ENGINEERING NEWS AND AMERICAN RAILWAY JOURNAL.

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THE BROOKLYN, N. Y., WATER SUPPLY SYSTEM is in need of extensive additions and improvements, according to a report recently made by Mr. James Moffatt, Deputy Commissioner of Water Supply of the Borough of Brooklyn. The list of improvements which are needed, and their cost, according to Mr. Moffatt, are as follows:

Additional conduit........		$1,200,000
Millburn engines and coal sheds........		150,000
Additional water supply, part of estimate........		300,000
Improvements at Gravesend and New Utrecht....		75,000
Storage reserve, postponing Millburn........		600,000
Protection from pollution, postponing filter beds..		100,000
Extension of distribution........		150,000
Improvements:		
Sinking test wells........	$10,000	
Electric light plant at Millburn and Mount Prospect	8,000	
Monuments	1,000	
		19,000
Cleaning of Ridgewood reservoir........		50,000
Total		$2,644,000
Cost of engineering and contingencies........		256,000
Grand total		$2,900,000

Mr. Moffatt states that as a result of insufficient conduit capacity millions of gallons of water east of Millburn have been wasted, and the pumps have often been kept idle, while at other times they are under a great strain. The present storage reservoirs keep on hand only three days' supply, so he proposes to build at Forest Park an additional reservior with a capacity of 250,000,000 gallons. Such a reservior could be built in two years, he states, at a cost of $600,000. In order to protect the water of the borough from pollution, Mr. Moffatt proposes to spend $75,000 for filter beds at Baisley's, in case it is decided that that water can be used. The report points out that the net income from the water department of the borough for 1898 will be $445,820, which will justify an additional issue of $3,940,000 in bonds to pay for the proposed improvements.

WORK ON THE NEW CLEVELAND, O., WATER-works tunnel has been abandoned in the heading from the shore shaft lakeward, where the recent accidents from gas explosions have taken place. Hereafter all work on this section of the tunnel will be conducted from the first lake shaft shoreward. By working the single heading this section of the tunnel will, it is stated, be completed as soon as the portion farther out in the lake, and all danger from further explosions will at the same time be avoided. A full description of this tunnel was published in our issue of Aug. 11, 1898.

THE BIRMINGHAM WATER SUPPLY, of England, is to be increased upon plans drawn up by Mr. James Mansergh and Mr. Gray, the corporation engineer. To this end the city has already acquired 45,562 acres of water shed on the rivers Elan and Claerwen, in Wales, about 73 miles from the service reservoirs of Birmingham. Storage dams will be built in the two valleys, storing about 18,000 millions of gallons of water and supplying 27,000,000 gallons per day to Birmingham. The present supply is about 18,000,000 gallons per day, with an average demand of 17,-000,000 gallons, and an emergency daily demand of 22,000,-000 gallons. The plans contemplate a tunnel 6,600 ft. long, leading from one water shed to the other. Of the 74 miles of aqueduct, about one-half will be in cut-and-cover work and in tunnel; the longest tunnels will be 4¼, 2⅛ and 1¼ miles long. The other half of the aqueduct length will be in siphon; that across the Severn Valley being 17 miles long, with a dip of 547 ft. below the hydraulic grade line. The estimated total cost of the project is $29,255,000. It is the present intention to do all this work by the corporation; by day's labor.

THE MOST SERIOUS RAILWAY ACCIDENT of the week occurred Sept. 15, on the Denver & Rio Grande R. R., in Black Canyon, Colo., a few miles west of Sapinero, in which three railway employees lost their lives. According to reports an empty passenger train west bound ran into a pile of rock which had fallen from the sides of the canyon and was thrown into the Gunnison River.

SPONTANEOUS COMBUSTION OF DUST in a grain elevator at Toledo, Ohio, on Sept. 20, caused an explosion and fire which cremated 8 men and fatally burned 8 more.

THE "AURANIA" OF THE CUNARD LINE, which sailed from New York on Sept. 6 for Liverpool, broke her crank shaft on the morning of Sept. 13 while about 110 miles from Fastnet. She was sighted by the British steamer "Marino," from Montreal for London, and towed into Queenstown on Sept. 16.

FIRE DESTROYED THE TOWN OF JEROME, ARIZ., on Sept. 11, depriving 1,500 persons of homes and killing between 10 and 20. The loss is estimated at about $1,-000,000. New Westminster, B. C., suffered a like fate on Sept. 11, the entire town being burned to the ground. Several lives were lost and $2,500,000 worth of property was destroyed.

A FIERCE HURRICANE swept over Barbadoes in the windward group of the Lesser Antiles on Sept. 11, and according to reports several hundred persons were killed and as many as 40,000 rendered homeless. The storm was accompanied by a tidal wave and heavy rains which added to the destruction. Kingston, the capital of St. Vinicent, is reported totally destroyed, and it is estimated that in this city alone 300 were killed and 20,000 made homeless.

THE PROGRESS IN APPLYING AUTOMATIC COUPlers and train brakes is briefly stated in the first semi-annual report of the delinquent railways to the Interstate Commerce Commission. The report shows that of 294 petitioning carriers, 290 owned, on June 1, 1898, 1,153,290 freight cars, an increase of 20,567 over the number reported owned on Dec. 1, 1897. There are 119,614 freight cars reported equipped with automatic couplers and 67,202 reported equipped with train brakes in the six months ending June 1, 1898, which makes a total of 792,443, or 69% of the freight cars equipped with automatic couplers, and 510,-636, or 44% equipped with train brakes up to June 1, 1898. Of 32,323 locomotives owned on June 1, 1898, there are 29,102, or 90%, which are equipped with driving-wheel brakes. There are 360,487 freight cars out of 1,153,290, or 31%, that are still unequipped with automatic couplers, and 642,654, or 56%, that are unequipped with train brakes, and 3,221, or 10% of the locomotives unequipped with driving-wheel brakes up to June 1, 1898. In explanation of this report, it may be stated that when the Interstate Commerce Commission granted the extension of the date when the Federal safety appliances law should go into effect until Jan. 1, 1900, one of the conditions was that every delinquent road should make a semi-annual statement of progress to the Commission.

THE CONTRACT FOR THE CANTON-HANKOW Railway was signed in Washington by the Chinese Minister and representatives of the China Development Co., on Sept. 15. Ex-Senator Calvin S. Brice is the head of the American company, and this concession grants it the right to build and control a railway about 800 miles long, traversing the richest and most populous section of China. This road would connect with the Belgian road from Pekin to Hankow, now said to be under construction, and the coming connection of Pekin with the Siberian railway would make an all-rail communication between Canton and St. Petersburg.

