In adopting the principle of continuous light in this country, the first railroads to do so followed the common English practice of using elongated glasses in spectacles designed to suit, in place of the circular discs used in the single-light spectacles. The 60-deg. continuous light spectacles made by the Union Switch & Signal Co. are designed with round spectacles, using either 6½ or 8⅜-in. glass roundels, as may be specified. The adoption of the circular glasses by this company was to secure the following advantages: First, the spectacle casting itself is capable of stronger design; second, the circular glass discs are from their shape less difficult to mold or cut, less liable to break, contain less glass and are cheaper than the elongated design; third, the size of the circular discs can be made to conform to standards already in use on any railroad, thus making replacement easy.

Arch Bridge Construction on the C. M. & St. P. Ry.

For some years past the engineering department of the Chicago, Milwaukee & St. Paul Ry. has been engaged in the improvement of bridges on various lines of the system, and the construction of arch bridges and a number of steel structures of large size has involved a great deal of interesting engineering work. For the present we will direct attention to some of the work of permanent character, in the erection of stone and concrete bridges, on the LaCrosse division, in Wisconsin. The most important structure recently built is a four-span stone arch, just completed, near Watertown, Wis. The old structure at this point consisted of four steel truss deck spans, two of 89 ft. length and two of 74 ft. length. In the new structure the spans are of equal length, 64 ft. in the clear, with a rise of 16½ ft., meeting upon concrete piers 8 ft. wide under the coping.

The details of construction are shown in the accompanying line drawing, Fig. 1. As will be seen by the plan view, at the top, the new piers are slightly off the alignment of the old bridge, and on new foundations, except in the case of one of the piers, which stands partly on the old foundation. The arches are segmental, covering an arc of 109 deg. 6 min. 44.6 sec., built to a radius of 39 ft. 3⅜ ins. The arch sheeting is 3 ft. thick and the spandrel walls at the crown are 4 ft. high. The bridge is a double-track structure, the width of the arch proper being 28 ft. 4 ins. and the width from out to out of spandrel walls, at the coping, 30 ft. The drainage from the arch ring takes place through 3-in. drain pipes at the haunches. The material in the ring courses is Kettle River sandstone, with a 2-in. chisel draft. The facing stones of two of the arches are of the same quality of stone, while in two of the others Stone City stone is used. The spandrel walls are built of Stone City stone. Other details regarding dimensions, the construction of abutment and wing walls, etc., are made clear in the illustration.

This structure comprises about 1850 cu. yds. of cut stone and 1975 cu. yds. of concrete. These arches are the largest which this company has built. The general policy of the company is to use cut-stone masonry for the long-span arches.

As the stone arches were built partly on the location of the old structure, it was necessary to move the latter to a temporary site, in order to carry the traffic while the arch structure was being erected. This was done by jacking up the truss spans and supporting them upon rollers running upon beds of rails laid on the piers, and on extensions of the same in the shape of pile piers. The motive power consisted of a hoisting engine with block and tackle hauling lines. The time consumed in moving the structure was from 6:20 a. m. to 8:35 a. m., or about 2 hours and 15 minutes. Figure 2 shows the operation of moving the old structure, in progress, and Fig. 3 shows the old structure on temporary supports, and the concrete piers of the arch, with the sills of the arch centers in place. Figures 4, 5 and 6 show the arch at various stages of the construction. The method of the framing of the arch centers will be apparent from these illustrations.

Arches of short span are being constructed either with brick sheeting faced with stone, or with reinforced concrete, with spandrel bench and wing walls of concrete. An arch of the former class is shown in Fig. 8. The old structure (Fig. 7) consisted of a 50-ft. plate girder span, on stone masonry abutments. The new structure is five-centered, and the clear length of the span is 33 ft. Figure 9 shows another structure of this class, the clear span being 32 ft. and the arch segmental. Both of these bridges are located near Oconomowoc, Wis., and are typical of a number of structures of this class which have been built within recent years.

As an experiment this company has built one arch structure of concrete reinforced with steel rods. This is located near Middle Inlet, on the Superior division. The span is 20 ft., and steel bars ½ inch square in section are molded in with the concrete, near the intrados and the extrados. The bars near the intrados are spaced at 12 ins. centers, and those near the extrados at 24 ins. centers.

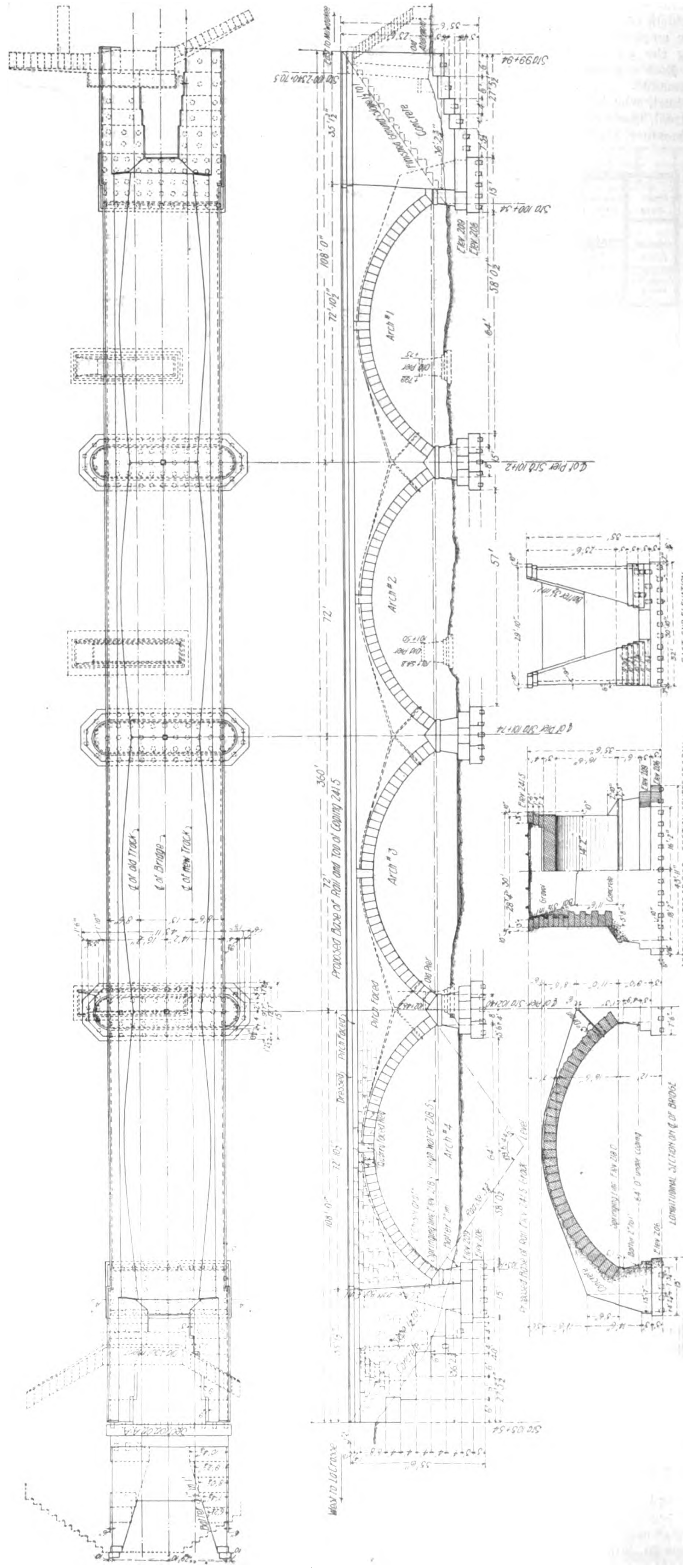


Fig. 1—Plan, Elevation and Sectional Views of Stone Arch Bridge for the Chicago, Milwaukee & St. Paul Ry., at Watertown, Wis.

