENGER DEPOT, MISSOURI PACIFIC R. R. (PLAN NO. 8.)

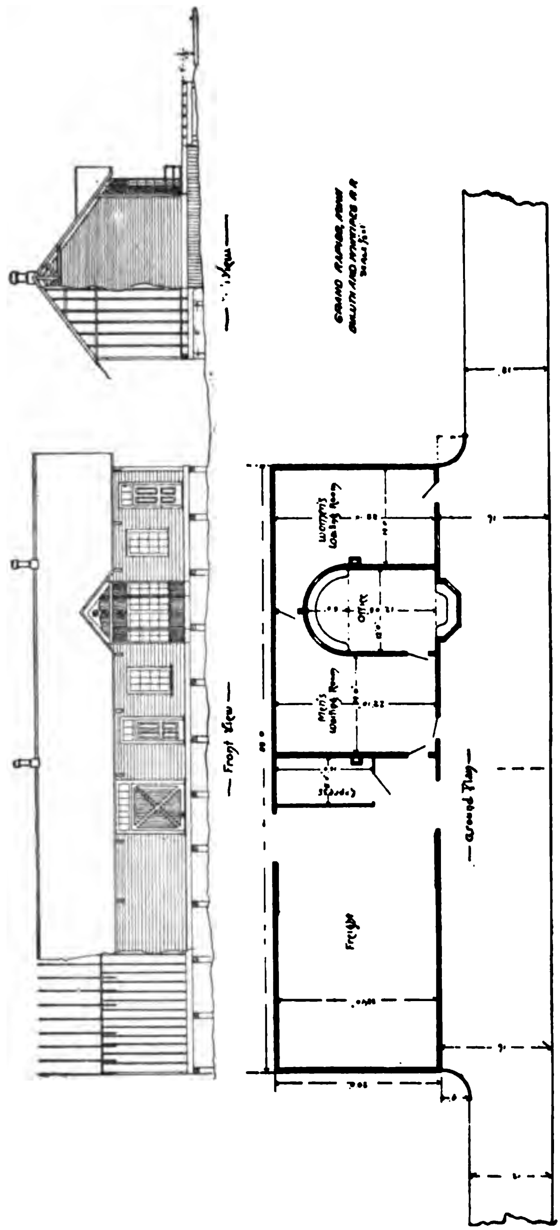


FIG. 137—LOCAL COMBINATION DEPOT, DULUTH AND WINNIPEG R. R. (PLAN NO. 4.)

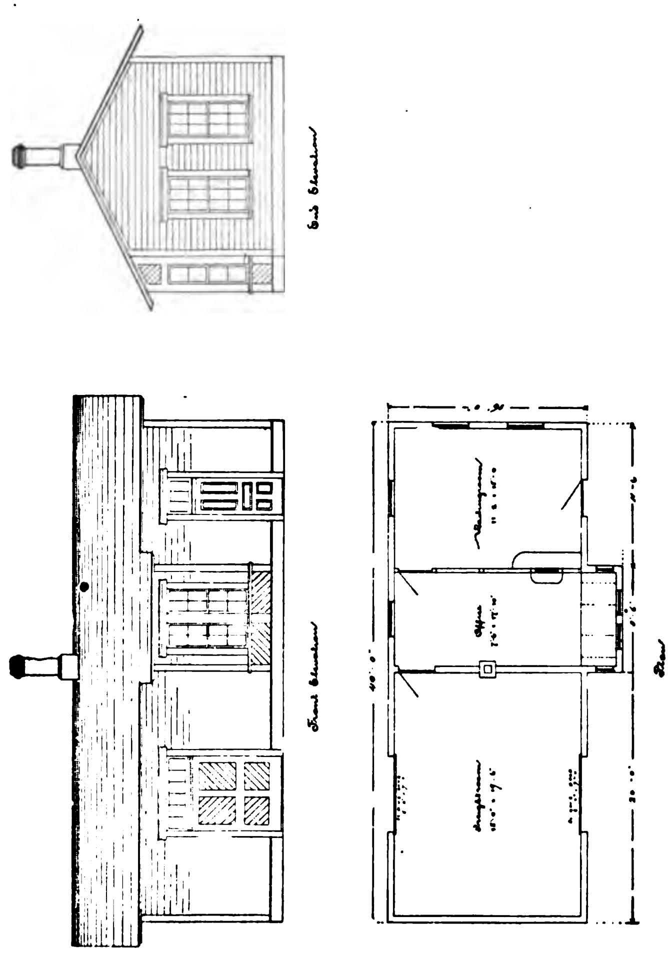


FIG. 138—LOCAL COMBINATION DEPOT, CHICAGO AND EASTERN ILLINOIS R. R. (PLAN NO. 5)

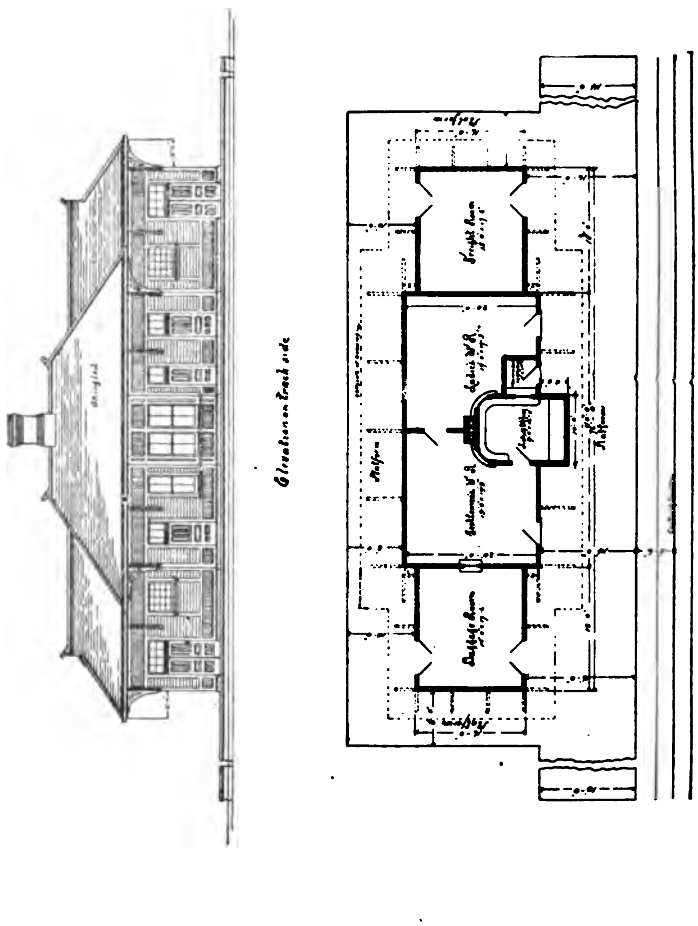


FIG. 189—LOCAL PASSENGER DEPOT, ILLINOIS CENTRAL R. R. (PLAN NO. 6.)

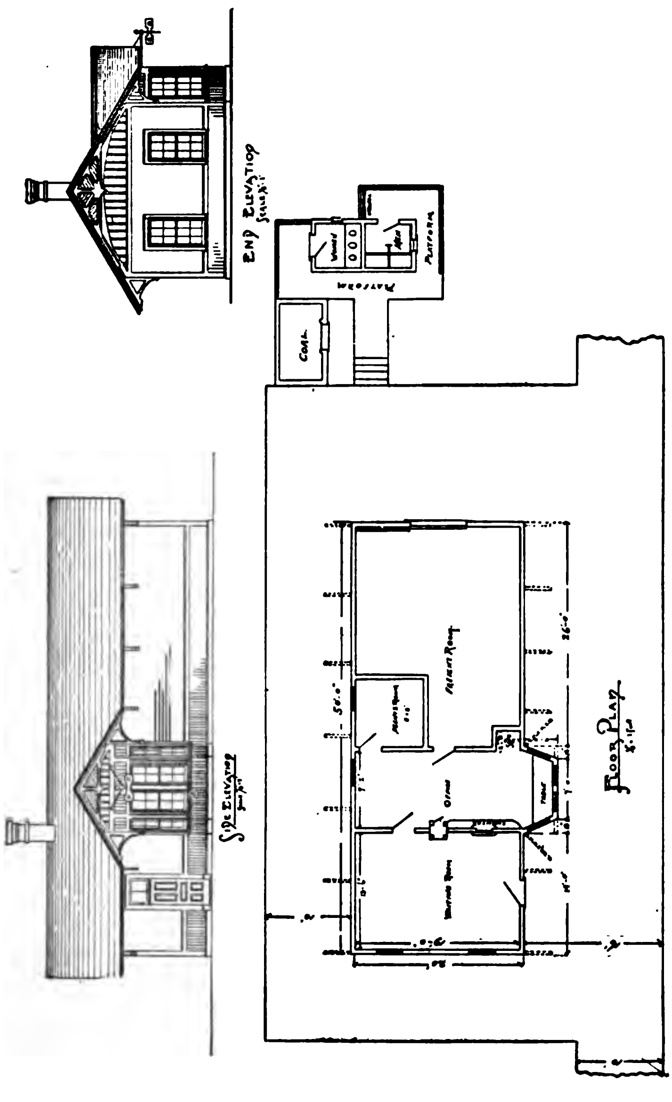


FIG. 140—STANDARD LOCAL COMBINATION DEPOT, UNION PACIFIC R. R. (PLAN NO. 7.)

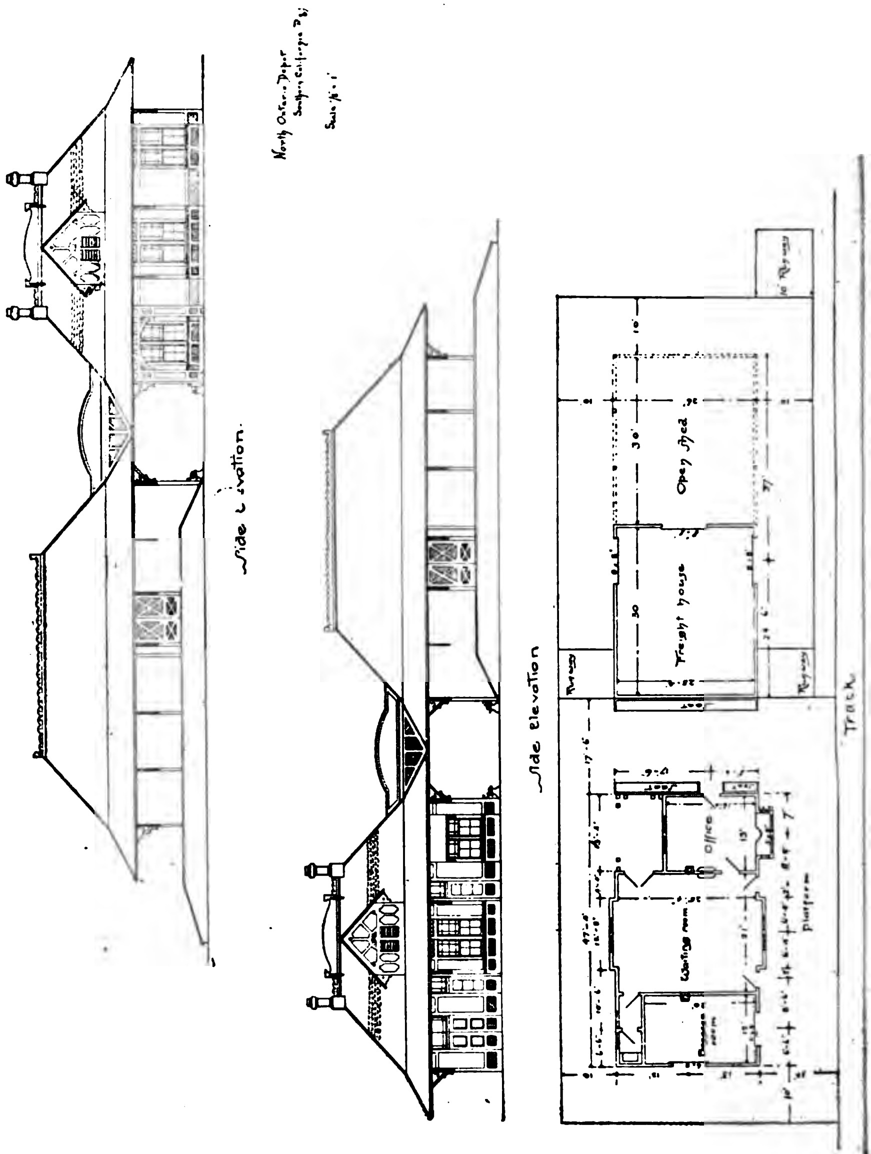


FIG. 141—LOCAL COMBINATION DEPOT, SOUTHERN CALIFORNIA R. R. (PLAN NO. 8.)

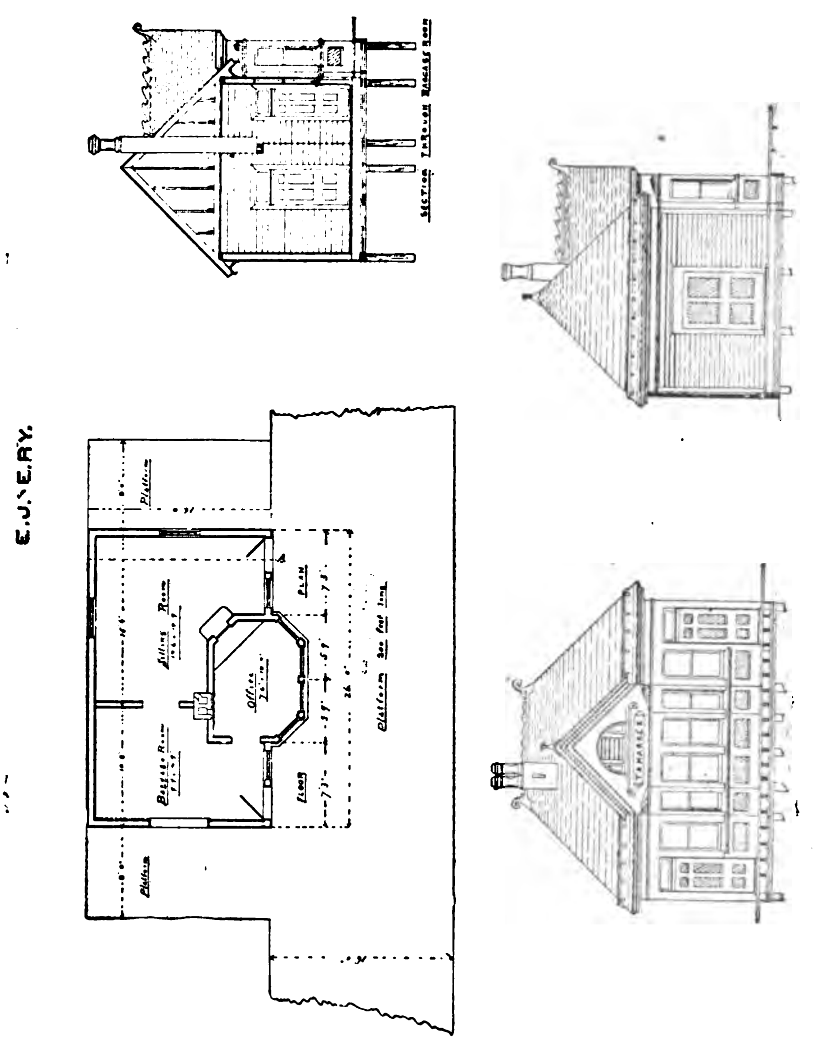


FIG 142.—LOCAL PASSENGER DEPOT, ELGIN, JOLIET AND EASTERN R. R. (PLAN NO. 9.)

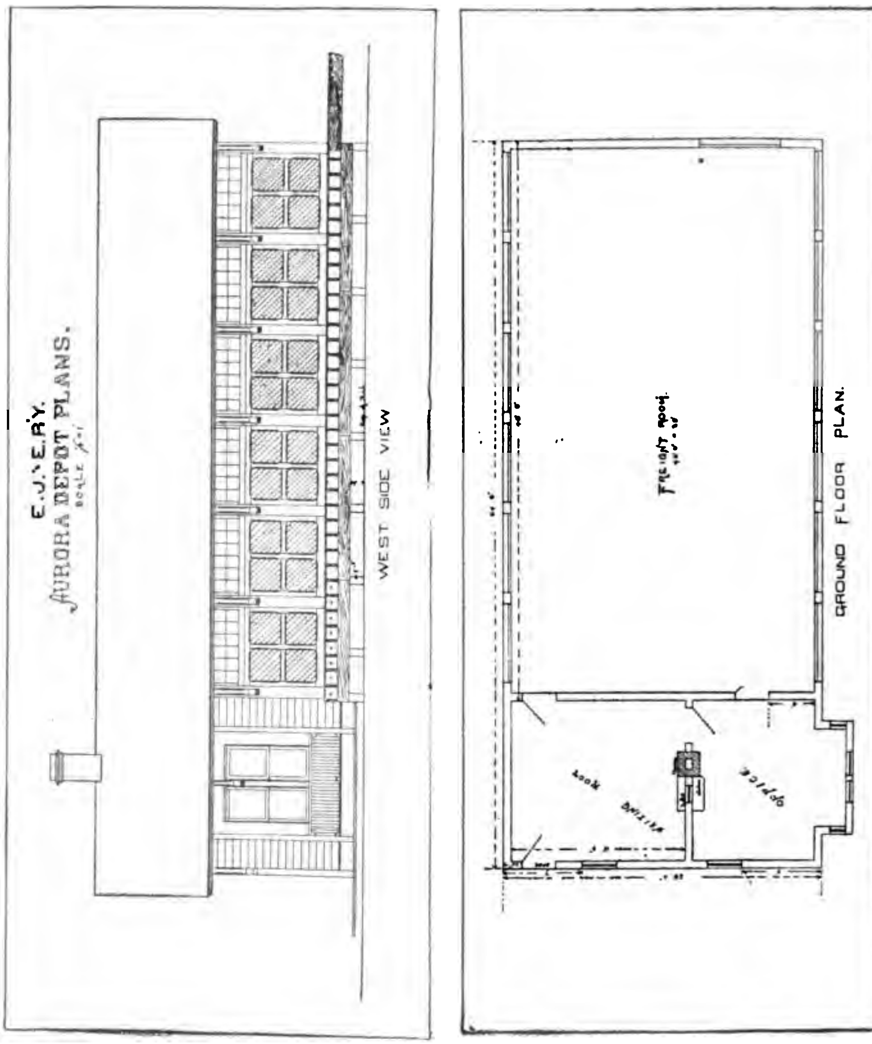


FIG. 148.—LOCAL COMBINATION DEPOT, ELGIN, JOLIET AND EASTERN R. R. (PLAN NO. 10.)

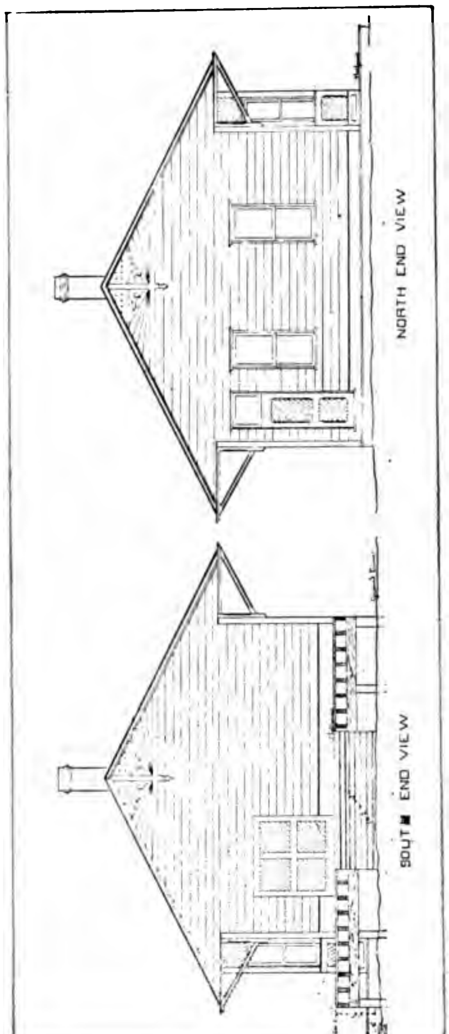


FIG. 144—(PLAN NO. 10—CONTINUED.)

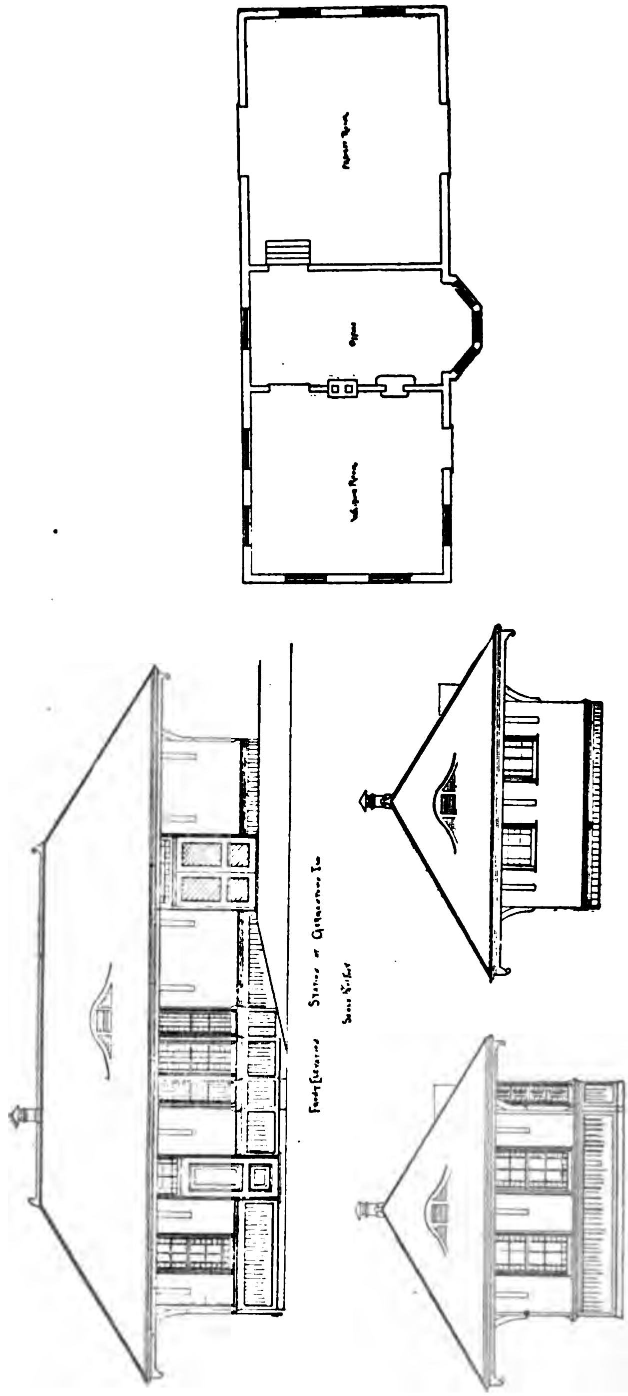


FIG. 145—LOCAL COMBINATION DEPOT, AT GERMANTOWN, ILL., LAKE ERIE AND ST. LOUIS R. R. (PLAN NO. 11.)

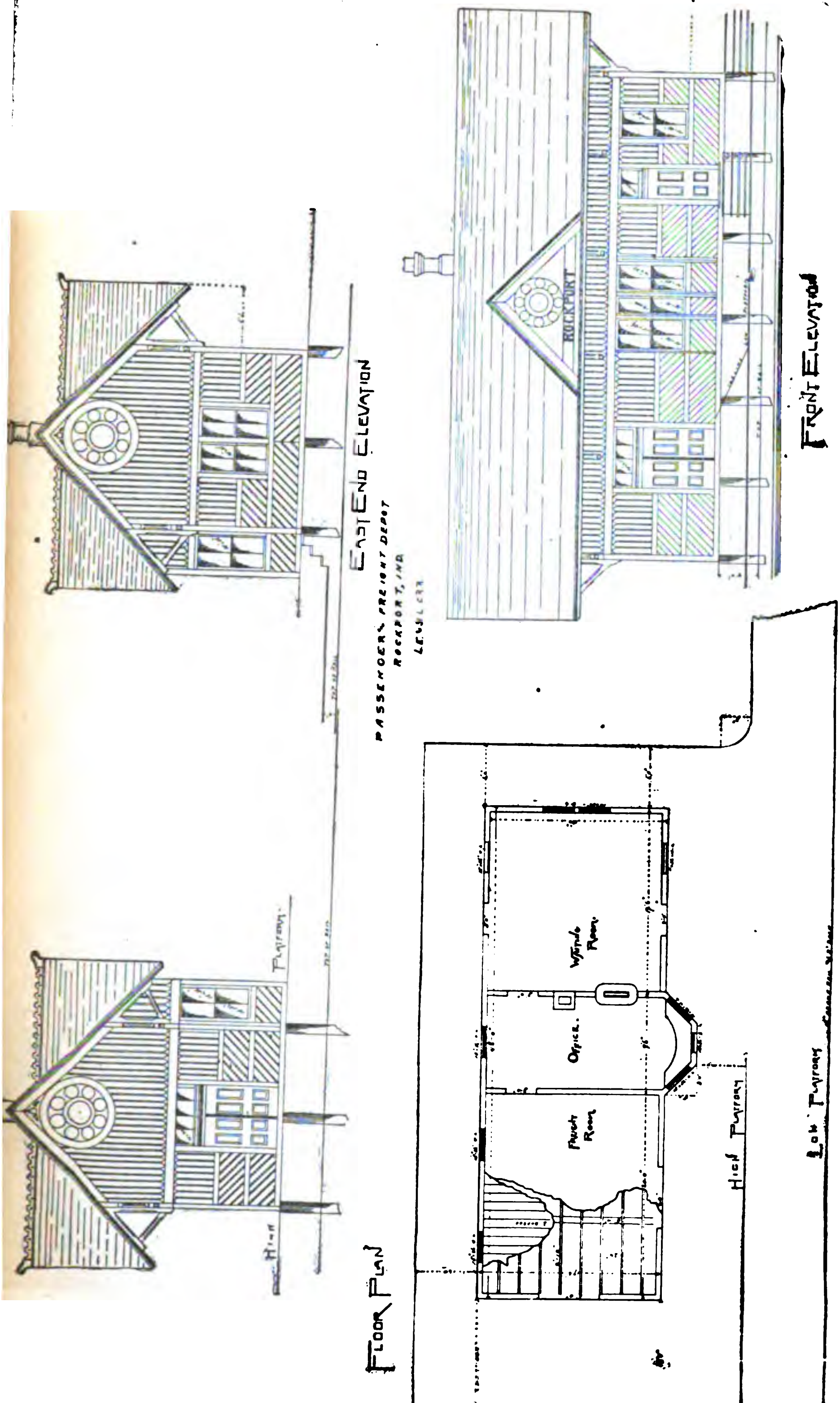


FIG. 146.—LOCAL COMBINATION DEPOT AT ROCKPORT, IND., LAKE ERIE AND ST. LOUIS R. R.—(PLAN NO. 12.)

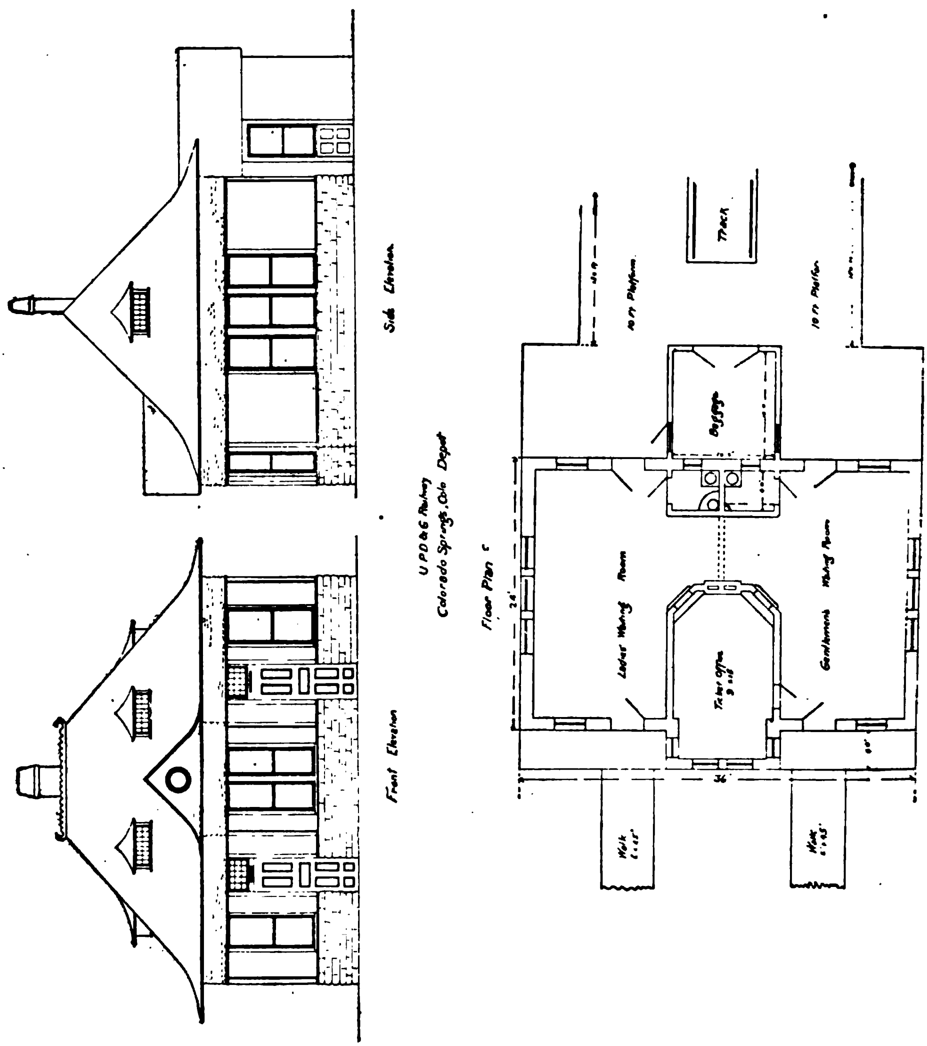


FIG. 147.—LOCAL PASSENGER DEPOT AT COLORADO SPRINGS, COL., U., P., D. AND G. R. R. (PLAN NO. 18.)

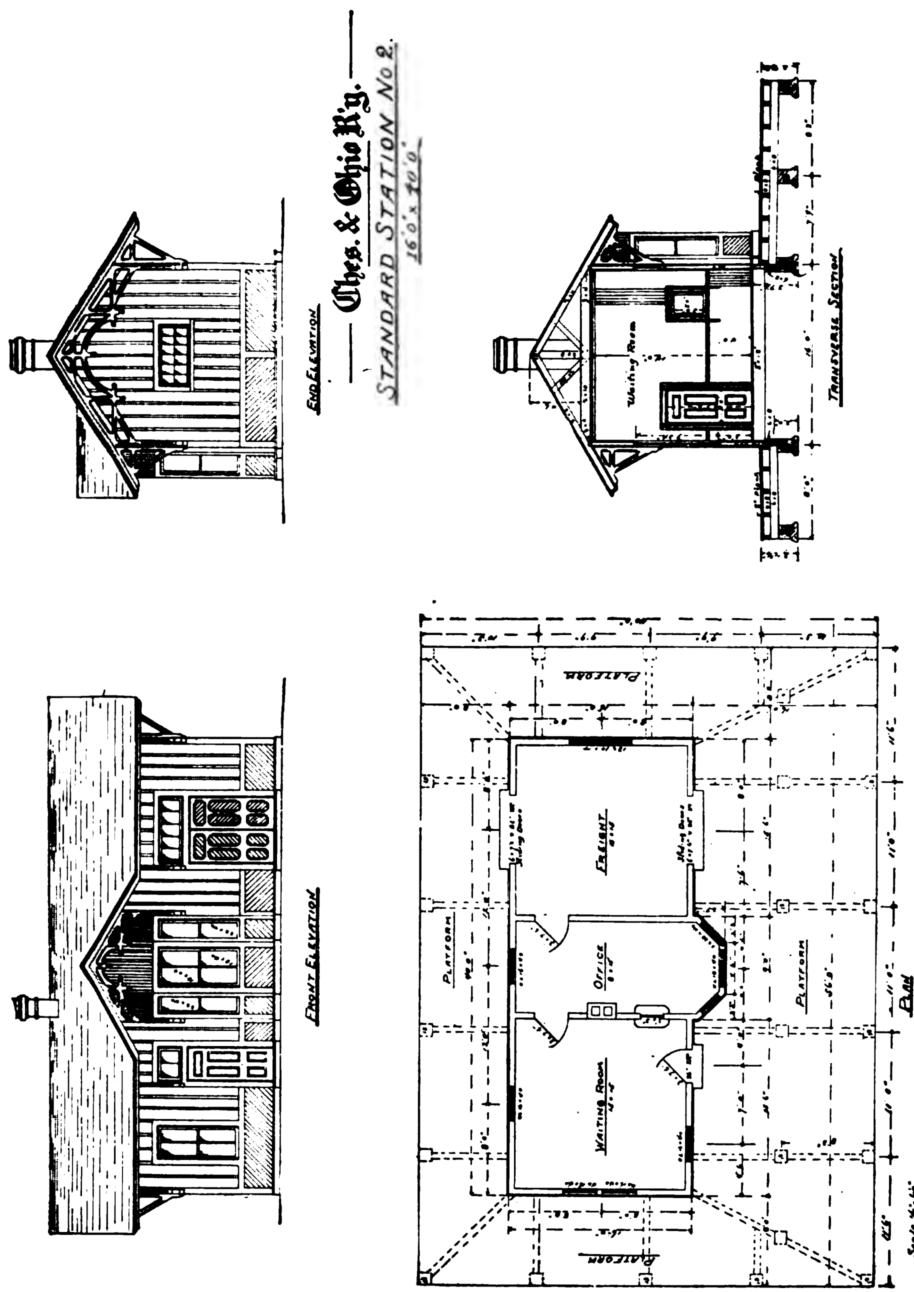
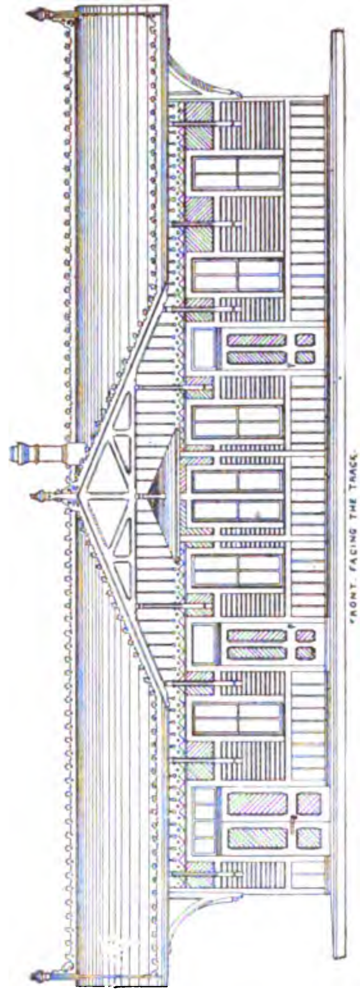
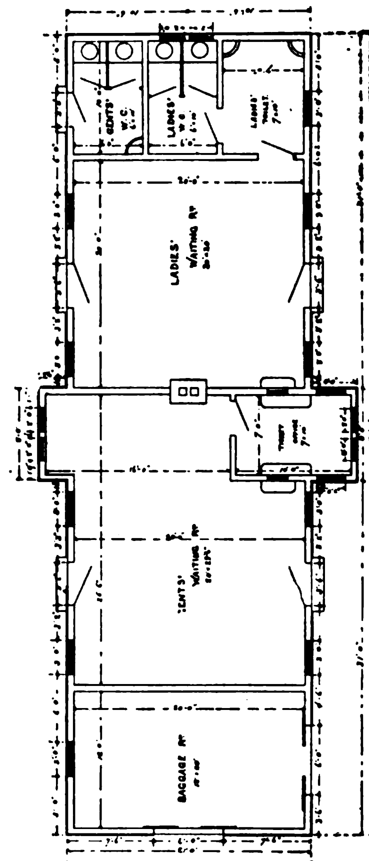


FIG. 148—STANDARD LOCAL COMBINATION DEPOT, NO. 2, CHESAPEAKE AND OHIO R. R. (PLAN NO. 14.)





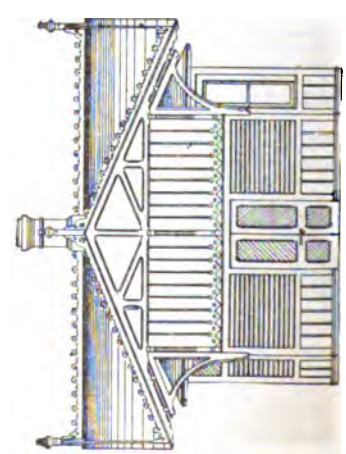


FIG. 149—LOCAL PASSENGER DEPOT, PENNSYLVANIA LINES WEST OF PITTSBURGH. (PLAN NO. 15.)

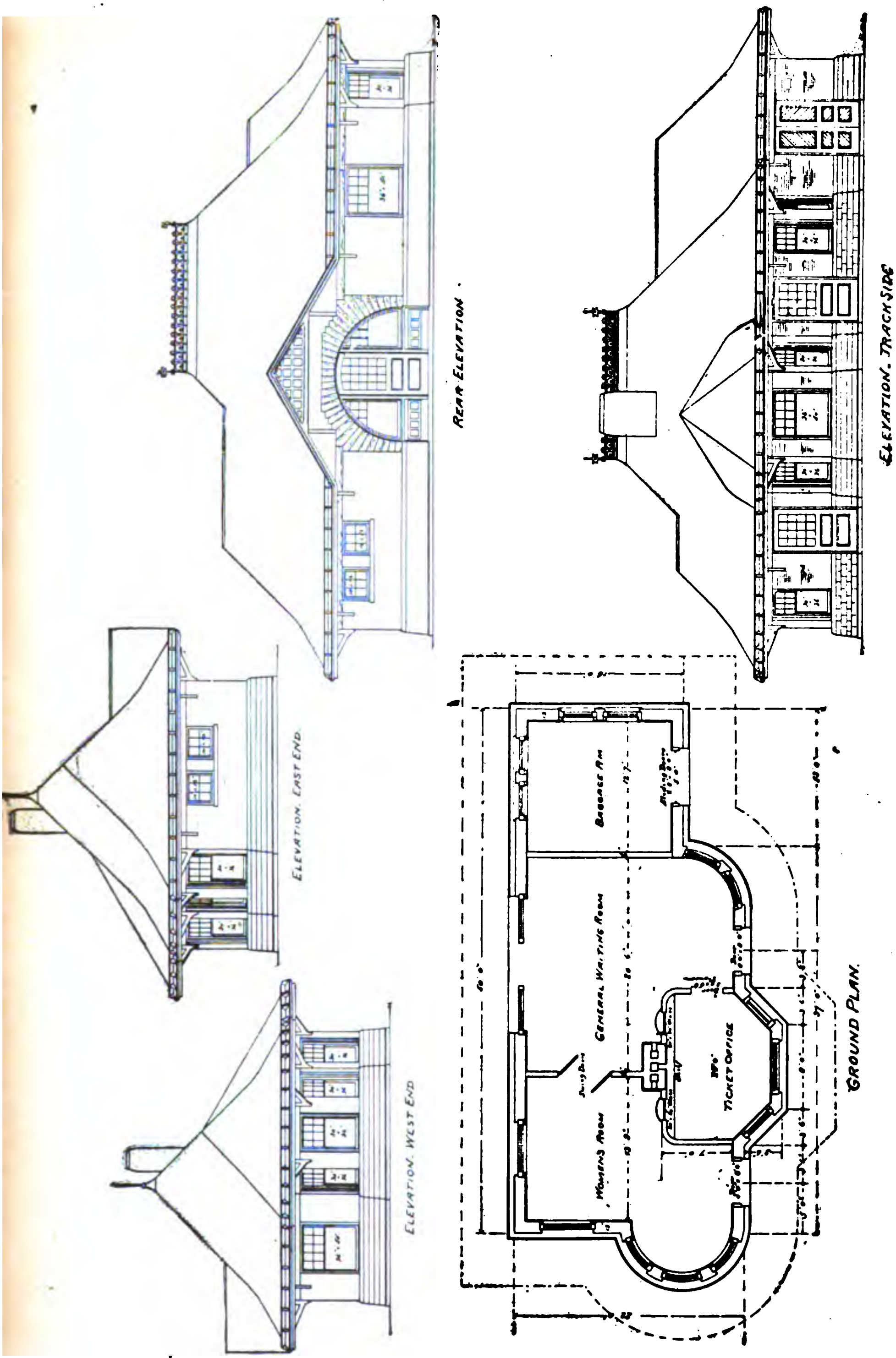


FIG. 150—LOCAL PASSENGER DEPOT AT SOUTHSIDE, O., C., C., C. AND ST. LOUIS R. R. (PLAN NO. 16.)

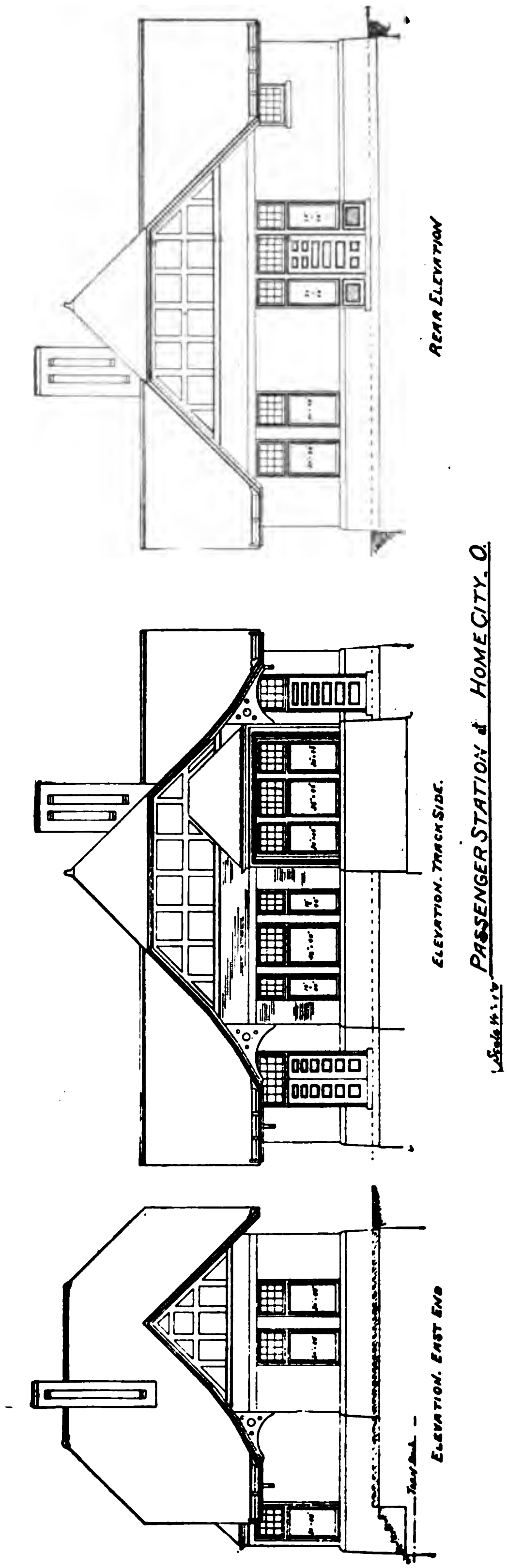


FIG. 151—LOCAL PASSENGER DEPOT AT HOME CITY, O., C., C., C. AND ST. LOUIS R. R. (PLAN NO. 17.)

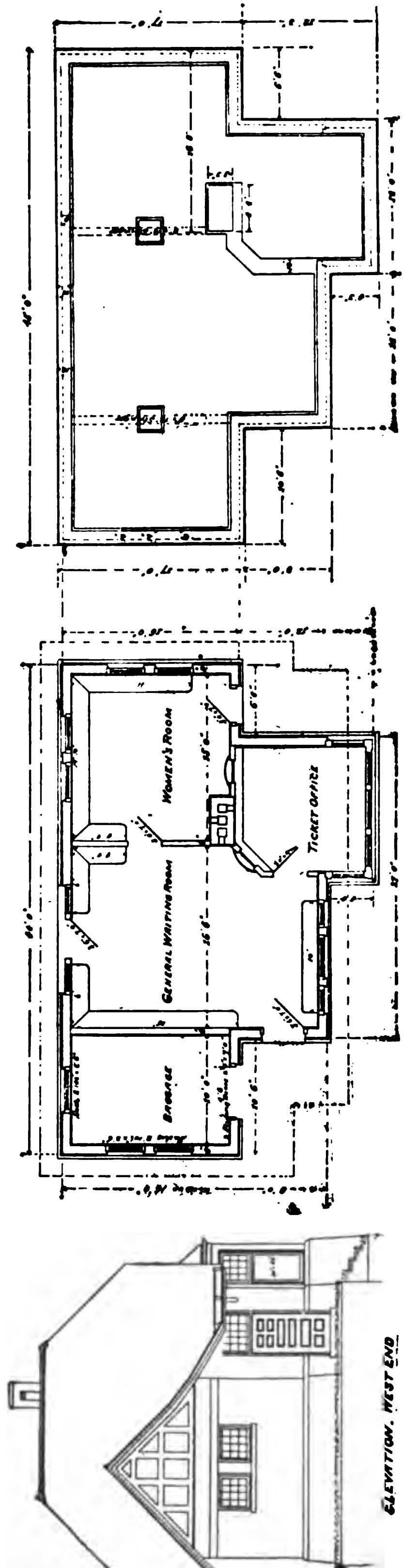


FIG. 152—(PLAN NO. 17—CONTINUED.)

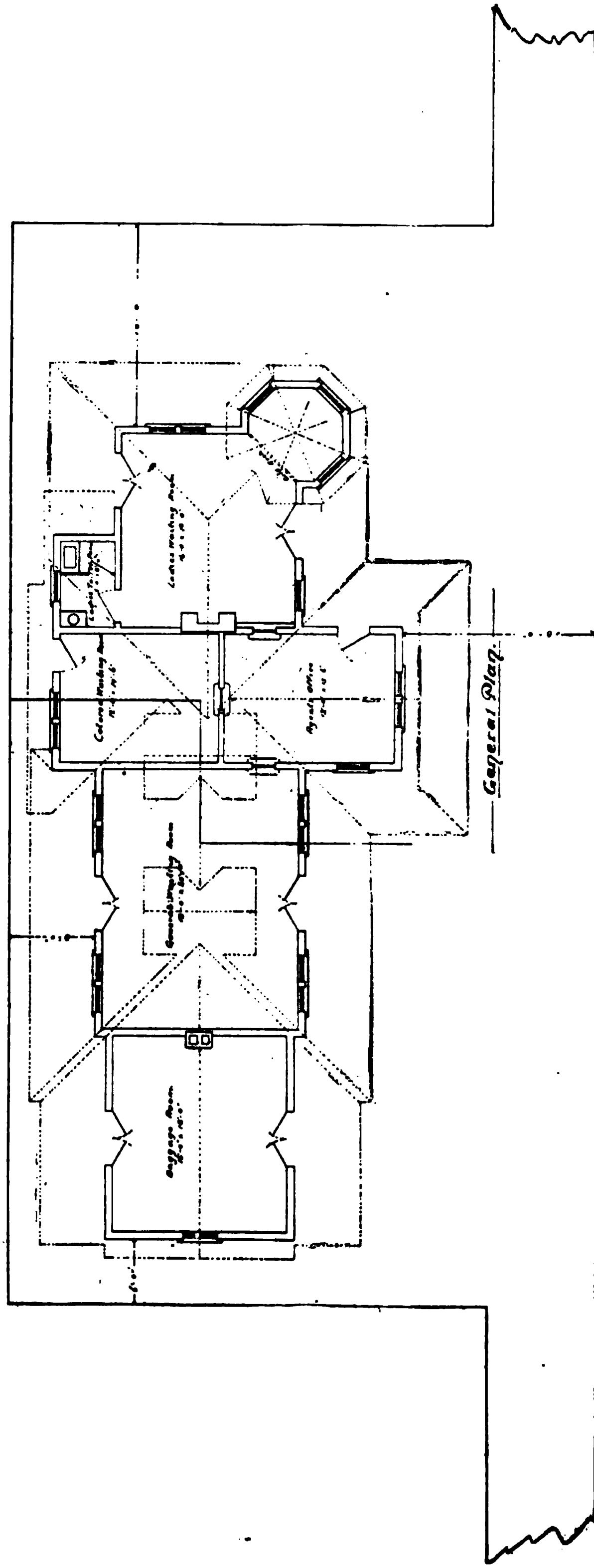


FIG. 158—FLOOR PLAN OF LOCAL PASSENGER DEPOT AT RICHMOND, KY., LOUISVILLE AND NASHVILLE R. R. (PLANS NOS. 18 AND 19.)

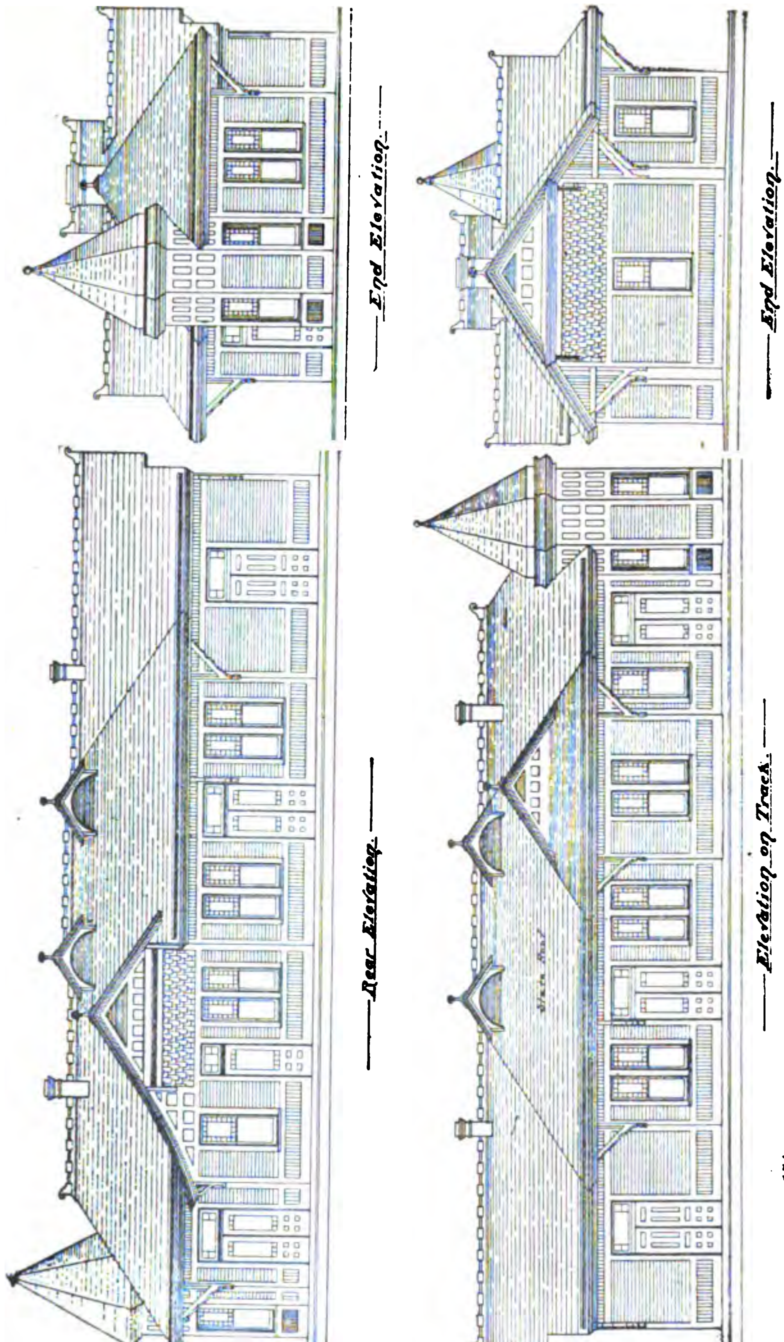


FIG. 154—ELEVATIONS OF LOCAL PASSENGER DEPOT AT RICHMOND, KY., LOUISVILLE AND NASHVILLE R. R.
(PLANS NOS. 18 AND 19—CONTINUED.)

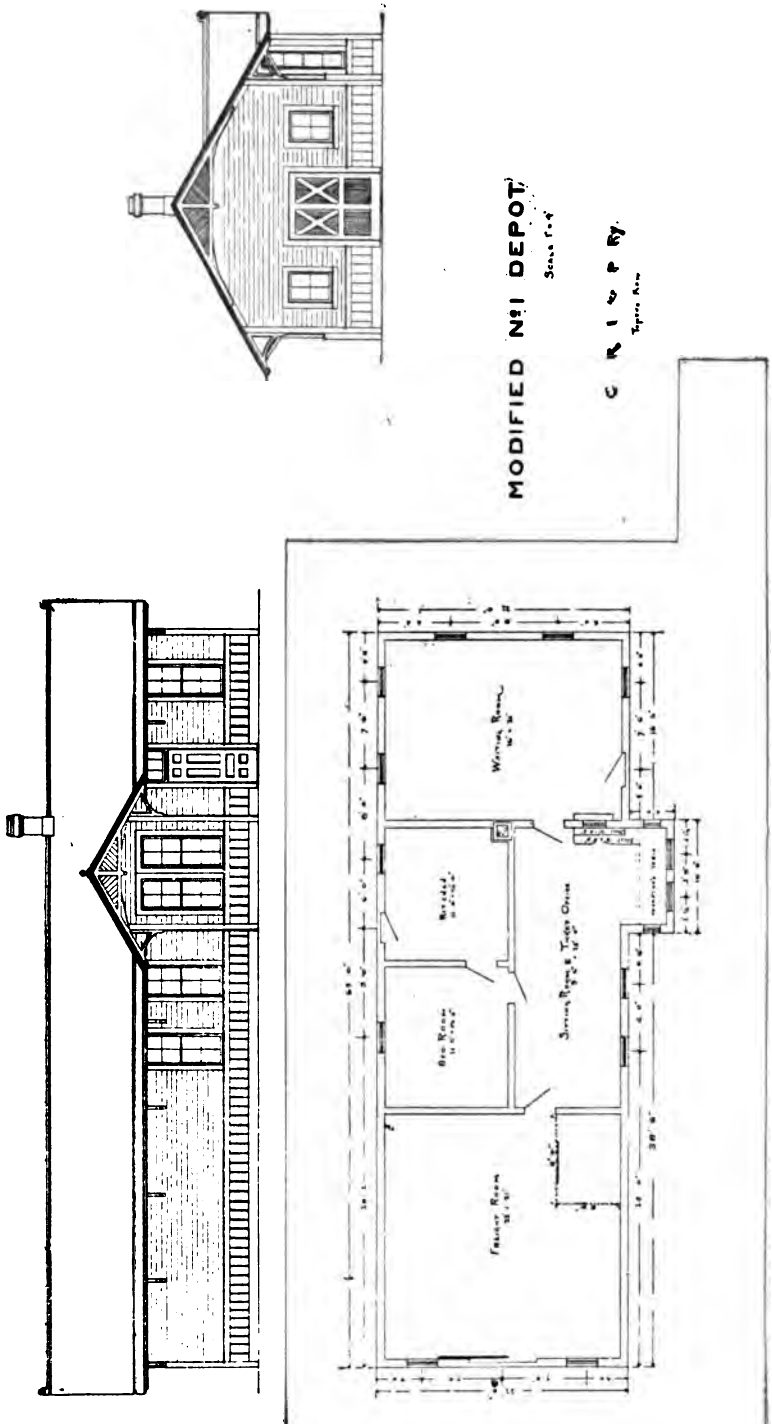


FIG. 155.—LOCAL COMBINATION DEPOT, NO. 1, CHICAGO, ROCK ISLAND AND PACIFIC R. R. (PLAN NO. 20.)

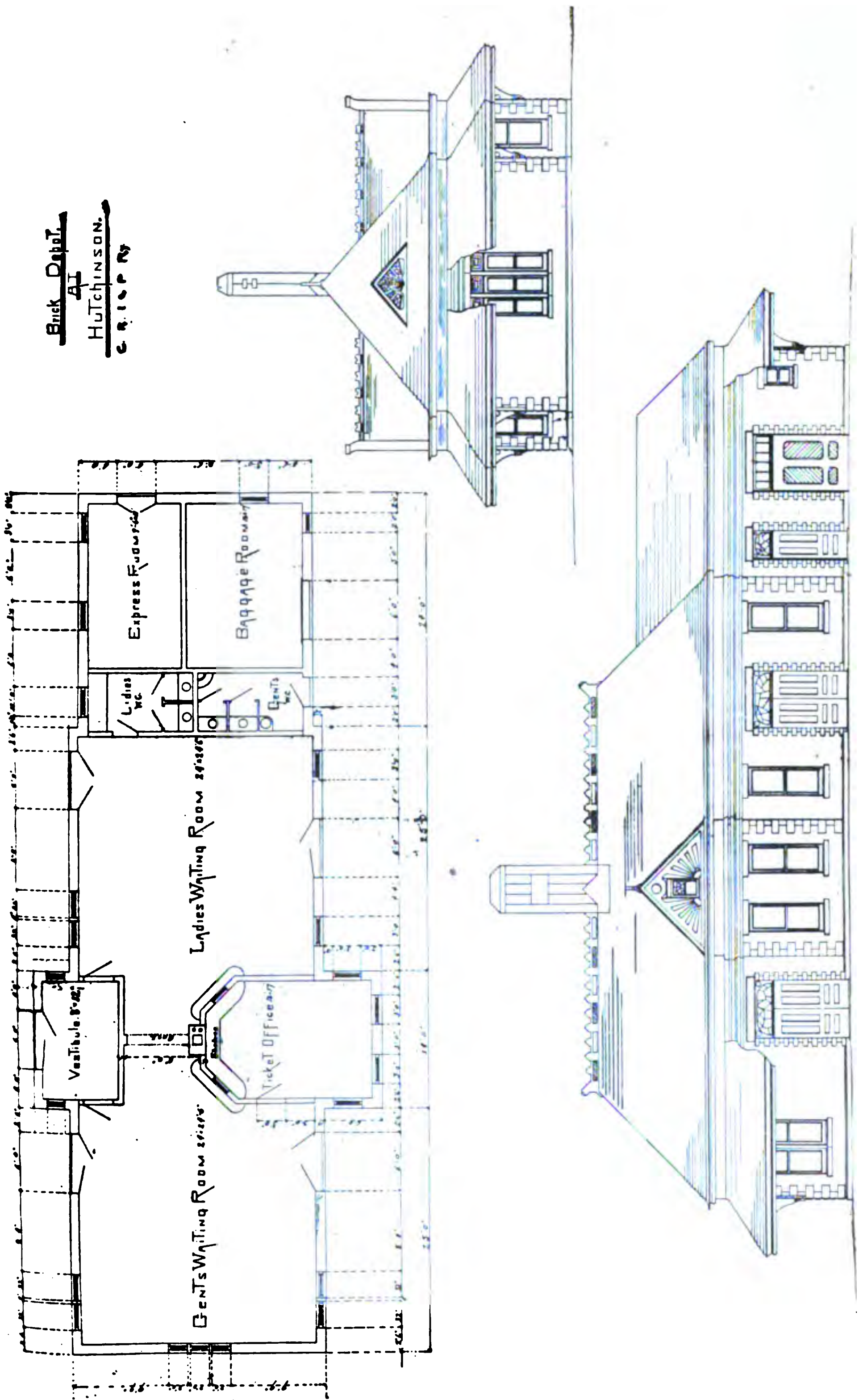


FIG. 156—LOCAL PASSENGER DEPOT AT HUTCHINSON, CHICAGO, ROCK ISLAND AND PACIFIC R. R. (PLAN NO. 21.)

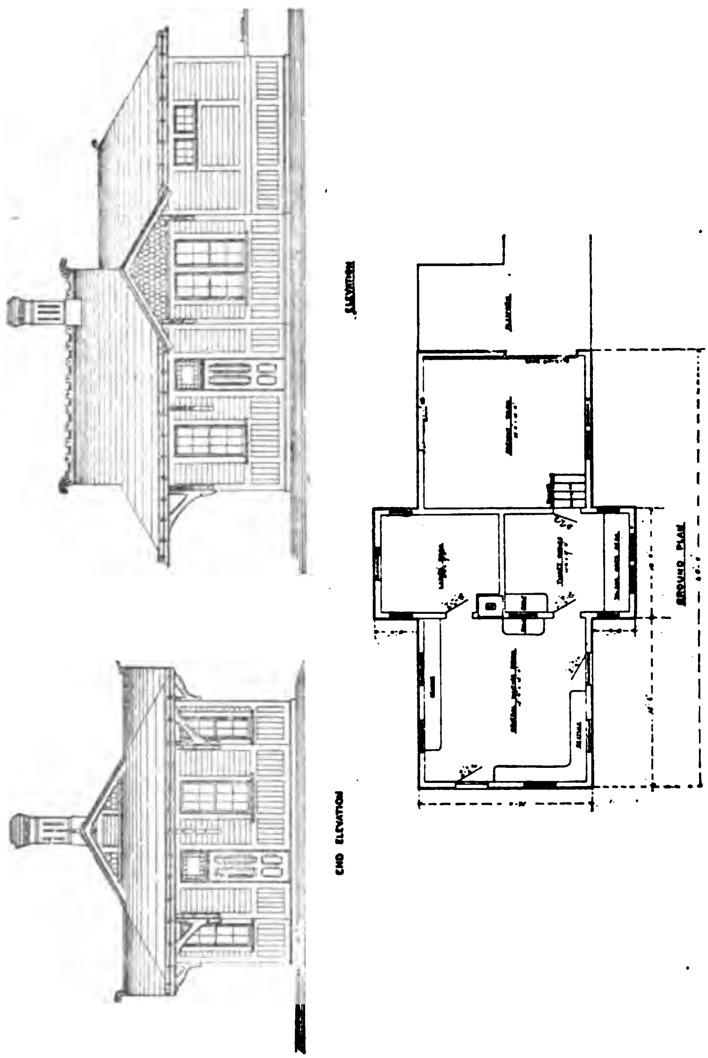


FIG. 157—LOCAL COMBINATION DEPOT AT KING'S CREEK, O., NEW YORK, LAKE ERIE AND WESTERN R. R. (PLAN NO. 22.)

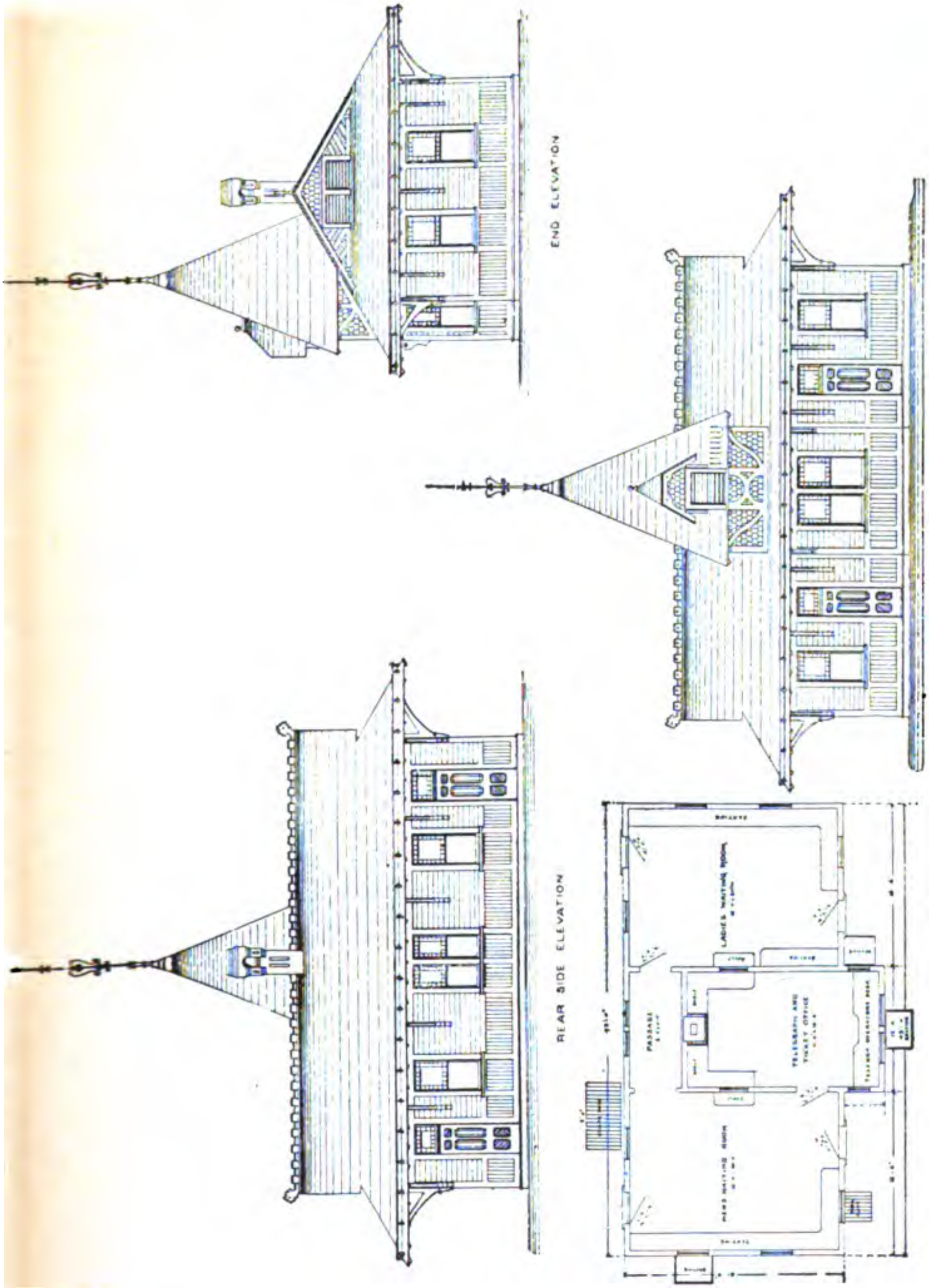


FIG. 168—LOCAL PASSENGER DEPOT AT BARBERTON, O., NEW YORK, LAKE ERIE AND WESTERN R. R. (PLAN NO. 23.)

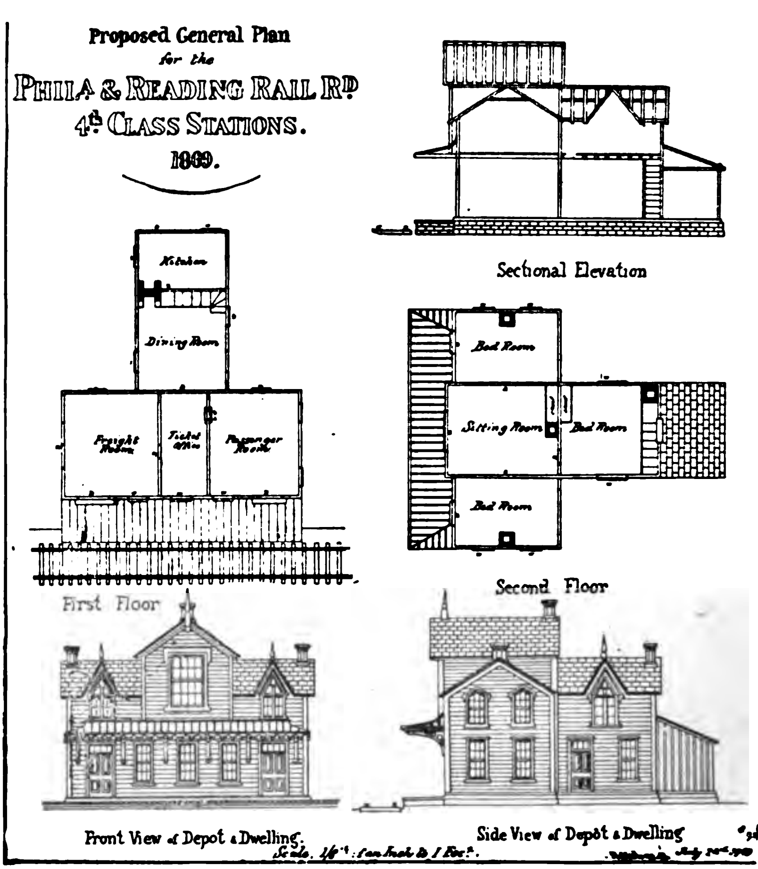


FIG. 159—LOCAL FOURTH-CLASS COMBINATION DEPOT, PHILADELPHIA AND READING R. R. DESIGNED IN 1869. (PLAN NO. 24.)

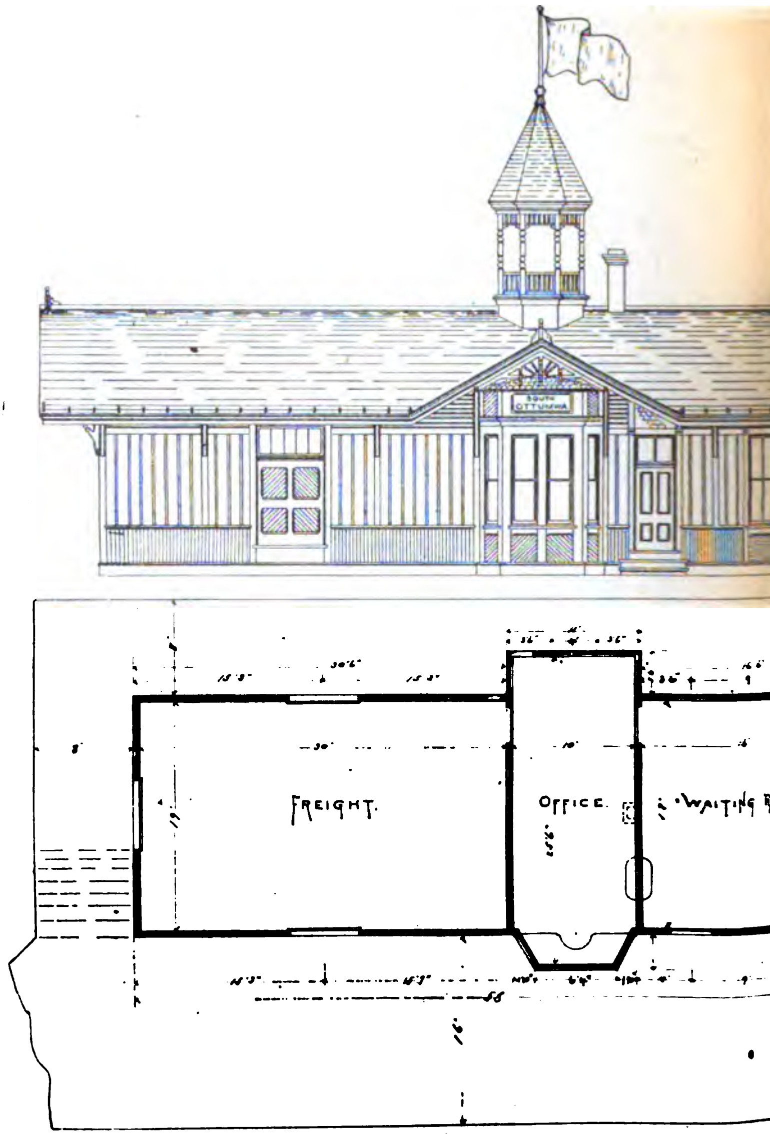
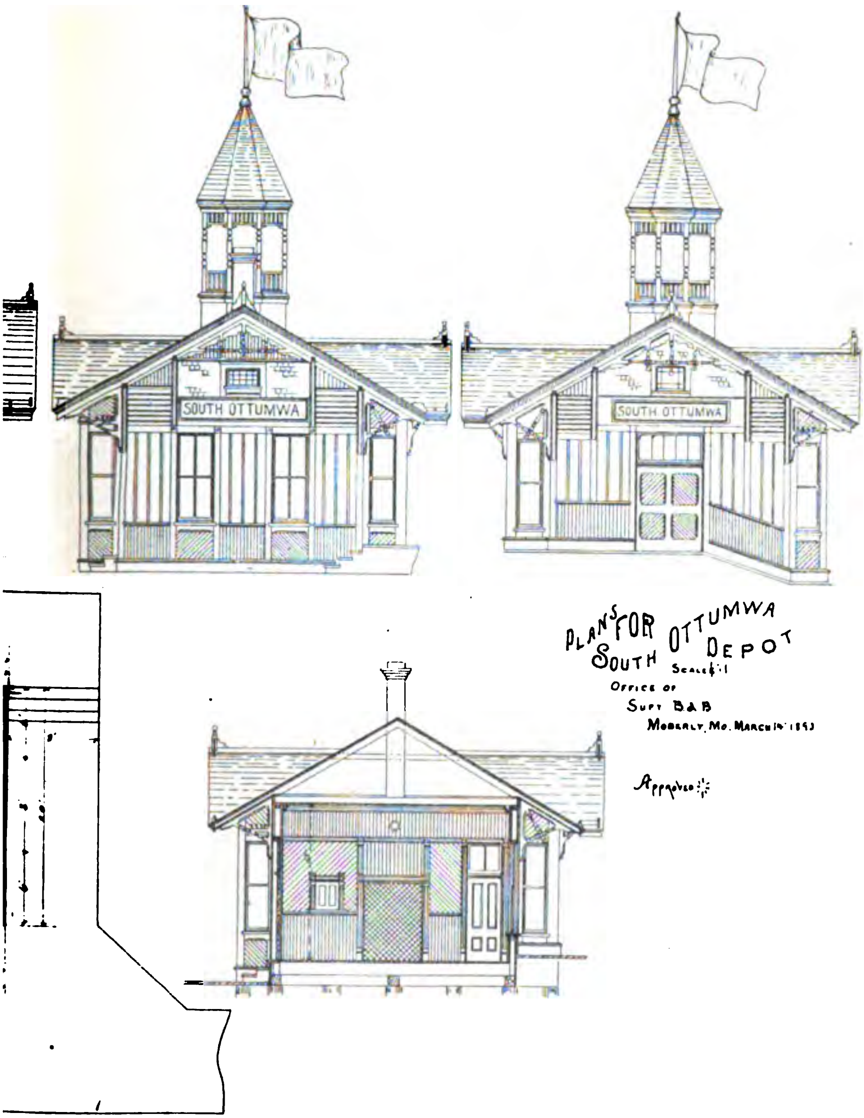


FIG. 160—LOCAL COMBINATION DEPOT



UTH OTTUMWA, WABASH R. R. (PLAN NO. 25.)