THE SHANSI, CHINA, IRON AND COAL CONCESsion to the Pekin syndicate of London was granted on May 21. The concession gives this syndicate the right to open and work the enormous coal and iron deposits in the Province of Shansi, described in Engineering News of March 31, 1898, and also the right to build and operate all railways necessary to connect these deposits with main trunk lines and navigable rivers. The bituminous coal measures cover 12,000 sq. miles; anthracite coal covers 13,500 sq. miles, in beds varying from 25 to 50 ft. in thickness; and excellent iron and petroleum abound in the same sections. This is the country examined and reported upon by Mr. C. D. Jameson, M. Am. Soc. C. E., and Mr. W. H. Shockley, M. E., also an American.

THE PERUVIAN ANTHRACITE COAL DEPOSITS are reported upon by the Bureau of the American Republics. The deposits are on the summit of the Andes, in the Province of Hualgoyoc, and a twenty-year concession was granted to Mr. C. B. Jones, in 1892, covering a section of land 100 miles long and from 25 to 125 miles from the coast. Engineers from the United States are now surveying a route for a railway from Pacasmayo, on the coast, to the coal lands, and a line is already in operation from Pacasmayo to Yonan, a distance of 41 miles. The total distance from the coast to the mines by the proposed route is 121 miles. Mr. G. Clinton Gardner, late of the Pennsylvania R. R. and the Mexican National Ry., says that the supply of coal is almost inexhaustible, and 10,-000,000 tons are within easy reach. He estimates that 2,000,000 tons can be mined annually and delivered at the sea cost for $2 per ton. The coal fields of the Andes include both anthracite and lignite, the anthracite lying on both the east and west slope of the mountain; that on the east lies 1,500 to 2,000 ft. below the summit, and is fully equal in quality to Pennsylvania anthracite. The railway will have to cross the Andes at an elevation of 14,000 ft. above sea level, though this summit is only 75 miles from the coast in a straight line. The Pacific Co., which has the exclusive right to mine the coal, is said to be backed by $20,000,000 capital; this company also has the exclusive right to build railways to the mines.

THE PRODUCTION OF PETROLEUM in this country in 1897, according to the annual report of the U. S. Geological Survey, is almost exactly the same as in 1896, the figures being for 1897, 60,568,081 barrels, and for 1896, 60,960,361 barrels, which figure was the highest ever reached in the history of the industry. The total production since 1859, when the first oil well was drilled, at Titusville, Pa., amounts to 831,150,595 harrels.

NEW RUSSIAN IRON AND STEEL COMPANIES are being constantly organized, according to foreign news items. The latest formed are as follows: The Riga Cast Steel Co., capital $375,000; the Gerlach & Pulst Machine Co., Warsaw, capital $500,000; the Falga Hardware Manufacturing Co., capital $200,000, and the Metalfahrik Co., of Kouni, formerly Schmidt Bros., capital $750,000. Most of these new works will need improved tools and machinery, and it is expected that much of this will come from America. There is also a large demand in Russia for railway supplies, including rail-benders, jacks, wrenches, track-drills, road-levels, etc.; but American manufacturers sending circulars to the several U. S. consuls for distribution should see to it that they are printed in Russian; any other course is a waste of time and effort. The trade in textile machinery is also a rapidly growing one in Russia. This machinery is now supplied by English and German firms; but energetic effort might secure a share of this trade for the United States. There are about 230 mills in Lodz, Poland, for the manufacture of cotton goods.

THE INTERNATIONAL SOCIETY FOR THE TESTING of Materials has practically doubled in membership since the Stockholm Congress of 1897. According to the official list of members lately sent out, the membership in the several countries is as follows: Argentine Republic, 1; Australasia, 1; Belgium, 18; Chili, 1; Denmark, 39; Germany, 387; England, 83; France, 66; Holland, 48; Italy, 35; Japan, 1; Luxembourg, 5; Norway, 42; Austria-Hungary, 111; Hungary, 47; Portugal, 8; Roumania, 20; Russia, 315; Sweden, 68; Switzerland, 83; Servia, 5; Spain, 36; United States of America, 68. The total membership is 1,528. This society has for its purpose the unification of methods of testing materials used in construction, with the view of ascertaining their true technical properties and of improving methods of testing. The present President of the Society is L. V. Tetmajer, of Zurich, and American engineers desiring further information concerning its objects should address Mr. Gus. C. Henning, Consulting Engineer, 220 Broadway, New York city. The annual dues are $1, or 5 francs.

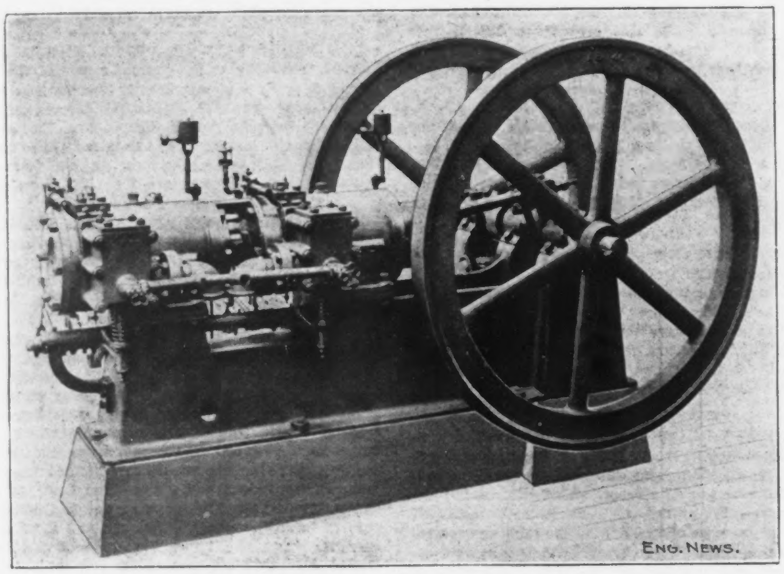
THE LARGEST DYNAMO IN THE WORLD is now being constructed by the Walker Co., of Cleveland, O., for the Boston Elevated Ry., Boston, Mass. This generator will have an output of 3,000 K-W. at 550 volts, or about 4,000 HP. Its speed will be between 75 and 80 revolutions per minute, its total weight 250,000 lbs., and the diameter of the circular cast-steel field frame 21 ft. 7 ins. The weight of this ring without field magnets will be 25 tons. There will be 24 inwardly projecting laminated cores and pole having a combined weight of 15 tons. The armature hub is 13 ft. in diameter and is in two parts, each of which weighs 10 tons. The shaft is 37 ins. in diameter. The armature laminations add 15 tons, and the armature will have in all 594 slots. The commutator will be 105 ins. in diameter, and will have 1,188 bars. To facilitate regulation and remove a portion of the strain from the shaft, the flywheel will be bolted directly to extensions on the armature hub. If this machine were to run at the speed of the Niagara generators, 300 revs. per min., it would have an output of 16,000 HP.

