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ELECTRIC TRACTION ON THE MANHATTAN ELEVATED has been "going to be adopted" a half-dozen times for as many years past; but now it has actually been decided to make the change and the directors have formally authorized an issue of $18,000,000 in bonds to make the change. According to a published statement by President Gould, the expert investigations of the results obtained in the generation, distribution and use of electrical power, by all the prominent electrical railway lines in the country, have shown that electric motive power on the Manhattan Elevated will effect a reduction of 2½ cts. per car mile in the operating expenses. This, on the basis of the present Manhattan traffic, will amount to over $1,000,000 per annum saving. The issue of $18,000,000 stock is expected to provide not only for the complete electrical equipment of the road and rolling stock, the construction of power stations, etc., but for the complete renovation and modernizing of the entire equipment.

ELECTRIC POWER FOR ELEVATED RAILWAYS presents a favorable showing in economy in the report of the South Side Elevated R. R. of Chicago, Ill., for the year ending Dec. 31, 1898. The months of November and December, 1897 and 1898, are the first strictly comparative months. The road, including the "Loop," measures 19.44 miles of track, and was operated entirely by steam in 1897 and entirely by the Sprague multiple unit system in 1898. In addition to all "Loop" expenses, there is a rental charge eqnal to 10% on the gross passenger receipts of the road. This should be considered really as an interest charge, not as an operative expense. For these two months the following comparative table shows (1) the ratio of expense to earnings, including "Loop" rental, taxes and licenses; (2) the ratio of expenses to earnings, excluding "Loop" rental, but including taxes and licenses; (3) the net earnings:

		(1)	(2)	(3)
November,	'97, steam..........	87.3	77.7	$10,603
"	'98, electric..........	57.3	47.7	39,448
December,	'97, steam..........	83.6	73.8	14,691
"	'98, electric..........	55.0	43.4	45,355

WATER POWER FROM THE DRAINAGE CANAL is again being suggested by the Trustees of the Sanitary District of Chicago. Sites proposed are at Lockport (just below the controlling works) and at some point below Joliet. The latter would involve the least expensive work, but is not generally so favorable. It is roughly estimated that it would cost from $3,000,000 to $4,000,000 to develop 24,000 HP., or as much as $6,000,000 for 30,000 HP. at Lockport, but these figures are apparently little more than guesses. As the Trustees have no money available for such work, it is proposed to lease the right to develop the power to a private company for a term of years, and the Engineering Committee voted on Feb. 4 to invite proposals to this end.

THE NEW YORK STATE CANALS improvement has been made the subject of a special report to the New York State Senate, which recently asked for the estimates for finishing the present contracts. This report says that in addition to the $9,000,000 already spent, $3,780,816 will be needed to pay for the work contracted for. The figures are as follows:

Total amt. paid on acct. of contracts..........	$7,238,795.08
Total amount retained	694,162.58
Total funds available for contracts awarded.	$7,932,957.66
Amounts paid other than to contractors as follows	1,099,531.99
Total for all payments made or due..........	$9,032,489.65
Deficit	32,489.65
Estimated amount required to finish all contracts	12,410,326.40
Estimated amount required to finish engineering	236,600.00
Estimated amount required to finish inspection	101,400.00
Add deficit	32,489.65
Total	$12,780,816.11
Total amount required to complete awarded contracts	3,780,816.11

No mention was made of the amount required to complete the entire improvement. The Clerk of the Court of Claims reports that up to Feb. 6 160 claims for damages have been filed against the state on account of the canal contracts. These claims aggregate $513,000. In regard to this matter Deputy Attorney-General John H. Coyne is quoted as saying:

"And they have just begun to come in. At this rate it would not be surprising to see the total amount of claims under this work run up to $2,000,000 during the year."

STATISTICS OF CANAL TRAFFIC through the great canals of the world are given in the latest issue of the "Summary of Commerce and Finance," published by the Treasury Bureau of Statistics. The canals included in this summary are the New York state canals, the Welland Canal the St. Mary's Falls Canal, the Kaiser Wilhelm Canal, the Suez Canal, and the Detroit River. The figures for five-year periods, since 1880, are as follows:

Year.	St. Mary's Falls, tonnage.	Detroit River, tonnage.	Welland freight trnsprtd.	New York canals, tons to tide water.	Suez, net vessel tonnage.
1880....	*1,734,890	20,235,249*	819,934	4,067,402	3,057,421
1885....	3,256,628	17,777,828*	784,928	2,715,219	6,335,752
1890....	9,041,213	21,750,913	1,016,065	3,024,765	6,890,094
1895....	15,062,580	25,845,679	869,595	1,603,745	8,448,383
1896....	16,239,061	27,900,520	1,279,987	2,073,378	8,560,283
1897....	18,982,755	....	....	1,878,218	7,899,373

*Gross tonnage.

Note.—The tonnage of the vessels passing through the Kaiser Wilhelm Canal, from the opening, has been as follows: For the years ending March 31, 1896, 1897, and 1898, 1,505,983, 1,848,458, and 2,469,795, respectively.

CONTRACTS FOR THE BOSTON DRY-DOCK were awarded on Feb. 6, 1899, by Secretary of the Navy Long. As noted elsewhere in this issue, the new dock will be of granite, 750 × 100 ft. clear inside measurement, with 30 ft. depth, and will accommodate the largest battleships now under construction. Its location will be about 200 ft. from the old Charleston Navy Yard dock. The contractors for the dock proper were O'Brien & Sheehan, of New York city, and the contract price was $857,200. The lowest bidder for the electrical appliances was the Thresher Electric Co., of Dayton, O., at $149,842, and it is stated that that bid will be accepted if the bonds are good.

TWELVE NEW WARSHIPS are provided for in the Naval Appropriation Bill reported to the House of Representatives on Feb. 8. There has been some delay in the completion of the bill by the committee owing to changes made by the Navy Department in its recommendations regarding the construction of docks. The successful proposal for constructing the granite dock at Boston (see this issue of Engineering News) has caused the department officials to change their recommendation for wooden docks to one for stone docks, and this, it is understood, the committee has incorporated in the bill.

The Navy Department officials have decided to build the armored cruisers with three screws each. The success and efficiency of the commerce destroyers "Columbia" and "Minneapolis," the only triple-screw vessels in the navy, are said to have been instrumental in bringing the officials to this conclusion.

The three battleships are to be seagoing, sheathed and coppered, and of about 13,500 tons each trial displacement, are to carry the heaviest armor and most powerful ordnance for vessels of their class, and are to have the highest speed and greatest radius of action. The estimated cost, exclusive of armor and armament, is $3,600,000 each.

The three armored cruisers are to be sheathed and coppered, and of about 12,000 tons trial displacement. They are to carry the heaviest armor and most powerful ordnance for vessels of their class, and are also to have the greatest speed and radius of action. Their cost is estimated at $4,000,000 each, exclusive of armor and armament.

The six ordinary cruisers are to be sheathed and coppered, are to have the highest speed compatible with good cruising qualities and great radius of action, and are to carry the most powerful ordnance suited to vessels of this class. They will have a displacement of about 2,500 tons, and will cost $1,141,800 each. The total cost of the new ships will be $28,225,400, exclusive of armor and ordnance.

In his annual report, Secretary of the Navy Long, adopting the recommendation of the Board of Construction, asked for authority to construct 15 vessels as follows: Three battleships of 13,000 tons each, three armored cruisers of 12,500 tons each, three protected cruisers of 6,500 tons each, and six cruisers of 2,500 tons each. The three protected cruisers were omitted from the bill as reported by the committee.

THE MOST SERIOUS RAILWAY ACCIDENT of the week was a head-on collision on the Chicago & Grand Trunk Ry., at Imlay City, Mich., on Feb. 6, which resulted in the death of three employees and the injury of five other persons. An eastbound passenger train was standing at the station when a westbound express ran at full speed into it. No reason is given for the failure of the westbound train to stop.

A LOCOMOTIVE EXPLOSION on the Erie R. R. near Cameron Station, N. Y., on Feb. 1, killed the fireman and seriously injured the engineer. The engine was drawing a freight train.

FOUR 80-HP. BOILERS EXPLODED at the Shreveport oil mills, Shreveport, La., on Jan. 30, killing four men and completely wrecking the brick boiler house.

A SNOWSLIDE ON THE DENVER & Rio Grande R. R., 9 miles east of Glenwood Springs, Colo., on Feb. 3, overwhelmed a work train and killed five men, besides injuring several others. The men were engaged in clearing the tracks of snow at the time the slide occurred.

A SERIOUS RAILWAY ACCIDENT occurred on the Central division of the St. Louis, Iron Mountain & Southern Ry., near Pollock, Ark., on Feb. 7. Owing to a failure of a freight train to stop when ordered, it collided head-on with a passenger train, killing two trainmen and seriously injuring two others.

A STAND-PIPE ACCIDENT occurred, Jan. 31, at Murphyshoro, Ill., the pipe tilting over until it fell to the ground. The standpipe was 15 ft. diameter and 150 ft. high, with a capacity of 198,180 gallons. Mr. Charles L. Ritter, Superintendent of the Murphysboro Water-Works & Elecrtic & Gas Light Co. informs us that the most plausible theory of the cause of the accident so far offered is that the foundations settled on the north side, examination by engineers showing a settlement of 1½ ins. in the direction taken by the pipe when falling.

AN AUXILIARY PIPE LINE SYSTEM for fire purposes is advocated in a resolution of the Chamber of Commerce of New York city, which was passed at the last meeting. The plan advocated is to lay the auxiliary pipes through the business section of the city, with supply branches to the Hudson and East Rivers, into which fire boats could pump.

THE REMOVAL OF RAILWAY GRADE CROSSINGS in the city of Worcester, Mass., can best be accomplished by elevating the tracks, with but slight depressions of the street, according to the Report of the Grade Crossing Commission, which has just been published. It is proposed by this report that the railway tracks shall be elevated 12 ft. at the Union Station, and that all streets, where the angle of the crossing possibly permits it, shall be crossed by masonry arches. When it is necessary to use metal structures they shall have solid floors, filled so as to be water tight and noiseless. The cost of the work recommended is estimated at $2,292,000.

BALLAST CARS FOR COAL TRAFFIC are being used by the Illinois Central R. R., and are given a capacity of 80,000 lbs. by increasing the height of all sides, and supporting them by stakes. The cars are of the Rodgers type, illustrated in our issue of Feb. 17, 1898. During the summer they are used for ballasting and other improvement work, but as this work cannot be carried on in the winter they are then made available for the coal traffic, thus keeping them continually in service.

A MUNICIPAL ICE SUPPLY IN BOSTON is one of the latest innovations to be introduced by that progressive city. The ice is being cut by the water department from its reservoirs. The ice is to be used for the public drinking fountains installed by the department last year. Possibly it will be furnished to some of the other city departments, next year if not this. Two ice houses have been built, and are now being filled under the direction of Mr. John R. Murphy, Water Commissioner.

THE ICE BRIDGE IN THE NIAGARA GORGE.

By Orrin E. Dunlap.

Nearly every year, in the month of January, an ice jam of great size forms in the Niagara gorge below the falls. At Niagara these jams are called ice bridges, from the fact that they bridge the river and afford a means of crossing from shore to shore. The conditions for their formation are severe cold weather in the lake region, followed by a thaw and high winds sweeping across Lake Erie. The thaw and wind break up the great ice fields, and the frozen blocks are swept down the lake to the entrance of the Niagara River, where they are caught by the current and carried down stream and over the falls. In the passage through the upper rapids and over the falls the huge sheets of ice are broken up into fragments, and it is these small cakes which wedge in the river below the falls and form the ice bridge. The great quantities of ice which come over the falls move onward down the river, filling the eddies on both sides; piling up in masses along the shores, and thus building out until the eddies are crowded and the ice therein is stationary. When this occurs the only movement is through a channel in the center, the lines of the channel being cut quite straight as the current forces the floating ice down stream Finally the flow of ice becomes heavier; the channel left for its passage becomes too small, and then a jam results. The immense quantity of water falling over the falls, estimated at 15,000,000 cubic feet a minute, presses the ice forward with irresistible force and it piles up in great masses. Such conditions are usually accompanied by extremely high water, which carries the ice still higher on the shores, tearing away docks, trees and buildings in its path.

While Niagara has had many notable ice bridges, none of them has been recognized as an element of great danger until this year. In the past all the bridges across the Niagara gorge have been of the suspension type. All these, however, have recently been replaced by steel arches. In the case of the lower, or Grand Trunk, arch the abutments were placed midway between the cliff tops and the water's edge, but in the case of the upper arch, the abutments are close to the normal water mark. This year the ice bridge formed a few days earlier than usual. It remained a few days and wasswept out by the current. Within a few hours, however, another and greater bridge took its place, and this remained in position until the afternoon of Sunday, Jan. 22, when, while people were crossing it, it started to move out. It was a moment of great peril for those on the icy mass, and there were wild flights toward the shores. All but three persons succeeded in escaping quite easily, but this trio, two men and a woman, were on the moving ice some time. One of these men was close toward the New York bank and observed the ice piling up in a great mound about the abutments of the steel arch bridge. As he was being carried down stream he watched his chance, and when beneath the arch he was lifted up on the moving ice so that he caught on the main span a short distance out from the abutments, and climbed down the arch to the shore. The other man and the woman ran across the river to the Canadian side, were they landed, as the ice again became jammed.

These were the incidents that led up to the formation of the greatest ice bridge Niagara has had in many years. The water was very high, and there was an immense quantity of ice coming over the falls. A conservative estimate is that the ice about the New York abutments of the steel arch was 50 ft high. It was piled in a rough mass that almost completely covered the masonry abutments and reached into the steel girders of the arch, slightly bending some of the laterals. It was quickly seen that the ice jam threatened the safety of the bridge, and men were set at work blasting the ice away. They succeeded in breaking quite an opening about the abutments, and the stream of water pouring out of the tunnel portal close by carried the broken ice beneath the bridge. With another movement of the ice mass, however, the ice again settled about the abutments and it was again necessary to blast it away.

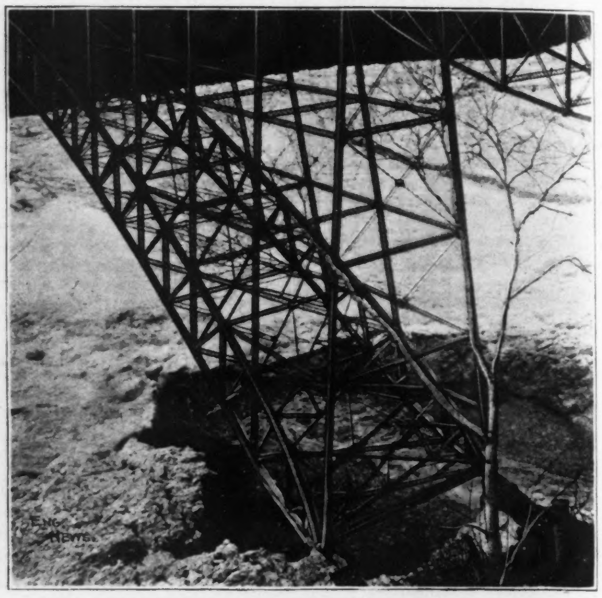
In blasting the ice about the abutments on the New York side of the river, about 25 lbs. of 40% dynamite was used. The method employed was to sink a bar in the ice six to eight feet and insert a stick of powder. The men who did the blasting found that the effect of the dynamite was not all that could be desired, owing to the fact that the mass was very light and filled with air seams in which the force of the explosive was spent. It was desired to use 60% dynamite, but this was not obtainable at the time. The men who did the blasting felt convinced from the conditions met that the ice would never be a source of much danger to the abutments. The ice appeared to have considerable depth below the water line.

The ice bridge may remain stationary for weeks. or at any time a high wind may sweep across Lake Erie, bringing the ice and water down in such quantities as to break it loose from the shore in a mass, and force it onward down the river. It is at such times that danger is present. for nothing could be expected to stand against the force of the ice pushed on by the body of water falling over the falls. Since the ice jam has formed in the gorge, the weather has been intensely cold, serving to solidify the mass and also making still greater ice fields in Lake Erie. With a thaw and a high wind, much of this ice will pass over the falls.

It may be thought that a sure way of preventing danger from the ice would be to break up the jam by explosives as soon as it forms. At Niagara, however, the stream is an international boundary, and people on both sides welcome the formation of a bridge with much rejoicing. Its novelty adds materially to the winter attractions at the falls, and tends to draw great crowds of visitors, on whom many businesses thrive. It is therefore apparent that should it be suggested that the entire Niagara jam be blasted out to leave an open channel for the water and ice, there would be intense opposition by many people on both sides of the river, who would see in the act a destruction of their source of profit.

It is gratifying to note the report that Chief Engineer L. L. Buck has stated, after an examination, that so far the ice has not in any way injured the abutments of the bridge. It is understood, however, that they will before another winter be protected by a pier or wall.

GENERAL VIEW OF THE ICE BRIDGE.



THE NEW YORK ABUTMENT OF THE BRIDGE AFTER THE BLASTING AWAY OF THE ICE.

THE ICE BRIDGE IN THE NIAGARA GORGE BENEATH THE NIAGARA FALLS AND CLIFTON ARCH BRIDGE.

THE CASTLEWOOD ROCK-FILL DAM AND THE CANAL OF THE DENVER LAND & WATER CO.

By W. P. Hardesty, C. E.*

A very interesting and bold piece of construction is the Castlewood Dam, near Denver, Colo. This is a loose rock-dam with masonry retaining walls, the only example of this type of construction to be found, to the best of the writer's knowledge. The Denver Land & Water Storage Co. was formed at Denver, in 1889, for the purpose of storing water and using it to irrigate land in the vicinity of the city, and the system to be described was constructed during the following year.

The reservoir and dam are located in Douglas county, a few miles southeast of Castle Rock, which is 32 miles south of Denver. As the intention was to use the water mostly for fruit growing, a large outlay for the amount of it secured was deemed proper. The supply of water is furnished by Cherry Creek, a stream whose tributaries come down from the divide between the Arkansas and South Platte rivers. Cherry Creek goes nearly dry during the summer, so cannot be relied on for much direct irrigation. Above the dam site it runs through a wide flat basin that forms a reservoir site. The present reservoir contains an area of 180 acres, covered to an average depth of over 34 ft., the capacity being 270,000,000 cu. ft., or two billion gallons. It is about a mile long by three-quarters of a mile wide in the

*Progress Building, Salt Lake City, Utah.

widest place. The bottom is flat and the sides comparatively steep, and the evaporation but slight.

Dam.—At the lower end of the reservoir site the valley of Cherry creek contracts into a canyon. At the head of this the dam has been built. The country here is quite rugged and of a peculiar formation. The high knolls and ridges are capped by sandstone and conglomerate in large blocks and masses, but these are underlaid by an almost pure clay. This clay formed the only foundation that could be obtained for any dam here.

The size of the dam compared with that of the reservoir was such that a solid masonry dam was not justified. So the consulting engineer for the company, Mr. A. M. Welles, of Denver, decided on a loose rock dam with a masonry facing and backing. The general design is shown by Fig. 1, and Figs. 2 and 3 are views of the structure from above and below, respectively, taken in 1898.

The dam is 600 ft. long on top, 70 ft. high above the ground on the upper and 80 ft. high on the lower side, and 8 ft. wide on top. The back or water side is battered 1 to 10, the face 1 to 1. The crest of the dam is of masonry, 4 ft. high and 8 ft. wide. The upper one-half of this is supported by the masonry retaining wall forming the back. This is a 4-ft. wall that slants or batters 1 to 10 up stream, thus leaning the same amount down stream and being supported by the loose rock filling. The lower slope wall is of large blocks of stone in single layers, laid directly on the loose rock. The upper wall is carried into the ground and rests on a concrete footing, at a depth varying from about 5 ft. near the ends to 22 ft. at the middle. The natural foundation consists of a hard sandy clay. This was partly covered by large boulders, which had to be removed. The masonry is all rubble, laid in Portland cement, and the blocks of stone are quite large. The loose rock filling is also of large pieces of stone, dumped in from above and not arranged by hand. The weight of the dam is estimated at 100,000 tons, or 9½ times the pressure of the water against it when full.

Near the middle of the dam is the spillway for carrying the surplus water. This is 100 ft. long and is 4 ft. below the crest of the dam. The upper retaining wall is here made vertical on the inside and battering on the outside, reaching a thickness of 11 ft. at the ground at the lowest point of the same. At the toe of the lower slope, or wall, a foot wall is placed for it to rest on, being 4 ft. wide and founded on concrete. At the west end of the spillway is the valve chamber. This is 6 × 7 ft. inside, and its walls are 5 ft. thick and vertical. There is 17 ft. of masonry under the bottom of the chamber. The details are shown in Fig. 1. Where the four sets of pipes from the reservoir enter the chamber the upper wall is stepped inward to give room for working the valves of each one, and the lower one is cut under to retain the size of the chamber, thus requiring arches to support it. These arches are 6 ft. wide, and the arch stones are 3½ ft. long by 3 ft. deep.

For a bulkhead to receive the impact of water from the pipes, two verticals of 14 × 6 ins. are set up flat and backed on the lower side by 2-in. plank, which in turn is backed by the lower wall, with cement grout between. The tops of these verticals are braced by horizontals leading to the upper wall. The reservoir is tapped by four sets of two 12-in. pipes. These begin about 37 ft. below the top of the dam, and are placed at vertical intervals of 6, 6 and 8 ft. When first built the bottom of the reservoir directly in front of the dam was 10 ft. below the lower pair, but it has since silted up to them. Masonry bulkheads are placed at the upper ends of the pipes, and they are enclosed in dry rubble with a certain proportion of masonry until they reach the dam. They pass through the upper wall of the chamber, embedded in concrete. At the bottom of the chamber a 36-in. conduit takes the discharge of the 12-in. pipes and passes it through the dam and returns it to the creek at the lower side. This conduit is enclosed in about 4 ft. of concrete. Access is had to the bottom of the chamber by an iron ladder. Adjoining the west end of the dam is an additional spillway or bypass, about 30 ft. wide. This is excavated in the earth and rock, is paved, and has masonry sides.