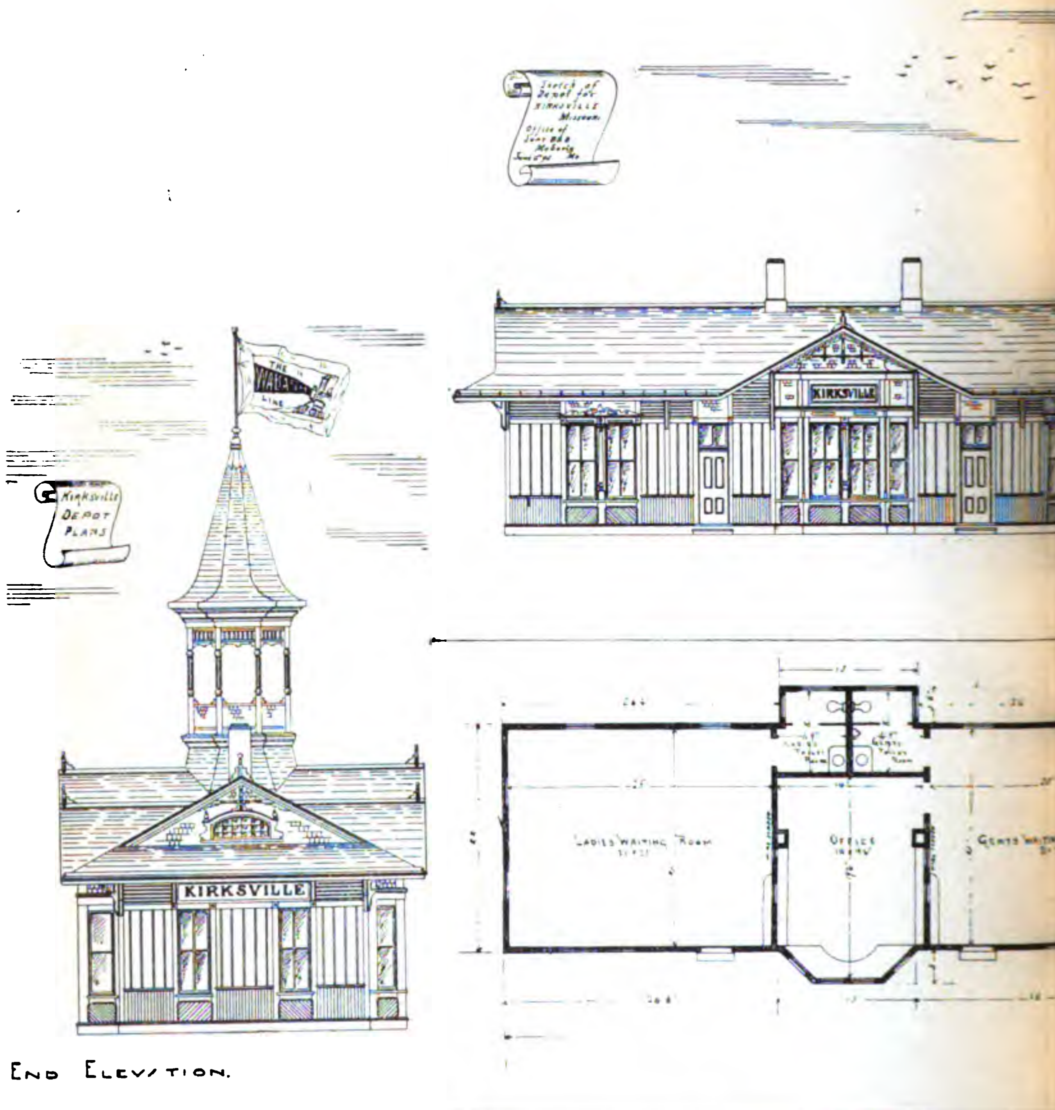
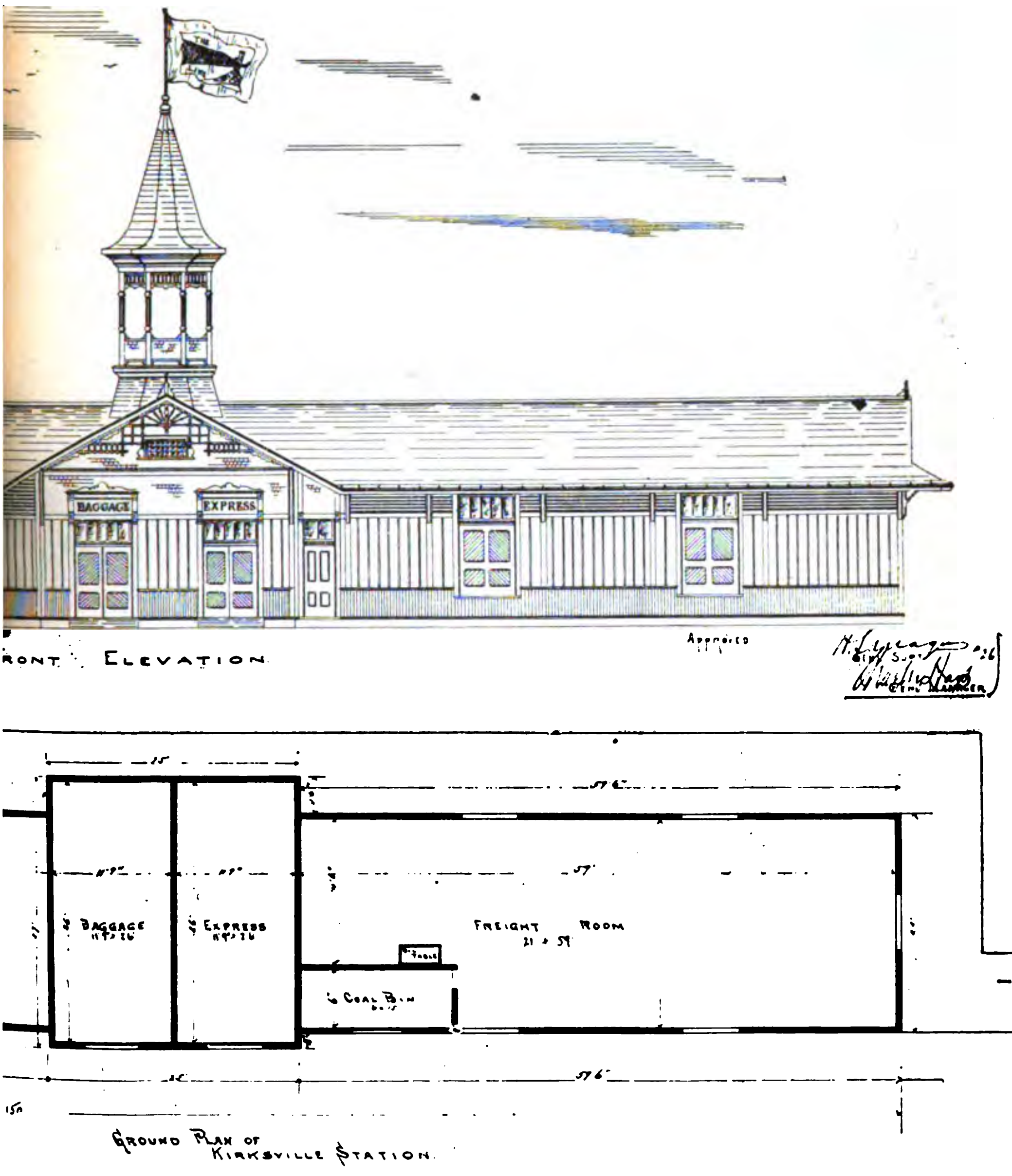


FIG. 161—LOCAL COMBINATION DEPOT AT



SVILLE, WABASH R. R. (PLAN NO. 26.)

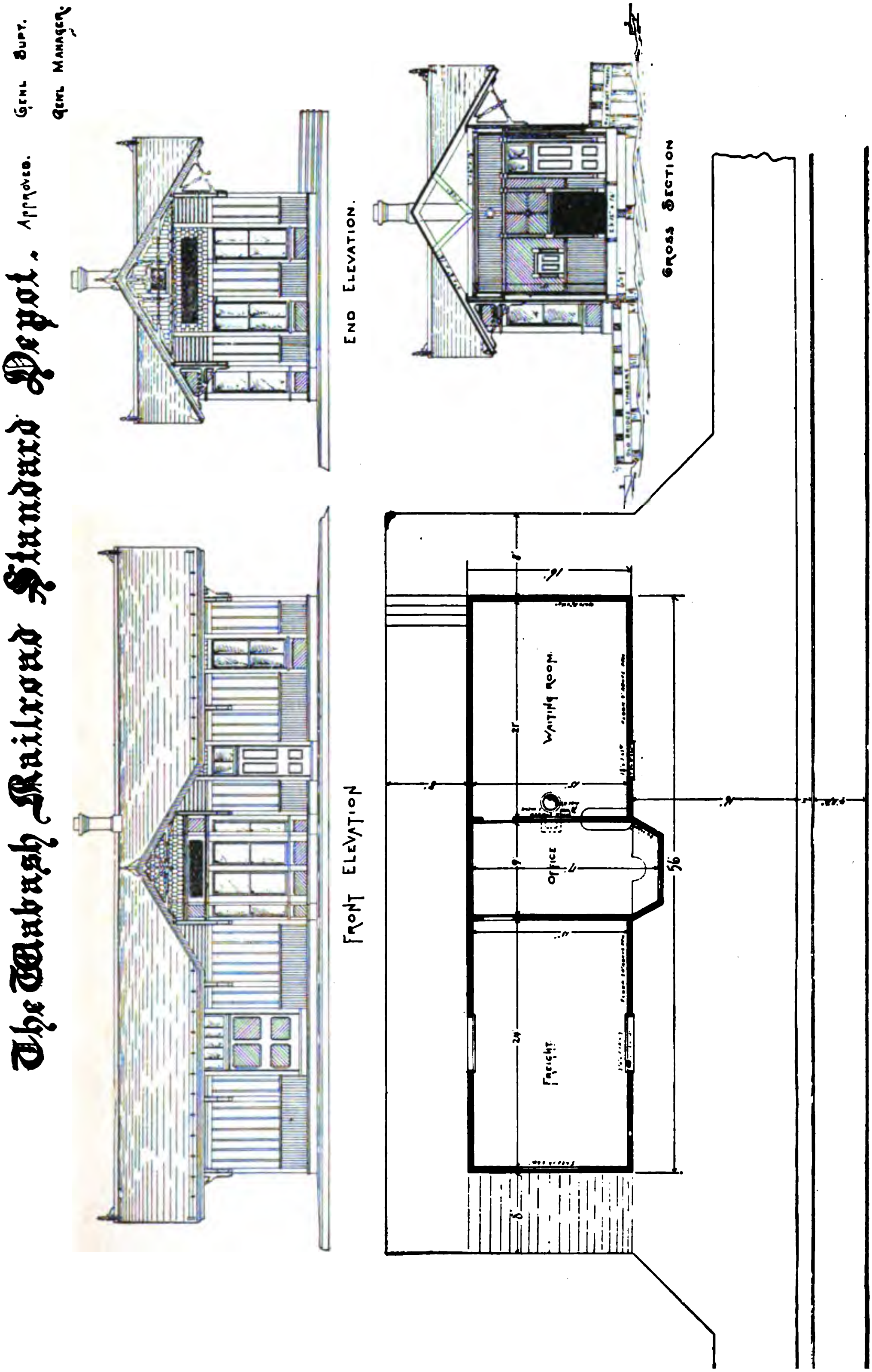


FIG. 162—STANDARD LOCAL COMBINATION DEPOT, WABASH R. R. (PLAN NO. 27.)

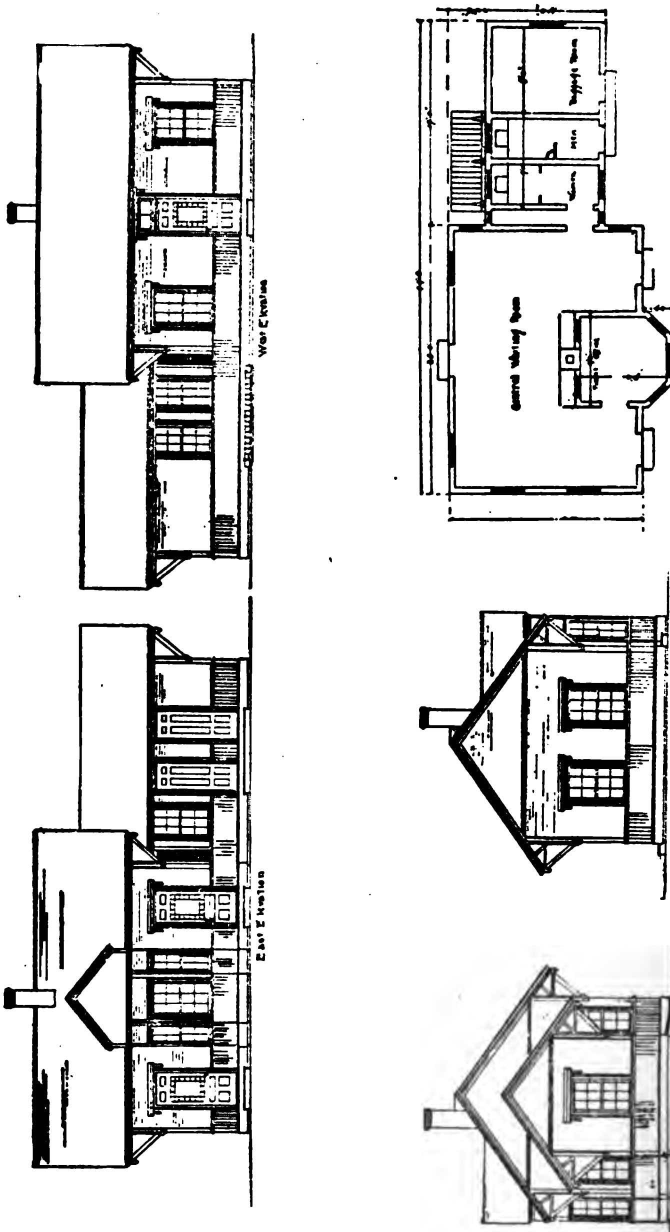


FIG. 163—LOCAL PASSENGER DEPOT AT SEABROOK, BOSTON AND MAINE R. R. (PLAN NO. 28.)

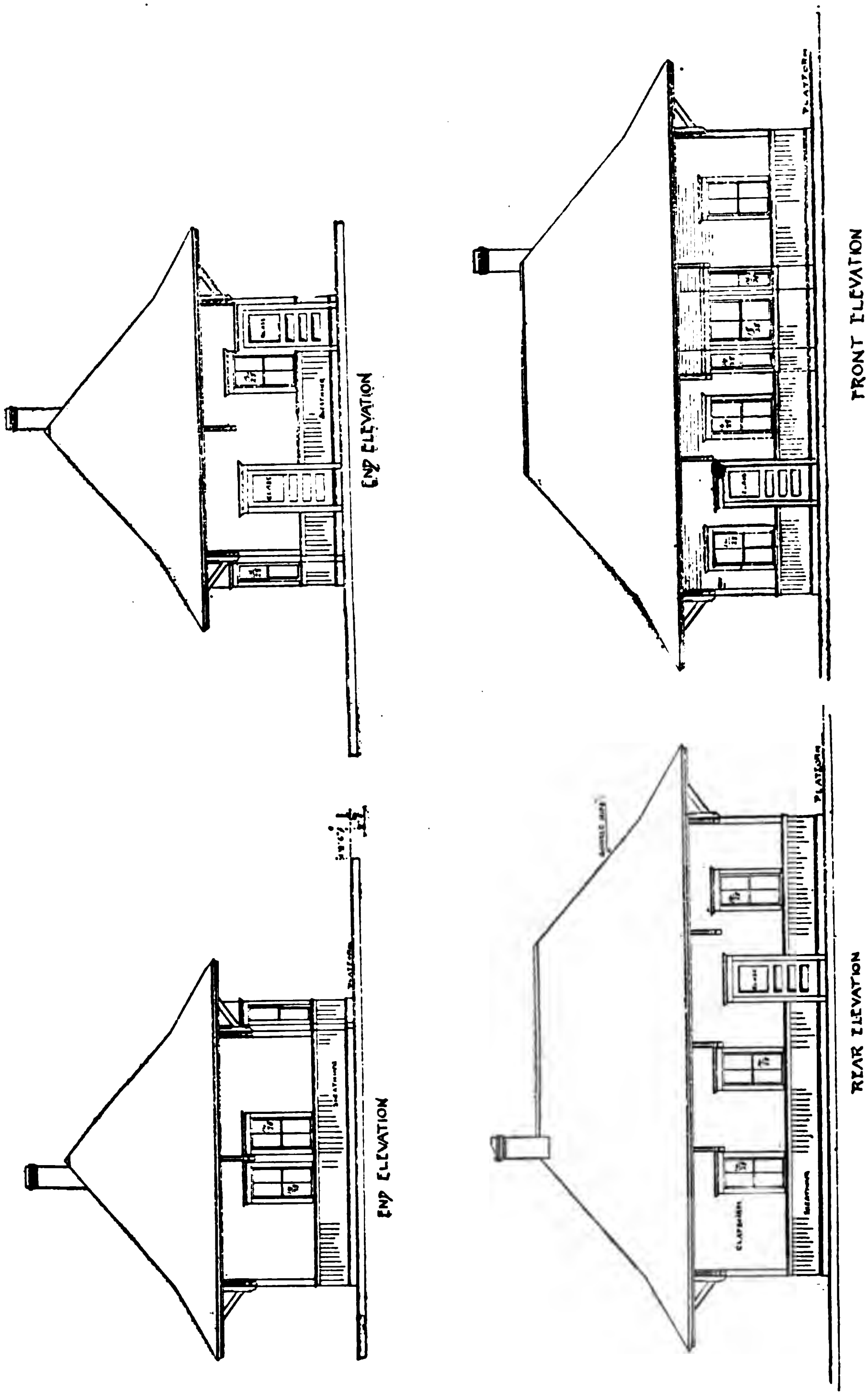


FIG. 164.—LOCAL PASSENGER DEPOT AT WALNUT HILL, MASS., BOSTON AND MAINE R. R. (PLAN NO. 29.)

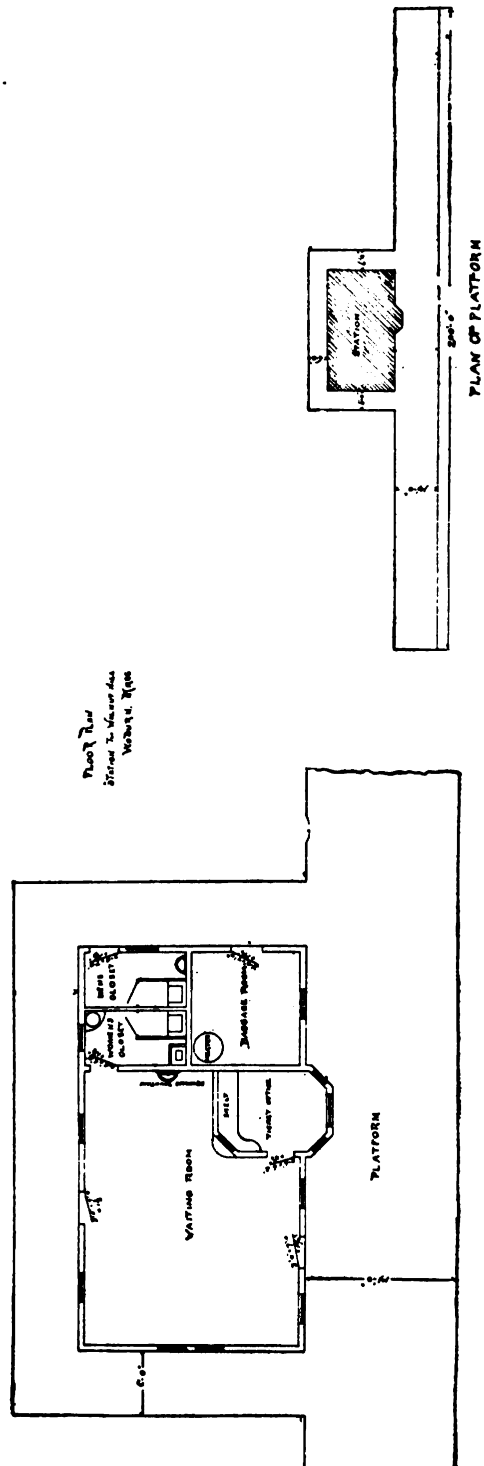


FIG. 165—(PLAN NO. 29—CONTINUED.)

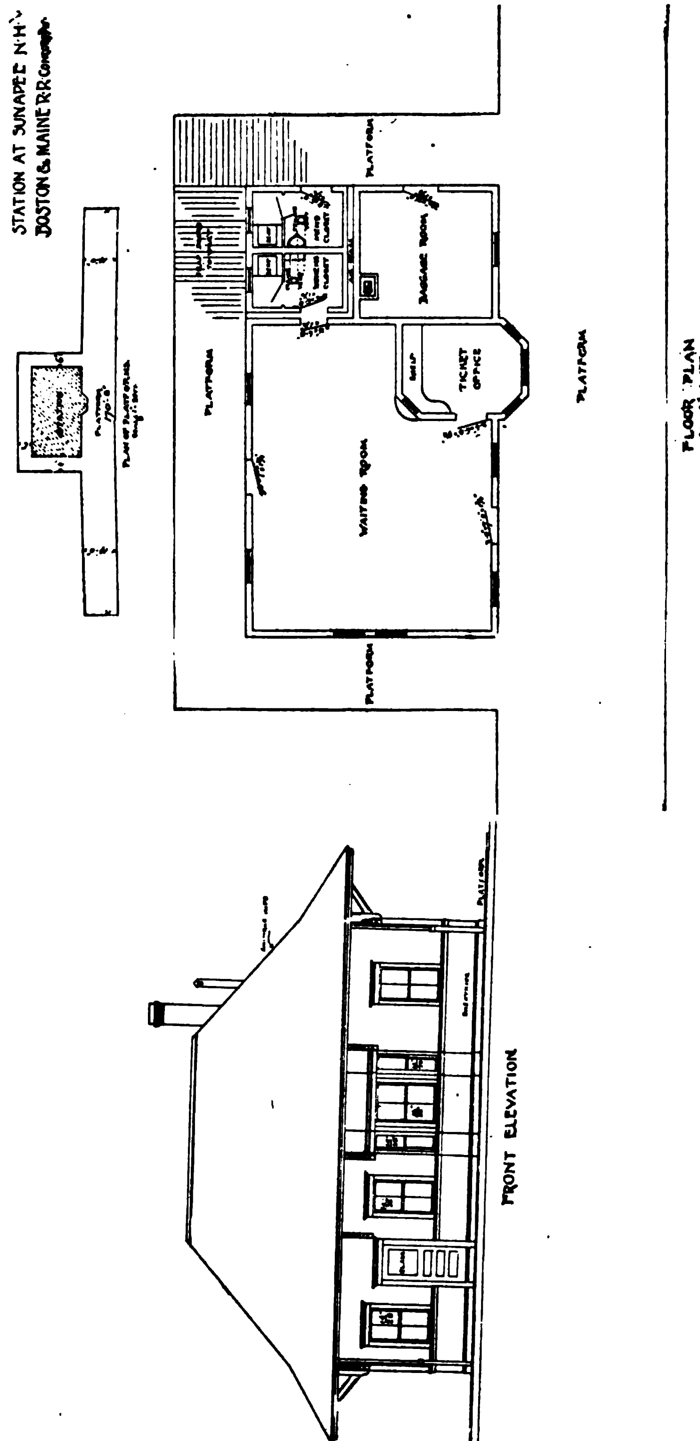


FIG. 168—LOCAL PASSENGER DEPOT AT SUNAPEE, N. H., BOSTON AND MAINE R. R. (PLAN NO. 30.)

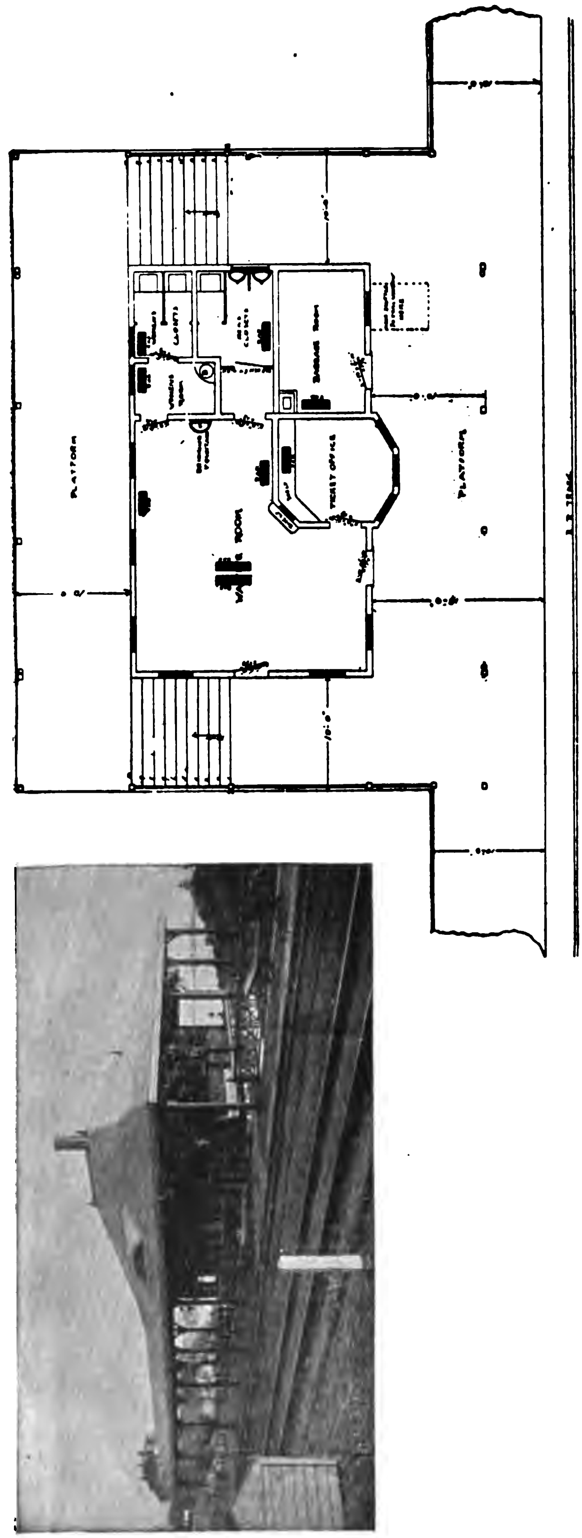


FIG. 167—LOCAL PASSENGER DEPOT AT WEST MANCHESTER, MASS. (PLAN NO. 31.)

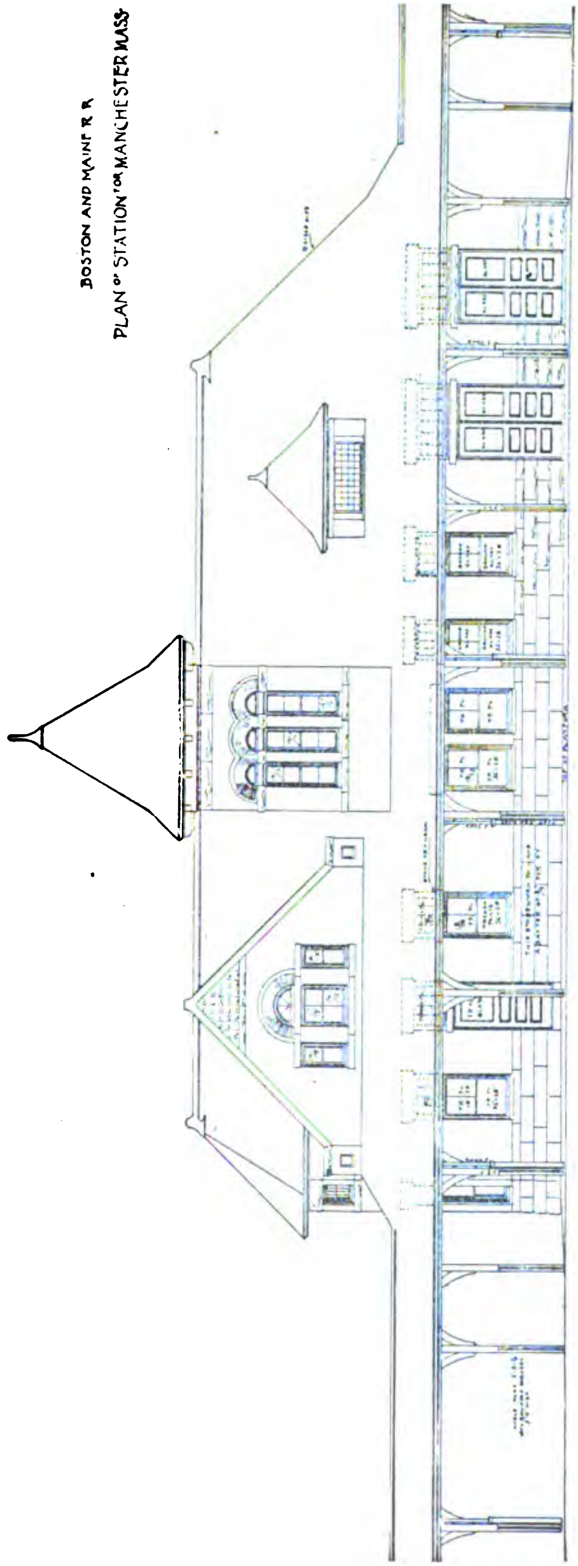


FIG. 168—LOCAL PASSENGER DEPOT AT MANCHESTER, MASS., BOSTON AND MAINE R. R. (PLAN NO. 32.)

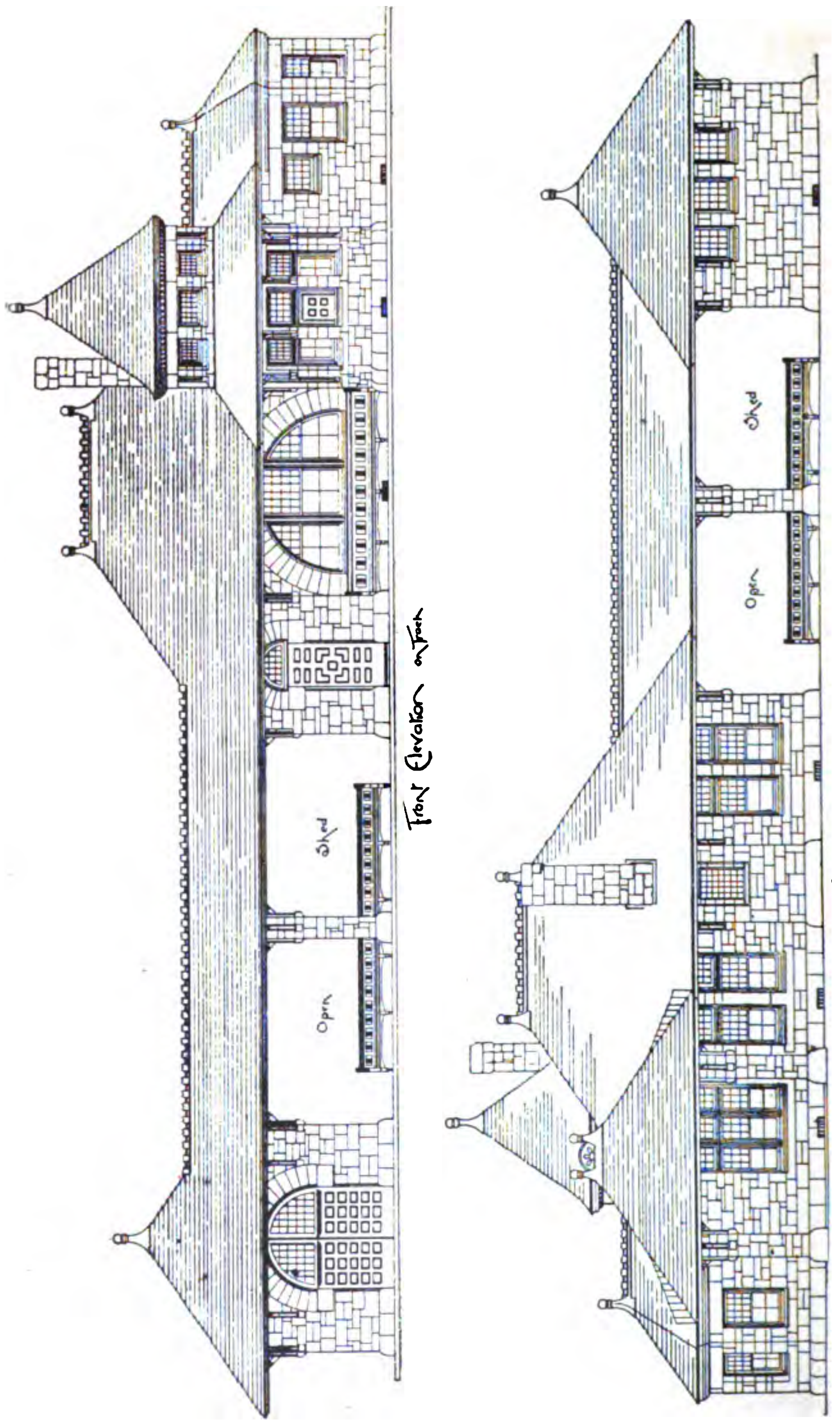
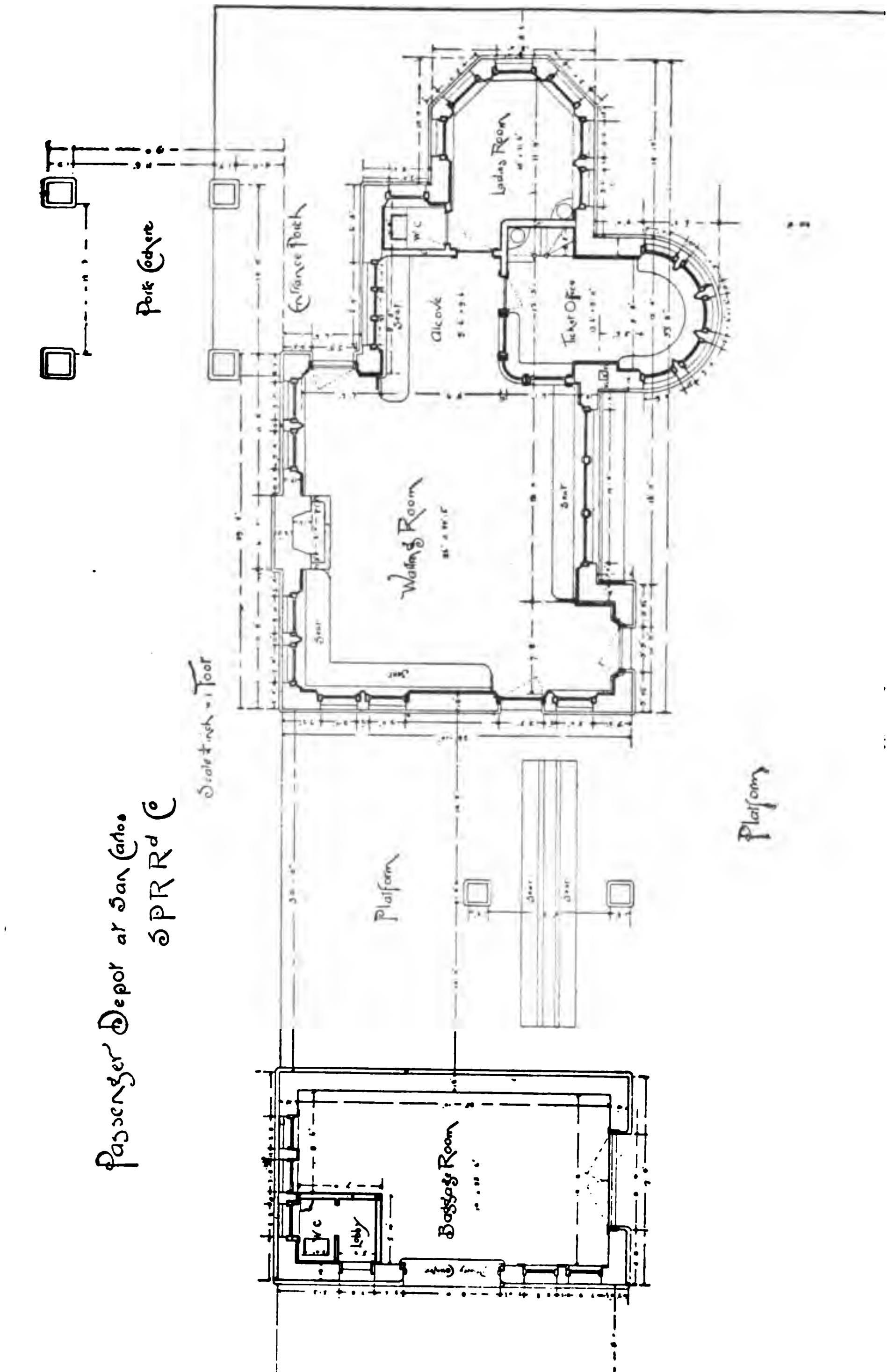


FIG. 169—ELEVATIONS LOCAL PASSENGER DEPOT AT SAN CARLOS, SOUTHERN PACIFIC R. R. (PLAN NO. 33.)


Passenger Depot at San Carlos
S P R Rd Co
Porte Cochere
Entrance Porch
Ladies Room
W C
Alcove
Seat
Ticket Office
Waiting Room
Seat
Seat
Platform
Seat
Seat
Platform
Baggage Room
W C
Lobby

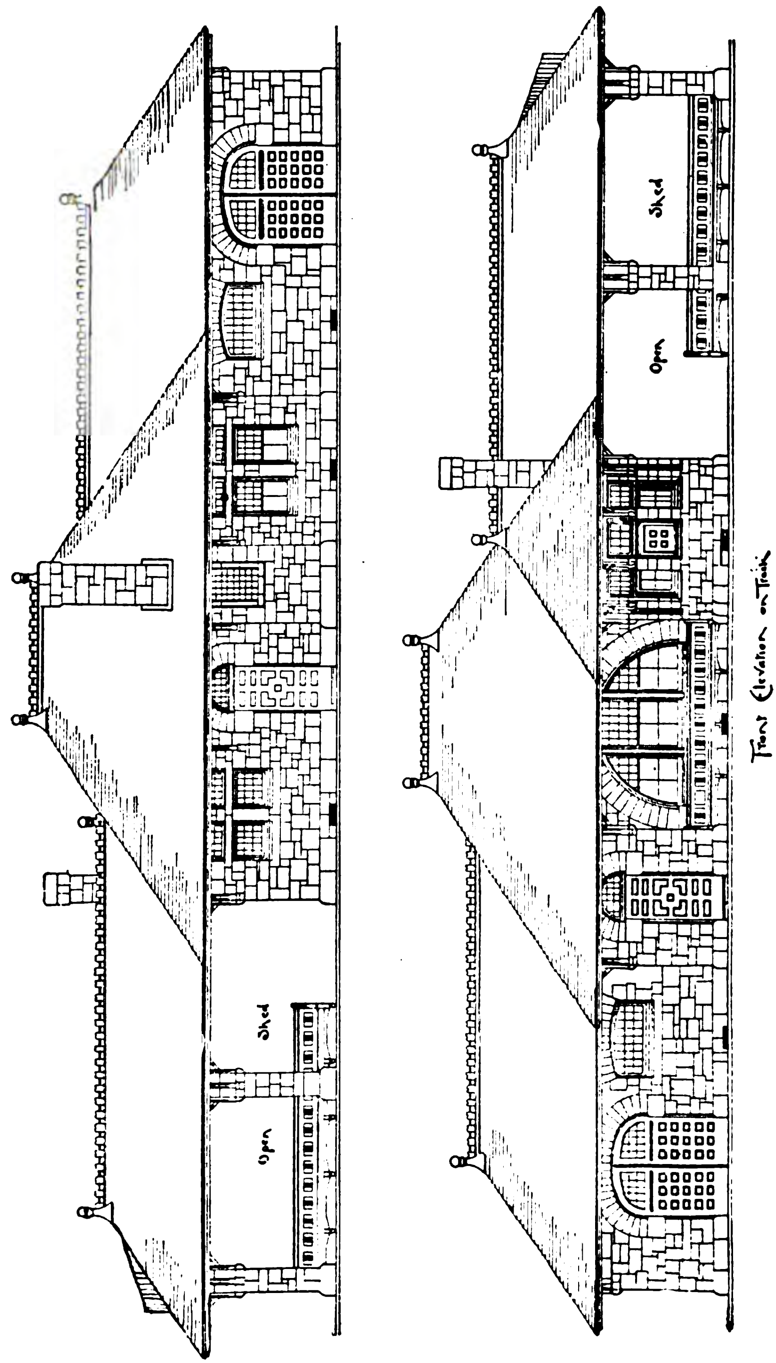
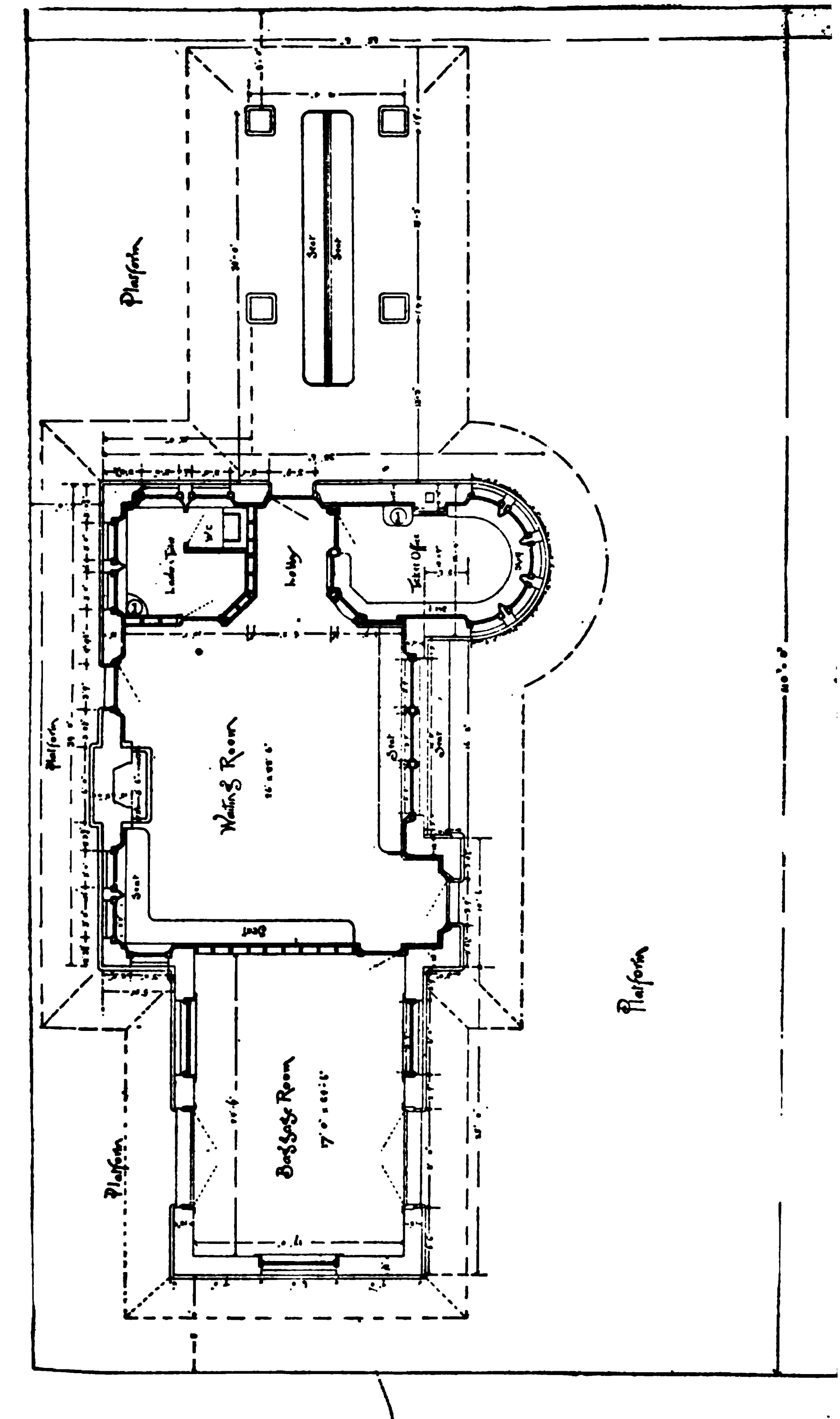


FIG. 171—ELEVATION OF LOCAL PASSENGER DEPOT AT LOS QUILUCOS, SOUTHERN PACIFIC R. R. (PLAN NO. 34.)


Platform
Waiting Room
Baggage Room
Ticket Office
Lobby
Seat
W.C.

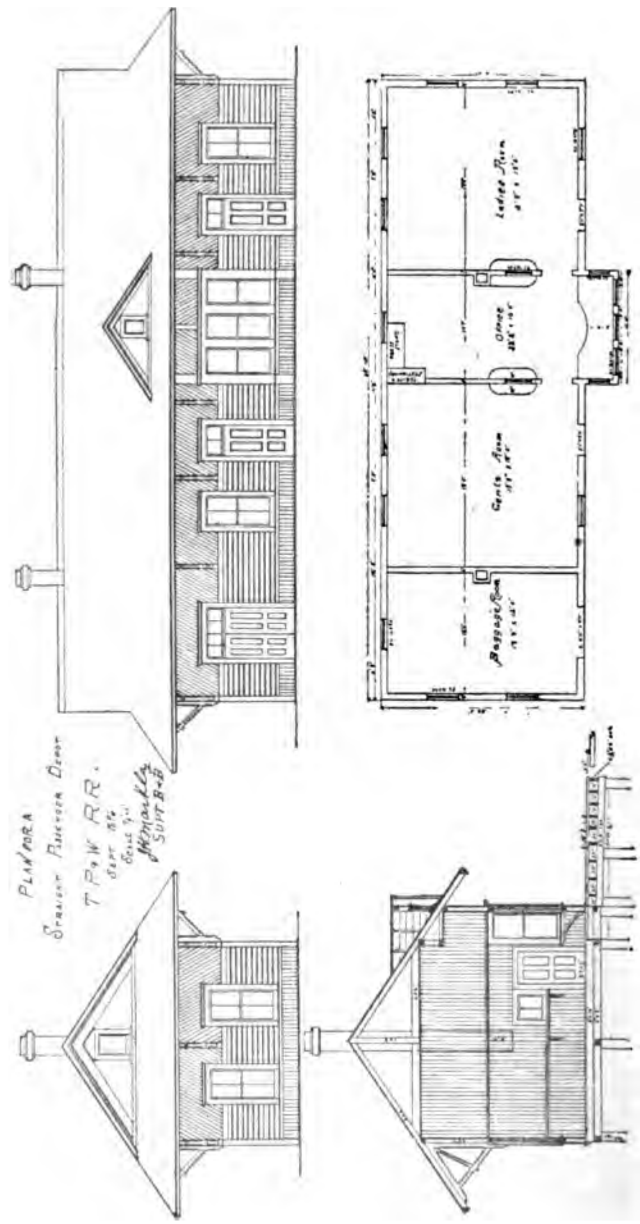
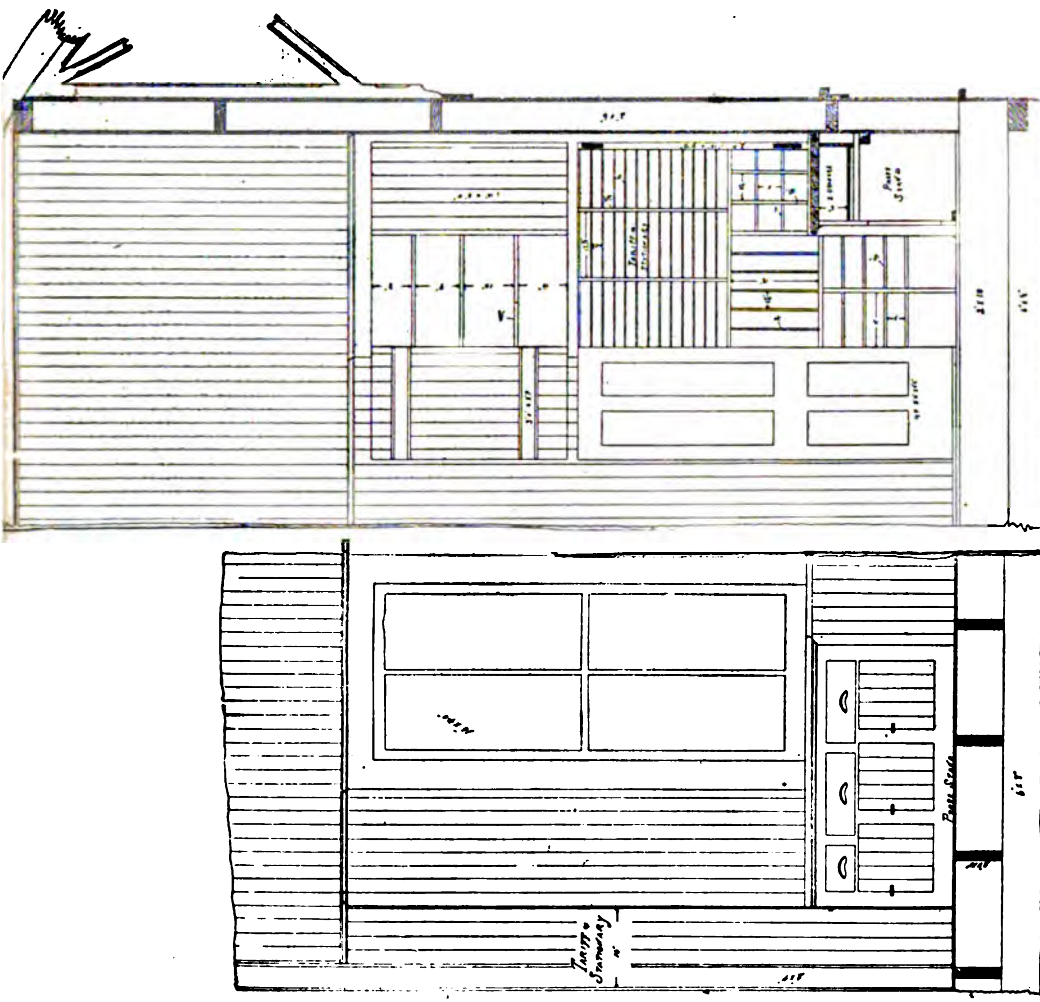


FIG. 173—LOCAL PASSENGER DEPOT, TOLEDO, PEORIA AND WESTERN R. R. (PLAN NO. 35.)



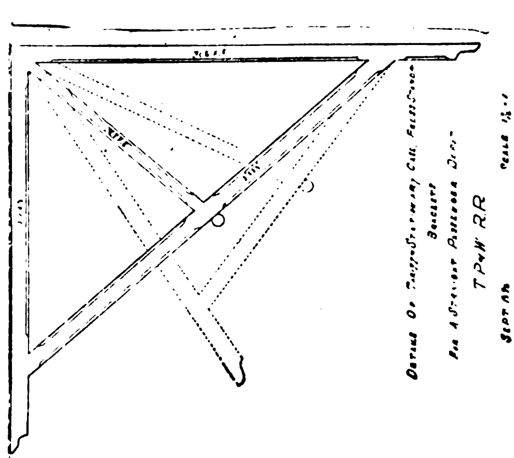


FIG. 174—DETAILS OF TARIFF AND STATIONERY CASE, PRESS STAND AND BRACKETS, FOR LOCAL PASSENGER DEPOT, TOLEDO, PEORIA AND WESTERN R. R. (PLAN NO. 35.)

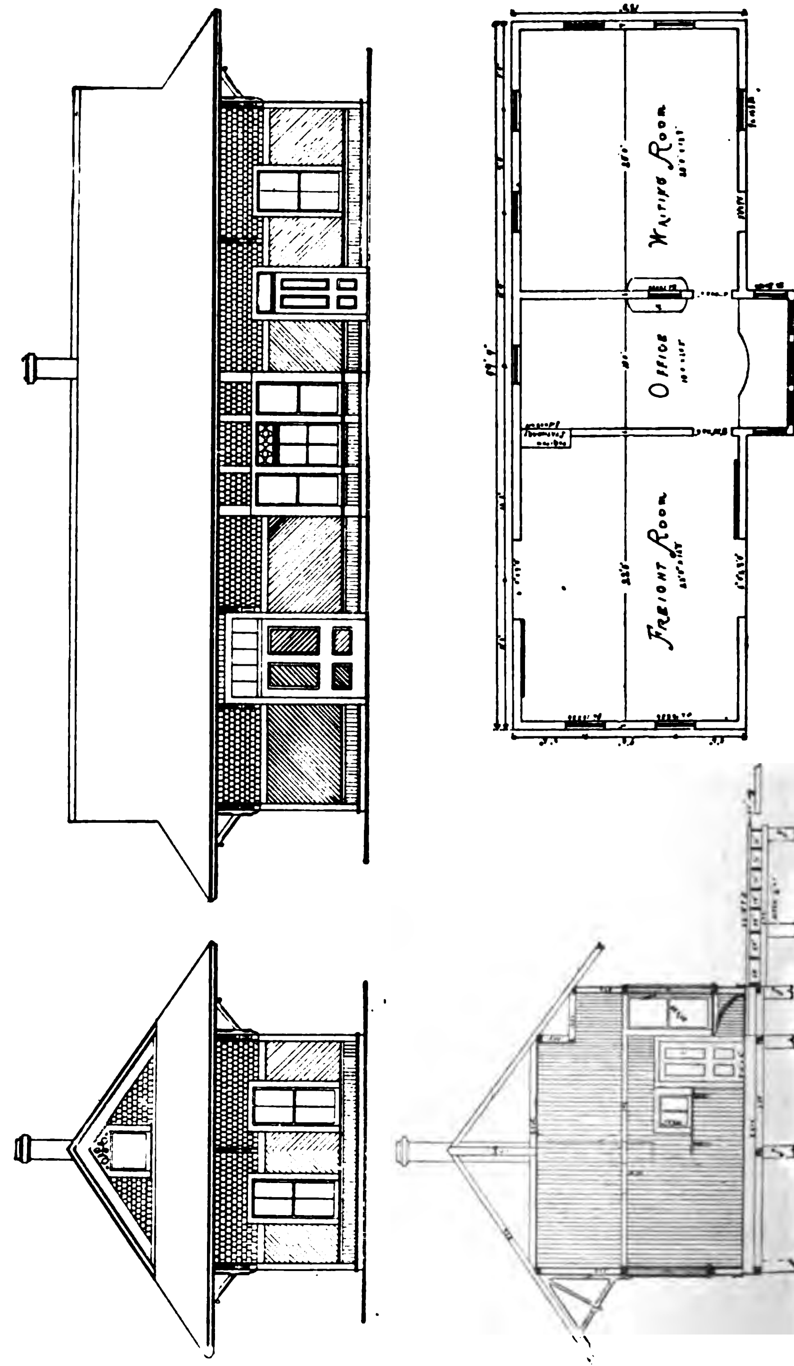


FIG. 175—LOCAL COMBINATION DEPOT NO. 1, TOLEDO, PEORIA AND WESTERN R. R. (PLAN NO. 36.)

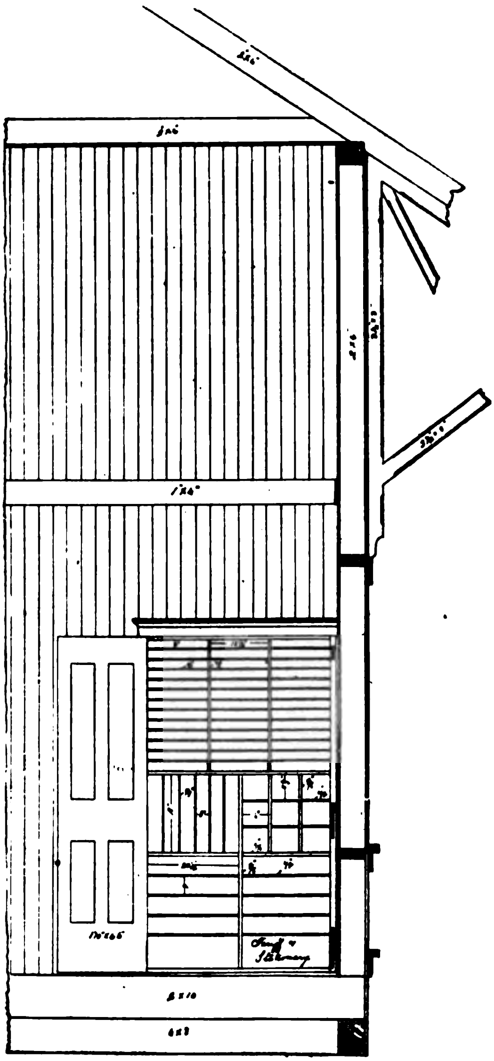


FIG. 176—DETAILS OF TARIFF AND STATIONERY CASE FOR LOCAL COMBINATION DEPOT NO. 1, TOLEDO, PEORIA AND WESTERN R. R. (PLAN NO. 36—CONTINUED.)

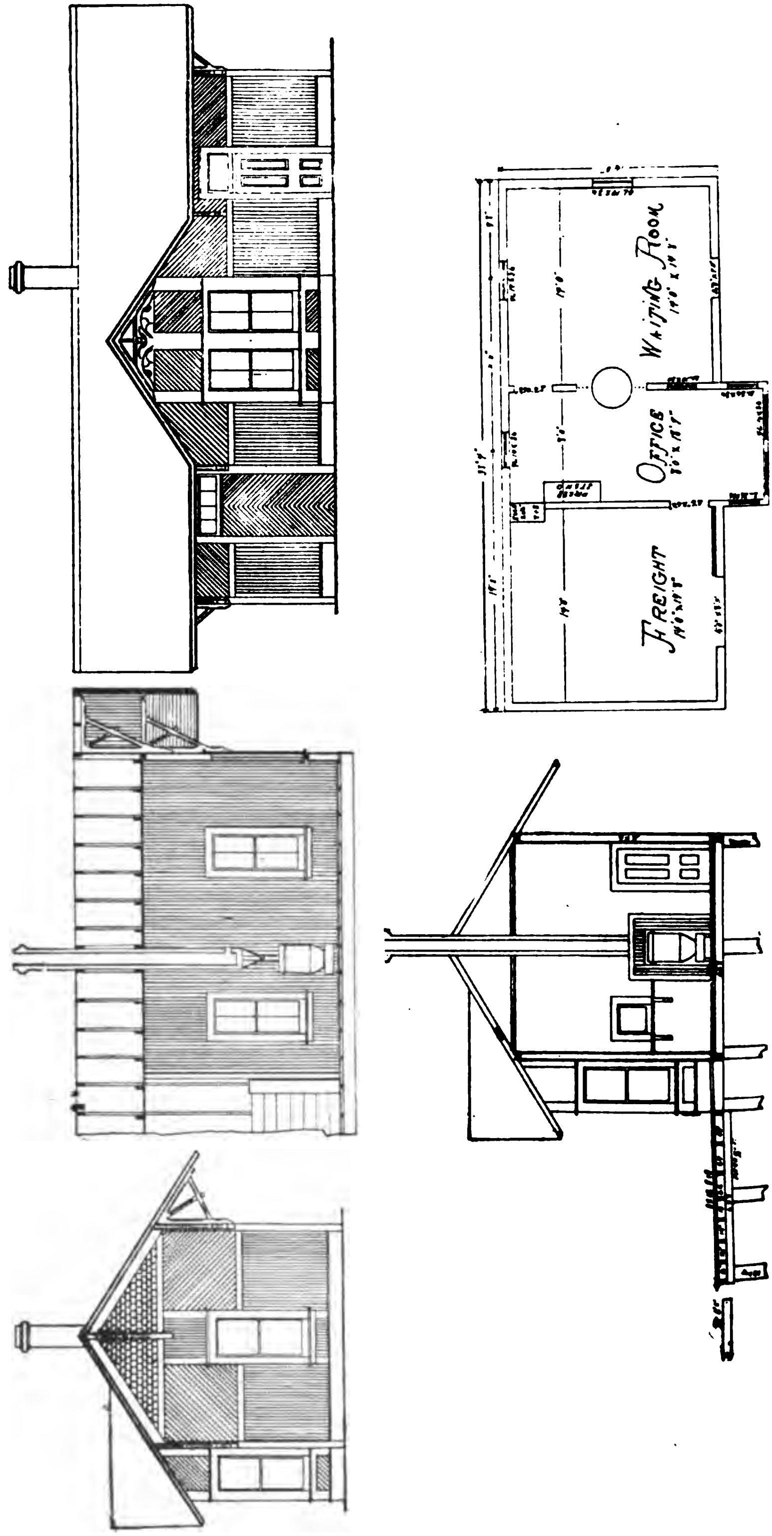


FIG. 177.—LOCAL COMBINATION DEPOT NO. 2, TOLEDO, PEORIA AND WESTERN R. R. (PLAN NO. 87.)

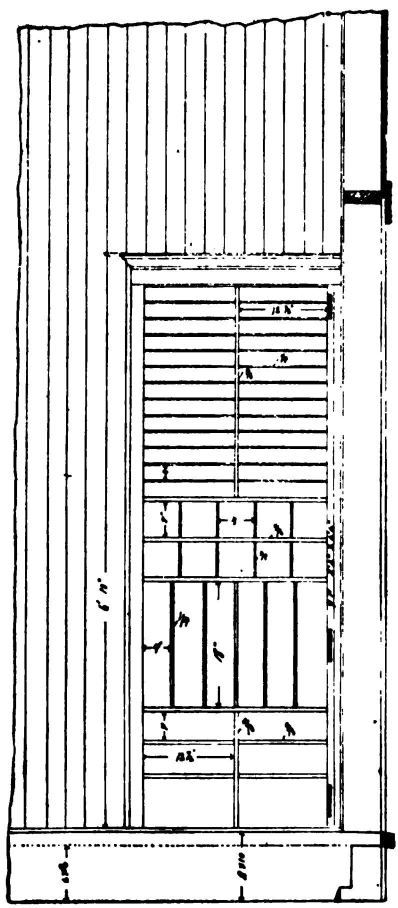


FIG. 178—DETAILS OF TARIFF AND STATIONERY CASE FOR LOCAL COMBINATION DEPOT NO. 2, TOLEDO, PEORIA AND WESTERN R. R. (PLAN NO. 37—CONTINUED.)

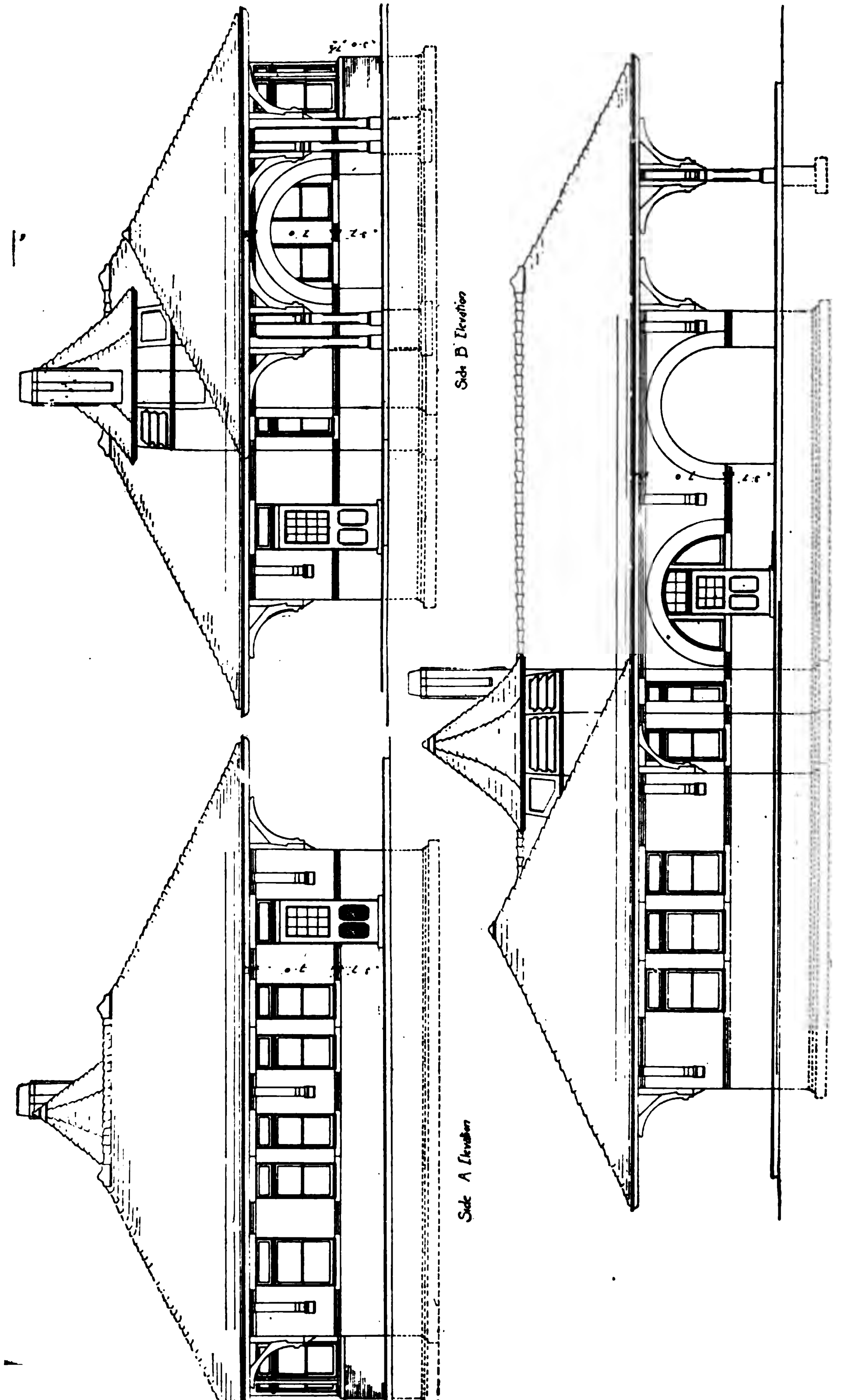


FIG. 179—ELEVATIONS OF LOCAL PASSENGER DEPOT AT GLEN COVE, L. I., LONG ISLAND R. R. (PLAN NO. 38.)

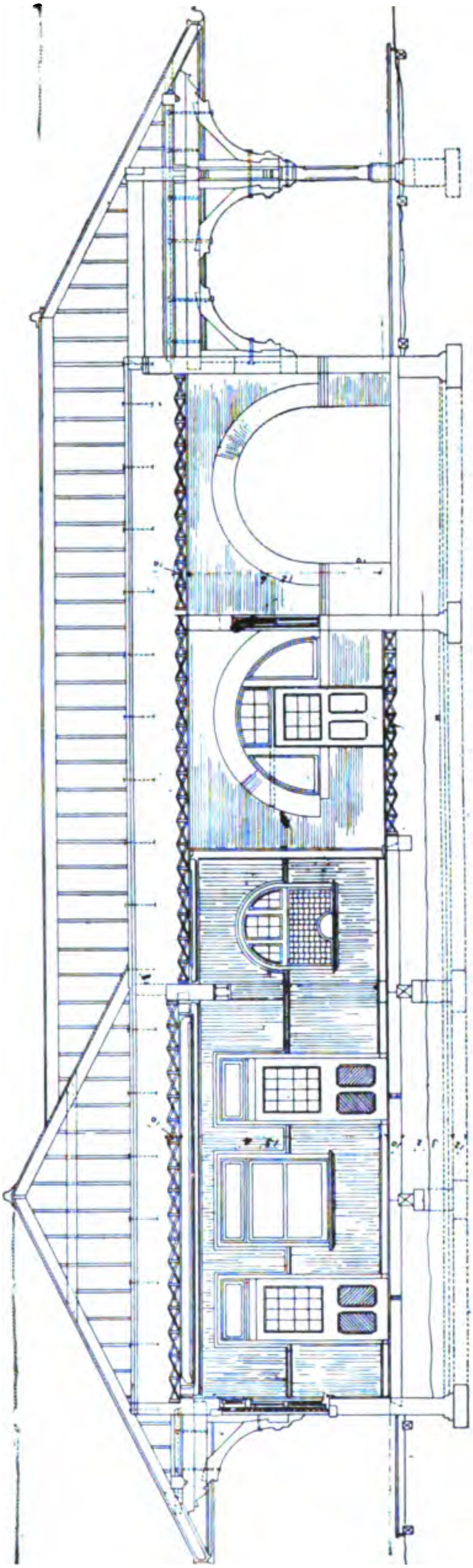


FIG. 180—LONGITUDINAL SECTION OF LOCAL PASSENGER DEPOT AT GLEN COVE, L. I., LONG ISLAND R. R. (PLAN NO. 38—CONTINUED.)

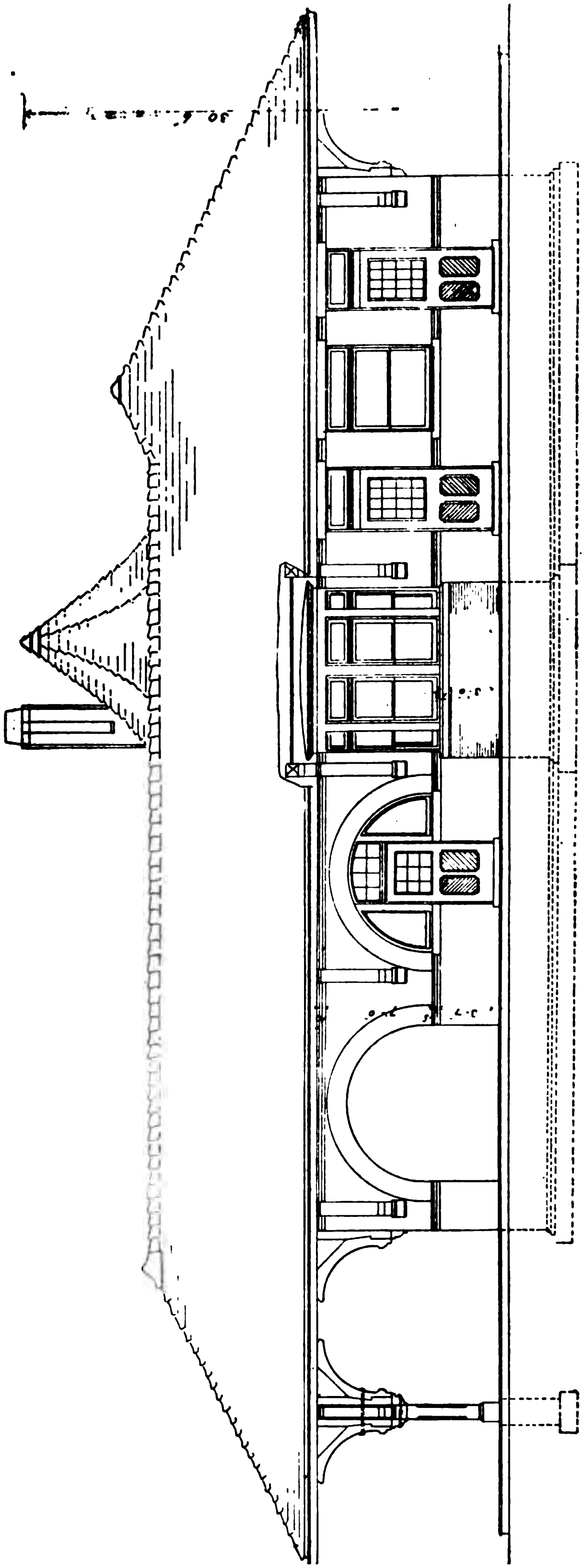


FIG. 181—TRACK SIDE ELEVATION OF LOCAL PASSENGER DEPOT AT GLEN COVE, L. I., LONG ISLAND R. R. (PLAN NO. 38—CONTINUED.)

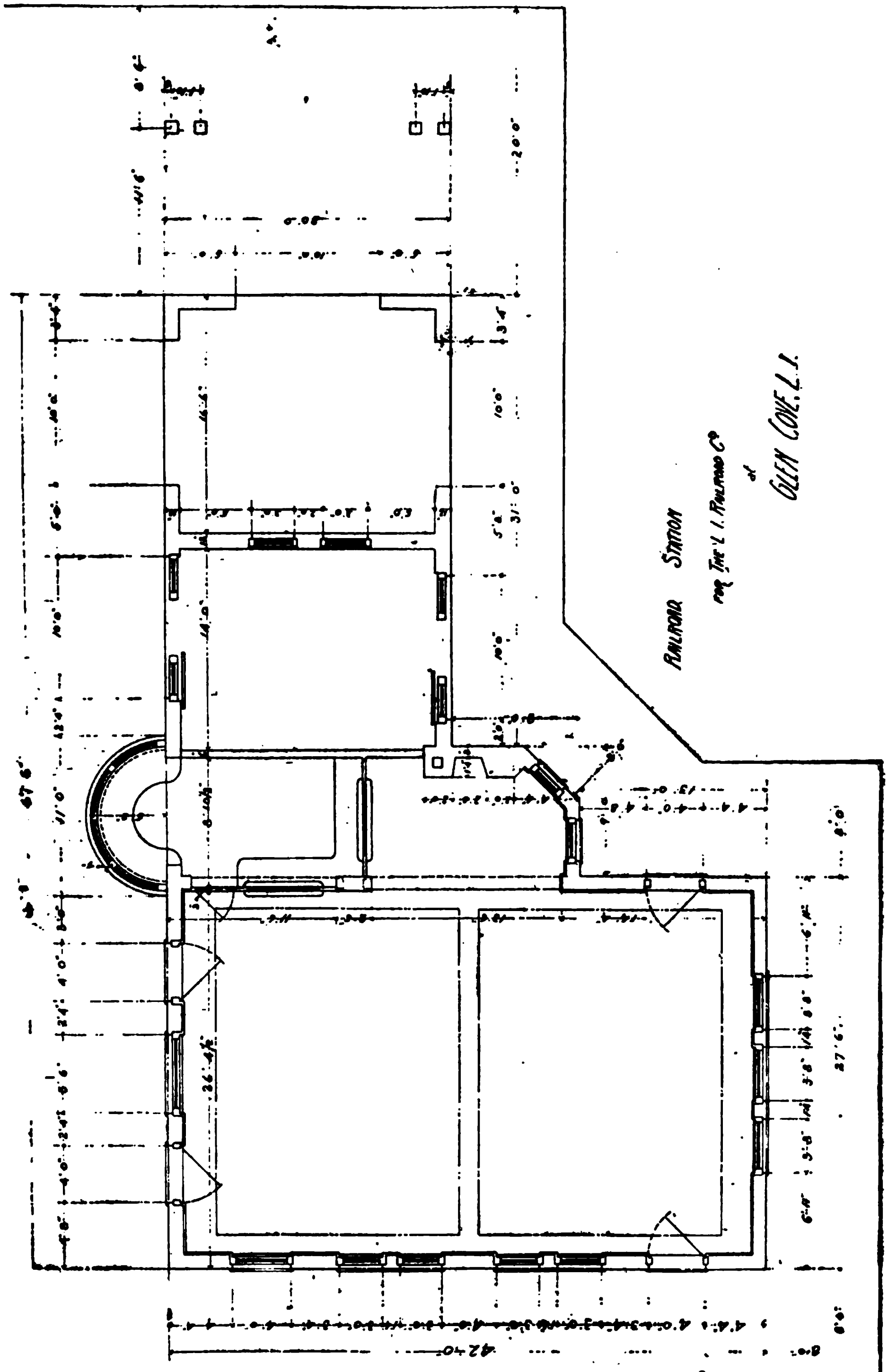


FIG. 182—GROUND PLAN OF LOCAL PASSENGER DEPOT AT GLEN COVE, L. I., LONG ISLAND R. R. (PLAN NO. 38—CONTINUED.)

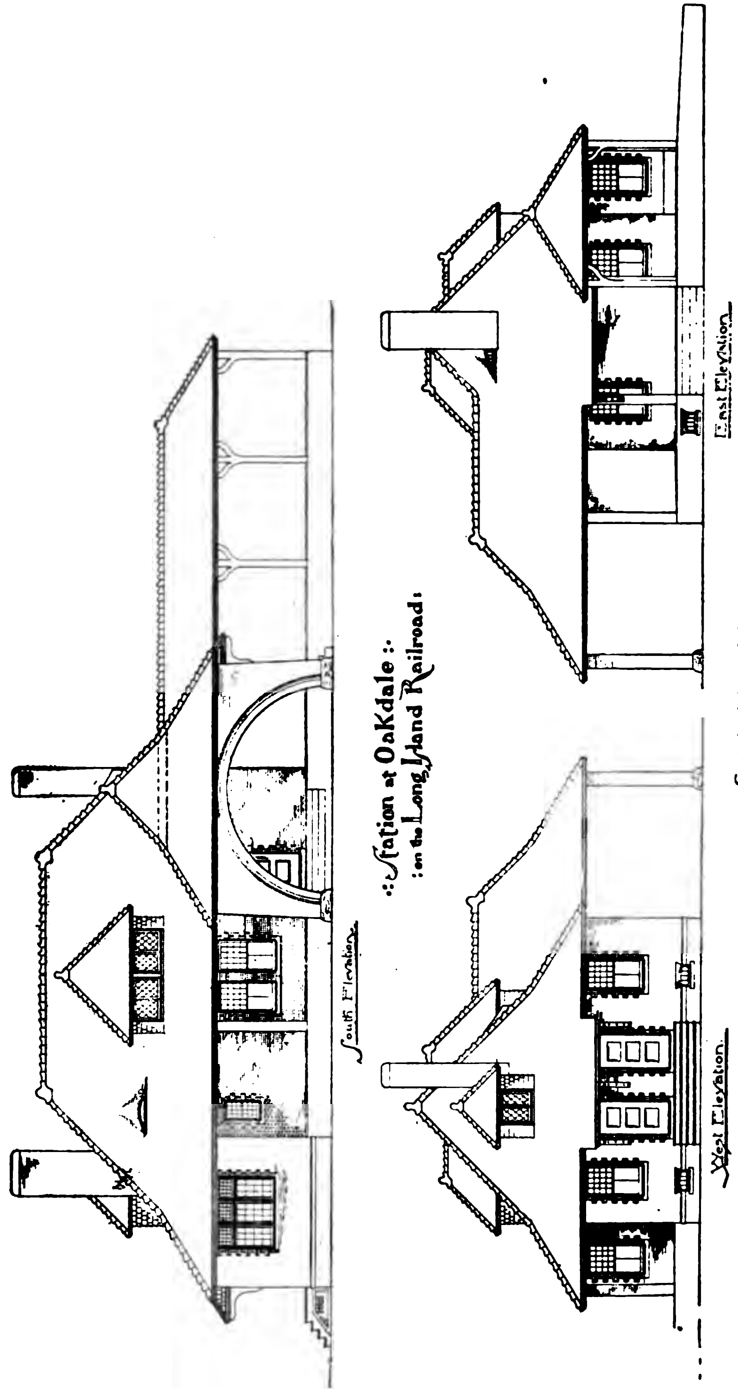
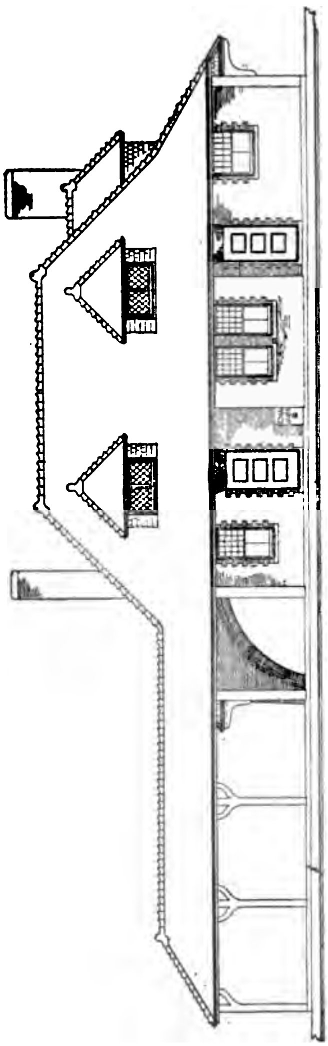


FIG. 188—ELEVATIONS OF LOCAL PASSENGER DEPOT AT OAKDALE, LONG ISLAND R. R. (PLAN NO. 39)



North Elevation.