A CONSOLIDATION OF THE WESTINGHOUSE ELECTRIC Mfg. Co., Pittsburg, Pa., and the Walker Co., Cleveland, O., has been officially announced. The capital stock of the Westinghouse Co. is given as $15,000,000, and that of the Walker Co. $2,500,000 with a like amount of bonds. This divides the street railway field between two companies, the General Electric Co. and the new combination.

A NEW DOUBLE-CYLINDER GAS ENGINE.

One of the difficulties in the operation of gas engines is that of ensuring steadiness of running, the violent impulse given periodically to the piston by the ignition of an explosive compound within the cylinder tending to cause greater irregularity than in a steam engine where the impulse is given by a steady stream of steam, even under high pressures.

Steady running is a very important requirement, especially for electric light plants, and the double cylinder gas engine which we illustrate herewith has been designed specially to meet this requirement. This result is obtained by using two cylinders acting alternately on the four-cycle principle, thus securing a two-cycle effect, or an impulse at every revolution, instead of at every second revolution, while retaining the advantages due to the four-cycle system. The cylinders are placed tandem and have a single piston rod, and single connecting rod and crank. A sleeve supports the piston rod between the cylinders. The crank shaft is supported by three bearings, and has two outside-hung flywheels. The valves are of the vertical lift poppet type, operated from a rod driven from the crank shaft by means of a spiral gear. The fuel consumption is about the same as in a single-cylinder four-cycle engine, but there are twice as many impulses, each of which has only half the force of these in the single cylinder engine.



DOUBLE-CYLINDER GAS ENGINE.
Frontier Iron Works, Builders.

Gasoline or any kind of gas may be used, and for the former the charge is delivered by a feed pump. The charge is exploded by an electric-spark igniter, and the point of ignition can be changed while the engine is running. On the larger engines a compressed air starting device is used, in which the air drives the engine during its first revolutions.

These engines are built by the Frontier Iron Works, of Detroit, Mich., to whom we are indebted for information. They are made in several sizes, ranging from 10 HP. to 100 HP. on the brake, with speeds of 240 to 160 revolutions per minute, respectively. Most of the engines thus far built have been of 30 to 60 HP. Some of them are in use in driving electric light plants and others for driving pumps for water supply. All the engines are tested for steadiness at the works by driving a dynamo furnishing current to 300 to 600 incandescent lamps. The average variation is said to be only 2% to 3% under varying load, the effect on the lamps being practically as good as when the dynamo is driven by a steam engine. This is accomplished without the use of a heavy flywheel on the countershaft or any other regulating device outside of the engine.

DIAGRAMS OF JOHNSON'S STRAIGHT LINE FORMULA FOR DETERMINING THE STRENGTH OF COLUMNS.

By John S. Fielding.

(With full-page plate.)

The accompanying diagrams, representing the well-known straight line formula for determining the strength of columns, which were worked out by Mr. Thomas H. Johnson, M. Am. Soc. C. E., and published in the "Transactions" of that society for July, 1886, may be of interest and value to engineers. For some years the writer had had a number of tables of values of the straight line formula in use in his office. These tables had been prepared by an assistant, and some of them had never been checked, and, wishing to check them, an endeavor was made to discover some easy method for so doing. In the search for this method the writer found that since the length of the column is assumed in inches, the variation in such length for each foot is 12, and the value of the allowed unit stress varies by $b\frac{12}{r}$. The formula $9{,}000 - 40\frac{l}{r}$, b = 40 and r = 1.0, the variation is 480 lbs., and with r = 1.1, the variation is 436 lbs., and so on. From this it was concluded that the values could very well be plotted and made into a diagram. The five diagrams illustrated represent the formulas $9{,}000 - 30\frac{l}{r}$; $10{,}000 - 30\frac{l}{r}$; $9{,}000 - 40\frac{l}{r}$; $10{,}000 - 40\frac{l}{r}$, and also a diagram comparing the different formulas with values of y from 8,000 to 16,000 and with values for b of 30, 40, 50, 60 and 70.

Mr. Fielding's article and the diagrams accompanying it were sent to Mr. Thomas H. Johnson, the author of the straight line formula, with the request that he should give his opinion as to their value and usefulness. Mr. Johnson's letter in reply to this request is as follows:

Sir: I do not know that any diagrams representing the straight-line formula have ever been published, other than as illustrations to articles upon the subject in the "Transactions" Am. Soc. C. E., and in Engineering News. Certainly I have seen none developed on the plan of those submitted by Mr. Fielding. Mr. Fielding's scheme is all right, and I have no criticism to offer to it as a method of graphically representing the formula. I would venture to say, however, that the numerical values assigned to f and h, in the formula used Mr. Fielding, do not represent the true equation for strength of columns, as they have been arhitrarily chosen without regard to the mathematical relation to the elementary moduli of the material, and its resistance as a column. In the original paper on this subject ("Transactions" Am. Soc. C. E., Vol. XV., p. 517), it was shown that the straight line representing the strength of columns is a tangent to the curve of Euler's equation, which depends on the modulus of elasticity of the material. If the constants used are such that the line will not be tangent to Euler's curve for the given material, the line does not and cannot represent the law governing the problem. The law is represented hy a straight line; but not hy any straight line.

In Engineering News of Dec. 22, 1888, and again in the discussion of Mr. Waddell's paper on "Bridge Designing" ("Transactions," Am.Soc. C.E.,Vol. XXVI.,p. 115), I sought to check the tendency to the use of arhitrarily-chosen constants in the straight-line formula, hy pointing out their dependence on the physical properties of the material. In the last-named paper I carried the suhject further than I had done previously, and showed the relation that must be maintained by the values of f and h (Mr. Fielding's notation) in order that the equation may truly express the proper working stresses in the column.