The dam and canal system were built by the Rosenfeld Construction Co., of Denver, by contract. They employed their own engineering supervision, and though the water company had inspectors on the ground during construction of the dam, these were very inefficient, consequently the work was slighted and not carried out according to the plans. The construction company failed about the time the work was completed. The experience here points to no exception to the general rule, that if a corporation wants good work done, it should have complete supervision of it through its own officers.

Many objections were made against this dam while it was being built by the inhabitants living along Cherry Creek, below the dam, as it was not generally considered safe. A stream of water flowed from beneath it, which gave additional uneasiness. In the spring of 1891 a committee composed of Messrs. J. P. Maxwell, State Engineer; H. F. Merryweather, Engineer of the Board of Public Works of Denver; and Donald W. Campbell, Consulting Engineer, was appointed to investigate. Mr. A. P. Boller, M. Am. Soc. C. E., Consulting Engineer, of New York, was present to represent the eastern investors in the enterprise.

The committee declared the dam faulty in construction, but thought it could be made perfectly safe by carrying out the recommendation of Mr. Boller. This was to provide an embankment of earth on the water side, carrying it up to the level of the spillway, pave it, and make other improvements. An embankment had already been built part of the way up, but not as far near the ends of the dam as originally intended by Mr. Welles.

This recommendation, however, was not carried out, and soon after this, through bad management and neglect, all the property began to deteriorate. The reservoir continued in use until May, 1897, when the dam partially failed. This was caused by the continued washing of the waves, finally undermining the foundation of the masonry on the east side. At this place it then settled, and several cracks 2 to 4 ins. deep were formed, extending horizontally. The reservoir was full at the time. The water poured through the cracks and came out on the lower slope of the dam. The reservoir was emptied; but during the following August the greatest flood ever known came down and filled the reservoir in four hours. Water from this passed through the breaks for ten days, with no additional damage, it is said.

The water, on reaching the toe of the lower slope, ran down the angle formed by this and the side-hill, undermining the masonry so that it settled badly downwards and outwards. At the west end of the failure a large crack ran up the slope.

During the eight years that the dam has stood there has been no settlement of the upper wall of the dam, except a comparatively slight one along the part that failed. Beginning 125 to 150 ft. from the west end, the lower half of the 8-ft. crest, which rested on loose rock, settled away so that a large crack was formed between it and the upper half, reaching nearly to the east end. This has been repaired by raising up the lower edge of the first course of masonry of the lower half until the crack was closed, then filling the open joint formed with cement and spawls. This, however, was only a matter of appearance, and did not figure any in the dam's stability.

After the break nothing was done with the property until last spring and summer, when, with the company reorganized, energetic steps were taken to put all the system in thorough repair. The dam has been repaired and improved as follows:

Where the break started, all the masonry of the upper wall at all disturbed was removed, making an opening about 30 ft. long, which, with an arched top and the addition of some props, supported itself temporarily.

The bottom of this was then widened out by an outside concrete footing, and the wall sloped up into the top of the opening made. At the toe of the lower slope or wall, where it failed, a foot wall was laid to prevent any future undermining, and the slope was then restored. At the foot of the spillway and for 50 ft. each way, an apron or pavement of stone with paved top was made to catch the shock of falling water. This is about 25 ft. wide at the bottom of the gorge.

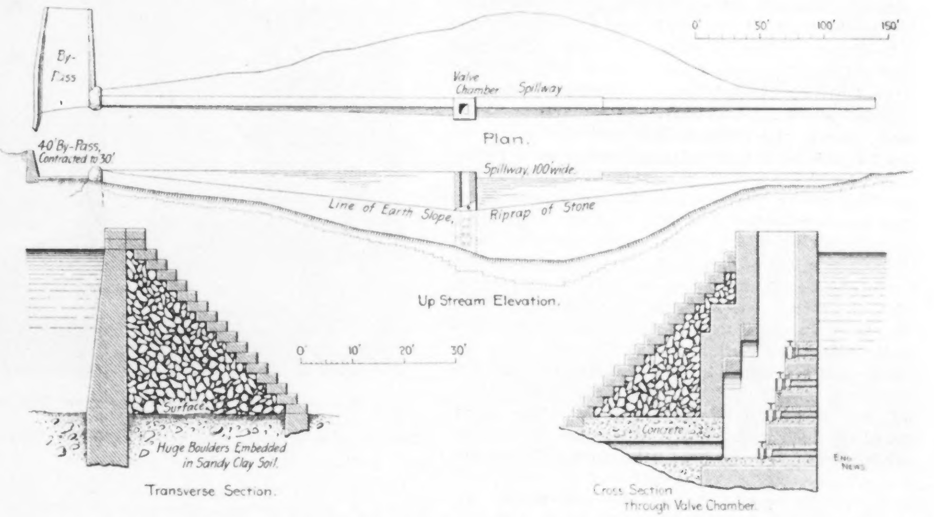


FIG. 1.—PLAN AND SECTION OF THE CASTLEWOOD ROCK-FILL DAM OF THE DENVER LAND & WATER CO.

Mr. A. M. Welles, Engineer.

On the upper side, the embankment of earth was very greatly strengthened as follows: A clay puddle wall was put in next to the masonry, beginning 3 ft. wide at the west end and increasing to 8 ft. at the valve chamber. For 150 ft. east of here (covering the lowest part of the ground) no puddle is used, but east of there—including the break—the puddling is 6 ft. wide. This clay puddle wall was carried down to the natural surface of the ground for its entire distance, except that along the line of the break it was carried to a level with the bottom of the foundations. The remainder of the old bank is regarded as having been packed enough by 7 or 8 years' exposure and water. No puddle was used where the dam is highest for the reason that there the foundations are too far below the surface of the water to ever be affected by wave action. Along the sides there is much more danger. The puddle walls were carried 1 to 2 ft. into the natural ground at each end. The top of the earth embankment in the middle, at the west end of the spillway, was made 35 ft. below the crest of the dam, and it runs in a straight line from there to the high ground near each end. A riprap of heavy stone covers the entire embankment, to protect it from the waves.

Mr. Welles has always maintained that the bringing of the embankment up to the top of the dam would be entirely unnecessary, and only serve to disfigure the structure.

Since being thoroughly repaired and having its earth embankment completed in accordance with ations along the shores of Loch Eil a steam launch with two barges also plied between Corpach and Kinlocheil, distributing materials at different parts of the works.

Leaving Kinlocheil, the railway continues to run parallel with the public road, and at 10 miles the Fionn Lighe River is crossed at an angle of 36½° on a double-span bridge. While most of the other bridges are composed entirely of concrete, that over this river has an iron superstructure. At Drimsallie, the public road is crossed on a 15-ft. span-bridge, and for the next mile and a half the track is carried over a low-lying stretch of country, along parts of which the moss or peat exceeds 7 ft. in depth. Where the railway is in cutting the moss is excavated below formation to a depth of 4 ft., after which a layer of brushwood is introduced and the track raised to formation level again with dry filling. On this section there are in all 90 culverts, all of which have been constructed of concrete. In nearly every case there is either an invert or pitching in the bottoms of the culverts, as the ground is of a gravelly nature, and scouring would be frequent had this not been resorted to. At 12 miles a 30-ft. span concrete bridge has been thrown across the Dubh Lighe River, and a quarter of a mile further on the line again crosses the public road near Craigaig shooting lodge, on the estate of the Earl of Morton. Up to this bridge the gradients have been easy, 32½ ft. being the difference of level between the highest and lowest points, while none of the curves are more acute than 20 chains. West of this, however, the district is mountainous, and the gradients are accordingly steeper and the curves sharper. For some distance after leaving Craigaig, the railway is carried on side-lying ground, and for this reason was somewhat difficult to form owing to subsidence. Entering a short tunnel at 13 miles, the line is carried through several deep cuttings for a considerable distance on a gradient of 1 : 50, passing the historical Glenfinnan on the left at 14 miles. The scenery here is very wild and rugged, and possesses numerous attractions for the lover of nature. At the head of Loch Shiel, which stretches away to the southwest, stands a monument erected by Glenaladale to mark the spot where Prince Charles Edward Stuart unfurled his standard in 1745.

The first piece of engineering work of any magnitude is here encountered, and consists of a viaduct over the Finnan Valley. The viaduct—which is being built entirely of concrete—is 416 yds. in length, and 100 ft. high. It has 21 spans of 50 ft. each, with semicircular arches 2 ft. 6 ins. thick at the crown. The piers, with the exception of two, are 20 ft. long and 6 ft. thick at top, with a batter on the face of 1 in 50. Piers Nos. 8 and 13 are stronger than the others, being 21 ft. long and 15 ft. thick at the top, but the batter on the face is the same; a void 9 ft. × 4 ft. 6 ins. being left down the center of each. The viaduct being on a 12-chain curve, the piers had to be tapered more than was required for radiation in order to have the spans 50 ft. at the inside and outside, as well as on the center line. In other words, the face of one pier was made parallel to the face of the next. The spandril walls are three in number, those on the side being 3 ft. 6 ins. thick, and the center one 4 ft. Six of the piers and the east abutment are founded on rock, while the others are on compact gravel and boulders. There is a deep rock cutting at either end of the viaduct, and the contractors have here erected a couple of steam stone-crushers. After being excavated, the rock is put through the crushers and then transferred to wagons, when it is run alongside the viaduct on a timber staging. A fair idea of the magnitude of this viaduct and the nature of its surroundings can be formed from Fig. 2.

Passing the site of Glenfinnan Station at 14¾ miles, the railway continues to rise on a 1 in 50 gradient, and curving behind the Stagehouse Inn again spans the public road at 15 miles. It is worth noting, in passing, that the road from here to Arisaig, a distance of 20 miles, was made by Telford in the beginning of the present century. The cost, which was between $80,000 and $90,000, was borne by Clanranald. Near 18 miles the line will span a stream on a viaduct extending to about 300 ft., and 60 ft. in height, while close at hand a second viaduct, having three spans of 50 ft., is nearing completion. For about ½ miles in this vicinity the railway descends rapidly, and skirting the southern shore of Loch Eilt, gets to the level again at 20 miles. At Arienskil, the River Ailort is crossed on a substantial concrete viaduct, and 50 yds. further on the railway is carried to the north side of the public road, alongside of which it runs for nearly a mile and a half. At 24 miles Kinlochailort Station is reached, and here a second tunnel is entered upon. This tunnel is 420 ft. in length, and 75 ft. under ground level. On emerging from the tunnel a girder bridge spans the public road, and after being carried through a rock cutting 45 ft. in depth the line crosses a road and stream on a double-span concrete bridge.

Up to 25 miles there is a preponderance of heavy rock cuttings and long embankments, and in this neighborhood two tunnels 75 ft. and 180 ft. in length respectively have been formed, Fig. 3. Between the tunnels an embankment 45 ft. in height, and a high retaining wall had to be constructed to prevent tailing out over the road. Fig. 4. For the third time within a mile the line is again carried over the public road, this time on a skew concrete bridge, Fig. 5.

Curving in a southwesterly direction, the track passes through a shallow part of Loch Dubh, and as the banks are composed of rock, the water does not affect them. The contractors are utilizing Loch Dubh as a means of supplying power for driving rock drills, and for this purpose the loch was raised 7 ft. by building a breast wall across the gorge which forms the outlet. This wall is fitted with screens, sluices, and scour, similar to the outlet for water-works. A 21-in. diameter steel riveted pipe conveys the water from the loch to a turbine 140 yds. distant. The turbine is an 11-in. double discharge horizontal type, working under a head of 75 ft., and passing 1,300 cu. ft. of water per minute, the area of ports being 75 sq. ins. The turbine—the casing of which is 3 ft. 6 ins. in diameter—gives 100 HP. and works at a speed of 900 revolutions per minute. The foundations and shaft were made long enough to accommodate a dynamo of 75 HP. which conveys electricity to motors for driving stone crushers and air compressors, and for illuminating tunnels. The air is conveyed along the route of the railway in cast-iron flanged or malleable iron screwed pipes, the greatest distance being about nine miles at present. On the iron pipe a tee with a valve is placed where required, and into this a flexible pipe is fitted, which connects with the rock drills in the cuttings. This method of generating electricity is adopted at different parts of the works—artificial "lochans" being formed where necessary—and at the rock cuttings at Glenfinnan Viaduct there is an air compressor capable of driving twelve drills. Portable compressors are also in use, and supply air for the drills in the smaller cuttings.

Leaving Loch Lubh, the railway passes through a 40-ft. cutting and on to a viaduct 53 ft. high, which crosses the Arnabol Burn. This viaduct, which is of concrete, has six spans, each of 50 ft. The line now follows the shores of Lochnanuamh, and traverses very wild and picturesque scenery—some magnificent views being obtained of the coast of Ardnamurchan. At 27 miles, Lochnanuamh Viaduct—eight spans of 50 ft. each, and similar in construction to that over the Arnabol Burn—is crossed, Fig. 6. Immediately beyond this viaduct the track is carried through a tunnel 150 ft. in length, and the steepest gradient on the undertaking, viz., 1 in 48, is here entered upon. In this vicinity there are other three tunnels, all of which are nearing completion. Their lengths are 270 ft., 195 ft., and 490 ft., respectively. This locality gives employment to the largest number of workmen, and huts, stores and workshops meet the eye at every turn. From a scenic point of view, this too is probably the grandest part of the route.

Still rising on the same gradient, the public road is again twice crossed, and near at hand a steam navvy is working in a cutting 41 ft. deep. This cutting, which extends to 1,200 ft., is composed partly of moss and partly of rotten rock, but the bottom is solid, and was taken out with the aid of rock drills. At 29 miles Beasdale Station is reached, and from this point the line runs for about a mile on the level through peat or mossy ground. At Borrodale, another tunnel 350 yds. in length—which is the longest one on the line—is entered, after which the railway is carried over the Borrodale Burn on a concrete viaduct with stone facings. This structure has three spans, two of 20 ft., and one of 127 ft. 6 ins., the rise of the latter being 22 ft. 6 ins. and the thickness of arch at crown 4 ft. So far as is known, no concrete viaduct has yet been constructed of a larger span than this. Passing through a deep cutting extending to 500 yds., near 30 miles, the line descends for about a mile on a grade of 1 in 50. Near here a 20-ft. embankment crosses a low-lying piece of ground where the moss is over 40 ft. deep, necessitating the laying of a false bottom. Crossing the Laraiche Burn on a three-span bridge, the railway soon reaches Arisaig at 32 miles. Situated on the shore of Loch-nan-Cilltean, this hamlet commands an extensive view of the Islands of Eigg, Rum and Muck, with the Atlantic stretching away towards the outer Hebrides. Continuing to fall on alternate gradients of 1 in 50 and 1 in 75, the railway again gets to the level at 34 miles, and sweeping round in a northerly direction, runs parallel to but at some distance from the rugged coast of Morar. Near 36 miles, the River Morar and public road are crossed on a concrete viaduct of four spans, viz., 20 ft., 90 ft., 50 ft., and 20 ft. respectively, the rise of the 90 ft. one being 24 ft., and the thickness at crown 3 ft., Fig. 7. From this point, and until Morar Station is reached, the line is formed through light moss and rock cuttings, and in the neighborhood of Glasnacardoch, three small bridges are in course of construction. On a grade of 1 in 80 the line clings to the rocky shores of the Sound of Sleat, and after passing through a number of minor rock cuttings, reaches Mallaig on the seaboard. The pier and breakwater to be constructed here are not included in the present contract, and are to be let out separately.

From the commencement of the line up to near Craigaig Lodge, a distance of about 12 miles, the permanent way has been laid, and the line partially ballasted. On this section the fencing is also practically completed, and the works finished off generally. At the other end of the railway the permanent way has been laid over a stretch of 8 miles, and the telegraph, which has also been erected between Kinlochailort and Morar, is being temporarily used by the contractors for telephonic purposes.

On an average between 1,800 and 2,000 men have been regularly employed at the works. Roughly speaking, the undertaking may be said to be completed to the extent of about two-thirds and with favorable weather the contractors are hopeful of having the railway ready for traffic by the spring of 1900. The engineers of the line are Messrs. Simpson & Wilson, Glasgow; and the contractors, as already mentioned, are Messrs. Robert McAlpine & Sons, of the same city.

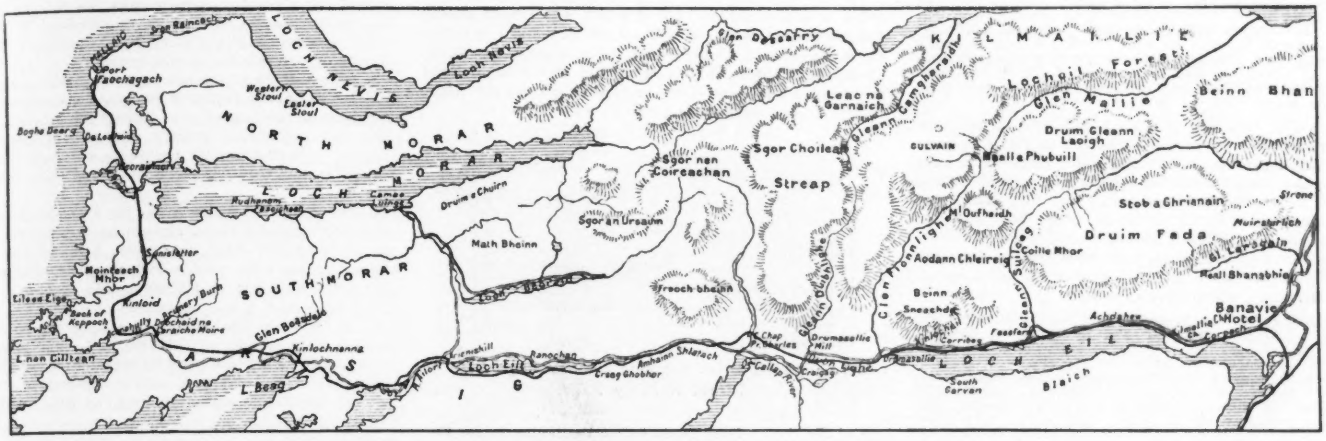


FIG. 1.—MAP OF MALLAIG EXTENSION OF THE WEST HIGHLAND RY., SCOTLAND.
Simpson & Wilson, Glasgow, Engineers; Robert McAlpine & Sons, Glasgow, Contractors.

A PROPOSITION FOR THE LICENSING OF CONTRACTORS.*

Engineers are perfectly familiar with the difficulties arising under our present system of letting contracts publicly to the lowest bidder. The conditions have become intolerable alike to contractors and engineers, and it is entirely probable that the tax-paying public is ready for an improvement, as it is believed that our taxpayers are willing to pay the actual cost of good work, together with a living profit to the contractor. This living profit it is now

*Condensed from a paper read by Mr. J. H. Burnham, of Bloomington, Ill., at the annual meeting of the Illinois Society of Engineers and Surveyors at Champaign, Ill.

the designer's original idea, this dam should now afford a fair test of this type, and its behavior will be watched with interest.

The dam and its type have had but few defenders among the engineers of Colorado, but all should be willing and anxious to have it given a fair trial. The principles originally criticised have seemed to stand the tests the best, the break having occurred where least expected, and that mostly through neglect in construction and maintenance.

The cost of such a dam is much below that of a solid masonry one, and there is very much less danger to the country below in case of a complete failure, as the structure would remain in place as a loose rock pile in any event.

Canal System.—The water, after passing through the dam and returning to the creek, passes on down the canyon. The distance to the mouth is over 1½ miles, and the fall nearly 300 ft. Here the water is diverted into the canal, called the Arapahoe Canal. The headgate consists of three gates, 3¾ ft. wide by 3¼ ft. high, of oak, but with slides made of angle irons. Screw stems are used for raising the gates. At each side of the headgate is a masonry wing wall 4 ft. thick, one reaching to the bank of the creek, and the other to the crib-diverting dam crossing the creek. This dam was originally a pile dam, of two rows of piles 3 or 4 ft. apart and braced together, each row boarded up with 2-in. plank. As reconstructed the past season, the present dam is a continuous or lap-jointed crib, built of pine and spruce logs—none of which are less than 30 ft. in length, 10 ins. in diameter at the top and 20 ins. at the butt. There are cross ties 6 ft. apart along each layer, drift-bolted at every point. This structure was built upon a bed or mat, 4 ft. thick, of willows and scrub oak brush, none less than 12 ft. in length, with their ends interlocking and making a mat over 20 ft. in width up and down the stream. Directly along the center of this the crib, 8 ft. in width, was constructed. The crib was then loaded with rock closely laid in place. The piles of the old dam were still left in place, and these were sawed off flush with the top of the new dam, thus locking it and helping hold it in place. The upper face of the crib was chinked and calked and graded to the level of the spillway with earth. At

Fig. 2.—View of Castlewood Dam from Above Showing Earth Embankment, Riprapped.

the lower side of the crib from which the brush mat projected some 6 or 8 ft., forming an apron, the mat was loaded with large rock, reaching nearly to the top of the spillway. The ends of the dam were riprapped over a considerable area, both above and below, with rock, to guard against eddying waters.