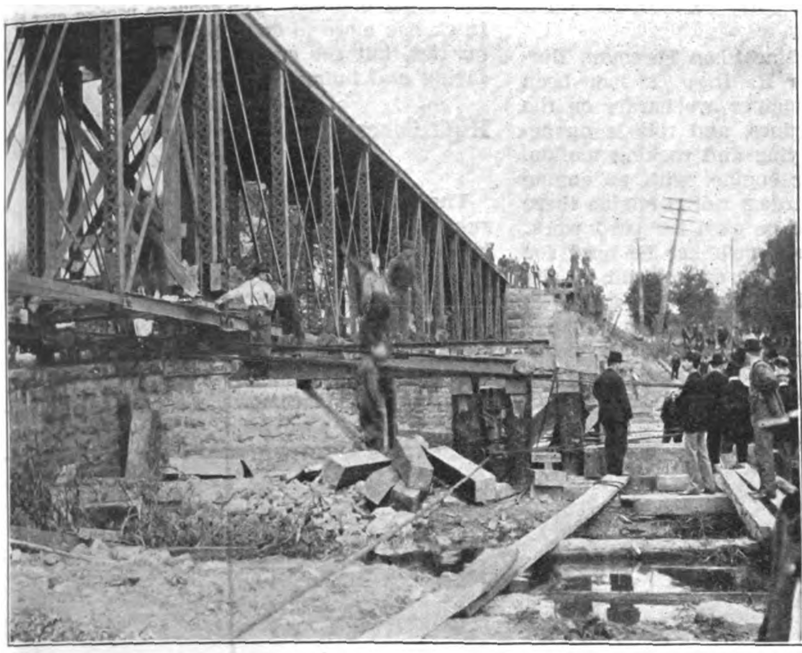


FIG. 2—MOVING A FOUR-SPAN STEEL TRUSS DECK BRIDGE TO MAKE ROOM FOR STONE ARCH CONSTRUCTION, C., M. & ST. P. RY.

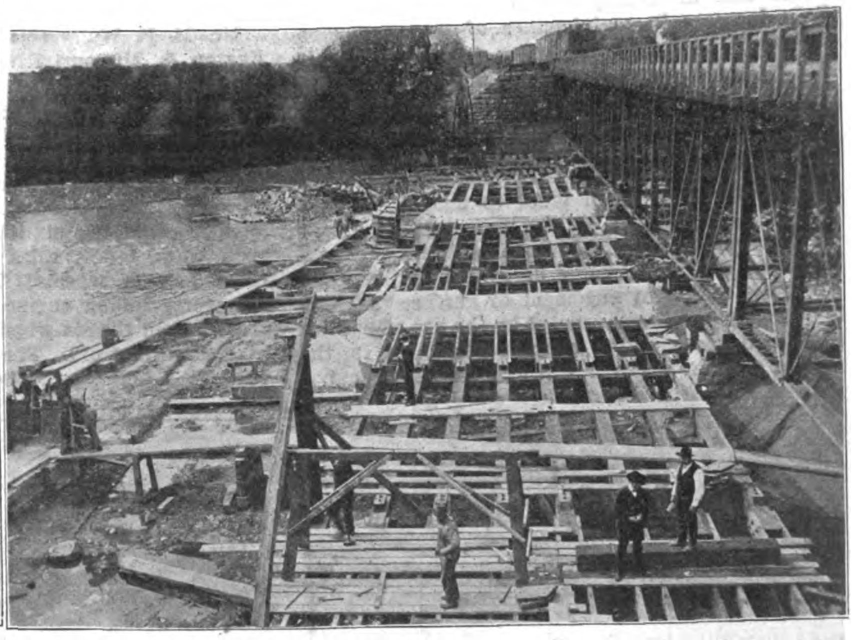


FIG. 3—FOUNDATION PIERS AND SILLS FOR CENTERING, WATERTOWN STONE ARCH BRIDGE, C., M. & ST. P. RY.

The interesting engineering work here referred to is being carried out under the administration of Mr. C. F. Loweth, engineer and superintendent of bridges and buildings, with Mr. J. J. Harding, assistant engineer, to both of whom we are indebted for illustrations and for the facts of the foregoing description.

Effect of Heavy Wheel Loads on Track and Reduced Cost of Moving Traffic.

In our issue of Feb. 28 we published extracts from a paper entitled "Relation of the Effects of Heavy Wheel Loads on Track to the Reduced Cost of Moving Traffic," read before the Rocky Mountain Railway Club by Mr. Hugh Wilson, trainmaster with the Burlington & Missouri River R. R. At the meeting of the club held on Jan. 17 this paper was discussed by men representing different departments of railway operation, thus bringing out views on the question from several standpoints. From this discussion we have taken the following extracts:

Mr. Hugh Wilson: I have gotten up a little statement to show how modern equipment will decrease the expense of handling freight. We will suppose a division of road over which the freight movement in one direction is 7000 tons. If this freight is handled by 40,000 capacity cars, the light weight of which averages 11 tons, it will make 350 loads of freight per day. The dead weight of the cars will be 3,850 tons daily, or the total tonnage will be 10,850 tons. Handling this with engines which will handle 1000 tons in a train will make about eleven trains per day. Place the same 7000 tons of freight in 80,000-pound capacity cars, it will make 175 loads. The average light weight of 80,000-lb. capacity cars is 18 tons. So the total tonnage of the light weight of the cars will be only about 3150 tons, or the total daily tonnage handled will be 10,150 tons—a daily saving of 700 tons using the 80,000-lb. capacity cars. This is due to the difference in light weight of the 40,000-lb. and 80,000-lb. capacity cars; yearly, the saving by using 80,000-lb. capacity cars on this line will be 225,500 tons, or 255½ trains.

According to the modern way of rating engines, this will not be the only saving. A class A Burlington engine on a 52-ft. grade with 15 cars will handle 485 tons, and in 40 cars will only handle 405 tons. There is a difference of 80 tons. With an engine that will handle 1000 tons on that line this difference can be about doubled. An engine handling 1000 tons in 40,000-lb. capacity cars ought to handle 1150 tons in 80,000-lb. capacity cars, due to the reduced journal friction and other train resistance. As stated, the total tonnage handled in hauling 7000 tons in 80,000-lb. capacity cars is 10,150 tons. This, if handled in 80,000-lb. capacity cars, makes a further reduction in the number of trains. The 10,150 tons will actually be handled in about nine trains per day. The total saving on this line by using 80,000-lb. capacity cars is daily two trains and yearly 730 trains. We have made another reduction by being able to rate the engines higher on account of the shorter trains. The total trains yearly to handle this freight in 40,000-lb capacity cars will be 4,015, and in 80,000-lb. capacity cars only 3,150. This reduction in trains is accomplished wholly through the use of the 80,000-lb. capacity cars. By the introduction of a heavier engine, say of double the tractive power of the old one, this can be cut in two again, making only 1,575 trains yearly. From this it is plain that the total reduction of trains yearly on this particular line by the use of modern equip-