Mr. Fielding presents five diagrams as follows, for the formulas:

$$P = 9{,}000 - 30\frac{l}{r};\quad P = 9{,}000 - 40\frac{l}{r};$$

$$P = 10{,}000 - 30\frac{l}{r};\quad P = 10{,}000 - 40\frac{l}{r},$$

and one for values of f = 8,000 to 16,000 inclusive, each in comhination with values of b, of 30, 40, 50, 60, and 70. There is nothing to show what materials these respective formulas are intended to represent, nor whether for round, hinged or flat ends. I suppose, however, Mr. Fielding's ohject is simply to ohtain the arithmetical solution of the equations as he finds them stated in various specifications. It is the persistent use of wrong constants in such specifications that I would like to correct if possible.

For any assumed value of f there can he only one value of h that will make the corresponding line a tangent to the curve of Euler's equation for the given material reduced to corresponding factor of safety, and for the same value of f the value of h will he different for each kind of material. The following tahle gives the correct values of h for wrought iron, mild steel (carhon 0.12), and medium steel (carhon 0.20) for the several values of f embraced in Mr. Fielding's diagrams, and for columns with hinged ends. The tahle assumes E = 27,000,000 for all three grades of material.

	Wrought iron,	Steel.	
		Mild.	Medium.
f	h	h	b
8,000	30	33½	36½
9,000	34	37½	41
10,000	37½	42	45½
11,000	41½	46	50
12,000	45	50	54½
13,000	48	54½	59
14,000	52½	58½	64
15,000	56½	63	68½
16,000	60	67	73

In Mr. Fielding's general diagram he gives too few values of h to make it availahle for all proper formulas. The only criticism which I have to offer is that these diagrams would tend to confirm instead of correcting the erroneous practice of writing the straight-line formula with arbitrary constants. You will note that my criticisms are directed chiefly to the latter. Yours truly,

Thos. H. Johnson, M. Am. Soc. C. E.,
Chief Engineer, P., C., C. & St. L. Ry.

Pittshurg, Pa., July 16, 1898.

EXPERIENCE WITH ACETYLENE GAS FOR CAR LIGHTING.

In our issue of March 31 last, we published some account of the experience with acetylene gas for car lighting on the Pontiac Pacific Junction Ry. Recently Mr. P. W. Resseman, general superintendent of this road, received a request for information concerning his use of this system of lighting from the Inspecting Engineer of the Government Railways of Egypt, Col. J. H. Western. From Mr. Resseman's reply we are permitted to publish the following extracts:

We have been using the Holland system on the Pontiac Pacific Junction and the Ottawa & Gatineau Ry. for nine months. There is really no comparison between the effectiveness of acetylene gas and coal oil for car lighting. With coal oil at 14 cts. per gallon, and carbide at 5 cts. per lb., the cost of acetylene gas for car lighting is somewhat less than the same lighting by coal oil. I consider that it is the coming light for railways.

We have in Canada a problem to face, however, that would not have to be met in any warm country. Owing to the severe frost in winter we have to place the gas generators inside the car to prevent them from freezing. The disadvantage of this lies in the fact that acetylene gas is most difficult to control, and the slightest leak in the generator causes a disagreeable smell in the car. This we hope to overcome and have been experimenting with better connections from generator to pipe.

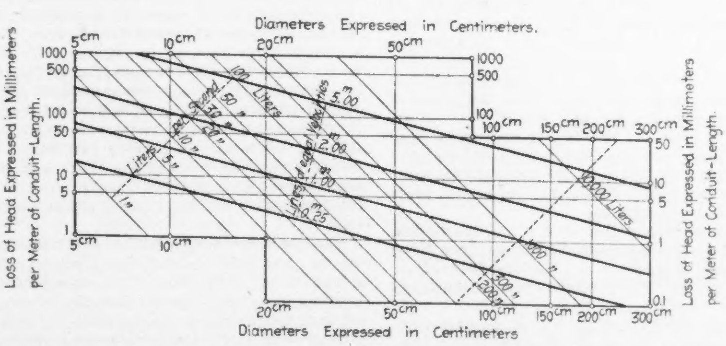
I find that an ordinary passenger coach, such as we run here, previously lighted by 14 coal oil burners, can be brilliantly lighted with five 25-c. p. burners, consuming each ½-ft. per hour. The carbide supplies 5 cu. ft. of gas per lb., making the total cost of the lights 2 cts. per hour, or for a run of 4 hours, 20 to 21 cts. per car. Of course, there is incidental waste that we cannot get fully controlled. The gas is lost by the vibration of the car, but on the whole, the light is efficient and inexpensive. It is absolutely safe as far as fire or explosions are concerned. The gas is generated in small quantities, confined beneath a 7-in. column of water, and any that may escape is so speedily diffused in the surrounding atmosphere that its explosive nature is at once neutralized. In the event of a car turning over, the lights go out immediately, and the gas escapes so quickly that fire cannot affect it. So far we have had no accident from acetylene gas, and I cannot conceive how an accident can occur. In Egypt or South Africa, where the generators could be placed on the roof or underneath the car, no difficulty would be apprehended from the acetylene gas smell. We have three small generators in each car, placed directly over the top of the toilet-room inside the car. We have experienced very little trouble other than the escape of gas by improper connection. Low-pressure gas is not affected by heat or cold. The generators cost here $12. The carbide is sold here at $4.50 per 100 lbs. Side lights give us the best results. We are using the ordinary gas fixtures, and porcelain globes with 5-in. rings.

LOGARITHMIC DIAGRAM FOR CALCULATING THE FLOW OF WATER IN CONDUITS UNDER PRESSURE.

In "Le Genie Civil," for June 18, M. Jean Rey describes a logarithmic diagram for the calculating the flow of water in pipes under pressure, devised by Civil Engineer A. Van Muyden. He calls it a universal diagram, and proposes it as a useful and simple tool exact enough in its results to satisfy all ordinary requirements in hydraulic estimates.

The original diagram of Van Muyden was based upon the experiments of Mr. Darcy, made in 1857, with an empirical formula applicable to pipes up to one meter diameter, and was thus published in 1884. In a new edition of his work, just issued, Mr. Van Muyden employs the formula of Maurice Levy, and extends its applicability to conduits up to 3 meters diameter. The results are practically in accord with the Darcy formula from 0 to 3 meters; beyond that they diverge and more nearly approach the theoretical law.

In the simplified diagram here presented the abscissas represent the diameters of the conduit, and the ordinates the losses of head expressed in millimeters per meter of conduit length. The transverse straight lines represent the delivery in liters per second, from 1 to 40,000 liters. The other transverse lines join the points of equal velocities.