The canal was designed to be 12 ft. wide in the bottom, but it is now in many places much narrower. The depth of water is 4 ft. The fall for 24¾ miles is 2.64 ft. per mile, then it is 5.28 ft. The main canal is 38 to 40 miles long, and there are 30 to 35 miles of laterals. The canal was intended to carry 150 cu. ft. per sec. A bank on the lower side only is needed. There are but few places where the canal is in embankment, by far the greater part of it being in through cut. No solid rock is encountered. For crossing the drainage streams along the route there are six pipe lines in the form of inverted siphons, while a number of flumes are used for the smaller openings. The six pipe lines, with names of the gulches they cross, are as follows, they being in regular order down the canal:

Name.	Length, ft.	Head at lowest point, ft.	Diameter, ins.	Fall, from end to end, ft.
Willow Creek	840	24	48	5.83
Lemen Gulch	1,210	53	48	3.65
Oak Gulch	350	22	48	0.50
Newlin Gulch	1,836	68.5	42	6.0
Badger Creek	813	47.7	42	3.0
Cottonwood Gulch...	483	29.7	36	2.08

The pipe lines were built of staves of Texas pine, milled to 1¾ ins., with steel bands ⅝-in. in diameter. The company supplied the material and ex-

Fig. 3.—View of Castlewood Dam from Below.

cavated the trench, and the contractor built the pipe in the trench at 75 cts. per ft.

The lumber cost $32 per M. laid down, and cost $5 per M. for dressing into staves. The bands with nuts cost 4 cts. per lb., and the cast-iron shoes 2½ cts. per lb. The pipe was buried except in two places, where it was suspended on trestles across creeks. Here it was exposed, but was painted. The spacing of bands varied from 24 ins., where the head was less than 8 ft., up to 10 ins., where the head was 47 to 68 ft., and it was presumed to give a factor of safety of four. The pipe is of the C. W. Dwelle pattern, in which the joints are not broken but come in one circumferential seam, the junction of which is made by means of an outside ring of staves 4 ft. long, which also makes the joints water-tight. Some of the cast-iron shoes were faulty, and so broke and caused washouts, but the bands served all right.

For much of their length the pipe lines received a very thin covering of earth, and for long stretches this was removed from various causes and the pipe subjected to decay from drying out when not in use. Added to this, the general neglect and disuse common to the whole system for several years past had caused it to deteriorate very fast, so that when steps were taken to put the canal in working order the past season, much of the pipe had to be repaired to make it answer at all. The contractor for the pipe line was Mr. W. R. Askew, of Denver, who claims that the Texas pine is fully as durable as California redwood.

The flumes are of one general type. The spans are usually 16 ft.; the mudsills, posts and caps are 10 × 10 ins.; the stringers, 6 × 12; the sills and posts for flume proper, 6 × 6; the sides of 1½-in. plank, with tongue and groove joints. A ⅛ × ⅞-in. tongue fitting in grooves of ½ × ½-in. is used for all the newer work. Originally the tongues were ¼ × 1½ ins. The side posts have batter posts of 6 × 6, and so do not have ties across the flume. The approaches to the flumes consist of long slightly flaring wings, with aprons and short wings at the ends.

A system of lower reservoirs to afford additional capacity is designed, being located on the plains country and adjacent to the land to be irrigated. One of these, the Clark reservoir, with a capacity of 30,000,000 cu. ft., was built soon after the canal.

The land to be irrigated begins about 20 miles south by southeast of Denver, and approaches to within 7½ miles of the center of the city. The company owns about 14,000 acres of fine fruit lands, and has a farm of its own, called the "Colony," on which it has 30,000 to 40,000 fine fruit trees. On account of the nearness of the Denver market the lands are considered to be very desirable for truck gardening and fruit growing.

During the construction of the dam and canal system, and for a long time thereafter, the affairs of the company were grossly mismanaged, and in about 1893 it went into the hands of a receiver. Then for a long time, mostly on account of lack of funds, the property was allowed to deteriorate badly. But early during 1898, the Denver Land & Water Co. was organized, the property taken out from the hands of the receiver, and steps taken to put the plant in good condition and to develop the property in accordance with the original idea. Mr. Jerome K. Smith was appointed general manager, and he has used great energy in putting the affairs in good shape. The engineer for the company is Mr. A. M. Welles, the original designer of the plant. The headquarters are at Denver.

THE MALLAIG RAILWAY EXTENSION THROUGH THE WESTERN SCOTTISH HIGHLANDS.

(With full-page plate.)

One of the most notable instances of the extensive employment of concrete in railway work of which we know is furnished by the new extension of the West Highland Ry. of Scotland, which is locally known as the Mallaig railway. This extension is 30.75 miles long and branches off from the parent line at the station of Banavie. It extends almost due west from here to the coast and then swings abruptly north to the port of Mallaig on the Sound of Sleat, which separates the mainland from the Isle of Skye. In fact, the fishermen and small farmers of Skye and the mainland, and, to a lesser extent, those of the outer Hebrides, will obtain by this route for the first time an adequate outlet to the south for their products. It is this traffic and the tourist travel into the picturesque Western Highlands of Scotland which will chiefly occupy the extension. From a scenic and historic point, indeed, the new line stands almost unrivaled by Scottish railways.

For the present purpose, however, the historic lochs and scurs of these Western Highlands are interesting chiefly for the difficulties which they presented to the constructing engineers of the new railway line. An idea of the character and magnitude of some of the problems met with in bridge and tunnel construction particularly is furnished by the accompanying views from photographs of the work sent us by Simpson & Wilson, of Glasgow, Scotland, the engineers of the extension. The contractors for the work were Robert McAlpine & Sons, of the same city. For the following particulars of the work we are indebted to an article in "The Engineer," of London:

The new railway, which is 39¾ miles in length, branches off from the West Highland line a little south of the station at Banavie, Fig. 1, and is to be carried across the Caledonian Canal on a swing bridge of 50-ft. span. From this point to Corpach—where the first station will be—a distance of 1¼ miles, two overhead accommodation bridges, formed of concrete, have been completed. Immediately on leaving Corpach Station the line comes so close to the shore of Loch Eil that a concrete wall, 350 yds. long and 7 ft. high, had to be built to retain the slope, and protect it from the lake. From 3 to 9½ miles the line continues to follow the shores of Loch Eil, and is hemmed in between the public road and the beach. The sea walls required between Corpach and Kinlocheil are 17 in number; they are all brought to formation level, and are each 9 ft. from center line of railway to the wall face. At 6¼ miles the Fassifern stream is crossed on a double-span concrete bridge, which was rendered necessary owing to there being insufficient head-room for the rise required for a single span. For the same reason a double 10-ft. culvert was constructed over the stream at 7½ miles. From Banavie up to Kinlocheil the railway is virtually level, and is completed to formation. Throughout the early stages of the works a pier was erected by the contractors at the head of Loch Eil, at which plant and materials were landed, and an adjoining yard contains an engineers' shop, smithy, and saw mill, as also cement and general stores. During the progress of opertending to rupture the bottom or sides, decreases with the depth, and while the question of stability and safety of such a dock may be a comparatively simple one, where the depth is shallow, it becomes one of great importance, magnitude and risk in the very deep docks which it is now necessary for the Navy to provide for its deep-draft cruisers and battleships. Accidents of this character have occurred, more or less serious, in several of the timber dry-docks owned by the government, extending from the bursting in of the altar system, as at League Island, Port Royal and New York, to the distortion of the floor of the dock, as at Port Royal, and the partial collapse in the case of Dry-dock No. 3 at New York.

9. Dry-docks are structures about which, when built, there should be no doubt, and it is quite safe to say that such freedom from risk in the case of a very deep dock can only be obtained from one built of masonry. A timber dry-dock, for its integrity, depends upon the success of pinning it down to the soil, or in admitting the water so freely to its interior as to relieve the pressure, making it a very leaky dry-dock, and even with these precautions safety cannot be considered as assured. A masonry dock is designed to resist the dangerous force referred to above by its own weight, and when so designed and well built, making a water-tight structure, it is absolutely safe.

10. The highest authorities upon the construction of dry-docks state that the preference is given to those dry-docks because of their stability. The masonry docks built for the Navy vary in age from 10 to about 65 years. They have been entirely successful, and, with the exception of one, the repairs to the dry-dock structure proper may be said to have been insignificant. The only considerable individual repair to a masonry dry-dock in the history of the Navy was to the one at the New York Navy Yard, amounting to about $100,000, during its life of 45 years, while the repairs to one of the two timber dry-docks at the New York yard have cost $171,000 in one instance, and the other will soon receive an outlay of $300,000 to repair natural deterioration and substitute a masonry for a timber entrance, all within an age of 10 years.

11. The records of the cost of repairs to the masonry docks have not been compiled with great exactness because of the difficulty of consulting fully all the old records in connection with them, but sufficient has been obtained to show that what is herein stated is substantially correct.

12. In consideration of all the circumstances, the Bureau has thought it to be its duty at this particular time, when it has been found possible to contract for the construction of a first-class concrete and stone dry-dock of the largest size for about $1,000,000, and when the Department is about to enter upon the construction of three timber dry-docks, at a limit of cost for each of $825,000, to urge that the matter be presented for the consideration of Congress, with the Department's earnest request that the law be changed to allow of the construction of three dry-docks of stone or concrete and stone, of the largest size, at a limit of cost of $1,100,000 each, in lieu of the three to be of timber, as provided for by the act approved May 4, 1898.

STREET RAILWAY TRAFFIC IN THE BOSTON SUBWAY.

Recent reports regarding the crowded condition of the Boston subway have led to an investigation of the matter by a member of the editorial staff of this journal. After a conference with Mr. Howard Carson, M. Am. Soc. C. E., Chief Engineer of the Boston Transit Commission, observations were made in the subway itself and the experience and opinions of persons who use it frequently were obtained. From this inquiry it appears that the crowding which is now a source of complaint is due, first, to the great popularity of the subway; and, second, to the limited space allotted by the legislature for the Park St. station, where at present the greatest platform crowding and confusion takes place. As to the popularity of the subway, observations indicate that in rush hours the traffic at the Park St. station which originally went south on the surface cars past this point is now over 300% greater than it was in December, 1894, whereas the normal increase in surface traffic in that time would not have been over 40 to 50 per cent. Car lines from other streets than Tremont have been forced into the subway by popular demand. In addition to this, the increase in the transfer system at Park St., and the better chances for getting a seat in cars starting from that point have tended to concentrate passengers there.

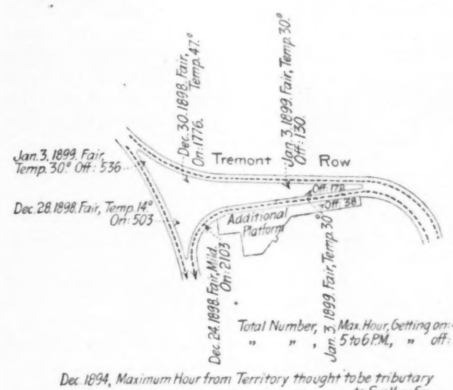
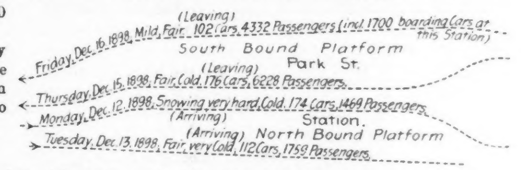


Fig. 2.—Traffic in the Boston Subway, at Scollay Square Station, 5-6 p. m.

Regarding the total traffic in the subway at the Park St. station, the last report of the Boston Transit Commission has the following to say:

> The present traffic of the company indicates that during the first year of the subway as a whole the number of passengers taking and leaving the cars at this station will be at least as great as the number of passengers entering and leaving Boston by steam-railroad trains at the Northern Union Station, or about 24,000,000, and also greater than the aggregate number of passengers last year entering the city by all the other steam roads, which are soon to occupy the new South Union Station.



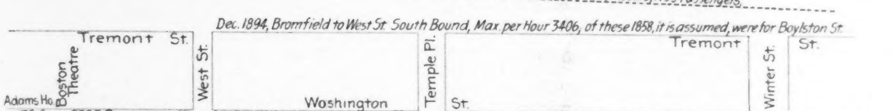


FIG. 1.—TRAFFIC IN THE BOSTON SUBWAY, PARK ST. STATION, 5-6 p. m.; ALSO IN THE SURFACE LINES ON WASHINGTON ST.

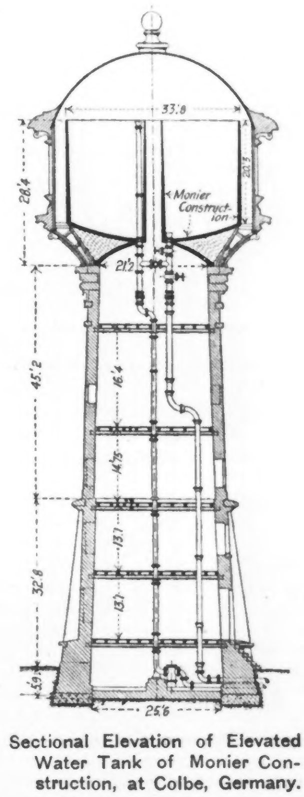
The actual subway traffic from 5 to 6 p. m. in both directions at the Park St. station of the subway and in the surface lines one block distant is given on the accompanying diagram, Fig. 1, kindly furnished us by Mr. Carson. The traffic at Scollay Sq., the next subway station north of Park St., is shown by Fig. 2. The diagrams also show the location of the subway in reference to nearby streets and buildings.

But it is to limitations of space, as well as to the large number of passengers, that the crowding at the Park St. station is due. The station here, as well as a long stretch of subway beyond, is beneath the Boston Common, to the use of which for these purposes there was much opposition. Consequently, the state legislature so limited the space that it is necessary to load cars for 27 different routes from five consecutive berths on one track. On the opposite side of the same platform, passengers alight with transfers to some of these 27 lines, thus adding to the crowd and confusion. The problem is to systematically distribute the passengers to the different routes, and the difficulty in doing this is greatly increased by the fact that the cars over different routes arrive in no regular order. At present the passengers are guided to their cars by an operator who displays placards with the names of the different routes opposite the numbers of the berths at which the respective cars will stop, the operator being able to see and identify the approaching cars sooner than the passengers. This present temporary system is to be replaced by an electrical signalling system. This will comprise a sign, on which will be displayed the name of each line of cars, and opposite to it a row of five pigeon holes, faced with glass and numbered consecutively from 1 to 5. In each hole will be an incandescent lamp. When the operator ascertains to which line an approaching car belongs, and at which berth it will stop, he will switch on the lamp in the hole with the number of the berth opposite the name of the line.

The subway was built very largely to relieve the crowded traffic on Tremont St., the demand for which was so great that the legislature ordered the surface tracks on that street entirely removed on the completion of the subway. There is a possibility that the tracks and some of the cars will be put back. Another possible source of relief, according to Mr. Geo. A. Kimball, M. Am. Soc. C. E., Chief Engineer of the Boston Elevated Railway, will be the elevated railways to be built under his direction. These will divert some traffic from the subway, will avoid much of the present transferring at Park St. station, and the longer cars will generally increase the subway's traffic capacity.

AN ELEVATED WATER TANK OF MONIER CONSTRUCTION AT COLBE, GERMANY.*

The accompanying illustrations show an elevated water tank, of Monier construction, having a capacity of 500 cu. m., or about 130,000 gallons. The iron used in construction is, for the most part, protected from the rust and the tank costs no more than it would if built wholly of iron. The tank is supported on a circular masonry tower, the lower part of which is used as a bathing establishment while the upper part serves as a residence for the superintendent.



Sectional Elevation of Elevated Water Tank of Monier Construction, at Colbe, Germany.

THE SUPPOSED "CORDUROY ROAD" of late glacial age, found at Amboy, Ohio, has been examined by Prof. G. Frederick Wright, of Oberlin, Ohio. He found a series of logs lying side by side, as in a corduroy road, and extending for a length of 200 ft. and covered by about 30 ft. of gravel, in which was the tooth and tusk of a mammoth; the tusk being 10 ft. long by 22 ins. in circumference at the base and weighing 155 lbs. But he decides, that while the resemblance to an artificial road is striking, the appearance of the logs showed that they were driftwood deposited during the closing centuries of the glacial period, when the water of Lake Erie was held at a level 150 ft. higher than it is at present. The logs and base of the deposit are now about 140 ft. above the lake level and four miles distant from the lake shore, on the banks of the Conneaut Creek. The gravel was brought down from higher land to the south, near the source of the creek.

*Abstracted from "Zeitschrift des Vereines Deutscher Ingenieure," by O. J. Marstrand, M. Am. Soc. C. E.

in many cases difficult to obtain; the inexorable law of remorseless and unscrupulous competition having driven bidders below prices which will allow fair cost, risk and a living profit.

At the meeting of this society in 1890, there was a discussion on the question: "In letting contracts, should the lowest bid always be accepted, and if not, what other features should influence the award of contract?" The evils resulting from the present system of letting public contracts to the lowest bidder are self-evident, and too well known by you to need more than a reference to the difficulties of the whole subject, which may be given by an extract from my own remarks in the discussion of the question above quoted:

> Awarding always to the lowest bidder ensures that the job will very frequently go to the ignorant low bidder; the bidder on the verge of bankruptcy, anxious to keep up appearances till better times; or to him whose chief end is to cheat and swindle in carrying out the plans. Honest contractors stand very little chance under this system, and would be driven out of the business if all of their work were to be secured in such public competition. If, on the other hand, full discretion were given to the officials to favor such bidders as their judgment approves, the way would at once be open for the filling of public offices with men who would never award a contract until their own percentage had been arranged for by the rules of "addition, division, and silence," and our last state would be worse than the first.

At the time this was uttered. I had been in the contracting business over twenty years, and then saw no prospect of any improvement, but in the nine years which have passed since that discussion, I have partially evolved a plan for improvement of methods. All will admit that what we need is to devise some plan which will, at least, partially ensure that most of our public work shall fall into the hands of such bidders as were deemed desirable by Prof. Ira O. Baker, in his remarks on the occasion above referred to, which were as follows:

> The character of the bidder should be taken into consideration. If his character will not pass for general honesty, uprightness and fairness in his business, his bid should be thrown out. Again, the experience of bidders must influence largely the letting of contracts. Every man awarded a contract should have an intelligent understanding of what his contract involved, and if he does not, his bid should be laid aside at once. The quality may next be made a test. I mean their financial ability to conduct the work to completion in the allotted time. I think that by applying the foregoing rules to all classes of letting contracts, very little trouble would be occasioned in getting the work well done for a reasonable amount.

The ideally perfect conditions which Professor Baker so graphically and correctly stated are rarely, if ever met in our present system of awarding contracts to the lowest bidders. Any other award is made so seldom that it is almost the universal rule that the lowest bidder obtains the contract, and the resulting troubles are too well known to need further repetition.

I propose that we simply extend the provisions of laws already in use, which have proved necessary and acceptable. We have laws providing that examining boards shall be appointed to examine druggists, mine inspectors, plumbers and architects. Now let us provide for the appointment of competent state examining boards to examine persons who wish to bid for paving our streets, laying our sewers, building our water-works and electric light plants, erecting our bridges, and doing other equally important work requiring technical knowledge.

This board, following the precedents already established, would license persons now in these occupations against whom no charges of incompetency or dishonesty were found, and in examining new aspirants it would, as is now the case in examining architects and plumbers, give a very careful consideration to their qualifications as prescribed by the proposed legislation.

All bidders should be required to deposit a certified check or cash deposit of definitely stated proportions, and to file bonds in the usual manner. Contracts could then be granted as now, to the lowest bidder, and, if the new law were wisely made and administered we could have hopes for an improved condition in a short time.

The examining board, or other proper authority, should receive regular reports from officials letting contracts, which reports should grade the bidder according to his honesty or efficiency in carrying out the work of the year. This might not be an actual grading, but it should result in making it known who were the reliable and who the unreliable bidders of the year. The next list of licensed bidders would omit the names of the dishonest, ignorant and inefficient contractors, and there would thus grow up what is now almost unrecognized, a gradual realization of the value of character and experience, qualifications which are now only of theoretical importance to a contractor.

One of the greatest advantages of the proposed plan would be the relief given to engineers or others in charge of the letting of public contracts, as they will wecome any project which promises to ensure that bidders shall be qualified for their business or which proposes a legal oversight of the records of the results of public lettings.

I am not aware this plan has ever been proposed before by any one. There may prove to be insuperable difficulties in the way, but, to my mind, a recognition of the evils complained of under our present system, should be a sufficient reason for causing us to give patient and careful consideration of any plan proposed for the improvement of our present system of conducting the letting of public contracts.

STREET RAILWAY CONSTRUCTION AT SOUTH BEND IND.*

By W. H. Rosencrans,† M. Am. Soc. C. E.

The city of South Bend, Ind., has at present about eight miles of street railway, all of which was rebuilt during the summer of 1898. Outside of the city there is a line along the bank of the St. Joseph River, southeast to Mishawaka, four miles, while another line leaves South Bend on the east and runs direct to Mishawaka, on the north

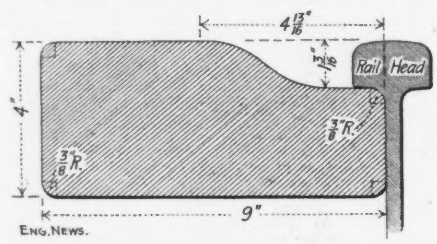


Fig. 1.—Special Brick for Use on the Gage Side of Street Railway Rails.

side of the river. Both roads follow the highways for the entire distance, but are constructed at the side of the road wherever possible. The same company has also acquired the Elkhart Street Ry. and the Goshen Street Ry., and during November and December last it connected these roads by an interurban line 10 miles long, on a private right of way, following the right of way of the L. S. & M. S. Ry. nearly the entire distance. A line has been located between Elkhart and Mishawaka, 10 miles, and will be constructed next spring, together with extensions to other towns in the vicinity of South Bend.

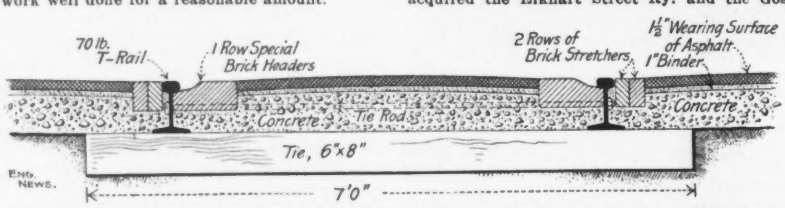


FIG. 2.—CROSS-SECTION OF STREET RAILWAY TRACK AT SOUTH BEND, IND.