FIG. 184—TRACK SIDE ELEVATION OF LOCAL DEPOT AT OAKDALE, LONG ISLAND R. R.
(PLAN NO. 39—CONTINUED.)

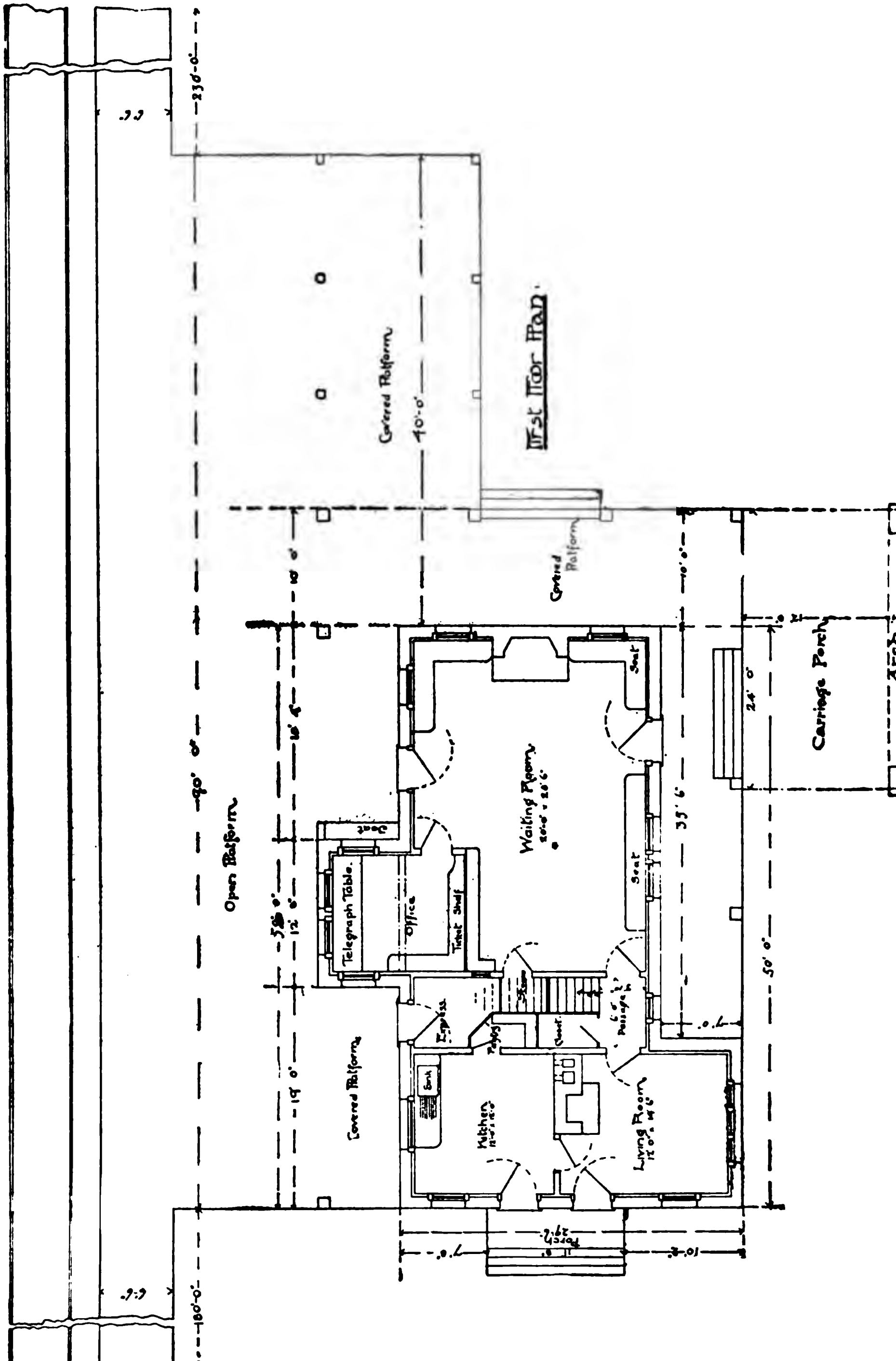


FIG. 185.—GROUND FLOOR PLAN OF LOCAL PASSENGER DEPOT AT OAKDALE, LONG ISLAND R. R. (PLAN NO 89—CONTINUED.

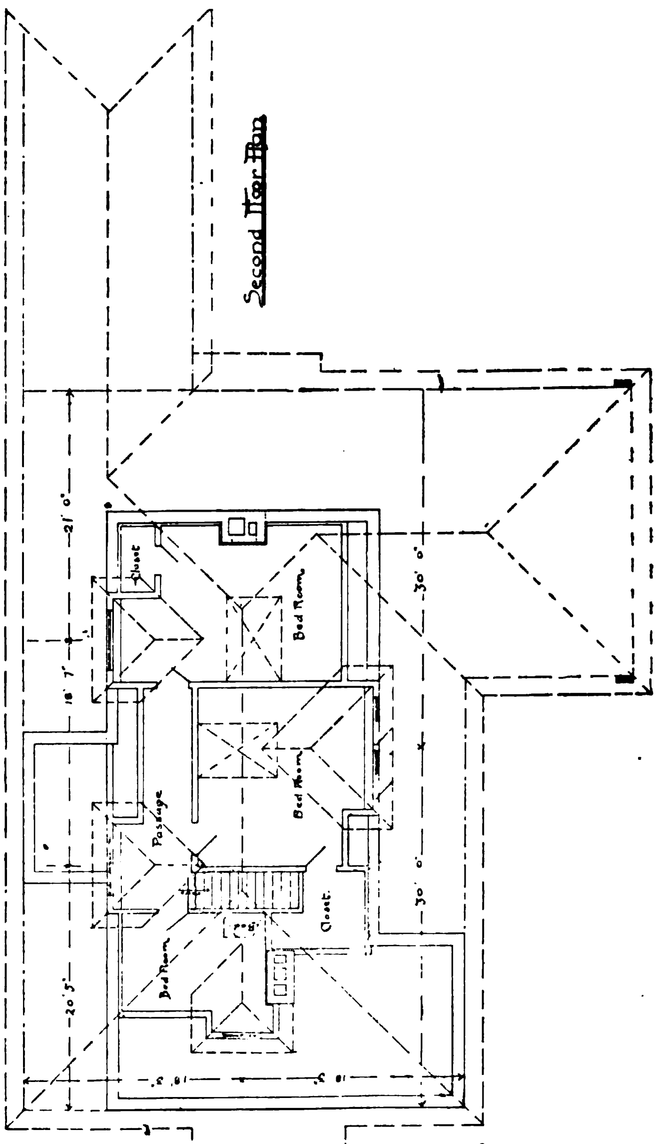


FIG. 186—SECOND FLOOR PLAN OF LOCAL PASSENGER DEPOT AT OAKDALE, LONG ISLAND R. R. (PLAN NO. 39—CONTINUED.)

DISCUSSION: SUBJECT—LOCAL STATIONS FOR SMALL TOWNS AND VILLAGES, GIVING PLANS OF BUILDINGS AND PLATFORMS.

Mr. Stannard, Wabash Ry.—I do not think I can add anything to what has been so well expressed by the committee in their report, which is very complete. There is only one thing which I would mention, and that is as to whether a platform should be constructed of concrete or brick. I think the day is coming when we shall have to use one or the other. I think the day for plank platforms at all important stations is forever gone.

Mr. Bishop, Chicago, Rock Island and Pacific Ry.—At all our large stations, we are adopting the use of vitrified brick. I will give you a statement of the cost of a brick platform I laid at Topeka:

2,302 sq. ft. of brick, laid on the flat; 4½ brick per. sq. ft.; costing	$3.25	per 100 sq. ft.
Labor and sand	1.62½	per 100 sq. ft.
	$4.89	per 100 sq. ft.
Including curbing and grading	8.18	per 100 sq. ft.
Laying 5,759 sq. ft. of brick, on edge, 7.6 brick per sq. ft., cost of brick	$5.49	per 100 sq. ft.
Cost of labor and sand	1.75	per 100 sq. ft.
	$7.24	per 100 sq. ft.
With curbing and grading	$10.45	per 100 sq. ft.

Cost of 347 lineal feet of curbing stone, 8 in. thick, 42 in. deep.

Cost of stone	11¼c.
Cost of cutting stone	14½c.
Cost of setting stone	10¼c.
Total	36 c.

A brick platform should have about one-fourth of an inch fall in twelve inches for drainage. At our small stations, we are doing away with all wooden platforms that we can, and all extensions we make out of cinders, using two wooden stringers, and rods, making them eight to twelve feet in width.

Mr. Riney, Chicago and Northwestern Ry.—At our station buildings, we use plank platforms, and we use both sills and joists, sills 8x10 and joists 3x8 and 3x10, pine. Our platforms are built so as to clear the ends of the ties.

Mr. Bates, Chicago, Milwaukee and St. Paul Ry.—We use brick in a great many cases. We set our curbing at the ends of the cross ties, and the edge of the platform at the height of the top of the rail.

Mr. Cummin, Long Island Ry.—It seems to me we are losing sight of one part of this report entirely. We are leaving the buildings alone and are keeping right to the platform question. I would like to hear a little discussion and get the sentiment of the members of this association in regard to the buildings themselves, as to the number of waiting-rooms, etc. I noticed in nearly all cases where plans were sent to me for the preparation of this report, that the buildings had from two to three waiting rooms. There were some few that had three rooms, and those that had were in some of the Southern States where there is an extra waiting-room for the colored people. I may be wrong, but it seems to me that in a small village or town, one waiting-room is sufficient. I am an advocate of the single waiting-room at a depot for a small place. When I first became connected with the Long Island road some years ago, it did not make any difference how small a place was, there had to be two waiting rooms, one for the men and one for the women. No matter what time of day or evening you went into the men's waiting-room, you would always find a number of loungers lying around there talking, smoking, etc. The ticket office, as a rule, was placed between the two waiting-rooms. From the ticket office you could hear what was going on in the rooms. I consider this system a detriment to any small town or village. We have done away entirely with the double waiting-room. We make one waiting-room do for all, and we allow no lounging around that room, and no smoking in the waiting-room. This plan has worked very successfully. We have sheds at the end of the depot, and if a man wants to smoke he is at perfect liberty to go outside and smoke, but we allow nothing of that kind in the station. In regard to platforms, the majority are plank. We have some concrete platforms, and personally I am highly in favor of them. Our platforms are ten inches above the rail, but in regard to the height of the platform above the rail, it seems to me that the whole question hinges on how high the bottom step of your car is above the rail. I noticed on a number of roads that the cars have extra steps on. Of course that would make a difference, but it seems to me the height of the platform should be gauged by the steps of the car, so that in walking down from the car the riser from the bottom step to the platform should be equal to the risers of the car. I think you will agree with me, if you are going down a flight of stairs, and there is a riser in those stairs different from the others the jar will be considerable, and I think that is a thing that should be looked after. The correct rise and height of the platform should be seen to, so that there will be uniformity throughout. Mr. Cummin then cited a case that had come under his own observation, where the track had been raised at a depot platform, causing such a lack of uniformity in the platforms that passengers stumbled, and he was obliged to go to work and rearrange the platform so as to prevent a continuation of the stumbling referred to.

Mr. Berg, Lehigh Valley Ry.—I would like Mr. Cummin to carry on the discussion of the single waiting-room depots, and explain how the toilet rooms are arranged.

Mr. Cummin, Long Island Ry.—In all small places the toilet rooms are separate from the station. In some depots we have toilet rooms. The women's toilet opens from the waiting-room, and the men's from the outside of the building.

Mr. Aaron S. Markley, Chicago and Eastern Illinois Ry.—Our road at small towns, and at a great many of the larges ones, has only one waiting-room. The height of the platform is four inches above the rail. We use cinders at small stations, thus doing away with the plank altogether for platforms, using old stringers for curb. At larger stations, we put in three inches of crushed stone on top of cinders, and find that this allows the handling of freight with trucks very nicely after once packed. The only objection to that kind of a platform is, in wet weather the material will stick to the shoes, and it is carried into the house. At our small stations, where the ticket office and the waiting-rooms are in one, one stove answers for both rooms, waiting-room and office, by having wire screen in partition opposite stove to prevent it from catching fire, and partition made of slats so that heat will circulate over the two rooms.

Mr. J. H. Travis, Illinois Central Ry.—In regard to the construction of waiting-rooms at depots. On all Southern lines, it is necessary to have at least two; we have got to have a white and a colored waiting-room. I believe it is the same pretty much in all the Southern States, Mississippi particularly. It is somewhat different, of course, in the case of waiting-rooms on Southern roads, such as the Illinois Central and other roads in the South, than it is on the Long Island road. I think the elevated platform is by far the safest and easiest of access. We have been running express trains since the beginning of the World's Fair, and have not had an accident of any kind. We can load and unload passengers in one-sixth of the time that we could in any other way. Our standard for outside platforms is three inches above the top of the rail. The safest and best platform is that level with the top of the rail, not to exceed three inches anyhow. I would prefer level with the top of the rail. We have not any standard depot, but our depots are constructed very similar to each other. They are built to meet the requirements of those they are intended to accommodate. At quite a number of our stations, including the majority of the whole line between the Ohio and the Mississippi Rivers, we have the passenger stations on one side of the track and the freight depot on the other side.

The passenger platform is generally on the opposite side of the track from the general business portion. We have two waiting-rooms at our regular passenger stations; the ticket office is in front with a bay-window, and generally an opening between the two rooms. The ticket and toilet rooms are separated by a partition clear up to the ceiling. The ticket office is in front, and right opposite to that would be the toilet room. I find this is as convenient as any. At our smaller stations north of the Ohio River, there is but one waiting-room. The depots here are a sort of combination, transacting both freight and passenger business, doing away with the necessity of a freight depot on the opposite side of the track. These depot platforms are three inches above the top of the rail, principally constructed of brick and concrete.

Mr. Yereance, West Shore Ry.—Our stations are the ones originally built for the line and are of several standard classes, designed to meet the needs of the communities they serve. Our smallest stations have but one waiting-room; those of the larges classes have two waiting-rooms, but for some reason the separating partition does not reach to the ceiling, and communication between these rooms is had by means of swing doors. In the latter cases, of course, we have to prohibit smoking in the men's room, and if smoking is prohibited, I do not see but one room will answer all purposes. When there are the two rooms, I have found that the privileges of the men's room, especially in small towns, are very apt to be abused by those who have not the slightest claim on the company to consideration. In country places we have the toilet accommodations outside the station building; in larger communities we have the entrance to the men's toilet room outside, but entrance to the women's toilet room from their waiting-room. Concerning station platforms, we are in favor of filing from the level of the bottom of the ties with cinders, up to a height of two or three inches from the top of the rail, and filling up to top of rail with stone-dust dressing. This makes, where it is packed hard, a very desirable substitute for a platform. Of course, in stormy weather, while this material is loose, there will be more or less of it tracked into the station, making the floor dirty and marring its finish.

Mr. Cummin, Long Island Ry.—We had high platforms on the Long Island road for sixteen years. We tried them in every conceivable way, but were glad to abandon them. On a division of about fourteen miles, the platform accidents amounted to more than the entire system three times over. A high platform will do very well for an elevated road, but it does not answer on a regular road, where you are running local, express, and all classes of trains. I claim from experience that it is the most dangerous platform that has ever been built, especially if you happen to have your station on a curve, which sometimes happens to be the case. This subject was discussed about a year ago in the Railway Age, but the subject did not last quite as long as I had hoped it would. It dropped very suddenly.

Mr. Travis said, in answer to a question addressed by Mr. Yereance, that when he used the term "express," he meant to make it understood that they had two distinct services into and out of Chicago. They had a local station and an express suburban service. Their local suburban trains stopped at all stations; their express suburbans did not. An express suburban would run from Van Buren street to Hyde Park without stopping, and the local suburban would stop every three or four blocks. The platforms on the cars of these trains are so constructed that they are about, on either side of the car, eleven inches wider than the car itself from the width of the platform. The platform is five feet six inches from the center of the track and is about two feet four inches high. The distance between the end of the extended portion of the platform of the car and the face of the elevated platform would be about six inches. We do not use the elevated platform throughout, but only in connection with our suburban business. On Chicago Day we carried 758,000 people going to and from the World's Fair, without a single accident. The only accidents we have had with our elevated platform have been due to people running, trying to catch a train, or with smart Alecks getting off before the train stopped. (Mr. Travis then explained in detail the suburban train service of the Illinois Central, how same was run during the World's Fair, the time between the running of trains, the stoppages made, the places where made, the methods employed for the protection of the numerous passengers handled, and concluded as follows): We adopted every extra precaution we could to insure safety in the way of making repairs and doing work around terminals. I have made an effort to have every employe carefully watch and not leave anything on any of the elevated platforms that might be considered in the nature of an obstruction or cause an accident, and I have gone so far as to say to the employes that if they saw anything that was wrong after their working hours, such as a piece of stick or bolt, or anything of that kind, in any place where there was the least liability of accident, to stop and take it away, and that I would be glad to reward them liberally for so doing. We left no stone unturned to prevent even the smallest accident from occurring.

Mr. Travis said, in answer to a question addressed by Mr. Yereance, that it was only for their quick service and suburban travel that they had the high platforms.

Mr. Cummin—I would like to ask Mr. Travis, if those cars that he has referred to, are not open cars where the passengers can unload themselves. The reason I ask that question is this, some of the members here are not used to open cars, and any one having experience knows that with open cars you can unload an entire car in the same time you would unload five people out of an ordinary car.

Mr. Travis replied in the affirmative.

Mr. Berg—I think this question of high versus low platforms bears about the same relationship to the work of our association as the much discussed question of the best splice bars in the Roadmasters' association, a number of whose meetings I have attended. It comes up periodically and produces quite a discussion. Mr. Yereance's question, when properly understood by Mr. Travis, brought out this valuable point, namely, that they (the Illinois Central Railroad) make a distinction in favor of the high platforms for their suburban trains and low platforms for their regular through trains.

REPORT: TANKS, SIZE, STYLE, AND DETAILS OF CONSTRUCTION, INCLUDING FROST-PROOF PROTECTION TO TANK AND PIPES.

After considerable correspondence with different members of this association we find that most roads use the standard 16x24-foot tank, with a capacity of 50,000 gallons. These tanks are placed on various styles of sub-structures, some of which are oak, others pine; but the most up-to-date sub-structure is that made of steel, which we find quite a number of roads have adopted or are about to do so.

As for Frost Proofing, some roads box up their pipes with brick-work, others use lumber, which is considerably cheaper and answers the purpose nearly as well. Where it is exceedingly cold during the winter it is good policy to house in the sub-structure and keep a fire under tank, allowing the smoke and heat to pass through a pipe near valve in tank and out through roof of tank. In this case it may be necessary to ceil over the upper joist in order to hold the heat from stove as much as possible.

There is an old saying that "The best is the cheapest," and it will hold good in this case, and your committee desire to offer the following: That a first-class white pine tank, placed at an elevation of 25 feet above rail on a steel sub-structure and stone foundation and connected with a 12-inch pine to a 10-inch standpipe, is the most economical and modern structure of the kind at the present time.

The transportation department are frequently asked how quick can you get a shipment of goods over your line, and here the question of water supply is one of great importance to them, and by reducing the stops for water from five to six minutes to one or one and a half minutes means hours to some roads in the delivery of shipments requiring quick transportation, and your committee, believing in progression in all matters coming under their charge, have offered you what they believe to be the best and most economical water tank and standpipe at the present date.

We also submit a detailed statement of material and labor to construct a 16-foot x 24-foot tank as used by the Chicago and West Michigan Railroad.

3 pieces oak 12 in. by 12 in. by 12 feet—432 ft. at 1.8c...........	$7.78
14 pieces white pine 12 in. by 12 in. by 16 feet—2,688 ft. at 1.3c..	34.94
2 pieces white pine 12 in. by 12 in. by 26 feet—624 ft. at 1.7c....	10.61
16 pieces white pine 4 in. by 6 in. by 20 feet, S 4 S—640 ft. at 1.3c.	8.32
23 pieces white pine 4 in. by 6 in. by 16 feet, S 4 S—736 ft. at 1.2c	8.33
10 pieces white pine 3 in. by 12 in. by 26 feet, S 4 S—780 ft. at 1.7c	13.26
2 pieces white pine 3 in. by 12 in. by 24 feet, S 4 S—144 ft. at 1.6c	2.30
2 pieces white pine 3 in. by 12 in. by 20 feet, S 4 S—120 ft. at 1.4c	1.68
2 pieces white pine 3 in. by 12 in. by 16 feet, S 4 S—96 ft. at 1.3c..	1.25
2 pieces white pine 3 in. by 12 in. by 14 feet, S 4 S—84 ft. at 1.3c..	1.09
6 pieces white pine 2 in. by 2 in. by 16 feet, S 4 S—32 ft. at 1.2c..	.38
8 pieces white pine 2 in. by 12 in. by 12 feet, S 1 S—192 ft. at 1.275c	2.45
16 pieces white pine 1 in. by 8 in. by 12 feet, S 2 S select—128 ft. at 3.0c........	3.84
10 pieces white pine 1 in by 12 in. by 16 feet, S 2 S select—160 ft. at 3.0c........	4.80
4 pieces white pine 1 in. by 10 in. by 16 feet, S 2 S select—53 ft. at 3.0c........	1.59
50 pieces white pine 2 in. by 6 in. by 14 feet—700 ft. at 1.175c....	8.23
1 piece white pine 8 in. by 12 in. by 12 feet—64 ft. at 1.1c........	.70
8 pieces white pine 2 in. by 4 in. by 20 feet, S 2 S—107 ft. at 1.275c	1.36
8 pieces white pine 2 in. by 4 in. by 16 feet, S 2 S—83 ft. at 1.1c...	.91
16 pieces white pine 2 in. by 4 in. by 14 feet, S 2 S—149 ft. at 1.1c	1.64
275 pieces white pine 1 in. by 6 in. by 16 feet, ceiling—2,200 ft at 1.7c........	37.40
4 pieces white pine 2 in. by 4 in. by 18 feet, S 4 S—48 ft. at 1.25c..	.60
8 pieces white pine 1 in. by 6 in. by 12 feet, S 2 S, select—48 ft. at 2.9c........	1.39
6 pieces white pine 1 in. by 6 in. by 16 ft—48 ft. at 2.0c..........	.96
5 M. shingles—$2.00........	10.00
16x24 ft. tub and hoops........	325.00
12 cap castings........	14.40
12 rods ¾ in. by 21 ft. 3 in. long, 12 rods ¾ in. by 8 ft. 3 in. long,	9.10
150 lbs. 10d nails........	4.50
100 lbs. 20d nails........	3.00

24 lbs. 4d nails	.84
48 ¾ in. cast washers	.48
250 yds. building paper	15.00
12 gals. mineral paint	12.00
12 gals. boiled oil	7.80
Labor, painting	25.50
Labor, erecting tank	161.37
Stone foundation	228.50
Total	$973.80

We also submit cost to erect tank as used by Chicago, Rock Island and Pacific Railroad.

16x24 ft. tank with 12 hoops, 3 lugs each	$275.00
1 indicator	5.00
1 set 7 in. fixtures	68.00
12 iron post caps	24.00
Rail joist, at $5 per ton	18.45
Sub-structure, frost proofing, etc	198.36
Paint	14.51
Foundation stone	68.75
Labor in foundation	116.00
Labor, painting	24.24
Labor, erecting tank	164.72
Total	$977.03

Mr. T. J. Kinder, superintendent B. & B., L. E. & W. R. R., sends the following cost to erect a 16x24-foot tank and steel sub-structure built by the King Bridge Co., of Cleveland, Ohio. This tank has a 30-foot elevation, built at Lima, Ohio, and cost $1,600.

We are indebted to Mr. Kinder for the above, as he is not a member of our association. We are also indebted to Mr. W. E. Harwig, master carpenter of the Lehigh Valley Railroad, for blue prints furnished, also detailed list of material and labor to erect one of their standard 20-foot tanks, as follows:

4,560 ft. 3 in. cypress for staves and bottom, at $28.00	$127.68
700 ft. 1 in. by 3 in. yellow pine plank for false bottom, $20.00	28.00
32 pieces 2 in. by 12 in. by 16 ft. white pine plank, $30.00	30.72
12 pieces 2 in. by 6 in. by 16 ft. white pine plank, $30.00	3.86
50 pieces 3 in. by 4 in. by 16 ft. hemlock scantling, $10.00	8.00
500 ft. 1 in. hemlock boards, $10.00	5.00
700 pieces white pine car siding, $25.00	70.00
200 lineal ft. beveled siding, $25.00	2.50
8 pieces 1 in. by 6 in. by 16 ft. white pine (facia boards)	
8 pieces 4½ in. O. G. battons	
4 pieces 1 in. by 3 in. by 16 ft. white pine (corner boards)	
4 pieces 1 in. by 4 in. by 16 ft. white pine (corner boards), 100 ft., $25.00	2.50

1 door 2 ft. 10 in. by 6 ft. 10 in.			3.00
1 door frame for door.2 ft. 10 in. by 6 ft. 10 in.			2.50
4 pieces 1 in. by 8 in. by 16 ft. white pine, for base, $30.00			1.29
1 piece 10 in. by 10 in. by 7 ft. white pine, for spire, $30.00			1.74
1 ladder			3.00
1 16 ft. ladder, white pine			3.00
2 pieces 4 in. by 7 in. by 26 ft. white pine, 9 pieces 2 in. by 7 in. by 16 ft. white pine, 2 pieces 4 in. by 7 in. by 17 ft. white pine, 6 pieces 4 in by 6 in. by 22 ft. white pine.	632 ft.	30.00	18.96
1 tell-tale			3.00
1 hank sash cord			.75
¼ in. side pulley			.05
2 kegs 8d wire nails, $1.78			3.56
1 keg 10d wire nails, $1.67			1.67
1 keg 20d wire nails, $1.53			1.53
5 lbs. 8d wrought nails, 2.5c			.13
1-6 lever padlock			.38
2 pairs 8 in. strap hinges			.35
1 8-in. hasp			.50
1 rod ⅞ in. by 7 ft. 10 in., with nuts and cast washers			1.50
56 cubic yards masonry, $5.00			280.00
2,720 lbs. wrought iron (hoops), 3c			81.60
Lead, etc			35.00
Labor			175.00
Total			$896.77

We also submit quite a number of blue prints from different roads; also blue prints from the King Bridge Co., of Cleveland, Ohio, and the United States Wind Engine & Pump Co., of Batavia, Ill., which we think will be of interest to all members of the association. We are respectfully yours,

W. O. EGGLESTON, Chicago and Erie Ry.,
W. M. NOON, Duluth, So. Shore & A. Ry.,
A. M'NAB, Chicago & West Michigan Ry.,
N. W. THOMPSON, P., FT. W. & C. Ry., *
Committee.

*I do not concur in the statement that a 12 inch pipe and 10 inch standpipe is necessary. With a 22 foot elevation, 8 inch pipe and 8 inch standpipes, our engines can fill a tank in 1½ to 2 minutes (3,600 gallons) if tub stands within 200 or 300 feet of standpipe. N. W. THOMPSON.

DISCUSSION: SUBJECT—TANKS, SIZE, STYLE, AND DETAILS OF CONSTRUCTION, INCLUDING FROST-PROOF PROTECTION TO TANK AND PIPES.

Mr. McGonagle, D. & I. R. Ry.—The principal points to bring out are the kind of lumber used in the tub, and the kind of material in the substructure, whether of wood or iron or steel, and the methods of frost proofing. I think these are the main features.

Mr. Nutting, C. & O. R. C. Ry.—In 1886 we bought six tanks 12x18 of Michigan pine and set them up directly. They have been in use ever since. The bottom half of the staves in tanks began to give out some time ago; on examining them, I found that the inside of the stave was entirely rotten, and that you could stick your finger through nine out of ten of them without any trouble. In 1890 we put up twelve more of these tanks, of the same kind of timber as the first lot, and they are going the same way as the others. Three years ago I had made at my headquarters some long leaf pine tanks. They have not been in use long enough yet for a true test. So far, they are giving very good satisfaction, and are, I think, better for the Southern climate than tanks made of white pine. White pine will shrink and swell more than yellow or long leaf pine, in the hot sun of the South. The sun striking the staves on both sides during the day, will shrink a white pine stave, "when the water gets low in the tank," from one-eighth to a quarter of an inch. With the long leaf pine we have not had this trouble. They have been in use three years or more; the hoops are tight; have never had to send men to attend to them, and they have stood remarkably well. For tank foundations we use both stone and wood. Masonry costs us three dollars per cubic yard.

The long leaf pine tanks cost us, ready to set up, less hoops	$75.00
4,575 feet of timber in substructure, cost	32.02
For labor putting up tank complete	97.75
Total for tank put up on wood foundation	$204.77

Mr. Garvey, Iowa Central Ry.—Three years ago I began putting up tanks on our road, beginning at the foundation. At first, I just dug a drain three feet wide and four feet deep, twenty-four feet for centers, and fourteen feet for outside, and we filled in with broken rock and gravel, and put rock on top, laying sills on that. In our climate the frost is very deep, and we changed the plan of using stone to driving piles. We drove twenty-two piles in foundation for a tank and sawed off about a foot above the ground and put on the frame. We use white oak and white pine 12x12, and we use 6x12 for sills, for joists under the top, and on the four center posts of the tank. We boarded them up inside and outside, and filled up between with sawdust. We put a door on and put a valve under the tank. We put a coat of coal-tar on the tank to prevent staves from rotting. I get a report every morning as to each tank. The agents are supposed to report the condition of the tanks every morning, and when these reports come in I see them, and if there is not as much water in any of them as there should be, I find out right away what the trouble is. These tanks have not been up long enough to warrant a definite opinion being given. There are other tanks on the road that were there before I came to it, but we are replacing these as fast as we can. We are having very good satisfaction with pine tanks so far. We put a shingled roof on the tank. Formerly we used to box the whole frame under the tank, but we lost two tanks by fire on account of tramps breaking in and building fires, and since then we have taken down all the sheet-iron and boxed up the pipe.

Mr. J. L. Neff, C., Northern Pac. & C. Ry.—I have had a little experience with water-tanks in a great many different ways. The first tanks I put up I had a great deal of trouble with; afterwards, I started in to suit myself. I did away with all sawdust, and I started in with eight thicknesses of boards. I took up my valves. The valve that was in the top I did away with. Since I have come back on the road, I have found that all the timbers have become rotted, and they have had to be renewed. I made a large box, taking in the four center posts, and filled in with sawdust. I had occasion to take down a tank at Marengo, Ill. It was made of two-inch staves. The agent told me that he had been attending to the water works twenty-four years and that that tank was up when he came on the road. This tub was made of the best material. After it was taken down, the man was asked what he was going to do with the lumber, and we understand he made framing for his house of it. This tank was probably from twenty-five to twenty-eight years old. I do not think heavy staves in a tub are a benefit.

Mr. Garvey, Iowa Central Ry.—I understand that if sawdust gets wet where it is packed in, it will certainly rot the timber; but as long as it can be kept dry, it will not rot the timber. We sometimes take off a board to see that it is all right. We are far up North. There are some places on our road where it is twenty-five degrees below zero sometimes, and you have to protect yourself.

Mr. Foreman, Philadelphia and Reading Ry.—We have both kinds of tanks, round and square. The square tanks are made of four-inch pine and hold 60,000 gallons. The square tanks were made in 1864 and are there yet. The round tanks are two inches, and have been there ten years. We put a roof on. My opinion is that the square tank is the cheaper. It costs from $700 to $800. We put bolts in them. As to the heating of them, we of course do not heat them all together. We have a stone foundation. In some cases we have got down to five feet; in other places, three. Have never experienced any trouble during the winter time.

Mr. J. H. Markley—I would like to ask if the foundations are not housed in.

Mr. Foreman—No, sir.

Mr. Large, Erie and Pittsburg Ry—I have had quite a long experience with water-tanks, thirty-five years, off and on. With round and square, large and small tanks; and I find that a round tank without a house around it, or, as we call it, a frost-proof tank, without any packing underneath it, and a vault built around the pipes not connected with it, of two thicknesses of boards set eight inches apart and filled with sawdust, has given the best satisfaction of any that I have had to do with. I have built them with no protection except the roof, where we got seventeen years' service out of them, and then they did not rot so much from outside exposure as from allowing an accumulation of sediment in the bottom of the tank. The L. S. & M. S. Ry. have recently taken down a tank that was put up in 1872, that was built in that way. The material in it was fairly good. If they were hard up, it would have lasted three or four more years; but they wanted a larger tank.

In answer to N. H. Markley, Mr. Large said: We used white pine all through the tank referred to as being put up in 1872. It was taken down within a month.

In answer to Mr. Nutting, Mr. Large said, in regard to the effect of paint on the outside of tanks: I have never put one up and allowed it to stand for any length of time without painting. I recollect that I put one up, a good many years ago, on the P., F. W. & C. Ry., and we painted it inside with coal-tar. The lumber was not properly seasoned, and we were delayed about getting the water turned into it; and when we got it turned in, the tank had shrunk so that it would not hold water. We took the hoops off and put in one more stave, and did not paint it. After several years we took the tank down, and the stave that was not painted was from three-eighths to one-half inch thinner than the balance of the staves, although they were originally all one thickness.

Mr. Thompson, P., Ft. W. & C. Ry.—My experience is the same as Mr. Large's. We work on the same division, and build the same kind of tubs. I always use sawdust. I put up four posts so as to close all the pipes, receiving and discharging, leaving about eight inches for air-space. Never had any trouble with pipes freezing. There are no valves in the pipes. Those up seventeen years are in fair condition. They have not yet rotted or fallen down. Whether it would be a good idea to build a steel tank, I do not know. We pay from $325 to $350 for a wooden tank ready to set up. The steel tank costs $533. A question in connection with the steel tank is, whether we could keep them from leaking. Would like to have the members study up this question, and give their views at some future time.

Mr. Bates, C., M. & St. P. Ry.—I have known some tanks to fall down through the rusting of the hoops from the inside, caused, as I believe, by using alkali water from artesian wells. I have samples of such hoops in my office, and if I had known they would have been of interest, I would have brought them to this meeting. In the inspection of tanks we have to be careful to try the hoops to see that they are not eaten up from the inside.

Mr. McIntyre—Would this not be due to lack of paint?

Mr. Bates—Very likely. I think hoops should be painted on the inside and the tank staves on the outside, before the tanks are erected. They would then hold water better, and last indefinitely.

Mr. Markley—We have tanks that were put in in 1881, and they are still in a good state of preservation. Have had no trouble with them.

Mr. Cummin, Long Island Ry.—The tanks on our road are all enclosed from the foundation up. We use cedar tanks altogether, frame 12x12, yellow pine. The entire foundation is closed in. On the ground floor we usually lay a two-inch floor. The outside of the frame is sheathed with one-inch pine, then clapboarded on the outside. We have no trouble with the pipes whatever, from freezing or otherwise. We have some tanks put in in 1884, and they are in first-class condition yet.

Mr. A. S. Markley, C. & E. I. Ry.—Last summer we took down two tanks that were put up in 1878, of white pine. They were not as bad as they might have been, and would have lasted at least another year. We have tanks up now since 1880, and they will probably last two or three years longer. We put up tubs in 1886, and, as far as I can judge, they are good for twenty-five or thirty years.

Mr. A. McNab, Chicago and West. Mich. Ry.—It is natural for members to think that we should have more trouble with our water-tanks on the north end of our road than we do on the south end, but my experience has been that we have had more trouble with our tanks freezing in Indiana, than we have had on the north end, and our tanks are all frost-proofed just the same; every tank we have is frost-proof. I sometimes think there is a good deal in the water; on the north end of our road we use all spring water, and we know it will not freeze as readily as the surface water. We use a 16x24 foot tub. On the north end we have several tanks with wood foundations, but on the south end they are all stone. We use twelve posts under our tanks, with iron caps on top of post. For our frost-proofing we have three thicknesses of seven-eighths ceiling and three thicknesses of paper, taking in the four center posts; our feed-pipe and discharge pipe come directly under the center of tub; we build a box around them entirely separate from the outside frost-proofing; we use about eight inches of sawdust in this box. Of course, we have double doors, and they are also filled with sawdust; and we have a valve in the discharge and feed-pipes under the tank, so that if anything occurs at the standpipe, we can shut the water off any time; we do the same thing, practically, where we use the double floor. About every two years, I have a man go over the road, and have the sawdust boxes filled up, as the sawdust settles more or less, and requires refilling. I do not think we have had a tank freeze up in four years; they are pretty well looked after.

A Member—Have you the cost of foundation for a water-tank?

Mr. McNab—The cost is $125.

Mr. McGonagle, D. & I. R. Ry.—Water-tanks that are built for the Duluth and Iron Range R. R. are usually made of cypress, three-inch staves, 16x24, built on stone foundations, with wooden posts. We build our tanks on the extreme edge of the right of way, and use standpipes. We do not put any of our water-pipes in the ground. When I first took charge of the Bridge and Building department on that road, all the water-pipes were buried in the ground about six feet. All the tanks were frost-proofed by filling the parts with sawdust. I spent two years tearing out what sawdust there was and taking up all the pipes. I did that, attempting to repair them on the same lines as they were built, but since then we have taken them out entirely and put them in wooden boxes. The boxes are very much as Mr. McNab has described. We build a small box around the pipe, cover this with tarred felt, then put on an inch strip about every four feet, encircling these boxes, then repeat this until we have three dead-air spaces. We find that the dead-air space is the secret of the prevention of frost from reaching the pipes. Since we have adopted this method of construction, we have never had any trouble, and are perfectly satisfied with the arrangement. This practice is all right for a temperature of 40 to 60 degrees Fahrenheit. I might add that we usually excavate our tank foundations in the form of a Greek cross, then put a layer of concrete eighteen inches thick over the whole surface, then build the piers. We are very particular to provide for sub-drainage from the lowest portion of the foundation, wherever it is possible to secure it.

Mr. Thompson, P., Ft. W. & C. Ry.—In our tank foundations the lowest course is six feet square, the next course five feet square, and the next four feet; then we have a cap-stone set there that is beveled in some places. Our standard foundation is of stone.

Mr. Markley—We are just putting in a foundation now, and we do not use foundation piers to exceed three feet square. We use good cement, but we do not exceed a yard or a yard and a half. All you have to look for is a good foundation.

Mr. McNab (to Mr. McGonagle)—Do I understand that your discharge pipe is above ground?

Mr. McGonagle—Yes. We put up light trestle bents about eight feet apart, and on this we place the frost-proof box in which the discharge pipe is carried. I will add, that in addition to the construction I have described, we take a three-quarter inch iron pipe and run it from the boiler to the tank and returning through this box, so that in extreme weather we can heat the boxes, if necessary. We very seldom find that necessary.

Mr. McNab—Do you use standpipes?

Mr. McGonagle—Yes. We carry the supply pipe from tank to standpipe in the same kind of frost-proof box as described heretofore, drop the box under the track and fill over it with cinders.

Mr. Riney, Chicago and Northwestern Ry.—I present a detailed statement, showing the cost of four of our tanks. The tanks are 16x24, on 24-ft. posts:

SPARTA, WISCONSIN.

Labor.	
Building tank	$263.00
Painting tank, two coats	26.25
Laying pipe and setting standpipes	178.20
Building masonry	209.00

Material.	
Water-tank	$275.23
2 8-in. Mansfield standpipes	380.00
540 ft. 8-in. pipe and fittings, valves, etc.	315.10
1 bbl. pitch, 1 bbl. oakum	6.40
Posts, caps and braces for tank	209.41
Stone and foundation and two standpipes	309.00
108 ft. 4-in. gas-pipe	21.60

EVANSVILLE, WISCONSIN.

Labor.	
Building tank	$200.57
Laying pipe	198.86
Painting, three coats	34.50
Digging well, 16x18, and walling up same	290.00
Foundation for pump-house and standpipe	120.00

Material.	
Tank complete, including posts, braces, and caps	$304.33
One 8-in. standpipe	190.00
Two 8-in. gate valves	45.00
608 lbs. lead	21.28
660 ft. 8-in. cast-iron pipe	254.55
Lumber for well, pump-house and stand-pipe foundation	23.09
80 ft. 4-in. gas-pipe	16.00
Paint	19.53
Stone, cement, etc.	288.50

ELROY, WISCONSIN.

Labor.		Material.	
Building	$238.35	Tank	$275.23
Laying pipe	93.17	One 10-in. standpipe	225.00
Painting, two coats	31.00	90 ft. 10.-in. cast-iron pipe	71.66
Tank and standpipe foundation	132.56	Fittings for pipe and standpipe	65.34
		Foundation for tank and standpipe	150.00
		Paint	13.02

MONONA YARD.

Labor.		Material	
Building	$228.35	Water-tank	$304.23
Laying 3,000 ft. of pipe, 20c. foot	600.00	10-in. standpipe	225.00
Painting, two coats	29.00	60 ft. 12-in. cast-iron pipe	71.66
Foundation standpipe	18.00	Valves, elbows and fittings	65.34
Foundation tank	111.56	2,586 lbs. lead, 3⅜c per lb	87.28
		250 pieces 6-in. cast-iron pipe	1,229.90
		Paint	19.53
		Material for standpipe	21.00
		Material for tank	129.00

Mr. Riney—All our standard tanks are put up on posts, and from them we use the standpipes. The eight outside posts are vertical posts and all left open. We have had no trouble with frost. The old tanks were all boxed in. We used stoves, but these are being done away with as fast as we can remove the tank. We are now using a 12-inch pipe from the tank.

Mr. Thompson—What is the distance from the standpipe to the tub?

Mr. Riney—From 700 to 2,000 feet.

Mr. McNab—I would like to ask if these figures include foundations or erection of tank, standpipe, and laying the pipe.

Mr. Riney—The figures given are for the entire work complete, as shown in the itemized statement.

Mr. J. P. Snow, B. & M. R. R., forwarded the following written discussion:

The custom on some lines of using timber sills under the posts of the ordinary tank appears to me to be bad practice. It is well known that timber in a horizontal position is not as durable as when vertical; moreover the sills are laid directly on the masonry and absorb moisture from it, and all spray from the spout (when used), and all leakage is quite likely to keep them wet on top. The load on the feet of posts as ordinarily framed in a 50,000-gallon tank is nearly 300 pounds per square inch. This, with the softening due to the sources of decay mentioned above, causes the sills to crush very early. The caps, although the same size as the sills, last as long as the posts.

The practice of using cast-iron bases for the posts is much better, but I agree with the committee that a steel or iron substructure is to be preferred to timber posts. I would favor posts made of two angle irons riveted Z fashion, furnished with a generous sized riveted top to receive the cap timbers and to be well braced with angle iron bracing.

I estimate this to cost for a substructure twenty feet high, $125, or $130 more than timber posts and sills.

REPORT: BEST AND UNIFORM SYSTEM OF REPORT BLANKS FOR BRIDGE AND BUILDING DEPARTMENT.

We have received from a number of roads copies of forms used by them, and find that with the exception of time books, there is a great diversity of forms and methods of reporting.

In many cases the forms are for general use of the various departments of the system, and seem to be prepared to suit the general accounts, and also indicate that the statements required of expenditures on bridges and buildings differ in almost every instance. Therefore, on account of the various conditions under which bridge and building department work is performed on the different systems, and by reason of the fact that in many cases the forms are adapted to general use, and that any change might affect the general accounts, we have deemed it best to recommend only the following forms, and have arranged and classified all the other forms submitted so that they may be examined by the members and notes taken of such as are suited to their respective roads.

FORMS RECOMMENDED.

Time Book: As per marked sample, to be 4½ inches x 7 inches, and the number of leaves to be varied in accordance with the size of the crew, covers to be oil boards with cloth back. This book is recommended because it shows the over-time. It is intended that it shall be in use one month only, and retained in the office of the person making the distribution of time.

For reporting material used, Mechanics Diary, U. P. System, with alterations shown in pencil on first leaf. The number of pages in the book to be determined by the road using it.

Form blank.

TIME BOOK for the Month of..189

NAME.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Total time.	Rate per day.	Amount. $	Cts.
Regular Time, Over Time, TOTAL TIME, DISTRIBUTION.																																			

Iron Bridges.

C., M. & St. P. Ry. Co.—Bridge and Building Department.

Statement of Cost.

.... Bridge No. .... over .... Division ....

....

....

Built during months of 189

Volume of Masonry:

Bridge Stone .... Cu. Yds.	Ass't Eng'r........................
Block Rubble............ " "	Masonry Foreman.................
Common Rubble .... " "	Foundation Foreman...........
Concrete................... " "	Iron Bridge Foreman...... ....
Total Masonry .... " "	

Foundation—				
Labor..	....	....	....	....
Lin. ft. Piles..	....	....	....	....
Ft. b. m. Sheet Piling	....	....	....	....
Ft. b. m. Grillage Timber	....	....	....	....
Lbs. Ironwork...	....	....	....	....
Masonry—				
Labor, Masons and Helpers	....	....	....	....
Cwt. Stone..	....	....	....	....
Sacks Cement...	....	....	....	....
Cars Sand..	....	....	....	....
Ironwork—				
Labor, Iron Bridge Crew, Erecting	....	....	....	....
Lbs. Ironwork...	....	....	....	....
Labor, Painting.......................................	....	....	....	....
Gal. Paint..	....	....	....	....
Floor—				
Labor, Carpenters	....	....	....	....
Ft. b. m. Timber......................................	....	....	....	....
Lbs. Ironwork...	....	....	....	....
Train Service..	....	....	....	....
Engineering...	....	....	....	....
Total Cost of Bridge...............................	....	....	....	....

Analysis of Cost.

Masonry exc. of Foundation, Labor and Material per Cu. Yd. of Masonry.......

Masonry exc. of Foundation, Labor only, per Cu. Yd. of Masonry.................

Masonry and Foundation, Labor and Material, per Cu. Yd. of Masonry ....

Iron work, Labor erecting and painting, per lb. of Ironwork ....

Ironwork, Labor and Material, per lb. of Ironwork..................................

Ironwork, Labor and Material, painting only, per Lin. ft. of Bridge ....

Floor, Labor and Material per Lin. ft. of Bridge ....

Floor, Labor only, per Lin. ft. of Bridge ....

Stone Arches, Rail-Top, and Stone Box Culverts.

C., M. & St. P. Ry. Co.—Bridge and Building Department.

Statement of Cost.

.... No. .... over .... Division ....

....

....

Built during months of 189

Volume of Masonry:	
Bridge Stone..................................	
Block Rubble	Ass't Engineer....................
Common Rubble	Masonry Foreman................
Concrete	Foundation Foreman ....
Paving..................................	
Total Masonry	

Foundation—				
Labor	....	....	....	....
....	....	....	....	....
....	....	....	....	....
....	....	....	....	....
....	....	....	....	....
Masonry—				
Labor, Mason Crew....................	....	....	....	....
....	....	....	....	....
....	....	....	....	....
....	....	....	....	....
....	....	....	....	....
Concrete—				
Labor, Mason Crew....................	....	....	....	....
....	....	....	....	....
....	....	....	....	....
....	....	....	....	....
Covering—				
Labor	....	....	....	....
....	....	....	....	....
....	....	....	....	....
Paving—				
Labor	....	....	....	....
....	....	....	....	....
Train Service..............................	....	....	....	....
Engineering	....	....	....	....
Total Cost	....	....	....	....

Analysis of Cost.

Masonry, Material and Labor per cu. yd. of Masonry..............................
Masonry, Labor only per cu. yd. of Masonry ....
Masonry and Foundation, Material and Labor per cu. yd. of Masonry..........
Concrete, Material and Labor per cu. yd. of Concrete............................
Concrete, Labor only per cu. yd. of Concrete ....
Covering, Material and Labor per Lin. ft. of structure ....
Paving, Material and Labor per sq. yd. of paving..................................

Bridge and Building Record Account Book: None of the roads submitted sample of their record books, with the exception of the C., M. & St. P. Ry., which submitted forms for cost of bridges and buildings. Their system is to record in an ordinary journal-ruled book the charges to the work as they appear in the monthly distribution of labor and material, and when the structure is completed the cost is analyzed as indicated by the forms submitted.

In our opinion the above forms are the best, and can be adopted by any of the roads submitting forms without any serious alteration in their methods of reporting.

GEO. J. BISHOP, C., R. I. & P. Ry.,
W. O. EGGLESTON, Chicago & Erie Ry.,
ONWARD BATES, C., M. & ST. P. Ry.,
M. RINEY, C. & N.-W. Ry.,

Committee.

REPORT: BEST AND UNIFORM SYSTEM OF REPORT BLANKS FOR BRIDGE AND BUILDING DEPARTMENT.

I hope the members will consider the scope of the committee as covering regular inspection reports, as well as reports of expenditures alone.

Of course, inspection reports must vary according to the organization and size of the road. Where the head of the department can inspect all bridges himself, he needs only his personal notes, which can best be kept, I think, in a pocket note-book constantly carried. He should have a new book each year, with all the bridges entered conspicuously in consecutive order, giving from a few lines to a couple of pages to each bridge, according to its probable need of attention. Where the system covers several divisions, each with its independent supervisor or general foreman, it would seem that periodical reports of the condition of the structures should be rendered to the central office; even if the office is indifferent to the exact condition of affairs in detail, reports must be rendered to the interstate and state commissioners, and in order to do this intelligently the management must keep in touch with the work more than can be done through the ordinary time returns.

I am not a believer in the necessity of very frequent inspection of bridges that are in good order. As a prominent engineer said, "A bridge that needs going over with a microscope every month, needs rebuilding."

I think the section men should be trained to report anything apparently wrong, which they will do very faithfully if encouraged to do so. For bridges in first-class shape, a yearly inspection by a competent bridge man should be sufficient. Others of more questionable condition should be examined once in three months, and others still that need watching should be looked over once a month or oftener. The reports of these inspections to the chief engineer, superintendent, or whatever official keeps the records, should give the physical conditions of all parts, changes made in the structure, if any, since the last report, and recommendations for repairs or renewals. I think these should be signed by the general foreman or supervisor, and that he should keep a copy or abstract, so that he may know each time what he reported previously. These reports are best filled out on the ground, while the inspector is on or under the bridge. I particularly object to a report filled out from notes, or, worse still, from memory, after the inspector has reached a convenient place for filling out the sheet. The supervisor may well delegate some trusty man to examine and fill out the blanks for all bridges in fairly good shape, but he should sign them, so as to insure his being cognizant of the statements made, and he should also fill out the blank for recommendations. The questionable bridges on which he would not care to sign a statement made by a subordinate, he had much better examine himself, anyway. These reports would keep the central office informed, not only as to the condition of the bridges, but also as to all changes made by renewals or repairs.

The blank contained in the abstract of the committee's report does not completely fill the bill, it seems to me. The dimensions, etc., covered by the first five items ought to be permanently on record, and need not be repeated at each inspection. The space for noting the condition of each item seems small and poorly arranged, and the size of sheet makes it inconvenient to carry in the field.

I submit a form that I had printed some years ago, which seems to me to be more intelligent, and convenient, although perhaps not covering so much ground as it ought to. Owing to a change of organization, these blanks are not now in use.

Bridge No. ....

....*189*

Points reported poor.

....

....

....

Recommendations

....

....

....

PERFORATED.

Bridge No......................... ....*189*

Masonry or Piles........................	*Bearings*........................
Timber........................	*Ties*........................
Bottom chord Pulled........................	*Roof*........................
Rivets........................	*Paint*........................
Line........................	*Camber*........................

Miscellaneous defects ....

....

Recommendations ....

....

....*Supervisor B. & B.*

These sheets are four inches wide by ten inches long; they are made up into books with pasteboard covers to protect them when in the pocket, and the stub is retained by the supervisor for his record of what he has heretofore reported. On the lining of the front cover, the following directions are printed. The signature serves to define the division from which the report is made.

INSTRUCTIONS TO INSPECTORS.

Blanks must always be filled out at the bridge site by the inspector. The recommendations should be filled out and signed by the supervisor.

NOTE ON ALL BRIDGES.

Masonry or piles: good, fair, or poor.
Bearings: good, poor, clean, or dirty.
Ties: good, fair, or poor.

NOTE ON WOODEN BRIDGES.

Timber: sound or decayed, good, fair, or poor.
Bottom chord pulled: 1-8, 3-16, 1-4, etc.
Roof: good or poor.
Line: good, or out-inches east or west.
Camber: inches up, or straight, or inches down.

NOTE ON IRON BRIDGES.

Rivets: number lose.
Paint: good, fair, or poor.
Defects not classified above must be given as miscellaneous.
If repair or renewal is thought to be needed, state it under recommendations.

It is often puzzling to ascertain how it is intended that blanks for any purpose should be filled out. For instance, I should be at loss how to fill the vertical columns of the blank presented by the committee, and if not filled out according to intention, and if not understood alike by all inspectors, the resulting record will be of little value. It was thought that the above instructions would explain what was wanted, so that the blanks would be filled properly.

J. P. SNOW, B. & M. R. R.

REPORT: THE MECHANICAL ACTION AND RESULTANT EFFECTS OF MOTIVE POWER AT HIGH SPEEDS ON BRIDGES.

The subject which your committee has been called upon to investigate is one which has been before the engineering profession for years, but up to the present time no one has been able to definitely formulate any positive law of action, or even to indicate in an approximate manner just what injurious effects quickly-moving loads have upon bridges.

We all know that trains rushing over a bridge will cause shocks, tremors, and vibrations. We can feel these effects by standing on the structure, and we realize that the heavier structure is less shaken than the lighter. But if called upon to state in accurate terms the amount of increased strain due to those moving loads, your committee must plead ignorance. The effects are there, they can be measured, and instruments can be made which will register them. These measurements, however, must necessarily cover such a broad field that in all probability no one committee will even be able to arrive at any conclusions worth speaking about. Your committee must ask to be excused if they have found it beyond their power to present to the association any original matter, but have resorted to the old trick of embracing in this report a resume of the facts presented and the experience gained by others, and compiling this information so as to represent our present knowledge on the extremely erratic action of motive power on bridges.

The attempted determination of impacts can be divided into three classes—

1. Those which are purely theoretical and which are of no interest to this association.

2. Those which had for their object the measurement of the stretch of the various members of a bridge during the passage of trains. These tests are practically limited to those made by European investigations on riveted bridges, the results of which indicated that impacts decreased as the length of the span increased, and in a rather uncertain and erratic manner that impacts in the various members of the same span are a vague function of the length of moving load required to cause the maximum strain in the member considered. Members of your committee made about one hundred tests of this character, but results were not sufficiently positive to justify their presentation in this report.

3. Those which had for their object the measurement of the deflection of the structure as a whole.

Among investigators who have endeavored to measure center deflections by mechanical means, perhaps no one has gone further into the question than Prof. S. W. Robinson, M. Am. Soc. C. E., who invented an instrument which accurately measured the deflection of bridges. The results of Professor Robinson's experiments were presented before the American society at the June meeting, 1895, and show that the increase of strain due to vibrations caused by unbalanced locomotive drivers is 28 per cent. of the maximum strain caused by the passing train when statically considered. He observed also that the increased strains due to vibrations caused by the body of the train were 50 per cent. greater than the corresponding part of the train statically considered.

Moreover, since he found certain cases in which the dynamic strains produced by the train load itself were greater than those caused by the engine, he was of the opinion that in designing bridges 50 per cent. should be allowed for impacts, instead of the 28 per cent. which he found in his diagram. He also found that the cumulative vibrations, depending upon certain relations between the load and bridge, were particularly prejudicial. Among these are the relation between the circumference of the driver and the panel length, and the relation between the wheel spacing and the panel length.

In actual practice it is the custom of different engineers to make variable allowance for the effects of impact. For example, some roads will assume that bridges under 100-foot span are subjected to impacts of varying amounts, while spans of greater length are subjected to no impact. Others assume that the strains caused by live loads are twice as great as those caused by the dead load only, regardless of the length of span. Some specifications allow a certain impact varying from 100 per cent. for very short spans to nothing for spans of 500 feet and over. Others, again, will allow for varying impacts depending upon the ratio of the minimum stress to the maximum.

All these attempts to establish a law of impact, and the assumption of such laws as given in the various bridge specifications, while undoubtedly indicating the unsettled knowledge of the subject, are nevertheless more or less valuable, and tend toward safe construction. It is to be hoped that in the near future a sufficient number of tests will be made to indicate in some definite manner which, if any, of the numerous assumptions are approximately correct.

GEO. W. ANDREWS, B. & O. Ry.,
J. E. GREINER, B. & O. Ry.,
WALTER G. BERG, Lehigh Valley Railway.

SUPPLEMENTAL NOTE.

The tests made by Mr. G. W. Andrews and myself on some Philadelphia Division bridges, B. & O. R. R., were made for the purpose of ascertaining the relative effects of two different types of engines on certain bridges on the Philadelphia Division, varying in length from fifty-eight to five hundred and fifteen feet.

There were two special cars attached to two engines of different types, and each train was run over the bridge at a speed of ten miles per hour and then at a speed of thirty-five miles per hour. The relative elongations in different members were measured by instruments which I designed and had made for that particular purpose.

While the results of these tests show conclusively that one type of engine was more favorable to the bridge than the other, no general conclusion can be drawn from the tests so far as impacts are concerned; for this reason, I deemed it best not to enter into any details concerning them in the report submitted to the Association.

J. E. GREINER, B. & O. Ry.

REPORT: BEST AND MOST ECONOMICAL RAILWAY TRACK PILE-DRIVER.

I herewith hand you a blue-print of the Louisville and Nashville Railroad Company's track pile-driver. This style of pile-driver has been in use on the Louisville and Nashville Railroad for the last twelve years. This pile-driver was designed by the Bridge and Building department. You will note that it is a pendulum driver; piles can be driven on any batter, or plumb. You will also note that the driver has two centers, you can drive piles close to the end of the car, or shift the driver ahead on to the forward center, and drive piles fifteen feet ahead of the car in case of a washout. You will also note that when the driver is on her back center, you can swing the driver around, and work from the other end of the car. This is a very important feature in a driver when you are between two washouts and cannot get to a turn-table, or a Y, to turn the driver on.

The leads are raised and lowered with the aid of a pole twenty feet long. This pole is made with a yoke on the bottom end, and fastens to the leads by means of two steel pins one and one-half inches in diameter, and ten inches long. It is adjustable. The top of the pole has two eye-bands. One eye-band is used for the suspension rope that holds the pole in position, the other end of the rope being fastened to the top of the leads. One end of the raising line is fastened to the other eye-band, and runs through a leading block which is made fast to a chain that is put under the track twenty-five feet ahead of the driver. The raising line runs from the leading block to sheave on forward end of driver, back to winch head on engine. This handles the leads by steam, and it can be done very quickly and easily.

Any kind of engine can be used on this driver. All that is wanted is an engine with a hoisting drum and a winch head. I am using a double engine, with seven-inch cylinders, and two friction drums and two winch heads, made by the Lidgerwood Manufacturing Company, of New York, No. 71. I use no nippers to raise the hammer, but make the line fast to the hammer, and handle it with the friction. The hammer weighs 3,300 pounds, which is, I think, the best weight for all kinds of pile driving. We use a two and one-half inch diameter, four strand, best Manilla rope for hammer line. I like it best for all purposes, and consider it better than a wire one. We carry on the driver a water-tank that will hold 300 gallons of water, and also a coal-box that will hold twenty-five bushels of coal. In working the driver, we couple the locomotive direct to the pile-driver with a long shackle made for that purpose, the tank of the locomotive being next the driver. This enables us to get water from the locomotive tank to the tank on driver by the aid of a steam syphon. We also use the syphon to fill the locomotive water-tank, when we can get water nearer than to run to a regular water station. We also get coal from the locomotive tender.

We also carry a tool-car with the driver. Twenty-four feet of this car is boxed up for tools; ten feet of car is open for coarse tools, pile rings, and a hand-car, which we always carry.

The tool-car contains the following tools:

500 feet of 2½-inch diameter best four strand manilla rope.
250 feet of 2-inch diameter best four strand manilla rope.
1 coil of ¼-inch diameter rope, 800 feet.
300 feet of 1-inch rope.
300 feet of ⅞-inch rope.
2 good switch ropes.
1 pair 8-inch patent, double sheave tackle blocks.
1 pair 12-inch patent, double sheave tackle blocks.
1 pair 16-inch patent, double sheave tackle blocks.
1 12-inch snatch block.
1 16-inch snatch block.
2 band pullers.
2 15-ton hydraulic, foot-lifting jacks.
4 10-ton screw jacks, 18 inches high.
2 5-ton screw jacks, 12 inches high.
6 steel bars, 5½ feet long.
4 steel bars, 4½ feet long.
2 claw bars.
4 track chisels.
2 14-pound double-faced mauls.
2 8-pound double-faced mauls.
6 5-feet cross-cut saws.
12 8-inch mill saw files.
8 6-pound chopping axes.
2 ship carpenters' hewing axes.
10 cant-hooks.
3 15-16-inch crank augers.
3 13-16-inch crank augers.
2 11-16-inch crank augers.
1 keg 10d. nails.
1 keg 30d. nails.
2 kegs track spike.
2 kegs 8x⅝-inch boat spike.

2 spike mauls.
1 track gauge.
2 7-8-inch S. wrenches.
4 3-4-inch S. wrenches.
2 5-8-inch S. wrenches.
1 12-inch monkey-wrench.
1 15-inch monkey-wrench.
1 18-inch monkey-wrench.
And wrenches to fit all the nuts on the pile-driver.
3 pairs adjustable pipe tongs.
1 hand hammer.
3 cold chisels.
2 12-inch flat files.
10-gallon can lubricating oil.
10-gallon can signal oil.
2 small oiling cans.
1 lamp filler.
8 white lanterns.
2 green lanterns.
2 red lanterns.
1 grindstone and frame.
1 hand-car.
1 velocipede car.

50 pile rings of various sizes to fit piles, made of good iron, 1 inch thick, 2½-inch wide.

For engine in pile-driver we carry:
5-gallon can of lubricating oil.
2-gallon can of cylinder oil.
1-pint oil can locomotive pattern.
1 squirt can.
1 soft hammer.
1 packing hook.
And wrenches to fit all the nuts on engine.

The above list of tools are necessary for the outfit of a road pile-driver.

The cost per day for running a pile-driver is as follows:

Foreman and ten men	$22.00
Engineer, fireman, and watchman	6.80
Conductor and two flagmen	7.00
Coal, oil, and waste	2.50
Use of locomotive	12.00
For use of driver and tools	2.50
	$52.80

This crew is for work on road where you are building short trestles, say from 30 to 40 piles each. Where a trestle is three or four thousand feet long the pile-driving crew should consist of a foreman and fourteen men, as there will not be so much delay in passing trains, as trestles of this length invariably have a side-track near both ends and consequently the pile-driver will drive more piles.

My pile-driver was rebuilt this year, and before rebuilding her several of the most improved railway pile-drivers were visited and examined to see if any improvements could be made on our driver. We found none. Taking into consideration the different kinds of work our driver can do, driving piles on any batter, changing centers, and driving piles 15 feet ahead of car, also changing ends and driving on either end of our car, as well as using her for a derrick in loading and unloading all kinds of material with a boom I have rigged on her for that purpose, I am satisfied that the Louisville and Nashville Railway Company have the best and most economical railway track pile-driver.

G. W. HINMAN, L. & N. R. R.

DISCUSSION: SUBJECT—BEST AND MOST ECONOMICAL RAILWAY TRACK PILE-DRIVER.

Mr. Aaron S. Markley, Chicago and Eastern Illinois Ry.—We have a Bay City pile-driver in service about five or six years. It is self-propelling. If pile-driving is to be done within a mile and a half of a side-track, we rarely use an engine to propel the driver. In that way we save the expense of train crew, engineer, and fireman. We are protected by the train dispatcher and get orders the same as if we had a regular train crew. We haul five or six cars on a level grade and two or three on our heaviest grade. All our unloading of sand, cement, and stone for masons, as well as similar work, is done with the driver. We pay our engineer $2.50 per day while running the driver. That saves, of course, the expense of labor referred to. When I first began using it I did not like it, but the longer we use it, the better we like it. I am safe in saying that in five or six years' service we have saved in train service the original cost of the machine. The price of the machine is $4,500. There are no repairs to amount to anything, the chains and sprocket-wheels are about the only thing that require renewing. They last from one to one and one-half years. The hammer line is hitched direct from the drum to the hammer. No cat-head is used. Forty to fifty piles can be driven per day, depending on location and number of trains with which we have to contend. Hammer which weighs 2,800 pounds is used. We tried wire cable, five-eighths, for hammer line, but found it too rigid. Ordinarily, the driver in running will make eight miles per hour.

Mr. Thompson, P., Ft. W. & C. Ry.—I have one of the Bay City drivers, which we bought about six years ago. When we got it I did not like it, and the more I use it the less I like it. It was called a self-propeller, but could only run about four miles per hour on good track. On sharp curves or when entering sidings, it could not move itself. We do not pretend to use it without an engine to handle it. It is a very heavy, cumbersome affair, and I think a driver could be built of a great deal less material that would be much better. It is very hard on hammer lines. Mr. Markley says a line lasts him three or four weeks. We think we are doing well to make one last three or four days.

Mr. McGonagle, D. & I. R. Ry.—The Duluth and Iron Range road has a Bay City driver. We liked it when we got it, and we still like it. We had some trouble about the rope, but the difficulty was in the construction of the head-block. We had three times more weight than was necessary. We readjusted the head-block and have had no further trouble. We use one and three-quarter-inch stevedore rope, as we find that the best rope. We used in one season a whole coil of manilla, in thirty days, then we bought stevedore and one coil lasted us six months.

Mr. Markley—Did the old stevedore rope have a core in it?

Mr. McGonagle—No.

Mr. Markley—We find that the core dropped and that disturbed everything.

Mr. Eggleston, Chicago and Erie Ry.—We have got a Bay City driver and the longer we have it, the better we like it. It is not self-propelling. We use one and three-quarter-inch manilla rope with 3,000 pound hammer, and we have run these ropes in all kinds of weather. I do not know but the propeller would work well in some places, but most of our work lies away a good distance from any siding.

Mr. Bishop, Chicago, Rock Island and Pacific Ry.—The Rock Island pile-driver is of their own plan, and their own build; has a 20-foot extension. The top and bottom sheaves are 14 inches; drum of engine is 20 inches. We use 1½-inch rope, and it drives about 150 piles before wearing out.

Mr. McNab, Chicago and West Michigan Ry.—The West Michigan pile-driver is one of their own design. It used to be so that it propelled itself, but we found there was not very much economy in doing so; it would only make six or eight miles an hour, and in going up grades of any length the boiler would not steam as fast as it used it, and we had to stop occasionally and blow up. We did away entirely with the propelling gear, and now we use an engine and crew every time we go out to drive piles. We use a 2,800-pound hammer; our driver swings nine feet each way from the center of track.

Mr. Garvey—What kind of a rope have you used?

Mr. Bishop—We use manilla rope.

Mr. Garvey, Iowa Central Ry.—We have had considerable trouble with ropes wearing out. We now use manilla rope, but from what I have heard to-day I think there must be something wrong with our sheaves; sometimes the rope would not run more than two or three days. We use 14x12 sheaves. We have on our road a great many private telephone wires which cross the track, and there is hardly any station where we do not have to lower the leads when we go out, but we have them so regulated that we can raise and lower them easily. We do the most of the raising and lowering with the weight of the hammer, and we find it is very good to have the hammer fixed that way.

Mr. Thompson—Have any of the members ever tried two-inch line, and have they used it for hoisting by hand or steam?

Mr. Bishop—I find they are not giving good satisfaction on the pile-driver we got. At the present time I am figuring to rig up with compressed air which will save two men.

Mr. Markley—There is no danger with the hammer, but there is with the pile-driver.

Mr. J. H. Travis, Illinois Central Ry.—We have always had better results with 1½-hammer line than with any other size, and we have had a great deal of driving to do on the Southern lines, where there are four or five miles of trestle at a place. We tried one and three-fourths and two inches, but we never did get as good results as we did from the one and one-half inch. In connection with this talk in reference to pile-drivers and their operation, I believe if we would all try to get up something that is better than we have had heretofore, it would be of more advantage and interest to the society than anything else. The great objection to all the pile-drivers that have been used in the Northern country within the last year is, that they have been turn-table drivers with fixed leads so that you can only drive your pile perpendicular at whatever distance from center to center that you wish. Some of the swing leads are very clumsy and there are a good many unnecessary parts about them, and I believe a pile-driver that has better advantages than any we have yet seen can be constructed economically and have the leads to swing as well as a pendulum driver. I am going to try it on one driver that we are going to build, by making a frame that will support the leads, and so you can raise the leads if necessary when the train is in motion. It is very seldom that this is necessary, but by dropping the hammer the weight of the same raises the leads. I am going to make one side of the frame with a 4-inch screw, allowing an adjustment in one part of the frame of four inches, and that would be all that is necessary, I think. I have not made any experiments yet that would enable me to know just how long the screw should be, but four inches would be all that would be necessary, I think. I expect to have one in operation before very long. I know that our chief engineer and all our managing officials insist on having two piles well battered so as to have a good base of support, and it would wreck the old-fashioned pile-drivers to do that.

REPORT: SPAN LIMITS FOR DIFFENENT CLASSES OF IRON BRIDGES AND COMPARATIVE MERITS OF PLATE-GIRDERS AND LATTICE-BRIDGES FOR SPANS FROM 50 TO 110 FEET.

As chairman of this committee, I will state that this subject was given us in 1894. Your committee have looked into the matter and find that the American Society of Civil Engineers discussed a similar subject, and a report on the same was read by Mr. J. A. L. Waddell in the year 1892, before that society. It occurs to your committee, that the discussion of this technical subject does not properly belong to our association; we should propound and discuss practical subjects relative to the maintenance department of our railroads, so that every member can fully understand and participate in the discussion thereof, and for this reason we have decided to give the usual practice of eminent engineers in the selection of classes of iron bridges for different spans.

Mr. J. A. L. Waddell, member Am. Soc. C. E., recommends as follows:

Plate-girders..................................to 100 ft. span
Lattice-girders..........................100 ft. to 150 ft. span
Pin spans.............................150 ft. and upwards

Mr. Edwin Thatcher, Keystone Bridge works, recommends as follows:

Plate-girders..................................to 90 ft. span

Mr. Woelfel, Pencoyd Bridge works, recommends as follows:

Plate-girders..................................to 80 ft. span
Lattice-girders..........................80 ft. to 110 ft. span

Mr. J. S. Deans, Phoenix Bridge Co., recommends as follows:

Plate-girders..................................to 75 ft. span
Lattice-girders..........................75 ft. to 135 ft. span
Pin spans.............................135 ft. and upwards

Mr. Aug. Ziesing, Lassig Bridge and Iron works, recommends as follows:

For deck spans—

Plate-girders......................to 90 ft. or possibly 100 ft.
Lattice-girders..........................from 90 ft. to 160 ft.
Pin spans........................from 160 ft. and upwards

For through spans—

Plate-girders................................to 80 ft: span
Half through lattice.....................80 ft. to 110 ft. span
Full through lattice......................100 ft. to 160 ft. span
Pin spans..............................160 ft. and upwards

Mr. Samuel Tobias Wagner, First Assistant City Engineer, Philadelphia, recommends as follows:

Plate-girders.................................to 80 ft. span
Lattice-girders..........................80 ft. to 125 ft. span
Pin spans..............................125 ft. and upwards

From the above tabulations it will be observed that considerable difference exists among engineers as to the limits of spans for different classes of iron bridges, and your committee realize that location and head room are large determining factors in selecting classes of bridges and fixing lengths of spans to be used; and as we are called on to maintain these structures only, we must leave to the American Society of Civil Engineers the discussion of this important and very interesting subject, well knowing that among the members of that society are some of the brightest minds and keenest judgments of any society in this or any other country in the world.

W. A. M'GONAGLE, D. & I. R. Ry.,
R. M. PECK, Mo. Pac. Ry.,
W. M. NOON, D. S. S. & A. Ry.,
H. E. GETTYS, N. & W. Ry.,
G. J. BISHOP, C., R. I. & P. Ry.,
ONWARD BATES, C., M. & St. P. Ry.

PAPER: LOCAL STATIONS.

The almost universal practice at present on the Boston and Maine Railroad is to make passenger stations with one waiting-room only. This applies to large as well as small stations. This room is generally made to occupy one end of the building—that looking towards the principal approach to the depot from the village or city. This arrangement is liked much better by every one than the old-fashioned style of separate or semi-detached rooms. In our very largest city stations, smoking rooms are sometimes provided, but they are very seldom occupied. In large stations built several years ago, with a large central general waiting-room, and a side parlor for ladies, and a smoking-room for gentlemen, the people will all be found in the general room; it is the exception to find any one seated in the other rooms. Even at points where emigrants are transferred, the rooms provided for them are not used enough to pay for their maintenance. It is being proposed to provide but one toilet room in rural stations, but none have been so built as yet. It is entirely practical, however, for small depots and will be adopted soon, I think. Most of the passenger cars built recently have but one closet, and they give just as good satisfaction as those with two.

Our heating is done almost universally with hot water, the very best makes only of heaters and radiators being used. A cellar with cement floor is always provided, and the heater and coal bin placed in it. Radiation in the waiting-room for points south of Central New England is provided at the rate of one square foot for 30 cu. ft. of space, and for points further north the ratio is increased.

The plumbing fixtures are the best procurable, the water-closet apparatus being Huber or Meyer-Sniffen make, with automatic seat flush. The drinking fountains and wash-bowls are of equally durable and expensive styles. This style of work is put into all new stations, large or small, wherever we have a water-supply. At places where there is no water, the closets must, of course, be dry and an air space is arranged similar to the plan shown for Seabrook.

Our frame depots generally have shingled roofs and are covered on the sides with clapboards on matched spruce boards with paper between. The inside is sheathed on walls and ceiling with narrow beaded sheathing of North Carolina pine, clear white spruce, whitewood or cypress, finished in natural color. The brick and stone depots have slate roofs, and are finished with light buff brick inside or with quartered oak or other hard wood. My personal preference for inside finish on depots of moderate size is a sheathed or paneled wainscot with walls and ceiling above plastered with adamant or other hard-setting plaster; the wainscot to be finished natural color, and the plaster painted with more or less fresco work.

Our new depots are furnished almost invariably with tar concrete platforms having granite curbs 7 by 18 inches. Where the slope of the ground precludes concrete, we use 2-inch plank platforms, the plank running at right angles to the rail and resting on joists generally 3 by 8 inches, or 10 inches, about 3 feet apart. These joists are supported on underlays resting on cedar posts set in the ground. Spruce plank are generally used, but long leaf

Southern pine is more economical on account of its durability. A medium quality of white pine makes an excellent platform where the wear is not excessive. The practice for some years past has been to put the edge of platform 2 feet 6 inches from outside of rail, with the top level with top of rail. A rise of about ¼ inch per foot is given from the front to the back. This requirement brings the timber into the ground so badly that concrete is much preferable to wood for platforms, and hence its use. We specify 4 inches of concrete after it is rolled, to be put down in three layers. It costs about 50 cents per square yard, and the granite curb from 60 to 75 cents per running foot, furnished and set. The concrete, if of proper materials, and if properly put down on good bottom, will stand any amount of hard usage from baggage and trucks.

J. P. SNOW, B. & M. R. R.

CHAPTER VI.*

1, REPORT: METHOD OF HEATING BUILDINGS WHERE THREE OR MORE STOVES ARE USED—2, REPORT: THE MOST SUITABLE MATERIAL FOR ROOFS OF BUILDINGS OF ALL KINDS—3, REPORT: HOW TO DETERMINE SIZE AND CAPACITY OF OPENINGS FOR WATERWAYS—4, REPORT: ICE-HOUSES—5, REPORT: BEST END CONSTRUCTION OF TRESTLES ADJOINING EMBANKMENTS—6, REPORT: BRIDGE WARNINGS FOR LOW OVERHEAD STRUCTURES—7, REPORT: STOCK-YARDS AND STOCK-SHEDS, INCLUDING ALL DETAILS OF CONSTRUCTION—8, REPORT: BRIDGE FLOORS.

REPORT: METHOD OF HEATING BUILDINGS WHERE THREE OR MORE STOVES ARE USED.

Early in the year a circular was sent to the members of the association, asking their views on this subject. A number of replies were received, some of which explain the views of the writers so explicitly that we have concluded to give them in full as written. Your committee have been surprised at the view taken, by a large number of the members, of the circular sent out by the committee.