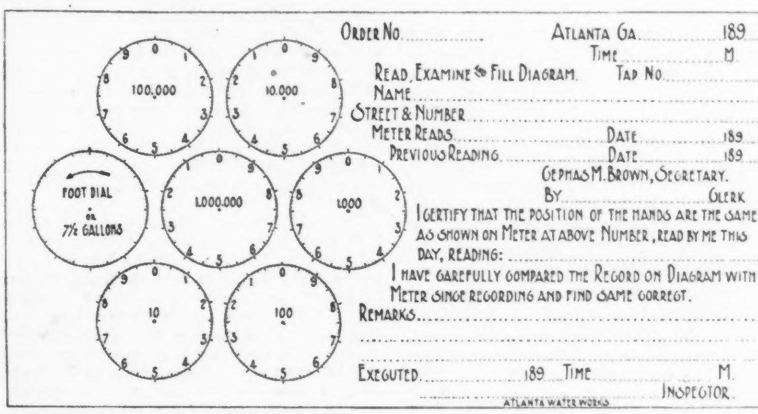


LOGARITHMIC DIAGRAM FOR CALCULATING THE FLOW IN CONDUITS UNDER PRESSURE.
Devised by A. Van Muyden.

A simple reading enables us to solve a variety of hydraulic problems. For example, the velocity of flow and the volume being given, the diameter of the pipe and loss of head can here be read; and this is true of the inverse statement. It is useful in calculating branches from a conduit, in establishing a flow for feeding a hydraulic motor and in arranging for the delivery from pumps, etc. The exactness of the diagram has been verified by numerous hydraulic installations in Switzerland, France and other countries. M. Rey deems the diagram so self-explanatory that he does not enter into further details.

A NEW FORM OF METER RECORD AT ATLANTA, GA.

The accompanying illustration shows a new system of recording meter readings which was recently put in operation at Atlanta, Ga. The reader uses a diagram on which the position of the hands is recorded, there also being a printed form to fill in, as shown by the illustration. We are indebted to Mr. Park Woodward, Superintendent of Water-Works, for the copy of the record blank reproduced herewith.



METER RECORDING BLANK USED AT ATLANTA, GA.

THE RAILWAYS OF THE UNITED STATES IN 1897.

From the advance sheets of Poor's Manual for 1898 the following statistics are taken relating to railway construction and operation in the United States for the year ending Dec. 31, 1897. As will be noticed, these figures cover railway operations for a period six months later than the statistics of the Interstate Commerce Commission, published in our issue of Sept. 1, 1898. The accompanying statement explains itself:

	Miles.
Mileage or railway	179,692.57
Second track, sidings, etc.	57,218.95
Total track	236,911.52
Steel rails in track	211,928.31
Iron rails in track	24,983.21

Number of locomotive engines		35,810
Cars	Passenger	25,275
	Baggage, mail, etc.	8,133
	Freight	1,229,335
Total revenue cars		1,262,743

Liabilities.

Capital stock	$5,453,782,046
Bonded debt	5,411,058,525
Unfunded debt	374,389,673
Current accounts	392,481,496
Total liabilities	$11,631,711,740
Excess of assets over liabilities	299,901,913
Total	$11,931,613,653

Assets.

Cost of railroad and equipment	$10,029,151,607
Real estate, stocks, bonds and other investmts	1,509,841,062
Other assets	222,089,700
Current accounts	170,531,284
Total assets	$11,931,613,653

Miles of railroad operated	181,132.70
Rev. train mileage:	
Passenger	342,464,408
Freight	500,326,372
Mixed	15,235,049
Total	858,026,179
Passengers carried	504,106,525
Passenger mileage	12,494,958,000
Tons of freight moved	778,385,448
Freight mileage	97,842,569,150

Traffic earnings: Passengers	$253,557,936
Freight	780,351,939
Miscellaneous	89,636,791
Total	$1,123,546,666
Net earnings	338,170,195
Receipts from other sources	95,013,907
Total available revenue	$433,184,102
Payments: Rentals, tolls, etc.	$58,600,768
Interest on bonds	231,046,819
Other interest	5,633,298
Dividends on stock	82,630,989
Miscellaneous	28,124,474
Total payments	$406,036,348
Balance, surplus	27,147,754

Summarizing some of the most important of the items in the above table and comparing them with the corresponding figures for 1896, we have the following results:

		Years 1897.	Years 1896.	Rate of increase or decrease
Miles road operated.		181,132.70	180,891.19	+ 0.13
Tons, freight moved		788,385,448	773,868,716	+ 1.88
Freight mileage		97,842,569,150	93,885,853,634	— 4.21
Passengers carried		504,106,525	535,120,756	— 5.80
Passenger mileage		12,494,958,000	13,054,840,243	— 4.29
Earnings	Freight	$780,351,939	$770,424,013	+ 1.29
	Passenger.	253,557,936	265,313,258	— 4.43
	Other	89,636,791	89,894,754	— 0.29
	T'l, gross	$1,123,546,666	$1,125,632,025	— 0.19
	Net	338,170,195	332,333,756	+ 1.76
	Ton-mile, ct	0.798	0.821	+ 2.08

The share capital corresponding to the mileage completed at the end of 1897 equalled $5,621,340,647, against $5,373,187,819 in 1896, the increase equalling $248,152,828, the rate of increase being 4.6%. The funded debts of all the lines at the close of the year aggregated $5,516,056,292, against $5,461,856,598 in 1896, the increase equalling $54,199,694, being an increase of 0.99%. The other forms of indebtedness of the several companies at the close of the year equalled $380,769,705 against $344,499,969 for 1896, an increase of $36,269,736. The total share capital and indebtedness, exclusive of current accounts of all the roads making returns, equalled at the close of the year $11,518,166,646, an increase in the year of $338,622,260 over the total of 1896 ($11,179,544,386), the rate of increase for the year being 3.3%. The cost per mile of all roads making returns, as measured by the amount of their stock and bonded indebtedness, equalled $60,679 against $59,732 for 1896.

The total mileage of new railway constructed during the year was 2,188.43 miles; divided among the different groups of states as follows:

States.	Constructed in 1897.	Total mileage on Dec. 31, 1897.
New England	46.79	7,265.52
Middle	236.90	22,123.64
Central Northern	381.81	40,112.14
South Atlantic	310.46	20,496.75
Gulf and Mississippi Valley	407.93	14,918.93
Southwestern	415.62	35,533.88
Northwestern	107.39	29,719.59
Pacific	281.48	14,432.74
United States	2,188.43	184,603.19

A DIAGRAM FOR FINDING THE TRANSVERSE STRENGTH OF STEEL RAILS.