The city lines (except on curves) were laid with 70-lb. girder T-rails, rolled by the Johnson Co., all rails being 60 ft. long. They are spliced by 36-in. 6-bolt splice bars. The old tracks were removed and the street excavated for a width of 8 ft. to a depth sufficient to allow 12 ins. of gravel to be laid below the ties. The track was laid upon this ballast, and was carefully lined and surfaced. The splice bars were cleaned of rust and scale before being put on, and the bolts were tapped with a hammer to ensure their being properly bolted up. Tie-rods through the rail-webs were placed at intervals of 10 ft. The joints were bonded with stranded bonds on the inside and a copper rod on the outside.

The street railway company is required to pave to 3½ ft. on each side of the center line, and also all spaces between double tracks, curves and switches. Concrete was laid between the ties and to a height of 1½ ins. above them, on all brick paved streets, but no concrete was placed upon the ties. The space between the rails was paved with brick, laid at right angles to the track, and having a crown of 1 in. For the flangeway, a special form of brick (Fig. 1) was designed, one end of which was made to fit under the rail head and against the web, leaving a flaring groove at the side of the rail head, the groove being of such section as to allow a narrow tired wheel to run out easily. Where asphalt paving was used, a line of headers of these special bricks was laid inside each rail, and two lines of stretchers outside, as shown in Fig. 2. With both kinds of paving, the space between the head and base of the rail, on the outside, was filled with grout, flush with the line of the rail head, forming an even face for the paving.

*From a paper by W. H. Rosecrans, presented at the annual meeting of the Illinois Society of Engineers and Surveyors, at Champaign, Ill., January, 1899.

†City Engineer, South Bend, Ind.

THE COMPARATIVE MERITS OF TIMBER AND MASONRY DRY-DOCKS.

A special report was made to Secretary Long on Feb. 3 by Commodore Mordecai T. Endicott, Chief of the Bureau of Yards and Docks, respecting the materials for the four new dry-docks provided for by Congress last summer. We print the report in full as follows:

Sir: Congress at its last session made appropriations for the construction of four timber dry-docks—one to be located at the navy yard, Portsmouth, N. H.; one at the navy yard, Boston, Mass.; one at the navy yard, League Island, Pa., and one at the navy yard, Mare Island, Cal.—to cost, when completed, not exceeding $825,000 each, and the Secretary of the Navy was authorized in his discretion to build one of said docks of granite or concrete faced with granite. In such case, the limit of cost of said dock was increased $200,000, making it $1,025,000. You exercised the discretion given you by the law providing for the construction of said docks, and decided that the one to be constructed at the navy yard, Boston, should be of granite or concrete faced with granite.

2. In pursuance of the law and your instructions thereunder, the Bureau prepared plans and specifications for a dry-dock of the largest size, calling for bids for its construction entirely of granite and also of concrete and granite. Invitations for proposals were advertised Dec. 27, 1898, and the bids were opened at the Bureau on Jan. 31.

3. The lowest bid received was for a dry-dock constructed of concrete and stone, amounting to $842,400, and for the pumping and other machinery, $130,000, making the lowest aggregate for the dry-dock complete, with accessory structures, $972,400, or $52,600 within the limit fixed by law for the cost of this structure.

4. As Congress has fixed for each of the timber dry-docks a limit of cost of $825,000, it is seen that a concrete and stone dry-dock can be constructed for about 25% additional to the cost of a timber dry-dock of the same general dimensions and equipment, as fixed by Congress The result of this advertisement for proposals is more favorable than was anticipated, as, from such information as the Bureau could obtain and from the cost of similar work in the past, it seemed extremely doubtful that such a dry-dock could be contracted for at a cost near the limit fixed by Congress.

5. In the past all the timber dry-docks built for the United States government have been by contract, after public competition, as to price, and all the masonry dry-docks built for the United States government have been constructed by day's labor by government employees and extending over long periods of time, due chiefly to the method adopted in appropriating for the works in partial sums from time to time. The present is the first time in the experience of the navy that it has been possible to compare the relative cost of timber and masonry docks of approximately the same size and built under substantially the same conditions.

6. The indications are exceedingly favorable and show the increased cost of a stone and concrete dock over a timber dry-dock to be such as to render it extremely inadvisable, in the opinion of the Bureau, to undertake again the construction of a timber dry-dock for the United States Navy. The superior advantages of the former dock, considered in connection with the moderate increased cost as now developed, should, perhaps, be sufficient to determine this matter without further argument; but I beg to set forth briefly some of the reasons why it is true, and suggest to the Department the propriety of now recommending to Congress the advisability of reconsidering its action in the provisions made for the construction of the timber dry-docks mentioned in the beginning of this letter, in the act making appropriation for the naval service, approved May 4, 1898.

7. A timber dry-dock is a temporary structure, and the distinctive material of which it is built—wood—requires very extensive renewal at the end of 25 years, amounting in some instances, and in some climates, to a practical rebuilding. While the first cost of a timber dry-dock is considerably less than that of a masonry dry-dock, the annual expenditure for its repairs and maintenance, having reference to the dry-dock structure proper, which is the only proper basis for comparison, is many times larger than that for a masonry dock. This is not mere speculation, but the condition of the timber dry-docks heretofore built for the Navy, no one of which exceeds 10 years in age, shows that they have already entered upon a period when the perishable material—wood—has so far deteriorated as to require considerable repairs, and the repairs already made and those provided for in special appropriations made by Congress for the purpose show that what was claimed to be a cheap dock, is really proving to be a very expensive one in the end.

8. Another and important consideration is that of the stability and safety of the structure. Of two timber dry-docks of the same general design and construction, differing in depth, the one of greater draft is subjected to much more unfavorable conditions, and the hydrostatic pressure, which is the force to be met and provided for more than any other in graving docks, is very much greater, and the stability and safety of such a structure against this force,

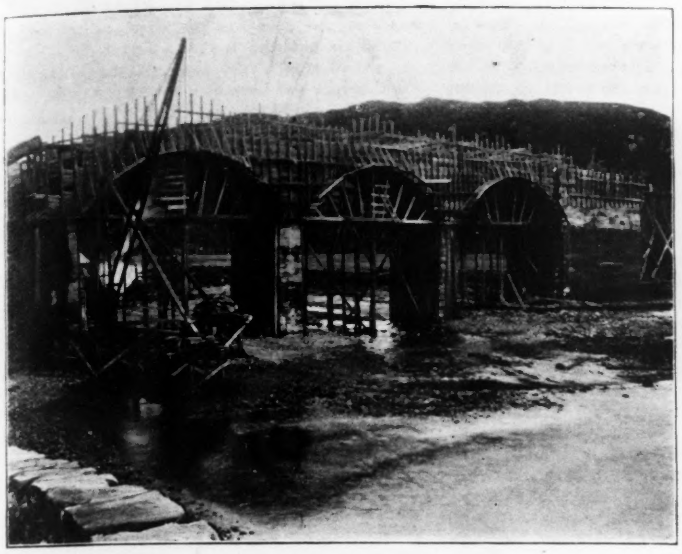


FIG. 6.—LOCH-NAN-UAMH VIADUCT UNDER CONSTRUCTION.
(Six 50-ft. Spans in Concrete.)

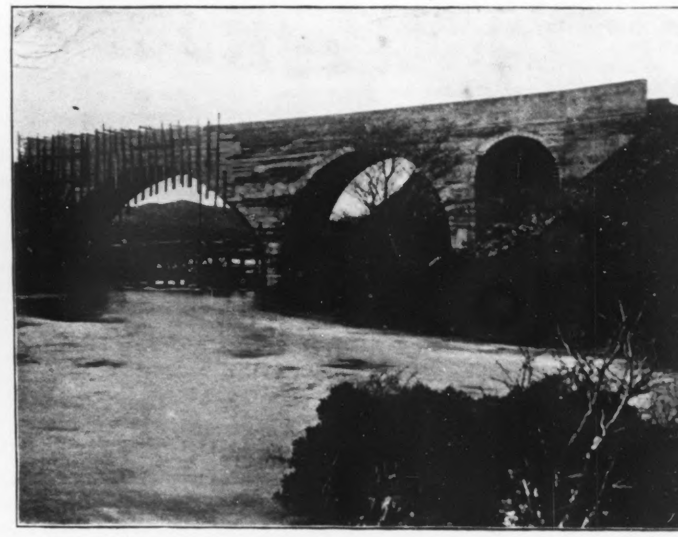


FIG. 7.—MORAR VIADUCT UNDER CONSTRUCTION.
(Main Span in Concrete 90-ft. Long.)

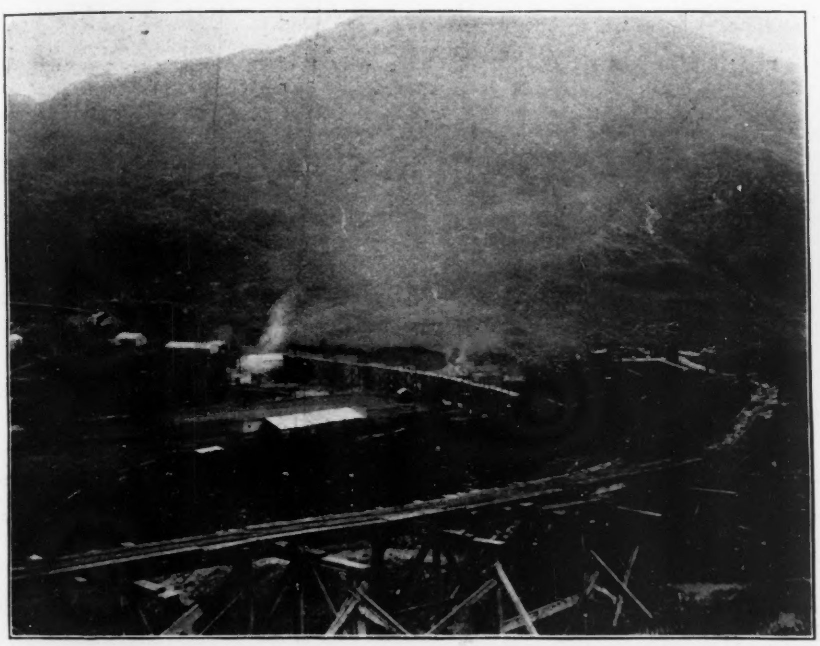


FIG. 2.—VIEW OF GLENFINNEN VIADUCT UNDER CONSTRUCTION.
(Twenty-one 50-ft. Spans in Concrete.)

FIG. 3.—TUNNEL AND ROCK CUT AT POLNISH.

FIG. 5.—SKEW CONCRETE BRIDGE, NEAR POLNISH.

FIG. 4.—RETAINING WALL FOR DEEP FILL AT POLNISH.

THE MALLAIG EXTENSION OF THE WEST HIGHLAND RAILWAY, SCOTLAND.

Simpson & Wilson, Glasgow, Engineers.

Robert McAlpine & Sons, Glasgow, Contractors.

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ADVERTISING RATES: 20 cents per line. Want notices, special rates see page 18. Rates for standing advertisements sent on request. Changes in standing advertisements must be received by Monday afternoon; new advertisements, Tuesday afternoon; transient advertisements by Wednesday noon.

The popularity of the Boston subway, as described elsewhere in this issue, should open the eyes of those who have so long opposed underground rapid transit in New York city. It has been urged with parrot-like repetition that New Yorkers would never patronize a "hole in the ground" railway, and that any underground road would be a financial failure on this account. Those who have been misled by these iterations should study the experience of Boston. There the subway has proved so popular that its traffic has surpassed all expectations. It is stated that at least one surface line was deserted and its cars left empty because the subway could be used instead, and was greatly preferred by the passengers.

New Yorkers have also been told once and over again that the proposed Rapid Transit underground road would be dark, damp and foul smelling. Any one who is influenced by such claims should ride through the Boston subway, with its white tiled walls, brilliant electric lights and pure air. Of course one main reason for the attractiveness of the subway cars is their speed. While the distance over which the subway extends is not great, the gain in time is very considerable, compared with the former conditions when cars had to move through the narrow and densely crowded streets in the center of the city. The relief to the traffic on Tremont street by the opening of the subway can only be appreciated by those who have seen that street in its former congested condition. Bostonians became somewhat accustomed to the former jam and confusion on Tremont St., but people from other cities often stood on the curb for some minutes before venturing to attempt a crossing.

The financial experience of Boston with its subway ought also to be studied with profit by New York. Boston set a competent engineering force at work to plan its subway and direct its construction, and it was built by direct contract, in a first-class manner throughout, and at a cost less than the engineers' estimate. It is leased for a term of years to the company which controls the Boston street railway system at a rental which pays all the interest on the bonds which the city issued to pay for the subway construction and leaves enough to constitute a sinking fund that will pay off the bonds when they fall due. Thus Boston gets an underground railway without cost to the taxpayers, and New York spends its millions on enterprises which bring no return until it has no credit left to loan.

Gas engines utilizing the gas from blast furnaces have been the subject of considerable discussion in metallurgical circles in Europe during the past two years. At the May, 1898, meeting of the Iron and Steel Institute Mr. A. Greiner, Director-General of the Cockerill Iron Works, at Seraing, Belgium, read a paper describing the experiments which had been made at these works. He described a "great 200-HP. engine," which was started at Seraing on April 11, 1898. It has a single horizontal cylinder 31½ ins. diameter and 39.4 ins. stroke, and runs at 100 revolutions per minute. "Le Genie Civil," of July 23 and 30, 1898, contained a paper by M. Dutreux on the direct utilization of blast-furnace gas in gas engines, abstracted in the "American Machinist" of Jan 26, 1899. He states that all the objections commonly raised against the employment of blast-furnace gas can be, and have been, successfully overcome. These objections are chiefly the following: 1. Very feeble calorific power of the gas, and its variable composition. 2. Dust getting into the cylinders and wearing their mechanism. 3. Difficulties of ignition arising from the great quantity of inert gas. 4. Variations of the pressure of the gas. 5. Too great dimensions of the engine cylinders required, because of the feeble calorific power of the gas. 6. Difficulty of starting motors of high power.

M. Dutreux mentions the engine "now being tried" at the Cockerill works, giving its rating at 150 HP., but says that it has given 203 HP. at the brake. He does not favor the use of the gas engine as a blowing engine, however, because of its high speed, which is not easily adapted to driving blowers, but says it is well fitted for generating electric power for distribution through iron and steel works to supplant the very wasteful small steam engines now employed. In the "Iron Trade Review" of Jan. 26 there is an extract from a letter from Mr. J. H. Cremer, metallurgical engineer, of Cleveland, O., who has recently visited the Cockerill works, and in it he states that their large furnace gas engine is running with extreme smoothness and steadiness without any appreciable variation in speed. He speaks of it as "a fine engine of 500 HP.," and says its thermal efficiency is rated at from 26 to 28%. It is likely that 500 HP. is a misprint for 200 HP., and the high thermal efficiency claimed is almost too much to be credible. Mr. Cremer does not share M. Detreux's doubts as to the availability of gas engines using blast-furnace gas for blowing engines, but, on the contrary, says "it would be reasonable to believe that such engines are the coming blowing engines for furnaces."

We are inclined to believe that if the gas engine using blast-furnace gas is the "coming" blowing engine, it will be a very long time before it arrives in this country. There is no doubt that the engine at Seraing is running successfully, but we have as yet no data as to the cost of attendance, repairs, etc., nor as to the first cost of the engine and its equipment, all of which are likely to be very high as compared with the corresponding figures for steam engines and boilers.

A curious result of lack of care in framing the guarantee clauses of a contract for a steam boiler has been brought to our notice. The guarantee of capacity and economy included three items: (1) That the boiler should be capable of being driven at its rated horse-power, a horse-power being defined as the evaporation of 34½ lbs. of water from and at 212°. (2) That it should be capable also of being driven 33⅓% above its rated horse-power, and that "when so operated the loss in fuel economy shall not exceed 5%." (3) That the boiler, "when provided with proper draft," should evaporate 8 lbs. of water from and at 212° per lb. of coal of a certain specified quality.

The boiler, being rated at 200 HP., all of the guarantees would have been fulfilled if the boiler, on a test for economy, had shown a capacity of 200 HP. and an evaporation of 8 lbs. of water per lb. of coal, and on a test for capacity had developed 267 HP., with an evaporation of not less than 7.60 lbs. of water per lb. of coal. The first day's boiler test was made, and the result was over 270 HP. and 8.2 lbs. evaporation, thus exceeding the highest figures named in both the capacity and the economy clauses of the guarantee. The single test might reasonably have been held to show that the guarantee had been completely fulfilled, but for the second clause of the guarantee, which said that the "loss in fuel economy," when the boiler is driven 33⅓% above its rated horsepower, should not exceed 5%, presumably as compared with the economy when the boiler was driven at its rated power. An economy test at rated power was, therefore, needed, and in this test it was necessary, in order to fulfill this clause of the guarantee, that the evaporation should not exceed $8.2 \div .95 = 8.63$ lbs. That is, a high economy on this test would be a non-fulfillment of the guarantee. Fortunately for the boiler-maker, the occasion did not arise for a controversy over the results of the second test, for the evaporation did not exceed 8.5 lbs., and, therefore, the "loss in fuel economy" of the capacity test did not exceed 5%, but was only $(8.5 - 8.2) \div 8.5 = 3.5\%$.

The incident is a lesson in the drawing of the guarantee clauses of a contract for performance of steam boilers. In this particular case the intent of the parties no doubt was: (1) That the boiler should be capable of being driven 33⅓% above its rated power. (2) That when driven at or near its rated power the evaporation should be not less than 8 lbs. of water from and at 212° per lb. of coal, and when driven at not less than 33⅓% above rating, not less than 7.6 lbs. The guarantee would then have been fulfilled if on the second or economy test the boiler had shown a very high result, while according to the contract as it was worded, such a high result would have been a non-fulfillment of the guarantee.

Two notable illustrations of the lack of care with which too many commercial and trade organizations take action with respect to important questions is found in the proceedings of the National Association of Manufacturers, at its recent annual meeting. A question which has been before the association for two years is the proposed compulsory adoption of the metric system in the United States. At the meeting a year ago, the Committee of the Association on Languages, Weights and Measures presented a report favoring the adoption of the metric system, and although one or two members who were well posted opposed it, the resolution was carried, nine out of ten of those who voted for it, doubtless, having no clearer idea than that they were voting for something to help the export trade. At the meeting in Cincinnati, last month, the same committee, by a vote of 10 to 4, reported a resolution favoring the passage by Congress of a law providing that after July 1, 1900, the metric system shall alone be used by the United States Government in all transactions requiring the use of weights or measures, excepting only the survey of the public lands. Under the rules of procedure adopted by the Association, however, this recommendation was turned over to the Committee on Resolutions. A few members who perceived the importance of the matter vigorously opposed the measure and presented the arguments against it in such strong terms that the Committee on Resolutions finally agreed not to report the resolution for formal adoption by the convention. It was pointed out to the committee that to require all Government work to be carried out under the metric system would greatly hamper machine shops taking Government contracts, as they would have to establish a duplicate set of standards throughout. The confusion it would introduce in the ordnance departments of the Army and Navy, and in the steam engineering department of the Navy are matters which will appeal with especial force to mechanical engineers.

A matter in which the Committee on Resolutions was not so fortunate in its action, was the resolution which was adopted relating to Nicaragua Canal legislation, and which was to the effect that the Association endorsed the Morgan bill as passed by the Senate, and urged the House of Representatives to concur with it in all its material features. The following is a verbatim extract from the official proceedings, giving the entire discussion which took place upon this important matter:

Mr. Fay: I have read, as many have, the daily reports in the papers upon these discussions, but I have never happened to see a succinct statement of what the bill, passed by the Senate, actually is. I understand, as well as I am able to comprehend the statements made by the newspapers, that the bill substantially buys the existing maritime canal for five millions of dollars and carries it out to a conclusion at the expense of the government. Am I correct in that understanding?

A Member: That is correct.

President Search: I am glad the gentleman raised the point, because it will clear up the matter in the minds of many of the members. All in favor of that motion will please show their assent by saying aye.

The motion was carried unanimously.

Here is one of the most representative commercial bodies in the land taking formal action in endorsement of a certain bill pending in Congress, when according to the open statement of members, many had no more accurate knowledge as to the contents of the bill than floating newspaper paragraphs concerning it. Yet immediately after adopting the resolution above quoted, the convention voted that their action upon the matter should be telegraphed to Washington, as if they expected Congress to accept their opinion, notwithstanding the small amount of knowledge on which it was based. We criticised the Senate bill in our issue of Jan. 26, and need say nothing further regarding it here, except that such an influential body as the National Association of Manufacturers should not have given its formal approval to so objectionable a piece of legislation, and doubtless would not have done so had the matter been understood by its members.

THE HEPBURN BILL FOR A NICARAGUA CANAL.

As we predicted in an editorial in our issue of Jan. 26, the House Committee on Interstate and Foreign Commerce has framed an entirely new measure for the construction of the Nicaragua Canal. In order to expedite legislation, however, it is called an "amendment" to the Senate bill, the "amending" consisting in striking out from the Senate bill everything save the enacting clause, and substituting the following:

That the President of the United States be and is hereby authorized to acquire by purchase from the States of Costa Rica and Nicaragua, for and in behalf of the United States, such portion of territory now belonging to Costa Rica and Nicaragua, or either of them, as may be desirable and necessary, on which to excavate, construct and defend a canal of such depth and capacity as will be sufficient for the movement of ships of the greatest tonnage and draft now in use, from a point near Greytown, on the Caribbean Sea, via Lake Nicaragua, to Brito, on the Pacific Ocean; and such sum as may be necessary to make such purchase is hereby appropriated out of any money in the Treasury not otherwise appropriated.