In selecting the plan of the station at Richmond, Ky. (see Figs. 153 and 154), it was not done with the idea of having the members give their views of heating a building located there, but because this building would naturally require three or more stoves to properly heat it. A large number of the replies received indicate, however, that the opposite was the opinion of the writer, and, in consequence, we believe that when this point is thoroughly understood, some of those who recommend stoves would probably change their views on the subject.

It is the opinion of your committee that for cleanliness, comfort, and economy, hot water heating would be the best for a building of this size. While the first cost is greater than that for steam heat or stoves, still we believe that the first cost should not always be considered in a final decision. In erecting the building, while, with a hot water plant it would be necessary to build a cellar—which we would recommend placing under the baggage

*Reports presented at Seventh Annual Convention, held at Denver, Colo., October, 1897.

room—the cost of building one chimney would be saved. The cellar could also be used for storing the coal, which could be put in through a chute and thus avoid having an unsightly coal bin on the station grounds. All annoyance to passengers from ashes, dust, etc., would be avoided, and a great saving in coal and labor made, as it is no more trouble to care for a hot water plant, properly put in, than to care for one stove. All trouble from gas would be avoided, and certainly the rooms can be kept in a cleaner condition than where three or more stoves have to be constantly cleaned out and attended to.

In the matter of economy—four stoves of a size necessary to heat the building would consume about thirty tons of coal per year, while a first-class hot water system would consume about twelve tons per year. Here we have a saving of about eighteen tons of coal each year, which your committee think would pay a large interest on the original investment.

Mr. George W. Andrews of the B. & O. R. R. writes as follows:

"Herewith you will find statement of various methods in use on this road for heating stations. In the small stations we use a No. 2 'Alaska' stove at a cost of about $12, set up. In medium size stations we have hot air heaters, which, while they give ample heat, are expensive to maintain. In large stations we have either steam or hot water. The steam is supplied by low-pressure steam boilers. In the station at Wilmington, Del., where hot water is used, we have the 'Perfect Hot Water Heater' made by Richardson & Boynton Co. of New York. For economy and general satisfaction I prefer the hot water system. The heater spoken of has been in use about eight years, and has not only given entire satisfaction, but has cost but little for maintenance. We wash it out every spring after fire has been drawn for the season, which is about the only work we have ever done to it. I am aware that many systems of hot water heating have been unsuccessful in the past, which I believe was due entirely to ignorance of the proper application of the principles governing hot water circulation. In the above-mentioned heater, as with many others now on the market, due regard has been given to these principles, and success has followed. These heaters occupy but little space, and the one we have uses about two tons of coal per month, and will heat 40,000 cubic feet of air-space."

Mr. J. P. Snow, Bridge Engineer of the Boston & Maine R. R., writes as follows:

"The system of heating universally adopted on the B. & M. R. R. is the two-pipe hot water system. For the station at Richmond, Ky., to which you call attention, I would recommend a cast-iron boiler of the Richmond, Gurney or Hub patterns, of proper size, placed in a cellar, and radiators giving a surface of about 1 foot to each 35 cubic feet of space in the three waiting-rooms shown, and in the toilet room and agent's office.

"I would distribute these radiators as well as possible around the room, placing them under the windows wherever practicable. In the baggage room I would run coils, giving about 1 square foot of radiation to 60 cubic feet of space. I would use Detroit radiators having valves and fittings of not less than the following sizes: 1 inch supply and return for radiators up to 40 square feet, 1$\frac{1}{4}$ inch supply and return for radiators from 40 to 60 square feet, 1$\frac{1}{2}$ inch supply and return for radiators from 60 square feet upward. I would use flow and return pipes, giving 1 square inch of section to 60 square feet of radiation supplied. I would use an open expansion tank placed above the ceiling, automatically supplied if there is a water service convenient. I would also run a feed pipe to the lowest part of the boiler for filling the system whenever it is emptied. If there is no water supply convenient, the tank should be placed as high as possible, but in a position where it can be easily filled by buckets. The above amount of radiation is largely guesswork, as I am not acquainted with the conditions of climate in the latitude specified. In Central New England or at latitude 42 degrees 30 minutes, we use a ratio of 1 foot of radiation to 30 cubic feet of space in waiting-rooms and ticket office, and 1 foot to 50 in baggage and express rooms. Farther north, or in latitude 44, we use 1 foot of radiation to 25 in waiting-rooms.

"Where the radiation is as much as 2,000 square feet, I should recommend a wrought-iron boiler of the 'Star' pattern instead of the cast-iron styles specified above.

"The hot water system is expensive in the matter of radiators when first put in, but it is quite economical in coal in moderate weather.

"In the coldest weather the amount of coal used is the same as it would be with steam, but at moderate temperatures, which obtain at least three quarters of the time during which a fire is needed, the hot water system takes decidedly less coal.

"What is known as the Paul Vacuum system is, I think, very good for depot heating, although it has not been adopted on our road. It is possible that it may require a little more attention than the system described above. It is essentially a steam plant with a small vapor pipe leading from each radiator or set of coils to an ejector operated by the water supply or some other force which will tend to produce a vacuum. This can be adjusted to work at any desired pressure, and its operation is wholly automatic. It is possible to lift vapor from the boiler, which will, of course, give off heat from the radiators when the water is at a temperature of not more than 160 in the boiler. It is then a mere matter of firing to obtain any heat required,—the plant being supplied, of course, with a safety valve set to blow at any desired pressure; the safety valve then governs the upper range of temperature and the vacuum ejector the lower range.

"With the hot water system it is entirely feasible to put on a pressure valve so that it can be run up to any desired temperature. This, however, is not advisable, it being better to put in more radiating surface, and allowing the use of a slower fire.

"I have not taken the time to compute the proper sizes of radiators, boilers, etc., for the depot illustrated, nor can I give you an estimate of the cost. The plans do not show a section of the building, so it would be impossible to get the exact cubical contents of the various rooms.

"I think the above, however, will give you an idea of the way the problem would be solved on our road."

Mr. George J. Bishop, of the C., R. I. & P. R. R., gives his views as follows:

"In reply to your circular of April 24th, 1897, on subject No. 1, 'Methods of Heating Buildings Where Three or More Stoves Are Now Used'—

"In my judgment I would say steam heat; of which there are two systems, one known as the high pressure and the other as low pressure.

"I would say a low pressure with a one-pipe system. If I wanted a boiler enclosed with brick and wished to use hard or soft coal, Haxtun's Patent Vertical Base-burning boiler No. 10 is very desirable for that purpose. Height of boiler 64 inches; outside diameter, 53 inches. Diameter of fire box, 48 inches; number of brick, 4,000; total weight of boiler, 4,000 pounds; square feet of radiation, about 1,500; cost, about $300.

"This does not include the labor of inclosing the boiler with brick.

"If I did not want a boiler inclosed with brick and wished to burn coal, wood or coke, the Bromich No. 5 boiler gives very good satisfaction.

"Diameter of boiler, 43 inches; height of boiler, 84 inches; diameter of fire box, 33 inches; number of 2-inch flues, 210; square feet of boiler surface, 185; square feet of direct radiating surface, from 1,400 to 1,900; cost, $275 for the boiler.

"I would locate the boiler in the basement, under the baggage room, allowing for space underneath platform for unloading coal and for storage, placing a coal hole in the platform for unloading coal and removing the ashes from the boiler when necessary.

"I would place standard vertical radiators in the ticket office, colored waiting-room, and baggage-room; also circular radiators in the ladies' and gentlemen's waiting-rooms; all radiators to have sufficient heating surface for heating each room, located as marked on plan.

"For economy, I would recommend this system. I think you can get more heat from the same amount of fuel. For comfort, you have a steady heat; for cleanliness, steam heat is far superior, as the boiler is located in the basement; you do not have coal hods, pokers, tongs, and coal shovels to handle; no stove pipe to take down and clean out; no stove or stove pipe to polish up; no coal to carry as when you use stoves."

The following would answer for a general specification for heating this building by steam:

The entire building to be completely warmed by direct radiation, located in the waiting-rooms, office, toilet and baggage-rooms, connected to a system of steam mains which will be suspended from the ceiling of the cellar.

The main to be connected to a boiler which is to be located in the cellar close to the vertical flue. The steam supply branches to the radiators are to rise to and through the floor and to connect with each of the radiators, inserting in the connection, close to the radiator, a lock shield stop valve, for the purpose of controlling each individual radiator.

The return pipe is to follow the same general direction as that of the steam, and it is to be located on the side wall of cellar near the floor, substantially supported. Branch vertical returns are to connect to each radiator, and are also to be provided with stop valves in a similar manner to that described for the steam branches.

Furnish and erect a boiler of any well-known make, such as "Toulmin," "Gurney,' or any other equally good pattern, and to be of ample size to heat the building in the coldest of weather without forcing.

The boiler to be provided and equipped with the usual set of fixtures, such as steam gauges, try-cocks, safety-valve, damper regulator, fire tools and all other necessary fixtures to render it complete and ready for steam.

The boiler to be covered in a proper manner with asbestos plaster at least 1½ inches thick, applied over wire mesh.

The boiler to be connected to the vertical chimney by means of a heavy wrought-iron smoke pipe, with a pivoted damper in its connection.

To have radiators located throughout the building, to be of the sectional type of an ornamental and neat finish. Each radiator to be provided with an automatic air valve of the "Onderdonk" or "Jenkins Bros." patent. They should be distributed as follows: Ladies' waiting-room, ladies' toilet, small waiting-room, office, gentlemen's waiting-room, baggage-room.

The above radiators are to be of ample capacity to warm the rooms in which they are located to seventy degrees in the coldest winter weather.

After steam has been put on, all of the radiators and exposed piping throughout the building to be neatly bronzed with the best gold or silver bronze color, over a good sound coat of sizing. All the exposed iron work around the boiler and in the cellar to be painted with black asphaltum varnish.

The above represents a complete steam heating apparatus left in perfect running order, with steam on, and would cost in the vicinity of New York, about $328.

For the heating of this building by hot water, using the same number of radiators, locating the boiler in the same position, running the pipes in the same general manner as specified for steam, equipping the radiators with valves, etc., including the same guarantee of temperature, etc., would cost about $379.

The approximate amount of coal that would be consumed in the steam heating apparatus would be about thirteen tons for a winter of six months, and, with careful management, the hot water system would consume ten tons of coal for the same period. This amount would, in all probability, be reduced if the caretaker of the boiler was careful.

In conclusion, your committee would like to have a full and complete discussion of this subject, believing that it will be of interest and value to every member of our association.

J. H. CUMMIN, L. I. R. R.,
G. W. HINMAN, L. & N. R. R.,
G. W. MARKLEY, C., C., C. & St. L. R. R.,
WM. BERRY, S. A. & A. P. R. R.,
Committee.

THE MOST SUITABLE MATERIAL FOR ROOFS OF BUILDINGS OF ALL KINDS.

In the beginning, we would state that this report is made largely from replies from members to our request for information, from our own personal experience, and a close observation of the many excellent methods and materials now in general use. We have not taken up the matter of rafters or construction, but confined the report to outside covering only. We consider a good roof must be rain-proof, fire-proof, light in weight, durable, attractive, economical, and not liable to get out of order. In giving names of manufacturers, we have endeavored to give those widely known, and strongly recommended for the special points under consideration, namely, durability and cheapness.

From a close study of the subject, we find that for small, cheap buildings, such as section houses, water tanks, tenement houses for employes,—that are away from danger of fire from locomotives,—the preference is for shingles, manilla roofing, or rubberoid. In using shingles, the Duluth, South Shore & Atlantic Railway is very fortunate in having a number of shingle mills located along the line, and in using cedar piling altogether; they take the cedar pile heads, after being driven and cut off,—these range from 16 inches to 4 and 5 feet long,—load and ship them to the nearest mill, where they are made into shingles of the best quality at 70 to 85 cents per thousand, costing laid per square $1.50 to $2. Ordinary pine shingles laid on, cost $2.50 to $2.75 per square; Fay manilla roofing, $1.50 to $4.50 per square; the rubberoid of the Standard Paint Company in general use for all kinds of buildings is certainly one of the cheapest and most durable, as it is also one of the lightest and most neat in appearance; this costs from $1.50 to $5 per square laid. Asbestos, another excellent roofing material preferred by many, would cost about the same by two leading firms, the Sawyer Paper Company and the Johns Manufacturing Company; laid complete, it would be about $2.30 to $3.50.

Now for warehouses, coal sheds, train sheds, and roundhouses, there is an excellent felt graveled roofing of the Ready Rock Asphalt Company from $3 to $5.50 laid per square; and for the better class of buildings, such as stations of stone or brick, the choice is most general for metal or slate, as durability and attractiveness are secured by both. There is the National Sheet Metal Company, which would cost from 5 to 16 cents per square foot; the N. and N. G. Taylor Company, which is from $7.50 to $15 laid per square. One of our members strongly advises for any roof above one-third pitch, the Maine slate, which has stood the test of thirty-five years on his road. There is the Scotts' Extra Coated Guaranteed Roofing tin of Follansbee Bros. Company, Pittsburg, which has many excellent qualities and gives good satisfaction. The Bangor slate is from $5 to $8; the tin roof about the same. There is another roofing with strong indorsements, the Ludowici Roofing tile; these are interlocking clay shingles at $6 per square. It is claimed neither wind nor storm, nor vibration of building will break them; there are no nails to rust and they are not affected by smoke.

In considering this subject, it is manifestly impossible for us to say, except from our individual experience, which is the most suitable material for roofing of all kinds of buildings, and a general answer cannot be given to cover all cases, owing to the difference in climate, and the prices of building material in various sections of the country. Our correspondence has been quite extensive and covers a wide range of observation and experience from ten to fifty years. In many cases these letters have been very carefully written to the smallest details of cost and labor, but, in order to make this report as short as possible, it is considered best to give the subject in general terms.

We are aware that much more might be said, but we will only add that our thanks are due to the members for their timely assistance. Especially do we thank Messrs. Bishop, Eggleston, Riney, Markley, Andrews, Austin, Cummin, Patterson, and Berg.

W. M. NOON, D., S. S. & A. R. R.,
G. W. TURNER, S. L. & S. F. R. R.,
N. W. THOMPSON, P., F. W. & C. R. R.,
Committee.

REPORT: HOW TO DETERMINE SIZE AND CAPACITY OF OPENINGS FOR WATERWAYS.

In our opinion, the desirable information to collect and compile consisted mainly of the methods actually adopted on railroads to obtain results quickly and in a practical manner, and that the discussion of the theoretical and engineering methods employed would not fall within our sphere, as such questions are usually determined by the engineering department of a railroad. Our aim was, therefore, more particularly to obtain information bearing upon the methods actually used by superintendents and engineers of bridges and buildings in determining the extent to which minor waterways may be reduced on existing lines, as the tendency of the day is to gradually shorten original temporary openings, or to replace trestling by permanent fills, which work usually falls under the maintenance of way departments.

From information collected last year by Mr. Aaron S. Markley, and from additional data obtained by your committee during the current year, it would seem that in actual practice this question is determined in a number of ways, which can, however, in general be classified under the following groups:

1. By personal observation, and information collected on the ground, as to flood height, size of channel, openings in the vicinity carrying the same stream, etc. This general information guides in the final selection of the size of opening, but the actual

determination is dependent on practical experience and individual views.

It might be said that, in the main, this seems to be the most usual method, if it can be designated as a method. It is, however, warranted and reliable in flat sections of the country where the bed and contour of a stream at flood times is known or well defined and the current more or less sluggish at all times. It is further probably the best method to pursue in thickly settled sections of the country where other openings on the same watercourse are generally to be found within a very short distance, and satisfactory deductions can be formed from a study of these and from information collected from parties familiar with the territory.

2. Drainage areas are prescribed for different sizes and kinds of openings, the limits for each opening allowing variations to be made according to the local conditions, topography, slopes, soil, rainfall, etc.

This method has many advantages if the table is prepared with reference to a specific section of the country, so that due allowance can be made for the variable rainfall conditions and the prevailing regional characteristics of the territory embraced. It does not eliminate, however, the personal equation in the question, especially as the range of the values in such a table necessarily has to be considerable. It will serve to indicate, so to say, at a glance the general class of opening required, but the final determination will be dependent on individual judgment and a personal examination of the district.

Mr. George J. Bishop (Chicago, Rock Island & Pacific Railway) wrote on April 12, 1897, as follows:

"There are several things to be taken into consideration before deciding the size of culvert pipe or arch required for a permanent opening through a railroad embankment. On the C., R. I. & P. Railway they send out a civil engineer to look up the drainage area of all permanent openings for waterways.

"The first thing to be done is to find the number of acres in the draw to be drained; the height of highest water that has been in the draw, and whether land is cultivated or not; also, if there are small buildings along the draw, that are likely to wash down stream and block up the opening.

"Where the basin is small and has steep banks, and a number of small draws that run in the basin, and where the fill is about 12 feet to 16 feet high, it will require a larger culvert pipe or arch than for a long, narrow draw with a large basin and high embankments, as the water that has fallen by a heavy rain runs off before the water has got to the opening from the upper end of the draw.

"In Kansas, Nebraska, and Eastern Colorado, we allow for drainage as follows, subject to the conditions above:

	—Acres.—	
	Minimum.	Maximum.
1 line of 16 in. cast-iron culvert pipe.........	20	40
1 line of 20 in. cast-iron culvert pipe.........	30	60
1 line of 24 in. cast-iron culvert pipe.........	45	90
1 line of 30 in. cast-iron culvert pipe.........	70	140
1 line of 36 in. cast-iron culvert pipe.........	110	220
1 line of 48 in. cast-iron culvert pipe.........	180	360
6 ft. arches, 4 ft. side walls................	240	400
8 ft. arches, 4 ft. side walls................	320	550
10 ft. arches, 5 ft. side walls................	500	850
12 ft. arches, 6 ft. side walls................	720	1,300
16 ft. arches, 8 ft. side walls................	1,280	2,300

3. Determination of the area to be drained and of the general characteristics of the country, soil, and stream, which information is used in connection with an empirical formula giving the area of waterway required, based upon the drainage area with variable coefficients to suit the different conditions.

In regard to this method, it can be said that the use of a "formula," even if an empirical one, casts a certain amount of scientific glamour around the question that, in many cases, may seem to enhance its value. As all such formulas have variable coefficients, it is evident that individual views and personal examination of the characteristics of the watershed and stream will have to govern largely in the final determination. Such formulas have the great merit, however, of serving as a guide to determine quickly the general range of the probable minimum, maximum and average values, and, therefore, can be classed as practicable and serviceable, especially when the range of the coefficients for the various climatic and local conditions has been properly predetermined.

Considering the allowances that have to be made anyhow for greater safety, especially so as to provide, more or less, for cloudbursts and unusual contingencies, it can be said that for all minor openings an empirical formula suitably applied and not taken too strictly, supplemented by personal examination of the territory, practical experience and sound judgment, will give as good practical results as minute and careful engineering surveys and theoretical calculations.

Probably the best-known empirical formula for determining directly the proper area of a waterway and one that has been used most extensively in American railroad practice was advanced many years ago by Mr. E. T. D. Myers, president Richmond, Fredericksburg & Potomac Railroad, namely:

$$\text{Area of waterway in square feet} = C \times \sqrt{\text{Drainage area in acres.}}$$

where C is a variable coefficient. For comparatively flat ground or slightly rolling prairie, C is generally assumed as 1; for hilly ground as about 1.5; and for mountainous and rocky ground as high as 4. In exceptional cases even much higher values have been found to be necessary to correspond to the actual quantity of water as gauged at flood times.

In regard to the proper values for the coefficient, Mr. Myers states (see his letter of August 3, 1897, quoted in full in the Appendix to this report): "The coefficient should be derived from careful and judicious gaugings at characteristic points within the region under treatment, and applied by a liberal hand."

It is generally claimed that this formula gives too large openings for very small drainage areas. Possibly this might be considered an advantage, as very small openings should never be made equal to the theoretical results, but ought to be made larger for practical reasons. Hence the formula in this respect certainly corresponds with practice if not with theory.

Another statement made against this formula is that it gives too small values for very large openings. It has generally been understood that Mr. Myers intended this formula to apply to minor openings on railroads and not to important streams. For the latter there is no question that a more careful study of the conditions and environments is absolutely necessary, and the sole use of an empirical formula in connection with a coefficient established by snap judgment in the office or a hurried trip over the ground is entirely out of place.

A formula advanced by Professor A. N. Talbot (Selected Papers of the Civil Engineers' Club of the University of Illinois) and stated by him to be "more as a guide to the judgment than as a working rule," is as follows:

$$\text{Area of waterway in square feet} = C \times \sqrt[4]{\text{Cube of drainage area in acres}}$$

in which C is a variable coefficient. "For steep and rocky ground, C varies from 2-3 to 1. For rolling agricultural country subject to floods at times of melting snow, and with the length of valley three or four times its width, C is about 1-3; and if the stream is longer in proportion to the area, decrease C. In districts not affected by accumulated snow, and where the length of the valley is several times the width, 1-5 or 1-6, or even less, may be used. C should be increased for steep side slopes, especially if the upper part of the valley has a much greater fall than the channel at the culvert."

Professor Ira O. Baker, University of Illinois, in his book on "Masonry Construction," says, in regard to Myers' formula, that for small drainage areas it gives the area of waterway too great and for large drainage areas too small. In regard to Talbot's formula, he says that he had tested it and found it agreed fairly well with the experience of fifteen to twenty years, and that, in these tests, it was found that waterways proportioned by this formula will probably be slightly flooded, and consequently be compelled to discharge under a small head, once every four or five years.

Our deceased member, Mr. L. K. Spafford (Kansas City, Fort Scott & Memphis Railroad), made use of Myers' formula with a coefficient from 1 to 3. He wrote on July 18, 1896:

"We have no iron-clad rules for deciding such matters, but usually, when the question of an opening arises, have a survey made, showing the area, and then make the opening from one to three times the square root of acres drained, the size of the opening depending on the topography of the ground. If the ground is level we would probably use twice the square root of the acres drained. If the ground is hilly, we would use three times the square root of the acres drained."

Our deceased member, Mr. R. M. Peck (Missouri Pacific Railway and St. Louis, Iron Mountain & Southern Railway), wrote on June 11, 1896:

"We determine the size of openings by a careful survey of the area of land to be drained. There is a great deal depends upon the natural lay of the land to be drained. If the country is very mountainous, and slopes of hills or mountains are steep and abrupt, we figure that one foot of area will drain four acres of land. Where the lay of the land is ordinarily flat and rolling, such as is found in good agricultural countries, we figure that one foot of area will drain six acres of land. These are the two extremes. We hardly ever go above or below these figures, but use all sizes between them, as the different and peculiar locations may demand."

This expressed in a formula would be:

$$\text{Area of waterway in square feet} = \frac{\text{Drainage area in acres}}{C}$$

where C varies from 4 to 6.

4. Careful surveys of drainage area, slopes, gradients, and cross sections of stream, determination of velocity of flow by observations or calculations, application of hydraulic formula to flow of water through various-shaped openings under different heads, at different stages of the water height, determination of probable average and maximum rainfall, the volume of water and the time within which it will reach the opening, etc.; from all of which information the shape and size of the opening is determined so as

to carry off the water quickly, and without scouring the bottom of the stream, or injuring the structure.

After a careful consideration of the question, your committee decided, as stated above, that it would not be advisable to enter into a detailed discussion of this branch of the subject.

In many instances certain data, such as the drainage area, the gradient and cross-section of stream, and the probable maximum flood height and velocity, can be ascertained very readily and sufficiently accurate for all practical purposes, and will throw considerable light on the question when such data are applied to elementary hydraulic formulas, or, more usually, deductions are drawn by ordinary arithmetical methods and reasoning.

For large and important openings and wherever careful research is desired, the proper investigation along the lines indicated above involves much detail study and field work by engineers. But even with the best talent and mathematical demonstrations brought to bear on the question, it will inevitably be finally settled largely on the basis of expert practical knowledge, as all the controlling formulas are dependent in the first instance on assumptions and finally on the proper choice of variable coefficients. Thus assumptions have to be made as to the probable maximum rainfall and the proportion of it reaching the waterway within a given period of time; the evaporation, absorption and percolation of the water on its way to the opening; the greatest allowable velocity at the bottom of the stream so as not to scour the bed; the greatest allowable velocity or pressure so as not to damage a structure discharging under a head of water dammed up by the railroad embankment; etc.

There are numerous formulas for the amount of water reaching a certain point of a water course, known by the names of their authors, as the Fanning, Craig, Dredge, Dickens, McComb, McMath, O'Connell, Hawksley, Adams, Buerkli-Ziegler, Kirkwood, etc. Most of them are quite complicated, and when applied to a given case it will be found that the results all differ, more or less, from each other, and will only serve for general guidance, unless the tests and conditions governing a particular formula are known to be in the main similar to the case under treatment. Further, the theory of the flow of water in open channels (leading to the embankment) and in closed conduits (passing under the embankment) is largely conjectural and dependent on actual tests and gaugings under conditions frequently entirely different from those under consideration.

All these features, therefore, emphasize the difficulties of the task and the necessity of employing specially trained engineers or expert hydraulicians for all important work of this kind, as the true value of the application of "theory" to this problem is directly proportional to the correctness of assumptions borrowed from "practice." In the hands of a practical and experienced adept the data bearing on the case, consisting of part theory, part assumptions, and part observed facts, will be molded into fairly good shape and some tangible and valuable results obtained.

In conclusion, it will be desirable to state that a uniform and practical solution of the question, "How to determine size and capacity of openings for waterways," cannot be formulated, owing to the great variation in climatic and local conditions connected with this subject. It will remain, more or less, dependent on information collected in examining the particular territory, observations, or gaugings and tests made under similar conditions, personal experience, individual views, and practical judgment.

Particular emphasis should be made of the fact that a very general opinion seems to prevail, that openings should in all cases be made ample and large enough for all contingencies, erring always on the safe side, as the possible damages and subsequent expenses connected with inadequate openings far exceed the small extra first cost of a slightly larger waterway. It is probably not practical to say that it is feasible to provide absolutely in all cases against every possible contingency of the future, and there is, naturally, a reasonable limit, even admitting the logic of the above argument. Reduced first cost, when placed in the balance with future savings, may frequently prove to be the heaviest consideration, even with the possible attendant danger to life in case of a washout. This feature of the question is largely dependent on the policy outlined by the management of a railroad. It is naturally correct to aim to make the structure just as safe as possible, considering all the governing conditions.

There is one additional feature that should receive mention, namely, the fact that the crude methods of construction adopted for openings are frequently more at fault than the insufficiency of the waterway area. The capacity of an opening is not only dependent on the actual area and shape of its cross-section, but also on the permissible pressure under a dammed-up head of water, or the velocity of flow that is allowable without damaging or disrupting the structure, scouring the bed, or working through the embankment. A closed culvert, discharging under the pressure caused by the water level being raised above the top of the opening, ceases to be a mere covered channel, and becomes a pipe, with bursting pressures proportional to the water head. In all such cases, where it is known that the flood height will be above the opening, it certainly seems desirable to build larger openings, or else a better class of structure, able to withstand the bursting pressure and the increased velocity of flow. The construction of the ends of waterway structures, the channel approach and run-off, the bed, and the material in the embankment exposed to the scour and wash, should all receive close attention in important and critical cases.

We append several valuable independent statements on this subject, and also typical extracts from a number of the letters received in pursuing our investigations.

We also present an engraving, showing the average annual

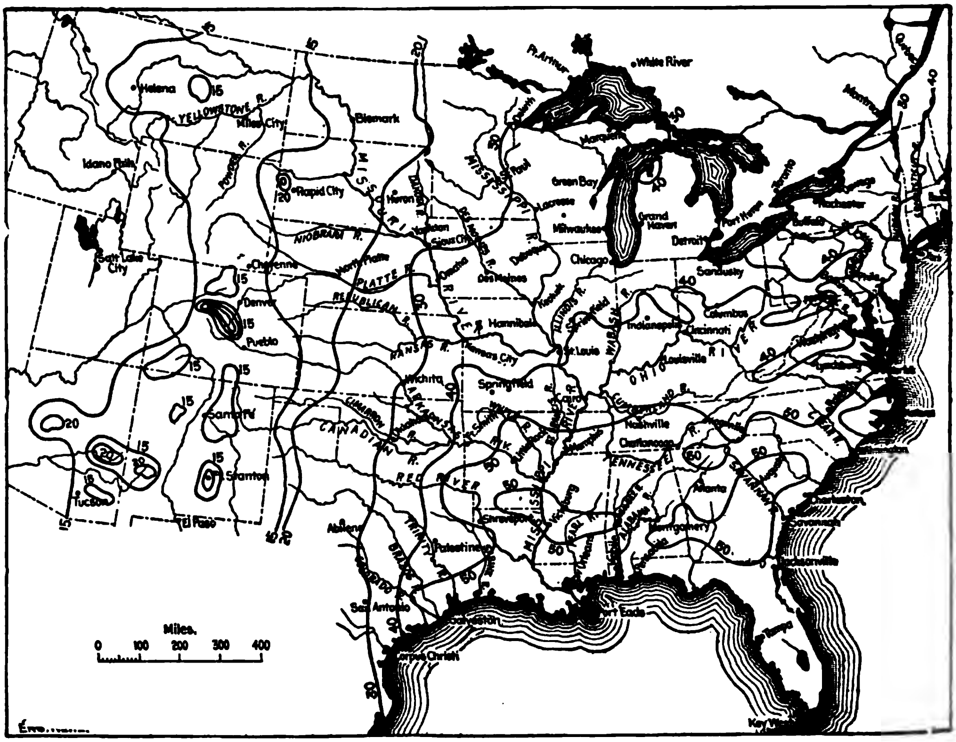


FIG. 187—AVERAGE ANNUAL RAINFALL OF THE UNITED STATES.
Figures show total depth in inches.

rainfall in different sections of the United States, the original cut having been published in Engineering News.

WALTER G. BERG, L. V. R. R.,
AARON S. MARKLEY, C. & E. I. R. R.,
ONWARD BATES, C., M. & St. P. R. R.,
A. J. KELLEY, K. C. Belt R. R.,
Committee.

APPENDIX TO REPORT OF COMMITTEE ON THE SUBJECT, "HOW TO DETERMINE SIZE AND CAPACITY OF OPENINGS FOR WATERWAYS."

Statement of Mr. Aaron S. Markley, Chicago & Eastern Illinois Railroad, Danville, Ill.:

The gauging of waterways under embankments requires a man of good judgment, familiar with the nature of the country, as well as the streams and the source of supply, together with the character of the soil and climate.

The most accurate and economical manner of determining this is to keep a record of highest water in streams at all times when rainfall is extraordinary, and calculate the required size of the opening from the area of flow of water at that time. This can be checked by the number of acres drained.

The more familiar a man is with the territory drained, the more capable is he to judge the capacity of the opening required. Rules that are applied to one section of the country for this purpose cannot be applied to all sections. In many instances, an opening which is sufficient for a given area in one section will not be sufficient in another section, the conditions of surface and character of soil being different. For instance, where banks of a stream are low, it will necessarily take a wide opening to avoid backing water up over adjoining land; where banks are high, a higher opening and not so wide may be placed. This is the case more particularly in iron pipes; where banks are high, a 60-inch pipe will answer, but if banks were low, two smaller one having the same area should be used. A most serious objection, however, to a double line of pipe over a single line is, that any accumulation of drift will pass through the latter more readily, making it less liable to clog up.

To avoid as much as possible the overflow of land, it is preferable to make openings of all classes as wide as possible, so that full flow of opening can be had without damage to abutting property.

In a territory where the ground becomes frozen, or is of such a character as not to be easily penetrated by the water as it falls, a larger opening must be provided than at such places where the water is absorbed quickly and comes to the opening slowly.

Following are notes showing the sizes of, and the area drained by, several openings which have been known to the writer from personal observation since the present openings have been put in, namely, from six to ten years ago. These openings were selected from several hundred along the line of road, in order to get those that were known to do all the work they could do and at the same time not overflow the adjoining land. The area drained by these openings has been surveyed under the direction of Mr. W. S. Dawley, chief engineer C. & E. I. R. R.

One 12-inch pipe drains an area of 12 acres, the main channel of which is 400 feet long and has an average fall of 5 feet in 100.

No. 1186. A 24-inch pipe drains an area of 50 acres; main channel 1,300 feet long, with an average fall of 3½ feet in 100.

No. 1088. A 36-inch pipe drains an area of 125 acres; main channel 3,500 feet long, with an average fall of 9-10 of one foot in 100.

No. 1219. A 36-inch pipe drains 170 acres; main channel 3,548 feet long, with an average fall of 1 4-10 feet in 100.

No. A, 1307. A 60-inch pipe drains 110 acres; length of main stream, 3,600 feet, with an average fall of 2 2-10 feet in 100.

No. 1255. A 14-foot stone arch drains a stream known as Lick Creek, near Danville, Ill. The accompanying illustrations show the cross-section of the arch and the topographical survey of the drainage area. A very careful survey was made of the main channel, tributaries, and land drained by this stream, and the drainage area consists of 3,560 acres, the main channel being 4½ miles long and one tributary 1¾ miles long, with an average fall of 29 9-10 feet per mile. This arch was completed and bank put on it in 1881. In 1889, the water was three feet above the crown of the arch for about three hours, the only time since it was built that it has backed up over the adjoining land to do any damage. At this time, the land owner brought suit for damage to crops, but the court held, in its decision, that the railroad company was not obliged to provide openings for waterspouts, as this case was decided to be. Suit was decided in favor of the defendant.

Having known this stream and observed its nature through all storms since the arch was built, I am familiar with its history, as well as the iron pipes referred to. Nearly all the land in this country is well tilled, and as a rule not very hilly. Being well tilled, the water finds its way to the main channel very readily, which makes some difference in the size of opening required.

It is my practice to note the stage of the water in as many streams as possible after all very unusual rainfalls, and to note the flow of water through the openings of all kinds, and if anything out of the ordinary, I note it in the last annual inspection book. When a wooden is to be replaced by a permanent structure, these records are referred to, and size of opening to be used decided upon in many cases. If no record exists, capacity of waterway is judged by what other waterways are doing under similar circumstances. What one opening will do, another one similarly situated, and the conditions being the same, will certainly do. I very rarely try to get information from the land owners, as their knowledge of the flow of water through opening is very limited, and the height of the water, as a rule, very much exaggerated. Openings under highways or private roadways sometimes are a practical guide, but in many cases banks are low each side of opening, so that water overflows roadway, which fact destroys any reliable information from that source.

Note.—The 14-foot arch, No. 1255, referred to above, has a waterway area of 142 square feet. It is 13 feet 10 inches wide at the spring-line of the arch, and 12 feet 11 inches wide at the foot of the side walls. The center of the arch is dropped 1 foot below the spring-line. The side walls are 5 feet 6 inches high, built with a batter of 1 to 12. The paving is dished 8 inches at the middle of the opening.

Statement of Mr. Onward Bates, Chicago, Milwaukee & St. Paul Railroad, Chicago, Ill.:

"I will not assume to give a rule for the proper determination of waterway openings under tracks, but will explain this company's practice. Waterways on new lines are determined by the engineering department, and I assume that waterways which the Superintendents of Bridges and Buildings are interested in are those which come in problems of renewals, usually of wooden bridges with permanent work. These are the problems which are met on this road, and we endeavor to solve them in the following manner:

"Track men are instructed to record high-water marks at all bridge openings, and as they have, ordinarily, at least eight or ten years' experience with the bridges before renewal for the first time, they should have definite information about high-water marks. After unusual floods, particular care is taken to ascertain high-water marks, both by track men and by employes of the bridge department. These high-water marks are entered in our office bridge books for reference when the bridges are to be renewed.

"Six months before the proposed renewal of bridges, lists of such as are to be renewed are furnished to the chief engineer and division superintendents. The chief engineer has an assistant engineer make a report, giving his recommendations for permanent openings. The assistant engineer takes into consideration the high-water marks, area, and slope of watershed, amount of rainfall, etc., and reports the area of waterway which he considers necessary at each bridge.

"The division superintendent makes a similar report, based on his own knowledge, as well as information which he obtains through the road masters and section foremen.

"The bridge inspectors make a third report, based on all of the information which they have access to. These three reports are compared, and the final area of opening decided by the chief engineer. If a study of the reports leaves doubts as to the recommendations, special surveys are ordered, and in some cases special trips are taken by the chief engineer and the question decided on the ground.

"Conditions are so variable that a formula for technically determining waterways will at best be nothing more than a rough check on a decision which is based on experience and judgment. By systematic observation and record of waterway requirements extending over the life of a wooden structure, we are enabled to arrive at a more rational determination of waterways than can be accomplished by an arbitrary formula. We have within the last ten years replaced thirty-five miles of wooden bridges with iron structures and embankments with satisfactory results as to size of waterways retained."

Statement of Mr A. J. Kelley, Kansas City Belt Railway, Kansas City, Mo.:

"Our practice has been to first ascertain the volume and velocity of water. This information can be obtained only by personal observations collected during heavy rainfalls. A very good rule and one that we have found to work well in determining the flood height is, that in case of storms the bridge foreman must be on duty and see that bridges and culverts are not being damaged by storms, and to make permanent high-water marks at all openings that are liable to be damaged by high water, also to note the velocity in feet per second. Having the flood height and velocity, it is an easy matter to determine the volume of water to be taken care of. I have one fen bent pile trestle 135 feet long and 24 feet high over a spring branch that ordinarily runs about six cubic inches per second. Last summer, during one of our heavy rain storms (four inches in less than three hours), I visited this place and found by float observations the surface velocity at the highest stage to be 1.9 feet per second. I made a high-water mark, and after the flood water receded found the width of stream to be 12 feet and an average depth of 2¼ feet. This, with a surface velocity of 1.9 feet per second, would give approximately a discharge of 50 cubic feet, or 375 gallons, per second. Having this information, it is easy to determine size of opening required."

Statement of Mr. J. P. Snow, Boston & Maine Railroad, Boston, Mass.:

"The present practice on the Boston & Maine Railroad in determining the size of waterways, large and small, is wholly by observation, governed by the evidence furnished by other openings on the same stream and by parties acquainted with the locality. The marks left by the streams at each spring freshet, coupled with the knowledge of residents as to the comparative heights of maximum floods, is a sufficient guide in case of actual streams.

"For small drains, the almost universal structure with us, where there is sufficient height of fill, is the stone box culvert. There is nothing saved in making these less than three feet square, and this size is sufficient for all places where there is no actual stream to guide one, as above, to a correct estimate of the size of opening required. Many Akron pipes from 12 to 24 inches have been laid, and a few cast-iron pipes up to 48 inches diameter. The excellent quality of granite found all over our territory permits us to use stone covering up to 8 and 10 foot span in some cases. Personally, however, I would limit its use to 6 feet clear opening. The regular quarry size of stone with us is 2 foot rise; these make excellent covers for culverts of not more than 6 foot span.

"Formulas may be useful to one wholly unacquainted with similar work and in case of disputes with land owners, etc., but the large range of the coefficient to be used throws the result back on personal judgment, the same as if no formula were used. The two formulas, Myers' and Talbot's, given on page 394 of Baker's 'Masonry Construction,' are as good as any that I know of.

"The possibilities of drift material must be considered in designing a culvert; double box culverts or two lines of pipes are objectionable where drift is to be expected. Where pipe culverts take the water from low-lying farm land, they must be placed low or there may be a claim that the water is set back, because the bottom of the pipe is not so wide as the natural stream. On account of this restricted flow, unless the water is raised to some height, I prefer a square, stone culvert in many localities to large pipe.

"For large streams, our system covers conditions varying all the way from tidal streams along the coast to torrent-carrying ravines in the White mountains. A tidal estuary may generally be safely narrowed considerably from the extreme water lines, if stone revetments are used to protect the bank from wash. Above the true estuary, where the stream cuts through the marsh, we generally find nearly vertical banks, and we are safe if the faces of abutments are placed even with the banks.

"In level sections of the country, where the current is sluggish, it is usually safe to encroach somewhat on the general width of the stream, but in rapid streams among the hills the width that the stream has cut for itself through the soil should not be lessened, and in ravines carrying mountain torrents the openings must be left very much larger than the ordinary appearance of the banks of the stream would seem to make necessary. In rebuilding old bridges, our general practice is to shorten them. The temptation is strong to build the new masonry inside the old, and in the majority of cases I think it is safe. We must, however, be sure of our foundation. First-class masonry will stand almost anything from water except undermining. Piles should be used wherever they can be driven. In a rapid stream with a rocky bottom, where it is impossible to drive piles, paved as many are in New England with rocks and boulders of all sizes tightly packed by the water, I think it safer to build on these packed stones without disturbing them rather than to excavate for the purpose of starting the wall below the river bed. Of course, we must remove the loose stone and get a fairly level bed, but if we excavate to any depth we are bound to loosen the naturally packed stones immediately in front of our new work and to leave a furrow of loose filling at this vital point. If we have no serious freshets for two or three years, the stream may repack this furrow in an unscourable manner, but if a severe flood occurs the season following the reconstruction, there is great probability that the water will find the soft spot and make an excavation that will cause chagrin to all parties interested.

"This digression on foundations is somewhat off the question, but the spectacle of a piece of first-class masonry undermined and ruined within twelve months of its completion has taught me that the character of the stream bed is as much a function of the waterway required as the span of the structure, and that the ground in front of the abutment needs as critical attention as that under it.

"No fixed rule depending on the acreage drained and the annual rainfall can be safely used in all parts of the country alike for determining the proper size of waterways. The judgment of a man acquainted with the region and the character of the ground should be obtained, but if the duty of designing the opening falls to a man not equipped with this knowledge, his only safe course is to leave openings surely large enough."

EXTRACTS FROM LETTERS RECEIVED BY THE COMMITTEE.

Mr. E. T. D. Myers, president Richmond, Fredericksburg & Potomac R. R., Richmond, Va., author of "Myers' Empirical Formula for Area of Waterways," kindly forwarded, on August 3, 1897, the following remarks to the committee:

"The committee's circular (see Sec. 4) renders it unnecessary to say anything more on the subject of the formula suggested by me a good many years ago, than that the coefficient should be derived from careful and judicious gaugings at characteristic points within the region under treatment, and applied by a liberal hand. Upon a line already constructed and cared for by an intelligent engineer, no formula can furnish so safe a guide or should take precedence of his own observation and experience; but neither with a formula, however wisely constructed, nor with information based upon the most careful observations over the period of a generation, can we be assured that we have provided, so far as area goes, sufficiently against cataclysms, against which it might be assumed that it is impossible to guard. While to a certain extent such an assumption may be warranted, it must be remembered that great lines of aqueduct to large cities must be proof against the extremest conditions to which they are subject; and yet many of these aqueducts are exposed to the vicissitudes of the weather equally with works like railways and canals of navigation. A 'washout' on a railway or a 'break' in a canal is a serious matter, but insignificant, of course, when compared with a 'water famine.'

"I think the engineers of aqueducts have, to a marvelous degree, succeeded in so constructing them as to be safe against interruptions from flood. Of course great care is bestowed upon the dimensions of their drainage works, and that which under ordinary circumstances might be considered extravagant, is in their case justifiable. Yet I am not satisfied that it is to this cause alone, or even to this cause chiefly, that their success is due. I am persuaded that it is rather in the superior construction, the infinite painstaking to insure the safety of a culvert when it ceases to be a mere covered channel and becomes a pipe discharging under pressure. When this takes place, the ordinary culvert is too apt to fail to do its duty. Between the hastily constructed dry stone box and the thoroughly built concrete, brick, or stone culvert, there is room for a legion of catastrophes. I am not prepared to argue that the construction of the less important works of the railway should rank either in execution or cost with those of the Croton, or the Washington, or the Baltimore aqueducts, for instance, but I am nevertheless of the opinion that it is more often the crude method of construction than the underestimation of the area of the waterway that gives us trouble on the railroads. When a railway embankment is called upon to act as a dam, as it may be in great floods, it should possess the qualities of a dam, and the outlet from the piled-up waters above it should possess the same integrity as the drainage culvert of a reservoir. Its foundations should be as secure, its masonry as impervious, the embankment immediately surrounding it as free of voids, the inlets and outlets as carefully protected from abrasion.

"Of course many pages have been and might be written as to the manner of securing such an end. Having had some experience both on railways and aqueducts, I have decided opinions on the subject of the masonry constructions on each, but I am warned to embody my views briefly in connection with the committee's report, and you will no doubt thank me for refraining from further elaboration."

Mr. Clemens Herschel, engineer water department, Lehigh Valley R. R., No. 2 Wall street, New York, N. Y., has kindly contributed the following information:

"I have read the committee circular of the Association of

Railway Superintendents of Bridges and Buildings, with a great deal of interest. There is very little that I can add to the remarks of the able and careful men, printed in the committee circular. One case I remember in Massachusetts, in which a railroad was condemned to pay some $95,000 damages, caused by a simple box culvert, some three feet square, connecting two ponds. The consequence was, that on account of the small velocity ordinarily obtaining through this culvert, it gradually, in the course of some thirty years, filled up; being out of sight, submerged, it was out of mind; so that one fine day, when, on account of melting snow, there was a very large inflow of water into the upper pond, the culvert was too small to maintain the level of the two ponds at practically the same height. As a still further consequence, the up-stream pond rose so rapidly that it overtopped a small subsidiary dam of the upper pond a mile or more up stream from the culvert, and caused a washout through the natural hills, something like seventy or eighty feet deep. This happened near Clinton, Mass., early in the '70s, on the road running from Clinton to Worcester. The moral is, that submerged culverts are bad things, as they are out of sight and out of mind, and are liable to silt up in course of time.

"I had to go all the way to Russia to learn a cheap way of preventing culverts from clogging up with drift-ice and drift-wood. This is done by driving a row of small piles in a semicircle up stream from the up-stream end of the culvert, using a radius of about twice the width of the culvert, and with intervals between the piles of about ten inches or a foot. This makes a coarse kind of a rack in a semicircle up stream from the culvert, which neither ice nor driftwood in any harmful quantity is liable to pass by, going through or over."

W. M. Noon, Duluth, South Shore & Atlantic Railway, Marquette, Mich.:

"I watch from year to year, and note the flow of water during freshets."

W. O. Eggleston, Chicago & Erie R. R., Huntington, Ind.:

"My experience is to watch the streams and rivers at their highest flood. This you can see nearly every year, and, by asking some old resident, an idea can be formed of size of opening required, of course allowing some for excessive floods. This has been my experience, and my judgment in this matter has never failed yet."

N. W. Thompson, Pensylvania Company, Fort Wayne, Ind.:

"It has been our custom to rely upon observation of the conditions at each particular point for determining the size of opening required. In case of doubt, or in the construction of new lines, we usually employ methods given by 'Trautwine's Engineers' Pocket Book.' "

C. C. Mallard, Southern Pacific Railway, Algiers, La.:

"In this part of the country, except in cases where the levees break and we have to provide for floods from the Mississippi, the subject is one which bothers us but very little. The streams we cross have little or no current, and in providing openings for the plantations we know that if they are a trifle larger than their drainage ditches and canals there can be no trouble."

William Carmichael, Union Pacific R. R., Junction City, Kan.:

"It is my opinion that the only safe way to determine the size and capacity of waterways is to look the ground over carefully and ascertain the possible number of acres of land the opening will have to drain. The nature of the soil should also be taken into consideration. If the opening is located where the soil would not take up any of the rainfall, the opening would necessarily have to be larger. I think where this plan is followed, and the parties do not figure too closely on the amount of rainfall, that the size of the opening can be easily gotten at. If one is in doubt as to the size of the opening, he should always give the opening the benefit of the doubt. The cost of building the opening large enough is very little, compared with the cost of washouts and a possible wreck."

M. F. Potter, Cleveland, Cincinnati, Chicago & St. Louis Railway, Franklin, O.:

"Mr. Wm. Carmichael's report on the subject is, in my judgment, as good a method as one can adopt in determining the size of opening required for waterways. Different localities, of course, require different calculations; but the method mentioned, together with a little common sense, will accomplish, I think, what is required, as near as any calculation that can be made. It is the method I have used for over twenty years, and have always had good success."

E. F. Reynolds, Chicago & Northwestern Railway, Ashland, Wis.:

"The question of sufficient waterway is a hard one to solve, and under most favorable conditions is nothing but guesswork on the part of Superintendent of Bridges and Buildings, as we do not have the proper instruments to thoroughly survey the thoroughfares and sometimes we have to put in openings very quickly. I can only say that I would surely compute the amount of water that has to my knowledge passed through, and would of course take into consideration any information I might gather from responsible parties; also would take into consideration in a timbered country the fact that there would be an increase of water after timber is cut off. I would then make my opening at least to carry twice the amount of water computed, taking everything into consideration."

S. F. Patterson, Boston & Maine R. R., Concord, N. H.:

"A good way in building new is to consult the people living in the vicinity, look up high-water marks, etc.; and in case of old structures, watch them and see if the openings carry off the water all right, and if not, enlarge them."

W. B. Yereance, West Shore R. R., Weehawken, N. J.:

"Generally speaking, I would not depart from my more expensive yet economical practice of 'providing sufficient.' In the solution of this problem, as in many others, there is but one side on which a mistake may be made—avoid all possibility of a mistake. It is much cheaper in the long run to decide upon the 48-inch pipe when the question seems to be as between that size and a 30-inch—though the subsequent cost of repairing the bank may be hidden in the labor account and not observed by the officers authorizing all expenditures. I do not consider it is possible to formulate any general rule that will satisfactorily cover all cases. I believe, with Mr. N. W. Thompson, that each case must be treated in the light of its own conditions."

H. L. Fry, Cape Fear & Yadkin Valley Railway, Greensborough, N. C.:

"We determine the size of openings by careful examination of the country to be drained, and by accurate measurement of flood area of streams."

George W. Andrews, Baltimore & Ohio Railroad, Wilmington, Del.:

"I do not believe any empirical method or formula can be successfully adopted for determining size of small waterways, as we seldom find two precisely the same. In my judgment, the best method is to make a careful survey of the property to be drained, number of acres, and condition of soil; then put in pipe or box culvert sufficiently large to carry off the natural drainage, with a margin of safety for heavy rainfall."

J. H. Markley, Toledo, Peoria & Western Railway, Peoria, Ill.:

"I have piped for my company 281 bridges with pipe ranging from 20 inches up to 7 feet. Out of this number of bridges piped I underestimated but two. I estimated the capacity of the pipe wanted by personal observation. I always make it a point to get over the line as soon as possible after very heavy freshets. I often can estimate the size wanted by an old opening in a public road either above or below the bridge in question. Surveying the drainage area is no doubt a good way to get at the capacity of the outlet. This, I claim, cannot be done unless the engineer is thoroughly acquainted with the soil. For instance, on the line of this road there is a tract of seventy-five acres that drains toward the road with no outlet. Two miles west of this the same number of acres require a 4-foot pipe to carry the water."

A. Shane, Cleveland, Cincinnati, Chicago & St. Louis Railway, Lafayette, Ind.:

"In reply to the question, 'How to determine size of waterways' I am tempted to assert that it is largely conjectural. One may, however, arrive at something near the size of an opening necessary, if he be familiar with the locality, and by taking a survey of the area drained, considering the chorography and the average rainfall, the rapidity with which the water may come together, and the volume when assembled to be provided for; that it is necessary for one to be familiar with the locality, is shown by a comparison of rainfall in different sections, for instance, for the year ending August 31, 1894, the average was in Maine from 42.1 to 50.1; in New Hampshire it was 41.9; in Vermont it was but 28.8, an din Connecticut it was from 49 to 50. In Pennsylvania, Ohio, and Virginia, there was not a great deal of difference, ranging from 31 to 52, but in Iowa the average was from 36.4 to 37.3, while in Kansas it was, in some sections, but 20, the general average being but 36 inches in the United States. At Port Said the rainfall for the same year was but two inches, while at Chirpongee it was 610.

"Although we have reliable data of rainfall in the past, they give us no definite knowledge of possible ones of the future. When we consider the disturbing effects of the works of progressive science upon the laws of nature, causing storms to be more local than general, and the facility with which water may pass off, owing to improvement constantly being made, it seems impossible for one to compute, with any degree of certainty, the volume or velocity with which water may pass away. But, should one be able to calculate the maximum of quantity and the minimum of time, and then determine upon the size of an opening required, there are other things; for instance, a waterway may be obstructed, a thing liable to occur at any time, and over which one has no control, having no jurisdiction over territory drained, and being unable to prevent the accumulation of debris. For this reason, I think the greatest care should be taken in putting in small openings, such as tile, pipe or box culverts, and judgment used as to whether they be adapted at all in some sections of the country. For, if a considerable area is to be drained, and the land be rolling, it is questionable whether such waterway be used at all, for one can have no assurance that it will not make trouble at some time. I think it well, in constructing a road or putting in a new opening, to be sure to get it large enough, and let time and experience determine whether it may be reduced without endangering the roadbed and damaging property above and adjacent to the railroad by backing up the water, and overflowing the land, or perhaps, changing its course. There seems to be a tendency toward an indiscriminate use of pipe culverts, thus jeopardizing the safety of trains, as was evidenced recently by several such openings either being washed out, or the road-bed in the immediate vicinity being damaged."

REPORT: ICE-HOUSES.

As the necessity for one or more ice-houses for railroad purposes presupposes the use of ice by the carrier, it seems desirable at the very outset to give some consideration to the question from the standpoint of the traffic and transportation departments. Let us consider, therefore (1) for what purposes, in what quantities, and where ice is needed; (2) how it is proposed to obtain it, and how delivered to the house; and (3) how distributed to meet the needs. This information must be given in order that the subsequent designs shall meet, as nearly as possible, the requirements, without necessitating too great an outlay, and permit of handling the ice at the lowest possible cost for labor, and the smallest percentage of waste or loss.

The ice may be used in refrigerator and dining-car service, station, office, and coach water coolers, and station and coach urinals; the quantities of ice used for each purpose vary widely on different roads. The point or points where the ice is needed is determined by the transportation and traffic departments, usually to best serve the needs of the refrigerator car service.

The supply may be obtained by manufacture, by cutting from ponds, etc., in season, and storing the entire year's supply, or from contractors as needed. It may be brought to the storehouse on endless belt, wagons, cars, or boats.

The distribution is usually made from large or main storage houses by periodical shipments in box or refrigerator cars, to points of minor distribution—infrequently in baggage-cars of passenger trains, though in the latter case, of course, with much loss.

The location of the ice-house is practically independent of the location of the proposed source of supply; the need of a large storage house becomes apparent only when the use of natural ice in considerable quantities is contemplated, and at the time the crop is harvested the temperature (in the central and northern parts of the country) will be so low that the ice can be hauled long distances, if necessary, with slight loss, the main part of which will be from breakage of the cakes.

But your committee feels that attention has not been sufficiently directed to the manufacture of its own ice by the road needing a supply. While on Southern roads especially such a proposition would in many cases be most forcibly presented by the traffic department in the light of the influence of a sufficient supply of ice in controlling, or even handling the dressed meat, dairy and fruit trade, it still devolves upon the engineer to prepare estimates of cost as between the two plans.

The cost of the natural ice supplied will vary so much in different localities that it is impossible to take any figure as an average cost to cover the case generally. Where in one case it may be 50 cents per ton put in the house, in another house on the same road the cost may run up to $1.25 or more in the house, and that although the different contracts were all placed at the same time, prior to or during the winter season. At other times of the year, of course, prices run much higher. Until the stock is actually housed there is in this latitude much cause for worry whether a full supply can be secured at any reasonable price. The demand for ice varies much as between different years, the main causes therefor being differences in severity of seasons and fluctuations in volume of refrigerator-car business handled. Of course, a full supply must be stored during the cold season, but in the event of but little ice being used during the ensuing year, a heavy loss is entailed. The shrinkage of such a stock we have known to amount to about 55 per cent. of the total.

With the manufacture of its own ice the road is independent of the season, can control the output to suit the requirements, secure an article sanitarily pure and avoid the expense of large storage houses, keeping only sufficient on storage to be prepared for emergency calls. We deem this question of the manufacture of ice by the road of sufficient importance to warrant the submission herewith of a plan, specifications and estimate for a 25-ton and 50-ton plant under the conditions to be met in New York City. (Specifications, plans and estimates omitted in this work.) These figures of cost include the plant complete (except the land on which it stands) including storage rooms of each 250 and 500 tons capacity respectively and refrigerating apparatus for keeping the ice in these rooms. This estimate is for a plant of the absorption type, but no discrimination is intended as against the compression system; each has its field of greater usefulness and higher efficiency. The main point to which we wish to call attention is the cost per ton of the ice as shown; this cost includes all items except water. Of course, such an installation would be even more profitable to operate where as a side issue refrigerating effort could be supplied to cold storage rooms such as certain roads now operate. One large road running out of New York has now in operation a 50-ton ice-making machine (compression type) which with slack coal at 66 cents per ton and common labor at 12 cents per hour will, when running at full capacity, turn out the ice at a cost for operation of between 50 cents and 55 cents per ton.

Although the showing made by refrigerating plants is attractive, we shall assume in our further discussion the use of natural ice by the carrier, as that is the more commonly used.

There are relatively very few points where a small ice-house is needed. For general station purposes a plentiful supply of good water is necessary; this is secured in small outlying towns and villages by either a pump or well at the station or from the local water system; here ice for station water-coolers is not needed, and for sanitary purposes in the toilet rooms some such agent as chloride of lime answers better than ice. Where the size and importance of the town demands the use of ice it may be found cheaper to procure this small supply from local dealers as needed; but should several such places be grouped together on the line it may be found desirable to locate at one of these points a small house; this will certainly be the case if local passenger trains are started from that point, as ice in coach water-coolers is, during the summer season especially, practically necessary, and in coach urinals is highly desirable. It almost goes without saying that an ice-house should be located at or adjacent to each division terminal. Such a house should be built on the same design as the larger houses, with dimensions so altered as to meet the requirements of that particular locality.

Ice-houses for storing ice to be used for special purposes, such as icing refrigerator cars, are built according to the standard design, but are further equipped with special appliances for handling ice, breaking and carrying it, and mixing with salt. Where the ice is to be used for but the single purpose, machinery for its handling may be introduced which will prove, if properly designed and adapted to the needs, highly economical.

In all ice-house construction the most important consideration is the

Insulation.—The ideal ice-house is simply a storage chamber absolutely protected on all sides against the absorption of external heat and supplied with well-designed drains for the prompt removal of all water resulting from the little melting that in spite of all practicable precautions will occur. Heat travels or is conveyed by radiation, conduction and convection. For the purposes of this discussion the outside of the building and the ground (however, themselves heated) may be assumed to be the source of the heat against which it is desired to insulate the storage chamber. Experiment has shown that cells or small chambers of dry, dead air form the best insulator. In the proportioning of these air-spaces two facts must be borne in mind, (1) the intensity of radiant heat varies inversely as the square of the distance from the source and (2) soon as a current, however slight, of air is formed in any air-space, heat is carried by convection around in that chamber. Of course two air-spaces are more effective than one, and three more than two, but there is an economic maximum dependent on the circumstances of each case.

Material of Construction.—Wood is best adapted for use in buildings of this character, being of itself a non-conductor of heat, and not retaining the heat as does either natural or artificial stone, it permits the cheapest and at the same time the most efficient construction. In some municipalities certain regulations have been established governing the construction of all buildings within the "fire limits" and such laws usually are directed first to the materials of construction; at such a point it will be well to consider the advisability of locating the proposed ice-house beyond these fire limits to conserve the use of wood in the construction.

Plan.—All ice-houses should be built in sections, the size of section being governed by the quantity of ice used; in some cases it is advisable to construct across each section lateral partitions which will still further reduce the amount of ice exposed to contact with the outer air while part of the stock is being removed. The building should stand with the gable end of the sections to the track, the doors then coming in the ends of the sections. At the center of each section and at about the level of the first door should be placed a platform, say 6x10 feet.

Proportions.—Assuming that a cubic foot of ice weighs 57.2 pounds, a ton of solid ice would occupy about 35 cubic feet. Some years since, 40 cubic feet was considered ample in which to store a ton of ice cut in such sized cakes as are usually stored, but that allowance has been increased to 45 and even 50 cubic feet. In storing ice, good practice requires each cake to be stood on edge, leaving at least an inch air-space on four sides of the cakes. Ice less than 10 inches in thickness, or not perfectly solid, it does not usually pay to store; the thicker it is the better, but the cakes in any one layer should be all of the same dimensions to secure the best results. The layers should be crossed. The practice of laying each cake on the flat and as close as possible to those adjacent and filling all interstices with finely broken ice is to be condemned—it costs more for labor, the wastage is greater than in the method before described, and when the ice is to be taken out, it is difficult to get good, merchantable cakes.

No covering should be placed on the ice after it is in place in the house; an inorganic substance, such as asbestos, would make the ice dirty and be too expensive to use; any organic matter, such as that generally employed—hay or sawdust—not only dirties the ice, but, being dampened by the melting, soon begins to rot, decompose, and become foul. For this reason, the use of any organic matter between walls is to be deprecated. The use of short-fibre asbestos in the outer air-space (see Fig. 188) has been suggested, but not to our knowledge tried; however, at a weight of 12 pounds per cubic foot and at a cost of $16 per ton in carload lots f. o. b. New York, the expense is practically prohibitory. This asbestos, if used loosely, as it should be if at all, settles after

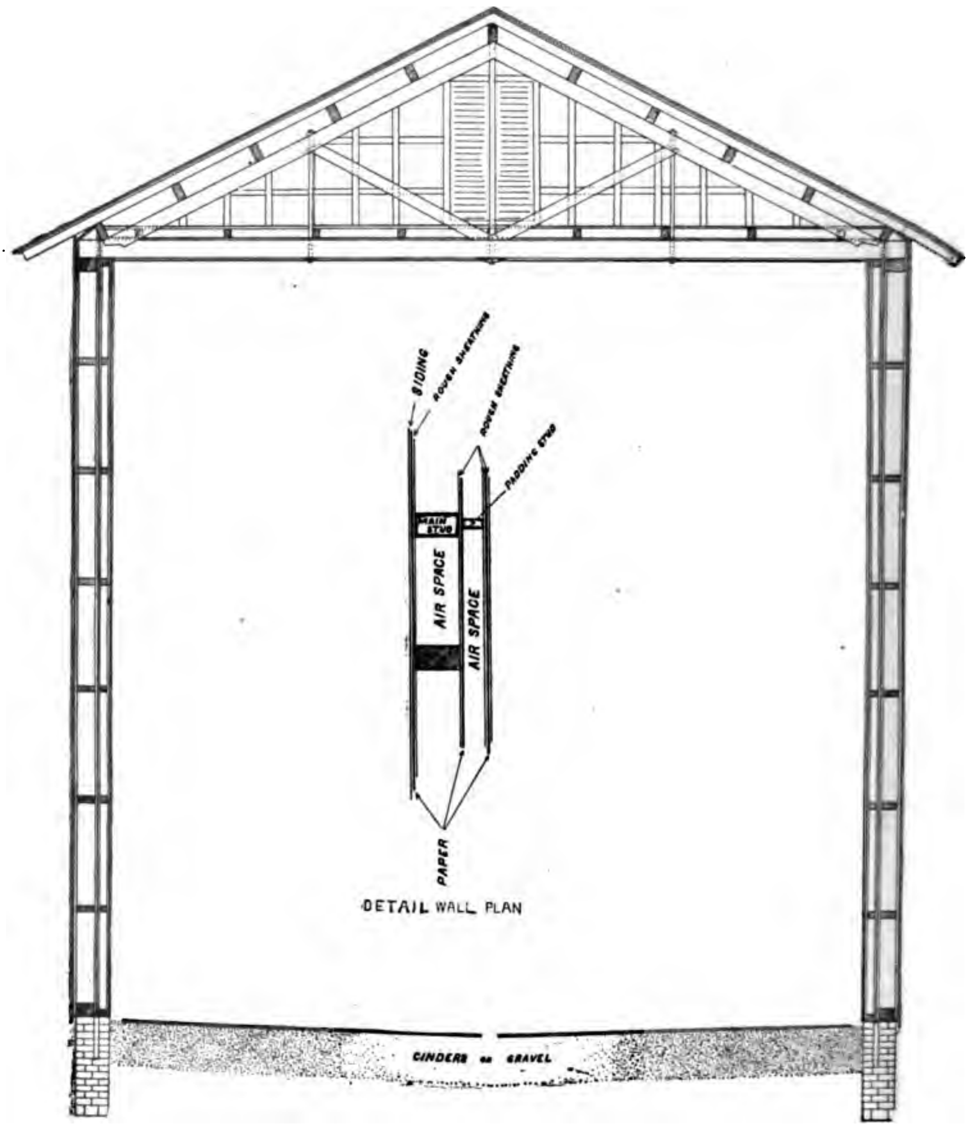


FIG. 188—DESIGN FOR STANDARD ICE-HOUSE SECTION, RECOMMENDED BY THE COMMITTEE ON ICE-HOUSES.

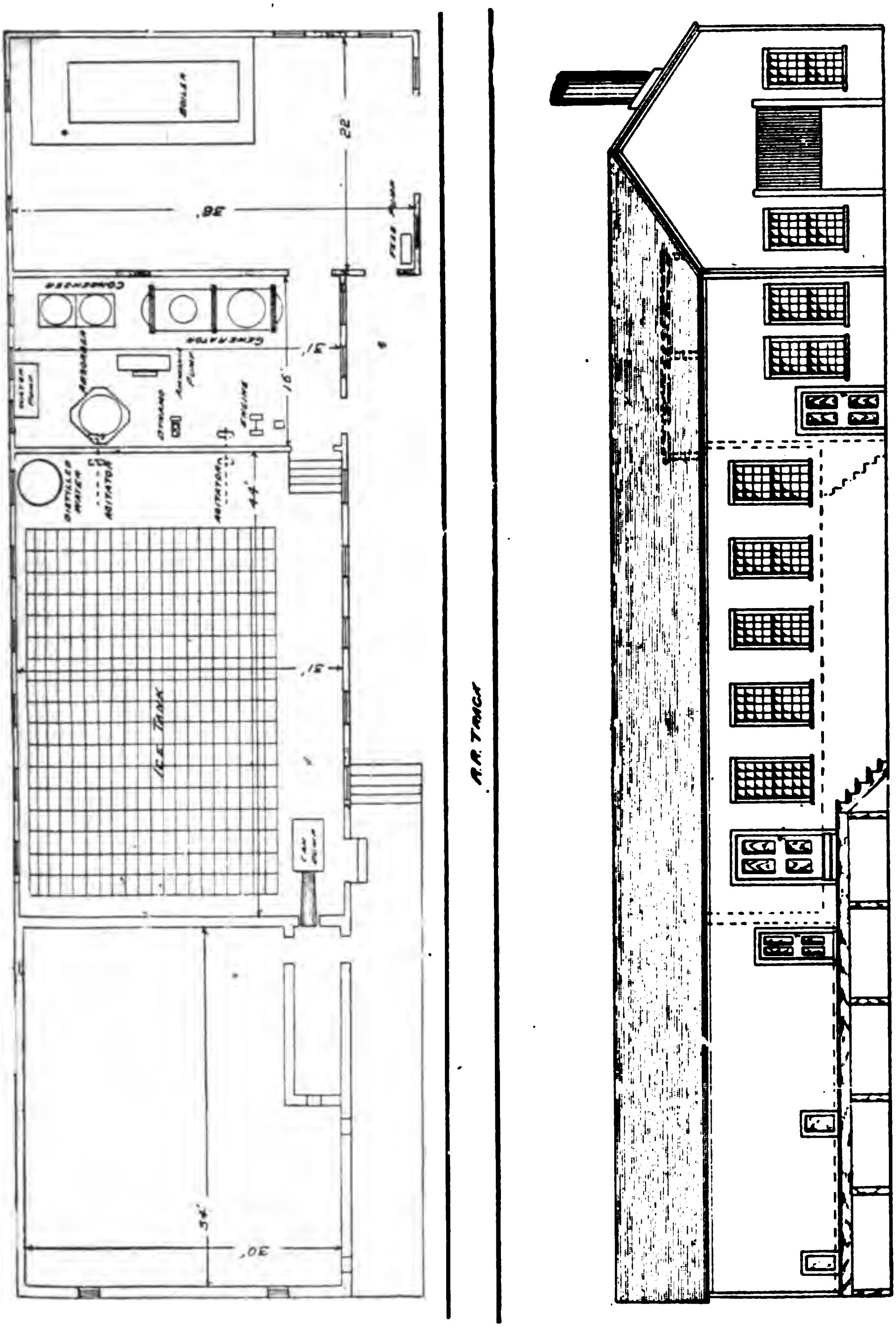
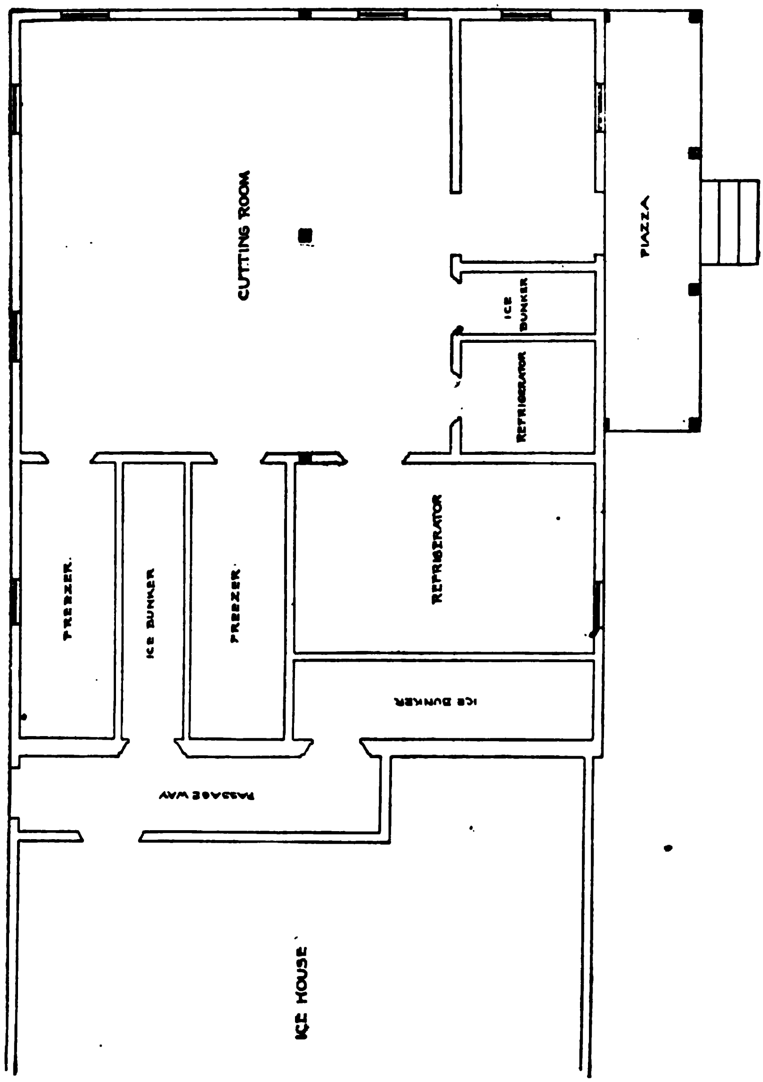


FIG. 189—PLAN FOR 25-TON ICE MAKING PLANT, DESIGNED BY THE HENDRICK MFG. CO., LIMITED, OF CARBONDALE, PA.



FLOOR PLAN

FIG. 190—ICE-HOUSE AND REFRIGERATOR BUILDING AT FABYAN HOUSE, N. H., BOSTON AND MAINE R. R.

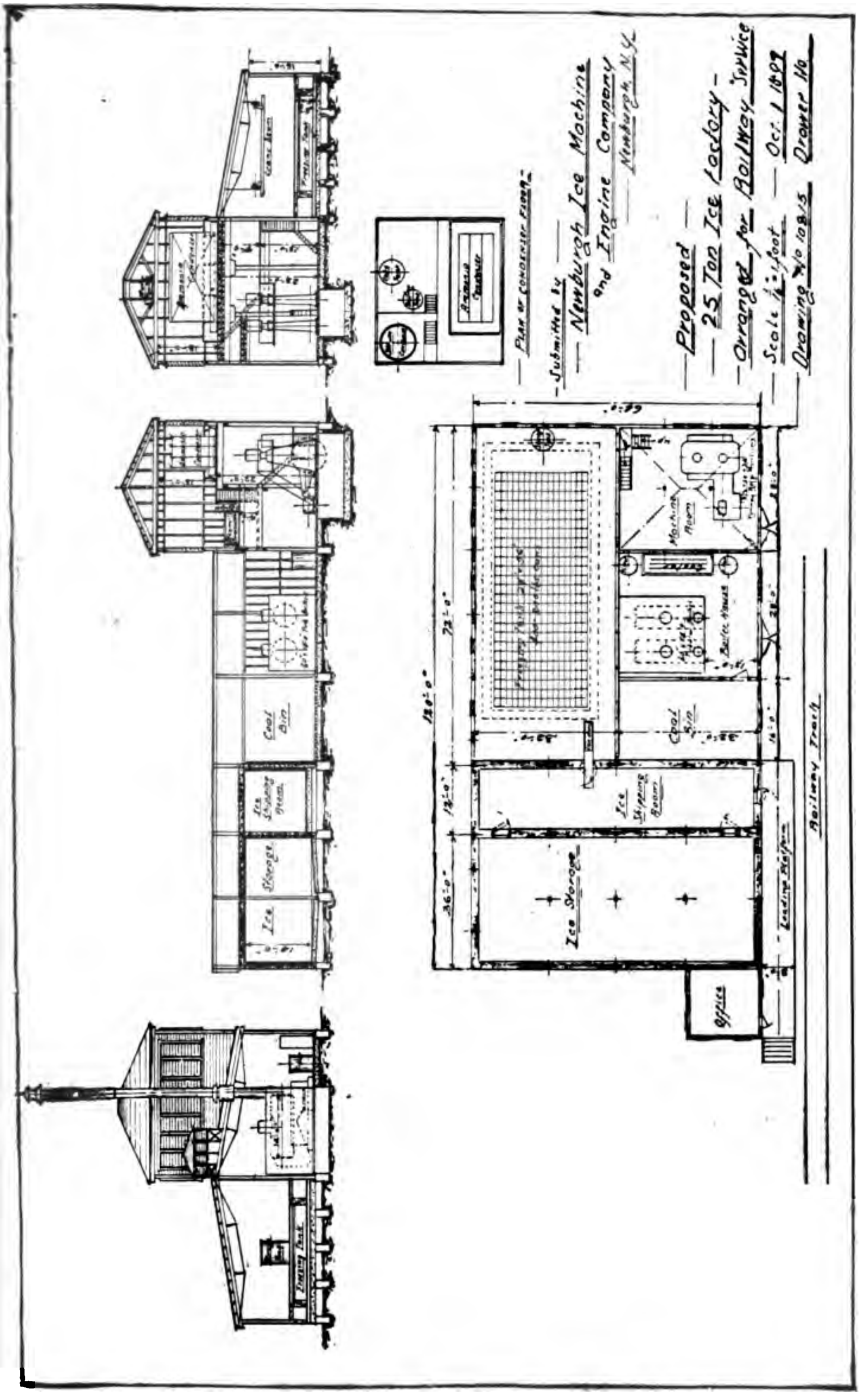


FIG. 191—PLAN FOR 25-TON ICE FACTORY ARRANGED FOR RAILWAY SERVICE, DESIGNED BY NEWBURGH ICE MACHINE AND ENGINE CO., NEWBURGH, N. Y.

REPORT: BEST END CONSTRUCTION OF TRESTLES ADJOINING EMBANKMENTS.

First. The end bent should be piled and consist of not less than four piles well driven, and properly spaced.

Second. The bulkhead should begin about one inch below the base of the rail, conform to the slope of the embankment and extend below the tops of the piles.

Third. The embankment at the end of the trestle should be made of such material obtainable as will shrink or settle the least.

(a) The piles in the end bent are called upon to bear not only one-half the load on their span, but also the shock of on-coming trains. Could the embankment be kept up to its proper height, there would be no trouble from the latter cause. Since there is more or less yielding to the embankment, trains crossing a trestle act like so many pile-drivers on the end bent, and the resistance of this bent gives the train the jolts so familiar to all. On this account, where all piles in a trestle have been driven to a uniform bearing, if any settlement takes place afterward, it usually occurs first in the end bents. The piles in the end bents should, therefore, wherever practicable, be long enough to go through the embankment and be driven to solid bearing in the ground beneath, and deep enough to guard against any possible danger from scour from the stream which the trestle crosses.

As the end bent is called upon to do the heaviest work, it follows that its piles should be spaced so that each one will be uniformly ioaded. We condemn the use of a three-pile bent for any but temporary work. It is rarely sufficient for the end bent and its worst feature is, that the giving away of any one pile is apt to cause the whole bent to fail. Trestles of this kind are particularly dangerous after they begin to rot.