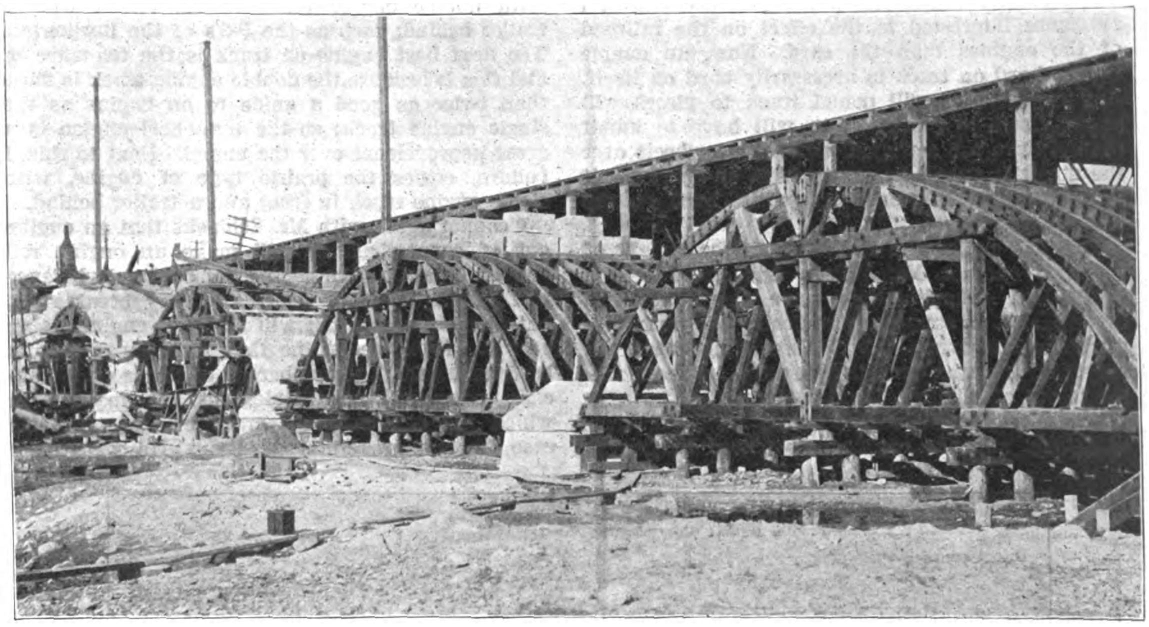


FIG. 4—PROGRESS VIEW OF WATERTOWN STONE ARCH BRIDGE, C., M. & ST. P. RY.

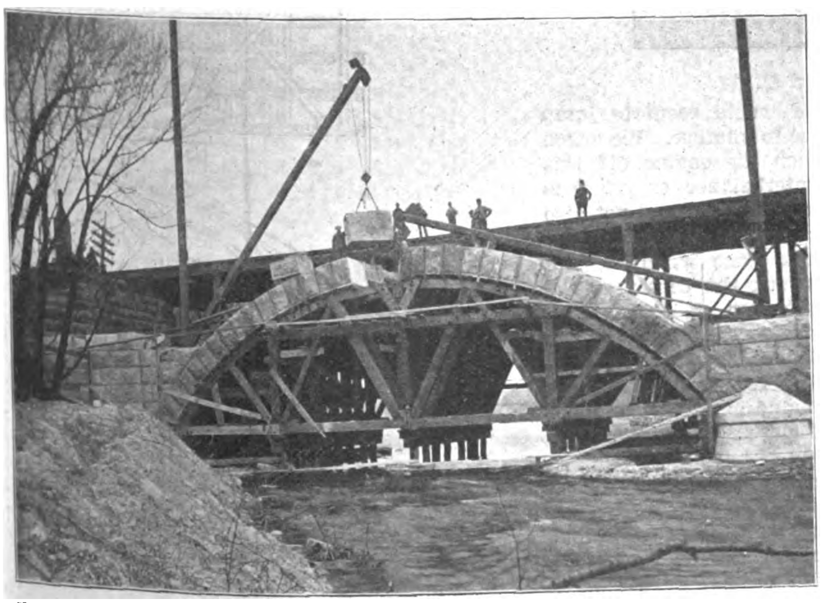


FIG. 5—PROGRESS VIEW OF WATERTOWN STONE ARCH BRIDGE, C., M. & ST. P. RY.

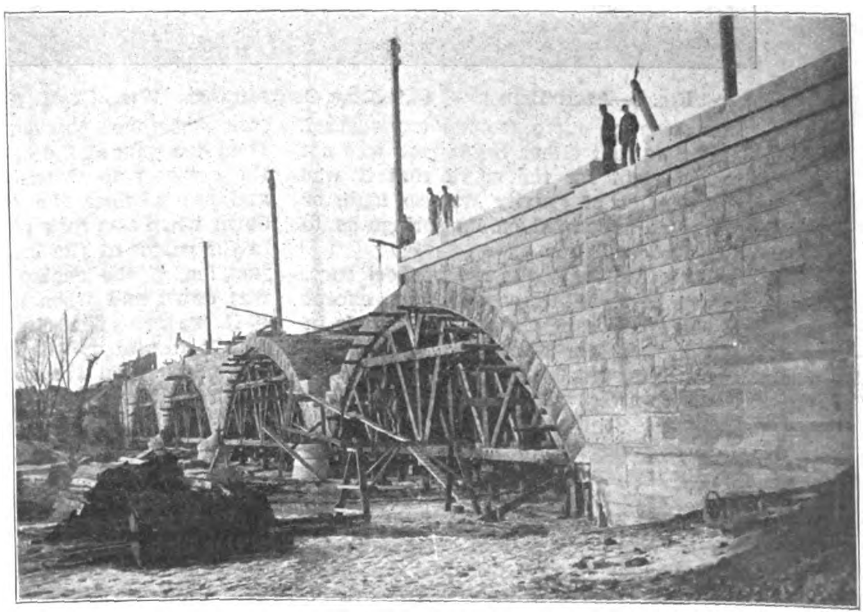


FIG. 6—PROGRESS VIEW OF WATERTOWN STONE ARCH BRIDGE, C., M. & ST. P. RY.

ment is 2,445 trains, or a reduction from 4,015 to 1,575 trains yearly. It would seem that the reduced cost of transportation would warrant a slight increase in maintenance of way expenses.

What I have tried to show in this paper is mainly that the wear on track material with the present equipment is no greater than it would have been had the old equipment been used to handle the same business. I am of the opinion that the track with the old equipment would not have required so much labor to keep it in line. Track is thrown out of line to a greater extent with the present equipment than the old, on account of a higher center of gravity of engines. However, this disarrangement of surface and line is being largely circumveneted by the use of heavier rails and more stable support for them in the nature of more ties per rail and deeper ballast.

centers they obtained a better counterbalance. When an engine is not properly counterbalanced it will roll and rock laterally.

Mr. M. E. Wells (Machine Shop Foreman, Burlington & Missouri River R. R.): It has been pointed out that mogul engines are harder on the track than ten-wheel engines, and this is on account of the lateral swaying and rocking motion. The four-wheel switching engine, with no engine truck or trailer, is the hardest riding engine there is, and, in fact, could not be used for road work. Neither could the six-wheel switcher be used for road work, but it rides better on account of the extra pair of wheels. The reason the mogul is the worst rolling engine is because it is only removed from the six-wheel switches by a single engine truck in front. The best riding engine so far built is, I believe, the Columbia or Atlantic type, with double engine truck in front and with a trailer behind; such as the P-2's of the Burlington. The next best engine on track is the ten-wheeler, and this is because the double engine truck is more than twice as good a guide to an engine as the single engine truck; so the ten-wheel engine is a great improvement over the mogul. Next to this, I believe, comes the prairie type of engine, with single engine truck in front and a trailer behind.

I cannot agree with Mr. Schlacks that an engine out of counterbalance will make an engine roll or rock laterally. An engine out of counterbalance will pound the track badly and may break rails, but I cannot see how it will make an engine swing or roll. It is the engine that rolls badly that is hard on track. I remember an engineer on a Vauclain compound complaining of the manner in which the engine would cross bridges. In this case the counterbalance was light. He complained that sometimes the engine would seem to jump from one span of the bridge to another. We asked the engineer to watch when the engine did this and see whether the counterbalance or pin was down when this took place, and if it was not also in the center of the bridge spans. We found this jumping of the engine took place when the pin was down and when it struck the center of the 16-ft. spans. The circumference of the driving wheels was about the same as the length of the spans, so when the engine got started right it would continue to jump all the way across the bridge. A consolidation engine is much easier on the track than the mogul engine, because of the fourth pair of drivers.