Sec. 2. That when the President has secured the territory in Section 1 referred to, he shall direct the Secretary of War to excavate and construct a canal and waterway from a point on the shore of the Caribbean Sea near Greytown, by way of Lake Nicaragua, to a point near Brito, on the Pacific Ocean. Such canal shall be of sufficient capacity and depth as that it may be used by vessels of the largest tonnage and greatest depth now in use, and shall be supplied with all the necessary locks and other appliances to meet the necessities of vessels passing from Greytown to Brito; and the Secretary of War shall also construct such safe and commodious harbors at the termini of said canal and such fortifications for defence as will be required for the convenience and safety of all vessels desiring the use of said canal.

Sec. 3. That in making surveys for said canal and harbors the Secretary of War shall detail such number of engineer officers of the Army, Navy and civil as may be deemed necessary, and may require of them the performance of such professional duties as he may desire.

Sec. 4. That in the excavation and construction of said canal the San Juan River and Lake Nicaragua, or such parts of each as may be made available shall be used.

Sec. 5. That in any negotiations with the States of Costa Rica or Nicaragua the President may have, the President is authorized to guarantee to said states the use of said canal and harbors, upon such terms as may be agreed upon, for all vessels owned by said states or by citizens thereof.

Sec. 6. That the sum of $115,000,000, or so much as may be necessary, is hereby appropriated out of any money in the Treasury not otherwise appropriated for the completion of the work herein authorized, said money to be drawn from the Treasury from time to time, as the same shall be needed, upon warrants of the President based on estimates made and verified by the chief engineer in charge of the work and approved by the Secretary of War.

Doubtless this bill will not get through the House without radical amendment; and in whatever form the bill may finally pass, the Senate members of the Conference Committee are likely to work for further changes. It is to be hoped, however, that the general form and tenor of the bill may be preserved, and that there may be no return to the most objectionable feature of the Senate bill, the construction of the canal by the Government under the guise of a private corporation. If those are wise, who are now working to secure something for the Maritime Canal Co.'s stockholders from the national treasury, they will content themselves with offering an amendment providing for the payment to that corporation of the actual cash value of its surveys and plant. Such an amendment would have a fair chance of success; whereas an attempt to perpetuate that corporation's existence in the manner proposed by the Morgan bill is almost certain of defeat.

As seen by its text above quoted, the Hepburn bill proposes that the canal and the land adjacent to it shall be, to all intents and purposes, United States territory. It may possibly be necessary to modify somewhat the language of Sec. 1, for it has been stated that the constitution of Nicaragua forbids the alienation of her territory. On the other hand, if the United States is to build, own and operate a canal there, it will be eminently necessary that it shall have such control of the waterway and of the adjacent territory as is necessary to protect it. We can by no means rely on the uncertain course of justice in the Central American states, for the safeguard of life and property in transit through the canal, or for the protection of the canal itself and its expensive structures from malicious injury. Any modifications necessary in the first clause of the bill, therefore, should still leave the United States in possession of actual sovereignty, if not nominal, over the canal and the territory adjacent to it.

It will be noted that the bill calls for a canal large enough to accommodate "ships of the greatest tonnage and draft now in use." The White Star line's "Oceanic," just launched at Belfast, and the largest vessel afloat, is 705 ft. 6 ins. long; with 68-ft. beam, and a draft of 32 ft. 6 ins. To accommodate this vessel a canal of at least 34 ft. depth would be necessary. The Maritime Canal Co.'s project in 1890 was for a canal of 28 and 30 ft. depth. The Ludlow Commission of 1895 advised increasing the depth to 30 ft. throughout. The surveys and estimates of the present Canal Commission are understood to be for a still greater depth; but just how much is not known. We are inclined to question the wisdom of fixing the dimensions of the canal so explicitly as is done by the Hepburn bill. The addition of two to four feet to the depth of the canal would add enormously to the cost of construction, and it is at least questionable whether vessels of the size of the "Oceanic" will ever be run on the ocean routes which the canal will accommodate. At any rate, this is a question which could better be left open, for later discussion in the light of more detailed surveys of the canal route, than fixed hard and fast by Congress.

Section 3 of the Hepburn bill, as quoted above, is to our minds the most seriously objectionable of any part of the bill. "The Secretary of War shall detail such number of engineer officers of the Army, Navy and civil as may be necessary," is a requirement which badly needs interpretation. The "engineer officers" of the Navy, strictly speaking, are the officers of the steam engineering staff. It is surely not intended to detail these officers on canal construction work. As for the "civil" engineer officers, the purpose of the framers of the bill was probably to provide for the appointment of civilian engineers to serve upon the work, but that purpose can hardly be discerned in the wording of the bill, and the status of such civilian engineers is left wholly undefined.

In any event, this ambiguity in Section 3 of the Hepburn bill should be removed before its passage; but the whole method for carrying out this great engineering work, so far as it is laid down in Section 3, seems to us to be seriously defective. It is, we grant, better to put the whole matter into the Secretary of War's hands than to do the work through the machinery of a private corporation, as proposed by the Morgan bill; but this is not, or need not be, the only alternative. As we said in our issue of Jan. 26, the entire responsibility for the Nicaragua Canal work ought to be turned over to a competent commission, to be appointed by the President and confirmed by the Senate. The most successful engineering works of the country have been constructed on this plan, and none other has been found so efficacious in promoting economical and efficient work, and defeating corruption and dishonesty. We may take for illustration such enterprises as the Boston subway, the Croton aqueduct and reservoirs for the New York water supply, the great drainage system for the cities of eastern Massachusetts, the new water supply of Cincinnati, the drainage system of New Orleans, and for a close parallel to the Nicaragua work—the Chicago Drainage Canal.

All these and many other of the most important engineering works carried out by cities and states have been executed through appointive commissions, and the results obtained bear witness to the success of the plan. On the other hand, the turning over by a legislative body, state or municipal, of the responsibility for a piece of work to some official already overburdened with duties has resulted in such scandals as that in connection with the New York state canal work.

The Secretary of War, manifestly, is already so overtasked that he can give but little personal attention to the Nicaragua canal work. In theory, in the case of governmental work conducted by the Corps of Engineers, the Secretary is the final authority. A recommendation made by the officer in immediate charge in his report passes through the division officer to the Chief of Engineers, and thence to the Secretary of War; but each one of these officials is as a rule too busy to do more than attach his formal endorsement, and so the whole thing is buried in the bulky reports of the Chief of Engineers. The defects of the present methods of conducting our River and Harbor work are well known. The engineer officers in charge do the best that they can; but they are powerless to remedy the defects of the system or to cut the red tape which hampers effective work.

The Nicaragua canal construction will involve the solution of some of the largest and most difficult engineering problems that have ever been presented to the profession. To insure the best, the safest and most economical design for the great dams, the enormous locks and the huge systems of excavation that will be necessary, the ablest and most competent engineers in the United States should be secured. If the entire work is placed in the hands of a competent commission, it cannot be doubted that this will be done, and the best engineering talent in the country will be consulted in fixing the design of the structures of unprecedented size which must be built.

If the work is done in the manner of ordinary routine River and Harbor work, on the other hand, we may be pretty sure that bureaucratic methods will have their sway. The engineer officers in charge will have to get along as best they can with such civilian assistants as they can secure at salaries of $100 to $200 per month, and the employment of consulting engineers to review the designs would doubtless be forbidden by the clerks in Washington.

Again, the letting of contracts for work upon the canal under the plan proposed in the Hepburn bill, might easily become such a matter of political preference as to lead to favoritism and discrimination in the award of contracts, and thus largely increase the cost of the work. A competent commission, on the other hand, can always satisfy itself as to the entire honesty and competency of its engineers, and as to the character of the contractors working under it. No corruption or dishonesty of any great moment can take place without collusion between all the members of the Commission and the principal engineers in their employ, and such a conspiracy is seldom possible.

Still again, a Commission is, or should be, a continuing body, taking the responsibility for an enterprise from start to finish. The office of Secretary of War, on the other hand, has a new incumbent every four years or oftener. Of necessity, therefore, the Secretary must delegate his functions to clerks. Is it wise to place a merely nominal head in entire charge of so vast a work as the Nicaragua Canal?

So we might proceed at much greater length with the argument against the administrative plan proposed in the Hepburn bill; but it can hardly be doubted that in the further progress of the bill in Congress these matters will be fully made public. The public demand for Nicaragua Canal legislation is undoubted; but the public is equally interested in having the canal honestly and economically built. It will reflect no credit on the nation to have such scandals arise in connection with the work as those which wrecked the Panama enterprise, or to have defects creep into the engineering design that may later result in the canal's destruction. If it is important that the canal shall be built, it is also important that it shall be well and honestly built, and Congress in making provision for the one need should by no means fail to provide for the other.

LETTERS TO THE EDITOR.

Catfish as Aids in Removing Sewer Obstructions.

Sir: The "Youth's Companion" of Jan. 19, 1899, contained a few lines, which may be of interest to engineers engaged in the maintenance of sewerage systems. The following is the clipping:

In Portland, Ore., according to the "Oregonian," the familiar catfish figures as a hardy pioneer and a valued adjunct to the street department, all because the terra cotta sewers and drains, especially those in the lower part of the city, frequently get choked.

If the sewer is not broken, it can be cleaned by passing a rope through it, to be pulled backward and forward until the obstruction is loosened and removed. The deputy superintendent of streets has had a great deal of such work to look after, and the worry connected with getting the rope through has gone far toward thinning his hair. He has at last discovered a quick, sure and easy method.

He goes to the river, catches a catfish, ties a string to its tail, drops it down a manhole into the sewer, and it at once starts for the river, and forces its way through any obstruction not as solid as brick, dragging the string after it. Then the deputy goes as far down the sewer as he deems necessary, and picks up the string, which he uses to draw a wire through the sewer, and with this a rope is pulled through and the sewer is soon cleared.

Very truly yours, Chas. W. Sherman,
Assistant Engineer Metropolitan Water Board.
3 Mt. Vernon St., Boston, Mass.

A Plea for a "Pioneers'" Society of Civil Engineers.

Sir: I notice from time to time in the Engineering News, advertisements for "Situations Wanted," and that among the list there are men who have had from 5 to 25 years' practical experience in field work. I belong to that class myself and have met quite a number of these men between the Atlantic and the Pacific who have been working all their lives for corporations that pay them laborer's or mechanic's wages, generally less than some classes of foremen receive. They are not all college men, but they frequently have to teach college men how to take cross-sections and set slope-stakes. It seems to me that these pioneers ought to have more consideration and prominence when new work is contemplated; and parties should be made up from men of this class instead of employing green men. Better and more rapid work would then be done and money would be saved for the corporation.

The "Am. Soc's." would not recognize this organization probably, because a good many of its members might not be able to raise much money for entrance fees, and it might not be desirable to let the general public see this "skeleton in the closet;" but it would be a very popular movement with the particular set of men with whom I am acquainted. Yours respectfully, H. T.
Philadelphia, Pa., Feb. 2, 1899.

The Organization of a Railway Engineering Department.

Sir: In Engineering News of Jan. 26 there appeared a communication signed "Railway Engineer," relative to a paper by me, which was read before the St. Louis Railway Club at their meeting of Nov. 11, 1897. This paper is still before that club for discussion, and it would be most inopportune for me to discuss the paper at this time. Nor is discussion necessary, for "Railway Engineer" and myself differ only in our attitude toward the capital invested of the maintenance-of-way engineer. My paper claims, and endeavors to show reasons for believing, that the members of our profession have been often less anxious for the interests of the stockholders than should be expected of them. Irritation has blinded them. The attitude they show is not a helpful, sympathetic, professional one towards non-professional fellow-officers.

The second purpose of the paper is to call the attention of the civil engineering profession to the fact that now is the greatest opportunity ever offered in this country for mature civil engineers, versed in maintenance and experienced in handling men. If the profession can furnish men to maintain track, bridges and buildings, now is the time for them to show it. The present hour is a most significant one. Willard Beahan.
Owego, N. Y., Jan. 30, 1899.

Paints for Preserving Iron Work.

Sir: An article, entitled "A New Paint for Preserving Iron Work" and treating of certain paint tests, in the Engineering News of Jan. 26, suggests the following observations:

Always suspect a man who has an infallible paint test. The only one which is conclusive is a long time exposure; and even in that case the test is of comparatively small value unless the surface was thoroughly cleaned and the paint applied carefully and under favorable conditions. It will be said that in actual practice it must be used on imperfect surfaces and by cheap labor and under whatever conditions present themselves; but that makes no difference. If you are going to make a test of paint, you absolutely must eliminate as many as possible of the things which make it a test of luck, for that is what it comes to. But when, as in this case, a man gets up a new paint and finds some one particular treatment which gives results favorable to his paint, and then proposes to the community to test all paints according to his method, it seems to me the matter is hardly worth considering. This man proposes to let the paint dry four days, then expose it to a current of steam at 212° F. The red lead man would probably say let it dry 24 hours, and in that case would beat him at his own game. The asphalt man would want a caustic soda test; and the maker of baking enamels, a high temperature of dry air. None of these things have any relation to the general use of paint; and in particular, the testing of paints after only four days' drying is inadmissible, because nearly all common paints require one or two months at least to become quite hard and permanent. I am inclined to think that baking at a moderate heat, say 250° F., effects a rapid oxidation, and in this way produces an effect something like long exposure at ordinary temperatures; that a carefully conducted acid test shows continuity of coating; that a wet-and-dry test like Toltz and Conradson's has considerable similarity to natural conditions; and there are other tests of interest; but no one of them is to be used alone, and as a whole they are of more value to the paint maker than to the enginer. For the latter a careful time test under the conditions where the paint is to be used is the best. Yours very truly,
A. H. Sabin.
45 Broadway, New York, Feb. 6, 1899.

The Military Services of the Late Gen. Geo. S. Greene.

Sir: I notice with interest the account of the life and professional work of General Greene in your last issue. You remark that General Greene's greatest work was in civil pursuits, in the practice of his profession; and it is, of course, true that most of his life was devoted to this, and that he won a deserved distinction by his work as a civil engineer. Notwithstanding this, it is appropriate at this time to recall the fact that General Greene possessed military talents of a high order, and the use of these talents in the crucial battle of the Civil War is believed by competent military critics to have been the deciding element in determining the outcome of the battle. I ask space for the following extract from a letter by Gen. O. O. Howard, published in the "New York Times," describing General Greene's work on the field of Gettysburg:

The attack upon our left the 2d day of July, 1863, where General Sickles was posted from the right of the peach orchard to the left at Devil's Den (which attack at last involved all the battle of the Round Tops and the lower ground northward), had caused General Meade to send General Slocum's corps away from the extreme right of his lines to that leftward field as reinforcement and support. Only one brigade—General Greene's, not to exceed six small regiments—was left to hold the log and stone barricades. The vacant space covered by these obstructions extended all the way from McAllister's Mill to Culp's Hill. At Culp's Hill was Wadsworth's division. Now, General Greene so disposed his men near the foot of Culp's Hill as to make the best possible defense. At his request for another brigade, I sent him three more regiments—all I could spare. Wadsworth and myself, west of Wadsworth, were participants in the same evening and night engagement, for Ewell's Confederates covered our whole front from McAllister's Mill to Culp's Hill, around that stony, wooded hill and on the north slope of the cemetery, touching the town. Ewell, beginning on my front about dusk, made a fierce, persistent, and noisy attack upon my batteries and their supports, and carried it on, blow after blow, upon the north, northeast and east of Culp's Hill. On the east of Culp's Hill he found General Greene's men all in line and ready for the Confederate charges. It was there a desperate contest, tougher than elsewhere, raging for two hours. Just how Greene manoeuvred I cannot tell,but when his right flank was turned his men simply made a sort of backward wheel to the rear, firing all the while. They gave such a raking fire along the vacant barricades out there in the woods and among the rough knolls and boulders that Gen. E Johnson, the left Confederate division commander, did not think it prudent to press on into the open space. He stopped his advance at the vacant barricades, waiting for the dawn of the next day.

In the open space were our trains, along the Baltimore Pike. During the night Geary's division returned, and made, with Greene, a long line back to Wolf's Hill. Ruger's division made another line from McAllister's Mill to Wolf's Hill. There at Wolf's Hill General Slocum massed cannon, all General Meade gave him, and had other troops in support. Gen. A. S. Williams commanded that 12th Corps, and Slocum all that field. At dawn there was a terrible awakening. The cannon roared and the muskets rattled. "What is it?" I called out as I opened my eyes in the cemetery. "Go to General Meade and see." An aide in a few minutes brought me the reply, "General Slocum is regaining his lines."

The Confederates had advanced into that harrow-shaped space, to meet three fires—two oblique, and the third from the cannon on Wolf's Hill, firing straight forward. Their charges were desperate. The fierce fighting continued for five hours, when the whole line and all the rough woodland from Culp's Hill to McAllister's Mill were again ours. All the while General Greene, holding his men well in hand, bore his part in the conflict.

What do not our people owe to him? But for him, or some such intelligent and gallant officer in his place, we should have lost that famous field.

Touching the extent to which General Greene retained his bodily vigor, at a greatly advanced age, it is of interest to recall that in 1885, when General Greene was 84 years of age, he was appointed a member of a board to settle a controversy which had arisen among the engineers employed upon the New Croton Aqueduct. The other two members of this board were Gen. John Newton and Gen. Quincy A. Gillmore, both of them younger than General Greene by 15 to 20 years. But they had to confess themselves too infirm to undertake the task of inspecting the work on the ground in detail, and General Greene was the only one to accomplish it. Very truly, J. E. C.
New York, Feb. 4, 1899.

Comparative Strength of Buckle Plates Laid Convex Face Up and Convex Face Down.

Sir: According to tests made by Rumschoettel, published in Dr. Winkler's "Vortaege ueber Brueckenbau," 1884, buckle plates with convex face down are from 3.7 to 4.4 times as strong as when turned up. Dr. Winkler also shows that there is less shear on the rivets in this case than in the latter, and gives tests of the latter case by Bauschinger, which show buckle plates riveted to be about 10% stronger than when not riveted.

Yours truly, Albert Reichmann.
Chicago, Ill., Feb. 1, 1899.

Sir: It has been our practice for a number of years to place buckle plates with the convex surface down instead of up. In the first place, the plate is stronger that way. In the second place, it takes only half as much concrete to fill the pyramids, apex down, as it does to fill the space around the pyramid, as is necessary when the apex is up. There is a saving in concrete, therefore, as well as dead load on the structure. Frequently, also, it is of advantage on account of the saving in depth of floor. By turning the apex down, a gain in space is made of just the crown of the buckle plate. Yours very truly,
The Osborn Co., Civil Engineers,
Cleveland, O., Jan. 30, 1899. Frank C. Osborn.

Sir: In regard to the best method of laying buckle plates the following information may be of interest. In 1895 two bridges were constructed in an inland town in Pennsylvania, the plans for which showed the buckle plates suspended. At the time of the letting of these bridges a majority of the agents, representing the bridge companies, insisted that it was a mistake to so place the buckle plates. The contracts were let, however, to two different companies, one of which was well satisfied that it was the proper way; the other, not being satisfied, insisted on making tests. The following is the result of the tests made in the presence of the city engineer, and reported to him by the company:

Tests were made on four ¼-in. buckle plates, each plate having three buckles of the following dimensions: 39 ins. in longitudinal direction of plate; 44½ ins. in transverse direction of plate (making distance center to center of support 48 ins.) and 3 ins. deep. To make the tests compare as close as possible with the actual conditions in the bridge, the plates were covered with a layer of concrete having a minimum thickness of 4 ins. and made of Portland cement, sand and ½-in. crushed stone. The concrete was allowed to set for 13 days; afterwards the plates were placed on a frame built of I-beams and on top of the concrete in the center of the middle buckle was then placed a 9¾ × 15½-in. plate having the long dimension in the transverse direction of the buckle plate and through this plate the load was applied.

Test A.—The buckles were turned down and the plate was not bolted to the supporting frame.

Test B.—The buckles were turned up and the plate was not bolted to the supporting frame.

Test C.—The buckles were turned down and the plate bolted with ⅝-in. bolts for every 9 ins. to the supporting frame.

Test D.—The buckles were turned up and the plate bolted with ⅝-in. bolts for every 9 ins. to the supporting frame.

Test.	Externally applied load.	Average deflection for each 1,000-lb. load applied.	Max. load applied	Weight of plate and concrete.
	lbs.	lbs.	lbs.	lbs.
A	30,000	0.0024	50,000	3,330
B	29,000	0.0016	less 29,000	4,100
C	34,000	0.0063	40,000	3,300
D	18,000	0.0028	*38,000	4,100

*The load reached this amount only for a moment as the resistance of the plate decreased, with increased pumping on the jacks.

For each special case an average deflection taken from observations before the stresses in the plate passed the elastic limit is given, but what proportion of the deflection represents the actual stretch of the plate is hard to tell, as the edges of the buckle plates were somewhat uneven and, therefore, did not give an even bearing to the buckle plate. When the load was applied these kinks were more or less taken out and besides that the edges began to turn up when the load became great. This latter effect seemed to indicate that it is important to have the buckle come up as close as possible to the supporting beam.

We did not succeed in breaking any plates, as we had to stop applying the load before that point was reached, as the plates deflected so much that they came to a bearing on the angle struts in the supporting frame. During test C, which was the last we made, we removed these angles and tried to break the plate, but then we met with the difficulty that the supporting beams bent. After tests A and C, the plates did not show any decided deformation from the original shape, but in B and D the sides of the buckles were bent, indicating that the plates must have acted something like a column, which also seems to follow from the behavior of the plates in tests B and D, as their resistance decreased after the load had reached a certain limit.

A tension test on a piece cut out from the side of one of the tested buckle plates showed an elastic limit of 38,200 lbs., ultimate strength of 60,500 lbs.; elongation in 8 ins. of 21%; and reduction of area of 65%.