(b) The bulkhead should be as wide and conform to the slope of the embankment for obvious reasons. Separating it from the trestle by furring strips, and extending the bulkhead below the tops of the piles, are for the purpose of keeping the ends of the stringers and tops of the piles from decaying, by having a free circulation of air around them. An air-space of less than two inches is apt to become clogged by earth or other material lodging in it. We prefer an air-space of not less than three inches. Where the bank is more than six feet high, one extra pile should be driven on each side of the track to hold the ends of the bulkhead from being crowded in by the embankment, and dependence should not be placed in the bolts through the stringers and cap to keep the end bent from being pushed out of place. Struts should be used from the cap of the end bent to the second bent, preferably to its piling at their ground line.

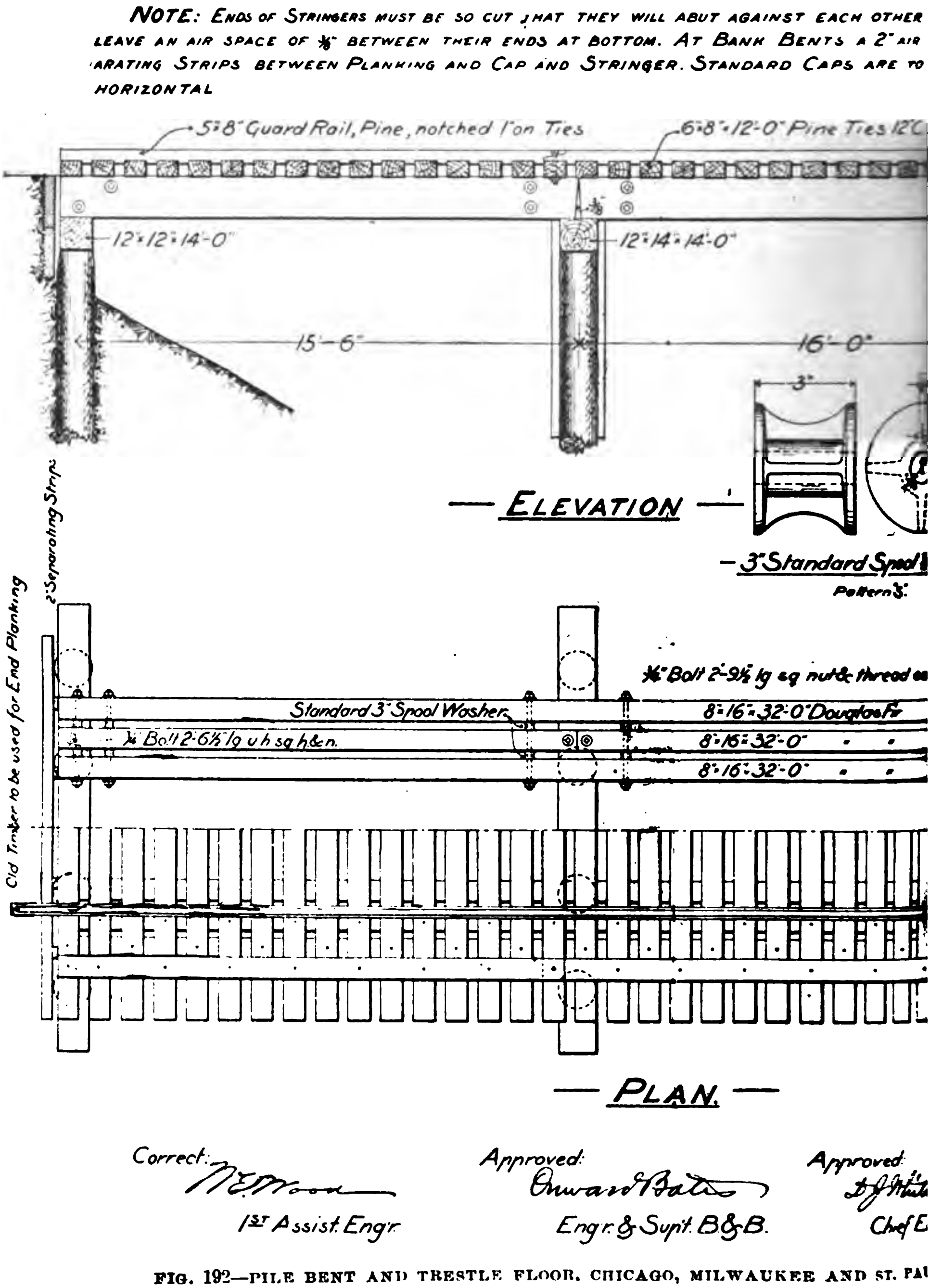
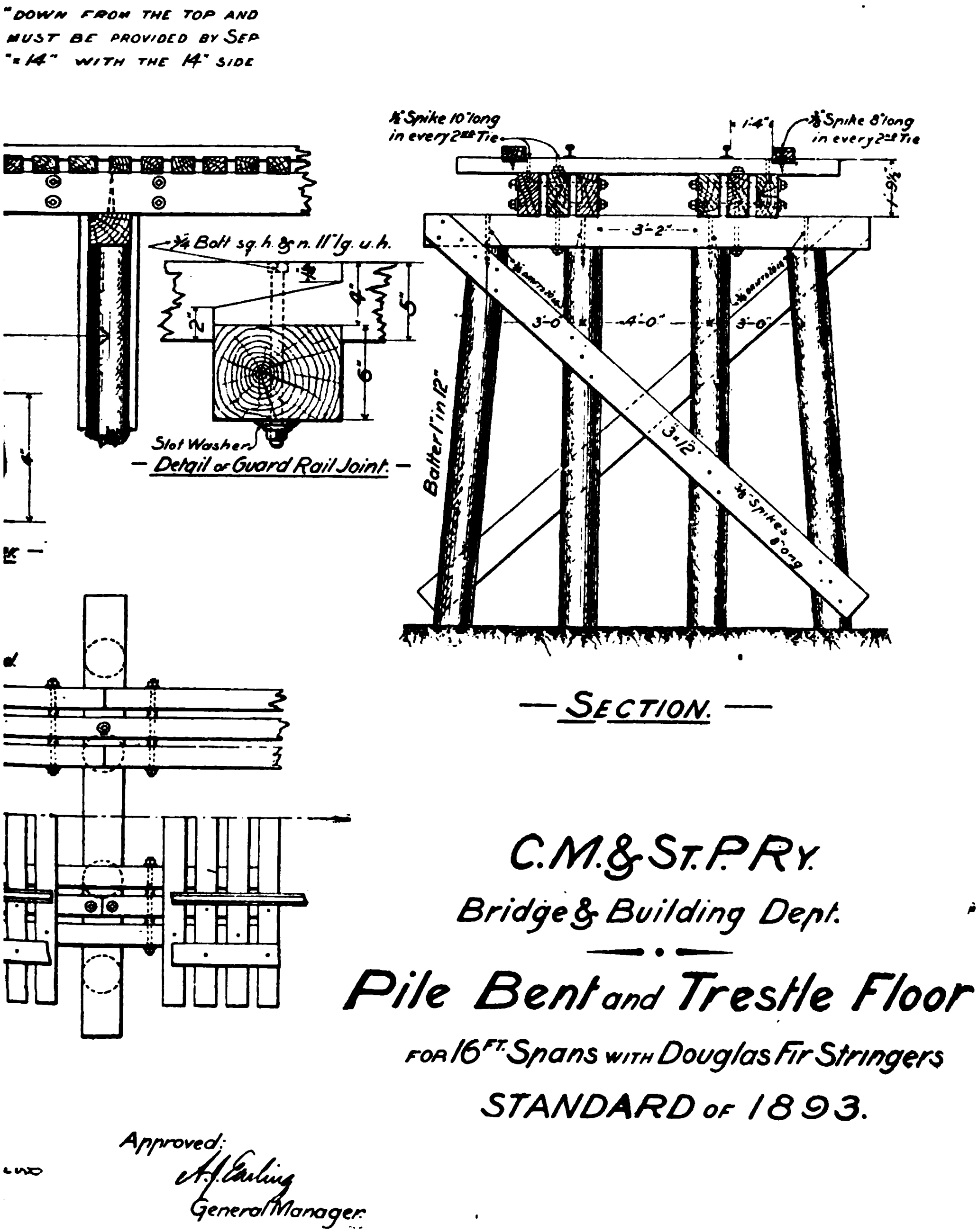


FIG. 192—PILE BENT AND TRESTLE FLOOR, CHICAGO, MILWAUKEE AND ST. PAUL



R. REPORT ON BEST END CONSTRUCTION OF TRESTLES ADJOINING EMBANKMENTS.

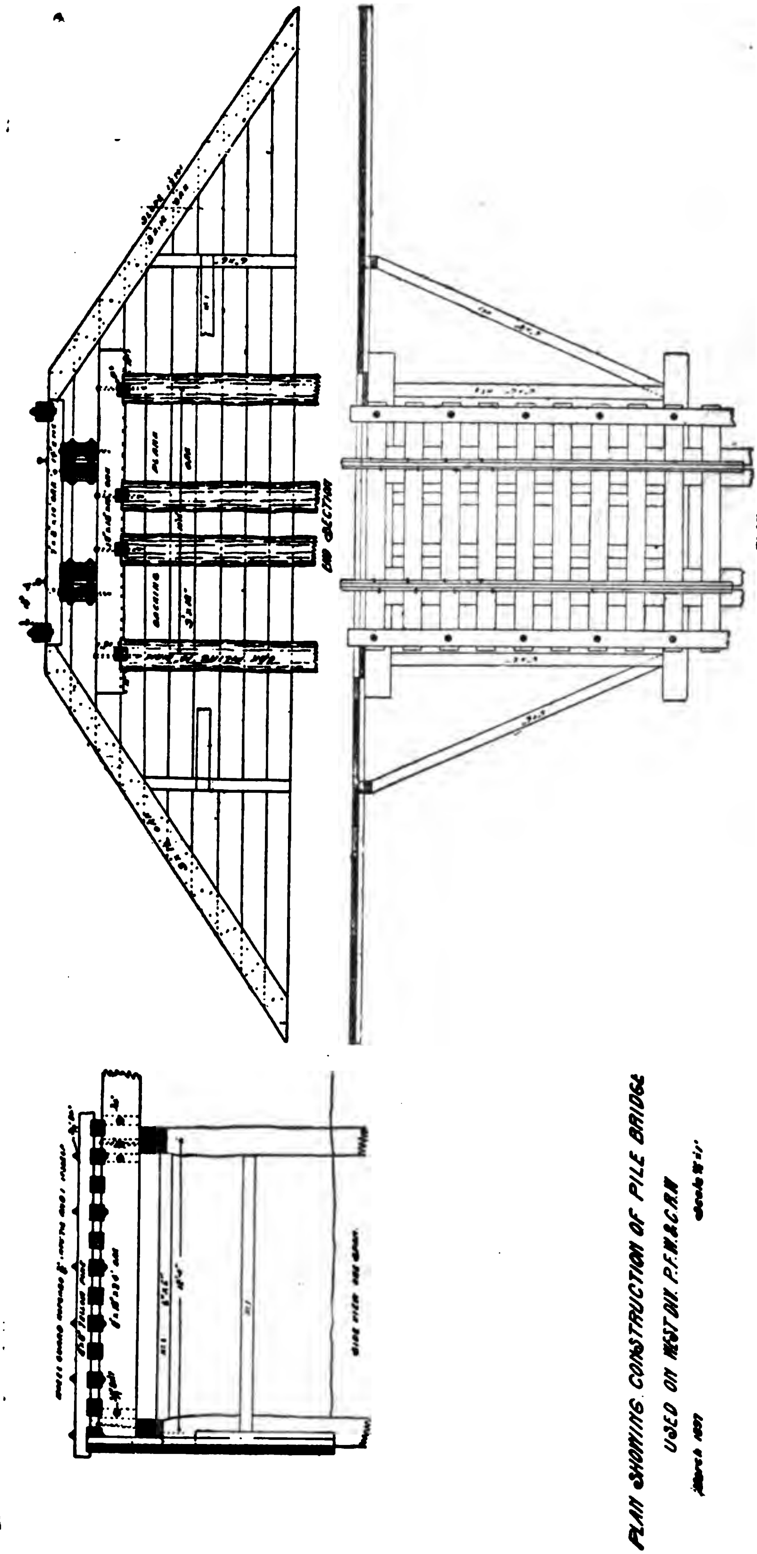


FIG. 193—PILE BRIDGE, WESTERN DIVISION PITTSBURG, FORT WAYNE AND CHICAGO R. R. REPORT ON BEST END CONSTRUCTION OF TRESTLES ADJOINING EMBANKMENTS.

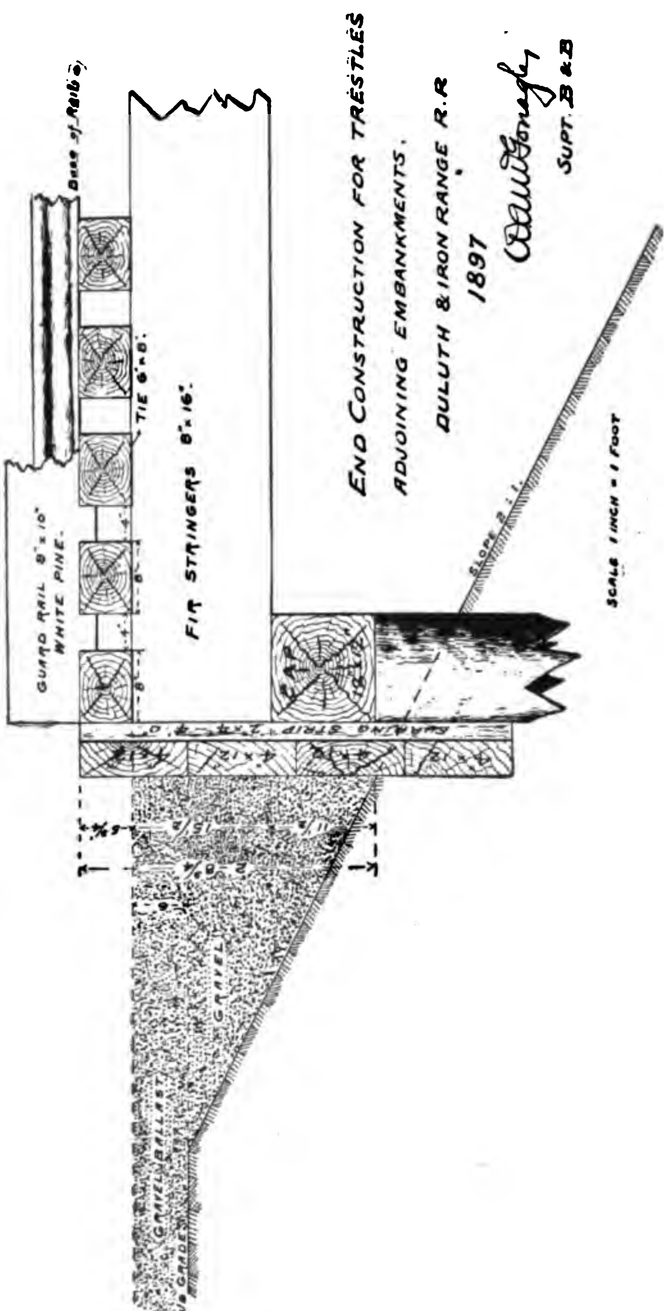
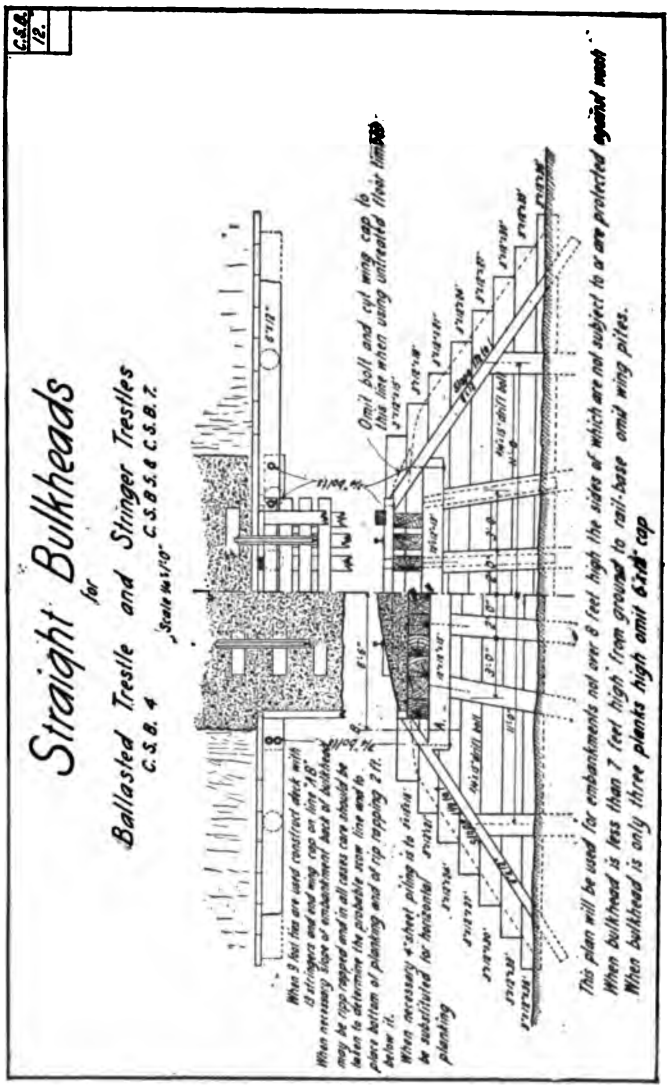


FIG. 194—END CONSTRUCTION FOR TRESTLE ADJOINING EMBANKMENTS, DULUTH AND IRON RANGE R. R. REPORT ON BEST END CONSTRUCTION OF TRESTLES ADJOINING EMBANKMENTS.



194 A—STRAIGHT BULKHEADS FOR BALLASTED TRESTLE AND STRINGER TRESTLES, SOUTHERN PACIFIC R. R. REPORT ON BEST END CONSTRUCTION OF TRESTLES ADJOINING EMBANKMENTS.

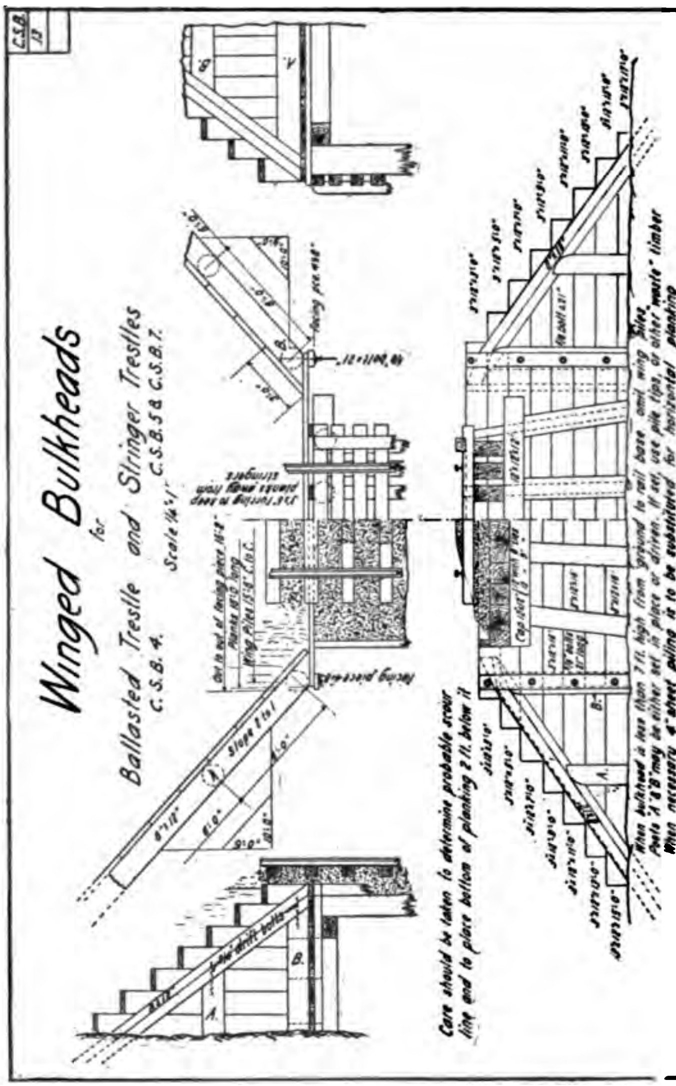


FIG. 194 B—WINGED BULKHEADS FOR BALLASTED TRESTLES AND STRINGER TRESTLES, SOUTHERN PACIFIC R. R. REPORT ON BEST END CONSTRUCTION OF TRESTLES ADJOINING EMBANKMENTS.

If planks are used for the bulkhead, a brace should extend on each side, from the end of the ties to below the outside ends of the bottom plank, to which the ends of the bulkhead planks should be spiked.

(c) We have already touched upon the necessity of keeping the embankment up to its proper height, hence the reason for using material that will shrink or settle the least, at the end of the trestle. Sufficient berm should be left at the bottom of the bulkhead to prevent the embankment from being undermined. Where the embankment is new, it is well to let the trestle extend temporarily one span beyond its final length over the embankment and rest it on mud sills, the extra span to be taken out when settlement has ceased.

We append herewith plans, illustrating points brought out in our report, from the following railroads: D. S. S. & A., C. & N. W., S. P. Company, C. M. & St. P., P. F. W. & C., D. & I. R. R.

C. C. MALLARD, So. Pac. Ry.,
W. S. DANES, Wabash Ry.

REPORT: BRIDGE WARNINGS FOR LOW OVERHEAD STRUCTURES.

There seems to be no doubt of the necessity, and we have found no tendency on the part of any one to dispute the value, of giving warning to railroad men on top of cars, of the fact that the train is approaching some overhead structure or tunnel, with less clearance than requisite to clear the tallest man standing on top of the highest car. A number of appliances for giving such warning are used on railroads and are known by a variety of names, such as bridge warning, bridge guard, tickler, telltale, whip guard, bridge indicator, bridge detector, bridge alarm, and bridge signal.

The general principle remains the same in all cases, namely, some appliance is suspended or swung over the track near the obstruction in such a manner and at such a height as to strike a man a light blow and thereby give warning that a low bridge, tunnel, or other overhead structure is being approached.

There are two radically different systems employed to accomplish the results desired. The system that is most extensively used, and which for convenience will be designated as the "vertical rope system," consists of having light vertical ropes or wires (known as tell-tales, whip-cords, ticklers, or danglers) suspended over the track from a rigid horizontal wooden or iron bar or hung from a flexible wire or cable, the bar or cable being suitably supported on the outside of the track or tracks by upright posts set in the ground and properly braced and backstayed. In the other system, called frequently the Walling system, from the name of the leading patentee, and which can be designated as the "swinging arm system," a light horizontal swinging arm is projected out from a post planted on the outside of the track so that the arm will strike a man on top of a car, but at the same time swing out of his way as he passes on and then return automatically to its original position again.

It can be stated at once that the swinging arm system requires a separate arm for each track to be protected and further a separate post for each track, unless a post is set between tracks with arms on two sides. In the vertical rope system, any number of tracks can be crossed and the posts kept clear on the outside of all the tracks, the only question involved being to give the supporting bar or cable the proper stiffness, and to backstay or brace the end posts sufficiently to resist the inward pull at the top.

Further, the testimony of the use of the swinging arm system on the Boston & Maine R. R. and on the Lehigh Valley R. R. indicates that it is not always safe. It has to be hung very delicately so as not to hit too hard a blow when struck, but in consequence, high winds affect it and blow it out of position. It can also be said that there is no positive assurance that in northern climates the pivoted joint connections will not become frozen and hence the apparatus dangerous under such conditions. Further, it is very easily damaged by trainmen striking it with brakesticks or by swinging it around with great force or catching hold of it when passing slowly under it.

There are other similar arrangements, in which light horizontal arms are counterweighted or variously arranged, but they have similar objections to those just mentioned.

Your committee is forced to consider that the vertical rope system, as it has been designated above for briefness, is the best under most circumstances. There are numerous modifications of it in details, but the general principles remain the same.

It will prove desirable to mention briefly some of the most important characteristics and practical features that should be considered in the design of a bridge warning.

Probably a very vital consideration is low first cost combined with durability. In this latter respect the iron tube supports and overhead bar used by the Southern Pacific Railway are very advantageous, while the preservation of timbers by chemical means on all roads having facilities for such work within reach will also prove a saving in the long run. As the material is standard stock, it can be framed and treated in large batches at a time and placed in stock. Of course, a very low first cost can be obtained by adopting very crude arrangements, but it is a question whether possible damage suits for accidents resulting from imperfect structures will not far outbalance the slight additional cost of a suitable construction in the start.

According to the data collected by your committee, bridge warnings seem to cost from $8 to $25 for a single track, and from $20 to $30 for a double track warning. With a cable support, a large number of tracks can be crossed with comparative ease and small additional cost over that of a double track warning. One member places the extra cost as only 5 cents per lineal foot. For an improved system using some means to prevent the ropes from catching on the cable, the probable extra expense would be from $3 to $5 per additional track over the cost of a double track warning. The standard iron tube frame bridge warning of the Southern Pacific Railway costs $25 complete for a single track.

In regard to the tell-tales, ticklers, or danglers, the usual construction is to use ropes, from one-fourth to three-fourths inches in size, knotted at the lower end and suspended from short pieces of wire or flat iron loosely or rigidly connected to the overhead bar or cable. In some cases the ropes are attached directly to the overhead bar or cable. It is a mistake to use too large a cord and especially a big knot at the lower end. In winter, ice will collect to such an extent that it is positively dangerous for a man to be hit by the end of one of these ropes. Rubber straps, sash cord, or old bell cord is frequently specified. On the Lehigh Valley R. R. the practice is to untwist old heavy rope and use one of the strands, which is economical and makes a softer rope. Some designs show wire or steel tape danglers, but this feature does not seem a good one, on account of rust and greater danger to men.

The ropes are generally spaced from four to eight inches apart for a distance of five to eight feet across the track. The lower ends are usually specified to be six inches lower than the lowest point of the overhead structure for which they are to give warning, or a standard height of from sixteen to seventeen feet above the rail is specified.

One of the important features is to prevent the ropes from being blown by winds or the engine exhaust, or more particularly from being tossed up by trainmen in such a way as to remain hanging on the top frame or bar. This is one of the most usual objections to the danglers. It can be overcome in a number of ways, several of which are indicated in the plans accompanying this report. The arrangement shown as in use on the Chicago, Rock Island & Pacific R. R., namely, a horizontal hood over the top of the horizontal bar above the tell-tales, has the great additional advantage of protecting the ropes to a certain extent from the weather, and hence less liability to freeze and become stiff and hard.

In regard to the location of the warning with relation to the bridge proper, it should not be too far away, as there is too much chance for a brakeman to rise up on the car between the warning and the bridge. Various distances of from 200 to 300 feet are specified, and in one case one quarter of a mile is mentioned. The distance should certainly be limited to about 200 feet, and in yards where much switching back and forward is done immediately under an overhead bridge, the location should be closer, or even a second warning put up.

Most roads seem to specify that bridge warnings shall be used at all overhead obstructions with a less clearance than twenty feet, although the range runs from eighteen feet, six inches to twenty-two feet.

An important maintenance feature is to arrange that the danglers can be easily repaired if torn off, tied up, or knotted together by brakemen standing on cars temporarily halted under the warning. The usual method of having a car hauled under the warning and workmen climb up on horses on top of the car is so cumbersome, especially out on the line, that it is put off from day to day, thus taking many chances with the life of the trainmen at night. The other system of setting up a ladder is equally objectionable. A tell-tale frame that can be let down, or if hung to a cable some arrangement to lower the entire cable, is generally preferable. It must be, however, practicable and guarded in such a way that tramps and unauthorized parties cannot tamper with it. Mr. W. B. Mitchell, of the Erie R. R., reports that he uses a small windlass locked in a box on the side post near the ground. The tell-tales are suspended from a cable, one end of which is wrapped around the drum of the windlass. When required, the cable is let down and after the repairs are made, hoisted into place, and a strain put on it. Special attention is directed to the device used on the Chicago, Milwaukee & St. Paul Railway, known as the "Nettenstrom Signal," which is giving good service, as per report of Mr. Onward Bates.

This is one of the advantages of using a cable, and it has also the advantage that a large number of tracks can be spanned with it. But it has the disadvantage that it is liable to sag badly and requires good backstaying and bracing of the side posts.

The effort to counteract the ruling passion of brakemen to show their agility by climbing up on bridge warnings when a car stops temporarily under one has produced numerous arguments for and against a rigid overhead construction. If made rigid, no serious harm will be done, while on the other hand, if not able to support the weight of a man there will be less temptation offered, but more damage done if the feat is attempted. This is a double-edged question that your committee will not attempt to settle.

Comparing the single post frame and a double post frame for a single track warning, it can be said that the single post can only be used where there is an opportunity to bury the foot well in the ground or otherwise thoroughly brace it. Where this is not feasible, a post each side of the track should be used. Further, a double post warning can be more readily and quickly framed and put up on the ground, whereas a single post frame with projecting arm requires more carpentry work, that should preferably be done in a shop, and the post has to be set with greater care in reference to the track and much closer to it.

We present in an appendix descriptions and illustrations (Figs. 197 to 205) of a large variety of bridge warnings and information kindly contributed by members of this association in response to the circular of inquiry sent out by the committee.

W. E. HARWIG, L. V. R. R.,
M. A. MARTIN, M., K. & T. R. R.,
JOSEPH DOLL, C., C., C. & St. L. R. R.,
Committee.

APPENDIX TO COMMITTEE REPORT ON "BRIDGE WARNINGS FOR LOW OVERHEAD STRUCTURES."

DESCRIPTION OF BRIDGE WARNINGS FROM DATA FURNISHED BY MEMBERS OF THE ASSOCIATION.

Erie R. R.—Uses for single track a one-post "Bridge telltale" with ropes suspended over track, as shown on Plan No. 1. Mr. W. O. Eggleston states the cost is $16.72 for one warning.

Wabash R. R.—Uses for single and double track a two-post "Bridge warning" with a wooden cross-bar from which the ropes are suspended, as shown on Plan No. 2.

Chicago, Rock Island & Pacific Railway—Uses on the lines west of the Missouri river, for single track a two-post "Bridge tell-tale" with wooden cross-bar from which the ropes are suspended, as shown on Plan No. 3. Mr. George J. Bishop states that while the design is similar to other bridge warnings there is one very good and novel feature about it, namely, a hood, 7 ft. 8 in. long and 5 ft. wide, above the ropes. Trainmen and the exhaust from the engine cannot throw the ropes so as to cause them to hang on top of the cross-bar. The cost for one single-track bridge warning is for material, $12.26, for labor on construction, $6.67, for labor in erection, $7.50; total cost, $26.43.

Pennsylvania Company—Uses a one-post "Bridge alarm" with one-half inch ropes hung to one-fourth inch rods run directly through the top cross-arm, as shown on Plan No. 4. Mr.

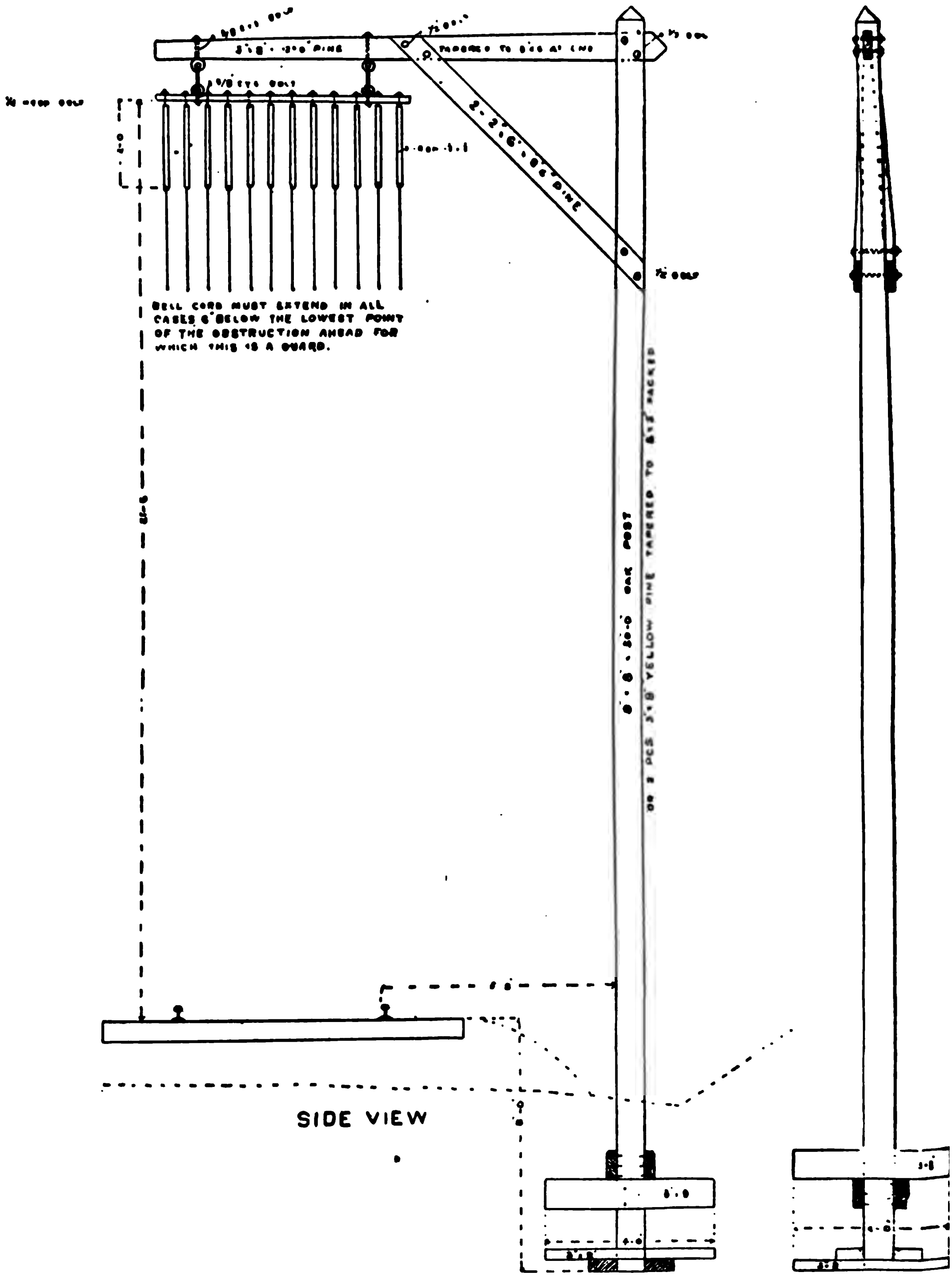


FIG. 195—BRIDGE TELL-TALE, ERIE R. R. (PLAN NO. 1.)

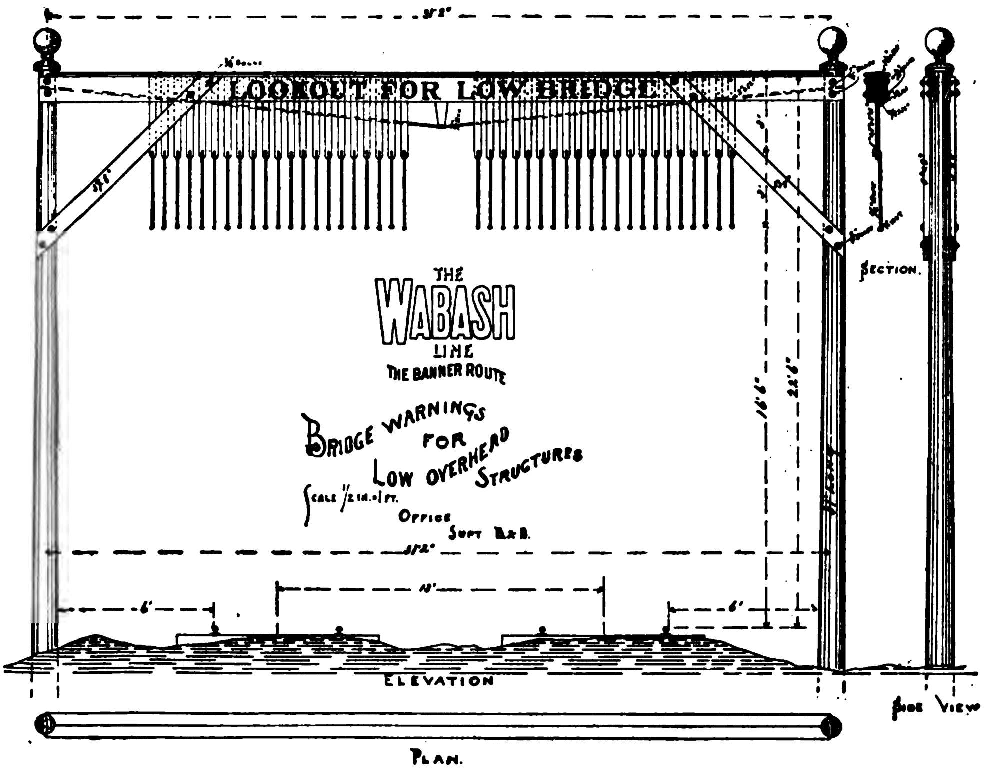


FIG. 196—BRIDGE WARNING, WABASH R. R. PLAN NO. 2.

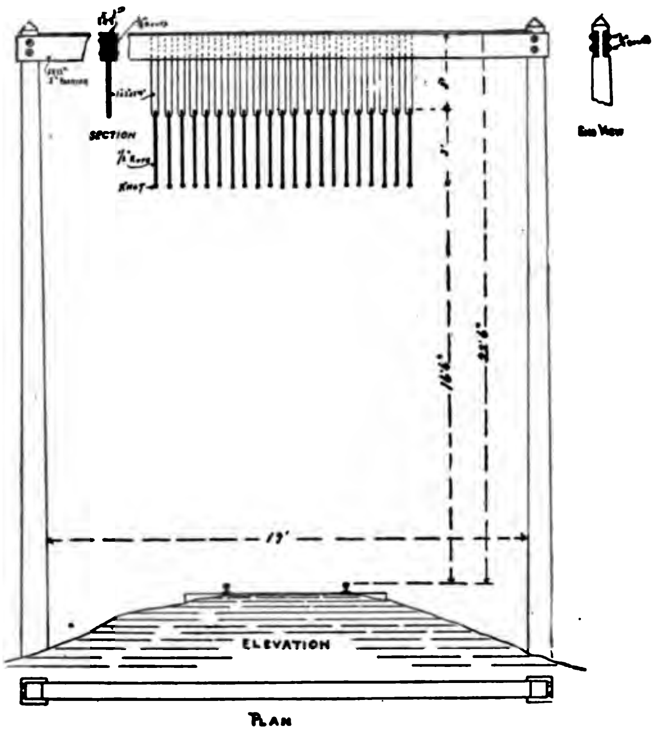


FIG. 196—BRIDGE WARNING, WABASH R. R. (PLAN NO. 2.)—CONTINUED.

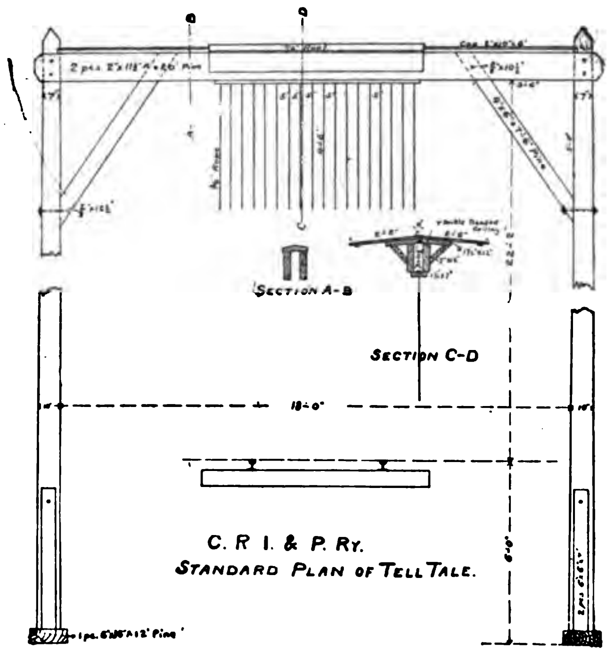


FIG. 197—TELL-TALE, CHICAGO, ROCK ISLAND AND PACIFIC R. R. (PLAN NO. 3.)

Pennsylvania Company

BRIDGE ALARM.

TO BE USED FOR ALL BRIDGES & STRUCTURES LESS THAN 18' 6" CLEAR HEIGHT ABOVE TOP OF RAIL.

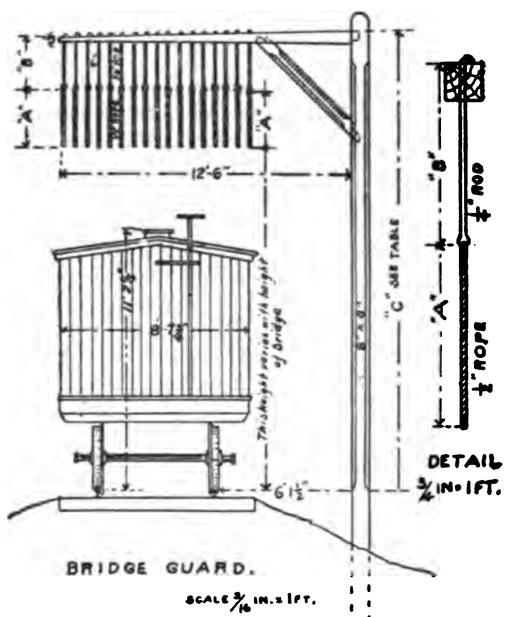


TABLE OF DIMENSIONS.

CLEARANCE OF STRUCTURE ABOVE RAIL.									
NOT OVER	15' 6"	16'	16' 6"	17'	17' 6"	18'	18' 6"	19'	19' 6"
LENGTH OF ROPE "A"	4' 1"	3' 7"	3' 1"	2' 7"	2' 5"	2' 3"	2'	2'	2'
" "B" BELOW BAR	3' 5"	2' 11"	2' 8"	2' 5"	2' 2"	1' 11"	1' 11"	1' 11"	1' 11"
" "C" ABOVE RAIL	23'	22' 6"	22' 5"	22'	21' 9"	21' 6"	21' 6"	21' 6"	21' 6"

NOTE:

1. THE BOTTOM OF THE ROPES MUST COME AT LEAST AS LOW AS THE LOWEST POINT OF THE BRIDGE TO BE PROTECTED.
2. USE WHITE PINE FOR ALL WOOD.
3. TIMBER BELOW GROUND TO BE TARRED.

FIG. 198—BRIDGE ALARM, PENNSYLVANIA COMPANY. (PLAN NO. 4.)

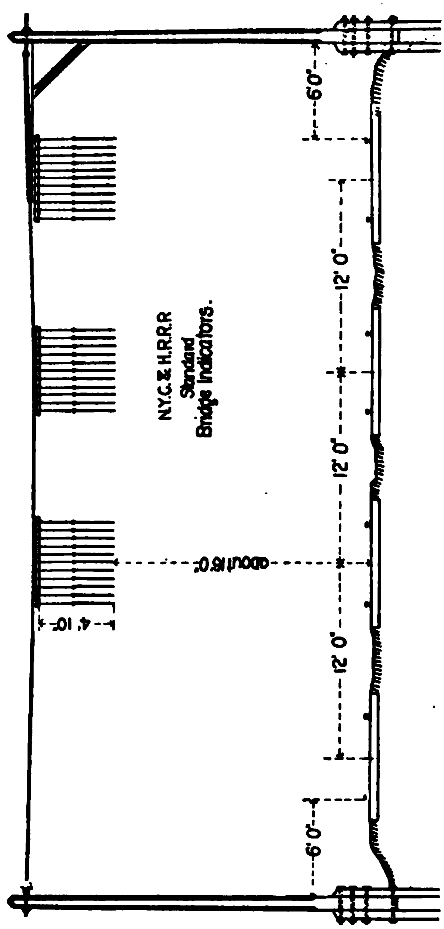


FIG. 199—BRIDGE INDICATOR, NEW YORK CENTRAL AND HUDSON RIVER R. R. (PLAN NO. 5.)

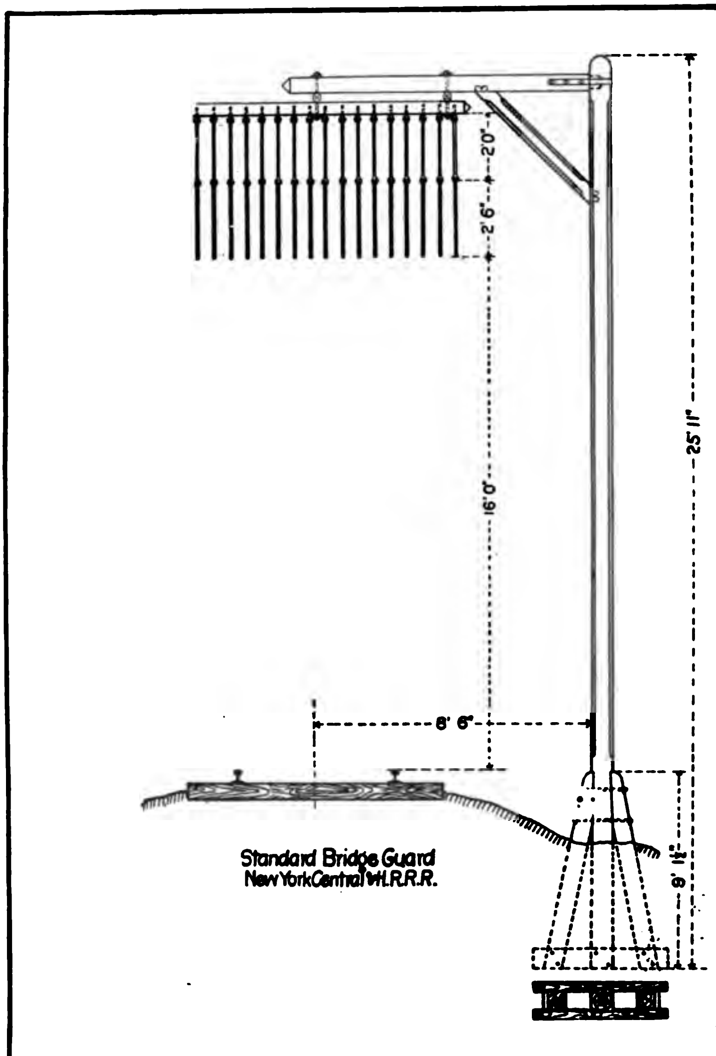


FIG. 200—BRIDGE GUARD, NEW YORK CENTRAL AND HUDSON RIVER R. R
(PLAN NO. 6.)

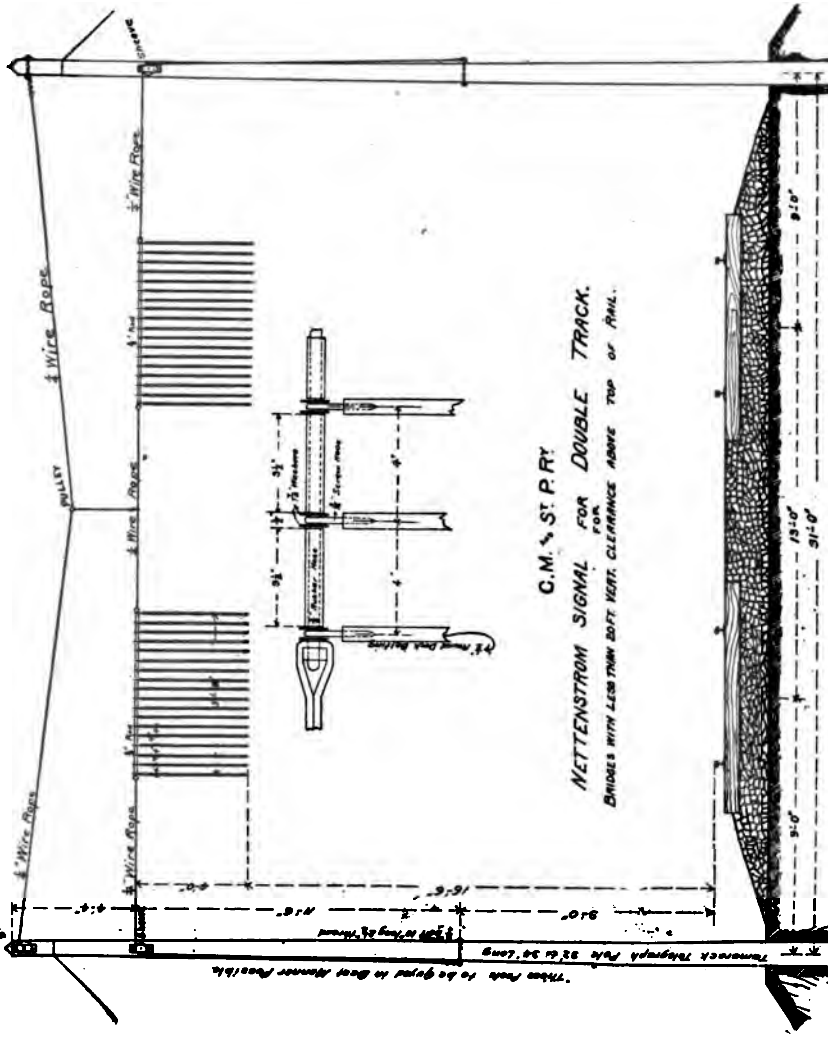


FIG. 201—NETTENSTROM SIGNAL FOR DOUBLE TRACK, CHICAGO, MILWAUKEE AND ST. PAUL R. R. (PLAN NO. 7.)

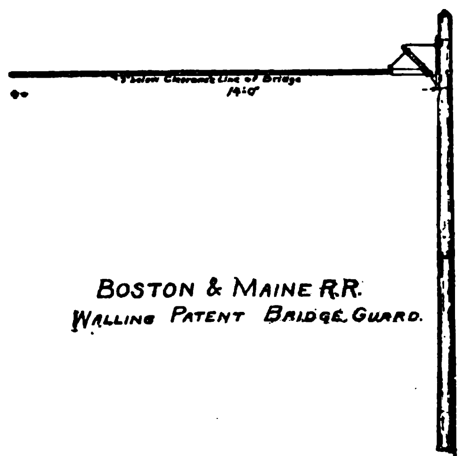


FIG. 202—WALLING BRIDGE GUARD, BOSTON AND MAINE R. R. (PLAN NO. 8.)

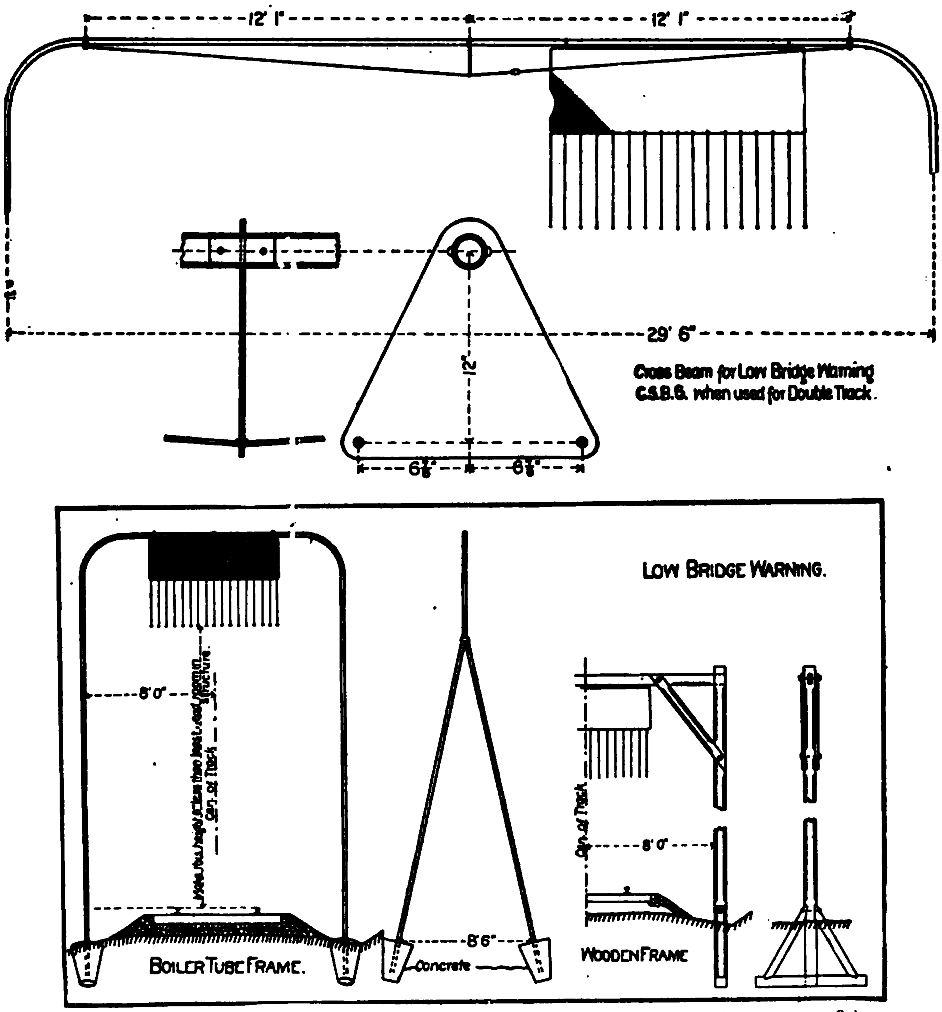


FIG. 203—LOW BRIDGE WARNING, SOUTHERN PACIFIC R. R. (PLAN NO. 9.)

N. W. Thompson states that he generally makes the ropes 2 ft. 10 in. long and the rods the same length, and then sets the post so that the ends of the rope are six inches lower than the lowest point of bridge. The ropes should not be longer than the rods or they will catch and hang on the cross-arm. These bridge alarms cost from $15 to $18, in position.

New York Central & Hudson River R. R.—Uses for several tracks the system shown on Plan No. 5, namely, ropes suspended from a wire cable stretched across the tracks between two side posts. For a single track the standard "Bridge guard" is a one-post structure, as shown on Plan No. 6. The timbers coming in contact with the ground are painted thoroughly with a preservative fluid called "Carbolineum Avenarius."

West Shore R. R.—Uses a one-post "Bridge guard" practically the same as shown on Plan No. 6, with the additional feature that on top of the cross-arm there is a board two feet high and eight feet long set up on edge, which board acts as a fender to prevent the ropes when thrown up from hanging on the cross-arm, which accomplishes the same result as the wire-netting frame used in other designs below the cross-arm, as shown, for instance, on Plan No. 9. Mr. W. B. Yereance says this bridge guard costs $10 at shop, and can probably be erected for about $2.50 to $3.

Chicago, Milwaukee & St. Paul Railway—Uses the "Nettenstrom Signal," as shown on Plan No. 7, for a double-track warning. The arrangement for a single track is similar to that shown in the plan, excepting that the heads of the side posts are connected by 2 in. x 6 in. x 18 ft. top bar with 2 in. by 6 in. knee braces. The chief feature of this design consists in the ease with which the supporting one-fourth inch wire rope can be lowered in case repairs are required. The ropes are one-half inch round duck belting, four feet long, and are spaced on a rod attached to the wire cable by three-eighths inch rubber hose with washers. Mr. Onward Bates states that this type of bridge warning has been in use on the Chicago, Milwaukee & St. Paul Railway for the past three years, and has proved much more satisfactory than the warnings used previously. The cost of a set of strips hung on the rod ready for use is about $3.25. The cost of poles, sheaves, wire rope, and the erection will of course vary according to circumstances, but the usual estimate for a single track warning erected is $20.

Boston & Maine R. R.—Has a number of different designs for "Bridge guards' in use with one-post and a wooden cross-arm from which ropes, rubber straps, wires, or steel tapes are suspended over the track. There is also a design in which light wooden slats, 1½ in. x ½ in. at top and ½ in. x ½ in. at bottom, are strung on a telegraph wire stretched across the track from the top of posts. Mr. J. P. Snow states that the design, shown on Plan No. 8, and designated by him as the "Walling bridge guard," is the one that is now generally used on the road. It is more durable than most of the others and is quite inexpensive. The warning made with flat steel tape is very cheap, and in some places gives good satisfaction, but on his road the tapes rust out in a very short time, from the blast of the engines. Wires and straps are apt to be thrown over the bar by the brakemen and hence rendered ineffective. The guard made with a light horizontal bar counterbalanced with a ball on the rear end has been used quite extensively, and works well when it is not out of order. The Walling bar is much less liable to get out of order, and is effective except in case of a very high wind.

Southern Pacific Railway—Plan No. 9 shows the wooden frame standard "Low bridge warning" and a more recent standard with boiler-tube frame, the latter being used exclusively at present on the Pacific system of the road. Mr. John D. Isaacs states that the cost of the boiler-tube frame warning for single track is $25, in place, all charges included. Also that it is best to make the wire screen with diagonal mesh, as shown on the plan, otherwise the cross-beam will sag.

Cleveland, Cincinnati, Chicago & St. Louis Railway—Uses for single track a one-post "Bridge alarm," similar, as far as the post and cross-arm are concerned, to Plan No. 4, and with ropes suspended from a wire-netting frame hung to the cross-arm, similar to Plan No. 9. The bridge alarm is to be used for all structures with less than twenty feet clearance above rail, and to be placed not more than 200 feet from the structure. The bottom of the "danglers" to be at least six inches below the lowest point of structure. Woodwork to be of white pine. Timber below ground tarred, above ground painted black. Post, 8 in. x 8 in., chamfered, and set in ground with cross-frame. Cross-arm, 13 ft. long, from 6 in. x 6 in., tapering to 3 in. x 3 in. The frame suspended from cross-arm is made of galvanized No. 12 wire netting, 1-in. mesh, 8 ft. 3 in. wide, and from 1 ft. 6 in. to 4 ft. deep, according to height of structure, the bottom of frame being set 21 ft. above rail. The danglers are made of cotton bell-cord, spaced 6 inches apart, and from 2 ft. to 4 ft. 6 in. long. The tops of cords are fastened to bottom of wire frame, and the ends are wrapped.

Cape Fear & Yadkin Valley Railway—Uses a "Bridge guard" almost the same as shown on Plan No. 4. The post is 8 in. x 8 in.; the cross-arm is 5 in. by 7 in., tapering to 5 in. x 3 in., the top is set 20 ft. above the rail, and the length of arm is 13 ft. from the post. The ropes are spaced 6 inches apart, are ½ in. in size, and 2 ft. 6 in. long. They are suspended from ¼ in. wire rods, 2 ft. 3 in. long, run through the cross-arm. Mr. H. L. Fry states that this bridge guard costs $8.

Duluth, South Shore & Atlantic Railway—Uses a "Tell-tale signal" similar to Plan No. 4. The ropes are ¼ in. in size, 6 ft. long, and the ends are 16 ft. above the rail. The ropes are hung from 3-16 in. rods, 2 ft. long, with eyes at both ends, fastened to cross-arm with staples. The side post is cedar. The cross-arm is composed of two pieces 1 in. x 12 in., tapering to 8 in., and 14 feet long, bolted to top of post, and braced with a plank brace.

Chicago & Northwestern Railway—Uses a one-post "Whip guard" very similar to the Cleveland, Cincinnati, Chicago & St. Louis Railway standard described above, and also a two-post standard. In the one-post design the post is 10 in. x 10 in., set in the ground with a suitable cross with 6 in. x 10 in. x 10 ft. sills and 4 in. x 6 in. braces. The cross-arm at top of post is 2 in. x 8 in., tapering to 4 in., with a top piece 2 in. x 6 in. laid flat. The cross-arm brace is made of two pieces 1 in. x 6 in. The wire netting frame is 9 ft. x 2 ft., made of woven No. 14 wire, 2 in. mesh, galvanized. Binding and stiffeners, No. 5 wire. The frame is spiked to cross-arm. The ropes are spaced 4 inches apart, and are 4 ft. 6 in. long. The ends of ropes are 17 ft. 6 in. above rail. The warning is located 300 feet from the structure. The cross-arm is 17 ft. 4 in. long, and the face of the post is set 12 ft. 6 in. from the center of the track. Mr. M. Riney says the warning is used for all structures with less than 22 feet clearance, and the cost of construction is for materials $7.80, for labor, $6, total cost, $13.80. The two-post standard is very similar to the one described, excepting the side posts are round cedar, the cross-arm is 6 in. round cedar, spiked to top of the side posts and braced with a 1 in. x 6 in. plank. Space between posts, 17 feet.

Union Pacific Railway—Uses a two-post "Bridge and tunnel alarm" with the ropes suspended directly from a light bar hung by two bolts to the cross-arm of frame, similar to the hanging of the tell-tale bar shown on Plan No. 1. The side posts are 8 in. x 8 in., set in the ground with a sill of two 3 in. x 6 in. by 14 ft. sticks on edge, braced with 6 in. x 6 in. sticks. Cross-arm 6 in. x 6 in. and 15 feet long in clear between posts. Knee braces two pieces 2 in. x 6 in., all bolted together with ½ in. bolts. Ropes are 3-8 in. sash cord braided and about 5 feet long, but made to come 6 inches lower than the lowest point of structure. The bar through which the ends of the ropes pass is 2½ in. x 2½ in. x 7 ft. long.

Chesapeake & Ohio Railway—Uses a "Bridge and tunnel guard post" very similar to the one shown on Plan No. 4. The ends of the ropes are set 16 feet above the rail. The face of the post is placed 6 feet from the rail. The ropes are spaced 8 inches apart and are tarred ropes, 3 feet long. They hang on ½ inch iron rods, 2 feet long, with eyes at each end. The rods hang on bolts put through the cross-arm. The cross-arm is 12 ft. 6 in. long, 5 in. x 8 in., tapering to 6 in. The knee brace is 5 in. x 6 in. The post is 10 in. x 10 in., set in the ground with 6 in. x 8 in. braces parallel with the track and a back brace square to the track consisting of two pieces, 2 in. x 8 in., bolted to the top of a dead post set in the ground.

Erie Railroad—Mr. W. B. Mitchell states that on his division the standard "Bridge tell-tale," shown on Plan No. 1, is in use for a single track warning, and that it costs about $12. For a number of tracks he has in use a design in general similar to that shown on Plans No. 5 and No. 7. He states that the cost for one pair of side posts is about $20, and that the cost of the wire and tell-tales is about 5 cents per lineal foot span across the tracks. They have a warning of this construction at Urbana, O., over three tracks, and it has not given any trouble since it was put up, about four years ago. The side posts are yellow pine, 30 feet long, 10 in. by 10 in., tapering to 8 in. x 8 in. The cross at foot is made of two pieces of oak, 3 in. x 8 in., 7 feet long, at right angles to each other. There are four foot braces, 6 in. x 6 in., oak, reaching up 4 feet and out 3 feet. The face of post is set 8 feet from the nearest rail. The tracks are spanned by a ½-inch wire cable, one end being fastened through the head of one side post and the other end attached to a small windlass near the ground on the second side post, the cable running over a small sheave at the top of the second side post. The windlass is enclosed in a box with the lid screwed down so that it cannot be tampered with. When repairs are necessary, the cable is let down very easily and speedily. There are twelve tell-tales over each track, spaced by pieces of gas pipe 5 inches long, and each set held on the cable by clamps at each end. The tell-tales are made of bell-cord, 2 ft. 6 in. long, fastened to an eye on the lower end of a 2 ft. piece of telegraph wire. The upper end of the wire is fixed tight in the rim of a small pressed iron washer that is strung on the supporting cable. Mr. Mitchell says that the cords when thrown up violently simply revolve around the cable and fall down again in their proper place and do not get hung on the cable. In spacing them with the gas pipe pieces, mentioned above, some play should be given, and the side clamps not pressed up too tight.

New Orleans & N. E. R. R., A. and V. Railway, and V. S. and P. R. R.—Mr. T. Kelleher states that the standard "bridge warnings" in use on his railroad system cost about $25, complete in position. For single track there are two standards, one with a single post and horizontal arm for earth foundation, and the other with two posts for rock foundation. In both cases there is a wire screen, 2 ft. 8 in. x 8 ft., hung by three ½ in. hook bolts to the top cross-arm. The rim of the screen is ½ in. in diameter and the body No. 10 wire, with 1 in. square mesh. There are 17 ropes, ½ in. in diameter, 3 ft. 8 in. long, hung from the bottom of the screen. Ropes are spaced 6 inches apart, and are double-braided cotton, well knotted to screen, and ends bound. The face of the side post is set 8 feet from the center of the track on tangents and 9 feet on curves. The ends of the ropes are placed 17 ft. 10 in. above base of rail. In the single-post standard, the cross-arm is 3 in. x 8 in., braced to post by two pieces 3 in. x 6 in., and bolted with ⅝ in. bolts. The post is 8 in. x 8 in. and set 5 feet in the ground, with 3 in. x 10 in. and 3 in. x 6 in. sills and cross pieces to prevent pulling out. In the two-post standard the sizes of timber are the same, excepting at the foot of the posts, where the construction is made to suit the different conditions encountered.

REPORT: STOCK-YARDS AND STOCK-SHEDS, INCLUDING ALL DETAILS OF CONSTRUCTION.

One of the largest and most important industries of the West is the stock business. When the stock is ready for the market it is necessary for the railroad companies to have good facilities for the prompt handling of the shipments. In building stock yards the style, to a large extent, is governed by the location and right of way owned by the railway companies. Stock yards should be located on high ground, slightly sloping, so pens can be drained. If high ground is not available, the location selected should be graded up for that purpose. The size of stock yards depends on the amount of stock in the vicinity for shipment, and the number of shippers.

Railway companies should have standard plans of stock yards, with details of construction for one or more pens, so that in case additional pens are required, they can be added at any time, without making any alterations in the pens already built.

(Note.—There may be a few instances where you cannot always adopt the standard stock-yard plan; as a general thing it can be done.)

On account of the sharp competition for stock shipments between the railway companies, the shippers are sometimes allowed permission to use the stock yards for a week or more, until they can secure enough for shipment, or for a better market. This practice is expensive to railway companies, as they are compelled in some cases to erect stock sheds for the protection of stock from storms and heat.

In cases of this kind railway companies, in order to keep the yards in proper condition on account of the cattle and hogs being held in the yards, are compelled to fill the holes in the yard with dirt, gravel, or broken stone, and in some instances, plank or pave one or more pens so as to make the yard passable.

At some stations stock yards are not considered complete without loading and unloading chutes, with gang-plank or double-deck chute for loading double-deck cars, and also stock scales for weighing.

All stock yards should have water and water-troughs in one or more pens, especially where hogs are handled; also a portable hog chute for unloading hogs from wagons.

PLANS NO. 1 AND 2. FIGS. 204, 205.

Chicago, Milwaukee & St. Paul Railway Company's standard plans for stock yard and shed.

No. 1 shows plan of yard, chute, fence, platform, and water-trough; also cross-section of shed and feed-rack.

No. 2 shows plan of details of yard, staple, gate-hook, gate-bar, gate-hanger, chute-gates with extension slide, rear alley gates, and sectional view of fence.

PLANS NO. 3, 4, AND 5. FIGS. 206 TO 210.

Toledo, Peoria & Western Railway Company's standard plan for stock yards and stock shed.

No. 3 shows plan of details of stock-shed, showing cross-section and elevation plan, stock yard gate, stock yard gate hinges, gate lugs and gate stops. Cost of stock shed 90 cents per lineal foot.

No. 4 shows plan of four-pen stock yard, showing section of fence and chute used at large shipping stations. Cost of labor $100, material $100, total $200.

No. 5 shows plan of two-pen stock yard, 36x72 feet, with chute and platform. Used at small stations. Cost of labor $56, material $52, total $108.

PLANS NO. 6, 7, 8, 9, AND 10. FIGS. 211 TO 215.

Standard plans of stock yards of St. Joseph & Grand Island Railway Co.

No. 6 shows details of stock-yard hardware.

No. 7 shows large gates and fence, small gates, panel of portable fence, in connection with portable chute and hay-rack.

No. 8 shows portable chute, chute with swing gate and platform.

No. 9 shows No. 1 yard, one pen 75x64 feet, with alley and chute; No. 2 yard, 75x148, with two pens and alley, chute and platform, also chute with sliding gates.

No. 10 shows No. 3 stock yard, 200x225 feet; nine pens, two alleys, two chutes, with platform and stock scale.

PLANS NO. 11, 12, 13, 14, 15, 16, 17, 18, 19, AND 20. FIGS. 216 TO 225.

Chicago, Rock Island & Pacific Railway Company's standard stock-yard and stock-shed plans.

No. 11, plan of stock shed, showing rear view, end view, front view, and cross-section, with feed-rack, and bill of material for 16 feet shed.

No. 12 shows four-pen yard, 104 ft. x 104 ft., with alley, chute, and loading platform, with stock shed located to face south. This style of yard is used east of Missouri river at large shipping stations.

Plan No. 13 shows stock shed to be used at very large feeding stations, 40x48 feet, 11 feet high, with four-ply gravel roof; showing ground plan, half side elevation, half longitudinal section, half end view and half cross-section, with hay-rack, feed-box, and water-troughs.

No. 14 shows details of front elevation of platform and chute, bridge, 4-foot chute gate, adjustable gate and platform, and side elevation of chute.

No. 15 shows details of yard, fence, and gate, 10-foot gate, gate-hinges, gate-stop, gate-hook, and eye-bolts.

No. 16 shows standard plan of yard No. 1, one pen 47x51½ feet, with alley, chute and platform. Cost of labor $39.25, material $90.75, total $130.

Yard No. 2, 47½x107 feet, shows two pens, with alley, chute, and platform. Cost of labor $49.75, material $115.25, total cost $165.

No. 17 shows plan of yard No. 3, 105x111 feet, three pens, with two alleys, chute, and platform. Cost of labor $64, material $140, total cost $204.

No. 18 shows No. 4 yard, 105x166½ feet, five pens, two loading chutes, one single and one double deck, two alleys and platform, with stock scale located for weighing both stock and grain.

No. 19 shows yard No. 5, 105x166½ feet, seven pens, one double-deck and one single-deck chute, and one unloading chute, two alleys, one scale located for weighing both stock and grain.

No. 20 shows plan of a branding chute.

(Note.—The Chicago, Rock Island and Pacific Railway Company use the standard plans of yard, 1, 2, 3, 4, and 5, west of Missouri river, wherever the company has right of way enough to build the vards. Otherwise, yards are built to suit the grounds that are available.)

PLAN NO. 21. FIG. 226.

Standard plan of stock yards of Wabash Railway, 72x101 feet, four pens, showing detail of section through chute, front elevation of chute, also alley and chute with platform. Cost of labor $65, material $81, total $146.

PLAN NO. 22. FIG. 227.

Standard plan of Pennsylvania Company's Northwestern System, showing detail of stock shed, side elevation, end elevation, and gate for stock pens; size of shed 26 2-3 x 48 feet. Cost of labor $20.70, material $33.11, total $53.81. No charge for supports, as sheds are built on yard posts.

GEO. J. BISHOP, C., R. I. & P. R. R.,
W. R. CANNON, C., R. I. & P. R. R.,
O. H. ANDREWS, St. J. & G. I. R. R.,
JAMES BRADY, C., R. I. & P. R., R.
Committee.

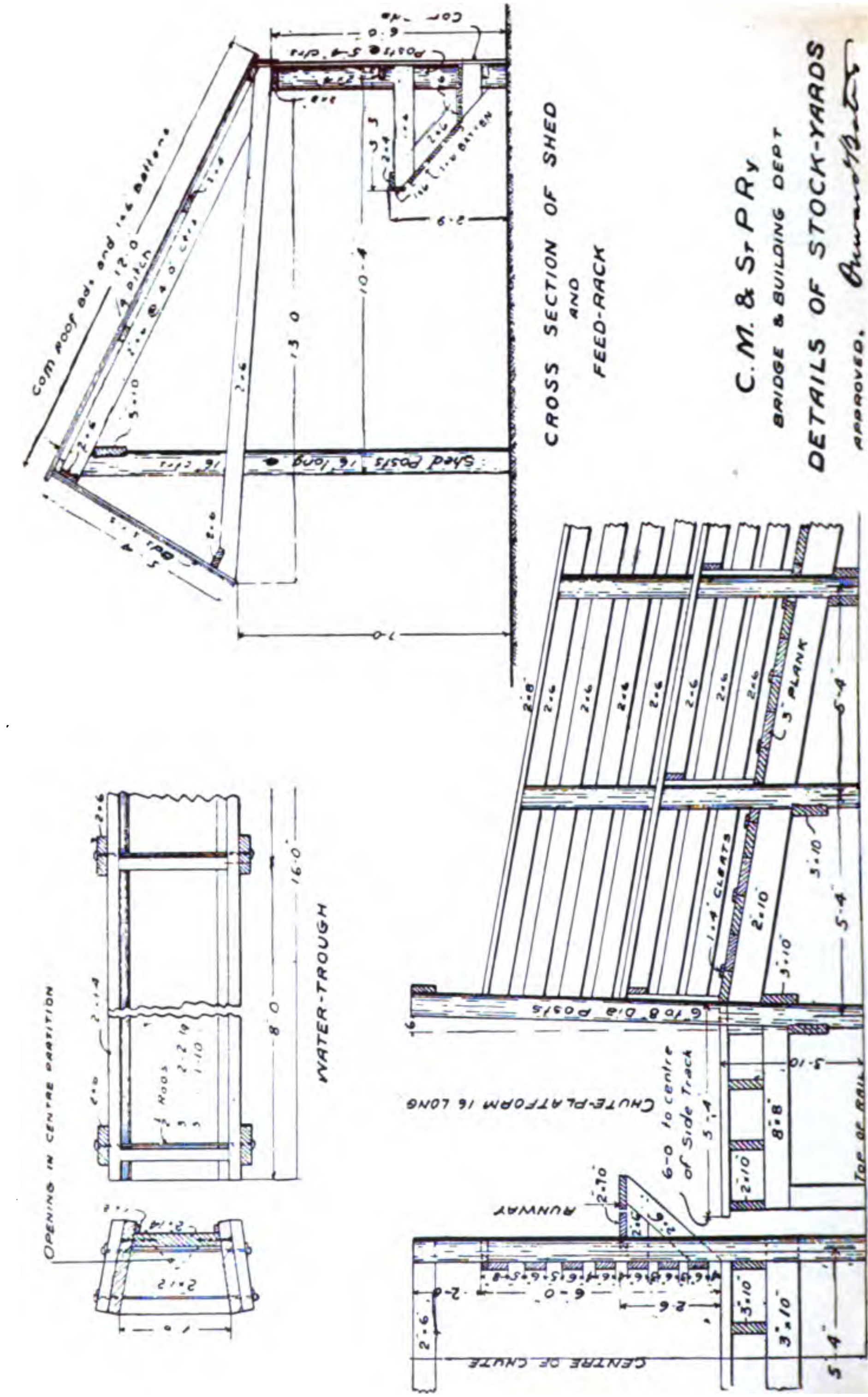


FIG. 204.—STOCK YARDS, CHICAGO, MILWAUKEE AND ST. PAUL R. R. (PLAN NO. 1.) REPORT ON STOCK YARDS AND STOCK SHEDS.

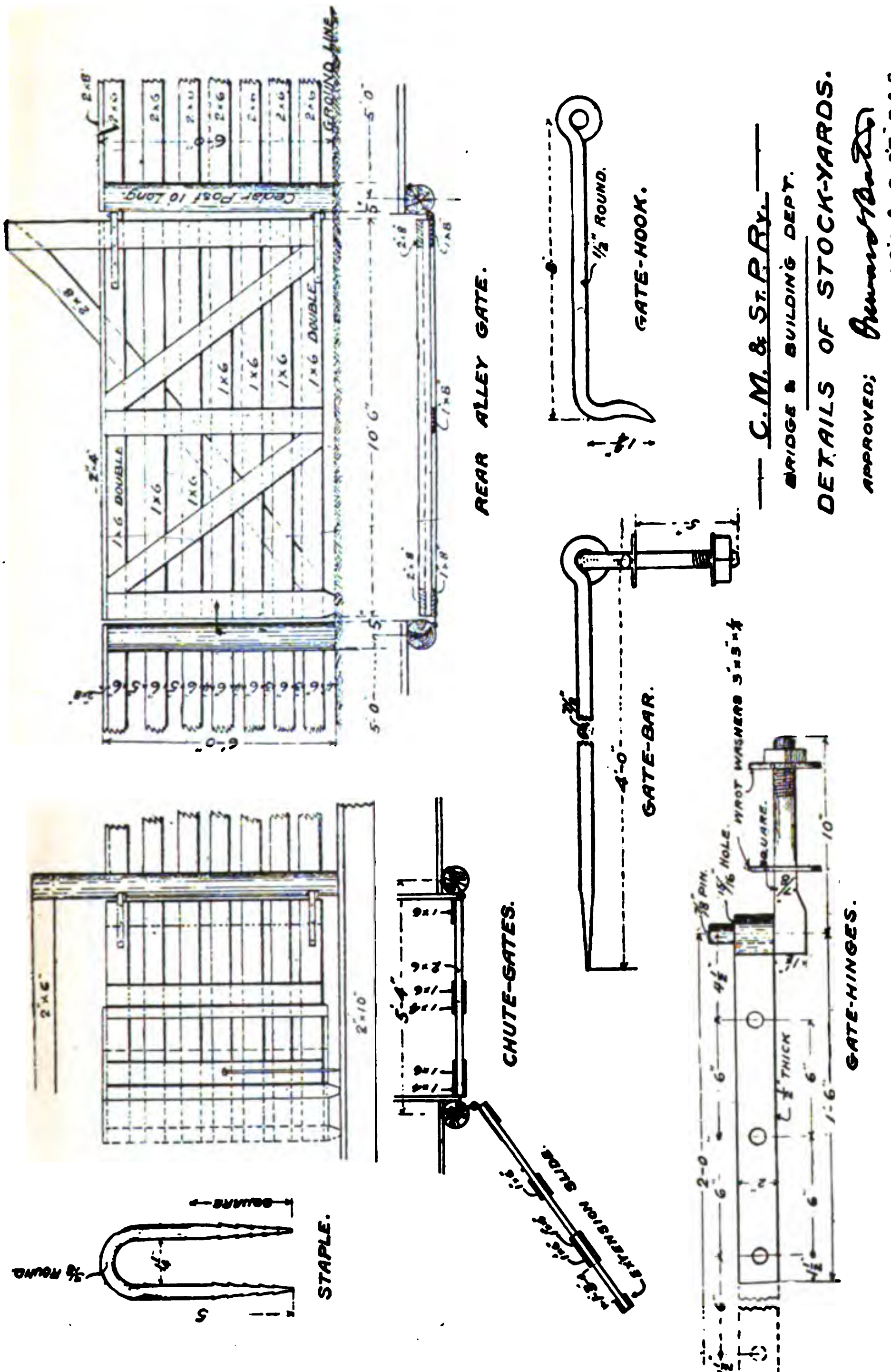


FIG. 205—STOCK YARDS, CHICAGO, MILWAUKEE AND ST. PAUL R. R. (PLAN NO. 2.) REPORT ON STOCK YARDS AND STOCK SHEDS.