(With full-page plate.)

We are indebted to the courtesy of Mr. W. M. Wickham, of Wilkinsburg, Pa., for the privilege of reproducing the accompanying diagram for the ready computation of the transverse strength of steel rails, of the American Society of Civil Engineers' standard section, and of weights up to 100 lbs. per yd.

It will be seen that the diagram includes both beams fixed at one end and beams supported at both ends, and that bending moments up to 17,000 ft. lbs., and fiber stresses up to 15,000 lbs. per sq. in. are included, while lengths up to 30 ft. are given. Steel rails are now used so extensively in structural work, for foundations, etc., and in bridge and culvert construction on railways, that we believe this diagram will be found a great convenience by very many of our readers. While the diagram is plotted for the Am. Soc. C. E. section of rail, it can be used for almost any section with little error by measuring the height of the section and taking the corresponding height on the diagrams. The following explanation by Mr. Wickham gives a clear understanding of the manner of using the diagrams:

Diagram for Strength of Standard Rails Used as Beams.—Case "A." Given the length of beam, load, method of loading, and fiber stress to find rail section:

(1) Compute bending moment due to load in pounds feet, and from corresponding figure on lower side of diagram, trace vertically to corresponding Case line (a, if beam is fixed at one end, or b, if supported at both ends), thence to right to intersection with line marked the given length; thence vertically (up or down as the case may be) to the given fiber stress, thence to the right, passing through the required rail section.

Corrections to bending moments due to weight of rails are based on the supposition that the rail resists bending with a fiber stress of 10,000 lbs. per sq. in., so that great accuracy can only be expected when using that stress. Where great accuracy is required for other stresses than 10,000 lbs., first find a trial section, by proceeding as above, then with a bending moment equal to the sum of those due to the load and to the weight of that rail, as found above, trace through the diagram, neglecting, of course, the correction due to weight of rail. If the resulting section is the same as the one used in finding the bending moment due to weight of rail, it is the required section. If it is not, repeat the operation, using a new section until that rail is found, the bending moment due to the weight of which, added to that due to load, is the same as the one found by tracing through the diagram. Bearing in mind that for stresses less than 10,000 lbs. the diagram gives a section too small and for stresses above 10,000 lbs. gives sections too large, only one or two trials need be made to find the correct section.

Case "B." Given the rail section, load and method of loading, to find fiber stress: Compute the bending moment due to load and add to that, that due to weight of rail; from corresponding figure on diagram trace vertically to intersection of horizontal line between given rail section and the one next heavier, and note the position of the intersection with respect to fiber stress lines.

ANNUAL CONVENTION OF THE STREET RAILWAY ASSOCIATION OF THE STATE OF NEW YORK.

The sixteenth annual meeting of this Association was held at the Manhattan Beach Hotel, Tuesday and Wednesday of last week. The morning session of the first day began with a fairly good attendance, and after the roll call, the President, Mr. G. T. Rogers, of the Binghamton R. R. Co., read his annual address, in which he said:

Rapid transit in large cities has exerted a marked influence for the health, comfort and welfare of the resident poor and working classes, and has resulted in an equalization of real estate values, thereby avoiding a congestion of the population that has existed in the past, and creating better living conditions for all.

The return upon the capital invested in street railway enterprises is generally overestimated by the public; many lines are constructed or extended and operated at an actual loss for years, but I believe that the public begins to see and appreciate the great advantage on their side, and that a more liberal policy will prevail.

The resolution, recently offered in the City Council of New York, "No seat; no fare," is simply another manifestation of the old delusion that all that is necessary to get rid of an evil or an annoyance is to pass a law against it. The question is not one of making the companies do something they are not willing to do, but one of making them perform an impossibility.

Considering the question of municipal ownership, President Rogers insisted that neither state nor municipal governments should enter into industries that can be as well or better conducted by private capital.

The report of the Executive Committee stated that nearly all street railways in the state were members of the Association. The appointment of Hon. Edwd. O'Connor, as counsel, and his untimely death were mentioned. Attention was called to the fact that out of the 190 measures and amendments affecting street railways, which had been introduced in the state legislature during the year, only a very small proportion had become laws.

The first paper of the morning session, by Mr. H. M. Kennedy, General Passenger Agent Brooklyn Heights R. R. Co., Brooklyn, N. Y., was on

"Methods of Developing New Traffic on Street Railroads."

This was a consideration of the advisability of establishing the office of general passenger agent on street railways. Some of the duties of the general passenger agent were to establish happy relations with the press, to advertise the existing attractions of the road, and to establish or encourage the establishment of pleasure resorts, etc. As an instance of the successful outcome of advertising, an ice-skating rink, where the owners were losing money, was mentioned. The company was induced to invest in some posters, which were displayed on the street cars, with the result that the rink became a paying investment, and street railway traffic on the lines leading to it was largely increased.

Mr. H. H. Vreeland, President of Metropolitan R. R., of New York, said that his road was not engaged in stimulating traffic, but was doing its best to take care of the traffic it now had. In New York, on the long lines, the daily travel was almost uniform, and in winter the night traffic was the largest. On other lines throughout the country in which he was interested systematic methods of increasing traffic such as had been outlined had been adopted, and by special arrangement and advertising a considerable traffic had been built up. In only one case, however, had he recommended a railway company to build a pleasure resort. Generally speaking he was of the opinion that a manager operating his line in the proper way, which included his being out of the office a good part of the time, had little time for other things.

Other speakers described what had been done in the smaller cities of the state to stimulate travel, and it was the general sentiment that by catering to the respectable element and offering attractions suitable for women and children, operated either by the railways or under their direction, a substantial increase in traffic would follow, which would amply repay the time and money expended. The matter of bicycle riding was introduced, and, after a brief discussion, it was agreed that the use of the wheel was at least not increasing. It was further stated that by a system of charging for entrance to parks, etc., the railway company need not suffer from the use of bicycles, horses or carriages.

The next paper, by Mr. H. S. Cooper, of Schenectady, N. Y., entitled "Signal Systems for Single Track Roads," was a consideration of the requisites for a satisfactory signal system. In conclusion, ten rules were formulated, which must be fulfilled by a signal system before it could be considered satisfactory. The discussion on this paper was brief, but clearly indicated that there was no street or suburban railway signaling system on the market which could be called rapid, safe and satisfactory. The opinion seemed to be about as stated by Mr. W. Caryl Ely, of Brooklyn, "the only safe way to run a single track road at high speeds is to double track it, and that as soon as possible."