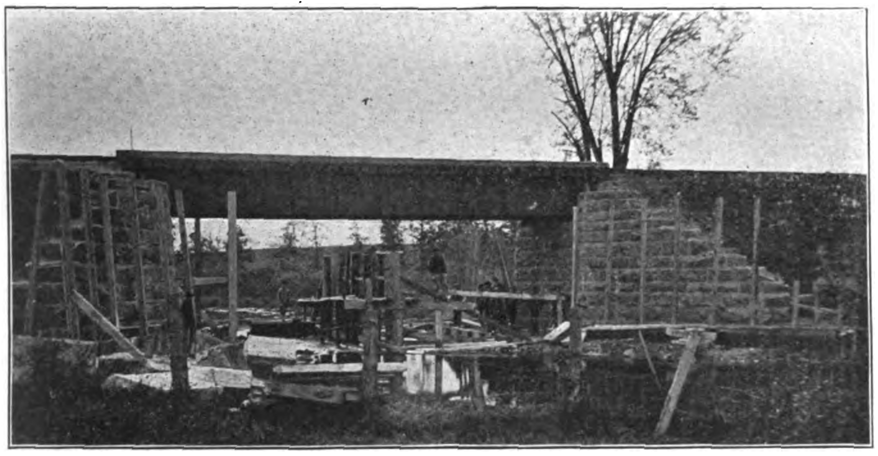


Fig. 7—Bridge "C 68," Near Oconomowoc, Wis., C., M. & St. P. Ry.

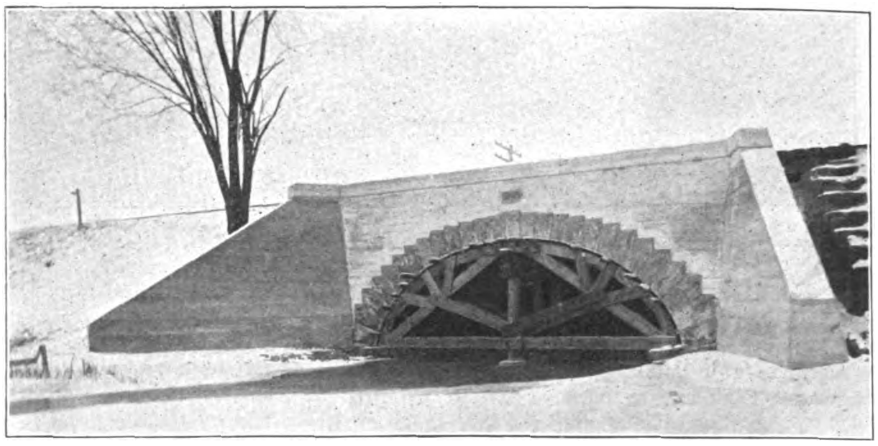


Fig. 8—New Structure at Bridge "C 68," C., M. & St. P. Ry.

Mr. F. P. Roesch: As a locomotive engineer, I am more interested in the effect on the railroad of the engines than the cars. Now, an engine that is hard on track is necessarily hard on itself. Any engine that will pound track to pieces will pound itself to pieces. You will have to admit that. If you ran a wagon with square wheels over the street it would be pretty hard on the asphalt pavement and it would be pretty hard on the wagon, too.

You will notice the difference in the weight of the two engines Mr. Wilson has mentioned is 13,100 lbs., although they have the same size drivers and, I suppose, practically the same dimensions otherwise. Mr. Wilson states that the mogul engine was very hard on the track, knocking it out of alignment and surface; then he says afterward, when the engine wheels were cut down to 64 ins. and the engine was placed in freight service, there was no more trouble experienced. Now, it is possible that either the engine was not counterbalanced right for the speed that it was run at, or its center of gravity was so high, or the engine was so supported on its springs as to produce excessive oscillation.

Fig. 9—Arch Bridge "C 64," Near Oconomowoc, Wis., C., M. & St. P. Ry.

We know that the longer the rigid wheel base, the greater will be its effect on all track, except tangent. If the addition of one pair of wheels in the truck will decrease the wear and tear on track, it would be policy to put four-wheel trucks under all engines and do away with the mogul type entirely.

Mr. W. J. Schlacks (Mechanical Engineer, Colorado Midland Ry.): Mr. Wilson says in the paper that the wheels were reduced 8 ins. on these mogul engines that rode so hard and they were placed in freight service and engines were comparatively easy on track. In reducing the wheels 8 ins. they would have had to get new wheel centers, and it is quite likely when they applied the new wheel

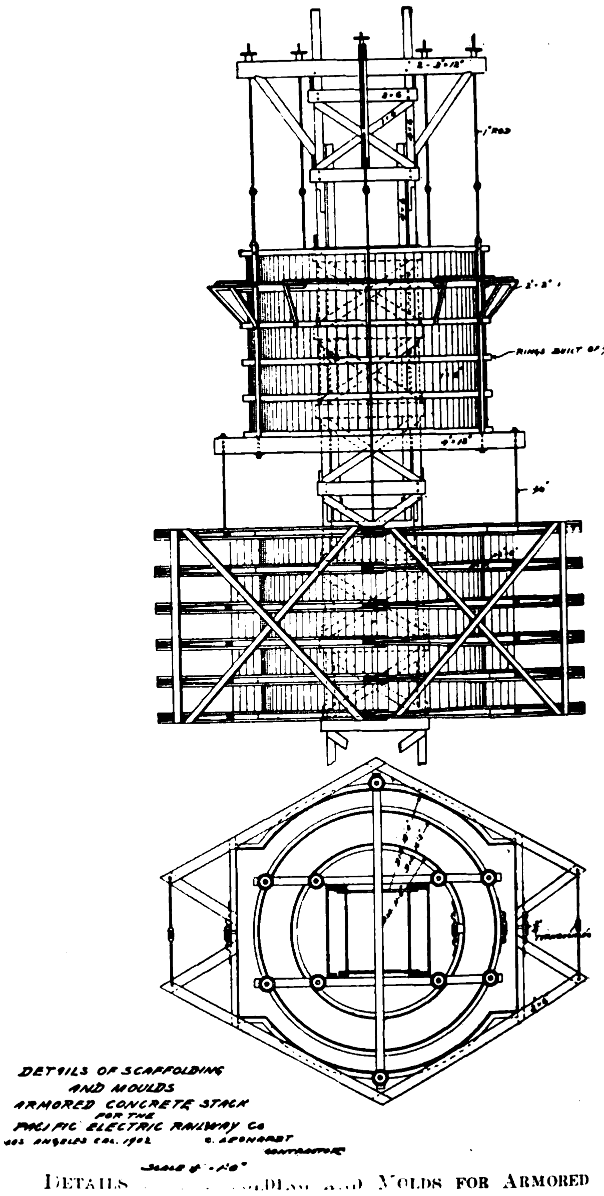
Mr. Roesch: I would say that all the work that is necessary to maintain the track in line is due to the high speed of passenger trains, and that necessary to renew rails is due to freight trains.

Mr. Wilson: That, I believe, is nearer right than anything we have got at to-night. It is a fact that the line of track is destroyed largely by the passenger engines. The tonnage passing over the track has more to do with the rail wear and wear on ties, but the speed of trains governs the surfacing and lining of track.

High Concrete Chimney for the Pacific Electric Ry.