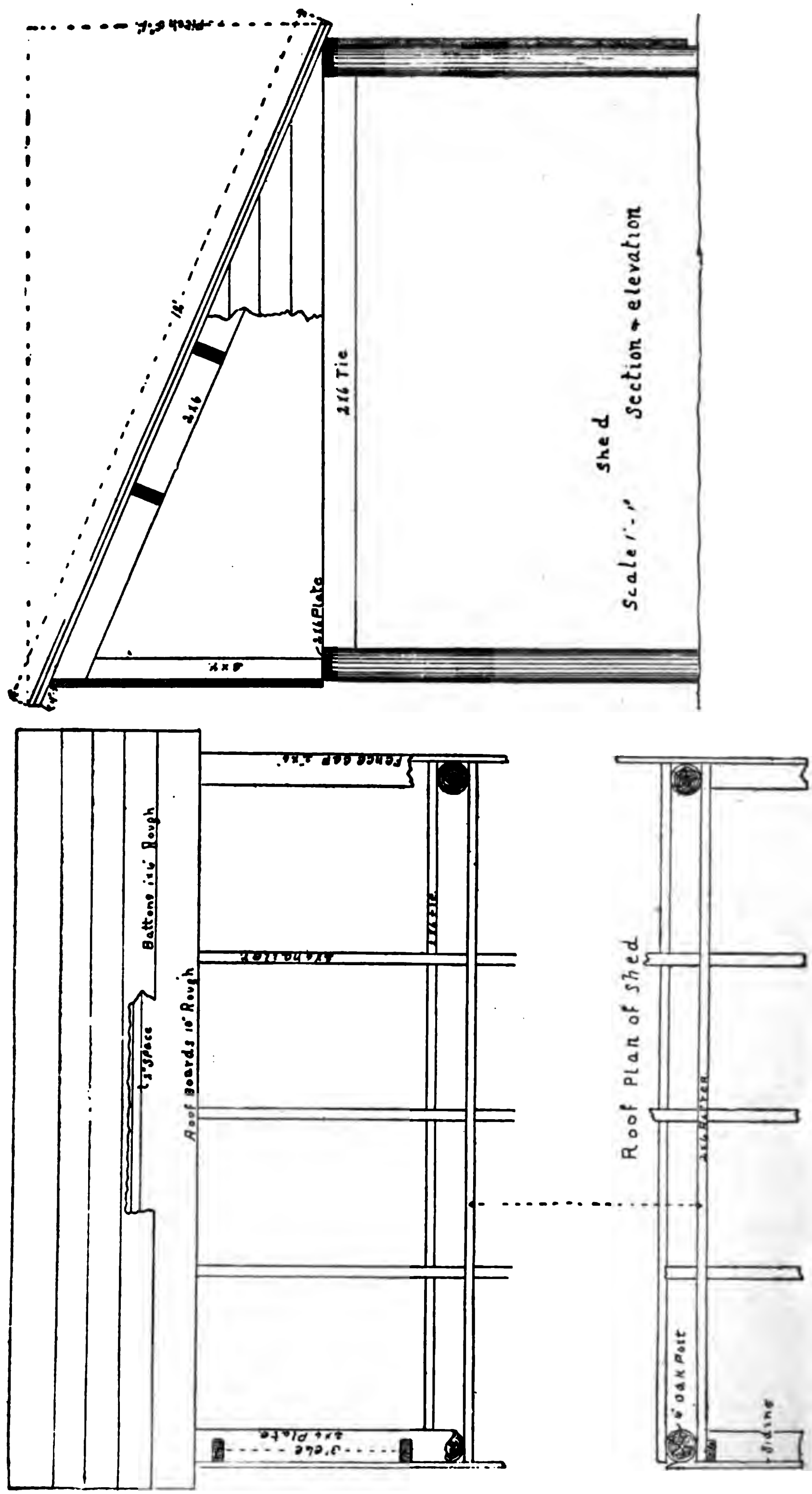


FIG. 206—STOCK SHED, TOLEDO, PEORIA AND WESTERN R. R. (PLAN NO. 8.) REPORT ON STOCK YARDS AND STOCK SHEDS.

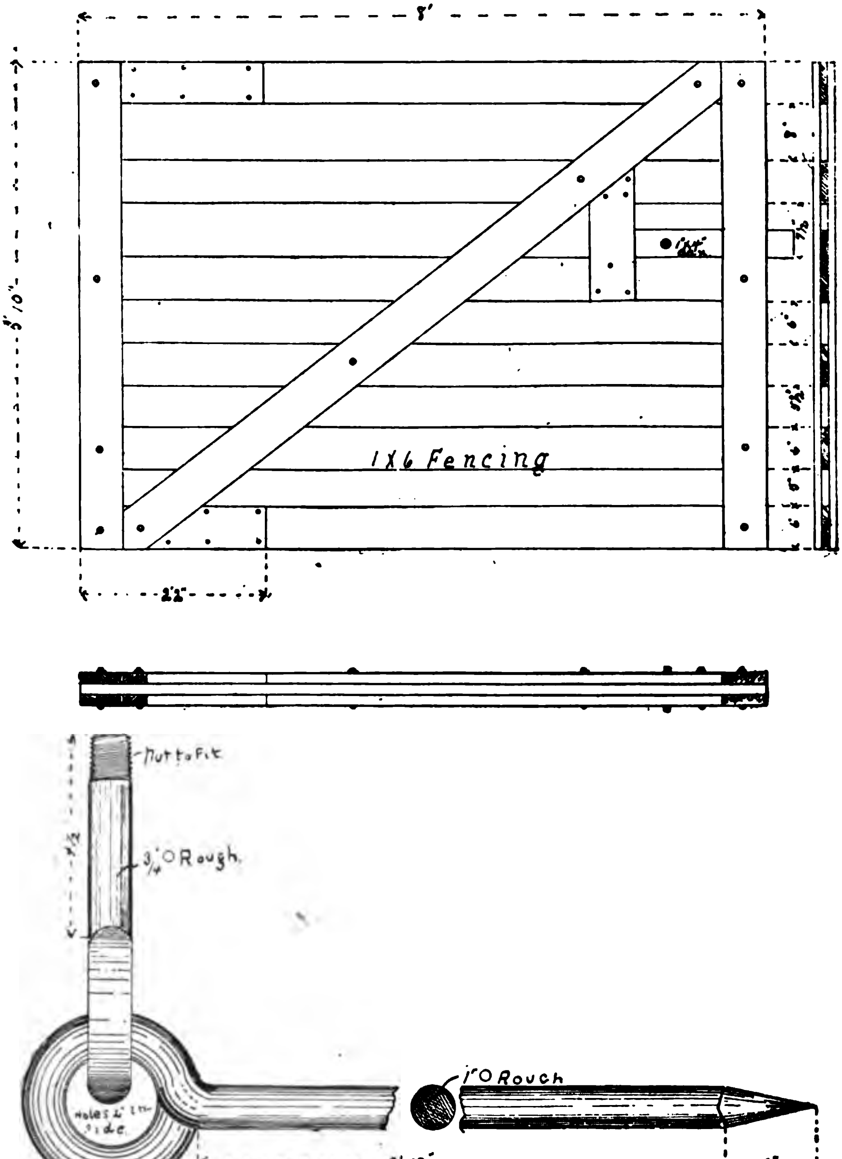


FIG. 207—STOCK YARD GATE AND PROP, TOLEDO, PEORIA AND WESTERN R .R. (PLAN NO. 3—CONTINUED.) REPORT ON STOCK YARDS AND STOCK SHEDS.

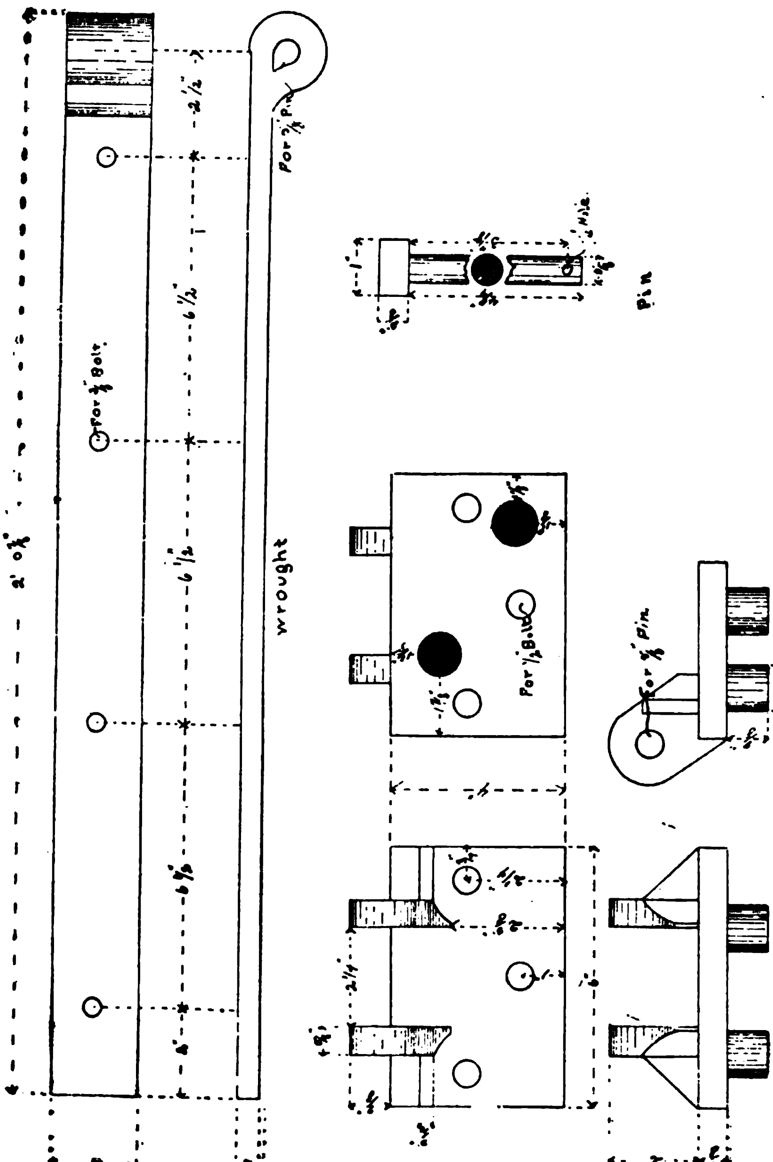


FIG. 308—DETAILS OF IRONS FOR STOCK YARD GATE, TOLEDO, PEORIA AND WESTERN R. R. (PLAN NO. 8—CONTINUED.) REPORT ON STOCK YARDS AND STOCK SHEDS.

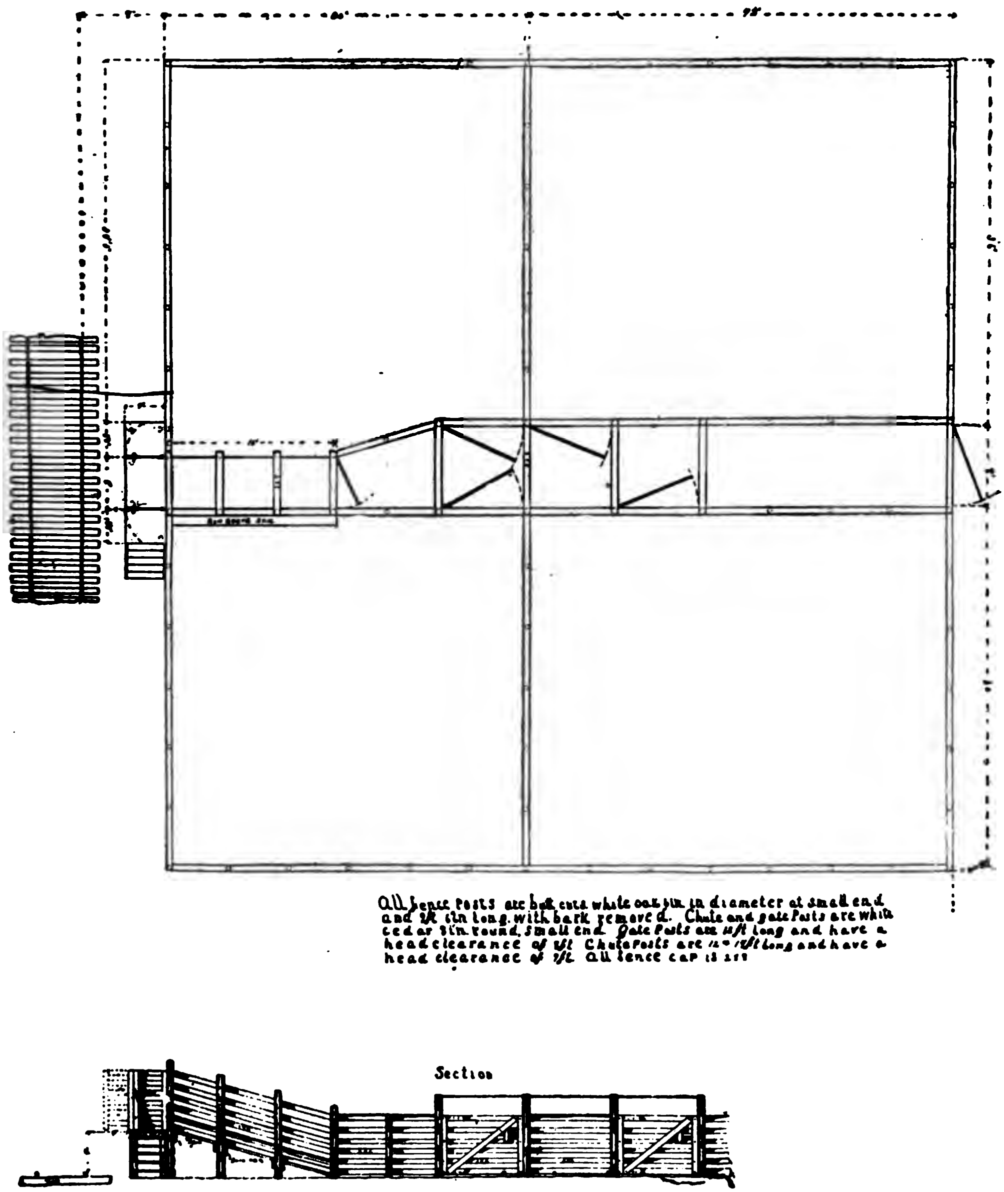


FIG. 209—FOUR-PEN STOCK YARD, TOLEDO, PEORIA AND WESTERN R. R. (PLAN NO. 4.) REPORT ON STOCK YARDS AND STOCK SHEDS.

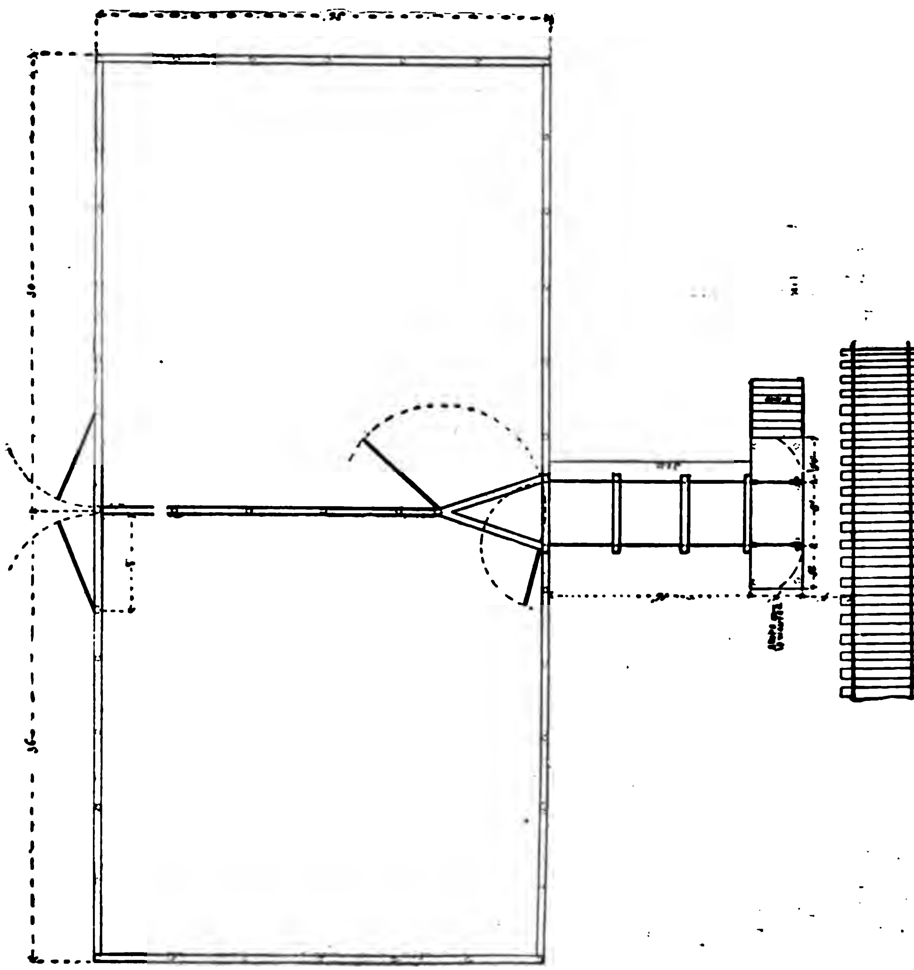


FIG. 210—TWO-PEN STOCK YARD, TOLEDO, PEORIA AND WESTERN R. R. (PLAN NO. 5.)
REPORT ON STOCK YARDS AND STOCK SHEDS.

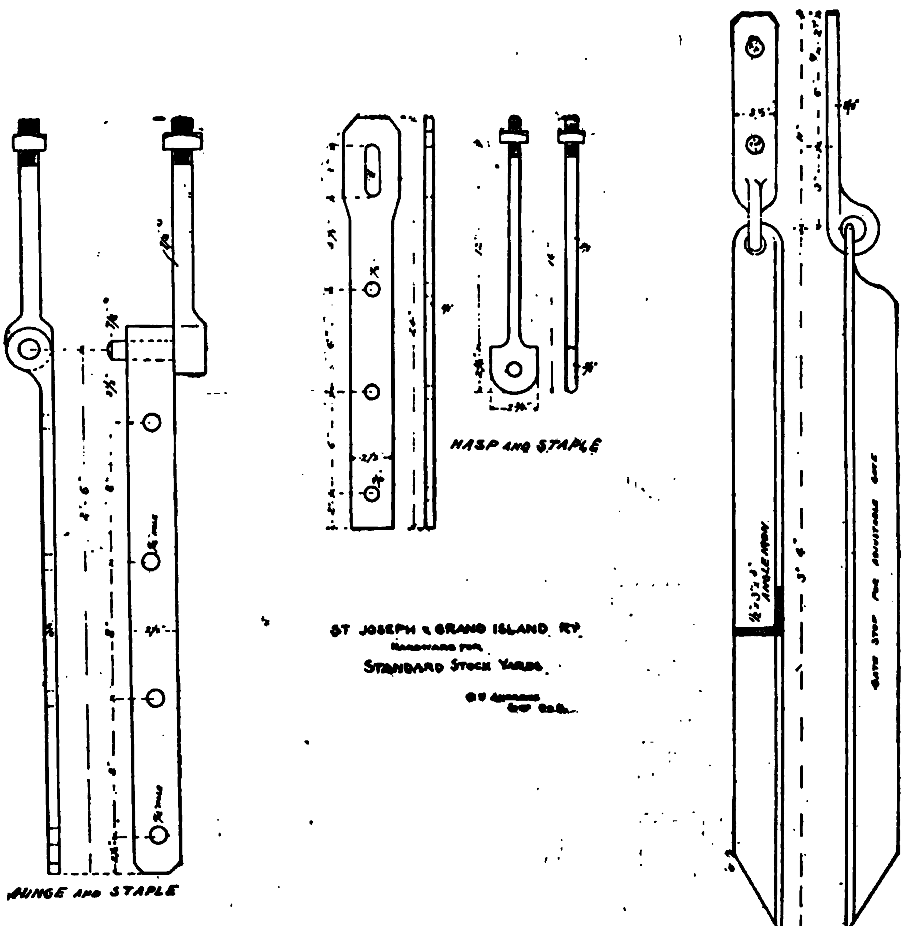


FIG. 211—STOCK YARD, DETAILS OF HARDWARE, ST. JOSEPH AND GRAND ISLAND R. R. (PLAN NO. 6.) REPORT ON STOCK YARDS AND STOCK SHEDS.

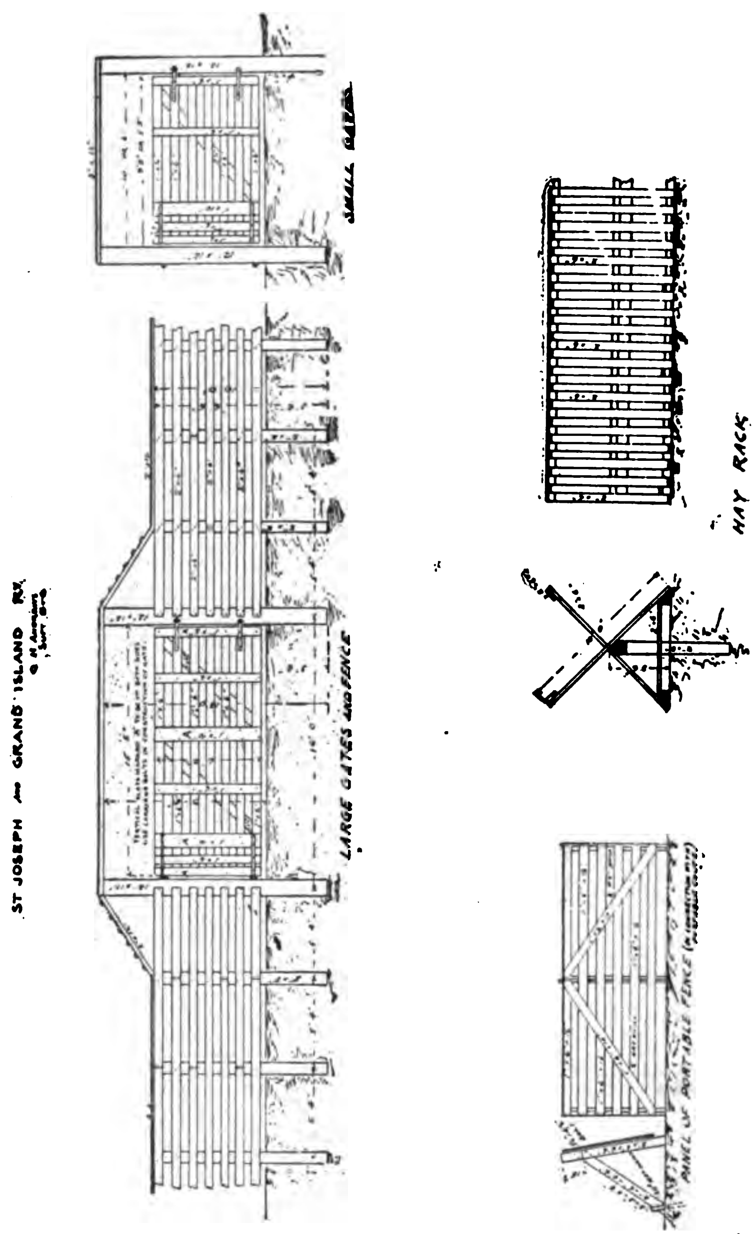


FIG. 212—STOCK YARD DETAILS, ST. JOSEPH AND GRAND ISLAND R. R. (PLAN NO. 7.) REPORT ON STOCK YARDS AND STOCK SHEDS.

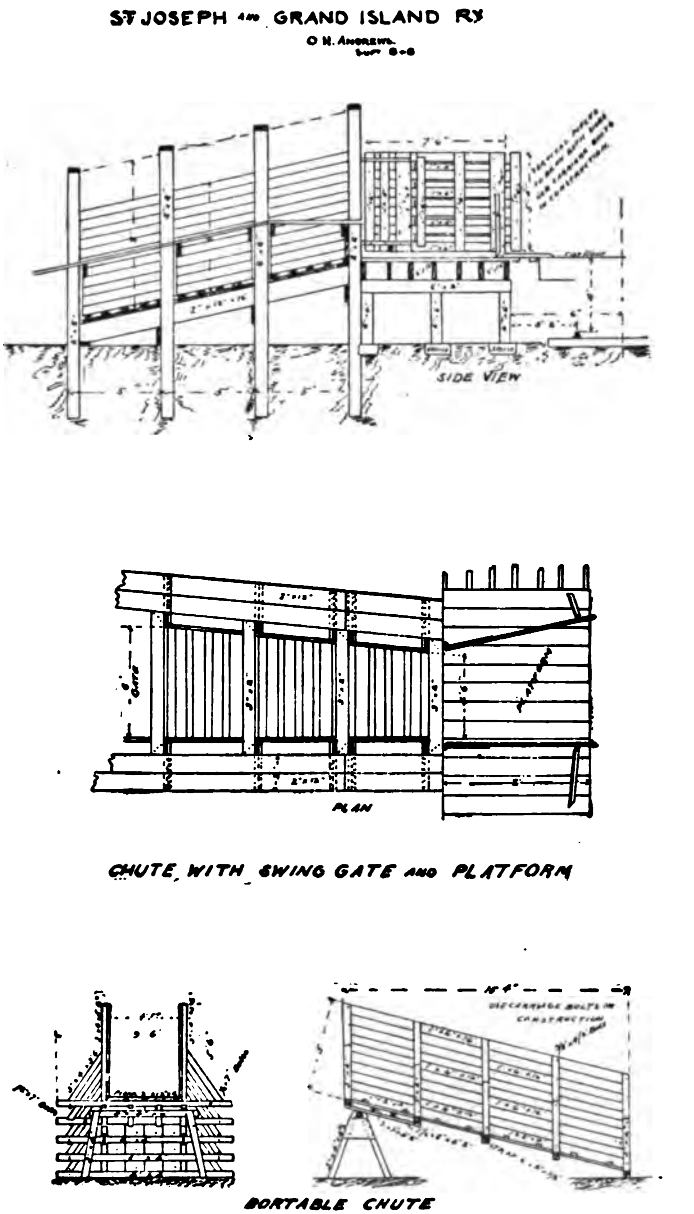


FIG. 213—STOCK YARD DETAILS, ST. JOSEPH AND GRAND ISLAND R. R. (PLAN NO. 8.) REPORT ON STOCK YARDS AND STOCK SHEDS.

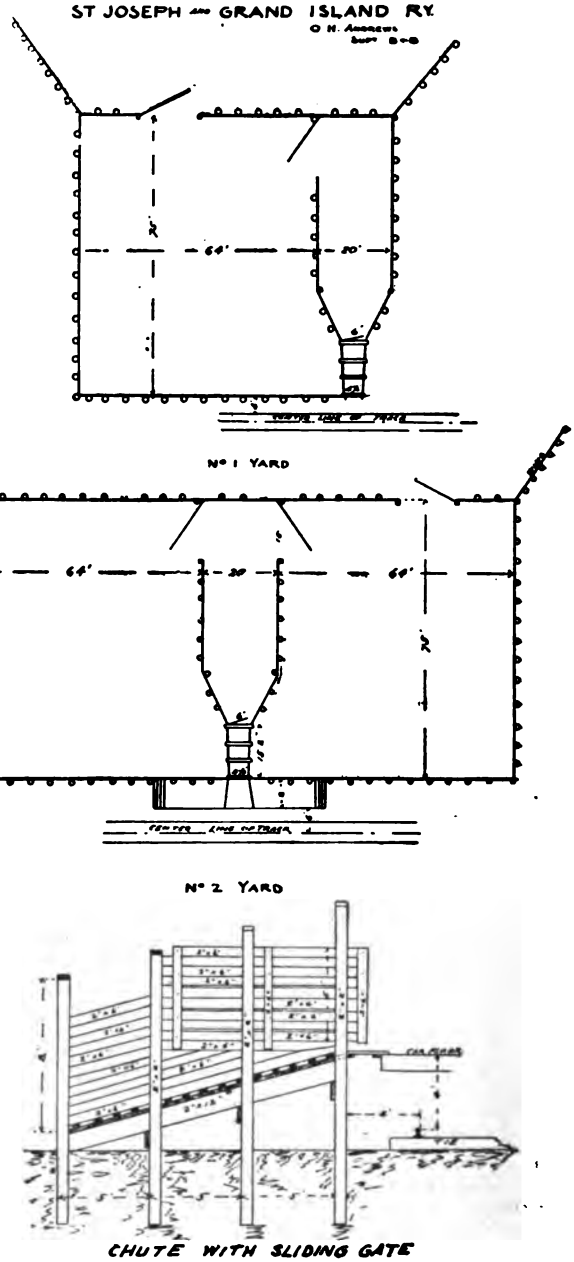


FIG. 214—STOCK YARDS NO. 1 AND NO. 2, ST. JOSEPH AND GRAND ISLAND R. R. (PLAN NO. 9.) REPORT ON STOCK YARDS AND STOCK SHEDS.

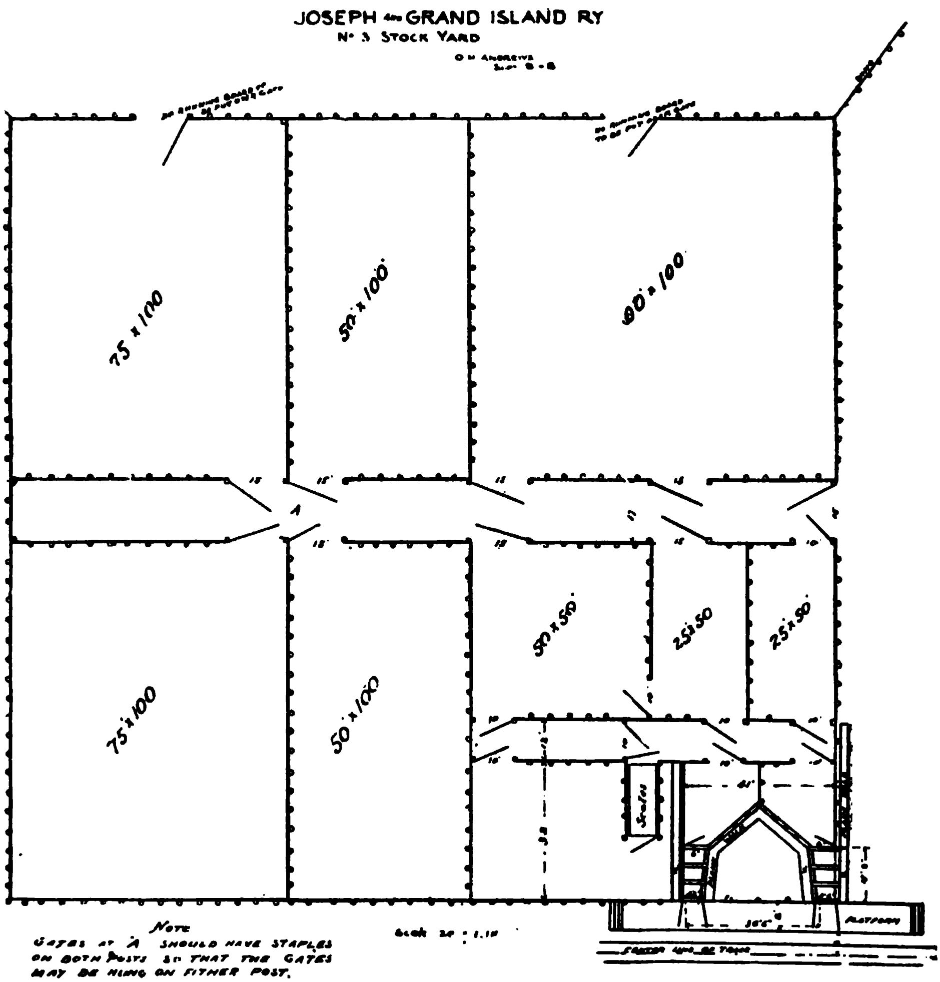


FIG. 215—STOCK YARD NO. 3, ST. JOSEPH AND GRAND ISLAND R. R. (PLAN NO. 10.) REPORT ON STOCK YARDS AND STOCK SHEDS.

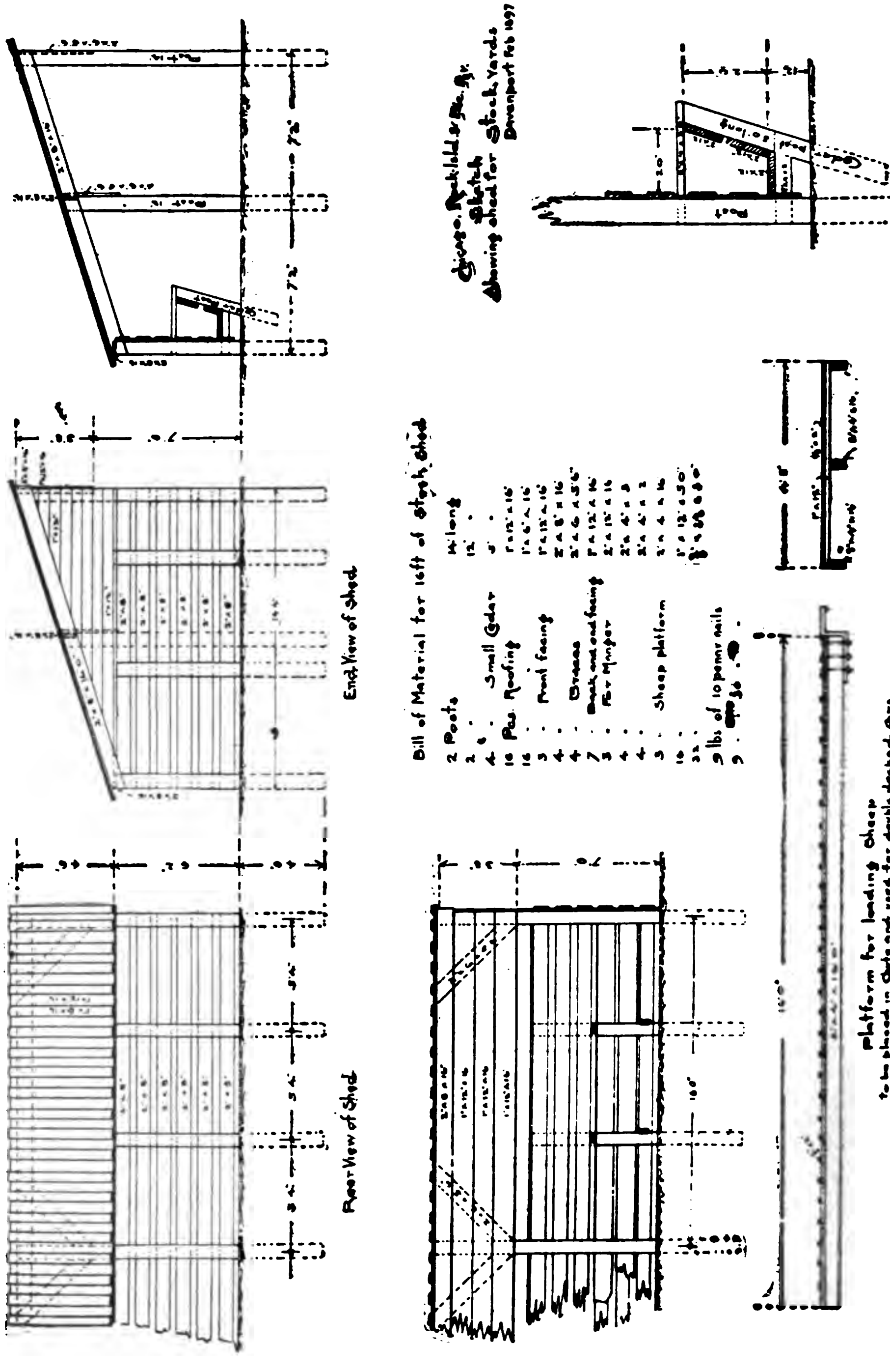


FIG. 216.—STOCK SHED, CHICAGO, ROCK ISLAND AND PACIFIC R. R. (PLAN NO. 11.) REPORT ON STOCK YARDS AND STOCK SHEDS.

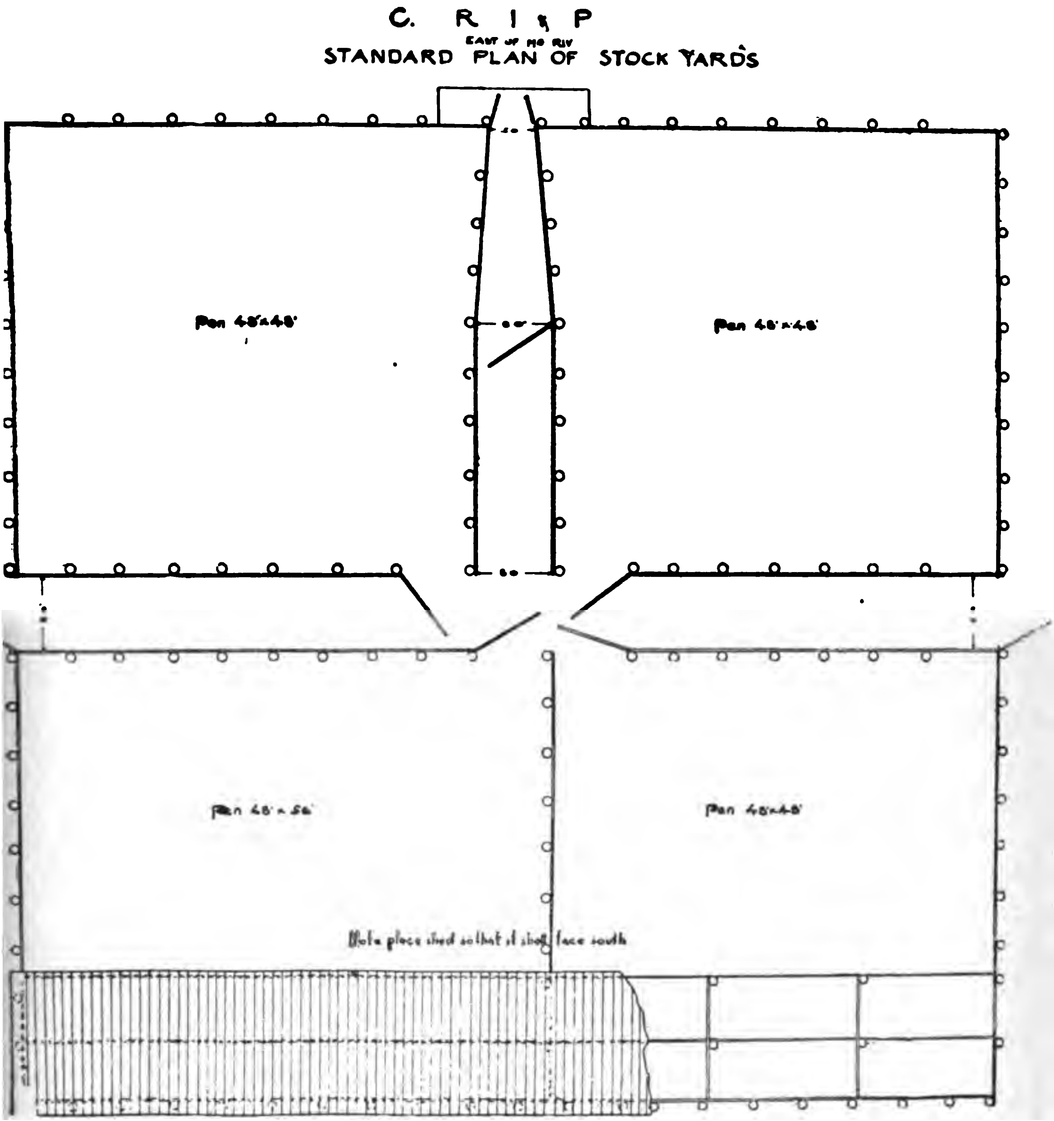


FIG. 217—FOUR-PEN STOCK YARD, CHICAGO, ROCK ISLAND AND PACIFIC R. R. (PLAN NO. 12.) REPORT ON STOCK YARDS AND STOCK SHEDS.

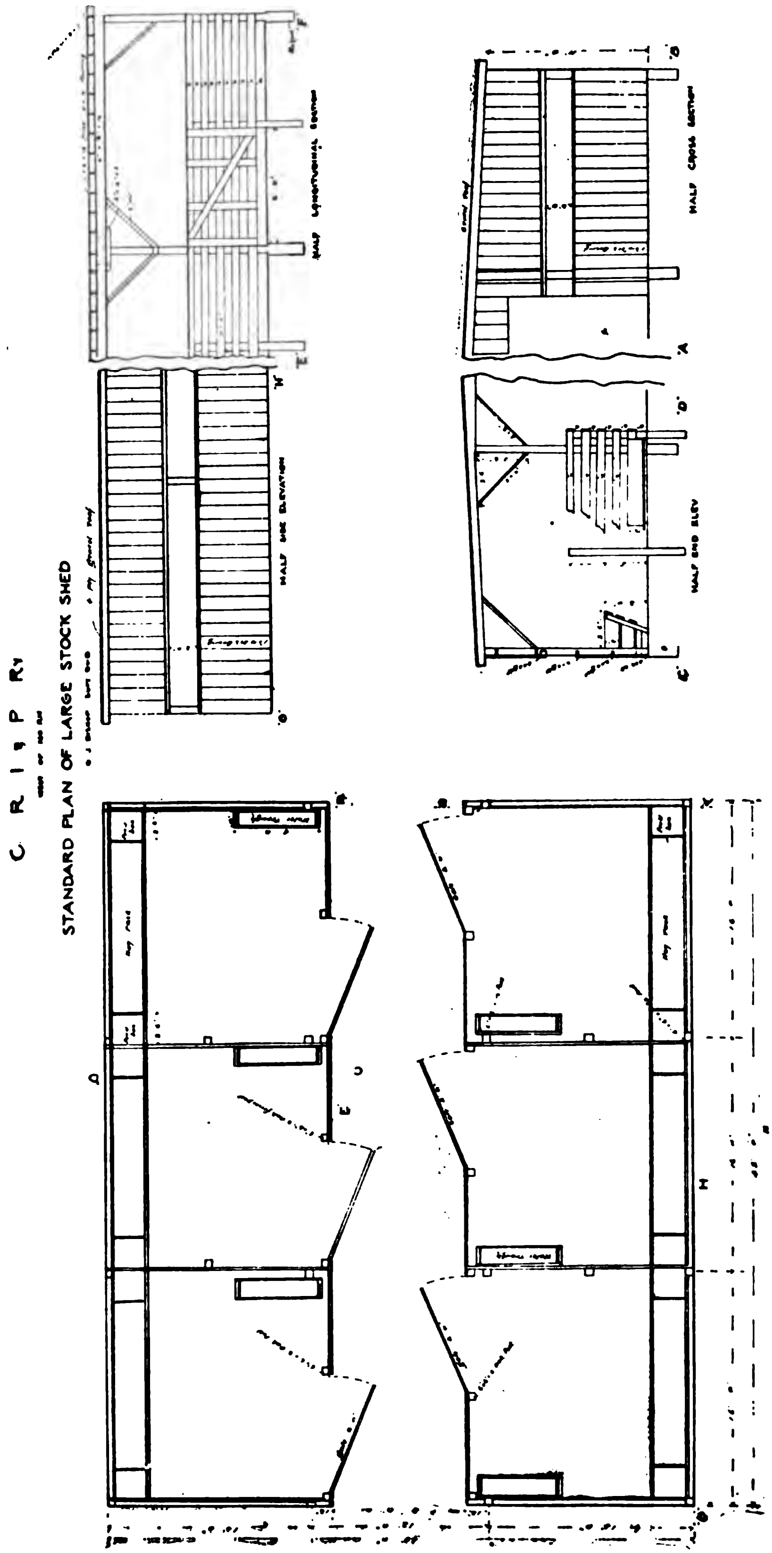


FIG. 218—LARGE STOCK SHED, CHICAGO, ROCK ISLAND AND PACIFIC R. R. (PLAN NO. 18) REPORT ON STOCK YARDS AND STOCK SHEDS.

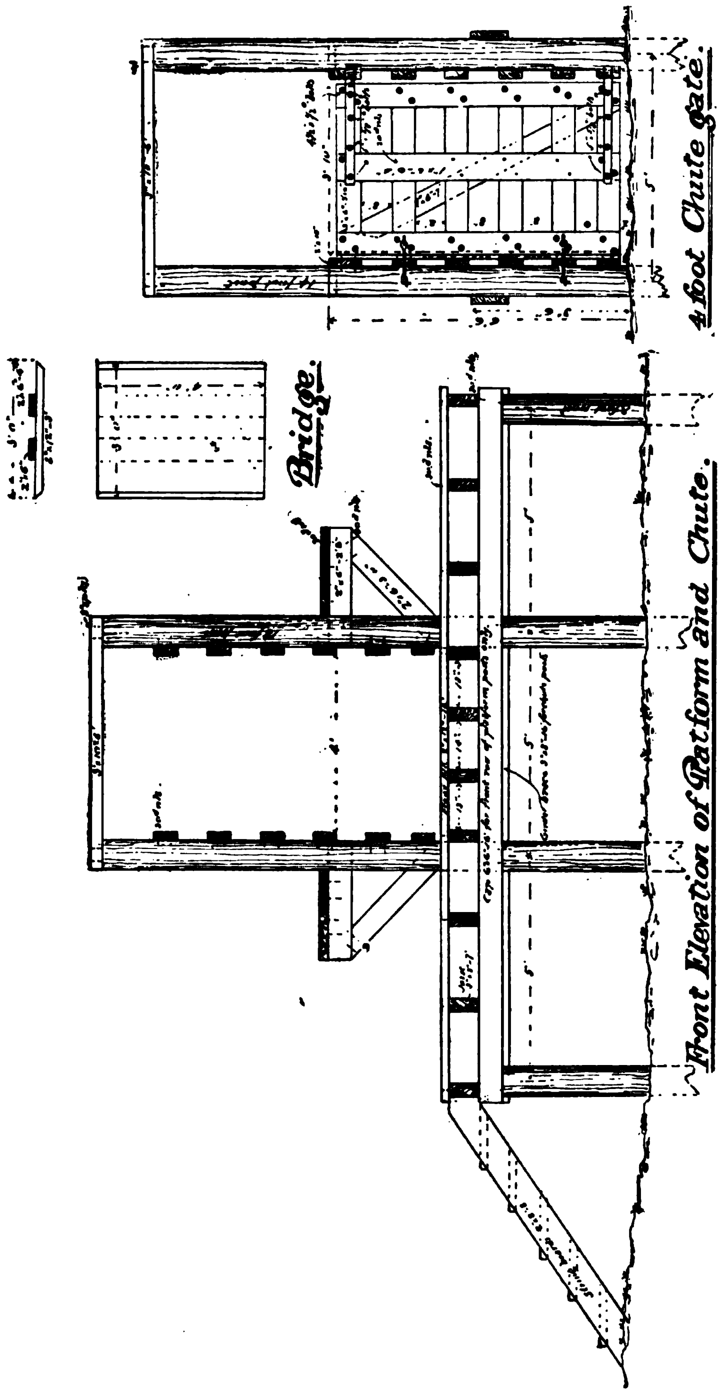


FIG. 219—STOCK YARD DETAILS, CHICAGO, ROCK ISLAND AND PACIFIC R. R. (PLAN NO. 14.) REPORT ON STOCK YARDS AND STOCK SHEDS.

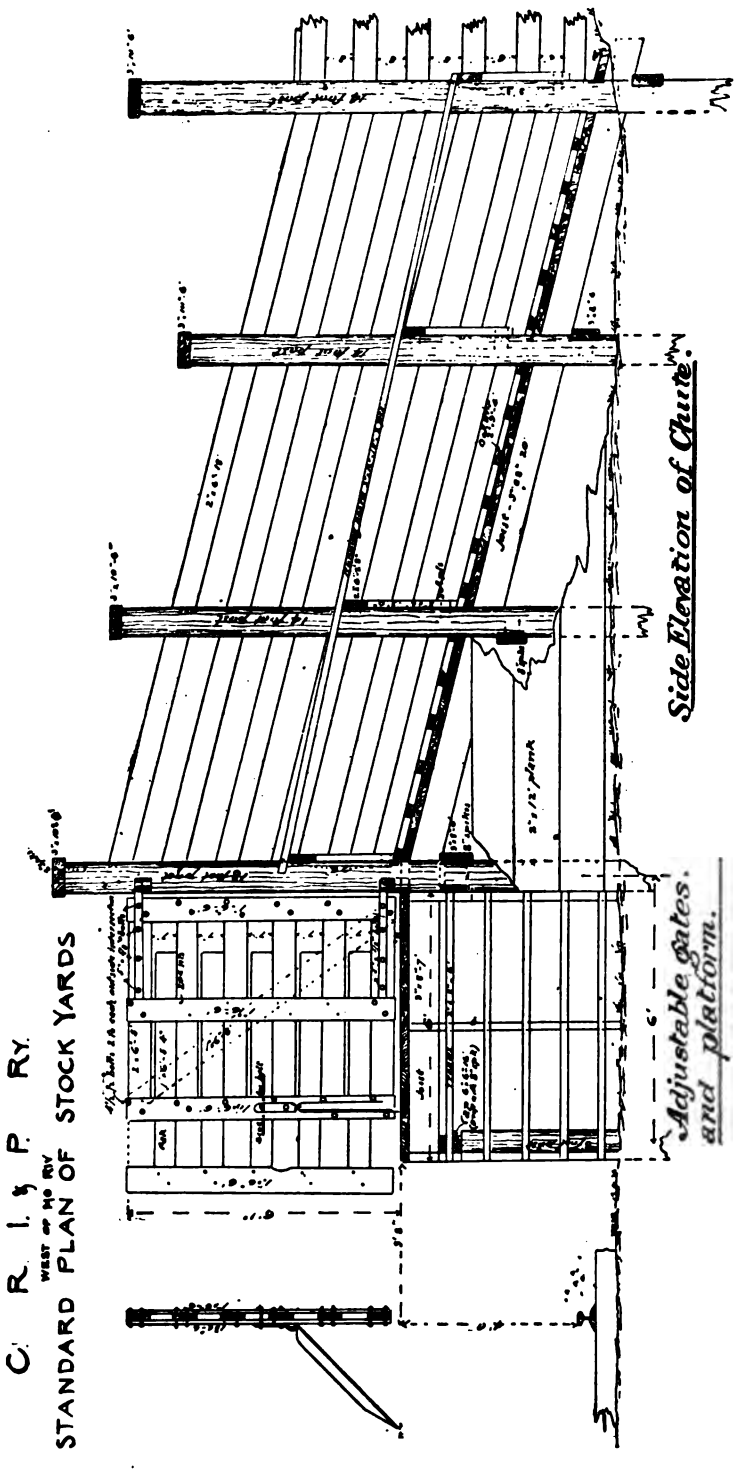


FIG. 219—STOCK YARD DETAILS, CHICAGO, ROCK ISLAND AND PACIFIC R. R. (PLAN NO. 14—CONTINUED.) REPORT ON STOCK YARDS AND STOCK SHEDS.

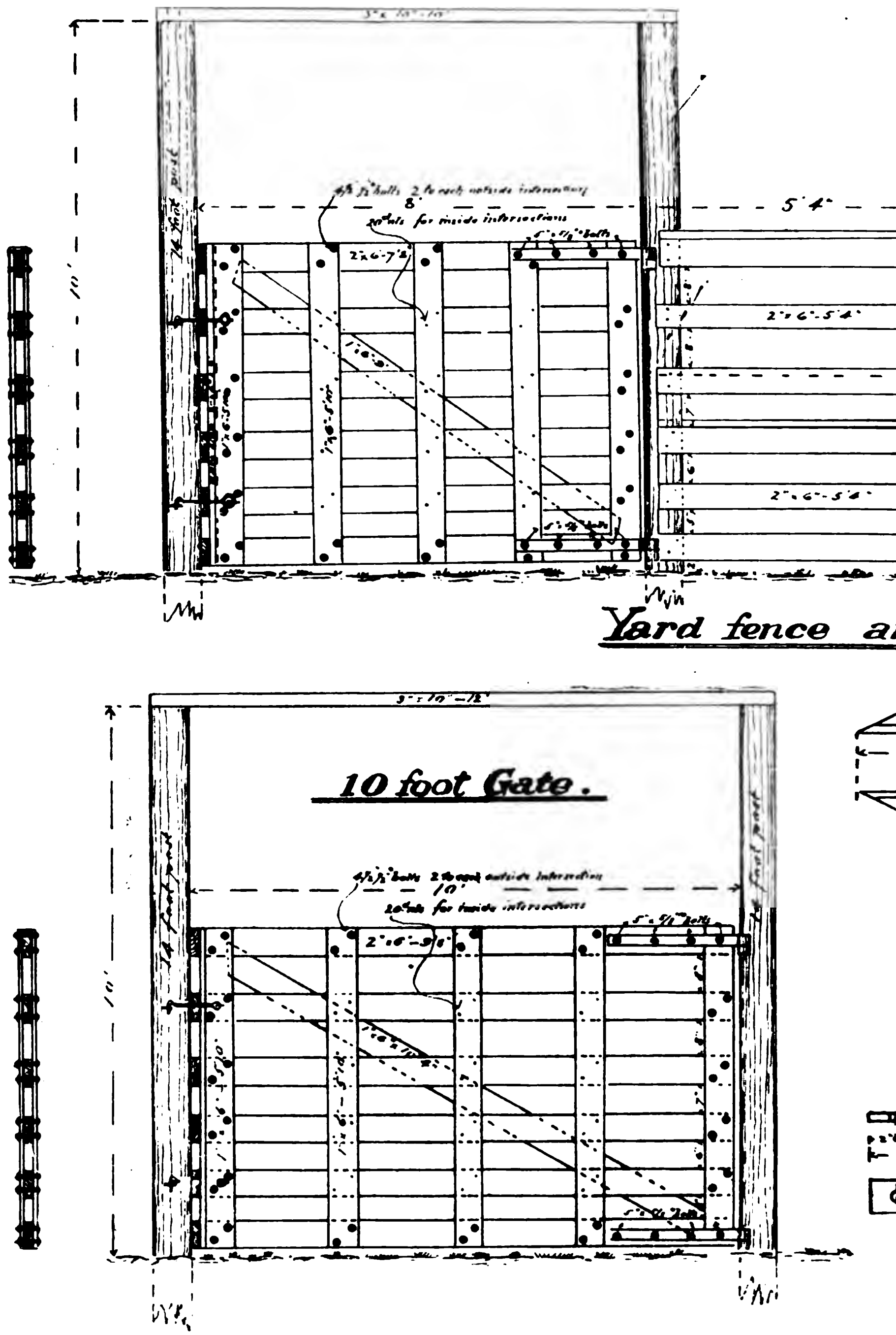
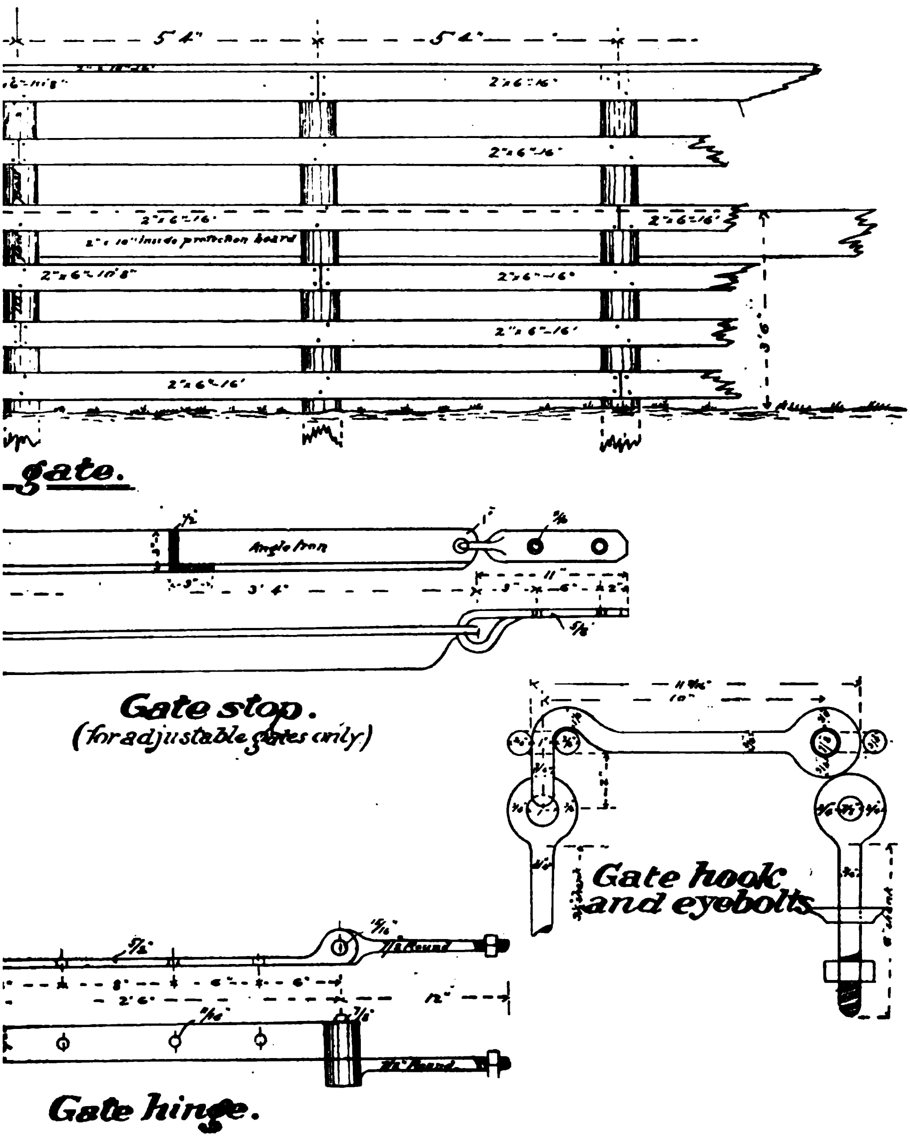


FIG. 220—STOCK YARD FENCE AND GATE, CHICAGO, ROCK ISLAND AND


5' 4"
5' 4"
2"x6"-16'
2"x6"-16'
2"x6"-16'
2"x10" Inside protection board
2"x6"-10' 8"
2"x6"-16'
2"x6"-16'
2"x6"-16'
gate.
Angle Iron
3' 4"
11"
Gate stop.
(for adjustable gates only)
10"
Gate hook and eyebolts
2' 6"
12"
Gate hinge.

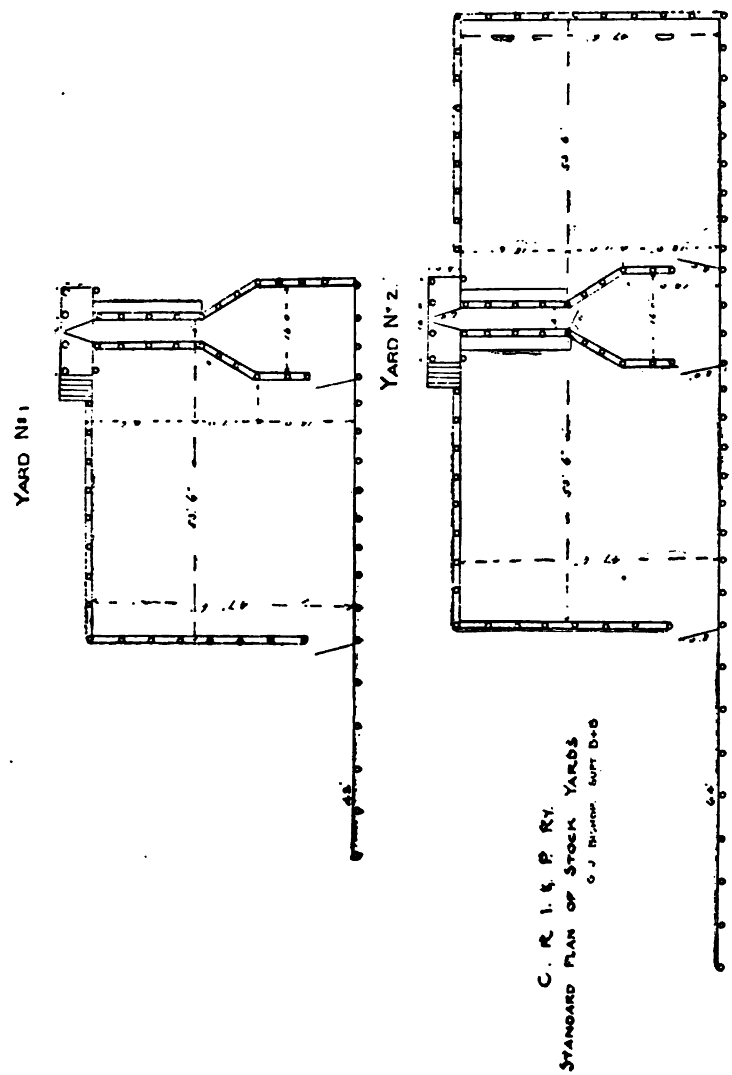


FIG. 221—STOCK YARD NO. 1 AND NO. 2, CHICAGO, ROCK ISLAND AND PACIFIC R. R. (PLAN NO. 16.)
REPORT ON STOCK YARDS AND STOCK SHEDS.

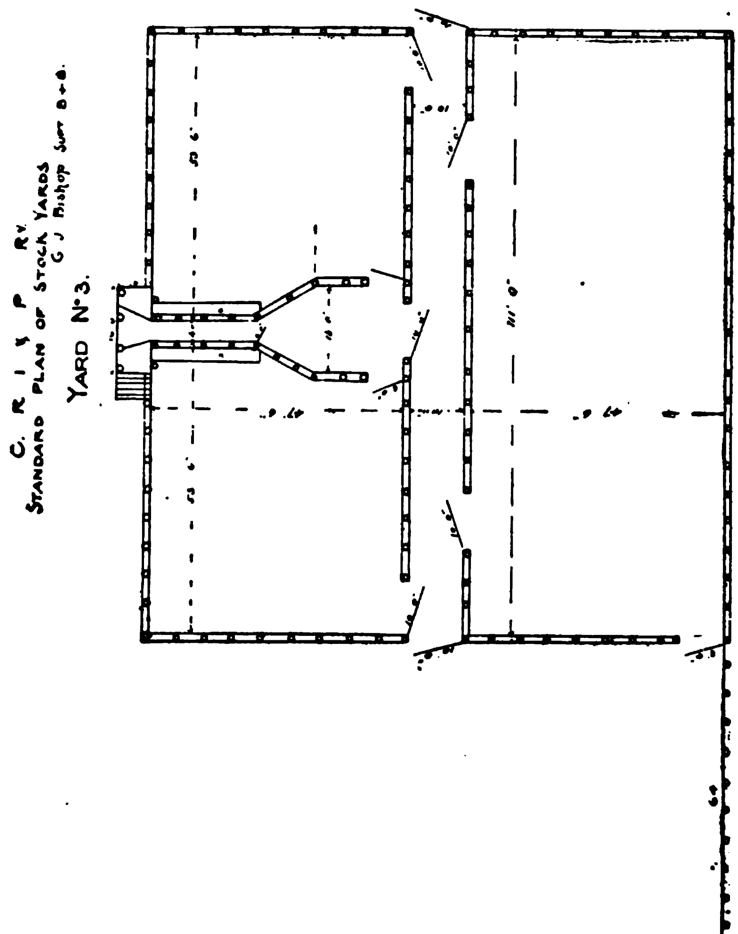


FIG. 222—STOCK YARD NO. 3, CHICAGO, ROCK ISLAND AND PACIFIC R. R. (PLAN NO. 17.)
REPORT ON STOCK YARDS AND STOCK SHEDS.

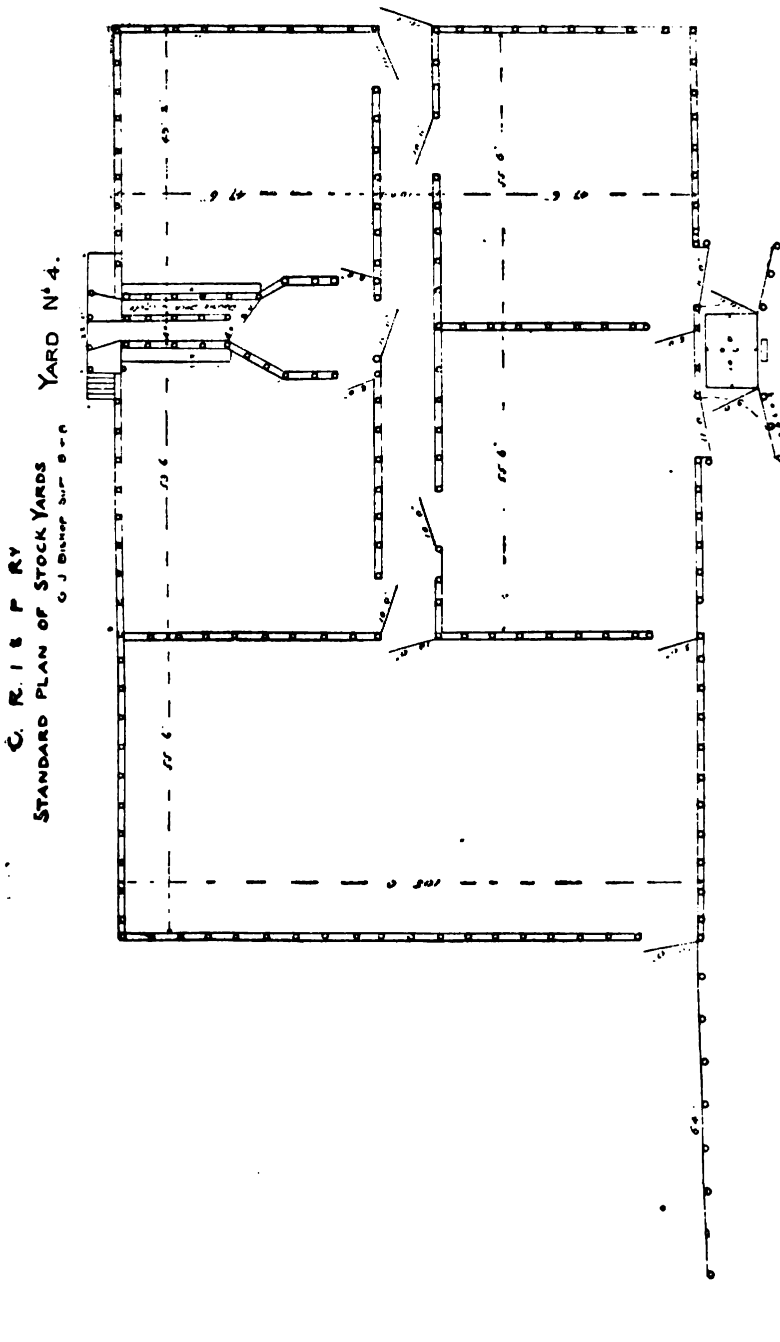


FIG. 223—STOCK YARD NO. 4, CHICAGO, ROCK ISLAND AND PACIFIC R. R. (PLAN NO. 18.) REPORT ON STOCK YARDS AND STOCK SHEDS.

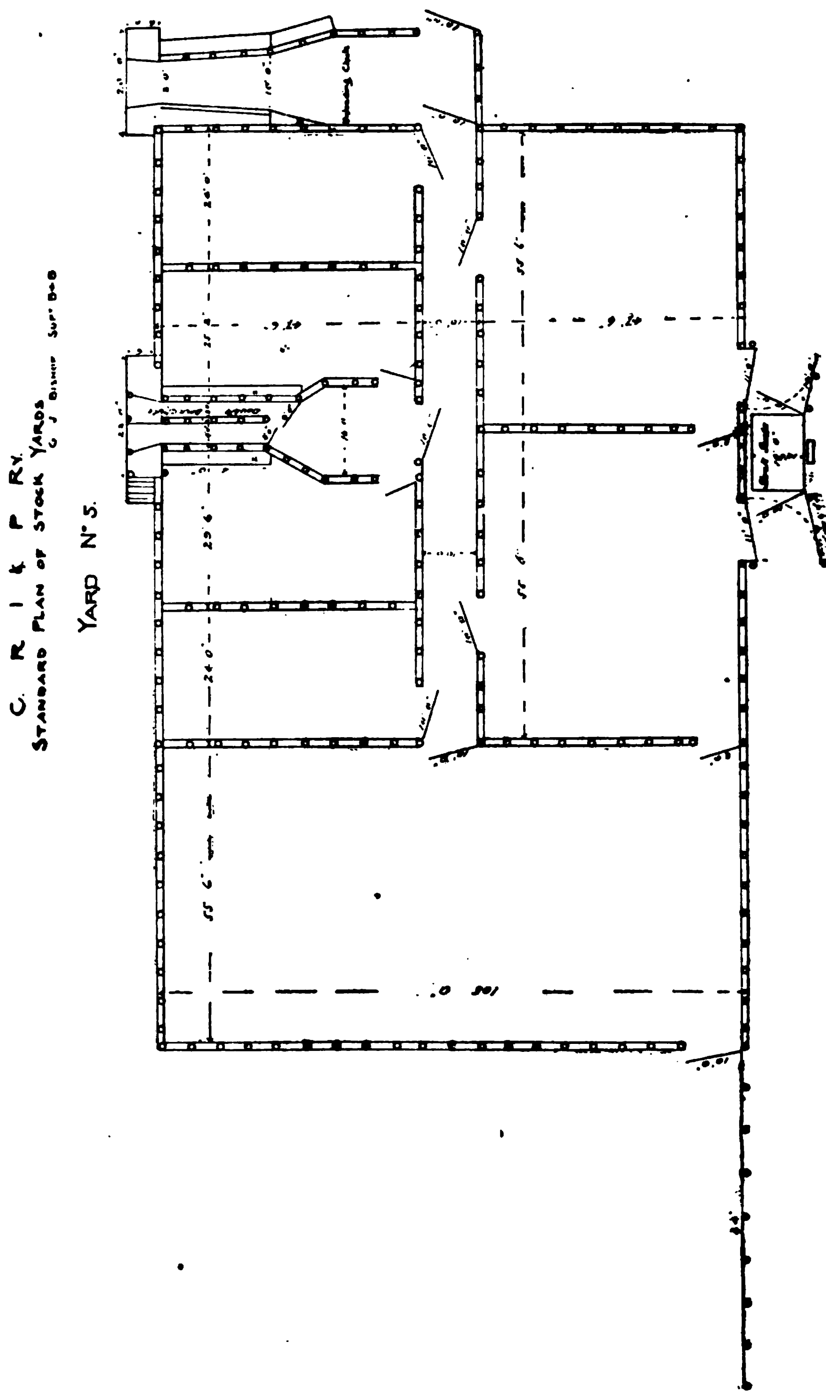


FIG. 224.—STOCK YARD NO. 5, CHICAGO, ROCK ISLAND AND PACIFIC R. R. (PLAN NO. 19.) REPORT ON STOCK YARDS AND STOCK SHEDS.

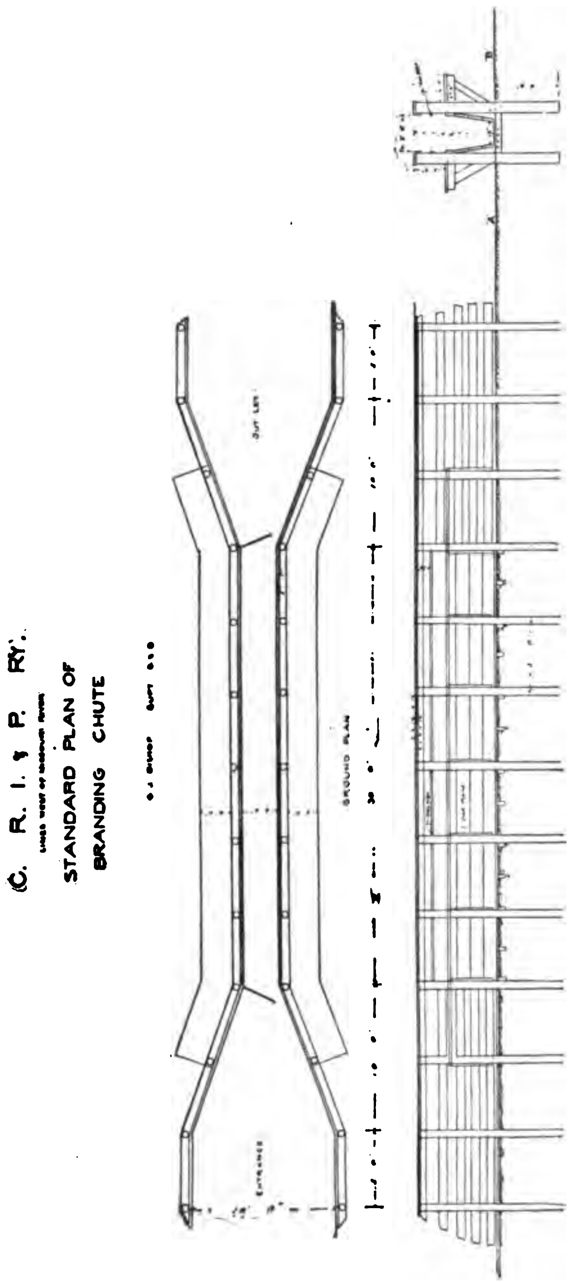


FIG. 225—BRANDING CHUTE, CHICAGO, ROCK ISLAND AND PACIFIC R. R. (PLAN NO. 20.) REPORT ON STOCK YARDS AND STOCK SHEDS.

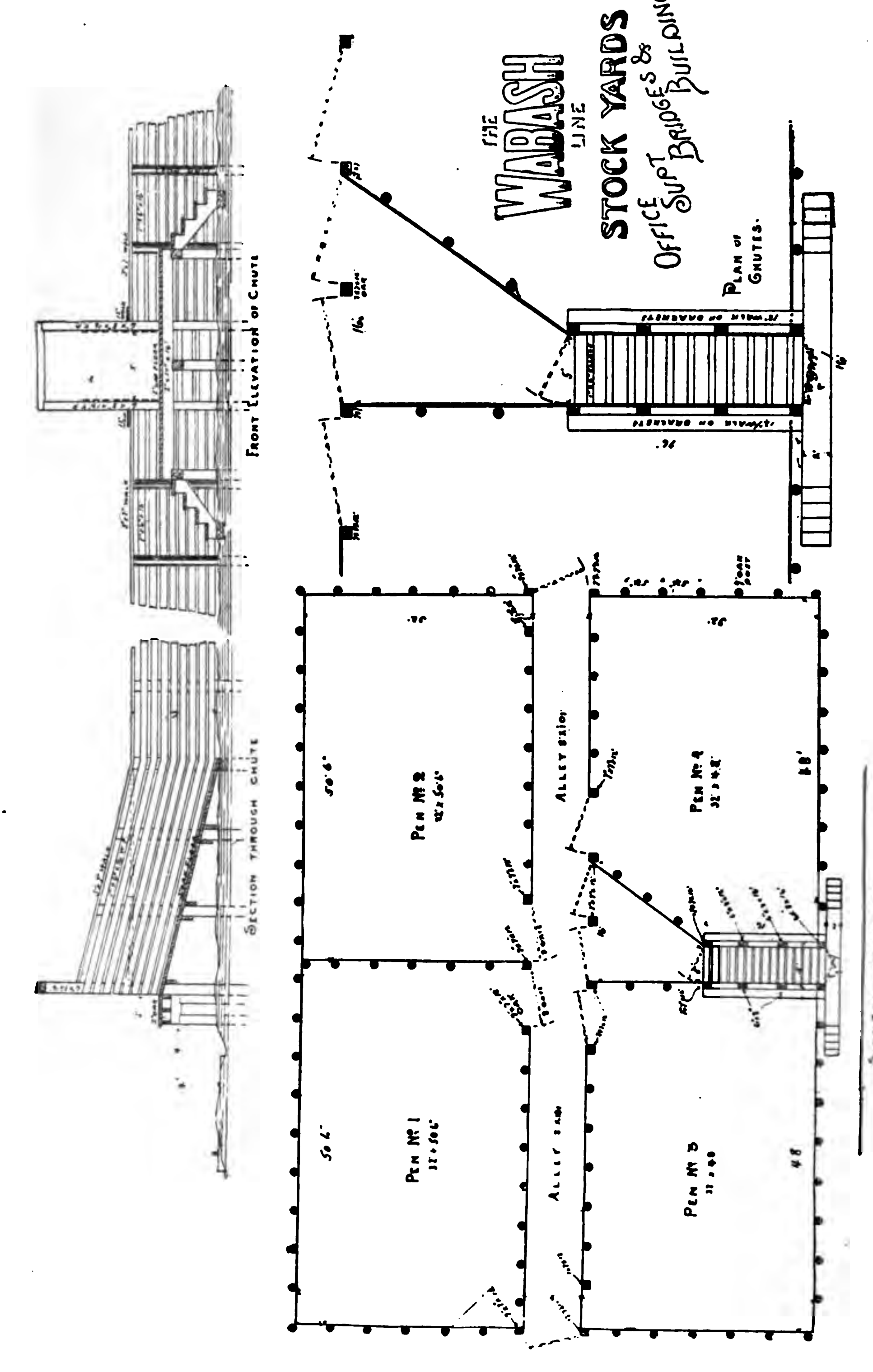


FIG. 330.—STOCK YARDS, WABASH R. R. (PLAN NO. 21.) REPORT ON STOCK YARDS AND STOCK SHERS.