The third paper, "By-Products at Power Stations," by Mr. M. M. Penner, Fredonia, N. Y., was a description of the experience his company had had with the sale of exhaust steam. The trials and tribulations encountered with some early apparatus and the successful operation of a later type was amusingly told. In the course of his paper it was stated that the exhaust from a 100-HP. engine would heat 1,000,000 cu. ft. of building.

At the afternoon meeting, called for 3 p. m., the reading and discussion of papers was continued, the first one being by Mr. W. J. Clark, Manager of the Railway Dept. of the General Electric Co., on "Electric Railways as an Auxiliary to Coast Defense."

The next paper presented, and the one of greatest interest to engineers, was by Mr. A. J. Moxham, Assoc. Am. Soc. C. E., President of the Johnson Company, Lorain, O. We present it practically in full as follows:

"The Composition of Steel Rails to Insure Maximum Resistance to Wear."

Many years ago the London & North Western Ry. Co. reached the conclusion that what was known as a "soft" or low carbon rail gave the longest life. This was reinforced shortly afterwards by Dr. Chas. B. Dudley, of the Pennsylvania R. R., who gave the result of tests that on the face of them were to be relied upon. His paper was an able contribution to the knowledge of the day. His general conclusions led to the "soft" rail, and he went further and endeavored to determine by comparison a factor for each special chemical ingredient. His conclusions created something akin to a sensation, and they were bitterly opposed by the steel experts of the time. Perhaps the fact that the steel manufacturer of that day was not sufficiently master of the situation to economically produce the ideal rail, according to Dr. Dudley's standard, may account for a good deal of the opposition.

During the same period, however, notwithstanding these deductions, the tendency in actual specification was always toward higher carbon. The writer during this interval was a supporter of the "soft" or ductile steel for rails; and even to this day, and in view of what is to follow, it is to the writer's mind a questionable thing whether a steel of great ductility and only of moderate hardness is not the steel for steam railroad purposes. It must be remembered, however, that the problem of wear upon a steam railroad is a very different thing from that of wear upon a street railroad. The rail in steam railroad use presents a clean head, because the rail is not buried. It has to oppose principally a rolling friction, for the number of times per mile that steam railroad trains are stopped is very few, taking a general average. The street rail, on the other hand, has not only to meet this rolling friction, but has to contend with the grit from the surrounding road-bed, and with stops every few feet. Not only are the stops incomparably more frequent, but they are again multiplied into a greater number of units, as many individual cars are the rule on street railroads as against the occasional train of the steam road.

Being unable to reach positive conclusions from the published authorities and from personal contact with the steel experts of the country, or even from our own experience, it was determined to conduct experiments to this end. It was accepted to begin with, that it would be folly to try to finesse in the matter; that the best that could be done would be to try to find general, safe indications. When it is remembered that each chemical ingredient puts its own particular stamp upon the steel, and a different stamp in each particular combination with the other ingredients, and that the number of such combinations may be infinite; when it is remembered that each different heat at which the steel is rolled affects the problem; that the amount of draft put upon each successive pass should not be ignored, the necessity of this conclusion becomes evident.

The experiments have lasted for three years. The first endeavor was to take broadly a "soft" steel and a "hard" steel for the rails to be tested, securing the difference by carbon alone, leaving all other ingredients as nearly as possible the same. The experiment with these was started in Octoer, 1895, and has been continued ever since. In June, 1896, rails were added to the experiment, supplied by the West End Street Railway Co. of Boston, who at that time had determined (with wisdom as will be seen subsequently) upon a steel both hard and ductile. The conclusions, therefore, are based upon what may be described as soft steel, hard steel and steel both hard and ductile.

The rails (some 33 in all) were laid in the South 8th St. tracks of the Nassau Electric of Brooklyn. They were laid continuously, so that the same car is obliged to pass over every rail, and therefore each rail is subject to the same wear, and the wear on the head only is considered. Street traffic is ignored. This point was selected in order to reach early conclusions, as the cars pass this point at extremely short intervals, thus giving a considerable wear in a short time.

Every rail has been measured at two points, taken about 10 ft. from each end, in order to eliminate the special wear at the joints. Each rail has two cast iron boxes bolted to the outside, at the points to be measured, to permit access for purposes of measurement without disturbing the road-bed. Originally the wear was registered both by actual measurement and by taking an impression of the head of the rail by means of type-metal castings. Two slots were provided in the tram of the rail to guide the type-metal mold. Notwithstanding the great care that was exercised in taking the impressions, this method of measurement was quickly given up as the results were far from being as accurate as those taken by micrometer calipers. With these calipers, measurements of each rail were taken at three points across the head of the rail: point No. 1 being near the gage line; point No. 2 being nearly in the center of the head, and point No. 3 being nearer the outside of the head.

Speaking accurately, point No. 1 is 2 ins.; point No. 2 is 1⅜ ins., and point No. 3 is ⅞-in., all from the outside of a head 2¼ ins. wide. Methods were adopted for accurately locating the same lines, so that the comparisons in the different measurements of wear could be relied upon.

There were 17 rails of low carbon averaging 0.28; fourteen rails containing high carbon (0.59), and two were West End rails. The least wear shown was in the West End rail, the hard rail follows a good second, while the greatest wear is shown in the soft rail.

Table I.—Composition and Specific Gravity of Rails Tested.

	Soft.	Hard.	West End.
Carbon	.280	.59	.570
Silicon	.026	.056	.234
Phosphorus	.106	.097	.050
Sulphur	.066	.059	.078
Manganese	.790	.83	.980
	1.268	1.632	1.912
Iron	98.732	98.368	98.088
	100.	100.	100.
Specific gravity	7.855	7.841	7.825
Based on iron only, ignoring the metalloids	7.956	7.971	7.977

The average monthly wear amounted to .0007 in. for the West End rail, .0012 in. for the hard rail, and .0017 in. for the soft rail. The results of the experiments are conclusive on this point.

It will be noted in Table I. that the West End rails show a specific gravity of 7.825, the hard rails 7.841, and the soft rails of 7.855. But in considering specific gravity it had best be based alone upon the iron in the composition. It is well known that the other chemical ingredients affect the net result almost imperceptibly in the matter of weight, but very greatly affect density of the iron (which is the bulk of the composition) in the matter of its physical property. It will be found that where specific gravity is referred arbitrarily to the iron and the metalloids are ignored, or rather deducted, the specific gravity will tally closely with what is to be expected from the actual use of the metal. For instance in this case, ignoring the metalloids, the specific gravity of the iron in the different rails will stand as follows:

Soft rail	7.956
Hard rail	7.971
West End rail	7.977

It is interesting to note the very close relations of this arbitrary specific gravity to the relative wear as shown in the test. This is not a point to be ignored, because it is an exponent of the mechanical treatment, and it explains consistently in this, as in many other cases, why the material with apparently (but not really) the least specific gravity will show the best results in use. The analysis shows that what is needed, as may be expected, is the densest steel.