A piece of concrete weighing 850 lbs. and 3 ft. 8 ins. long and 4 ft. wide taken from the end of a plate with buckles turned down, broke in bending for an external force of 5,150 lbs. and a similar piece weighing 1,900 lbs., 4 ft. long and 4 ft. wide, taken from a plate with buckles turned up, broke in bending for an external load of 7,100 lbs.

In support of the argument that the buckle plates are stronger when suspended than when they are turned up, I would respectfully call your attention to page 146 of the A. & P. Roberts Co.'s (Pencoyd Iron Works) hand book for the year 1898.

Yours truly, J. P. P.

(Hereafter we will lay our buckle plates with the convex face down.—Ed.)

Notes and Queries.

A correspondent in India wants information as to the equipment and construction of 150 miles of narrow gage railway (American type) in that country. Further details will be found in our Construction News columns.

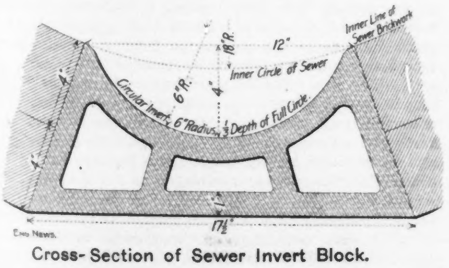
F. G. F. calls attention to the misspelling of "frustum" in naval civil engineer examination questions (Eng. News, Jan. 19, p. 35), and asks why engineers and others so generally add an extra "r" and spell it "frustrum?" We presume it is because of a natural tendency in pronouncing the word to add an "r" sound between the "t" and the "u." There is no authority, however, for the addition of the extra "r."

A NEW FORM OF SEWER INVERT BLOCKS.*

In the design of sewerage systems for towns and cities on the flat prairies, the engineer frequently meets with conditions which preclude the use of grades sufficient to give the so-called cleaning velocities. Large sewers are especially liable to limitations in grade, as the crown must be kept down, and the inverts must be kept up, according to the level of the outlet. If, as a recent writer states, the minimum velocity of dry-weather sewage is 1.5 ft. per second, and this discharge is 1-120th of the full capacity of the sewer, then the velocity when full (which is that for which the grade is usually calculated) must be 6 ft. per second, which is frequently difficult to secure.

The most common method of bettering such conditions is the use of egg-shaped sewers, the advantages claimed being (1) increased velocity, and (2) greater average depth of flow. The writer believes that the first of these is generally overestimated, as shown by the following table, which is based on Kutter's formula, using the actual value of the hydraulic radius for the different depths. The 30-in. and 48-in. circular sewers have nearly the same discharging capacity as egg-shaped sewers 24 x 36 ins., and 40 x 60 ins., respectively, and the velocity for small flows in egg-shaped sewers is less than 20% in excess of that in the circular sewers for the same quantity of sewage. This difference would not of itself pay for the extra cost of the egg-shaped sewer, which will be 10% more than that of a circular sewer of the same capacity. The advantage of depth is more clearly in favor of the egg-shaped section.

The writer desires to present for comparison with the egg-shaped sewer a special form of invert block for circular sewers, the blocks being of vitrified clay, similar to the



Cross-Section of Sewer Invert Block.

material now used to some extent for circular sewers. It will be seen from the accompanying cut, that the surface is depressed below the invert of the circular sewer, forming a gutter or trough 4 ins. deep, with a radius of 6 ins. When flowing the full width of the invert, the effect would be the same as a flow in a 12-in. vitrified pipe, 4 ins. deep. For a 36-in. sewer, this discharge would be about 1-75th of the capacity of the sewer, and if we take the invert to be as smooth as sewer pipe, the resultant velocity, by Kutter's formula, would be 45% greater than that for the same flow in the circular sewer. With flat grades, liable to deposit, for shallow depths of flow, the contrast would be even greater. In average depth of flow, there would be an advantage over both the circular and egg-shaped sections.

The general form of invert block, shown in the cut, is subject to modification, and the objections to a single vertical joint may be avoided by making a shoulder at each side of the cross-section. The approximate weight is 50 lbs. per lin. ft., and manufacturers report that the blocks will not be unreasonably expensive, one firm giving a selling price of 25 cts. per ft. As that is a saving of about 13 bricks per lin. ft., the net additional cost of this invert block would be from 10 to 20 cts. per ft.

Comparison of Velocities in Egg-Shaped and Circular Sewers.

Kutter's formula: $n = 0.015$; $s = \frac{1}{1000}$.

Section.	Dpth, ins.	Area, sq. ft.	R.	C.	V.	Q.	Capacity.	Ratio* V to V for full sew'r	Ratio* V in egg to V in cir. for same Q
Cir., 30".	30.0	4.909	0.625	89.6	2.24	10.99	1.0	100.0	...
	9.0	1.238	0.427	81.8	1.69	2.09	0.2	76.0	...
	4.5	0.461	0.232	69.3	1.06	0.49	0.05	47.3	...
	2.0	0.142	0.108	54.6	0.55	0.08	0.01	24.7	...
Egg, 24×36"	36.0	4.594	0.5794	88.0	2.12	9.725	1.00	100.0	100
	12.0	1.136	0.4132	81.1	1.65	1.872	0.19	77.8	102
	6.0	0.414	0.2518	70.9	1.13	0.466	0.05	53.1	112
	2.4	0.112	0.1208	56.6	0.62	0.070	0.01	29.4	119
Cir., 48".	48.0	12.566	1.000	99.1	3.13	39.33	1.00	100.0	...
	14.4	3.171	0.689	91.5	2.40	7.61	0.19	76.7	...
	7.2	1.182	0.371	84.1	1.84	2.18	0.06	58.9	...
	3.3	0.378	0.177	63.9	0.85	0.32	0.01	27.1	...
Egg, 40×60"	60.0	12.756	0.966	98.5	3.07	39.050	1.00	100.0	98
	20.0	3.157	0.688	91.6	2.41	7.608	0.19	78.5	100
	10.0	1.177	0.429	81.8	1.70	1.999	0.05	55.3	108
	4.0	0.331	0.214	67.7	0.99	0.329	0.01	32.3	117

*Ratio of per cent.

*Abstract of a paper read by Prof. A. N. Talbot, of the University of Illinois, at the annual meeting of the Illinois Society of Engineers and Surveyors, held at Champaign, Jan. 25 to 27, 1899.

THE JERSEY CITY WATER CONTRACT award has been approved by Mr. Edward Hoos, Mayor, and it is expected that the contract will be executed soon, unless the agitation for a review of the case in the State Supreme Court is successful. The award has been made to Mr. Patrick H. Flynn, 189 Montague St., Brooklyn, under bids received on Aug. 18, 1898. This date was the eighth occasion on which Jersey City has received bids for a new water supply since Nov. 1, 1892. (See Eng. News, April 25, 1895, for some of the earlier attempts.) The proposed contract gives the city the option of taking water by the million gallons for 25 years or of buying the works. The works must be capable of supplying at least 50,000,000 gallons a day, and the drainage area must be large enough to furnish 70,000,000 gallons. The prices by the million gallons will be as follows: For the first 25,000,000 per day, $36; for successive 5,000,000 gallons in addition, $34, $32 and $24, respectively; for from 45,000,000 to 70,000,000 gallons, $20. If the city buys the works at their completion, it must pay $7,395,000 for a 50,000,000, or $8,850,000 for a 70,000,000-gallon plant; the corresponding figures for the works if bought at the end of 5, 10 or 15 years are $7,895,000 and $9,350,000. The name of the contractor's engineer has not been announced. Mr. C. A. Van Keuren is now Chief Engineer of the Street and Water Commissioners, but it is said that the specifications on which bids were received were drawn by Mr. Geo. T. Bouton, Clerk of the Board. According to the proposal, the main features of the works will be as follows: A 7,362,000,000- gallon intake reservoir, at Boonton, N. J., with a flow line 292 ft. above mean high tide and an effluent pipe at elevation 256.5; a masonry dam, forming this reservoir, 105 ft. high above the foundations; 122½ sq. miles tributary drainage area, including some eight or more ponds and lakes, but requiring no artificial storage, other than the intake reservoir, to supply 50,000,000 gallons a day; a single 76-in. steel conduit (except for two 6.85 ft. brick-lined tunnels through Hook and Watchung mountains, respectively) to the present Bergen reservoir, delivering water with a pressure equal to a head of 210 ft. above mean high tide. If a 70,000,000-gallon plant is demanded by the city more storage and a 30,000,000-gallon conduit will be added.

THE EFFECT OF DEAD ENDS on the character of water drawn from them was recently reported on by Sir Edward Frankland, a noted English chemist, in connection with an epidemic of typhoid fever at Paisley, Scotland. The conclusions of the report, as given in the London "Architect," are as follows:

(1) That chemical analysis has shown the water in the dead ends of the mains to be organically somewhat inferior to that circulating in the trunk mains, both of the high and low level services.

(2) That the bacteriological examination has shown the water in the dead ends of the mains to be, in almost every case, somewhat richer in bacterial life than the water circulating in the large mains of both supplies.

(3) That colon bacilli, and other forms more or less resembling the typhoid bacilli, have been found in six of the twelve samples collected from the taps in the affected area, while no suspicious forms were discoverable in the two samples taken from the trunk mains.

(4) That all the four samples taken from plugs inserted in the dead ends of mains in the affected area contained colon bacilli.

(5) That whilst the results referred to above do not actually prove a connection between the water supply and the recent epidemic, they are obviously quite in harmony with the existence of such a connection.

(6) That on general grounds the water in the dead ends of mains is most calculated to cause mischief, because in the event of any dangerous contamination of a water supply having taken place, the morbific material (typhoid bacilli) will tend, not only to accumulate in such areas of sluggish circulation, but they will also remain there for a longer period of time than in any other part of the network of mains. The water consumer in such an area will, therefore, not only be more likely to receive typhoid bacilli, but will receive them in larger numbers and over a longer period of time, and there is thus a greater probability of his infection being secured. These considerations show the high importance of the regular and frequent flushing of all such dead ends being carried out, and the serious danger to the water consumer of any want of attention to this duty.

According to the "Water-Works Directory and Statistics" (English) for 1898, the water supply of Paisley is from surface sources.

A BILL TO ESTABLISH A STANDARD MEASUREMENT of flowing water has been introduced in the Montana legislature. It provides that "a cubic foot of water (7.48 gallons) per second of time shall be the legal standard for the measurement of water in this state." Where water rights have already been granted in terms of miner's inches, 100 miner's inches, the bill says, shall hereafter be considered as equivalent to a flow of 2½ cu. ft. (18.7 gallons) a second.

A LIMIT UPON THE HEIGHT OF BUILDINGS in New York city is recommended by the committee of the New York Board of Trade and Commerce, which has had the matter in charge during the past two years. In 1897 this committee drafted a bill to be introduced into the State Legislature. Efforts to promote the passage of the bill were unavailing, for the reason that the control of the matter was to be vested in the municipality of Greater New York under the charter then pending, and it was therefore deemed inexpedient for the Legislature to act. The matter has been held in abeyance until now, when the committee thinks that the time has arrived to push the work. The committee says:

It is the opinion of your committee that the question must be considered from the standpoint of public safety alone, and, to this end, we recommend the enactment of an ordinance which shall provide that on the wider streets and avenues of this city no building hereafter erected shall exceed 200 ft. in height, and that no building used as a hotel or apartment house shall exceed 165 ft. in height. These measurements shall be from curb level to the highest point of the cornice or roof beams of a building. Justly proportionate lesser heights should be provided for the erection of structures on the narrower streets and avenues of the city. The committee recommend that in every building erected to a height of 137 ft. and over there shall be two separate stairways leading from the ground floor to the roof, one of which shall be remote from the elevator shaft. The committee further recommend that in all buildings now in existence, or hereafter erected, 137 ft. and over in height there shall be provided and maintained a fully equipped auxiliary fire plant that shall be satisfactory in all respects to the Fire Department of this city.

TESTS OF SMOKELESS POWDER for large caliber guns were made at the Indian Head proving grounds on Feb. 7, 1899, which showed remarkable results from the new explosive being manufactured for the United States Navy. An ordinary 13-in. gun of 0.35 caliber length was used in the trial, with the regulation projectile and a charge of 325 lbs. of the new powder, and a muzzle velocity of 2,500 ft. was obtained. It is stated that this surpasses any result heretofore obtained in this country, if not in the world.

KITE PHOTOGRAPHY, says Mr. W. A. Eddy, of Bayonne, N. J., seems to have been first tried by a Mr. E. D. Archibald, of England, in 1886; Wenz, of Paris, took it up in 1890-91, and Batut, of France, is also on record as an early experimenter. The European kite photographers seem to have attempted map views only, and Mr. Eddy claims the first perspective view taken from a kite, at Bayonne, May 30, 1895. Since then he has taken about 400 views, nearly all perspective. In 1894 Mr. Eddy, for the first time, lifted a meteorgraph 1,400 ft. into the air and brought it back with a clear record. Mr. Eddy has also tried kite telephones; a self-recording "rain-kite;" an aerial camera-obscura, for observing distant objects by the aid of a powerful telescope directed to the dark cavity of the camera; kites for measuring wind velocities by the pull of a string balance; self-illumined, single-plane kites; shooting-star signal lanterns, etc. In 1898, 26 Eddy kites were sent to Porto Rico by order of Gen. A. W. Greeley, to be used in photographing the enemy's fortifications; but no report has yet been made on their use, though they were employed for military flag signaling.

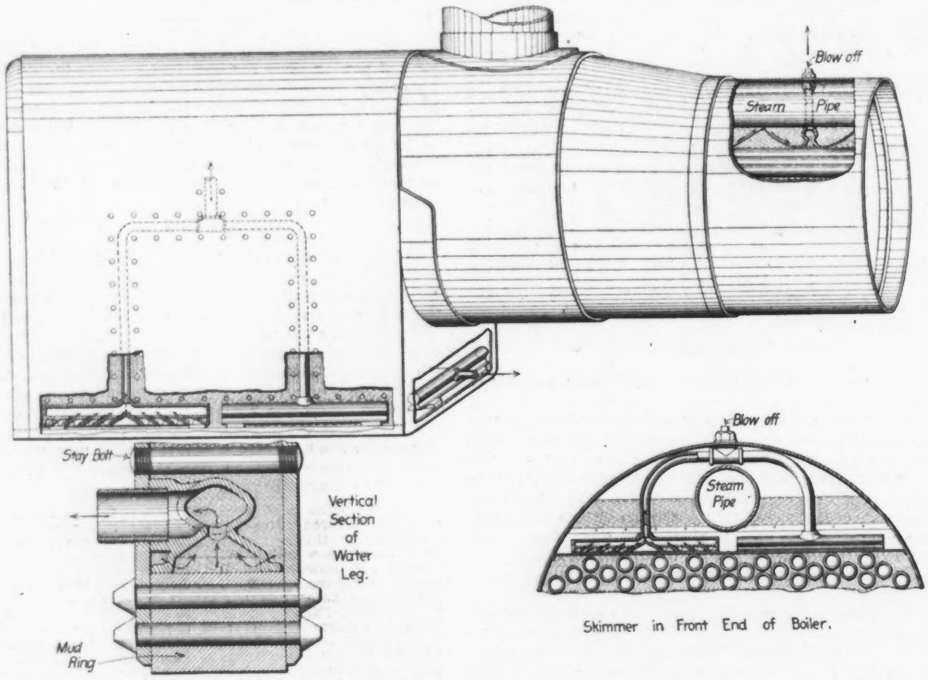
BLOW-OFF DEVICE FOR LOCOMOTIVE BOILERS.

The important effect which the prevention or removal of scale has in increasing the effective performance of locomotive boilers, by reducing the time required for washing out and avoiding the incidental injury to the boiler which results from frequent washing out, has led to the introduction of several devices for collecting and blowing out scale and mud. In the present article we describe an improved form of the Hornish boiler cleaner, the original form of which has been somewhat extensively used on locomotive, steamboat and stationary boilers. The device consists of two separate parts, one to prevent the accumulation of deposit in the boiler barrel, and the other to prevent similar accumulation in the water legs around the firebox. The former can be applied to any boiler, but the latter can only be put into a new boiler or when the firebox is renewed.

At the front end of the boiler barrel is a surface skimmer, placed between the steam pipe or dry pipe and the tubes, and extending the full width of the boiler, its end being riveted to the tube plate. The skimmer forms a basin of 20 to 25 gallons capacity. Across the skimmer are two discharge-heads, with pipes to the blow-off. These heads have inclined openings or nozzles, as shown, through which the sediment is discharged when the blow-off is opened. The skimmer is designed to catch the solid matter in the feed water during its first circulation, before it has time to settle on the tubes or in the water legs. Similar discharge-heads are placed in the water legs, the nozzle-openings increasing in size with the distance from the blow-off pipe, so as to give a uniform force.

The arrangement is so designed as to prevent wasting clean water during the process of blowing off. As the impurities settle around the discharge-heads, they will first be blown out by the pressure within the boiler, and the blow-off is closed as soon as clean water appears. If the nozzles should become clogged from neglect, they can be cleaned by blowing steam or water through them from the outside of the boiler. The apparatus for the boiler barrel has been fitted to one of the locomotives of the Chicago & Northwestern Ry., and Mr. Marshall, Assistant Superintendent of Motive Power and Machinery, reports that it was found of great value in preventing forming and in removing sediment. In fact, it enabled the engine to make double its ordinary mileage between the times of washing out the boiler.

This device is the invention of Mr. F. W. Hornish, 908 Masonic Temple, Chicago, Ill., to whom we are indebted for blue prints, etc.



BLOW-OFF DEVICE FOR CLEANING LOCOMOTIVE BOILERS.
F. W. Hornish, Inventor.

TESTS OF WATER METERS AT WYOMING, O.

The reliability of the leading types of water meters has been so well established by numerous shop tests and daily service, that it is not at all surprising that the general conclusion set forth in the most recent account of new tests should be as follows:

> As a general proposition, only two or three of the meters fell so low in the author's esteem as to make them doubtful devices for the measurement of water; but any meter represented in these tests (if not damaged by use) is superior to the prevailing mode of charging for water by a survey of the premises.

The quotation is from a paper by Mr. John W. Hill, M. Am. Soc. C. E., read before the American Society of Civil Engineers on Feb. 1. The basis for the paper was some meter tests conducted by Mr. Hill as a trustee of the water-works of Wyoming, O., a suburb of Cincinnati. The results of the tests were compared with those obtained at Boston, years ago, and at Hamburg more recently. In addition, some general considerations on the subject of water meters were presented, all under the general title, "The Accuracy and Durability of Water Meters." We shall confine ourselves principally to the main results for accuracy at Wyoming, referring our readers to the full paper, in the proceedings of the society, for the details of the test and the comparisons and general discussion of the subject of water meters.

A total of 17 different meters was tested, the makes, and a comparison of errors of registry being given in the accompanying table:

Comparison of Errors of Registry in Water Meter Test at Wyoming, O.

Meter.	No. of tests.	Error: Maximum.	Error: Minimum.	Error: Average.
Piston Meters.				
Worthington	18	+10.32	+0.67	+2.08
Crown	15	−9.45	−3.77	−6.28
Hersey	10	−3.64	+0.53	−2.13
Empire	23	−0.86	+0.23	−0.18
Union Rotary	16	−16.34	+0.33	−2.32
Disk Meters.				
Nash	15	−0.75	−0.04	−0.38
Hersey	15	+1.31	−0.25	+0.22
Trident, No. 23,178	15	−4.27	−0.04	−0.73
" " 23,179	6	−20.63	−0.01	−6.88
" " 23,180	6	−14.03	−1.32	−5.70
" " 23,176	8	−56.37	−0.66	−19.30
Pittsburg, No. 8,011	11	−10.71	−0.60	−3.05
Pittsburg, No. 10,798	13	−24.68	+0.27	−4.77
Niagara	15	−17.10	+0.32	−2.36
Standard	14	−7.13	+1.79	−0.35
Lambert	11	−17.42	−0.84	−5.11
Inferential Meter.				
Columbia	19	+66.31	−0.78	+13.42

The meters were placed on a ¾-in. domestic service (actually 13-16-in.), and operated under static pressures of from 85 to 106 lbs. Bray disks with orifices were used to obtain streams of various sizes.

Observations on loss of head "indicates that the disk meters consumed less of the static head on the service pipe" than the piston or inferential meters. On this point Mr. Hill says further:

> If the disk meter can be shown to be as durable in service, and in other respects equal to the piston and inferential meters, it is entitled to first place in the types of water meters. The author's tests were not made to show the durability of water meters, but, from authentic data placed in his hands for professional purposes by a city water department, he is led to the conclusion that the present disk meter (if not so in all examples at present) can be made as durable as the other types of meters; and if this opinion is well founded, it must become the standard of water meters for domestic uses.

The actual losses of head for ⅝-in. piston meters was about 84% on Worthington, Crown and Empire, and 72% for Union rotary, with ½-in. orifices; 17% for Worthington and Crown, 15% for Empire, and 8% for Union rotary, with ¼-in. orifices; and from 1.18 to 0.82 for all four meters with ⅛-in. orifices. A ¾-in. Hersey piston meter showed better results, as would be expected with a meter the same size as the service pipes. For the eight ⅝-in. disk meters the loss of head was not far from 75% for ½-in.; 9 or 10% for ¼-in., these being averages, and generally considerably below 1% for ⅛-in. orifices. The ⅝-in. Columbia inferential meter gave 91% less for ½-in. orifice, 25% for ¼-in., and 3% for ⅛-in.