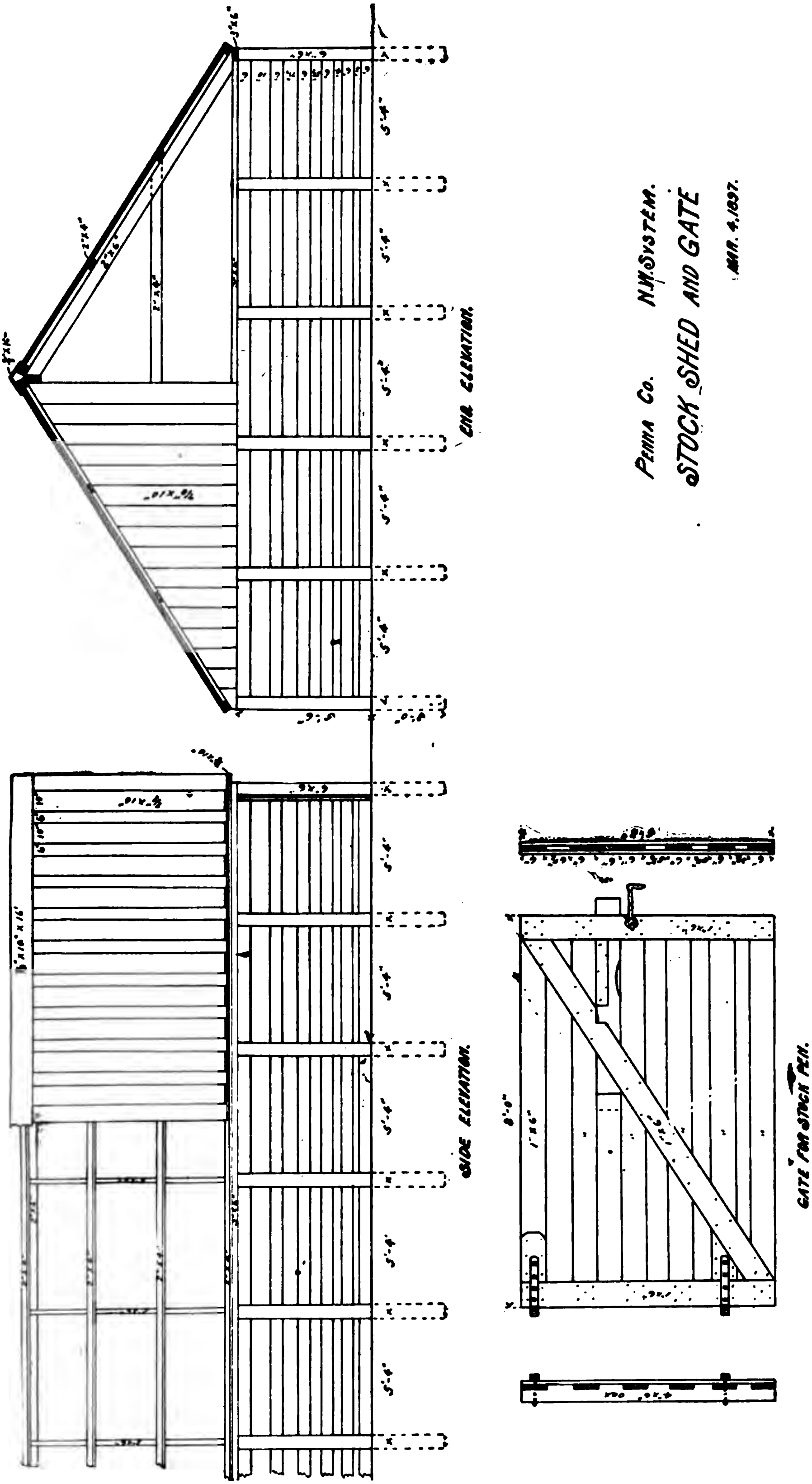


FIG. 227—STOCK SHED, PENNSYLVANIA COMPANY, NORTHWEST SYSTEM. (PLAN NO. 22.) REPORT ON STOCK YARDS AND STOCK SHEDS.

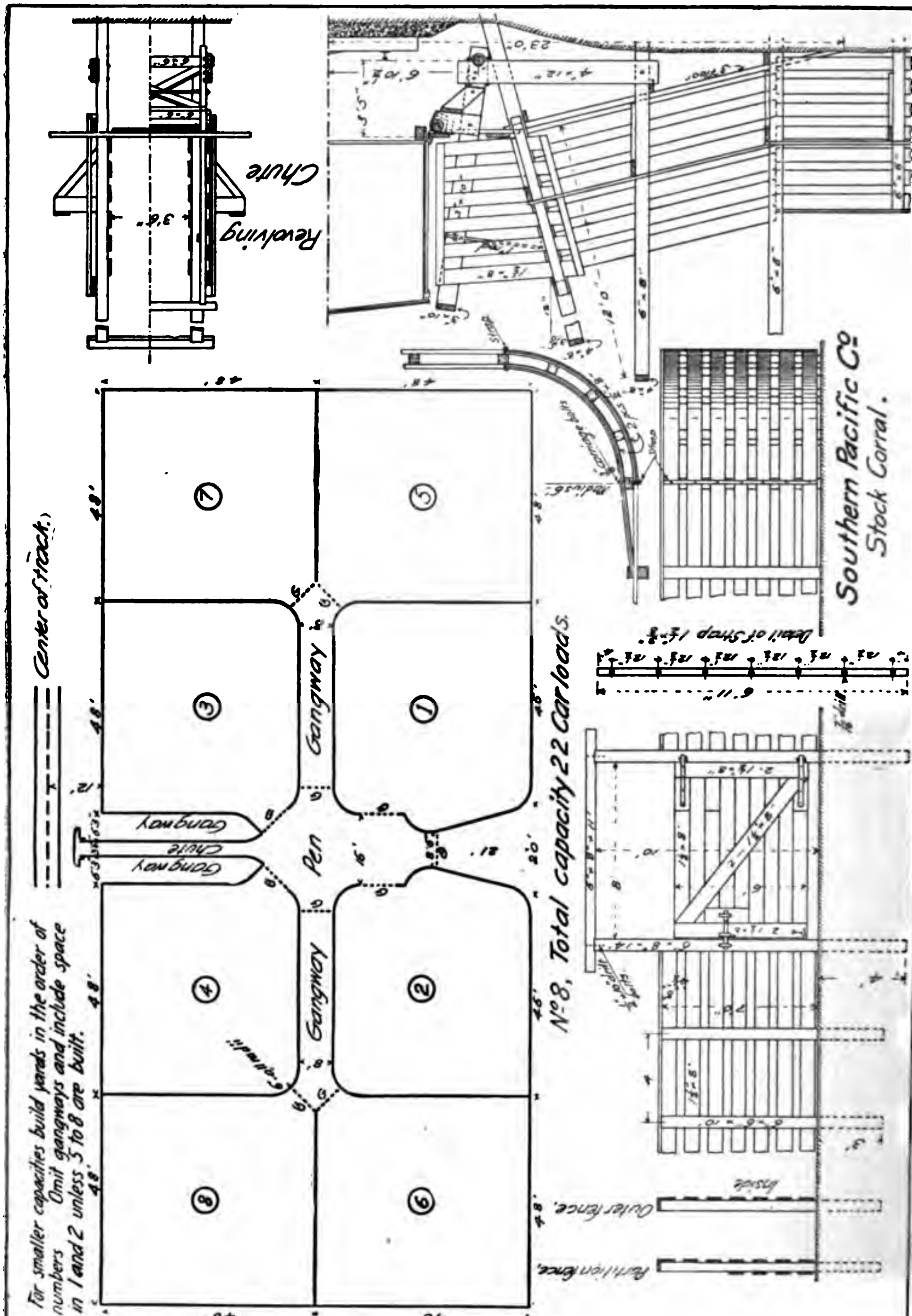


FIG. 228—STOCK CORRAL, SOUTHERN PACIFIC R. R. PLAN PRESENTED BY MR. JOHN D. ISAACS.

REPORT: BRIDGE FLOORS.

Railway bridge floors can be classed either as open floors, where the track is carried by timber cross-ties supported by longitudinal stringers or girders, and solid floors where the rails are supported by a tight floor either directly or with the intervention of ties and ballast. At the present day the open floor is the form of floor generally used for American railway bridges. The use of tight floors has been confined principally to bridges built in or near cities for the purpose of eliminating grade crossings of highways and railways, and the different conditions and legal restrictions governing each particular case have resulted in a great variety of designs. Your committee therefore has decided to limit this report to a discussion of the various types of open floors, as any attempt to treat fully of solid floors would make the report unreasonably long.

The accompanying illustrations have been selected from the drawings received by the committee to illustrate the different types of open bridge floors.

The ordinary functions of the floor are to support the track and transfer the load to the main trusses or girders. In addition, the floor should be so designed and built that a derailed car will safely cross the bridge.

In a paper entitled "Accidents to Railway Structures," by Mr. Thos. Curtis Clark, presented at a meeting of the American Society of Civil Engineers in February, 1871, there is a drawing showing the floor system in use at that time. Briefly described, the ties were nine feet long, with an eight-inch face and spaced fifteen inches apart in the clear. The stringers were spaced five feet center to center. As the result of accidents showing the necessity of providing means for carrying a derailed car safely over a bridge, the present floor has been developed.

The component parts of the floor are the ties, guard timbers and guard rails, stringers and floor beams.

The timber guard sticks outside of the rails were first used to prevent derailed wheels from running off of the ends of the ties. Mr. John D. Isaacs, of the Southern Pacific Co., writes: "This timber, in case of derailment, without the use of an inside guard rail, becomes an element of danger. If any of the wheels of a derailed truck crowd against the guard timber it is very apt o slew the truck and throw the car overboard." The same fact is stated in a circular relating to guard rails on bridges, issued by the Massachusetts Railroad Commission, and a writer in the Railroad Gazette for 1886, page 774, states that four or five cases have come under his observation where a wooden guard stick nine inches out from the outside of the rail has been the undoubted means of at least hastening if not causing wrecks by slewing derailed trucks around on bridges.

The inside iron guard rail eight to ten inches clear of the running rail is now generally depended upon to keep derailed wheels on the ties and has already been made the subject of a report to this society.

The proper use of the guard timber is to act as a spacer for and to prevent bunching of the ties by a derailed wheel. This is accomplished by notching the guard sticks over the ties, and also fastening them to the ties by bolts or lag screws. From 1 to 1½ inches depth of notch, and a bolt at every fourth tie for fastening has been found to be sufficient. Lag screws for fastening to ties have the advantage over bolts, that they can be used in places where it would be difficult to get at the lower end of a bolt to screw up the nut. Also, they obviate the trouble that arises from the nuts getting loose and falling off when bolts are used. On some wooden bridges the guards, ties, and stringers are bolted together with one bolt.

The guard timbers are spliced with a scarf joint and one bolt at a tie (Pl. 6, Fig. 1), or merely butted with bolts in two adjacent ties (Pl. 6, Fig. 2). The timber should be placed far enough outside of the running rail to be clear of the outside wheels of a derailed truck, when the inner wheels are running against the guard rail. With the guard rail 10 inches clear of the running rail, this will require at least 6 feet 10 inches clear between the guard sticks. The sticks are spaced farther apart than this, generally at or near the ends of the ties, to be out of the way of snow plows.

The rails are supported by, and fastened to, the ties. The clear spacing between the ties has been decreased so that a derailed wheel running over the floor will not drop down between the ties. The spacing now used varies from 4 to 7 inches; the former being considered objectionable, as being too close.

Before the use of inside guard rails the length of tie was increased to twelve feet to keep wheels on the floor. This necessitated supporting the ties outside of the rails, as derailed wheels would break off the ends. This was accomplished either by the use of outside stringers under the ends of the ties or by increasing the spacing between the track stringers.

With the use of proper guard rails the minimum length of tie is governed by the required clear distance between the guard timbers. With sticks 8 inches wide, the length of ties would be 8 feet 2 inches. The length of 12 feet has, however, been adopted, as it enables the guard sticks to be placed clear of everything, furnishes a convenient platform to work on in case of accident, closes the gap between tracks on a double track bridge, is an additional preventative of accident in case the wheel jumps the guard rail, and in case the guard rails are not used the greater width is necessary.

The ends of ties projecting beyond the guard sticks, as shown on several of the drawings, are waste material so far as protection from accident is concerned, and one of the double guard sticks shown on Pl. 9, Fig. 4 can be classed under the same heading.

When ties are subjected to transverse stress by placing the stringers outside of the rails, the rails serve to distribute the wheel load over three or more ties so long as the wheels are on the track. The load from a derailed wheel will come practically all on one tie, and unless considerable margin has been allowed in proportioning the tie it will be dangerously overloaded. Heavy timbers placed as near as possible to rails and bolted to every tie are sometimes used to distribute the wheel load over the adjacent ties.

The disadvantage of ties acting as beams are fully stated by Mr. Snow in his discussion accompanying this report.

To prevent the ties moving sideways, they are notched over or fastened to the stringers. On wooden bridges it is sufficient to spike the ties to the stringers with ½-inch boat spikes without notching. On iron bridges the ties are notched from ½ to 1 inch, and in many cases are fastened to the iron work by bolts through every third or fourth tie. Except in localities where there is danger of the floor being blown off the bridge, there does not appear to be much necessity for these bolts.

Unless greater sizes are required, due to the tie acting as beam, an 8-inch face and depth sufficient to hold the spike and allow for notching are all that is necessary—say 6 inches for ties on wooden bridges, and 7 inches with ½-inch notch for ties on iron bridges.

Stringers and floor beams are used to support the track and transfer the load to the main girders or trusses. Their arrangement will be given in the following detailed description of the various types of floors.

Wooden stringers (Plates 1 and 2).

These bridges are built both with long and short ties. The main stringers are placed directly under the rail and the ends of long ties supported by side stringers. A certain portion of the load depending on the relative stiffness of ties and stringers, is carried by the side stringers. The formulas for determining this amount have been deduced and published by Prof. G. F. Swain, in the Railroad Gazette for 1888. The practice on the B. & M. R. R. is to put six sticks under the track, two under each rail and one each side 10 feet out to out, and consider the side stringers to carry 20 per cent. of the load.

Plate No. 1 shows the different details used for single track trestles, and Plate No. 2 those for double track. The first three examples shown on Plate 2 are objectionable, inasmuch as it is necessary to disturb both tracks at once when renewing the ties. The form of construction used by the Boston & Maine Railroad allows either track to be renewed independently of the other, which is quite advantageous.

Through Wooden Truss Bridges: Plates 3 and 4.

The floor beams are either supported on top of, or are hung below, the bottom chord. The first method furnishes a direct support for the floor beams, but the deflection of the loaded floor beams brings the load on the inner edge of the chord. When the floor beams are hung below the chord, the hanger can be designed to distribute the load over the whole width of the chord. By the latter method, there is also a gain in head room over the rail, equal to depth of chord plus depth of floor beam. Another advantage of suspended floor beams is that they do not have to be cut away at the ends when near a panel point of the truss, to clear the braces.

Fig. 1, Pl. 3, is an example of the floor where the ties are used for floor beams. The clear spacing between is 7 inches. At panel points the tie has to be supported from the one each side, as shown on Fig. 1, A. The 8x8 guard stick is bolted to every tie, and aids in distributing the wheel loads. A bridge with a similar floor, recently taken down on one of the branches of the B. & M. R. R., had a 10x10 guard stick bolted to every floor beam, and a 4x4¾ inches angle iron for an inside guard rail, also bolted to every floor beam. This evidently was more efficient in distributing the loads from a derailed wheel than the example shown.

When ties and stringers are used, the floor beams are either spaced uniformly or concentrated at the panel points, both methods being shown on Plate 4. The latter method reduces the bending in the chord to a minimum, but calls for a larger stringer. By using side stringers and considering them to carry part of the load, the bending moments, and consequently the sizes of the floor beams, will be reduced.

With suspended floor beams, the lateral bracing rests on top of the beams, and the stringers are cut on to it. When the floor beams are uniformly distributed, this will not affect the strength of the stringers; but when floor beams are concentrated, it becomes a serious matter.

Wooden Pony Trusses (Plate 5).

The floors for these bridges are similar to those for through trusses.

The manner of bracing the top chord is mentioned here, as it is affected somewhat by the design of the floor. The top chord is braced from a collar beam fastened to the bottom chord. When the floor beams rest on top of the chord the collar beam can be bolted below the chord, and is out of the way. When the floor beams are hung below the chord, the collar beam will deflect with the floor, and throw the top chords out of line unless the collar beam is blocked down below the tops of the floor beams, as shown in Fig. 2.

In Fig. 2, the collar beam is bolted to the truss independent of the truss rods. This is preferable to the method shown in Fig. 1, as the trusses can be built complete and erected in place, and shrinking or crushing of the collar beam will not affect the adjustment of the truss rods.

Wooden Deck Trusses: Plates 3 and 6.

The floor beams rest on top of the top chord, and unless the bridge is roofed over, the arrangements and details are the same as for through bridges. The top of the top chord is protected from the weather by galvanized sheet iron, as shown on Pl. 6, Fig. 2. The bridge shown on Pl. 3 is also protected in the same manner.

With a record of service of from forty to fifty years for wooden truss railway bridges, when properly designed and protected from the weather, it would appear to be economy to cover all wooden truss bridges. This does not affect the floor for through or pony trusses, but the roof for a deck bridge makes a change in the design of floor necessary.

There are several different ways of putting a roof on a deck bridge. The example shown on Pl. 6, Fig. 1, is the standard of the Boston & Maine Railroad, and is to be recommended as protecting everything except the ties and guard sticks from the weather.

Rolled Beam Bridges (Plates 7 and 8).

Examples are given for both single and double track bridges. The arrangement of ties and spacing of stringers differ, but little from wooden stringer bridges. Side stringers, when used, cannot be figured as carrying any of the load when wheels are on the rails, owing to the greater rigidity of track stringers compared with the ties.

Deck Plate Girders (Plate 9).

The usual method of construction is to place two girders under each track, the girders being spaced from 6½ to 9 feet on centers, the spacing being governed to some extent by length of span and depth of girder.

Fig. 2 shows the ordinary form of construction. The ties act as floor beams and deflecting under a load bring the reaction along the inner edge of the top flange, tending to bend it down.

Fig. 3 shows a method of concentrating the load at the center of the flange, and preventing side movement of the ties without the necessity of notching them out the full width of the flange.

The top lateral bracing in this style of bridge should be designed so that there will be no interference with the ties.

The standard deck girder of the Boston & Maine Railroad differs from the foregoing by the addition of floor beams and stringers. The stringers support the tie under the rails, and the girders, spaced nine feet center to center, act as side stringers for supporting the ends of ties in addition to their regular duties. There is one system of longitudinal bracing in the plane of bottom flange of floor beams. The bridges are riveted up complete in the shop, transported to the site, and put in place at a minimum cost for erection. Ties of minimum thickness are also used.

Through plate girders (Plate 10).

Fig. 1 shows the simplest floor, where the ties act as floor beams and are supported by the bottom flange angles. Mr. James McIntyre has charge of some of these bridges and writes: "This construction I do not approve of, on account of the constant springing of the floor tending to weaken the flange angles and flange plates." The lateral bracing and ties interfere with one another, the ties bearing against and loosening the bracing.

Fig. 2 shows the method used to overcome these difficulties. The shelf angle carries the ties and there is plenty of room for the lateral bracing.

Floor beams and stringers are introduced to shorten the span of and reduce the size of the tie.

Fig. 3 shows one variety of iron floor with only two stringers, spaced 8 feet 0 inches, center to center. The arrangement of ties is similar to that for a deck girder. Notching the ties is reduced to a minimum by extending the web of stringers above top of flange angles, and cutting ties on to it.

Fig. 4 shows method of supporting the ties under the rails and at the ends, the details being the same as for rolled beam bridges. The next step in the progress of development would be a solid floor.

Through Iron Truss Bridges—Plate 11.

Generally there are two stringers to a track spaced from 5 to 8 feet c. to c. and headed into the floor beams. The B. & M. R. R. uses an arrangement of stringers as shown on Fig. 4, Pl. 12.

The details of ties are the same as for deck girders, sizes being governed by spacing of stringers. At the floor beams there is a break in the continuity of the spacing of the ties, caused by the floor beam flange increasing the clear distance between the adjacent ties. This is not a very important matter, as the top of the floor beam is seldom more than two or three inches below top of tie, and a derailed wheel would go over all right and the wide space does not make a noticeable difference in riding of the track.

Wooden stringers in combination bridges are placed on top of floor beams as shown in Fig. 4.

The clear distance of 14 to 15 feet between trusses of through bridges is more than ample to keep clear of a derailed car when it is kept in place by the guard rails and has been adopted with reference to the safety of brakemen on the sides of cars. The State of Vermont requires a clearance of 15 feet for this purpose. When the tops of through girders extend above the level of a car floor they should be built with the same clearance, but shallower girders can be placed nearer the rails.

Iron Deck Trusses—Plate 12.

Fig. 1 shows an example where the ties are used as floor beams, the details being similar to deck girders.

Fig. 2 and 3 are examples of iron floors with the floor beams riveted to the posts, the top chords acting as side stringers. In Fig. 2 the lateral bracing is both in the plane of the bottom flange of the chord and of top flange of floor beam. In Fig. 3 a greater depth of truss is obtained, but the bracing which is fastened to the top flange of the floor beam is below the chord and causes bending in the post.

Fig. 4 is an example where the floor beam rests on top of the chord, the simplest and best form when the depth can be spared. The spacing of stringers and details of ties will vary the same as for through bridges.

The various methods of connecting the track on the bridge with the track on the ground at ends have been fully shown in the drawings. The timber wall plates on parapet walls are sometimes blocked up at the ends to give more elasticity. The objections to these timber wall plates are fully given in Mr. Snow's discussion before referred to.

By arranging the parapet stone as shown on the different drawings of the Boston & Maine Railroad bridges the distance between first bridge tie and first grade tie is about the same as the distance between two ties in the ballast.

Skew Bridges—

The simplest arrangement for deck bridges is to lay the bridge ties parallel to the parapets, and fan out the grade ties. The bridge ties do not receive their load at the same time, and tend to jump and wear out more rapidly. The grade ties are either too far apart under one rail or so close together under the other that it is difficult to tamp them.

The first figure on Plate 13 shows a method of keeping the bridge ties square to the track. The Union Pacific Railway treats the end grade ties in the same manner. One objection to this method is the short lengths of ties supporting sometimes only one rail and tending to work loose.

There is always somewhat of a jar when the train passes from the ballast road-bed to the more rigid bridge floor, and unless both wheels of an axle pass onto the bridge floor at the same time there is a noticeable lurch. The best remedy for this is to square up the end of the bridge floor.

For skew trestles the end bents can easily be built square. One way of squaring the floor is to have a longitudinal sill on the bank supporting the other ends of the ties which rest on one stringer only. This is objectionable, as the sill will rot and settle, and it is something that is neither bridge floor nor track, and is liable to be neglected. The best way is to square up the ends of the stringers so that the first bridge tie is wholly on the bridge and the first grade tie is wholly in the ballast. Methods of doing this are shown on Plates 13 and 14.

When rebuilding skew bridges on old abutments it is very easy to make the design so that all the main bearings will be supported on the old masonry, and whatever additional masonry is necessary for secondary bearings and parapet walls, can be built with the old bank as a foundation, without danger of settlement.

In concluding their report, your committee make the following recommendations:

1. Ties 12 feet long, spaced 6 inches apart in the clear, supported directly under the rails and near the ends.

2. Suitable inside guard rails and spacers at ends of ties.

3. Squaring the floors at the ends of skew bridges.

4. Connecting bridge floor with approach by the method shown on Plate 9, Fig. 1.

5. Making the floor independent for each of the two tracks of a double-track bridge, as shown on Plate 8, Fig. 2.

BEN. WILDER GUPPY, B. & M. R. R.,
C. P. AUSTIN, B. & M. R. R.
F. W. TANNER, M. Pac. R. R.,
Committee.

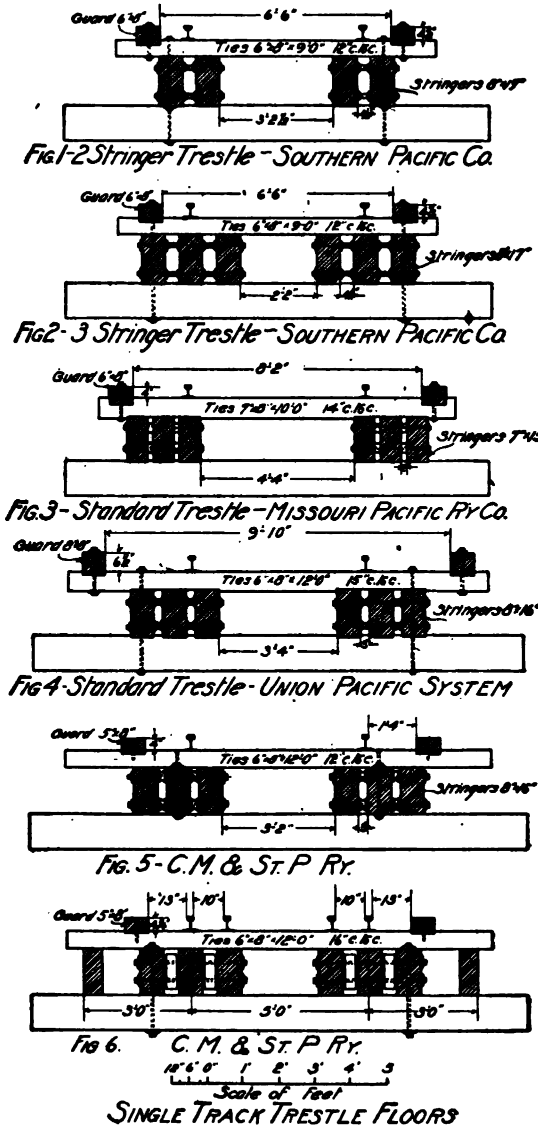


PLATE 1.

FIG. 229—REPORT ON BRIDGE FLOORS.

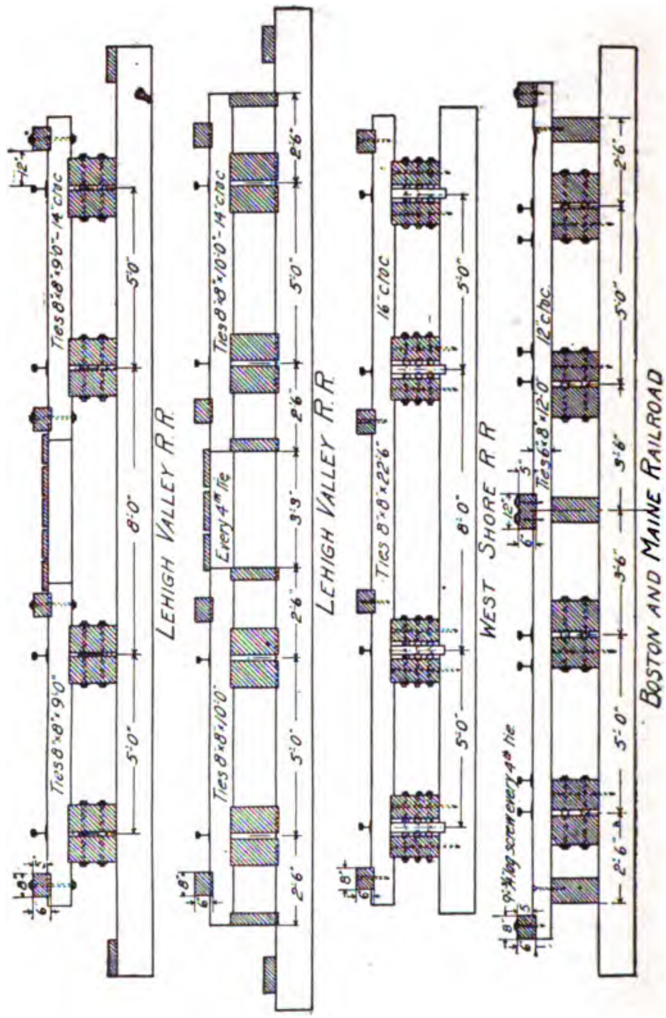


PLATE 2.

FIG. 2 O—REPORT ON BRIDGE FLOORS.

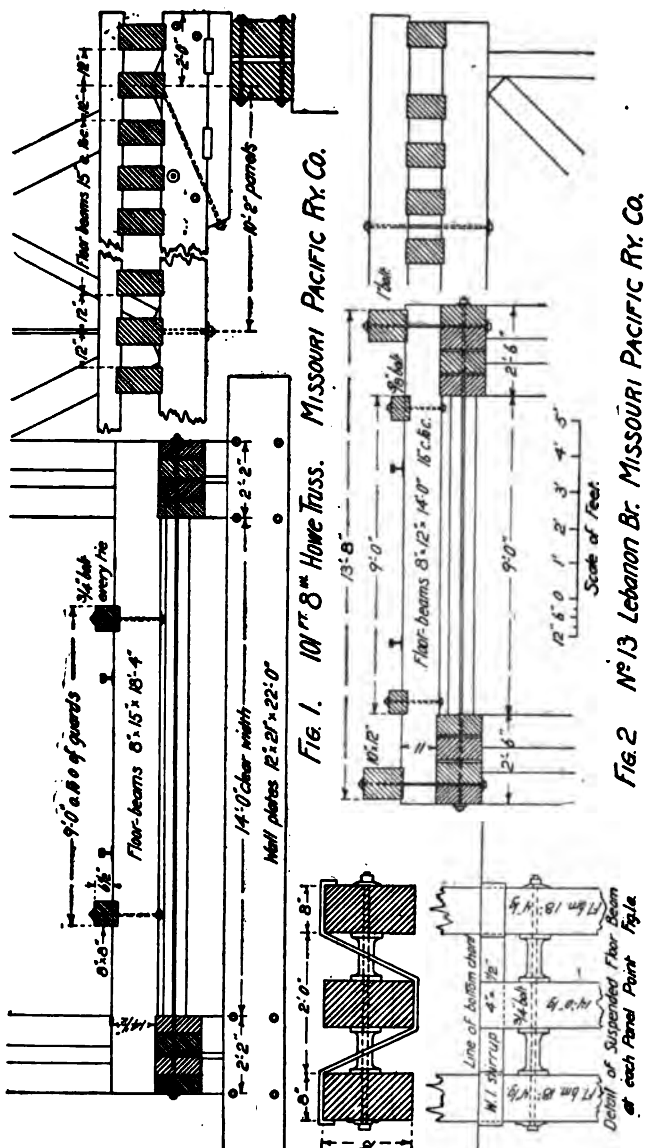


PLATE NO. 3.

FIG. 281.—REPORT ON BRIDGE FLOORS.

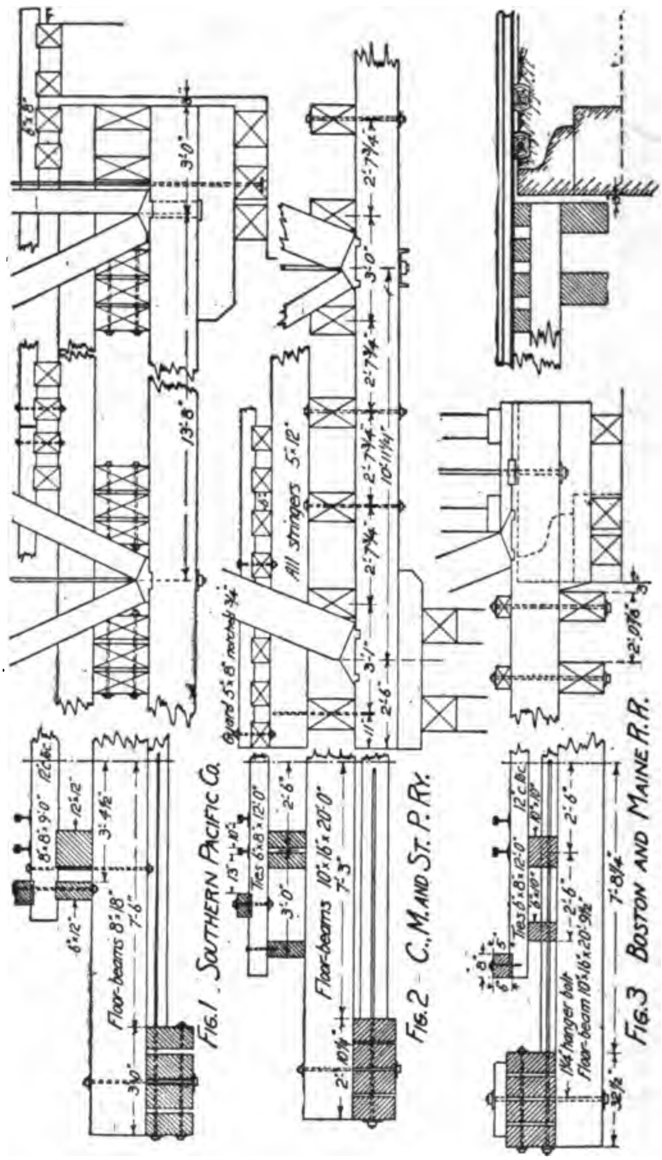


PLATE 4.
FIG. 232—REPORT ON BRIDGE FLOORS.

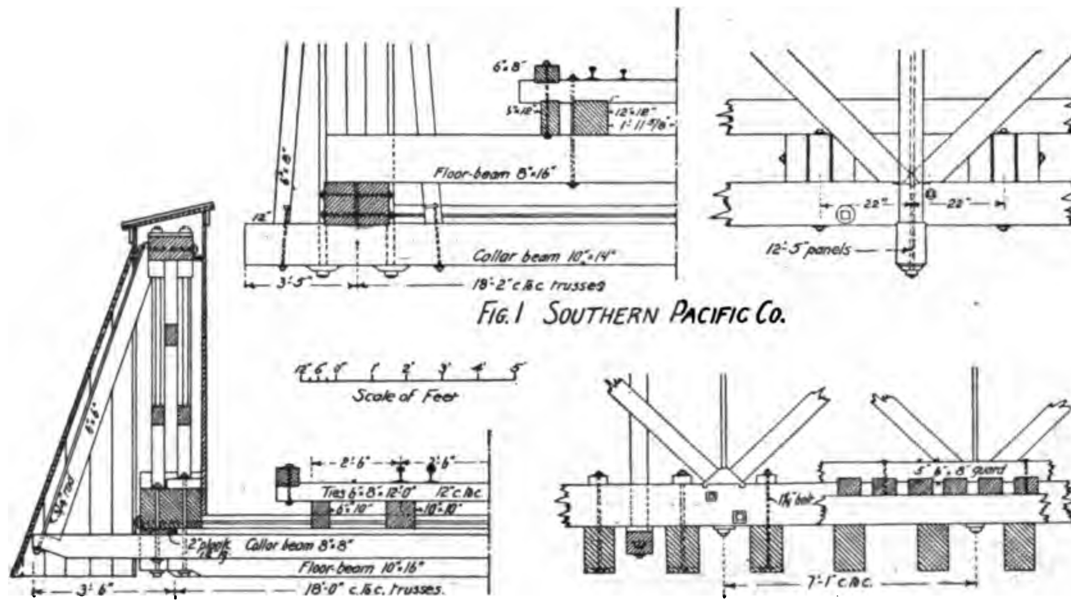


FIG. 2 - Ellmore Brook Bridge — ST. J. AND L. C. R.R.

PLATE 5.

FIG. 233—REPORT ON BRIDGE FLOORS.

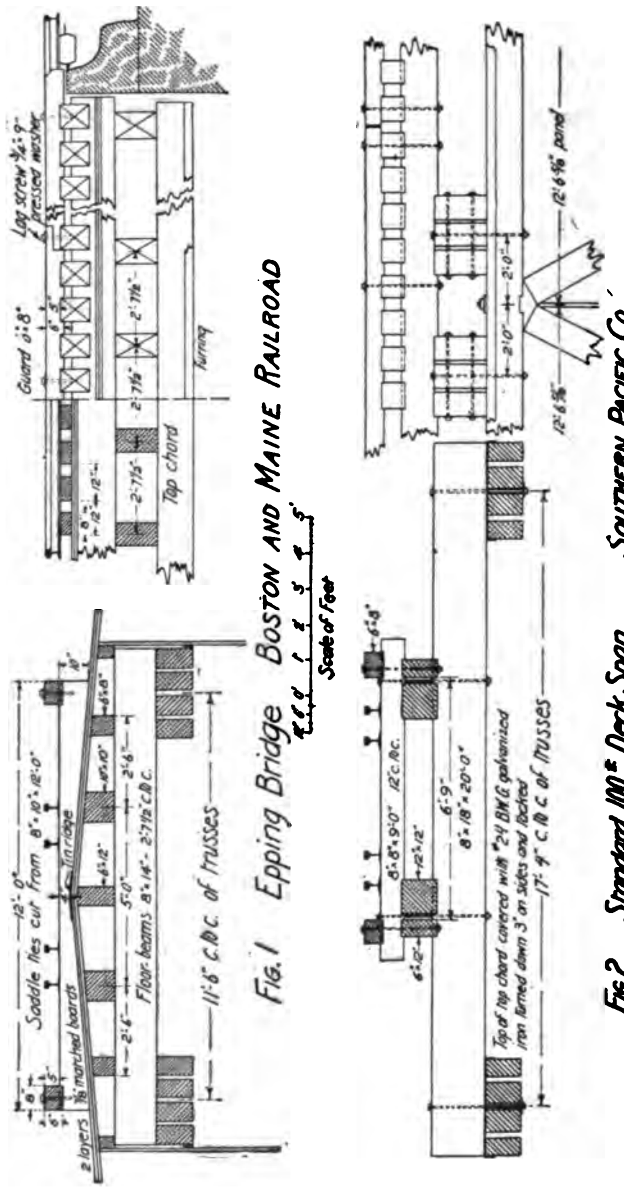


PLATE 6.

FIG. 284—REPORT ON BRIDGE FLOORS.

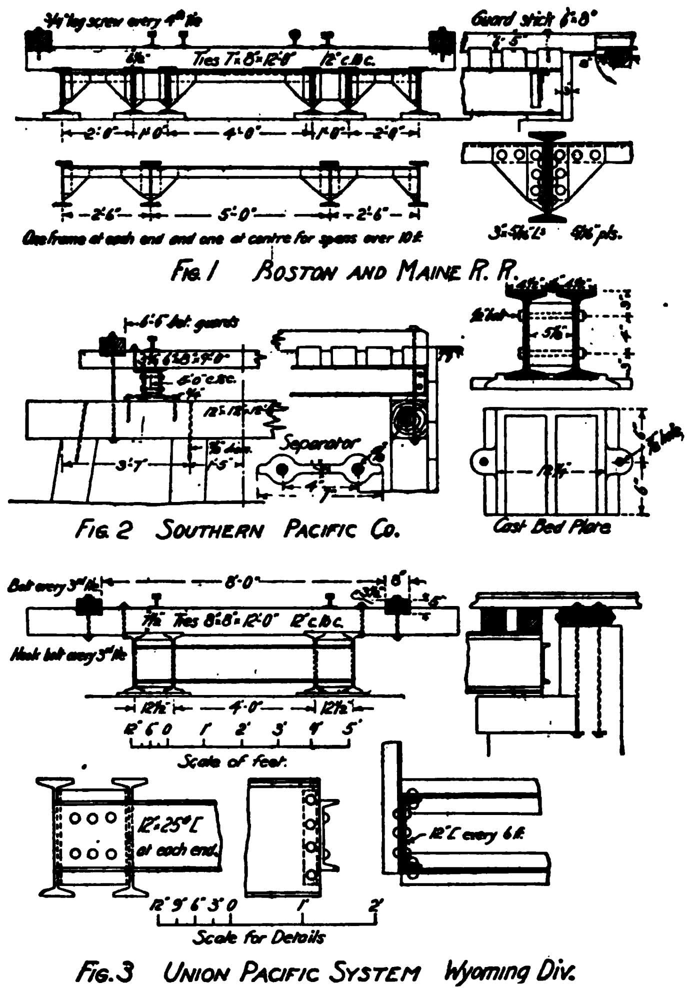


PLATE 7.

FIG. 285—REPORT ON BRIDGE FLOORS.

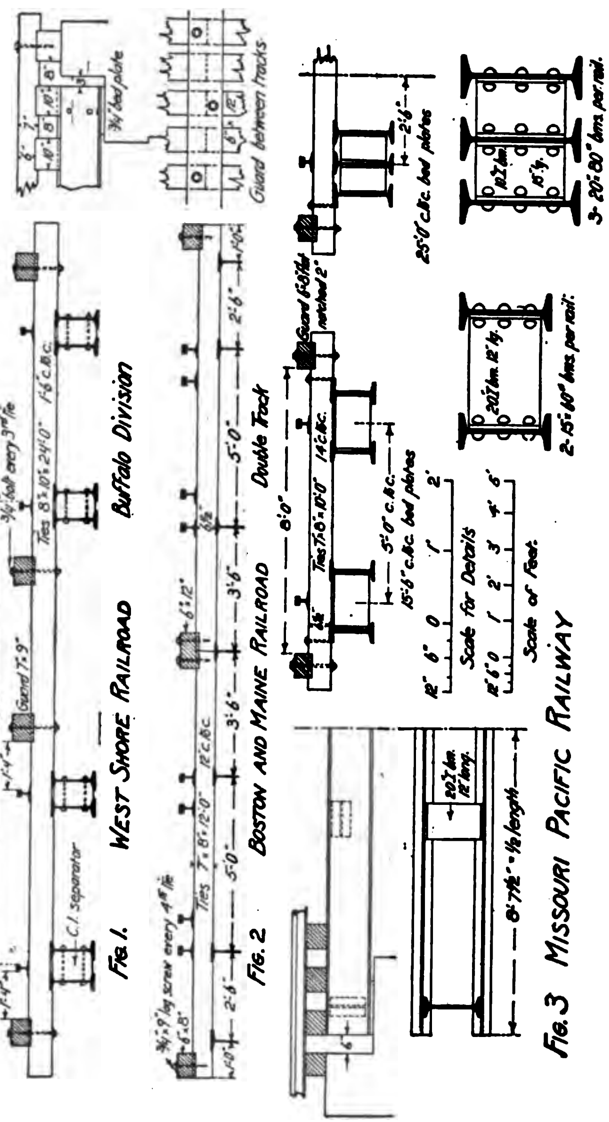


PLATE 8.
FIG. 288—REPORT ON BRIDGE FLOORS.

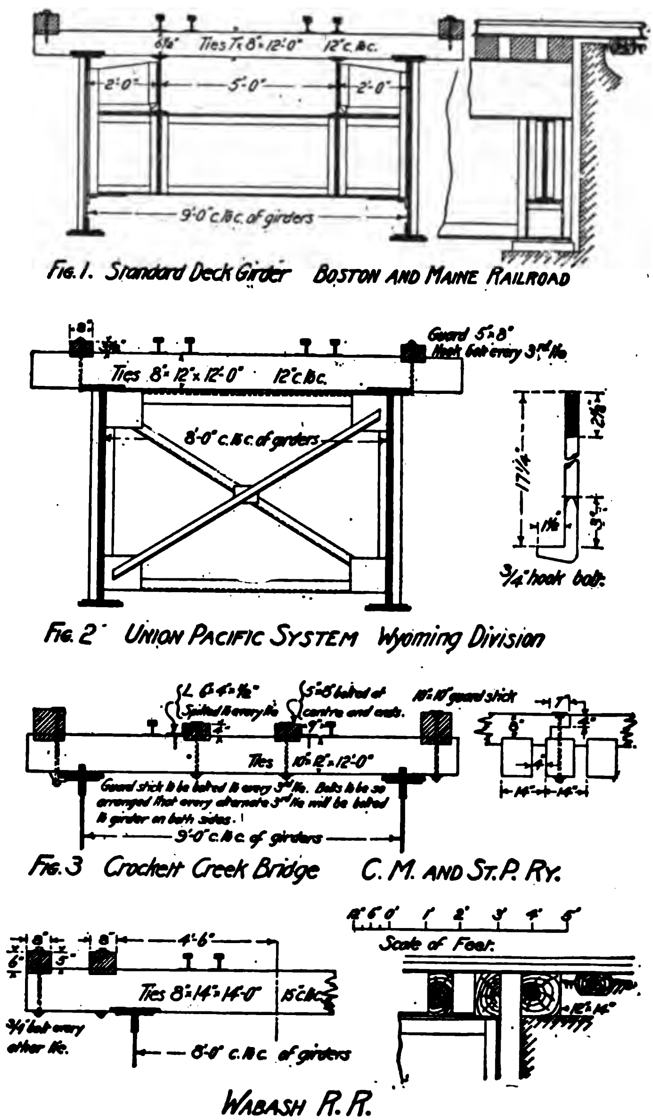


PLATE 9.

FIG. 237—REPORT ON BRIDGE FLOORS.

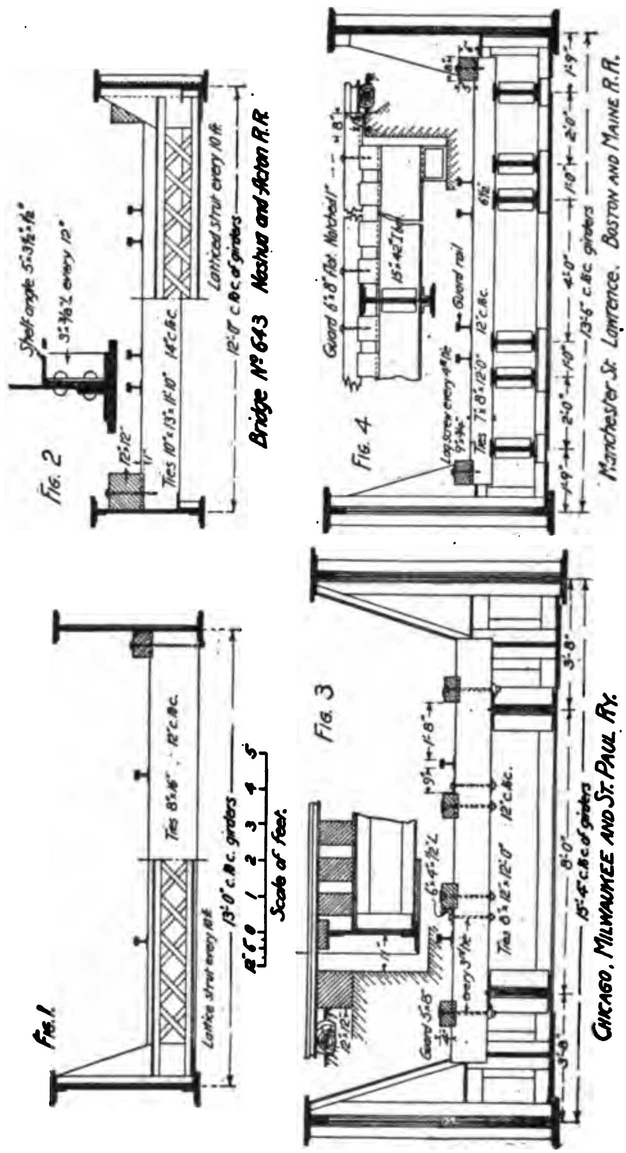


PLATE 10.
FIG. 288—REPORT ON BRIDGE FLOORS.

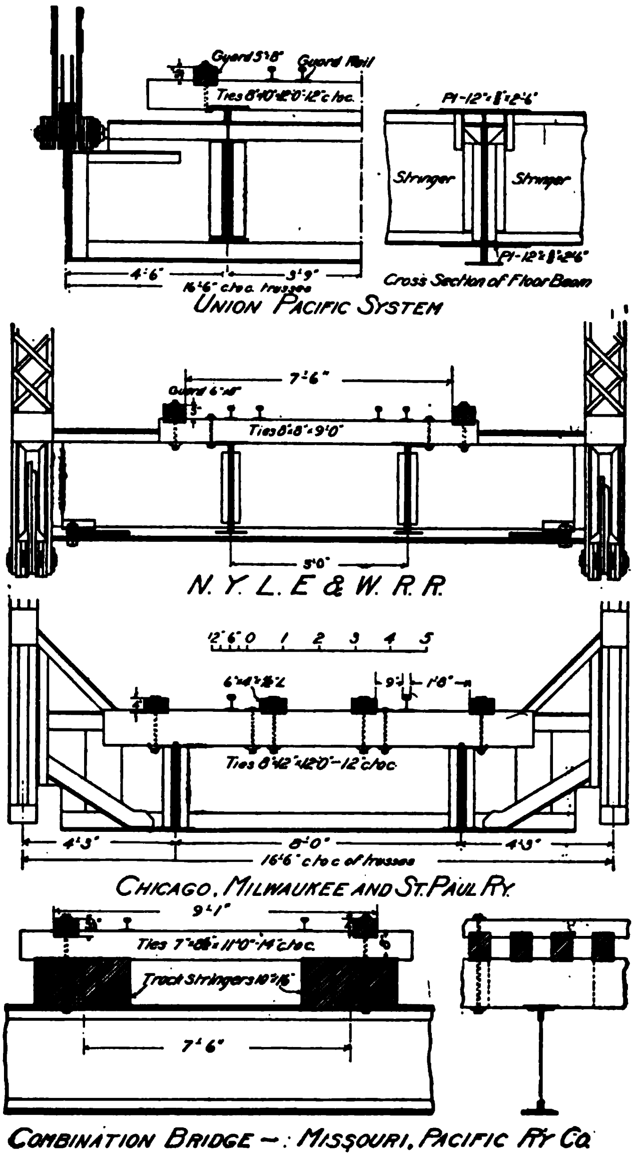


PLATE 11.

FIG. 239—REPORT ON BRIDGE FLOORS.

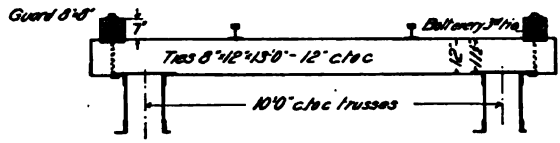


FIG 1-STANDARD DECK TRUSS - C. & O. RY.

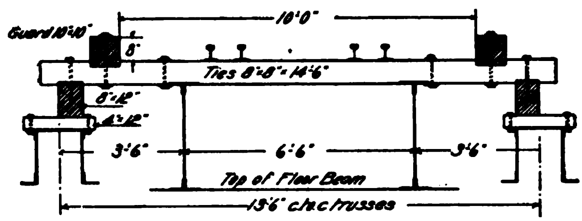


FIG 2-MANCHESTER BRIDGE-M. & N.W. R.R.

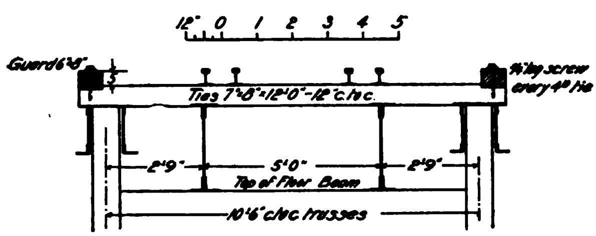


FIG 3- DECK TRUSS -B. & M. R.R.

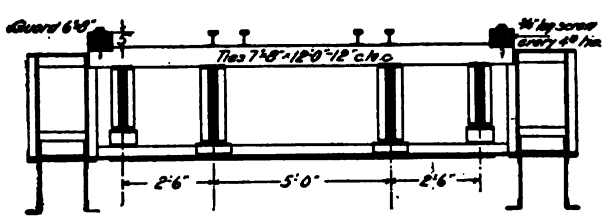
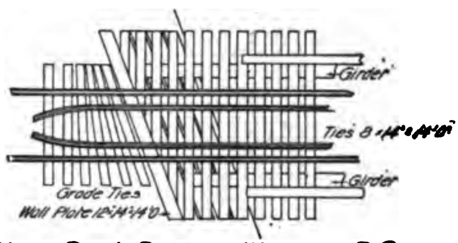


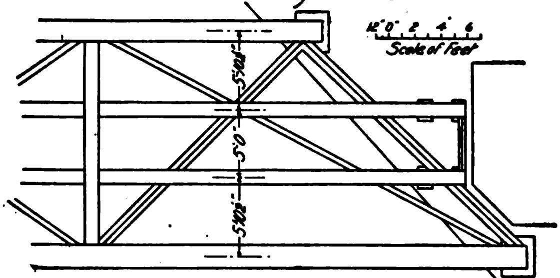
FIG 4- B. & M. R.R.

PLATE 12.

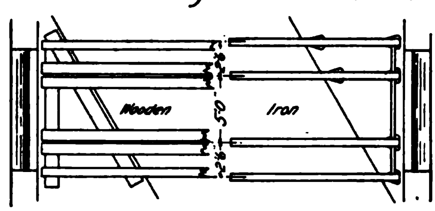
FIG. 240—REPORT ON BRIDGE FLOORS.



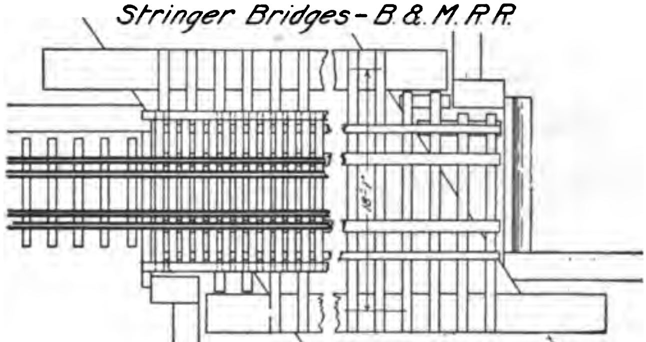
Skew Deck Bridge—Wabash R.R.



#23 Mahoning Div.-Erie R.R.



Stringer Bridges—B.&.M.R.R.



Thro' Howe Truss—B.&.M.R.R

PLATE 13.

FIG. 241.—REPORT ON BRIDGE FLOORS.

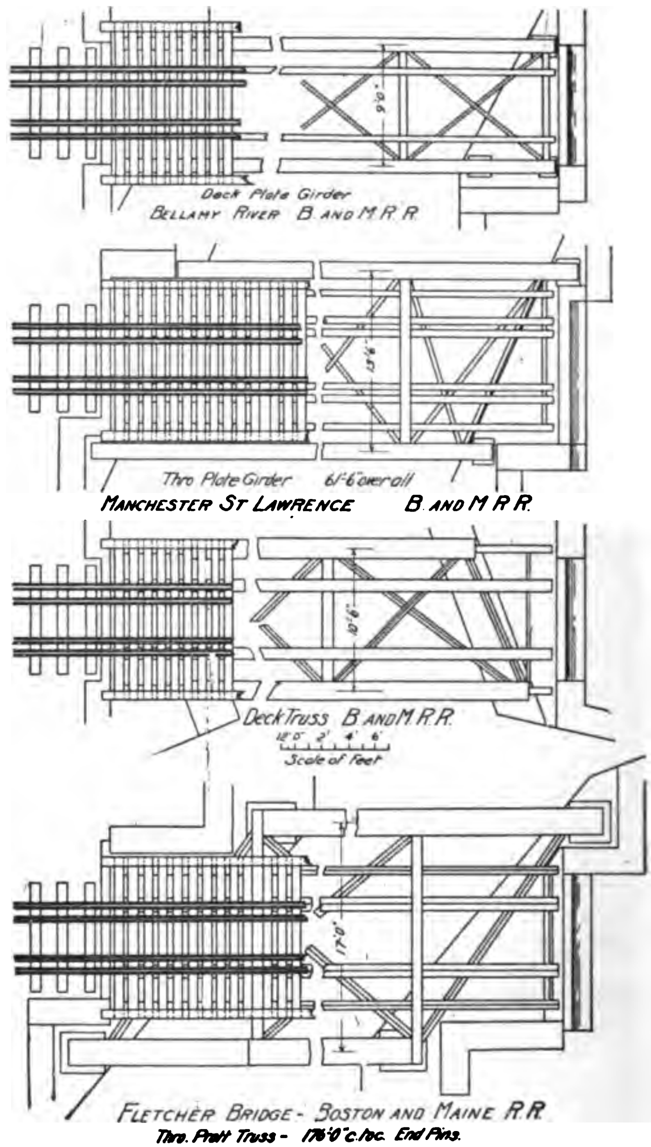


PLATE 14.

FIG. 242.—REPORT ON BRIDGE FLOORS.

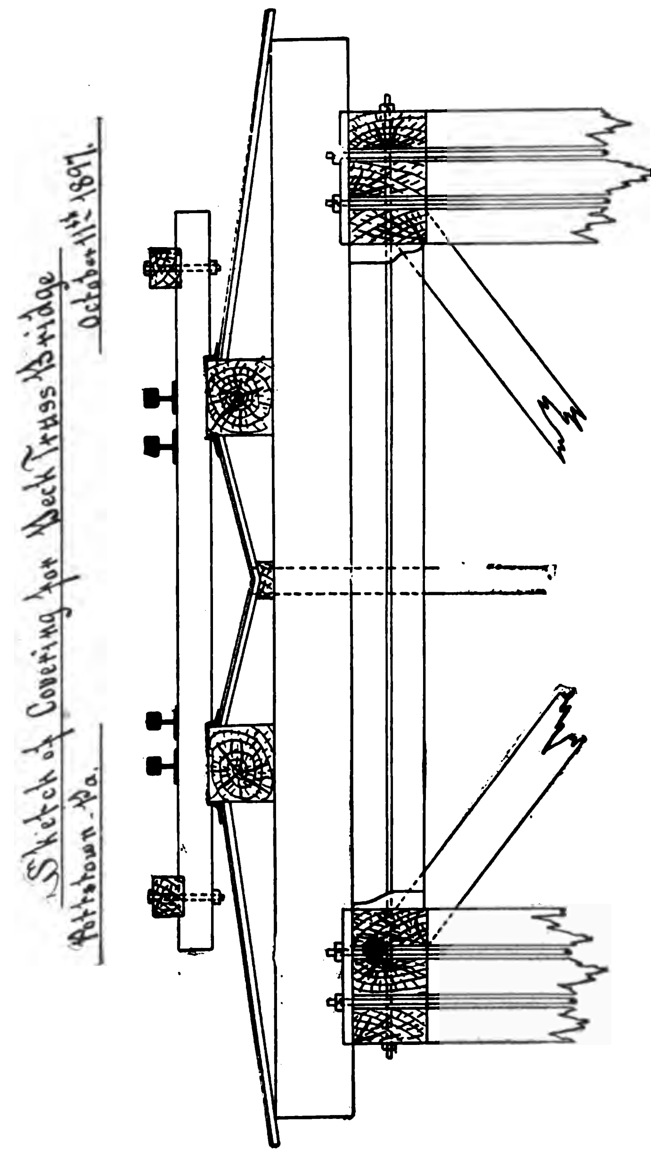


FIG. 248—PLAN OF COVERING FOR A DECK TRUSS BRIDGE, RECOMMENDED BY MR. JOHN FOREMAN, PHILADELPHIA AND READING R. R.

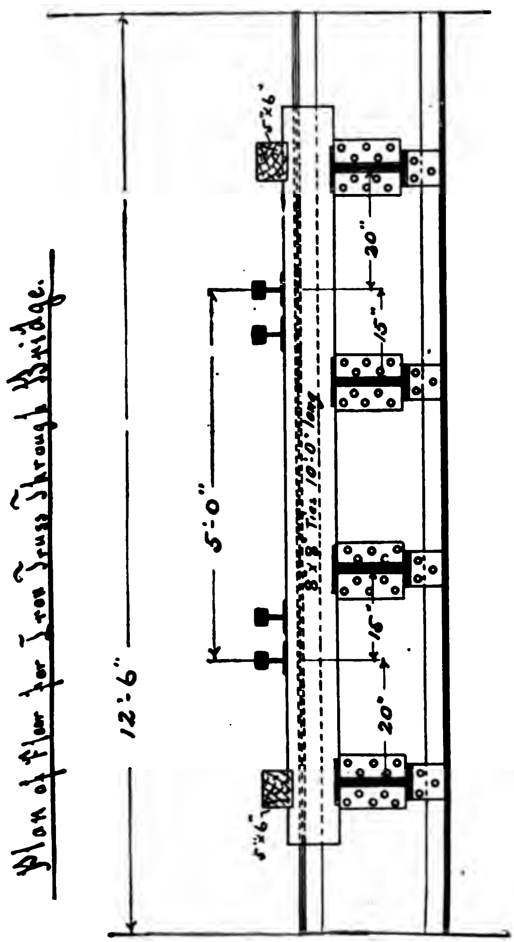


FIG. 244—PLAN OF FLOOR FOR AN IRON TRUSS THROUGH BRIDGE, RECOMMENDED BY MR. JOHN FOREMAN, PHILADELPHIA AND READING R. R.

DISCUSSION: BRIDGE FLOORS.

The two sketches herewith show different styles of floors for wooden and iron through and deck railroad bridges and roadway bridges. (See Figs. 243 and 244.)

The durability of the floor depends entirely on the location; for instance, an iron floor on an overhead bridge is not as good as a wooden floor on account of the deterioration of the metals caused by the action of the sulphur from the engines.

As to the best plan of floor, I will leave it to the association to decide, but I consider where stringers and ties are used that two longitudinal stringers under each rail with 8x8 inch ties laid close enough so as to prevent them bunching, should the cars get off the track, makes the best and most economical floor system; some of our railroad bridges have this style floor and are very satisfactory.

At present, on most railroads 9x12 inch ties and one stringer under each rail is used. I consider using the 9x12 inch ties there is a great waste of timber, and is not as safe as when two stringers are laid under each rail and 8x8 inch ties laid 6 inches apart are used. I think the floor system of all bridges should be arranged so as not to be overloaded with ties, especially iron bridges, as tie timber is getting scarce, poor in quality, and expensive.

All iron floor systems for railroad bridges are intended to be filled up with ballast and for roadway bridges with concrete or paved. The cost of floors depends entirely on the style, width of bridges, and weight they have to carry.

JOHN FOREMAN, Phila. & Read. Ry.

APPENDIX TO REPORT ON

STRENGTH OF BRIDGE AND TRESTLE TIMBERS.

(Continued from page 237.)

APPENDIX B.

RECORD OF TIMBER TESTS WITH SMALL SPECIMENS.

(a) Hatfield's tests ("Transverse Strains," 1877) have been widely quoted and utilized. Unfortunately the tests were all made on unusually small specimens, and hence much higher results than corresponding full-size tests show.

Tensile tests, specimens about one-third inch in diameter.

Compressive tests, nine tests of each kind of timber, specimens one to two diameters high.

Shearing tests, nine tests of each kind of timber, specimens small.

Transverse tests, specimens one inch square, short spans.

(b) Laslett's tests of English and foreign timbers ("Timber and Timber Trees," 1875; revised edition, 1894).

Tensile tests, specimens two inches square.

Compressive tests, small cubes one to four inches in size.

Transverse tests, specimens two inches square and six feet span.

(c) Professor Thurston's small-size tests (Journal Franklin Institute, October, 1879, and September, 1880).

Tensile tests, specimens one-half inch in diameter.

Compressive tests, specimens about one and one-eighth inches in diameter and two and one-fourth inches long.

Transverse tests, specimens three inches square and four and one-half feet span.

(d) St. Louis bridge tests made during construction of bridge. All timber well-seasoned excepting the white oak.

Compressive tests on blocks with and across grain, cubes three to six inches in size, two to four tests of each kind. Compressive tests on round columns, about two and one-fourth inches in diameter, and from two to twenty-four inches long; as a rule, length about thirteen inches or six diameters; none of the columns over eleven diameters.

(e) F. E. Kidder's small-size transverse tests (Van Nostrand's Magazine, February, 1880); five yellow pine specimens, about one and one-fourth inch square, and eight white pine specimens, about one and one-half inch square, all on supports forty inches apart. Very well seasoned timber of excellent quality.

(f) U. S. Ordnance Department small-size tests, Watertown arsenal, Col. T. T. S. Laidley.

Tensile tests, specimens generally about one inch in diameter.

Compressive tests with and across grain, specimens small size.

Compression across grain taken as the force producing an indentation of one-twentieth inch.

Transverse tests, well-seasoned sticks, from one and one-fourth inch to four inches square, and spans of twenty-two to forty-four inches.

Shearing tests, small specimens.

(g) John C. Trautwine, some small-size tests for shearing across grain (Journal of the Franklin Institute, February, 1880), valuable as representing shearing values for small, round, wooden tree nails and pins.

These shearing tests, specimens five-eighths inch round, gave the following values for the ultimate breaking, shearing stress across grain in pounds per square inch:

Ash	6,280	Locust	7,176
Beech	5,223	Maple	6,355
Birch	5,595	White oak	4,425
White cedar	1,372 to 1,519	Live oak	8,480
Central American cedar	3,410	White pine	2,480
Cherry	2,945	Northern yellow pine	4,340
Chestnut	1,535	Southern yellow pine	5,735
Dogwood	6,510	Yellow pine, very resinous	5,053
Ebony	7,750	Poplar	4,418
Gum	5,890	Spruce	3,255
Hemlock	2,750	Black walnut	4,728
Hickory	6,045 to 7,285	Common walnut	2,830

(h) U. S. Tenth Census Report, small-size tests of T. P. Sharples. A very large number of American woods, 412 species, were tested in over 1,200 specimens. This series of tests is the most comprehensive, as regards the number of species, ever undertaken, but the results are more of comparative than practical value, as the number of specimens for each kind was very small and the specimens, as a rule, only 1 57-100 inches square in size. The pieces for transverse tests were a little over three feet long, and those for compressive tests with the grain 12.6 inches long. Results for ultimate compression across grain were recorded for a pressure producing an indentation of 1-100 inch to 1-5 inch.

(i) U. S. Army tests by Captain Rodman (Ordnance Manual) were made over twenty-five years ago on small specimens, although larger than other earlier experiments. The pieces for transverse tests were about three inches by six inches, and five feet span.

(j) Professor Thurston, for U. S. Geological Survey, 1880, forty small-size tests of Oregon pine and California spruce.

APPENDIX C.

U. S. FORESTRY DIVISION TESTS OF LONG-LEAF PINE.

The United States Agricultural Department, under the supervision of Dr. B. E. Fernow, Chief of Division of Forestry, has in progress the most thorough examination of timber physics on a large scale, based on truly scientific principles, ever undertaken in this country. The methods in use and the results were published in detail, during 1892 and 1893, in "Timber Physics," Parts I and II, Bulletins No. 6 and 8, Forestry Division, U. S. Department of Agriculture, since which time the work has been delayed owing to insufficient appropriations by Congress, although it is expected that Part III, giving the researches for the four important species of Yellow Pine, will be published the latter part of 1895.

The material examined up to 1893 was exclusively "Long-Leaf Pine" (Pinus palustris), cut from twenty-six specially selected trees from four different sites in Alabama. The range of the results of over two thou-

CONDENSED TABLE OF RANGE OF MECHANICAL PROPERTIES OF "LONG-LEAF PINE.

Compiled from "Timber Physics," Part II, Bulletin No. 8, Forestry Division, U S. Department of Agriculture.

[Ranges reduced to uniform basis of 15 per cent. moisture.]

		Butt Logs.		Middle Logs.		Top Logs.		Average of butt logs.	Grand average of all tests.
		Least.	Greatest	Least.	Greatest	Least.	Greatest		
Weight, in pounds, per cubic foot		28.00	64.79	35.85	53.56	30.18	56.56	47.83	46.27
Transverse strength.—	Modulus of rupture or ultimate breaking extreme fiber stress, in pounds, per square inch	4,762	16,200	7,640	17,128	4,268	15,554	12,614	12,250
	Extreme fiber stress at the elastic limit, in pounds, per square inch	4,930	13,110	5,540	11,790	2,553	11,950	9,460	9,430
	Modulus of elasticity, in pounds, per square inch	1,118,800	3,117,370	1,136,120	2,981,720	842,000	2,697,460	1,925,644	2,069,650
Crushing strength.—	Ultimate breaking compressive stress, with the grain, in pounds, per square inch	4,781	9,850	5,030	9,300	4,587	9,100	7,452	7,228
	Ultimate breaking compressive stress, across the grain, in pounds, per square inch	675	2,094	656	1,445	584	1,766	1,598	1,517
Tensile strength.—	Ultimate breaking tensile stress, in pounds, per square inch	8,600	31,890	6,330	20,500	4,170	23,280	17,359	*16,029
Shearing strength.—	Ultimate breaking shearing stress, with the grain, in pounds, per square inch	464	1,299	539	1,230	484	1,156	866	852

* Not reduced for moisture.

sand mechanical tests, conducted by Prof. J. B. Johnson, at Washington University, St. Louis, Mo., on large and small specimens, is shown in the table herewith, the results having been reduced to the uniform basis of 15 per cent. moisture.

The following is offered in explanation of these tests:

Transverse Tests.—The full-size tests were made on a machine of 100,000 lbs. capacity, and the small-size tests on a machine capable of breaking a 4-inch square stick 6 feet long.

The ultimate extreme fiber stress is computed from the well-known formula,—

$$f=\frac{3Wl}{2bh^2}$$

where f=stress on extreme fiber in lbs. per square inch.
W=load at center of beam in lbs.
l=length of beam between supports in inches.
b=breadth of beam in inches.
h=height of beam in inches.

The results of each test were plotted as rectangular co-ordinates, using the loads as ordinates and the corresponding deflections as abscissas. The so-called elastic limit is determined from this curve by the arbitrary rule locating it at that point of the curve where the rate of deflection is 50 per cent. more than it is at first, it having been found that this rule usually places the elastic limit at the point where the deflection, after remaining almost proportional to the loads, suddenly begins to increase rapidly. The extreme fiber stress at the thus established elastic limit is calculated the same as the ultimate extreme fiber stress, using the load on the beam at the elastic limit in place of the ultimate breaking load.

The modulus of elasticity for rectangular sections is computed from the well-known formula,—

$$E=\frac{Wl^3}{4Dbh^3}$$

where E=modulus of elasticity.
D=deflection of beam in inches.
W, l, b and h same as above.

To find this modulus a tangent line is drawn to the strain diagram at its origin, and the co-ordinates of any point on this line used as the W and D from which to compute E. The modulus of elasticity is a true measure of the stiffness of the material, and is the most constant and reliable property of all kinds of engineering materials, and is a necessary means of computing all deflections or distortions under loads.

Crushing or Compression Tests.—The endwise compression tests were made, as a rule, on sticks 4 in. square and 8 in. long, although some tests were made on sticks 4 in. square and 40 in. long. The machine used was a Universal Testing machine.

The crushing or compression tests across grain were made on sticks 4 in. square and 6 in. long. The load is recorded when the limit of the distortion, i. e., indentation, is 15 per cent. of the height, i. e., thickness of timber compressed.

The department has a machine for testing full-size columns with a capacity of 1,000,000 lbs., capable of crushing a timber column 12 to 14 in. square, and up to a length of 36 ft. No tests had been made on this machine up to the spring 1893, the date of the last published results.

Tensile Tests.—The tensile tests were made on a Universal Testing machine, the specimens being cut from the ends of previously broken beams, the section of specimens being 2½x⅝ in.

NAMES AND CHARACTERISTICS OF SOUTHERN LUMBER PINES.

From "Timber Physics," Part II, Bulletin No. 8, Forestry Division, U. S. Department of Agriculture.

Names.					
Botanical Name.	*Pinus palustris* Miller. Syn. *P. australis* Michx.	*Pinus cubensis* Griesebach. Syn. *Pinus Tæda* var. *heterophylla* Ell. *P. Elliotii* Engelm. *P. cubensis* var. *terthrocarpa* Wright.	*Pinus echinata* Miller. Syn. *Pinus mitis* Michx. *Pinus virginiana* var. *echinata* Du Roi. *P. Tæda* var. *variabilis* Aiton. *P. variabilis* Lamb. *P. rigida* Porcher.	*Pinus Tæda* Linn. Syn. *Pinus Tæda* var. *tenuifolia* Aiton.
Best Common Name.	Long-Leaf Pine.	Cuban Pine.	Short-Leaf Pine.	Loblolly pine.
Local, Market, and Lumbermen's Name.	Southern yellow pine. Southern hard pine. Southern heart-pine. Southern pitch-pine. Hard pine (Miss., La.). Heart pine (N. C. and South Atlantic). Pitch-pine (Atlantic). Long-leaved yellow pine (Atlantic). Long-leaved pine (Atlantic). Long-leaved pitch-pine (Atlantic). Long-straw pine (Atlantic). North Carolina pitch-pine. Georgia yellow pine. Georgia pine. Georgia heart-pine. Georgia long-leaved pine. Georgia pitch-pine. Florida yellow pine. Florida pine. Florida long-leaved pine. Texas yellow pine. Texas long leav.d pine	Slash-pine (Ga., Fla.). Swamp pine (Fla. and Ala.), in part. Bastard pine (Fla., Ala.) Meadow pine (Fla., E. Miss.), in part. She pitch pine (Ga.).	Yellow pine (N. C., Va.) Short-leaved yellow pine Short-leaved pine. Virginia yellow pine (in part). North Carolina yellow pine (in part). North Carolina pine (in part). Carolina pine (in part). Slash-pine (N. C., Va), in part. Old-field pine (Ala., Miss.). Bull-pine (?). Spruce-pine.	Slash-pine (Va. N. C.), in part. Loblolly-pine (Gulf Region). Old-field pine (Gulf Region). Rosemary-pine (N. C., Va.). Short-leaved pine (Va., N. C., S. C.). Bull-pine (Texas and Gulf Region). Virginia pine. Sap-pine (Va., N. C.). Meadow pine (Fla.). Corn-stalk pine (Va.). Black pine (Va.). Fox-tail pine (Va., Md.). Indian pine (Va., N. C.). Spruce-pine (Va.), in part. Bastard pine (Va., N. C.). Yellow pine (No. Ala., N. C.). Swamp pine (Va., N. C.). Long-straw pine (Va., N. C.), in part.