The Pacific Electric Ry. is building a network of suburban electric railways centering in Los Angeles, Cal., and a new power station for operating the system has recently been constructed. A remarkable engineering feature of this installation is a chimney 180 ft. high, built of armored concrete. The plans for building this chimney were submitted to experts in this line of construction, resulting in a recommendation for armored concrete as superior to either steel or brick, in the matter of stability and strength. The bid which accompanied the plans also demonstrated that a chimney could be built of this material more economically than with either brick or steel.

The hight stated (180 ft.) is measured above the base, which is 15½ ft. below the level of the ground. The exterior diameter of the chimney above the shoulder where it first assumes a circular form, is 15 ft. 2 ins., the inner diameter being 11 ft. The shoulder is 51 ft. above its base, and is immediately above the two flues which enter the chimney from opposite sides.



Details [illegible] Molds for Armored Concrete Stack, Pacific Electric Ry.

road? The universal practice, almost, in this country, is to provide two arms, two high signals, and they both show red at night. At night the engine runner gets his proper light clear, but still he passes a red high light. There is an effort on the part of some railroads to withdraw the lower of the two lights and thus reduce the number of red lights. At night, the entire indication on the D., L. & W., as I understand it, at a diverging point, would be, to stop a main line train, simply one red light. The lower light is blinded. When the main line is clear, the upper one shows, showing green; the lower is blinded.

Mr. Wilson said that the objection to multiplicity of red lights, spoken of by Americans, was also a live question with English railroad men, and he thought that the blinding of minor lights was a move in the right direction. Nevertheless, any two signals at the same point have a relation to each other and caution must be exercised in obscuring either or any one of the signals in such a group.

Mr. Ten Eyck.—I thoroughly believe that the two high blades are necessary at a diverging route; the high blade and a dwarf, on the ground, make an undesirable combination.

Mr. Kelloway.—We have done away with red for dwarf signals. We use blue for danger on dwarfs, unless the dwarf is blinded at the foot of post. Wherever a dwarf is put on as a substitute for a high signal it is blinded. The main line runner never sees a high red light unless it means for him to stop.

Mr. Adams.—Mr. Wilson spoke of the danger of making a mistake if you disturb two signals which have a relation to each other. Mr. Ten Eyck said something in agreement with him and Mr. Ten Eyck described his practice, on signal bridges, where with two signals, and one of them not burning at night, the engineman would make a mistake and take the other one. Perhaps you have heard how there was a serious collision recently on a curve on a four-track road, where the engineman took the wrong one of two lights on a bridge and crashed through the whole length of a passenger car ahead of him. There was a blinding snowstorm at the time. Mr. Wilson's dictum is important; these signals have a relation to each other. The engineman has no right to read one, or consider one, unless he sees the other also. Any runner who sees one light and guesses what it is, is foolhardy. He should not pass that signal bridge until he sees both lights.

Ore Docks on the Great Lakes.

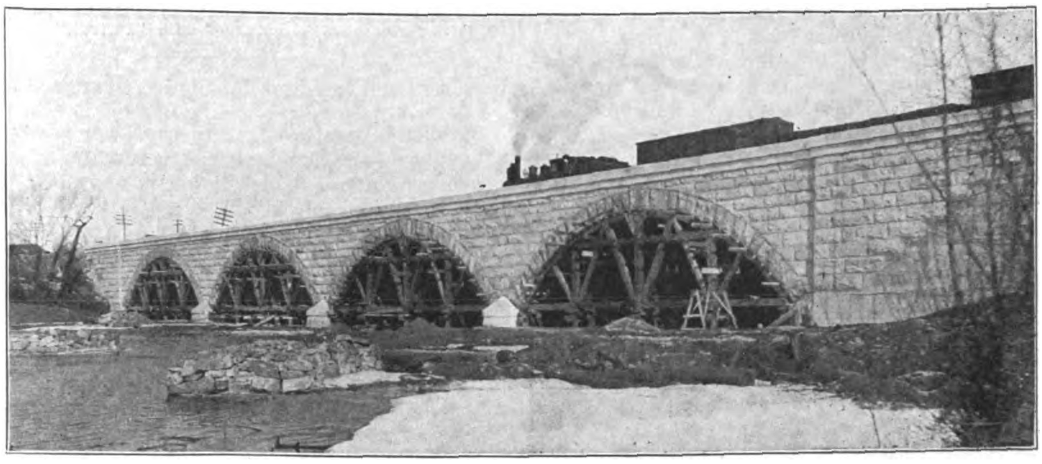
Mr. R. Angst, chief engineer of the Duluth & Iron Range R. R., has kindly furnished us with a compilation of the principal data of the shipping ore docks on the Great Lakes. The record has been revised to date. This data we show by the accompanying tabulation. The Duluth & Iron Range R. R. dock No. 1, at Two Harbors, has 312 ft. of single pockets and 1076 ft. of double pockets.

A4 RECORD OF ORE DOCKS ON THE GREAT LAKES. REVISED TO MAY 1ST 1903.

RAILWAY	LOCATION	DOCK NO.	NUMBER OF POCKETS	STORAGE CAPACITY TONS	HEIGHT WATER TO CENTER OF HINGE HOLE	HEIGHT WATER TO DECK OF DOCK	WIDTH OF DOCK OUTSIDE TO OUTSIDE OF PAR'L'M POSTS	LENGTH OF SPOUTS	LENGTH OF DOCK	ANGLE OF POCKETS
Chicago & North Western Ry	Escanaba Mich	1	184	24104	28' 10"	48' 6"	37' 0"	21' 0"	1104'	39° 30'
" "	"	2	320	58000	40' 0"	70' 0"	50' 2"	30' 0"	1920'	45° 0'
" "	"	3	226	30284	31' 2"	32' 8"	37' 0"	27' 0"	1336'	45° 0'
" "	"	4	250	32750	36' 6"	39' 2"	37' 0"	30' 0"	1500'	45° 0'
" "	"	5	232	43152	28' 6"	53' 3"	37' 0"	21' 8"	1392'	40° 0'
" "	Ashland Wis.	1	234	36036	32' 10"	54' 0"	46' 8"	27' 0"	1404'	39° 30'
" "	"	2	234	25740	36' 6"	51' 8"	46' 0"	21' 0"	1404'	42° 0'
Duluth & Iron Range Rail Road.	Two Harbors Minn	1	202	40400	35' 5"	59' 4"	49' 0"	27' 0"	1388'	38° 42'
"	"	2	208	41600	33' 5"	51' 6"	49' 0"	27' 0"	1280'	38° 42'
"	"	3	90	16200	28' 10"	52' 0"	49' 0"	25' 0"	372'	38° 42'
"	"	4	168	36960	37' 0"	62' 0"	48' 0"	29' 0"	1112'	38° 42'
"	"	5	168	33600	30' 0"	54' 6"	49' 0"	25' 0"	1112'	38° 42'
Duluth Missabe & Northern Ry.	Duluth Minn	1	384	57600	30' 0"	53' 0"	49' 0"	27' 9"	2336'	45° 0'
"	"	2	384	69120	32' 0"	57' 6"	49' 0"	27' 9"	2336'	45° 0'
"	"	3	192	40320	40' 7"	67' 1/2"	59' 0"	27' 9"	1152'	45° 0'
Duluth, South Shore & Atlantic Ry.	Marquette Mich.	1	270	27000	25' 0"	45' 0"	40' 0"	20' 4"	1700'	39° 0'
"	"	4	200	28000	27' 9	47' 3"	36' 8"	21' 1"	1200'	39° 45'
Lake Superior & Ishpeming Ry.	Marquette Mich.	1	200	36000	30' 9"	54' 0"	50' 0"	24' 7"	1232'	38° 44'
Great Northern Ry.	Superior Wis.	1	250	40500	32' 0"	57' 0"	49' 8"	27' 2"	1525	45° 0'
"	"	2	350	87500	40' 0"	73' 0"	62' 8"	32' 4"	2100'	45° 0'
"	"	3	160	40000	40' 0"	73' 0"	62' 8"	32' 4"	960'	45° 0'
Minneapolis St Paul & Sault Sainte Marie Ry	Gladstone Mich.	1	120	15000	26' 6"	47' 0"	37' 0"	21' 8"	768'	40° 0'
Wisconsin Central Ry.	Ashland Wis.	1	314	48356	40' 0"	66' 2"	36' 0"	27' 0"	1908'	50° 45'
Chicago, Milwaukee & St Paul Ry	Escanaba Mich.	1	240	50400	40' 2½"	66' 6"	52' 0"	[illegible]	1500'	45° 0'
Algoma Central & Hudson Bay Ry	Michipicoten Ont.	1	12		34' 0"	43' 4"	25' 0"	22' 6"	311' 9"	44° 0'

Stone-Arch Bridge at Watertown, Wis., C., M. & St. P. Ry.