The concluding words of Mr. Hill's paper contain the following sentiments regarding the more extensive use of water meters:

> Prior to this investigation of water meters for domestic service, the author has several times been called upon in a professional capacity to examine and report upon some of the better known forms of meters, to settle disputes between water-works officials and dissatisfied water takers. From this experience, and the occasional use of water meters for test purposes, he has acquired a confidence in the reliability of these devices, which, unfortunately, is not generally shared by water-works engineers. This confidence has been strengthened by the present investigation to such an extent that he believes the use of water meters should become, at the earliest possible date, an essential feature of all water-works which pretend to conduct business upon modern enlightened principles.

THE COMING EXHAUSTION OF THE WORLD'S WHEAT SUPPLY.*

Statistics are rarely attractive to a listening audience; but they are necessary evils, and those of this evening are unusually doleful. They show that England and all civilized nations stand in deadly peril of not having enough to eat. As mouths multiply, food resources dwindle. Land is a limited quantity, and the land that will grow wheat is absolutely dependent on difficult and capricious natural phenomena.

Wheat is the most sustaining food grain of the great Caucasian race, which includes the peoples of Europe, United States, British America, the white inhabitants of South Africa, Australia, parts of South America, and the white population of the European colonies. Of late years the individual consumption of wheat has almost universally increased. In Scandinavia it has risen 100% in 25 years; in Austro-Hungary, 80%; in France, 20%; while in Belgium it has increased 50%. In 1871 the bread-eaters of the world numbered 371,000,000. In 1881 the numbers rose to 416,000,000, in 1891 to 472,600,000, and at the present time they number 516,500,000. The augmentation of the world's bread-eating population in a geometrical ratio is evidenced by the fact that the yearly aggregates grow progressively larger. In the early seventies they rose 4,300,000 per annum, while in the eighties they increased by more than 6,000,000 per annum, necessitating annual additions to the bread supply nearly one-half greater than sufficed 25 years ago. How much wheat will be required to supply all these hungry mouths with bread? At the present moment it is not possible to get accurate estimates of this year's wheat crops of the world, but an adequate idea may be gained from the realized crops of some countries and the promise of others. To supply 516,500,000 bread-eaters, if each bread-eating unit is to have his usual ration, will require a total of 2,324,000,000 bushels for seed and food. What are our prospects of obtaining this amount?

According to the best authorities the total supplies from the 1897-98 harvest are 1,921,000,000 bushels. The requirements of the 516,500,000 bread-eaters for seed and food are 2,324,000,000 bushels; there is thus a deficit of 403,000,000 bushels, which has not been urgently apparent owing to a surplus of 300,000,000 bushels carried

*Extract from the presidential address of Sir William Crookes at the last meeting of the British Association for the Advancement of Science, held Sept. 8-12, at Bristol, England.

over from the last harvest. Respecting the prospects of the harvest year just beginning, it must be borne in mind that there are no remainders to bring over from last harvest. We start with a deficit of 103,000,000 bushels, and have 6,500,000 more mouths to feed. It follows, therefore, that one-sixth of the required bread will be lacking unless larger drafts than now seem possible can be made upon early produce from the next harvest.

For the last 30 years the United States have been the dominant factor in the foreign supply of wheat, exporting no less than 145,000,000 bushels. This shows how the bread-eating world has depended, and still depends, on the United States for the means of subsistence. The entire world's contributions to the food-bearing area have averaged but 4,000,000 acres yearly since 1869. It is scarcely possible that such an average, under existing conditions, can be doubled for the coming 25 years. Almost yearly, since 1885, additions to the wheat-growing area have diminished, while the requirements of the increasing population of the States have advanced, so that the needed American supplies have been drawn from the acreage hitherto used for exportation. Practically there remains no uncultivated prairie land in the United States suitable for wheat-growing. The virgin land has been rapidly absorbed, until at present there is no land left for wheat without reducing the area for maize, hay and other necessary crops. It is almost certain that within a generation the ever-increasing population of the United States will consume all the wheat grown within its borders, and will be driven to import, and, like ourselves, will scramble for a lion's share of the wheat crop of the world. This being the outlook, exports of wheat from the United States are only of present interest, and will gradually diminish to a vanishing point. The inquiry may be restricted to such countries as probably will continue to feed bread-eaters who annually derive a considerable part of their wheat from extraneous sources. But if the United States, which grow about one-fifth of the world's wheat, and contribute one-third of all wheat exportations, are even now dropping out of the race, and likely soon to enter the list of wheat-importing countries, what prospect is there that other wheat-growing countries will be able to fill the gap, and by enlarging their acreage under wheat, replace the supply which the States have so long contributed to the world's food? The withdrawal of 145,000,000 bushels will cause a serious gap in the food supply of wheat-importing countries, and unless this deficit can be met by increased supplies from other countries there will be a dearth for the rest of the world after the British Isles are sufficiently supplied. Next to the United States Russia is the greatest wheat exporter, supplying nearly 95,000,000 bushels. Although Russia at present exports so lavishly, this excess is merely provisional and precarious. The Russian peasant population increases more rapidly than any other in Europe. The yield per acre over European Russia is meager—not more than 8.6 bushels to the acre—while some authorities consider it as low as 4.6. The cost of production is low—lower even than on the virgin soils of the United States. The development of the fertile though somewhat overrated "black earth," which extends across the southern portion of the empire and beyond the Ural Mountains into Siberia, progresses rapidly. But, as we have indicated, the consumption of bread in Russia has been reduced to danger point. The peasants starve and fall victims to "hunger typhus," whilst the wheat growers export grain that ought to be consumed at home.

Starvation, however, may be averted through the laboratory, and before we are in the grip of actual dearth the chemist will step in and postpone the day of famine to so distant a period that we, and our sons and grandsons, may legitimately live without undue solicitude for the future. It is now recognized that all crops require what is called a "dominant" manure. Some need nitrogen, some potash, others phosphates. Wheat pre-eminently demands nitrogen, fixed in the form of ammonia or nitric acid. All other necessary constituents exist in the soil; but nitrogen is mainly of atmospheric origin, and is rendered "fixed" by a slow and precarious process which requires a combination of rare meteorological and geographical conditions to enable it to advance at a sufficiently rapid rate to become of commercial importance. There are several sources of available nitrogen. The distillation of coal in the process of gas-making yields a certain amount of its nitrogen in the form of ammonia; and this product, as sulphate of ammonia, is a substance of considerable commercial value to gas companies. But the quantity produced is comparatively small; all Europe does not yield more than 400,000 tons per annum, and, in view of the unlimited nitrogen required to substantially increase the world's wheat crop, this slight amount of coal ammonia is not of much significance. For a long time guano has been one of the most important sources of nitrogenous manure, but guano deposits are so near exhaustion that they may be dismissed from consideration.

Much has been said of late years, and many hopes raised by the discovery of Hellriegel and Wilfarth, that leguminous plants bear on their roots nodosities abounding in bacteria endowed with the property of fixing atmospheric nitrogen, and it is proposed that the necessary amount of nitrogen demanded by grain crops should be supplied to the soil by cropping it with clover and ploughing in the plant when its nitrogen assimilisation is complete. But it is questionable whether such a mode of procedure will lead to the lucrative stimulation of crops. It must be admitted that practice has long been ahead of science, and for ages farmers have valued and cultivated leguminous crops. The four-course rotation is turnips, barley, clover, wheat—a sequence popular more than 2,000 years ago. On the Continent, in certain localities, there has been some extension of microbe cultivation; at home we have not reached even the experimental stage. Our present knowledge leads to the conclusion that the much more frequent growth of clover on the same land, even with successful microbe-seeding and proper mineral supplies, would be attended with uncertainty and difficulties. The land soon becomes what is called "clover-sick" and turns barren. There is still another and invaluable source of fixed nitrogen. I mean the treasure locked up in the sewage and drainage of our towns. Individually the amount so lost is trifling, but multiply the loss by the number of inhabitants, and we have the startling fact that, in the United Kingdom, we are content to hurry down our drains and water courses, into the sea, fixed nitrogen to the value of no less than $80,000,000 per annum. This unspeakable waste continues, and no effective and universal method is yet contrived of converting sewage into corn. The more widely this wasteful system is extended, recklessly returning to the sea what we have taken from the land, the more surely and quickly will the finite stocks of nitrogen locked up in the soils of the world become exhausted. Let us remember that the plant creates nothing; there is nothing in bread which is not absorbed from the soil, and unless the abstracted nitrogen is returned to the soil, its fertility must ultimately be exhausted. Witness the yield of 40 bushels of wheat per acre under favorable conditions, dwindling through exhaustion of soil to less than 7 bushels of poor grain, and the urgency of husbanding the limited store of fixed nitrogen becomes apparent.

The only available compound containing sufficient fixed nitrogen to be used on a world-wide scale as a nitrogenous manure is nitrate of soda, or Chili saltpetre. This substance occurs native over a narrow band of the plain of Tamarugal, in the northern provinces of Chili, between the Andes and the coast hills. In this rainless district for countless ages the continuous fixation of atmospheric nitrogen by the soil, its conversion into nitrate by the slow transformation of billions of nitrifying organisms, its combination with soda, and the crystallization of the nitrate have been steadily proceeding, until the nitrate fields of Chili have become of vast commercial importance, and promise to be of inestimably greater value in the future. The growing exports of nitrate from Chili at present amount to about 1,200,000 tons.

The action of nitrate of soda in improving the yield of wheat has been studied practically by Sir John Lawes and Sir Henry Gilbert on their experimental field at Rothamstead. This field was sown with wheat for 13 consecutive years without manure, and yielded an average of 11.9 bushels to the acre. For the next 13 years it was sown with wheat, and dressed with 5 cwt. of nitrate of soda per acre, other mineral constituents also being present. The average yield for these years was 36.4 bushels per acre—an increase of 24.5 bushels. In other words, 22.86 lbs. of nitrate of soda produce an increase of one bushel of wheat. At this rate, to increase the world's crop of wheat by 7.3 bushels, about 150 lbs. of nitrate of soda must annually be applied to each acre. The amount required to raise the world's crop on 163,000,000 acres from the present supply of 2,070,000,000 bushels to the required 3,260,000,000 bushels will be 12,000,000 tons distributed in varying amounts over the wheat-growing countries of the world, in addition to the 1,250,000 tons already absorbed.

It is difficult to get trustworthy estimates of the amount of nitrate surviving in the nitre beds. Common rumor declares the supply to be inexhaustible, but cautious local authorities state that at the present rate of export, of over 1,000,000 tons per annum, the raw material "caliche," containing from 25 to 50% of nitrate, will be exhausted in from 20 to 30 years. Dr. Newton, who has spent years on the nitrate fields, tells me there is a lower class material, containing a small proportion of nitrate, which cannot at present be used, but which may ultimately be manufactured at a profit. Apart from a few of the more scientific manufacturers, no one is sanguine enough to think this debatable material will ever be worth working. If we assume a liberal estimate for nitrate obtained from the lower grade deposit, and say that it will equal in quantity that from the richer quality, the supply may last, possibly, 50 years, at the rate of 1,000,000 tons a year; but at the rate required to augment the world's supply of wheat to the point demanded 30 years hence, it will not last more than 4 years.

In its free state nitrogen is one of the most abundant and pervading bodies on the face of the earth. To convey this idea in an object-lesson, a room measuring 146 × 80 × 70 ft. contains 27 tons weight of nitrogen in its atmosphere. In the free gaseous state this nitrogen is worthless; combined in the form of nitrate of soda it would be worth about $10,000. For years past attempts have been made to effect the fixation of atmospheric nitrogen, but I think I am right in saying that no process has yet been brought to the notice of scientific or commercial men which can be considered successful either as regards cost or yield of product. The fixation of atmospheric nitrogen, therefore, is one of the great discoveries awaiting the ingenuity of chemists.

As far back as 1892 I exhibited, at one of the Soirees of the Royal Society, an experiment on "The Flame of Burning Nitrogen," by which it was shown that nitrogen is a combustible gas. The reason why when once ignited the flame does not spread through the atmosphere and deluge the world in a sea of nitric acid is that its igniting point is higher than the temperature of its flame—not, therefore, hot enough to set fire to the adjacent mixture. But by passing a strong induction current between terminals, the air takes fire and continues to burn with a powerful flame, producing nitrous and nitric acids. This inconsiderable experiment may not improbably lead to the development of a mighty industry destined to solve the great food problem. With the object of burning out nitrogen from air, so as to leave argon behind, Lord Rayleigh fitted up apparatus for performing the operation on a larger scale, and succeeded in effecting the union of 29.4 grammes of mixed nitrogen and oxygen at an expenditure of 1 HP.

Before we decide that electric nitrate is a commercial possibility, a final question must be mooted. We are dealing with wholesale figures, and must take care that we are not simply shifting difficulties a little further back without really diminishing them. We start with a shortage of wheat, and the natural remedy is to put more land under cultivation. As the land cannot be stretched, and there is so much of it and no more, the object is to render the available area more productive by a dressing with nitrate of soda. But nitrate of soda is limited in quantity, and will soon be exhausted. Human ingenuity can contend even with these apparently hopeless difficulties. Nitrate can be produced artificially by the combustion of the atmosphere. Here we come to finality in one direction; our stores are inexhaustible. But how about electricity? Can we generate enough energy to produce 12,000,000 tons of nitrate of soda annually? A preliminary calculation shows that there need be no fear on that score; Niagara alone is capable of supplying the required electric energy without much lessening its mighty flow.

CALCIUM CARBIDE AND ACETYLENE.

A paper by Mr. Henry Fowler, Assoc. M. Inst. C. E., with the above title, recently published by the Institution of Civil Engineers in a pamphlet of 67 pages, including discussions by members, is one of the best papers we have yet seen on the subject of the manufacture of acetylene and its availability, commercially, as an illuminant. The paper treats first of the scientific principles involved in the production and use of the gas, on its impurities, and its toxic and explosive properties. It is stated that inside of two years there were eleven explosions of the gas, resulting in death or injury to persons near the apparatus, and that experiments have been made which have led the Home Office to consider the advisability of placing all acetylene of a pressure greater than a few inches of water, under the Explosives Act. The author makes a computation of the cost of lighting by acetylene, based on calcium carbide, at £16 per gross ton (about $70 per net ton), and 11,000 cu. ft. of gas per ton, making the gas cost 29s. 1d ($7.07) per 1,000 cu. ft., for material alone, not counting the expenses of making, depreciation of plant, etc. Taking these into account, the cost becomes 33s. ($8.02) per 1,000 cu. ft. in the holder. On this basis the cost of acetylene for a given amount of light becomes as low as that of coal gas at 2s. 6d. (61 cts.) per 1,000 cu. ft. if it is used in burners of not less than 31 candle power. In burners of 8.6 c. p. it is about twice as expensive as coal gas. It is thus peculiarly suitable, says the author, for the light of country houces, public buildings, etc., where coal gas cannot be obtained and oil is found to be objectionable. No small burner yet in use gives a high value for acetylene. Acetylene has been proposed as an enricher of coal gas, but an addition of 1% of acetylene gives an enrichment of only 1 candle, and at present prices of cathide of calcium, the cost is too high to enter into competition with existing enrichers.

A mixture of Pintch oil gas with acetylene explodes if a pipe leading to it is raised in temperature, if the mixture contains 75% of acetylene, but not if the mixture contains equal parts of coal gas and acetylene. If calcium carbide falls to £16 per ton or less, a mixture containing 30 to 40% of acetylene may be advantageously used for lighting railway cars. The German railways have decided to use a mixture of 25% acetylene and 75% oil gas for car lighting.

AN UNSYMMETRICAL RAIL SECTION.

An important consideration in the discussion of the efficiency of different forms of rail sections is the comparatively small amount of metal available for wear. That is to say, the small amount which, being removed from the head by wear, will render the rail unserviceable for main track. The remainder of the metal in the head, and all the metal in the web and base, is then practically good only for scrap. A form of rail designed to increase this amount of metal, and so give an increase in the life of the rail, with a consequent reduction in expense for renewals, was patented in 1894 by Mr. William T. Manning, M. Am. Soc. C. E., Chief Engineer of the Baltimore & Ohio R. R., and interest in this rail is revived at the present time by the report that it is to be given a practical trial. The Carnegie Steel Co., of Pittsburg, Pa., has orders for 1,000 tons of 90-lb. rails of the Manning section for the Baltimore & Ohio R. R., and 500 tons for the Pittsburg & Western R. R.

The form of the section is in general similar to that recommended by the rail committee of the American Society of Civil Engineers, in 1893, but its special feature is an unsymmetrical head. A slight amount of metal is added to the top of the rail, and about ¼-in. in thickness is added to the inner side of the rail head. The top corner radius of 5-16-in. is retained, but instead of the side of the head being vertical, it is curved inward on a radius of 1 in. Fig. 1 shows a comparison of two forms of sections, while Fig. 2 is a section of the much more rapid rate after the wheel flange has got a full bearing. The first of these conditions he provides for by the extra ¼-in. of metal on the gage side of the rail head. To prevent the flange from getting a full bearing, he makes the head vertical for only ¼-in. below the corner and then rounds off the lower part by an inward curve, as shown. He states that the metal between this curved line and a vertical line would not only be useless, but would provide a full flange bearing, allowing the rail to assume such a shape as would invite derailment from sharp flanges.

Mr. Manning further claims that while the use of heavier rail sections has been warranted by the improvement in track and the economy in maintenance which they effect, yet they give little if any increase in the life of the rail, or any reduction in the renewal expenses, but rather an increase in these expenses. He presents the accompanying comparison (Table II.), of distribution of metal in rails of different weights, but appears to have made a serious error in regard to the 67-lb. rail. He gives this as having 50% of the metal in the head, which is a most unusual proportion, and at the same time he compares this with Am. Soc. C. E. sections having 42% of the metal in the head. There is no 67-lb. section of this latter form, the sections varying by 5 lbs. per yd., but a 67-lb. rail based on the same proportions would have 28.14 lbs., 14.07 lbs. and 24.79 lbs. in the head, web and base, respectively, instead of the amounts given in the table. Thus,

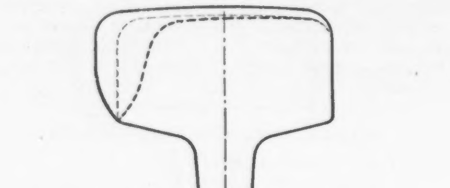


Fig. 1.—Comparative Sections of Rails of the Manning and Am. Soc. C. E. Type.

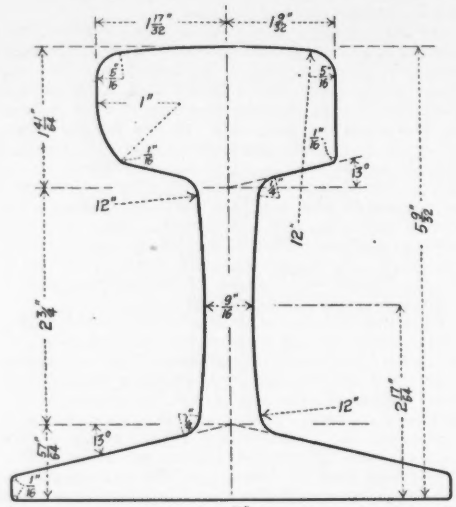


Fig. 2.—Cross-Section of the Manning Rail, 90-lbs. per yd.

85-lb. Manning rail. The dimensions of this rail and of the 85-lb. rail of the so-called Am. Soc. C. E. section, are given in Table I.:

TABLE I.—Dimensions of 90-lb. Rail Sections.

	Manning.	Am. Soc. C. E.
Height, ins.	5 9/32	5⅜
Width of base, ins.	5 3/16	5⅜
" of head, ins.	2 13/16	2⅝
" on gage side, ins.	1 17/32	1 5/16
" on outer side, ins.	1 9/32	1 5/16
Side of head, gage side	1-in. curve.	Vert.
Side of head, outer side	Vert.	Vert.
Depth of head, ins.	1 41/64	1 19/32
Height of web, ins.	2¾	2 55/64
Depth of base, in.	57/64	59/64
Thickness of web, in.	9/16	9/16
Edge of base	Vert.	Vert.
Thickness of edge of base, in.	5/16	5/16
Height to c. of bolt hole, ins.	2 17/64	....
Radius of top of head, ins.	12	12
" top corners, head, in.	7/16	5/16
" bottom corners, in.	1/16	1/16
" fillets, in.	¼	¼
" sides of web, ins.	12	12
" corners of base, in.	1/16	1/16
Fishing angles, °F	13	13
Metal in head, %	45	42
" web, %	20	21
" base, %	35	37

In a pamphlet recently issued by Mr. Manning, setting forth the advantages of his rail, he presents two conditions as being conceded by men of large experience: (1) The life of rail for main track use is limited to its initial wear (before being moved), and that wear cannot extend beyond the point where the wheel flange begins to cut the angle splice bar; (2) The rail is destroyed at a

instead of an increase of only 2.2 lbs. in the head for the 85-lb. rail, as compared with the 67-lb. rail (as stated by Mr. Manning), there is really an increase of 7.56 lbs. in the head (or wearing part), and 10.44 lbs. (instead of 15.8 lbs.), in the non-wearing parts.

TABLE II.—Distribution of Metal in Rails (Manning).

Weight, per yd.	Metal in Head, lbs.	Metal in Web, lbs.	Metal in Base, lbs.
67 lbs.*	33.50 (28.14)	12.06 (14.07)	21.44 (24.79)
85 lbs.	35.70	17.85	31.45
100 lbs.	42.00	21.00	37.00

*The weights given in the pamphlet for the 67-lb. rail are evidently incorrect, as we have shown, and we have therefore added in parentheses the distribution for a 67-lb. rail designed on the Am. Soc. C. E. proportions.

Mr. Manning argues against the practice of turning rails, on the ground that the wheels do not get a proper bearing on such rails. This is his main reason for the unsymmetrical head which is the basis of his patent, for a rail section with simply an unusually wide head (which this rail would be if made symmetrical) could hardly be patented. We do not think that actual experience bears out the reasoning against turning rails (except in special cases), nor do the worn sections which are illustrated appear to support this reasoning, the unworn outer side being in fair condition for use as the gage side. It may be noted that when the rail was first invented, Mr. Manning proposed that the additional metal on the side of the head should present a vertical face, and that when this side of the head was worn nearly to the limit the rail should be turned. The engineer or roadmaster would, of course, see that the rail was not allowed to wear to such an extent as to make it unfit for service when turned.