BOTANICAL DIAGNOSIS.	Leaves	3 in a bundle, 9 to 12 (exceptionally 14 to 15) inches long.	2 and 3 in a bundle; 7 to 12 (usually 9 to 10) inches long.	2 and 3 in a bundle; 1½ to 4 inches long; commonly 2½ to 4 inches.	3 in a bundle; 5 to 8 in's long.
	Cones (open)	6 to 9 inches long, 4½ to 5 inches in diameter.	4 to 6½ (usually 4 to 5) inches long; 3 to 4½ inches in diameter.	1½ to 2 inches long; 1½ to 1¾ inches in diameter.	2½ to 4½ inches long; 1¾ to 3 inches in diameter.
	Scales	⅞ to 1 inch broad; tips much wrinkled, light chestnut brown, gray with age.	11-16 to ¾ inch broad; tips, wrinkled; deep russet brown; shiny.	5-16 to ⅜ (exceptionally about ½) inch broad; tips light yellow-brown.	⅜ to ½ inch broad; tips smooth; dull yellow-brown.
	Prickles	Very short, delicate, incurved.	Very short; straight; declined.	Exceedingly short (1-10 inch), delicate straight, declined.	Short; stout at base.
	Buds	¾ inch long; ¼ inch in diameter; silver white.	About ½ inch long; ¼ inch in diameter; brownish.	⅜ to ½ inch long; about ¼ inch in diameter; brownish.	½ to ¾ inch long, ¼ inch in diameter; brownish.
DIAGNOSTIC FEATURES.	Specific gravity of kiln-dried wood. Possible range.	.58 to .90	.65 to .84(Sarg.)	.39 to .76	.38 to .61
	Specific gravity of kiln-dried wood. Most frequent range.	.60 to .70	....	.50 to .60	.43 to .48
	W'ght, pou'd's pr. cubic foot, kiln-dried wood. Possible range.	44 to 52	38 to 50	36 to 44	31 to 36
	W'ght, pou'd's pr. cubic foot, kiln-dried wood. Average.	48	47	40	34
	Character of grain seen in cross section	Fine and even; annual rings uniformly narrow throughout; not less than 8 (mostly about 18-25) rings to the inch.	Variable and coarse; rings mostly wide; from 6 to 8 rings to the inch.	Very variable; medium, coarse; rings wide near heart; followed by zone of narrow rings; not less than 4 (mostly about 10) rings to the inch.	Less variable, mostly very coarse; 3 to 12 rings to the inch; generally wider than in short leaf.
	Color, general appearance	Even dark reddish-yellow to reddish-brown.	Dark straw color with tinge of flesh color.	Yellowish-red.	Whitish to brownish yellow; the dark bands of summer wood being proportionately narrow.
	Sapwood, proportion	Very little; rarely over 2 to 3 inches of radius.	Nearly one half of the radius.	Commonly over 4 inches of radius.	Very variable, ½ to ¼ of the radius.
	Resin	Very abundant; tree turning into "light wood;" pitchy throughout.	Abundant, sometimes yielding more pitch than long-leaf; not turning into "light wood."	Moderately abundant, least pitchy; only near stumps, knots, and limbs.	Abundant; more than short-leaf, less than long-leaf and Cuban.

Dr. Fernow summarizes the more important deductions, that can be made on the basis of the tests of Long-Leaf Pine, published up to 1893, as follows:

"With the exception of tensile strength, a reduction of moisture is accompanied by an increase in strength, stiffness, and toughness.

"Variation in strength goes generally hand in hand with variation in specific gravity.

"The strongest timber is found in a region lying between the pith and the sap, at about one-third of the radius from the pith in the butt log; in the top log the heart portion seems strongest. The difference in strength in the same log ranges, however, not over 12 per cent. of the average, except in crushing across the grain and shearing, where no relation according to radial situation is apparent.

"Regarding the variation of strength with the height in the tree, it was found that for the first 20 to 30 feet the values remain constant, then occurs a more or less gradual decrease of strength, which finally, at the height of 70 feet, amounts to 20 to 40 per cent. of that of the butt log for the various exhibitions of strength.

"In shearing and crushing across and parallel with the grain, practically no difference was found.

"Large beams appear 10 to 20 per cent. weaker than small pieces.

"Compression tests seem to furnish the best average statement of value of wood, and if one test only can be made this is the safest.

"The investigations into the effect of bleeding the trees for turpentine leave no doubt of the fact that bled timber is in no respect inferior to unbled timber."

The following additional extracts from Dr. Fernow's report, and the accompanying table herewith, copied from his report, will prove not only interesting and aid in defining the class of timber covered by these tests and called "Long-Leaf Pine," but will form a useful and valuable record, especially as the original publication (Bulletin No. 8) is out of print and difficult to obtain:

"There are in the Southern Atlantic and Gulf States ten species of pine which are or can be cut into lumber. Two of these—the white pine (Pinus strobus L.) and the pitch-pine, also called yellow or black pine (Pinus rigida Mill.)—occur only in small bodies on the Allegheny mountains, from Virginia down to Northern Georgia, being rather Northern pines. Three—the Jersey or scrub-pine, occasionally also called short-leaf or spruce-pine (Pinus virginiana Mill.) along the coast to South Carolina; the sand, scrub, or spruce-pine (Pinus clausa (Engelm.) Sarg.), found in a few localities in Florida; and the pond, also called loblolly or Savannah pine (Pinus serotina Mx.) along the coast from North Carolina down to Florida—occur either so sparingly that they do not cut any figure on the lumber market, or do not often produce sizable trees for saw-logs.

"There remain, then, five distinctly Southern species which are actually cut for lumber; one of these, the spruce-pine, also called cedar pine or white pine (Pinus glabra Walt.) probably does not reach the market except by accident. But the other four may be found now in all the leading markets of the East.

"There exists considerable confusion among architects, builders, engineers, as well as dealers in lumber and lumbermen themselves, as to the identity of these species and their lumber. The confusion arises mainly from an indiscriminate use of local names, and from ignorance as to the differences in characteristics of their lumber as well as the difficulty in describing these.

"The table herewith, showing the names, which have been found applied to the four species furnishing Southern pine lumber, will most readily exhibit the difficulty arising from misapprehension of names. These names are used in the various markets and in various localities in the home of the trees. Where possible the locality in which the name is used has been placed in brackets by the side of the name."

Prof. J. B. Johnson makes the following statements regarding the extensive tests made under his charge as reported above:

"The long-leaf pine timber is specially fitted to be used as beams, joists, posts, stringers in wooden bridges, and as flooring when quarter-sawed. It is probably the strongest timber in large sizes to be had in the United States. In small selected specimens, other species, as oak and hickory, may exceed it in strength and toughness. Oak timber, when used in large sizes, is apt to be more or less cross-grained, knotty, and season-checked, so that large oak beams and posts will average much lower in strength than the long-leaf pine, which is usually free from these defects. The butt cuts are apt to be windshaken, however, which may weaken any large beams coming from the lower part of the tree. In this case the beam would fail by shearing or splitting along this fault with a much smaller load than it would carry without such defect. These wind shakes are readily seen by the inspector, and sticks containing them are easily excluded, if it is thought worth while to do so. For highway and railway wooden bridges and trestles, for the entire floor system of what is now termed 'mill' or 'slow-burning' construction, for masts of vessels, for ordinary floors, joists, rafters, roof-trusses, mill-frames, derricks, and bearing piles; also for agricultural machinery, wagons, carriages, and especially for passenger and freight cars, in all their parts requiring strength and toughness, the long-leaf pine is peculiarly fitted. Its strength, as compared to that of short-leaf yellow pine and white pine, is probably very nearly in direct proportion to their relative weight, so that pound for pound all the pines are probably of about equal strength. The long-leaf pine is, however, so much heavier than these other varieties that its strength for given sizes is much greater.

"A great many tests have now been made on short-leaf and on loblolly pine, both of which may be classed with long-leaf as 'Southern yellow pine,' and from these tests it appears that both these species are inferior to the long-leaf in strength in about the ratio of their specific gravities. In other words, long-leaf pine (Pinus palustris) is about one-third stronger and heavier than any other varieties of Southern yellow pine lumber found in the markets. It is altogether likely that a considerable proportion of the tests heretofore made on 'Southern yellow pine' have been made on one or both of these weaker varieties."

APPENDIX D.

PROFESSOR LANZA'S FULL-SIZE TRANSVERSE TESTS.

Professor Gaetano Lanza, of the Massachusetts Institute of Technology, author of "Applied Mechanics," and one of the best known writers and experimenters on the strength of timber in this country, obtained the following results from full-size transverse tests made in his Boston laboratory.

a. Transverse strength of spruce.

From sixty-eight full-size tests of spruce beams:—

Ultimate breaking extreme fibre stress in pounds per square inch, 2,828 to 8,748; average, 5,046.

Modulus of elasticity in pounds per square inch, 897,961 to 1,588,548; average, 1,332,500.

For the calculation of deflection of a spruce beam under a given load to be applied for a long time, the modulus of elasticity should be assumed as 666,300.

Professor Lanza states that, judging from results of spruce obtained from Boston, Mass., lumber yards, the ordinary run of spruce would not allow a higher ultimate breaking extreme fibre stress than 3,000 pounds, and even that might in some cases be too high; that the very best selected stock at any one lumber yard would not allow over 4,000 pounds to be used; and to allow 5,000 pounds per square inch to be used special sticks from different dealers would have to be collected, if a considerable amount of such lumber were desired.

b. Transverse strength of yellow pine.

From fifty-one full-size tests of yellow pine beams:—

Ultimate breaking extreme fibre stress in pounds per square inch, 3,963 to 11,360; average, 7,486.

Modulus of elasticity in pounds per square inch, 1,162,467 to 2,386,096; average, 1,757,900.

For the calculation of deflection of a yellow pine beam under a given load to be applied for a long time, the modulus of elasticity should be assumed as 878,950.

Professor Lanza states that for yellow pine of fair quality it would not be correct to use for the ultimate breaking extreme fibre stress a number greater than 5,000 pounds per square inch, especially for large sizes, such as 9x14 inches, 12x16 inches, etc. Although the average result from the tests showed 7,486 pounds, nevertheless in the case of one particular beam it was 5,300, notwithstanding the fact that this beam was quite free from knots, cracks, crooked grain, and other defects, and had been selected as one of exceptionally good quality.

c. Transverse strength of white oak.

From thirty-six full-size tests of white oak cut in Pennsylvania and Ohio:—

Ultimate breaking extreme fibre stress in pounds per square inch, 3,535 to 7,834; average, 5,863.

Modulus of elasticity in pounds per square inch, 744,774 to 1,777,500; average, 1,131,100.

d. Transverse strength of white pine.

From thirty-seven full-size tests of white pine:—

Ultimate breaking extreme fibre stress in pounds per square inch, 2,456 to 7,251; average, 4,451.

Modulus of elasticity in pounds per square inch, 727,200 to 1,565,000; average, 1,122,000.

Eight full-size tests of kiln-dried western white pine showed an average ultimate breaking extreme fibre stress of 5,482, and an average modulus of elasticity of 1,183,037.

e. Transverse strength of hemlock.

From seventeen full-size tests of eastern and Vermont hemlock:—

Ultimate breaking extreme fibre stress in pounds per square inch, 2,059 to 6,535; average, 3,825.

Modulus of elasticity in pounds per square inch, 4[illegible]2,670 to 1,327,200; average, 922,250.

f. Time tests for deflection of timber beams under transverse strain.

From a large number of full-size time tests on spruce and yellow pine beams centrally loaded for different periods, some over half a year, Professor Lanza concludes that the deflection of a timber beam under a long-continued application of the load, may be two or more times that assumed when the load was first applied; and that, in order to compute it by means of the ordinary deflection formulae, the modulus of elasticity should be assumed at not more than one-half the value obtained from quick tests.

APPENDIX E.

MISCELLANEOUS FULL-SIZE TESTS.

a. Some English full-size transverse tests of timber beams, made by Messrs. Edwin Clark, and C. Graham Smith, show the following average values for the ultimate breaking extreme fibre stress, and for the modulus of elasticity, both in pounds, per square inch:—

American red pine....3 tests; fibre stress, 4,842; mod. elast. 1,204,943
Memel fir............2 tests; fibre stress, 5,274; mod. elast. 1,855,900
European pitch pine...4 tests; fibre stress, 6,984; mod elast. 2,046,275
European red pine....2 tests; fibre stress, 4,572; mod. elast. 1,247,000
Quebec yellow pine...4 tests; fibre stress, 4,491; mod. elast. 1,309,833
Baltic fir.............2 tests; fibre stress, 5,454; mod. elast. 1,507,850

b. Messrs. David Kirkaldy & Son, London, England, made a series of full-size tests of American white oak in 1884, for the International Forestry Exhibition, Edinburg, 1884, with following results:—

All sticks, scant four and one-half inches by scant twelve inches; five tests for each average result.

Transverse tests, ultimate breaking extreme fibre stress in pounds per square inch:—five feet span, 6,890 pounds; eleven feet span, 8,550 pounds.

Compression tests, ultimate breaking stress in pounds per square inch:—twenty-five inches long, or about six diameters, 3,285 pounds; fifty inches long, or about eleven diameters, 3,418 pounds; 100 inches long, or about twenty-three diameters, 2,891 pounds.

APPENDIX F.

LONGITUDINAL SHEARING UNDER TRANSVERSE STRAIN.

Beams loaded transversely sometimes fail by shearing longitudinally along the neutral axis. The intensity i, of the longitudinal shearing stress in pounds per square inch in a rectangular beam, is expressed by the formula:—

$$i=\frac{3F}{2bh}$$

where F equals total vertical shear in pounds at the point of beam selected; and b and h respectively the breadth and height of beam in inches. For a center load, W, this formula becomes:—

$$i=\frac{3W}{4bh}$$

a. Professor Lanza found the following average calculated values for the ultimate breaking longitudinal shearing stress in pounds per square inch for the different full-size beam tests conducted in his laboratory:—

For beams that failed by longitudinal shearing—

9 spruce beams, average....................................198 pounds
5 yellow pine beams, average...............................222 pounds
2 white oak beams, average.................................266 pounds
3 white pine beams, average................................151 pounds

For beams that failed by flexure, and not by longitudinal shearing—

58 spruce beams, average...................................182 pounds
45 yellow pine beams, average..............................231 pounds
31 white oak beams, average................................176 pounds
33 white pine beams, average...............................134 pounds
17 hemlock beams, average..................................123 pounds

b. Professor Charles B. Wing, Leland Stanford University, California, published in Engineering News, March 14, 1895, an account of certain full-size tests of Douglas fir beams, two of which failed by longitudinal shearing under transverse loading, the value of the longitudinal shearing stress, calculated by the formula, having been respectively 185 and 143 pounds per square inch. The average calculated longitudinal shearing stress for nine of the full-size beams, that failed by flexure, was at the time of breaking 160 pounds per square inch, or probably very near the ultimate limit. Professor Wing concludes, from these results, that the danger of failure by longitudinal shearing should not be lost sight of in using large timber beams in flexure.

APPENDIX G.

PROFESSOR LANZA'S FULL-SIZE TESTS OF TIMBER COLUMNS.

a. An extensive series of full-size tests of wooden mill-columns were made in 1882 at the United States arsenal, Watertown, Mass., by Professor Lanza, for the Boston Manufacturers' Mutual Fire Insurance Company, the results having been published in a special pamphlet. The columns were generally round, and the ends as a rule flat. The least diameters varied from about 6 to 11 inches, the lengths from about 11 to 14 feet. A series of tests on blocks, 2 feet long, the same size as the columns, were also made, with the result that the ultimate crushing strength of the short blocks was very nearly practically the same as for the columns tested, for which the quotient of length divided by the least diameter varied from about 15 to about 25. In other words, colloquially speaking, the tests covered columns of about 15 to 25 diams.

The results show as follows:

Yellow pine posts and blocks, 18 tests: Ultimate breaking crushing strength in pounds per square inch, 3,604 to 5,452; average, 4,544; modulus of elasticity for crushing in pounds per square inch, 1,631,035 to 2,443,411; average, 1,996,351.

White oak posts and blocks, 10 tests: Ultimate breaking crushing strength in pounds per square inch, 3,132 to 4,450; average, 3,470: modulus of elasticity for crushing in pounds per square inch, 1,104,953 to 1,748,817.

Old and seasoned white oak posts (ten of which had been in use about 25 years), partly with uneven end bearings so as to represent actual conditions existing frequently in old structures, 18 tests: Ultimate breaking crushing strength in pounds per square inch, 2,943 to 6,147; average, 3,957 pounds; modulus of elasticity for crushing in pounds per square inch, 1,448,964 to 2,138,804.

Professor Lanza states, that in all these tests the columns gave way by direct crushing, and hence that the strength of columns of these ratios of length to diameter can properly be found by multiplying the crushing strength per square inch of the wood by the area of the section in square inches.

A set of tests was made of columns with eccentric loading, showing a great falling off of strength, due to the eccentricity of the load.

Professor Lanza offers among others the following conclusions, which are of interest for railroad work:

"The strength of a column of hard pine or oak, with flat ends, the load being uniformly distributed over the ends, and of the diameters tested, is practically independent of the length, for the ratios of length to diameter used in the tests, such columns giving way practically by direct crushing; the deflection, if any, being as a rule very small, and exerting no appreciable influence on the breaking strength.

"The crushing strength per square inch varies considerably in specimens of different degrees of seasoning, also in large and small specimens. The average crushing strength of such yellow pine posts as were tested, not thoroughly seasoned, and not very green, is about 4,400 pounds; whereas for such oak as was furnished me, which was green and knotty, but no more so than is usual for use in building, the average is about 3,200 pounds.

"I would recommend the use of iron caps and pintles, instead of wooden bolsters, as wood is very weak to resist crushing across the grain, and the wooden bolster will fail at a pressure far below that which the column is capable of resisting, and the unevenness of the pressure brought about by the bolster is so great as to sometimes crack the column at a pressure far below what it would otherwise sustain.

"Any cause which operates to distribute the pressure on the ends unevenly, or to force its resultant out of center, is a source of weakness, and brings about a very considerable deflection, which exerts an important influence in reducing the breaking strength."

b. Several tests of some well-seasoned old spruce round struts, of excellent quality, with even flat end bearings, made at the Watertown arsenal for the Jackson Company, showed an average ultimate breaking crushing strength of 5,071 pounds per square inch, the diameter being slack 6 inches and the length full 10 feet, or, in other words, length of strut about 21 diams.

c. Professor Lanza presented at the December, 1894, meeting of the American Society of Mechanical Engineers the results of his latest tests of thirteen full-size fairly well-seasoned spruce columns of fair average quality obtained from Boston lumber yards. Rectangular specimens, about 8 to 10 inches wide, 8 to 12 inches high, and 6 to 18 feet spans. The ratios of length to least side varied from about 9 to 27. The specimens with the higher ratios broke by deflection, those with the lower ratios by crushing.

The results were as follows:

Ultimate breaking crushing stress in pounds per square inch, 1,969 for 15 diams. to 3,195 for 9 diams.; average 20 to 27 diams., 2,424; average 15 to 20 diams., 2,670; average 10 to 15 diams., 2,442; average 9 diams., 2,875; grand average, 2,540. Modulus of elasticity in pounds per square inch, 834,270 to 1,656,300; average, 1,280,260.

APPENDIX H.

U. S. GOVERNMENT FULL-SIZE TESTS OF TIMBER COLUMNS.

a. The most extensive and reliable set of tests of timber struts ever undertaken in this country were made by the United States government in 1880 to 1883, under the direction of Col. T. T. S. Laidley, U. S. A., at the United States arsenal, Watertown, Mass., recorded in Exec.

Doc. No. 12, 47th Congress, 1st session, and Exec. Doc. No. 1, 47th Congress, 2d session. The tests covered full-size white pine and yellow pine rectangular struts with flat end bearings. The areas of the sticks varied from 27 to 235 square inches, and the lengths from 4 to 28 feet. There were several hundred full-size sticks broken.

b. Prof. William H. Burr, of Columbia College, New York City, analyzes these government tests of columns as follows:

Flat end yellow pine columns were observed to begin to fail with deflection at a length of about 22 diameters. The short yellow pine columns, of a less length than 22 diameters, gave an ultimate breaking compression stress in pounds per square inch of 3,430 to 5,677, averaging 4,442. The long yellow pine columns of a length from 22 to 62 diameters gave values respectively from about 3,500 pounds to 1,700 pounds.

Flat end white pine columns began to fail with deflection at a length of 32 diameters. Thirty short white pine columns of a less length than 32 diameters failed generally at knots by direct compression, and gave an ultimate breaking compression stress in pounds per square inch of 1,687 to 3,700, averaging 2,414. The long white pine columns of a length from 32 to 62 diameters gave values respectively from about 2,000 pounds to 1,000 pounds.

A large number of tests were made on compound columns formed of two or three sticks, separated by packing blocks and bolted together at the ends and at the center. The tests showed that the compound columns possessed essentially the same ultimate resistance per square inch as each component stick considered as a column by itself.

c. Some additional full-size tests, made in 1881 for the United States government by Colonel Laidley at Watertown arsenal, on timber struts, showed as follows:

Very straight grained yellow pine, 20 years seasoning, 12 tests, ultimate breaking compressive stress in pounds per square inch, 5,593 to 8,644; average, 7,386.

Very slow growth yellow pine, 3 tests, ultimate breaking compressive stress in pounds per square inch, 7,820 to 10,250; average, 9,339.

Very green and wet yellow pine, 3 tests, ultimate breaking compressive stress in pounds per square inch, 2,795 to 3,180; average, 3,015.

Spruce, thoroughly seasoned, full-size struts, 12 tests, ultimate breaking compressive stress in pounds per square inch, 3,967 to 5,754; average, 4,873.

APPENDIX I.

PROFESSOR BURR'S FORMULAE FOR TIMBER COLUMNS.

Professor William H. Burr, of Columbia College, New York, author of "Elasticity and Resistance of the Materials of Engineering," offers the following formulae for timber struts based upon the above government tests, in which formulae

p = ultimate breaking compression stress in pounds per square inch;
l = length of strut in inches;
d = least side or diameter of strut in inches;
s = safe working compression stress in pounds per square inch.

For yellow pine $$p = 5{,}800 - 70\frac{l}{d}$$

For white pine $$p = 3{,}800 - 47\frac{l}{d}$$

For wooden railway structures, with a factor of safety of about 8, these formulae will read for the safe working stress:

For yellow pine $s = 750 - 9\frac{l}{d}$

For white pine $s = 500 - 6\frac{l}{d}$

For temporary structures, such as bridge falseworks carrying no traffic, with a factor of safety of about 4, these formulae will read for the safe working stress:

For yellow pine $s = 1{,}500 - 18\frac{l}{d}$

For white pine $s = 1{,}000 - 12\frac{l}{d}$

The preceding formulæ are to be used only between the limits of $20\frac{l}{d}$ and $60\frac{l}{d}$ for yellow pine, and between $30\frac{l}{d}$ and $60\frac{l}{d}$ for white pine.

For short columns below $20\frac{l}{d}$ and $30\frac{l}{d}$, respectively for yellow and white pine, use the following unit stresses in pounds per square inch.

	Ultimate.	Safe for railway bridges.	Safe for temporary structures.
Yellow pine....	p = 4400	s = 550	s = 1100
White pine.....	p = 2400	s = 300	s = 600

All these values are applicable to good average lumber for the practical purposes indicated.

APPENDIX J.

PROFESSOR ELY'S FORMULAE FOR TIMBER COLUMNS.

Mr. Edward F. Ely, instructor Massachusetts Institute of Technology, Boston, gives the following rule and unit co-efficients for timber columns based upon the above mentioned government tests. The average and the lowest results of these tests were plotted and the following rule established from the diagrams:

Total breaking strength of column in pounds equals area of section in square inches multiplied by the ultimate breaking crushing strength in pounds per square inch.

The ultimate breaking crushing strength in pounds per square inch for each particular case is obtained from the following table, it being dependent on the ratio of the length to the least side of the rectangular strut.

Kind of Timber.	Length in inches divided by least side of strut in inches.	Ultimate crushing strength in lbs. per square inch.
White pine..............	0 to 10 10 to 35 35 to 45 45 to 60	2,500 2,000 1,500 1,000
Yellow Pine..............	0 to 15 15 to 30 30 to 40 40 to 45 45 to 50 50 to 60	4,000 3,500 3,000 2,500 2.000 1,500

APPENDIX K.

PROFESSOR STANWOOD'S FORMULAE FOR TIMBER COLUMNS.

Mr. James H. Stanwood, instructor Massachusetts Institute of Technology, published in The American Architect and Building News of April 9, 1892, and of March 10, 1894, the following formulae for timber struts based upon the full-size U. S. government tests made at the Watertown Arsenal, and also on full-size tests of Professor Lanza. The experimental data for full-size white and yellow pine struts, on which the formulae are based, are quite extensive and reliable, while there is not so much information at hand covering full-size tests of oak and of spruce columns.

The formulae for the ultimate breaking crushing strength per square inch of columns with square ends are as follows:

For yellow pine $$s = 4{,}250 - 43\tfrac{1}{3}\frac{l}{d}$$

For white pine $$s = 3{,}150 - 40\frac{l}{d}$$

Where s = ultimate breaking crushing stress in pounds per square inch;
l = length of column in inches;
d = least diameter in inches.

The following safe working formulae are recommended:

For yellow pine or white oak (using a factor-of-safety of about $4\frac{1}{4}$)

$$s = 1{,}000 - 10\frac{l}{d}$$

For white pine or spruce (using a factor-of-safety of 4)

$$s = 800 - 10\frac{l}{d}$$

Where s = allowable safe working crushing stress in pounds per square inch, and l and d, same as above.

APPENDIX L.

C. SHALER SMITH'S FORMULAE FOR TIMBER COLUMNS.

Professor Burr, in his book "Elasticity and Resistance of the Materials of Engineering," gives certain data relative to C. Shaler Smith's formula for timber columns that will prove very interesting owing to the extensive use that has been made of this formula.

Mr. C. Shaler Smith conducted, during the winter of 1861-'62, a series of over 1,200 tests of full-size yellow pine square and rectangular columns for the ordnance department of the Confederate government, from which his well-known formula for timber struts was developed.

The tests were grouped as follows:

1. Green, half-seasoned sticks answering to the specification "good merchantable lumber."

2. Selected sticks reasonably straight, and air-seasoned under cover for two years and over.

3. Average sticks cut from lumber which had been in open air service for four years and over.

The formulae for these three groups were,—

For No. 1: $$p = \frac{5{,}400}{1 + \frac{1}{250}\,\frac{l^2}{d^2}}$$

For No. 2: $$p = \frac{8{,}200}{1 + \frac{1}{300}\,\frac{l^2}{d^2}}$$

For No. 3: $$p = \frac{5{,}000}{1 + \frac{1}{250}\,\frac{l^2}{d^2}}$$

Where l = length of column in inches;
d = least side or diameter of column in inches;
p = ultimate breaking compressive stress in pounds per square inch.

In order to provide against ordinary deterioration, and also reckless building, bad workmanship, etc., Mr. Smith recommended the formula for group No. 3 as the best for general application.

He also recommended that the factor-of-safety shall be the square root of the quotient of the length divided by the least diameter until twenty-five diameters are reached, and five thence forward to sixty diameters, which last limit is the extreme for good practice.

Mr. Smith's formula formed the basis of the principal timber column tables in "Trautwine's Pocket Book," but comparison with more recent results of full-size tests will show that it is very safe, unless very bad workmanship or an unusual set of conditions prevail.

Mr. Smith recommended for white pine columns the use of formula No. 3 with 3,000 substituted for the constant 5,000.

APPENDIX M.

PROFESSOR BOVEY'S FULL-SIZE TESTS OF CANADIAN DOUGLAS FIR, RED PINE, WHITE PINE, AND SPRUCE.

Professor Henry T. Bovey, of McGill University, Montreal, Can., presented a most valuable and voluminous paper on "The Strength of Canadian Douglas Fir, Red Pine, White Pine, and Spruce," to the Canadian Society of Civil Engineers, Transactions, Vol. IX., January 25, 1895, based upon the experiments conducted for a period of more than two years in the testing laboratories of McGill University. The paper covers 110 pages of the printed transactions and gives minute information as to the manner of conducting the tests, the origin, quality, and condition of the timber tested, as also full and detail results of the tests. A synopsis of this valuable paper is all that can be attempted here. Parties directly interested should obtain the full report by addressing Professor Bovey or the Canadian Society of Civil Engineers at Montreal.

Professor Bovey makes the following general remark:—"The tables showing the deflections of beams under transverse loading, and also the tables showing the extension of specimens under direct tension, tend to prove conclusively the statement made by the author many years ago. i. e., that timber, unlike iron and steel, may be strained to a point near the breaking point without being seriously injured. It will be observed that in almost all cases the increments of deflection and extension, almost up to the point of fracture, are very nearly proportional to the increments of load, and it seems impossible to define a limit of elasticity for timber. This probably accounts for the continued existence of many timber structures in which the timbers have been and are still continually subjected to excessive stresses, the factor of safety being often less than 1½. Whether it is advisable so to strain timber is another question, and experiments are still required to show how timber is affected by frequently repeated strains."

The Douglas fir used in these tests came from British Columbia. The red pine was cut in 1893 in the neighborhood of the Bonnechere River, Nipissing District, County Renfrew, Ontario (west of the city of Ottawa). The white pine came from the valleys of tributaries of the Ottawa River, northerly and westerly from the city of Ottawa. The new spruce was cut near the Skeena River, British Columbia, on the Pacific coast, about 600 miles north of Victoria. The old spruce was from the Province of Quebec, west of Maine.

I. TRANSVERSE STRENGTH.

In the transverse tests the results given are the calculated "Maximum Skin Stress" (ultimate breaking extreme fibre stress) in pounds per square inch, and the "Co-efficient of Elasticity" (modulus of elasticity) in pounds, corresponding to the actual breaking load applied at the center of the span.

All the tests were made on large size sticks with spans varying from 5½ feet to 24 feet.

The weight of timber is given in pounds per cubic foot at date of test.

a. Transverse strength of Canadian Douglas fir.

Large size sticks, spans 5½ to 17 feet, breaking load applied centrally.

		Maximum skin stress lbs. per square inch.	Co-efficient of elasticity. Pounds.	Weight in lbs. per cu. foot.
New timber, Specially Selected, Four tests.	minimum	8,020	1,934,500	38.92
	maximum	10,441	2,178,100	41.22
	average	9,054	2,036,529	40.02
New timber, First quality, Fifteen tests.	minimum	4,027	926,500	28.27
	maximum	8,382	1,770,563	37.80
	average	6,081	1,431,209	33.80
Old trestle timber:				
6½ years in use		6,135	1,201,620	32.80
8 years in use		7,339	1,878,950	38.59
9 years in use		7,086	1,665,560	33.75
11 years in use		4,613	949,270	33.11

Professor Bovey recommends the following data for adoption in practice:

"In the case of specially selected timber, free from knots, with sound, clear, and straight grain, and cut out of the log at a distance from the heart,—

Average weight in lbs: per cubic foot = 40.
Average coefficient of elasticity in lbs. per square inch = 2,000,000.
Average maximum skin stress in lbs. per square inch = 9,000.
Safe working skin stress in lbs. per square inch = 3,000.

"In the case of first quality timber, such as is ordinarily found in the market,—

Average weight in lbs. per cubic foot = 34.
Average coefficient of elasticity in lbs. per square inch = 1,430,000.
Average maximum skin stress in lbs. per square inch = 6,000.
Safe working skin stress in lbs. per square inch = 2,000.

"In specifying these data it will be observed that 3 is adopted as the factor of safety. Upon this hypothesis the factor of safety for the stick giving the minimum skin stress is more than 2, and this, in the opinion of the author, is an ample factor for a material which experience and all experiments show, may be strained without danger very nearly up to the point of fracture.

"Further, the results obtained in the experiments with the old stringers show that the strength of the timber had been retained to a very large extent, and that the rotting had not extended to such a depth below the skin as to sensibly affect the efficiency of the sticks, which still possessed ample strength for the work which they were designed to do.

"If 2 is adopted as the factor of safety, and, in the opinion of the author, 2 is an ample factor for the great majority of cases, the rotting (in these old stringers) might extend without danger to a depth of 3.4 inches.

"Again, it will be observed that the skin stress and the elasticity are subject to a wide variation. This variation is due to many causes, of which the most important are the presence of knots, obliquity of grain, and, more than all, the locality in which the timber was grown, the original position of the stick in the log from which it was cut, and the proportion of hard to soft fibre, or of the summer to the spring growth. The tensile, shearing, and compressive experiments upon specimens cut out of different parts of the same log all show that the timber near the heart possesses much less strength and stiffness than the timber at a distance from the heart.

"A careful study of the results obtained up to date would seem to indicate that the best classification defining the strength of the timber would be found by dividing the section of a log into three parts by means of two circles, with the heart as the center, and by designating the central portion as third quality, the portion between the two circles as second quality, and the outermost portion as first quality."

A most interesting paper on the structural characteristics of Douglas fir from a botanical standpoint was read by Professor Penhallow, F. R. S. C., at the meeting of the Royal Society of Canada, in Ottawa, in 1894, in connection with a paper read by Professor Bovey on the strength of the timber (Transactions Royal Society of Canada, Section III., 1894, Papers Nos. 11. and III.).

b. Transverse strength of Canadian red pine.

Large size sticks; spans, 13 to 17½ feet; breaking load applied centrally.

		Maximum skin stress lbs. per square inch.	Co-efficiênt of elasticity. Pounds.	Weight in lbs. per cu. foot.
New timber, 6x7 in to 6x13 in., 6 tests.	minimum	3,937	1,198,550	30.96
	maximum	6,752	1,802,633	37.55
	average	5,137	1,434,747	34.78
New timber, 3x8 in. to 3x11 in., 4 tests.	minimum	4,339	1,575,200	31.56
	maximum	6,928	1,784,800	37.69
	average	5,725	1,648,519	34.43

Professor Bovey recommends the following data for adoption in practice:

Average weight in lbs. per cubic foot = 34.6.
Average coefficient of elasticity in lbs. per square inch = 1,430,000.
Average maximum skin stress in lbs. per square inch = 5,100.
Average safe working skin stress in lbs. per square inch (3 being the factor of safety) = 1,700.

"In the accounts of the several beams it will be observed that the failures are almost invariably due to the crippling of the material on the side in compression, indicating that the tensile strength of the timber exceeds its compressive strength, and this was subsequently verified by the direct tension and compression experiments."

c. Transverse strength of Canadian white pine.

Sizes 9 in. x 15 in. and 9 in. x 18 in.; spans, 8½ to 24 feet; breaking load applied centrally.

		Maximum skin stress lbs. per square inch.	Co-efficient of Elasticity. Pounds.	Weight in lbs. per cu. foot.
New Timber, 15 tests.	Minimum	2,500	433,250	33.64
	Maximum	4,936	1,184,240	41.49
	Average	3,388	754,265	37.88
Old Stringers, in use 8 years, 3 tests.	Minimum	2,495	650,930	26.08
	Maximum	3,589	982,480	28.30
	Average	3,099	854,333	27.54

Professor Bovey recommends the following data for adoption in practice:

Average weight in lbs. per cubic foot = 37.8.
Average co-efficient of elasticity in lbs. per square inch = 754,000.
Average maximum skin stress in lbs. per square inch = 3,300.
Average safe working skin stress in lbs. per square inch (3 being the factor of safety) = 1,100.

"Further experiments will probably show that these data require some modification. The actual skin stress and coefficients of elasticity are certainly greater than those given above."

d. Transverse strength of Canadian spruce.

Large size sticks; spans 10 to 24 feet; breaking load applied centrally.

		Maximum skin stress lbs. per square inch.	Co-efficient of Elasticity. Pounds.	Weight in lbs. per cu. foot.
New Timber, 3 tests, all from same log.	Minimum	4,614	1,011,460	26.61
	Maximum	5,908	1,528,499	26.61
	Average	5,120	1,203,633	26.61
Old Bridge and Culvert Stringers, 3 to 8 years in use, 5 tests.	Minimum	2 934	905,601	26.47
	Maximum	5,709	1,352,250	33.09
	Average	3,875	1,189,800	29.15

II.—COMPRESSIVE STRENGTH.

The tests for compressive strength were made on sticks with from 5 to 40 square inches of cross-section, and in lengths from a few inches up to 6½ feet. The result given in each case is the ultimate breaking load in pounds per square inch of cross-section of stick.

The experiments were made chiefly with columns cut out of the sticks already tested transversely. These columns were carefully examined to see that the previous test of stick had caused no injury.

Professor Bovey states that the following inferences from the compressive tests may be drawn:

"The compressive strength of Douglas fir and of other soft timbers is much less near the heart than at a distance from the heart. The compressive strength of the timber increases with the density of the annular rings.

"When knots are present in a timber column, the column will almost invariably fail at a knot, or in consequence of the proximity of a knot.

"Any imperfection, as, for example, a small hole made by an ordinary cant hook, tends to introduce incipient bending or crippling.

"When the failures of average specimens commence by an initial bending, the compressive strengths of columns of about 10 to 25 diameters in length agree very well with the results obtained by Gordon's formula, the coefficients of direct compressive strength per square inch being 6,000 pounds for Douglas fir, and 5,000 pounds for white pine.

"Gordon's formula, however, is not at all applicable in the case of specially good or bad specimens. It is often found that a very clear, sound specimen, of even more than 20 diameters in length, will show no signs of bending, but will suddenly fail by crippling under a load as great as that sufficient to crush a shorter specimen.

"The greatest care should be observed in avoiding obliqueness of grain in columns, as the effective bearing area, and therefore also the strength, are considerably diminished.

"If the end bearings are not perfectly flat and parallel, the columns will in all probability fail by bending concave to the longest side.

"The average strength per square inch, independent of the ratio of length to diameter, is,—

New Douglas fir	5,974 lbs.,	average of 122 tests
Old Douglas fir	6,265 lbs.,	average of 54 tests
New red pine	4,067 lbs.,	average of 35 tests
New white pine	3,843 lbs.,	average of 68 tests
Old white pine	2,772 lbs.,	average of 56 tests
New spruce (British Columbia)	3,617 lbs.,	average of 69 tests
Old spruce	5,136 lbs.,	average of 20 tests

"It should be pointed out that none of the old Douglas fir columns exceeded 4.4 diameters in length, while the great majority of the new Douglas fir columns were from 4 to 25 diameters in length. This explains the reason of the greater average compressive strength of the old Douglas fir. A similar remark applies to the new and old spruce."

III.—TENSILE STRENGTH.

The tests for tensile strength were made on uninjured pieces of the beams previously broken by transverse strain. The specimens were less than one square inch in cross-section. Particular attention was paid to the effect of repeated loadings, also to a comparison of strength and stiffness in different portions of the same log. The recorded results are too voluminous to be given here in detail.

Professor Bovey states that the results of the tensile tests will show:—

"That the increments of extension, up to the point of fracture, are almost directly proportional to the increments of load.

"That the presence of knots is most detrimental both to the strength and to the stiffness, inasmuch as they practically diminish the effective sectional area, and also produce a curvature in the grain.

"That wood near the heart possesses much less strength, and much less stiffness than that more distant from the heart.

"That the strength and stiffness are also dependent upon the proportion of summer to spring growth.

"That irregularities of readings, both with the extensometer and with the rule, are chiefly due to the presence of a knot, or to curly or oblique grain caused by a knot."

a. Tensile strength of Canadian Douglas fir.

Owing to the small size of the specimens, the variations in the quality of the material, especially the presence of a knot or curly or oblique grain, cause a most marked difference in the recorded tensile breaking weight in pounds per square inch of cross-section.

The results of seventy-one tests of new Douglas fir vary from 2,485 to 18,856 pounds; averaging 11,612 pounds.

If the thirteen results less than 8,000 pounds be excluded, as being clearly caused by imperfections in the material, the average of the remaining fifty-eight tests will be 12,955.

To show that the recorded maximum of 18,856 pounds is not a phenomenon or an error, it would be well to mention that there are fifteen results from 15,000 to 18,856 pounds; namely, nine above 15,000, two above 16,000, two above 17,000, and two above 18,000.

Four tests of old Douglas fir showed a minimum tensile strength of 11,414 pounds per square inch, a maximum of 13,954 pounds, and an average of 12,663 pounds.

b. Tensile strength of Canadian red pine.

Nine tests of red pine showed a minimum tensile strength of 6,274 pounds per square inch, a maximum of 14,372 pounds, and an average of 10,644 pounds.

c. Tensile strength of Canadian white pine.

Ten tests of white pine showed a minimum tensile strength of 8,503 pounds per square inch, a maximum of 14,273 pounds, and an average of 11,396 pounds.

d. Tensile strength of old Canadian spruce.

Fifteen tests of old Canadian spruce showed a minimum tensile strength of 7,662 pounds per square inch, a maximum of 12,792 pounds, and an average of 9,763 pounds.

IV.—SHEARING STRENGTH.

Great difficulty is encountered in tests for shearing strength to get absolutely reliable results.

The shearing strengths, which are of importance, are the resistances along planes tangential and radial to the annular rings. The compound shearing strength can be considered as the resultant of the tangential and radial shears.

Professor Bovey states that the following inferences may be drawn from the results of the shearing experiments:—

"The shearing strength of the timbers is much less near the heart than at a distance from the heart.

"Generally speaking, the shearing strength increases with the weight per cubic foot.

"The shearing strength increases with the density of the annular rings, or rather with the proportion of hard to soft fibre.

"A failure sometimes occurs, for which it is difficult to find a complete explanation.

"As a result of the experiments, the average (breaking) shearing strength of Douglas fir in pounds per square inch is 411, 377, or 403, according as the plane of shear is tangential, at right angles, or oblique to the annular rings.

"In practice, therefore, it will be safe to adopt as the average (breaking) co-efficients of shearing strength for Douglas fir, 400 pounds per square inch for shears tangential and oblique to the annular rings, and 375 pounds per square inch for shears at right angles to the annular rings."

Average breaking shearing strength in pounds, per square inch.

Kind of Timber.	Tangential Shear.	Radial Shear.	Oblique Shear.
New Douglas fir	411	377	403
Old Douglas fir	302	310	371
Canadian red pine	392	....	333
Canadian white pine	382	273	363
Old Canadian spruce	332	389	382

The number of tests on which above table is based is not very large, which fact, combined with the acknowledged difficulty of obtaining accurate shearing tests, should cause the data presented to be considered as approximate only.

APENDIX N.

REPORT OF WASHINGTON STATE CHAPTER, AMERICAN INSTITUTE OF ARCHITECTS, ON STRENGTH OF STATE OF WASHINGTON TIMBERS.

In the California Architect and Building News, of March, 1895, there is published a report of a special committee of the Washington State Chapter of the American Institute of Architects on "Authenticated Tests of Building Materials of the State of Washington," which gives valuable information from actual breaking tests of the transverse strength of Washington timbers, the figures given below indicating the calculated ultimate breaking stress in extreme fibre in pounds per square inch, based upon the actual breaking load applied at the center of the span.

a. Transverse tests by C. B. Talbot, Civil Engineer, Northern Pacific Railroad.

Size, 2x4 inches; span, 4 feet. Ultimate extreme fibre stress in pounds per square inch.

Washington yellow fir, age 1½ months to 6 years; minimum, 6,890 lbs.; maximum, 9,720 lbs.; average of 5 tests, 7,847 lbs.

b. Transverse tests by A. J. Hart, M. C., Chicago, Milwaukee and St. Paul Railway.

Sizes, 6x14 inches, 8x16 inches, and 9x16 inches; span, 16 to 20 feet. Ultimate extreme fibre stress in pounds per square inch.

Washington yellow fire, age, 1 day cut; minimum, 6,143 lbs.; maximum, 7,982 lbs.; average of 4 tests, 7,323 lbs.

Ditto, age 6 years; minimum, 5,953 lbs.: maximum, 6,088 lbs.; average of 2 tests, 6,020 lbs.

Ditto, used 6 years in a bridge; minimum, 4,138 lbs.; maximum, 5,817 lbs.; average of 2 tests, 4,978 lbs.

c. Transverse tests at mills of St. Paul and Tacoma Lumber Company, Tacoma, Washington, March, 1890, by A. J. Hart and C. B. Talbot.

Sizes, 6x14 inches, 8x16 inches, and 9x16 inches; spans, 11 to 17 feet. Ultimate extreme fibre stress in pounds per square inch.

Washington (Douglas) fir, minimum, 5,263 lbs.; maximum, 7,561 lbs.; average of 9 tests, 6,273 lbs.

Ditto, age 3 years; 1 test, 5,591 lbs.

Ditto, age 6 years; 1 test, 3,725 lbs.

Ditto, culled stick; 1 test, 3,544 lbs.

d. Transverse tests by S. Kedzie Smith, City Engineer, Ballard, Washington.

Sizes, 3x8 inches, 3x12 inches, and 4x12 inches; spans, 8 to 14 feet. Ultimate extreme fibre stress in pounds per square inch. Quality of lumber a little above the grade of good merchantable lumber, air seasoned for forty days.

Washington red fir, medium fine grained; 1 test, 6,138 lbs.

Ditto, coarse grained; minimum, 4,605 lbs.; maximum, 5,700 lbs., average of 6 tests, 5,182 lbs.

Ditto, very coarse grained; 1 test, 4,255 lbs.

Ditto, grand average of above 8 tests, 5,186 lbs.

Washington yellow fir, close grained; minimum, 7,500 lbs.; maximum, 8,160 lbs.; average of 2 tests, 7,830 lbs.

e. Comparative transverse tests by C. B. Talbot, Civil Engineer, Northern Pacific Railroad.

Size, 2x4 inches; length, 4 feet; clear span, 3 feet 9 inches; breaking load applied at center of span. Ultimate extreme fibre stress in pounds per square inch.

Washington fir, age 3 months; hard, fine grained; actual breaking load, 4,320 lbs.; extreme fibre strain, 9,720 lbs.

Coeur d' Alene (Washington) pine, age 1½ months; fine grained; actual breaking load, 2,274 lbs.; extreme fibre strain, 5,116 lbs.

Eastern oak, age 1 year; dry; actual breaking load, 2,428 lbs.; extreme fibre strain, 5,463 lbs.

Eastern white pine, age 1 year; dry; actual breaking load, 1,610 lbs.; extreme fibre strain, 3,622 lbs.

In other words, the transverse strength of Eastern white pine, Eastern oak, Washington pine, and Washinfiton fir, is relatively propor tional to 1,610, 2,428, 5,116, and 9,720, or approximately as 1 to 1½, to 3 1-5 to 6.

f. The following are the averages of all tests for transverse strength, (excepting culls, and old bridge timbers), mentioned in the above committee report, giving the ultimate breaking extreme fibre stress per square inch:—

Washington yellow fir, 13 tests, 7,402 lbs.

Douglas fir, 11 tests, 5,979 lbs.

Washington red fir, 8 tests, 5,186 lbs.

Grand average of all kinds of Washington or Douglas fir, 32 tests, 6,359 lbs.

APPENDIX O.

MISCELLANEOUS TESTS OF THE NORTHWEST AND PACIFIC COAST TIMBERS.

a. In addition to 10 full-size tests of Washington fir, mentioned above (Appendix "N, d"), Mr. S. Kedzie Smith, city engineer, Ballard, Wash., made 9 similar tests reported in The Puget Sound Lumberman, August, 1894, and February, 1895. The results from these 19 full-size tests are,—

Ultimate extreme fibre stress in pounds per square inch, 3,530 to 8,160, average 5,420.

b. Mr. Arthur Brown, superintendent bridges and buildings, Southern Pacific Railroad, established following average ultimate breaking stresses as results of tests of Pacific Northwest fir (The Puget Sound Lumberman, February, 1894):

Tensile	15,900 lbs. per square inch
Crushing	6,000 lbs. per square inch
Shearing with the grain................	600 lbs. per square inch
Modulus of elasticity..................	1,272,000 lbs. per square inch
Transverse (extreme fibre stress)........	13,630 lbs. per square inch

c. The results of about 40 transverse tests of California Spruce and Oregon Pine, made by Professor Thurston at the Stevens Institute of Technology for the United States Geological Survey in 1880, were as follows:

Average Ultimate Breaking Extreme fibre stress in pounds per square inch, for California spruce, 12,228, and for Oregon pine, 11,071.

Average Ultimate Breaking Compressive stress for short pieces in pounds per square inch, for California spruce, 9,200 pounds to 12,800, and for Oregon pine, 9,200 to 11,500.

d. In Engineering News of April 20, 1893, Mr. W. B. Wright, formerly division engineer, M., St. P. & S. Ste. M. Railway, gives information relative to some tests of Oregon pine or Douglas fir from the State of Washington made by Mr. George S. Morrison at the Pittsburg Testing Laboratory, in 1886. There is a distinction made between red and yellow fir. The average co-efficients of ultimate breaking strength in pounds per square inch were as follows:

Compression, Red Fir, 2 tests, 6,099 lbs.
Yellow Fir, 2 tests, 6,132 lbs.
Tension, Red Fir, 4 tests, 10,872 lbs.
Yellow Fir, 5 tests, 11,550 lbs.
Transverse Strength, Red Fir, 11 tests, 15,894 lbs.
Yellow Fir, 9 tests, 15,030 lbs.

e. A few small-size tests of Douglas fir and Oregon Sugar pine were made at the machine shops of the Oregon and California Railroad with results given below. Specimens for crushing test were 1 inch square and 24 inches long; for transverse test, 1 inch square and 12 inches span; for tensile test, 1-10 inch by 1 inch.

Ultimate Breaking Strength in Pounds per Square Inch.

	Douglas Fir.	Oregon Sugar Pine.
Crushing strength (24 diams.)	3,085	3,391
Transverse strength, extreme fiber stress	8,658	8,370
Tensi e strength	16,600	11,000
Sidewise crushing at 1000 lbs. pressure per square inch	2-100 in. indent.	4-100 in. indent.
Shearing strength, 13 tests:		
Least	515	
Greatest	833	
Average	689	

APPENDIX P.

PROFESSOR SOULE'S TESTS OF CALIFORNIA REDWOOD.

Special Bulletin No. 2, June 1, 1895, University of California, Department of Civil Engineering, gives the data from tests thus far conducted on California Redwood in the University laboratory by Mr. Frank Soule, professor of civil engineering, as follows:

Clear, straight-grained, well air-seasoned and dry Humboldt Redwood (Sequoia Sempervirens).

Average specific gravity of 126 pieces, .48.

Average weight per cubic foot, 29.91 pounds.

Percentage of moisture, average, 15 per cent.

Ultimate strength.	Pounds per square inch.
Tension, 27 specimens	6,521
Compression, longitudinal, 31 specimens	4,385
Compression across the fibre, reduction in height of piece of 3 per cent., 30 specimens	966
Compression across the fibre, reduction in height of 15 per cent., 30 specimens	1,197
Longitudinal shear (pieces clamped to prevent splitting) 8 specimens	548
Modulus of rupture, 9 specimens	4,955
Coefficient (modulus) of elasticity, 8 specimens	797,467

APPENDIX Q.

UNITED STATES GOVERNMENT WATERTOWN ARSENAL TESTS OF THE SHEARING STRENGTH OF TIMBER WITH THE GRAIN RESISTING THE PULLING OUT OF PINS OR KEYS.

Col. T. T. S. Laidley, United States army, made some tests for the United States government in 1881, at the Watertown arsenal on the resistance offered by timber to the shearing out of round bolts or square keys, the force being exerted with the grain of the timber. The bolts and square keys were of wrought iron, the bolts 1 inch in diameter, and the keys 1 inch and 1¼ inch. The timber specimens were 2 inches thick and thoroughly seasoned. The surface resisting shearing was therefore twice the distance of the center of the hole from the end of the stick multiplied by the thickness of the stick, which in this case was two inches.

Ultimate Breaking Shearing Stress with the grain in pounds per square inch resisting the tearing out of bolts and keys.

Timber.	Center of Hole from End of Specimen.					Average.
	2 in.	4 in.	6 in.	7 in.	8 in.	
Spruce:						
Round bolt	399	359	275	......	202	309
Square key	410	329	242	279	......	315
White pine:						
Round bolt	457	611	450	......	327	461
Square key	550	412	332	236	......	382
Yellow pine:						
Round bolt	607	720	456	......	337	530
Square key	599	369	572	438	......	494

APPENDIX R.

TRANSVERSE TESTS OF FULL-SIZE OLD AND NEW BRIDGE STRINGERS MADE FOR THE CHICAGO, MILWAUKEE AND ST. PAUL RAILWAY, UNDER THE DIRECTION OF MR. ONWARD BATES.

Mr. Onward Bates, engineer and superintendent of bridges and buildings, Chicago, Milwaukee and St. Paul Railway, presented a paper on "Pine Stringers and Floor Beams for Bridges," to the American Society of Civil Engineers (Transactions, November, 1890), in which the detail results are given of 67 full-size tests of new and old bridge stringers of white pine, Norway pine, and Douglas fir, made under Mr. Bates' direction.

Mr. Bates states that the tests lead to the following conclusions:

"Green timber is not as strong as after it has seasoned."

"Age and use do not weaken the timber. It preserves its strength until weakened by decay."

"Knots do weaken the timber seriously, both in reducing the effective section of the beam, and in causing the fibre to be curly and cross-grained."

"While age does not weaken the timber itself, it weakens it by season-checking."

The paper contains very valuable and pertinent information as to the quality and characteristics of bridge timbers of the kinds examined. Also a report of Mr. A. J. Hart on Douglas fir.

The principal average results obtained in the three sets of tests, made respectively at West Milwaukee, Minneapolis, and in the territory of Washington, are as follows:

a. Results from forty full-size transverse tests of bridge stringers made at West Milwaukee shops, April, 1889, by Mr. George Gibbs, mechanical engineer, of which 30 stringers were of white pine and 10 stringers of Norway pine, and of which 14 were new stringers selected indiscriminately from accepted stock, and 26 were bridge stringers that had been in use from 3½ to 8½ years:

Ultimate breaking extreme fibre stress in pounds per square inch, 2,350 to 5,376; average, 3,906.

Modulus of elasticity in pounds per square inch, 712,500 to 1,684,100; average, 1,123,090.

The range of results according to the age, kind, and section of stick is given in the tables accompanying the paper, and is very instructive.

b. Results from 14 full-size transverse tests of new white pine bridge stringers made at Minneapolis, December, 1889, by Mr. A. J. Hart, district carpenter, of which 7 stringers were from accepted stock, and 7 stringers from stock that had been rejected by the railroad lumber inspectors.

Ultimate breaking extreme fibre stress in pounds per square inch:

Seven accepted sticks, 3,162 to 5,131; average, 4,140.

Seven rejected sticks, 2,160 to 4,178; average, 3,248.

Average of all 14 sticks, 2,160 to 5,131; grand average, 3,694.

c. The results from 12 full-size transverse tests of Douglas fir bridge stringers, made by Mr. A. J. Hart, at the mills in the territory of Washington, March, 1890, have been mentioned above in Appendix N. Of these sticks 9 were new timber, 2 had been in use for 3 years each, and 1 for 6 years. Mr. Bates sums up the results as follows:

Ultimate breaking extreme fibre stress in pounds per square inch:

All 12 tests, 3,597 to 7,544; average, 5,791.

Omitting a very old and dry stick, that had been in use 6 years, and also a green stick of very poor quality, the results of 10 tests were 5,268 to 7,544; average, 6,214.

APPENDIX S.

COMPARATIVE TRANSVERSE TESTS OF FULL-SIZE OLD AND NEW WHITE PINE BRIDGE STRINGERS. MADE BY MR. W. H. FINLEY FOR THE CHICAGO AND NORTHWESTERN RAILWAY.

Mr. W. H. Finley, engineer of bridges, Chicago and Northwestern Railway, published in Engineering News of May 23, 1895, also in The Railway Review of June 1, 1895, the detail results of full-size comparative transverse tests of old and new white-pine bridge stringers, made at West Chicago shops, April 18, 1895.

There were 12 pieces of old stringers from the 85 foot covered Howe truss span, erected over the Fond du Lac River, Wisconsin, in 1864, and taken down in March, 1895, hence representing timber 31 years in actual use.

Results from the 12 pieces were as follows:

Ultimate breaking extreme fibre stress in pounds per square inch, 5,139 to 10,616; average, 7,051.

Modulus of elasticity in pounds per square inch, 715,000 to 1,900,000; average, 1,208,250.

For comparison two 10-inch by 10-inch sticks were selected from the stock of new white pine in the railroad company's lumber yard at West Chicago. The sticks were well seasoned, and above the average in quality. The results were as follows:

Average ultimate breaking extreme fibre stress in pounds per square inch, 5,402; modulus of elasticity in pounds per square inch, 982,500.

Mr. Finley remarks that these tests confirm the conclusions reached by Mr. Onward Bates in the similar tests conducted by him (see Appendix R), namely:

"Green timber is not as strong as after it is seasoned."

"Age and use do not weaken the timber. It preserves its strength until weakened by decay."

APPENDIX T.

TESTS OF DOUGLAS FIR AND CALIFORNIA REDWOOD MADE FOR THE SOUTHERN PACIFIC RAILWAY BY MR. JOHN D. ISAAOS.

Mr. John D. Isaacs, assistant engineer, Southern Pacific Railway, summarizes the results of tests made under his direction as follows:

"Regarding strength of Oregon pine (properly Douglas fir) and Redwood timber, the following are the averages of many experiments (neglecting abnormal results) made several years prior to 1895, by our company under my supervision."

Ultimate Breaking Strength in pounds per square inch.

	Douglas Fir.	Redwood.
Tensile	15,900	8,000
Crushing	6,000	3,000
Shearing parallel with grain	600	276
Modulus of elasticity	1,272,000	600,000

Allowable Safe Unit Stresses in pounds per square inch.
Used in practice under ordinary conditions, by Mr. Isaacs.

	Douglas Fir.	Redwood.
Tensile	1 600	800
Crushing	1,200	600
Shearing parallel with grain	150	50
Bearing perpendicular to grain	400	150

"In trestlework red wood is principally used for sills, posts, and caps, or wherever the timber is subject to rapid decay, although creosoted fir timber has been replacing red wood for the latter purpose on the Southern Pacific Railway system.

"The tests were made as follows: A large number of logs were cut from different portions of trees from various localities and exposures. After air-seasoning the logs were cut into 1 inch square pieces; half of the pieces from each section were tested by tensile and the other half by compressive strain, the pieces being turned down to a round for about 8 inches in length. All pieces were tested, except such showing sap or splits running across the grain. The diameters were gauged very carefully. The machine was a home-made apparatus of about 25,000 pounds capacity, with a pressure gauge for recording pressures. The shearing tests were made by pulling a half-inch round out of some of the one-inch pieces. The modulus of elasticity was determined by bending pieces of various dimensions.

"All of the experimental results have been checked at various times by isolated experiments. An extended experience with a great variety of timber structures has confirmed my opinion that the units given above are just right for good practice.

"While the testing methods, as compared with more efficient laboratory machines, may appear somewhat crude, the results obtained are probably just as near the truth, considering the varying characteristics of different pieces of the same species of timber."

APPENDIX U.

PROFESSOR WING'S FULL-SIZE TRANSVERSE TESTS OF DOUGLAS FIR.

Professor Charles B. Wing, Leland Stanford University, California, published in Engineering News of March 14, 1895, an account of the methods used and results obtained by him in a series of full-size transverse tests of Douglas fir. None of the specimens were selected for testing. The timber was ordered from a San Francisco lumber yard, and would probably rate as a poor lot of "No. 1 Merchantable." The sticks contained considerable sap. Some of the sticks failed by shearing along the fibre parallel to the length of the specimen (see Appendix "F.—b."). Professor Wing states that it was noted that knots, even when sound and tight, weakened the stick by decreasing the section, and by causing the fibre to be cross-grained and curly, easily crushing when in compression.

The ultimate breaking extreme fibre stress in pounds per square inch obtained from ten sticks, each 6 in. x 10 in. x 17 feet long, was 4,590 to 7,951, average 6,293. The stick giving the limit of 4,590 was a stick that would have been culled in an ordinary lumber inspection. Excluding this stick the results ran from 5,580 to 7,951, average 6,482.

An additional series of ten tests was made with pieces 3 in. x 5 in. x 4 ft. 3 in. long, cut from uninjured parts of the large sticks that had been previously broken. The results showed ultimate breaking extreme fibre stress in pounds per square inch, from 6,438 to 12,056, average 9,-257. The stick giving the lowest limit had a knot through the center. Excluding this the lowest limit was 7,960.

APPENDIX V.

MR. A. L. JOHNSON'S FORMULA FOR TIMBER COLUMNS.

Mr. A. L. Johnson, civil engineer, in charge of physical tests of U. S. Forestry Division under the direction of Prof. J. B. Johnson, of Washington University, St. Louis, Mo., with the consent of Dr. B. E. Fernow, chief of forestry division, has kindly contributed the following formula for timber columns, which is exceedingly valuable, not only as being the latest contribution on the subject, but especially as it is based on unpublished actual full-size tests made at Washington University, supplemented by a critical study and examination of previous full-size column tests.

Mr. Johnson writes on September 13, 1895, as follows:

The formula was obtained by plotting the tests of full-size beams, and is as follows for timber columns with square ends (but not for fixed ends):

$$f = F \times \frac{700 + 15c}{700 + 15c + c^2}$$

where f = ultimate breaking unit crushing stress on long column;
c = ratio of length to least cross-sectional dimension $\left(\frac{l}{d}\right)$;
F = ultimate breaking unit crushing stress on short column.

Mr. Johnson recommends the following values for F, those for American white oak, long-leaf pine, short-leaf pine, white pine, and cypress being obtained from recent tests of the U. S. Forestry Division, the other values being compiled from the best information available:

Ultimate Breaking Crushing Stress for short columns in pounds per square inch.

American white oak	4,000	Red cedar	3,500
Long-leaf pine	5,000	California redwood	3,250
Short-leaf pine	4,200	Norway pine	3,800
White pine	3,500	Colorado pine	3,150
Bald cypress	3,375	Douglas fir	4,400

Mr. Johnson explains that all long-column formulae, prior to the above one presented by him, are based upon the assumption that a "square-ended" column is practically a "fixed-ended" column, and hence half the length of the column is the length used for the theoretical investigations. In reality the so-called square-ended columns in practice can hardly be considered as fixed-ended, in spite of the end fastenings, and hence the lateral deflection curve under compression will be a true continuous curve from one end of the column to the other, and that the theoretical deductions should be based upon the full length of the column.

Mr. Johnson considers his formula as of very nearly if not the true theoretical form, and the co-efficients are entirely empirical, based upon actual tests, hence its superior value to previous column-formulae.

APPENDIX W.

MR. A. L. JOHNSON'S RECOMMENDATIONS FOR UNIT VALUES.

Mr. A. L. Johnson, civil engineer, in charge of physical tests of U. S. Forestry Division, under the direction of Prof. J. B. Johnson, of Washington University, St. Louis, Mo., with the consent of Dr. B. E. Fernow, chief of forestry division, has kindly contributed the accompanying table showing the values recommended by him for the ultimate breaking unit stress of various kinds of timber. The values for American white oak, long-leaf pine, short-leaf pine, white pine, and cypress are obtained from results of the tests conducted since 1890 by the U. S. Forestry Division, and hence can be considered as authoritative advance information as to the best average values shown by these tests, the test results for all the species mentioned, excepting for long-leaf pine, not having been published up to the present time. The values for the other species given in the table, of which the U. S. Forestry Division has made no tests, were compiled by Mr. Johnson from the best test data available, making due allowance for the fact that much of the data at hand was based on small-size tests. The units given in the table are for large-size sticks as used in practice.

The ultimate crushing strength across grain is taken as the stress, producing an indentation of three per cent. of the thickness of the compressed stick.

Recommended Values for Unit Stresses of Timber. A. L. Johnson, October, 1895. Ultimate Breaking Stresses in Pounds Per Square Inch.

Species.		Modulus of strength at rupture in lbs. per sq. in.	Modulus of elasticity in lbs. per sq. in.	Relative elastic resilience in inch lbs. per cu. in.	Crushing strength endwise lbs. per sq. in.	Crushing strength across the grain lbs. per sq. in.	Tensile strength lbs. per sq. inch.	Shearing strength parallel to fibres lbs. per sq. in.
Long-leaf pine..	D	7,750	1,440,000	1.30	5,000	645	12,000	500
Short-leaf pine..	D	6,500	1,200,000	1.30	4.200	645	9,000	400
White pine.....	D	4,400	870,000	1.00	3,500	440	7,000	300
Norway pine...		5,450	1,132,000		3,800	430		
Colorado pine..		4,900	888,000		3,150	540		
Douglas fir.....		6,600	1,380,000		4,400	500		
Redwood.......		7,200	452,000		3,250	345		
Red cedar......		5,000	670,000		3,500	750		
Bald cypress....	D	5,000	900,000	1.10	3,375	360	6,000	240
White oak......	D	6,000	1,100,000	1.25	4,000	1,200	10,000	800

NOTE.—The values marked "D." were obtained from experiments made by the United States Forestry Division. The other values were obtained from various sources, chiefly from the tenth census report, but so modified as to give results comparable with the forestry division values.

These values are for eighteen per cent. moisture, representing a half dry condition. For modifications of these values for other moisture conditions, and for fuller general description, see bulletin on "Timber Trestle Design," issued by the forestry division.

ADDITIONAL DATA.

As chairman of the committee reporting last year on the subject of "Strength of Bridge and Trestle Timbers," I desire to record some additional data that have come to my notice since the presentation of that report, namely, publications since October, 1895, relating to the strength of timber, and a new straight-line column formula, adopted by one of our members, Mr. J. E. Greiner, engineer of bridges, B. & O. R. R., as also a diagram (Fig. 245) representing the various formulas and results of full-size tests for yellow-pine columns.

In addition, I wish to mention the evident value attributed to this report by the technical press and others, not with a view to calling attention to the personal efforts and work of the members of that committee, but purely as an object lesson to this association, and all its members, illustrating how we are gradually forcing ourselves to the front, and taking the stand that belongs to us by right, in our own particular sphere and line of work among the technical, and railroad associations.

The report was published, more or less in full, by a very large number of the leading technical papers of the country, and briefly noticed in a number of home and foreign journals.

The United States government reprinted the report and all the accompanying tables, as an appendix, in a pamphlet on the "Economical Designing of Timber Trestle Bridges."

The secretary of this association has received numerous requests from individuals for copies, and, personally, I know that college professors, municipal and railroad engineers, have sent for copies for use in their professional work. It has also been utilized, to my own knowledge, in two of our large cities, where a revision of the building laws has been in progress during the last year.

Mr. F. E. Kidder, the well-known architect, of Denver, Colo., and author of "Kidder's Pocket Book," has recently published an article on the value of uniform and standard unit stresses for timber, for the use of engineers and architects, especially with a view to establishing greater uniformity in the building laws of our various cities. After referring to the scant data available, consisting mainly of Barlow's "Essay," published in 1817; Hatfield's book on "Transverse Strains," published in 1877, and Trautwine's "Engineer's Pocket Book," Mr. Kidder states as follows:

"The most thorough work that has yet been done in this direction is that of the committee on "Strength of Bridge and Trestle Timbers," of the Association of Railway Superintendents of Bridges and Buildings, as evidenced in its report presented at the fifth annual convention of the association, held in New Orleans, October 15 and 16, 1895.

"This report is a very exhaustive resume of all published tests that have been made on American lumber, as well as the recommended values of authors and structural engineers. The report fills forty-nine closely-printed octavo pages, and contains a great mass of valuable information on the subject.

"As a result of the investigation of this committee, standard unit stresses were recommended for all varieties of timber used in bridge work at the present day. That these standards will have great weight with engineers, and even if necessary, with the courts, cannot be questioned. As further evidence of an increased interest in this direction, the report of the proceedings of the twenty-ninth annual convention of the American Institute of Architects contains two very valuable papers on the strength of timber, one by George W. Bullard, of Tacoma, Washington, and the other by Prof. J. B. Johnson, of Washington University, St. Louis."

After comparing the units reported by the committee of this association with other recommended values and the units in existing city building laws, Mr. Kidder continues:

"It should be noticed that the values recommended by the railway superintendents and individuals agree, in general, very closely. . . . . It would seem that, with the data now available, standard unit stresses might be adopted which would be uniformly recognized throughout the country."

An editorial on the "Working Stresses for Timber Structures," in The Engineering Record of November 9, 1895, after a general discussion of the question, concludes as follows:

"In view of the preceding considerations, which fail to present in more than outline the actual state of the case, it is a fortunate event for the interest of good timber design that a committee of the American Association of Railway Superintendents of Bridges and Buildings reported to their fifth annual meeting at New Orleans, on October 15, last, a set of ultimate resistances and working stresses, which may at least be considered provisionally justified by such few reliable tests as have been made on full-size columns and beams. This set of quantities, which we printed in our preceding issue, has great value for all architects and engineers, and it should be well considered by them in their timber designs; and for the most part it would not be out of place in the building laws of all large cities. Many of the quantities given are not different from those which well-informed engineers have been using, but it is the best succinct statement of empirical constants for timber of a complete character which has as yet been put forth."

Numerous similar notices could be quoted, not only in regard to this particular report, but also in connection with other reports presented last year, which have been equally favorably criticised and reprinted in the technical press, and extensively utilized for practical railroad work.

The moral of all this is, that we here have direct evidence that the work this association has done in the past is bearing fruit, which is a most gratifying sign. The aims of this association are not only to spread information among our members on the technical subjects we are all interested in, but to disseminate such knowledge throughout the country, so as not only to make improved methods more generally known, but especially so as to standardize the existing practice, and thus obtain uniformity, as far as possible, in the various details of our work.

Publications Since October, 1895, Relating to Strength of Timber.

Bulletin No. 10, U. S. Department of Agriculture, Division of Forestry, entitled "Timber," being a discussion of the characteristics and properties of wood.

Bulletin No. 12, U. S. Department of Agriculture, Division of Forestry, entitled "Economical Designing of Timber Trestle Bridges." In this pamphlet the report of the committee of the Association of Railway Superintendents of Bridges and Buildings on "Strength of Bridge and Trestle Timbers" is reprinted, together with the accompanying tables.

Circular No. 12, U. S. Department of Agriculture, Division of Forestry, on the "Mechanical and Physical Properties of Southern Pine," published March, 1896, being advance data and summary conclusions extracted from a comprehensive bulletin on the subject of "Southern Pines," which will be published as soon as the department can do so. The department also has in preparation a bulletin on the "Principles and Practice of Dry Kilns."

Mr. William Hood, chief engineer, Southern Pacific Railway, published in Engineering News of June 25th, 1896, extensive data in regard to tests of Oregon pine or Douglas fir made under his direction.

The Department of Civil Engineering of the University of California, at Berkeley, Cal., has been engaged in extensive tests of Pacific coast timbers during the past year.

The data of all tests of timber made at the Massachusetts Institute of Technology, Boston, Mass., have been republished from the Technology Quarterly in a special pamphlet, entitled "Results of Tests Made in the Engineering Laboratories of the Massachusetts Institute of Technology." Address the secretary of the Society of Arts.

The results of comparative tests of Washington fir and Eastern white oak, made by Mr. O. D. Colvin for the Northern Pacific Railroad, were published in Railway Review, issue of March 7th, 1896.

Notes on white pine timber overloaded in actual use were published in Railway Review, issue of March 28, 1896.

Article of F. E. Kidder on "The Proper Unit Stresses for Timber," was published in The Inland Architect, issue of August, 1896. The unit values established by the report of the committee of the Association of Railway Superintendents of Bridges and Buildings are very favorably commented on and compared with the values prescribed by building laws in Boston, Buffalo, New York, Brooklyn, and Chicago. This article was republished in Railway Review, issue of October 3, 1896.

Notes on the strength of timber by George W. Bullard, of Tacoma, Washington, and by Prof. J. B. Johnson, of Washington University, St. Louis, are included in the proceedings of the twenty-ninth convention of the American Institute of Architects held in 1896, at St. Louis.

Column Formulas for Yellow Pine.

Since the presentation of the report of the committee on "Strength of Bridge and Trestle Timbers" at the New Orleans convention, I have had occasion to prepare a diagram showing various formulas for yellow pine columns in comparison with actual, full-size tests, which diagram was published in the proceedings of the American Society of Civil Engineers. I have prepared a similar diagram, which I present (Fig. 245), embodying the data and formulas mentioned in last year's report, in addition to the straight-line formula adopted last spring by Mr. J. E. Greiner, a member of this association, for the new 1896 issue of the General Specifications for Bridges and Buildings, Baltimore and Ohio Railroad.

Mr. Greiner's formula for yellow pine columns is:

$$\text{Breaking weight} = 5{,}000 - 65\frac{l}{d}$$

For the safe unit stress for columns over seventeen diameters, Mr. Greiner specifies as follows:

Long leaf yellow pine........................ $1{,}200 - 18\frac{l}{d}$

White oak.................................. $1{,}000 - 15\frac{l}{d}$

White pine................ .... $800 - 12\frac{l}{d}$

where l = length and d = least thickness, all in inches.

Mr. Greiner wrote to Mr. Berg as follows in regard to his reasons for adopting the above form of formula:

"I send you herewith a copy of our 1896 specifications, in which you will find the several unit stresses on timber which, after a mature consideration and examination into the results of all tests made up to date, I have adopted for our regular practice. If you plot the formula for long-leaf yellow pine given in these specifications, on the diagram sheet, copy of which you were kind enough to send me, and consider that the formula given in my specifications has a factor of safety of five, you will observe that the unit of stresses decrease more rapidly as the values of $\frac{l}{d}$ increase than is indicated by the other formulas plotted. My reasons are:

1 There are but few tests having values of $\frac{l}{d}$ between forty and sixty as compared with the number between twenty and forty, and these few tests were all more or less selected timber.

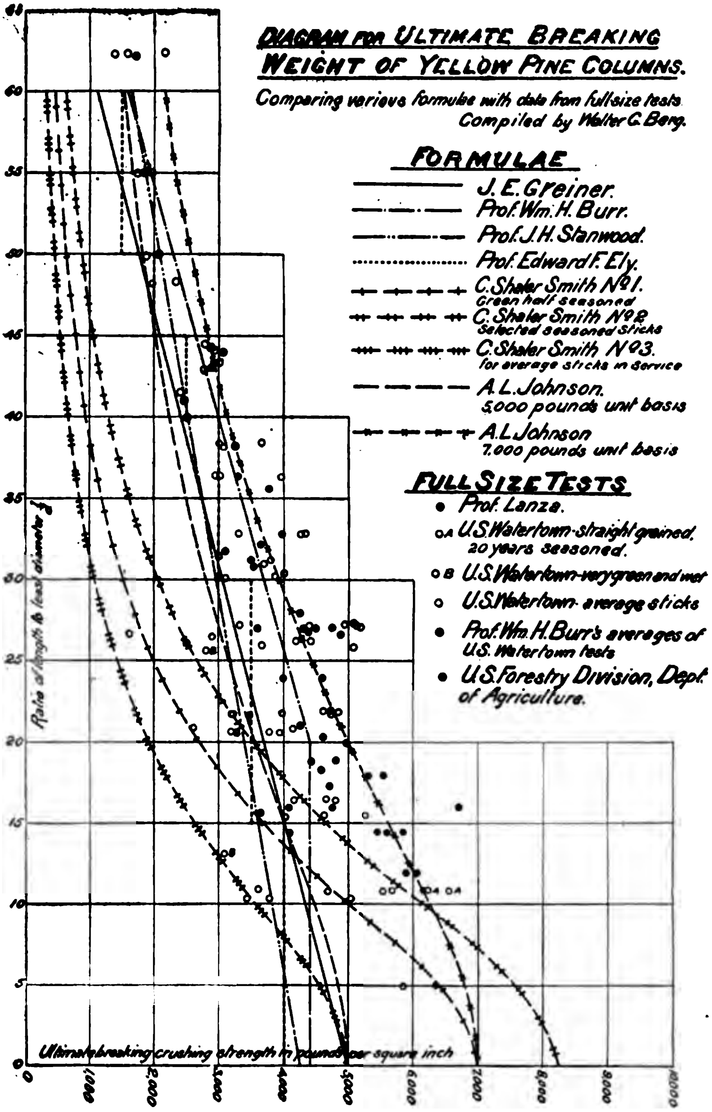


FIG. 245—DIAGRAM FOR ULTIMATE BREAKING WEIGHT OF YELLOW PINE COLUMNS.

2. Timber when used in ordinary service, is almost invariably fresh and unseasoned and, owing to the exposure to the rays of the sun, it is more apt to warp or bend when the values of $\frac{l}{d}$ are greater than forty, than when these values are less than forty.

3. The longer the stick, the greater number of defects it is likely to have.

4. As 1,200 pounds on the extreme fibres is generally recognized as about the right thing for either tension or compression in beams, I consider it advisable to use this same 1,200 pounds as a basis of the column formula.

5. A straight line formula will represent the plotted values of all tests made, just as well as any possible curve will do it, and it is more readily applied.

I hesitated a long time before adopting a formula differing from those already proposed by engineers of recognized standing, but so long as no two of them agree and one more formula will cut no figure, I preferred to add one more, which in my judgment will fulfill practical purposes and is just as good as the others proposed."

An examination of the diagram (Fig. 245) would seem to indicate that a straight-line formula will give as good practical service as a complicated one, and that Mr. Greiner's formula offers a simple, safe and conservative rule for proportioning timber columns.

WALTER G. BERG.

...THE...

Q & C Compound Lever Jacks.

Standard Track Jacks.

QUICK TRIP ACTION.

Six Sizes.

—•—

Automatic Lowering Jacks.

FOR

CAR WORK, BRIDGES, &c.

Seven Sizes.

—•—

Strong. Quick. Safe.

Oil Box Jacks

FOR CAR INSPECTORS ETC.

—•—

Automatic Lowering Jacks,

WITH

QUICK TRIP ACTION.

Six Sizes.

—•—

Solid Main Frame.

SEND FOR CATALOGUE.

THE Q. & C. COMPANY,

700-709 Western Union Building. ...CHICAGO, ILL.

Perfected Granite Roofing

is in service from Maine to California, in Canada, Central and South America. We can refer to the largest railroad companies, who have officially adopted our roofing. This roofing will resist the action of steam, gases and fumes better than any other roofing and is therefore the most desirable for **Railroad Buildings, Engine and Boiler Houses, Factories, Foundries and Machine Shops.**

Frost will not Crack It,

and it is not affected by climatic changes. Perfected Granite Roofing is coated and graveled all complete at our works and ready for use, thus saving the expense and annoyance of painting and sanding in an imperfect manner, as is the case when any other composition roofing is used.

It Is Applied to Steep as well as Flat Roofs,

and will not run from the heat of the sun. After having given this roofing one fair trial, you will continue to use it, as thousands are doing.