In our issue of March 14, this year, we published an account of the construction of a four-arch stone bridge for the Chicago, Milwaukee & St. Paul Ry. at Watertown, Wis. This bridge consists of four spans of 64-ft. clear length, with a rise of 16½-ft. The arches stand on concrete piers 8 ft. wide. The details of moving the old steel structure off the site of the new bridge and the plans and details of construction of the new bridge were published in our previous article, with a number of illustrations of the bridge in an incomplete state. We now show a photographic view of the completed arches before the centers were removed. From the standpoint of permanent construction this view of the bridge is interesting. The bridge is a double track structure 28 ft. 4 ins. wide. It was erected under the supervision of Mr. C. F. Loweth, engineer and superintendent of bridges and buildings of the C., M. & St. P. Ry.



STONE ARCH-BRIDGE AT WATERTOWN WIS., C., M. & ST. P. RY.

Notes on the Treatment of Timber.

By S. W. Labrot, President of the American Creosote Works, Ltd., New Orleans.

The process of timber treating is the result of two operations: First, the perfect sterilizing and drying of the timber. Second, the forcing into the open pores of the wood an antiseptic chemical. It cannot be said that either of these operations is the more important, as the failure to fulfill one of them will surely cause disappointing results.

The perfect seasoning of timber is a very difficult and costly operation, due to the fact that wood being such a poor conductor of heat, much time and high temperatures are necessary to thoroughly penetrate the entire section of the timber under treatment, without which the treatment must ncessarily be very imperfect. To sterilize the timber the temperature must be raised to 220 deg. F., which degree of heat kills all of the wood destroying bacteria. To accomplish the above ends the timber is loaded in to small iron cars and drawn into a steel cylinder, the cylinder doors are closed and the timber then subjected to the action of live steam until there shall exist in the cylinder a pressure corresponding to the desired temperature. When sufficiently prolonged the heat and the inward force of the steam will gradually raise the inside temperature of the timber above the life point of the bacteria; thus perfect sterilizing is accomplished. While the germ life within the timber is destroyed, the evaporation of the saps and moisture, and to some degree the softening of the resinous layers of the timber, is also taking place. Great care must be used to avoid overheating the timber, it being now well determined that temperatures over 300 deg. F. have a very damaging effect upon the strength of timber, which is due to resinous substances evaporating at about 305 deg. F., thus breaking down the structure of the wood. To avoid this danger, and yet insure sufficient heat to destroy bacterial life and evaporate the saps, we show the following steam pressures and the time for continuance. These figures are the results from many years of experience.

Figures for Freshly Cut Green Timber.*

*For comparatively dry timber, cut two months and over, the hours for steaming may be reduced 25 per cent; however, the same steam pressure should be used.

Minimum section 3-inch, steam for 8 hours, pressure 15 lbs. with temperature 250 deg. F.

Minimum section 6-inch, steam for 10 hours, pressure 20 lbs. with temperature 260 deg. F.

Minimum section over 8-inch, steam for 10 to 16 hours, pressure 40 lbs. with temperature 285 deg. F.

When the steam pressure has been carried out properly and with power sufficient to bring the complete section of the timber to 220 deg. F., the pressure is removed and the cylinder freed from all accumulated moisture, leaving the timber in condition to be perfectly dried by the vacuum action that is now to be applied. At this stage of the treatment the lowest temperature of the timber is about 230 deg. F., so that when the vacuum begins to be produced, furious evaporation takes place until when the vacuum gage reads 22" we have the temperature of the timber over 50 deg. above the boiling point and an outward pressure from the sap cells of about 8 lbs. per sq. in. The combined action of these forces results in vaporizing all of the saps and moisture within the timber, this vapor being drawn out and condensed through the vacuum pump. It is necessary to apply this process for 4 to 10 hours, depending upon the time and heat of the steaming period.

During the vacuum period care must be used to keep the temperature of the cylinder always above the boiling point corresponding to the existing vacuum, otherwise the vacuum is of little use.

With the steaming and vacuum well and completely executed, the timber within the cylinder is absolutely dry and sterilized, with the sap cells open and ready to absorb the intiseptic solution. This completes the first step in the process of timber treating, requiring from 10 to 26 hours, depending upon the sizes and condition of the wood. The timber is now ready for the antiseptic chemical.

Zinc Treating, Burnettizing.

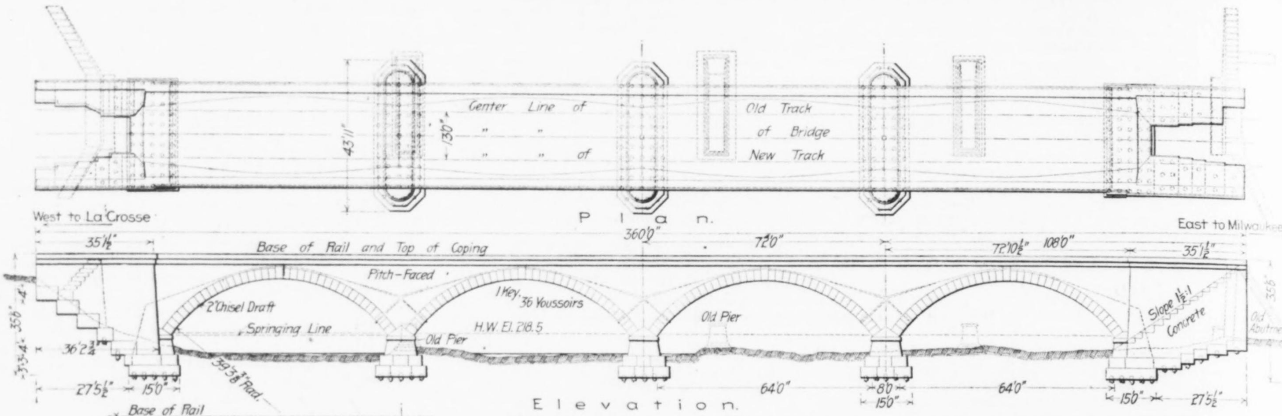
The antiseptic chemical used in this case is zinc chloride ($ZnCl_2$), which is the cheapest of all the methods of treating timber and the most used in this country. A very dilute solution has shown to give as good results as the heaviest solutions, until now the adopted standard is two to two and one-half per cent, forcing about 1½ gals. of this solution into each cubic foot of timber being treated. The life of sap pine ties is 12 to 16 years.

Zinc-Creosote.