The advantages claimed for the new section apply mainly to the special wear of rails on curves, and as the Baltimore & Ohio R. R. is noted for the amount of its curvature, it is doubtless a good road on which to try the Manning rail. This may be seen from the fact that the pamphlet referred to gives the life of 75-lb. rails (of the Am. Soc. C. E. section), on curves of 5° 40' as only three years, and this is assumed to be the limit of the initial life of rails. The tonnage carried in this case is not stated, but from other information given in this pamphlet this may be estimated at 11,100,000 tons per year. This would be 33,300,000 tons for the three years, or one-fifth to one-sixth of the tonnage given in Wellington's "Economic Theory of Railway Location," as the average limit for the wear of the rails. These severe curves, however, are exceptional cases, as compared with the total railway mileage. Renewals on account of side wear usually form but a small percentage of the total renewals, except on roads or divisions having considerable curvature and heavy traffic. Ordinarily, the tangents comprise the greater portion of the line and the average life of good heavy rails will be very much more than three years.

Actual experience will show how far the advantages claimed can be realized in practice, but we certainly do not think that—except in a few special cases—this modification of the form of section will "give the rail from 50 to 75% (and probably 100%) additional life in its initial position, before consigning it to less important work than main track." Neither does it seem probable that it will effect a saving of 37% per ton per year in cost of rail renewals, as claimed. As far as we can see, equally good results could be obtained by a broad-headed rail which could be turned when the gage side had sustained a reasonable amount of wear. An objection to such a broad head is that badly-grooved wheels would tend to cause a flow of metal on the outside of the head, but most well-managed roads are now endeavoring to keep tire wear within reasonable limits.

A TEST OF THE MOELLER CONCRETE AND METAL FLOOR SYSTEM.*

After the close of the industrial exhibition held last year in Leipzig, Germany, a series of tests was made under the direction of the building authorities in order to get some information regarding the relative strength of the different roof and floor systems which were exhibited. One of the floor systems which withstood the tests the most successfully was the concrete and metal girder system known as the Moeller girder roof. The general construction of this floor system is shown in Fig. 1, which also shows the method of making the breaking test.

The span to be tested had a clear length of 8 m. (26 ft. 3 ins.), and as it had been standing over eight months, the Groschowitzer cement used

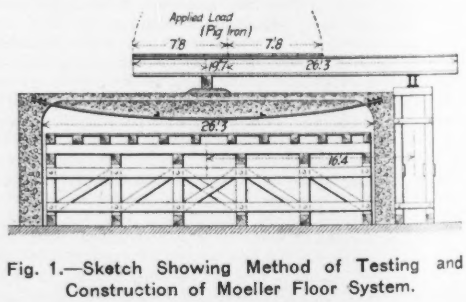


Fig. 1.—Sketch Showing Method of Testing and Construction of Moeller Floor System.

in its construction could be regarded as having thoroughly set. The concrete used in the arch was mixed in the proportion of 1 to 2½ sand and 3½ broken stone or gravel, and that in the abutments in the proportion of 1 to 6 sand and 6 gravel. The

*Abstracted from an article in "Centralblatt der Bauverwaltung," by O. J. Marstrand.

hangers were iron bars, 230 × 20 mm. (9 1-16 × 25-32 ins.), placed 1.25 m. (4.1 ft.) apart, c. to c. The versed sine of the arch, measured from the lower edge of the upper concrete flange, which was 0.15 m. (6 ins.) thick, was 0.41 m. (1.35 ft.).

The method of loading is illustrated in the accompanying cut, Fig. 1. The total weight of girders, beams and platform was 2,400 kilos. (5,291 lbs.), and the load was applied through pieces of pig iron weighing 100 kilos. (220.5 lbs.) each. The following results were observed: With a load of 11,580 kilos. (25,580 lbs.), the deflection at the center amounted to 1 mm. (0.039 ins.), while the foundations settled 1.6 mm. (0.063 ins.). At a loading of 21,570 kilos. (47,500 lbs.), the first appearance of a fine crack in the concrete was noticed, at a distance of 1.9 m. (6.23 ft.) from the abutment. The deflection was 35 mm. (1.37 ins.). After 12 hrs. it was 36.5 mm. (1.44 ins.). The tension in the iron bar, corresponding to this load, was 2,908 kilos. sq. cm. (41,400 lbs. per sq. in.), and the compression in the concrete 81.4 kilos. per sq. cm. (1,159 lbs. per sq. in.). The arch broke, finally, under the application of a single load of 64,225 kilos. (141,500 lbs.), corresponding to 58,400 kilos. (128,800 lbs.), at the crown, producing a strain on the iron of 3,353 kilos. per sq. cm. (47,700 lbs. per sq. in.). The compression in the concrete flange, under this load, amounted to about 94.3 kilos. per sq. cm. (1,345 lbs. per sq. in.). The adhesion between the iron and concrete was destroyed. The four angle irons, fastened to the suspending bars at the abutments, remained fixed in their position. No great amount of horizontal thrust can have taken place, as hardly any displacement of the weak abutment walls was observed. Even when the arch had dropped down after the removal of the supporting scaffolding and wedges the side-walls retained their position. It should be noted that the construction, as a whole, might have been made stronger by using iron bars of heavier section since the concrete was strained to only about one-half of its ultimate resistance to compression.

FIG. 1.—LIGHT BUGGY OPERATED BY STORAGE BATTERIES. FISCHER EQUIPMENT CO., MAKERS.

FIG. 2.—HANSOM CAB OPERATED BY STORAGE BATTERIES. FISCHER EQUIPMENT CO., MAKERS.

A CENTERING TOOL FOR LATHE WORK.

The centering tool here described was devised by Mr. M. H. Lockwood, of Missouri State University, Columbia, Mo. It consists essentially of two sets of parallel bars, placed at right angles, and so pivoted to cross-strips and to a base-ring that the straight edges of one set shall always be at right angles to the corresponding edges of the other set.

The illustration represents a tool capable of taking in work varying in diameter from zero to 1¾ ins. The bars are thrown open by pressing together the arms A and B; though springs could be introduced tending to automatically clasp the object to be centered. Provided, the tool is accurately made, a tap with a hammer on the head of the center-punch will mark the exact center of the shaft, etc. Each set of bars moves independently, and the tool can be used with square, oblong, elliptical or other forms of work.

As shown in Fig. 1, two bars in each set are pivoted at their centers to the ring at the ends of two diameters drawn at right angles to each other. As the bars rotate about their pivots, the parallel faces of the bars are always equidistant from their respective diametrical lines; and as a consequence, the diagonals of the rectangular parallelogram formed will always intersect at the center of the ring. This arrangement could be successfully used as an attachment to a lathe, connected with the tail-piece, or slide-rest.

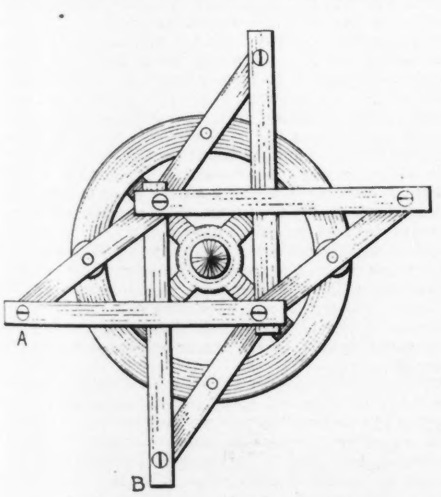


Fig. 1.—Centering Tool; Bottom Plan.

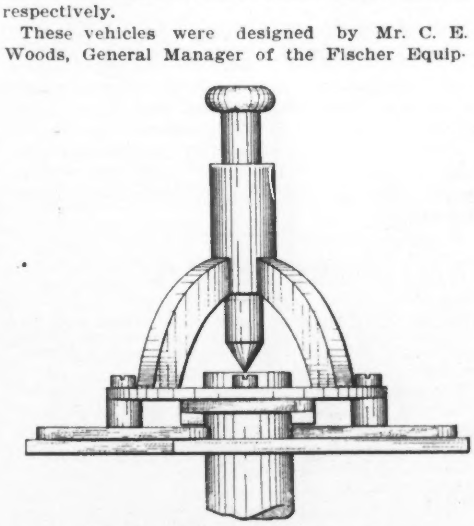


Fig. 2.—Centering Tool; Elevation.

STORAGE BATTERY MOTOR-CARRIAGES IN CHICAGO.

The motor vehicle is gradually developing from the experimental stage to that of an established institution, and motor carriages, cabs and delivery wagons are already in use in several large cities, some of which vehicles have been illustrated in our columns. In the majority of cases these vehicles are operated by storage batteries, and we illustrate herewith two electric motor-vehicles out of a number of different styles which have recently been put in service in Chicago.

Fig. 1 represents a light carriage for two persons, which is said to be the lightest road buggy ever built, the total weight being only 750 lbs., of which the batteries represent 450 lbs. It has one 2½-HP. motor, and battery capacity sufficient for a run of 25 miles on one charge, the maximum speed being 12 miles per hour. It has 32-in. wheels and can ascend grades of 5%.

Fig. 2 represents a hansom cab, weighing 2,600 lbs., which has two 3½-HP. motors, and sufficient battery capacity for a run of 30 miles with one charge. The speeds are 3, 6 and 12 miles per hour, and the vehicle can ascend grades of 8%. The batteries weigh 1,000 lbs. The cab has electric lights in the side lamps, and electric lights and foot-warmers inside. The Victoria hansom is very similar, but has the driver's box in front. These cabs have front and rear wheels 32 and 38 ins. diameter, respectively.

These vehicles were designed by Mr. C. E. Woods, General Manager of the Fischer Equipment Co., 110 East 20th St., Chicago, who has paid particular attention to their design from a carriage-builder's point of view, as well as from an electrician's point of view. About 25 different styles of vehicles are now being made, including carriages, cabs, omnibuses and delivery wagons, and the company reports a number of orders on hand. A special feature of these vehicles is that wooden wheels and hard rubber tires are used almost exclusively, being considered generally preferable to wire wheels and pneumatic tires, especially for city streets.

The controlling mechanism is so simple that the vehicles can be operated by anybody after a little instruction. It is impossible to apply the brake without first cutting off the power from the motors; and it is also impossible to apply the power without first liberating the brake; this is effected by means of an interlocking device between the brake and controller, so that both controller and brake are operated by one handle. A separate reversing switch is used, by which all vehicles can be operated either backwards or forwards, and this is provided with a lock, so that the vehicle cannot be operated by anyone not possessing the key. The various speeds are obtained by varying the arrangement of the batteries in series or parallel, and great care has been taken to secure a uniformity of discharge from the batteries when in parallel, the contacts and connections having nearly four times the cross section ordinarily required, so that the resistances may be perfectly uniform.

On the light road buggy, Fig. 1, only one motor is used, with a differential gear. All the vehicles for harder and heavier work are equipped with two motors, one attached to each rear wheel. Provision is made for automatic adjustment in the turning of corners or the turning round of the vehicle.

The motors are built with ironclad armatures and special coil windings, which coils are wound before being placed upon the armature. This enables the coils to be shipped to any point, and they can be fitted into the armature without any difficulty whatever by those who understand anything about armature winding. All the vehicles have 40 battery cells, and the batteries are arranged to be either removed from the vehicle and replaced by duplicate sets, or to be charged while standing in the vehicle. The charging occupies about three hours.

Experimental work on gears has resulted in a noiseless operation of the gearing, special compositions in rawhide being used which produce no sound whatever in the performance of their work.

For the photographs and particulars we are indebted to the manufacturers, who state that the mileage capacity given is nearly 25% less than the actual mileage capacity obtainable, as these mileage capacities are their actual guaranteed figure. Varying conditions of road and weather, as well as the fact that sometimes batteries are not quite fully charged when starting out, has led the company to make this guarantee of mileage capacity on conservative lines. The cost of maintenance of batteries per year is given as $50 for the light road buggy, $80 to $100 for different styles of cabs and carriages, and $160 to $300 for delivery wagons and omnibuses. The cost of operation per mile is given as ¾-ct., 1 to 1½ cts., and 2¼ to 4 cts. per mile, respectively. The higher cost for the battery maintenance of delivery wagons and public conveyances is due to their being subjected to much heavier service than the vehicles in private use only.

BOOK REVIEWS.

TIMBER TEST RECORD for Engineers, Architects, Inspectors of Wood in Construction Contracts, Bridge Men, etc.—By Walter G. Berg. Chicago: B. S. Wasson & Co. Paper; 8vo.; pp. 706. $1.

This is a reprint of the complete compilation of timber tests made by leading authorities and the U. S. Forestry Division, which was prepared by Mr. Berg as a report for the 1895 convention of the Association of Railway Superintendents of Bridges and Buildings.

GAS AND PETROLEUM ENGINES.—Translated and Adapted from the French of Henry de Graffigny, and edited by A. G. Elliott, B. Sc. Whittaker & Co., London and New York. Cloth; 12mo; pp. 140. 75 cts.

This little book is one of Whittaker's "Electro-Mechanical Series." It is a good, but very brief, treatise on gas and petroleum engines. One chapter deals with the theory of the gas engine, avoiding mathematics, however, as far as possible. A short chapter describes the history of the engine, and the bulk of the book is taken up with descriptions of existing gas and petroleum engines, with some account of gas producers. A few pages treat of the maintenance of gas and oil engines.

STANDARD TURNOUTS ON AMERICAN RAILROADS.—By F. A. Smith, C. E., M. E., Editor of the "Roadmaster & Foreman." Chicago: B. S. Wasson & Co. Flexible leatherette; oblong; 7¾ x 4½ ins.; pp. 41; $1.

This pocket-book is intended specially for section foremen and others employed in practical track work, and contains ten lay-outs for split switches and ten for stub switches, including three-throw split and stub switches. Each diagram occupies one page, while on the opposite page is a description of the diagram, with instructions for doing the work. All the turnouts are for straight track, but the book covers the majority of cases entrusted to the section foremen, and should prove very useful. The measurements given are in even feet and inches, as far as possible, it being recognized that small variations from theoretical exactness have no influence upon the practical accuracy of the turnout.

ALTERNATING CURRENT WIRING AND DISTRIBUTION.—By William Le Roy Emmet, M. A. I. E. E.; 2d edition, revised and extended. New York: The Electrical Engineer; 4⅝ x 6¾ ins.; pp. 98; 33 illustrations. $1.00.

While there are dozens of books published upon the subject of alternating currents, many of which contain matter relative to wiring and distribution, we recall none which combines so much practical and workable information in such a convenient form as is found in this little book. While not intended for professors and advanced theoretical students, the information contained is of such a nature and the method of treatment is such that it will afford instructive reading to all. The wiring tables will save the use of intricate formulas, and for the practical designing and installing engineer are alone worth the price of the book. Those wishing a brief but correct and clear statement of the practical side of alternating current distribution will do well to purchase this handy little work.

REPAIRS OF RAILWAY CAR EQUIPMENT, with Prices of Labor and Material.—By H. M. Perry, M. C. B. Chicago: "The Railway Age." Cloth; 6 x 8 ins.; pp. 172. Price, cloth, $2; flexible leather, $5.

The rules of interchange and the work of the M. C. B. Association have reduced the work and proportionate cost of car repairs to a systematic basis. The author, in his preface, refers to the importance of car repairing, and states that his purpose has been to furnish a ready means of reference for estimating the cost of repairs, for making the bills of material and reports on damaged cars, and for comparing the different methods of doing work. The book consists of a series of tables of average cost of detail repairs to passenger and freight cars, including inside finish, brake rigging, heating systems, etc., as well as general constructive details. The prices for labor and material are based on the M. C. B. rules. The book includes detail bills of material for cars, trucks, car platforms, etc., and has a number of tables of weights of materials, board measure, capacities of springs, etc. The typography is excellent, and there is a good index.

AMERICAN TRADE INDEX.—Descriptive and Classified Membership Directory of the National Association of Manufacturers of the United States. Arranged for the Convenience of Foreign Buyers. Philadelphia: National Association of Manufacturers. Cloth; 6 x 9 ins.; pp. 276; $3.

This is a publication giving information about those manufacturers in this country who are members of the National Association and who are interested in foreign trade. One part contains the names of manufacturers, arranged alphabetically, and under these names the principal articles manufactured by each are enumerated. Another part gives an alphabetical list of the articles manufactured, and under each head the names and addresses of the manufacturers. A third part gives registered telegraphic addresses. The book in this, its first edition, contains a good list of names and much useful information for foreign buyers; its value will evidently be much enhanced as the membership list of the association increases. The principal part of the edition is to be distributed free to the principal English-speaking merchants in foreign countries, and an edition in Spanish is to be distributed in the West Indies and in Spanish-American countries.

DICTIONNAIRE TECHNIQUE: Francais-Anglais, des Outils et Ustensiles employes dans les Metiers Manuels, la petite industrie, le Menage, etc., suivi d'un index Anglais-Francais.—A. S. Lovendal. Paris: Boyveau et Chevillet, 22 Rue de la Banque. Paper; 7¼ x 4½ ins.; pp. 158. 3 francs.

The title well describes the purpose of this work. It gives the French names and English equivalents for tools and implements employed in the building trades, in all industries and in household use or agriculture. It is in no sense a technical dictionary for the use of engineers alone, except as they may have need for the meaning of names connected with the above employments. But in this sense it is useful to the readers of French technical works; for in this dictionary we find named, for example, fourteen different types of windlasses, the terms connected with lifting apparatus generally; surveyors' instruments and appliances; miners' tools; masons' and stonecutters' tools, etc. The bulk of the material given may be generally classified as hardware; and to those interested in this class of tools, utensils and appliances the book would be invaluable. The English definitions are unusually clear. They are evidently written by one who understands French, and, what is even more important, the use of the tool described. The definitions are ranged under the head of trades or broad classes of tools, such as axes, saws, chisels, etc. This classification is somewhat awkward, as it is necessary in some cases to know the trade to which the tool belongs; but this system is somewhat common in French works of this class, and it is a difficult matter to handle otherwise; an alphabetical arrangement would be impossible for both languages without doubling the bulk of the book.

RAILWAY MANAGEMENT AT STATIONS.—By E. B. Ivatts, late Goods Manager, Midland Great Western Railway (Ireland). London: McCorquodale & Co. Third edition. Cloth; 8vo.; pp. 605. Price 6 shillings ($1.50); postage, 12 cts.

This book is a comprehensive treatise on the business management and practical details of railway operation, somewhat upon the plan of Mr. M. M. Kirkman's excellent books on the business conduct and practical details of American railway management. Although it refers mainly to the methods in use on British railways, which are described in detail, yet there is much in the book which is of general application, particularly in regard to the technical education of the staff, and the necessity of systematic methods properly carried out. The author strongly advocates what is known as the civil-service system, that is, promotion by merit (as shown by examination), rather than by favor or chance. He presents a system of progressive and periodical examinations in technical matters to be taken and passed by the junior clerks and assistants and other grades of employees. He believes that employees in the railway service should be properly trained, and not left to pick up their knowledge in a haphazard way, and he states that one object in writing this book was to form a text book for the technical study of railway business. Mr. Ivatts has had extensive experience upon railways in England, Ireland, India and Canada, and is thus familiar with all the details of railway affairs.

After describing the organization and training of the railway staff, and the system of discipline, the author takes up the practical affairs of railway working, and enters into the details of the freight (or "goods") service. The various rules and regulations are given, together with the laws as to responsibility of carriers, etc. He also describes the several stages of procedure in receiving, sorting, loading, shipping and delivering freight. In fact, he follows out not only the clerical work in the office, but the practical work in the freight shed and the freight yard. Brief notes as to litigation over losses, damages, etc., of freight during transportation, are also given.

The passenger traffic is dealt with in the same comprehensive way, and the author refers to the "unfortunate insular prejudice" in favor of the compartment system of cars. He advocates long saloon cars of the American type for second and third class passengers, leaving the first class passenger to their "coveted seclusion, for which they should pay well." Special chapters deal with such subjects as soliciting traffic, ticket office and general station book-keeping, the inspection of station agent's accounts, the cartage of freight to and from the station (which in England is largely done by the railway companies), cattle traffic, parcels traffic, passengers' baggage, etc. In the latter a modification of the American baggage check system is proposed, but it is a poor compromise between the English and American systems.

The chapters on yard work and marshalling trains are interesting, and it appears that the laying-out of freight yards in England is no more satisfactory to the operating staff than in this country. Mr. Ivatts refers to the patchwork method in which yards have been altered and enlarged, and blames the engineers for laying them out without understanding the traffic requirements. Considering the expense and delay involved in operating a badly designed yard, there should certainly be co-operation between the engineering and operating departments in regard to such work. The author points out the advantages of making up trains with cars in "station order," and refers to the dangers of running trains in sections. His detailed descriptions of the proper methods of covering up freight with tarpaulins (box cars being but little used), and of applying the axle grease (which is a stiff paste) to the boxes, appear somewhat strange to American ideas.

The chapters on office and clerical work include not only the forms of statement used, and the classification and keeping of accounts, but also the methods of correspondence and filing letters, with lessons in handwriting and shorthand, but there is no reference to typewriters, although we believe English railways do use these labor-saving instruments. There are special chapters on health resorts and sanitariums for railway clerks, legal questions relating to passenger traffic, and abstracts of the Acts of Parliament relating to the regulation of railways; and finally there are a glossary of railway terms and a system of technical examinations.

The book is well written and well printed, except that the paper is so thin as rather to spoil the clearness of the type. The binding, however, is not as strong as it should be for a book of this character. Separate indices are provided for the parts relating to freight traffic and to passenger traffic.