With this method the antiseptic solution used is a 2 per cent solution of chloride of zinc, to which is added creosote oil. These two mix perfectly at 100 deg. F., the creosote oil being added to the zinc solution in order to waterproof the timber and prevent the leaching out of the zinc salt. Very extensive experiments have been carried on in Germany and Austria to determine the amount of creosote oil to be mixed with zinc, and the conclusion arrived at is that 1½ lb. of creosote mixed with 12 lbs. of zinc and this amount of mixed solution forced into each cubic foot of timber will give a cross tie a life averaging 20 years against decay. The object of these tests was to treat a tie in such a manner as to have its destruction due to wear and decay as simultaneously as possible. This mixed solution with the above quantities of chemicals has been adopted as standard for the German and Austrian State Railways for all tie treating. Where the exposure is very damp we recommend doubling the quantity of creosote oil, making the mixed solution contain about 25 per cent creosote oil and injecting into the timber 17 lbs. of the mixed solution for each cubic foot of wood. Life of timber treated by this method varies from 18 to 20 years.

STONE ARCH BRIDGE ON THE CHICAGO, MILWAUKEE & ST. PAUL RY. AT WATERTOWN, WIS.

The work of double tracking the La Crosse Division of the Chicago, Milwaukee & St. Paul Ry. includes the construction of a four-span, double-track, stone arch bridge over the Rock River at Watertown, Wis. This bridge is now being built, and will take the place of a single track iron bridge with four deck truss spans, built in 1884. The line is straight and level at this point. Each arch will have a span of 64 ft., a rise of 16 ft. 6 ins., and a radius of 39 ft. 3⅜-ins. The bridge will be 30 ft. wide over the coping courses, which will be level with the tops of the ties. The tracks are spaced 13 ft. c. to c. The general design and details of the structure are clearly shown in Fig. 1.



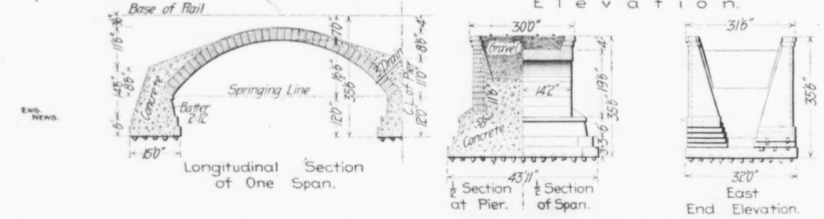


FIG. 1. STONE ARCH BRIDGE ON THE CHICAGO, MILWAUKEE & ST. PAUL RY. AT WATERTOWN, WIS.

C. F. Loweth, M. Am. Soc. C. E., Engineer and Superintendent of Bridges and Buildings.

The foundations are of oak piles driven to refusal into a very hard stratum of gravel and clay. Concrete will be used for the piers and for the abutments below the slope line of the embankment; also for spandrel filling and for the backing of the arch rings. For the arch rings and facing of abutments and spandrel walls cut stone will be used. Of this, two complete arches and the face ring of the remaining two arches will be sandstone from the Kettle River quarries of Minnesota; limestone from the Stone City, Ia., quarries will be used for the abutments, spandrel walls and inner sheeting of two arches. The arch rings will be 3 ft. deep, with ⅜-in. joints at the intrados. The filling over the arches will be of gravel, on which the ballast and track will be laid. This filling will be drained by 3-in. tile drains through the backing and arch sheeting.

Fig. 2 shows the style of centering for each arch. It consists of eight framed ribs spaced 3 ft. 10 ins. apart c. to c.; these are all supported on three intermediate bents of eight piles each, and by blocking on each foundation footing. Greased hardwood wedges are placed under the ribs and secured in place to prevent slipping. Lagging strips 4 × 5¾ ins. are placed at each voussoir joint.

The maintenance of uninterrupted traffic during the construction of the new bridge being necessary, it was decided that this could be accomplished most economically by shifting the four old spans with the track to one side of the proposed new structure. In their new position the spans are supported on one side by the up-stream end of the old piers, and on the other side by temporary pile bents. The spans were first jacked up 9½ ins. and the base plates and roller bearings removed. Rails were then laid on each temporary pier, at right angles to the track, and directly over these were placed inverted rails fastened to the trusses. Between these rails were placed double-hub cast-iron rollers. After everything was made ready, the four old spans were simultaneously moved to the north a distance of 17 ft. by one 20-HP. double-drum steam hoisting engine, lines being run to each end of each span. The moving was accomplished in about 35 minutes. The spans were then again jacked up, the rails and rollers removed, and wood blocking substituted.

A strip of land adjacent to the company's right of way at the west end of the bridge, was rented for use as a stone yard. Here, two steam fall and hand boom line derricks are employed in unloading. From the yard to the bridge the stone is carried on push cars which run on a track laid for this purpose. This track extends the full length and above the north half of the new bridge at a level with the proposed base of rail. A derrick is located at the center of each pier, and at the abutments: these are raised on temporary frame supports, so as to enable them to set all of the stones from the key courses of one arch to that of the adjacent arch. All of these derricks are operated by steam power. The derricks, trestle and centering, with the work in progress, are shown in Fig. 3.

FIG. 3. CONSTRUCTION OF THE STONE ARCH BRIDGE AT WATERTOWN, WIS.; C., M. & ST. P. RY.

The estimated cost of the entire work is $40,700, which includes about 4,000 cu. yds. of masonry, temporary bridge, removal of old structure, excavation, centering, filling, ballast and new track. The old bridge was moved on Aug. 17, 1902, and it is expected that the bridge will be completed by March, 1903. As is customary on this road, the construction is being done by the Bridge and Building Department, of which Mr. C. F. Loweth, M. Am. Soc. C. E., is the Engineer and Superintendent. Mr. J. C. Hain, Engineer of Masonry Construction, has immediate supervision of the work.

A METHOD OF CALCULATING THE RANGE OF SPEED TO BE OBTAINED FROM A PAIR OF EQUAL CONES.

By Frank B. Kleinhans.*

A problem that invariably confronts one in the design of belt-driven machinery, is the changing of speeds, and in machine tools, the range of speed is perhaps greater than is required for any other class of machinery. The cone is mostly used for this purpose, and perhaps will be for many years to come. Although inferior to a geared drive in some respects, yet its simplicity is an advantage which makes it preferable to gearing in many cases.

The problem which is here considered is the range of speed which is obtained from a pair of equal cones. The cases where the cones are not equal are very rare indeed. The accompanying illustration shows a pair of equal cones, in connection with a first and a second back gear. These are arranged to obtain the range of speed for a boring mill, but the same arrangement will apply

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to any other machine where such a range of speed is necessary.

In the following computation, we will let n = number of steps; a_1 = diameter of small step of the cone, and a_2 = diameter of large step of the cone. In the case shown in the illustration, n = 6; a_1 = 19, and a_2 = 34.

$$\left(\frac{a_2}{a_1}\right)^{\frac{2}{n-1}} = \text{The constant multiplier.} \quad (1)$$

$$\left(\frac{34}{19}\right)^{\frac{2}{5}} = \text{The constant multiplier for this case.}$$

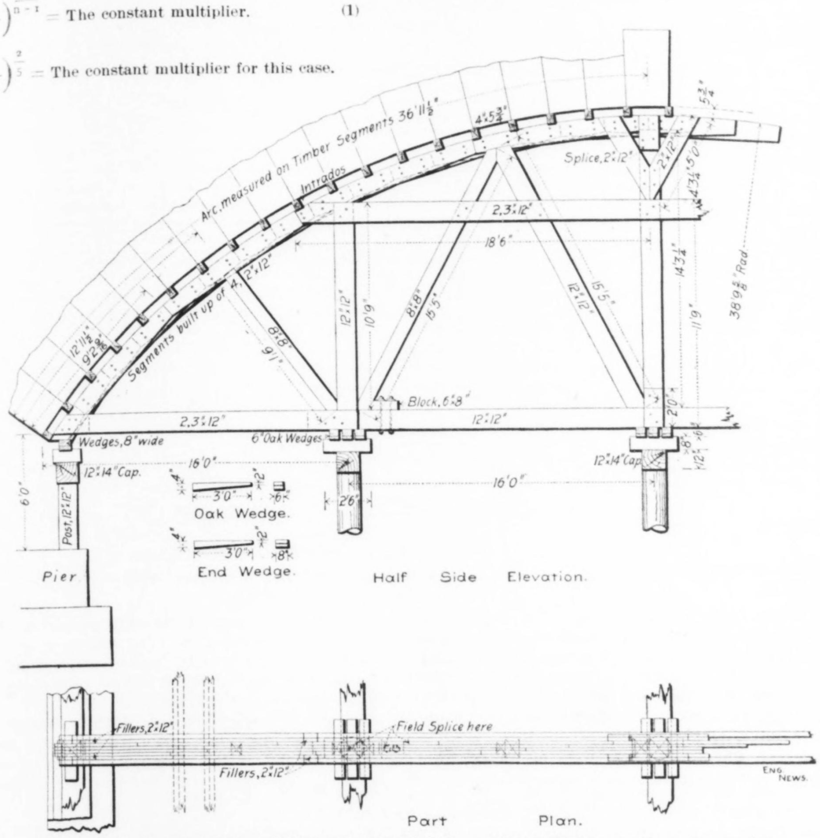

FIG. 2. TRUSS RIBS FOR CENTERING OF STONE ARCH BRIDGE, C., M. & ST. P. RY.

By applying logarithms, we have,

$$\text{Log}\left(\frac{34}{19}\right)^{\frac{2}{5}} = (\text{Log } 34 - \text{Log } 19) \times \frac{2}{5}$$

Log 34 = 1.5315
Log 19 = 1.2788

$$\begin{array}{r} .2527 \\ 2 \\ \hline 5\,)\;.5054 \\ \hline .1011 \end{array}$$

The number corresponding to this logarithm is 1.263, which is the constant multiplier for this case. That is, if you have the speed at which the cone will run, with the belt on the largest step of the machine cone, the next speed will be obtained by multiplying the known speed by this constant, thus:

1 = The 1st speed.
1.263 = The 2d speed.
$(1.263)^2$ = The 3d speed, etc.

$$\text{and } (1.263)^5 = \text{The 6th speed} = \left(\frac{34}{19}\right)^{\frac{2}{5}\times 5} = \left(\frac{34}{19}\right)^2.$$

$$\text{Therefore, } \left(\frac{a_2}{a_1}\right)^2 = \text{The range of the cone.} \quad (2)$$

Only as many speeds can be gotten as there are steps in the cone, without going through some back gearing. Each cone has its proper back gear, and the ratio of this gear must be such as to continue the geometrical series of speeds given by the cone.

$$\left(\frac{a_2}{a_1}\right)^{\frac{2n}{n-1}} = \text{The proper first back gear.} \quad (3)$$

$$\left(\frac{34}{19}\right)^{\frac{12}{5}} = \text{The proper first back gear for this case} = 4.04.$$

The first set of gears shown in the illustration must therefore be juggled so as to give this reduction of speed; of course, it cannot always be exactly obtained, but it should be gotten as nearly as possible.

$$\left(\frac{a_2}{a_1}\right)^{2+\frac{2n}{n-1}} = \text{The range of the cone and the proper first back gear.} \quad (4)$$

$$\left(\frac{34}{19}\right)^{2+\frac{12}{5}} = \text{The range of the cone and the proper first back gear for this case}$$

$$= \left(\frac{34}{19}\right)^{\frac{22}{5}} = 13.$$

With the back gear marked first in the illustration, a range of speed, from 1 to 13, can be

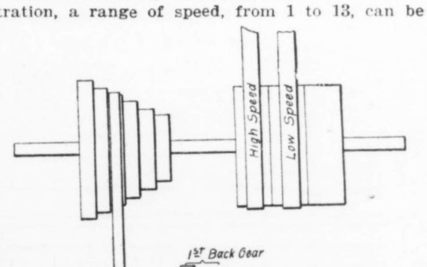

Diagram Showing Cone and Back Gear Arrangement for a Boring Mill.

obtained, but this range would not be great enough for this case, and a second back gear would have to be added.

$$\left(\frac{a_2}{a_1}\right)^{\frac{4n}{n-1}} = \text{The proper second back gear.} \quad (5)$$

$$\left(\frac{34}{19}\right)^{\frac{24}{5}} = \text{The proper second back gear for this case} = 16.35.$$

The range for this case will be obtained thus:

$$\left(\frac{a_2}{a_1}\right)^{2+\left(\frac{4n}{n-1}\right)} = \text{The range of the cone and the first and the second proper back gears.} \quad (6)$$

$$\left(\frac{34}{19}\right)^{2+\frac{24}{5}} = \text{The range of the cone and the first and the second proper back gears for this case}$$

$$= \left(\frac{34}{19}\right)^{\frac{34}{5}} = 52.3.$$

The speeds for the case considered have all been figured out, and have been arranged in the accompanying table for convenience and reference. It will be noticed that while the gap between the first two speeds is very small, yet between the last two speeds the gap is very great. For this reason, a two-speed counter is frequently resorted to. The second speed is such as to bring a speed midway between those shown in the table. Knowing one speed of the countershaft, the other can be obtained from it thus,

$$\frac{\left(\frac{a_2}{a_1}\right)^{\frac{2}{n-1}} + 1}{2} \times \text{by the low counter speed} = \text{the high counter speed.} \quad (7)$$

$$\frac{\left(\frac{34}{19}\right)^{\frac{2}{5}} + 1}{2} = 1.132 \text{ for the case considered.}$$

It will be noticed that if any speed in the table is multiplied by this number, it will give a speed midway between that one and the next higher. Sometimes a third back gear is added and the proper gear will then be obtained thus,

$$\left(\frac{a_2}{a_1}\right)^{\frac{6n}{n-1}} = \text{The proper third back gear.} \quad (8)$$

$$\left(\frac{a_2}{a_1}\right)^{2+\frac{6n}{n-1}} = \text{The range of the cone, and the first, second and third proper back gears.} \quad (9)$$

Table of Comparative Speeds by the Cone Arrangement Shown in Fig. 1.

A	Cone	1.00	1.26	1.59	2.01	2.54	3.20
B	1st back gear	4.04	5.10	6.44	8.13	10.30	13.00
C	2d back gear.	16.35	20.60	26.00	32.80	41.50	52.30

NOTE: Line A shows the range of the cone; lines A and B show the range of the cone and the 1st back gear; lines A, B and C show the range of the cone, the 1st and the 2d back gears.

RECORDING UNIT COSTS OF CONTRACT WORK.

By Emile Low,* M. Am. Soc. C. E.

At the annual convention of the American Society of Civil Engineers, held at Washington, D. C., May 21, 1902, an informal discussion was held on the following subject: "Is it possible and desirable to keep accounts of cost of work in such a manner as to ascertain unit costs on each class of work?"

Only a few members took part in the discussion, and their remarks were of a general nature, not going into details and methods by which definite results could be accomplished.

The writer desires to be placed on record as saying that the keeping of such accounts is very desirable and can be readily accomplished. In this connection he desires also to give his experience in this matter, and offers the following notes for the benefit of his fellow engineers.

In railroad construction it is almost the universal practice to keep an account of the forces employed by the contractor. These accounts, usually called "force accounts," are more or less elaborate, according as their value is rated by the Chief Engineer.

The data for these force accounts are collected by the Resident Engineer or some one of his party while passing over the work attending to his usual duties, the information being jotted down perhaps in the back of a note-book, or even on a stray piece of paper, an entire lack of system being the predominant feature of the method.

Usually these force accounts are rendered weekly to the Chief Engineer, upon blank forms furnished by his office. From the necessity of the case

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