In the tension tests the results were as follows:

	Ultimate tensile strength, lbs. per sq. in.	Elastic limit, tension.	Elastic limit of compr'sion.
Soft rail	75,860	45,730	35,000
Hard rail	118,100	62,500	50,300
West End rail	120,380	53,160	47,100

The first column follows closely the determined wear.

Column two, it will be noted, does not follow the rule of wear, and in this is a lesson, the indication being that having secured a given amount of hardness, and consequently of strength, the more ductile the rail, the better the wear. In the compression tests the same lesson is learned. The elastic limit of compression standing as given in column three.

At a glance it would appear that the rail which compressed the least would wear the longest, but where difference in compression is indicative of greater elasticity without a sacrifice of ultimate strength, the more elastic rail is better.

As stated before, the only variation in chemical composition which we need look at in this comparison is the carbon, for while there is a slight variation between the two silicons in the given rails the total percentage of silicon in either is not a factor, and can therefore be ignored. The greater durability of the hard rail as compared with the soft rail speaks for the higher carbon, and it may here be noted, that so far as the higher carbon is concerned, it involves no higher cost to the street railway men.

On comparison the carbon of the West End rail is practically the same as that of the hard rail and the silicon considerably higher; but the real point of difference between the hard rail and the West End rail lies in the lower phosphorus and higher manganese. It is well known that the low phosphorus, accompanied by an increasing manganese, conduces to greater ductility. On this point, however, a word of caution is necessary. Any decrease of phosphorus from what is known as standard in Bessemer steel (0.10) can only be achieved at a greatly increased cost of manufacture, and therefore, so far as the chemical constituents of the rail are concerned, the whole problem to the street railway man is how far it is economical to go in lower phosphorus, the other hardening elements remaining the same. A steel such as is represented by the West End rail, or even a steel still lower in phosphorus it is possible to make, the question being purely one of cost. On to-day's basis an extra cost of $1.50 per ton on the low phosphorus steel is a low estimate; it would be safer to take it at $2.00. Taking the average price of girder rails at, we will say, $25.00, the extra cost of the low phosphorus would be 8%. What would be the increased wear of the rails?

The average monthly wear of the hard rail is	.0012
The average monthly wear of the West End rail is	.0007

On the face of it, it would appear, therefore, that those who could afford it were amply justified in demanding and purchasing the low phosphorus steel, but there is a hope for those who cannot afford it; and there is some doubt, after all, as to the advantages to be gained from the use of low phosphorus steel.

It is well known that a steel rail can be used until at least ½-in. is worn away from the head, or 0.5 in. On this basis, and taking the average wear of the different rails as shown in the test, it would take

35 years to wear away ½-in. with the soft rail;
35 years to wear away ½-in. with the hard rail;
60 years to wear away ½-in. with the West End rail;

and this is the case of a road which represents not average, but excessive wear; the rails in question having borne the wear of heavily loaded cars running on an average of 580 per hour for 20 hours per day, during the time of the experiments, or a two-minute headway. This means during the busy part of the day less than ½-minute headway, and during the night hours a wider interval. Taking the ordinary line, its average headway is greater than this, consequently the theoretical wear would be less. Now, all who are interested in electric roads, and have used girder rails are aware of the fact that nothing like this wear can be obtained in practice. This being the case we must look to something else besides quality of steel. The entire defect is in the rail joints used.

Had these measurements of wear been taken at the joints instead of elsewhere, the lesson would have been different. Rails are taken out of the track to-day, not because the rail as a whole has reached the point of destruction, but because the joints have become too bad for further use. It must be remembered that the experiments in question have not been extended long enough to show the effects upon the rail of the degeneration of the joints. On the wear at the joints reaching a certain point, the wear of the rail increases rapidly. For instance, in the soft rail the average monthly wear being .0017 during the time of this experiment, in 7 or 8 years from this date the wear will have continued to go on at a constantly increasing ratio, starting from the point of defect at the joint.

In the early days of girder rails the joint construction was so light that the joints quickly went to pieces. During later years, using a heavier rail and larger and better fitting splice bars, we have heard less of the joint question, for compared with the earlier roads the present track is smooth. Nevertheless, the evil still exists, and a few years from now those who to-day are deluding themselves in the belief that they have a long life for their existing tracks will awake to find out that even the construction of to-day is wasteful and extravagant. The joint which is accepted now as being passably fair is reducing the life of the rail to one-half, or perhaps even one-third of what it should be.

The conclusions to be drawn seem to me to be as follows:

First. That for street railway use, a hard rail will give the best results.

Second. That the most economical way to secure this hardness is by increase of carbon, accepting the manufacturers standard specifications for the other ingredients.

Third. That the next step should be towards an improvement of the joints.

As is well known to all present, the writer has pinned his faith to the electric welded joint as settling the question once for all, by making the union homogeneous with the rail and possessing an advantage from an electrical standpoint in the matter of conductivity. Nevertheless the cast-welded method also demands careful consideration. It is certainly preferable to anything in the nature of splice bars that we know of, provided one glaring fault can be overcome, viz.; the softening of the steel that occurs from the large body of hot cast metal located at that point, and it would appear that some means could be devised to overcome this evil.

Fourth. After making the joints perfect, what we have termed the "West End rail" would certainly justify its extra cost.

It is unnecessary to give the analysis applicable to each of these classes. I would caution, however, against the use of carbon as high as 0.59, as that was purposely taken high in what we term the "hard" rail in this experiment, the object being to reach an extreme. Carbon should be limited to from 0.50 to 0.55, with the usual leeway to cover manufacturing contingencies. It also remains a question whether the reduction of phosphorus to 0.08 (which may be done within economical limits of cost) will not give results so closely approximating the 0.05 of the West End rail as to make that figure an economical one. In any case the certainty exists that so far as the steel is concerned, a rail of the following analysis should give a theoretical wear, if the joint is perfected, of from forty or fifty years, viz.: Carbon, 0.55; silicon, 0.10 or under; phosphorus, 0.08 or under; sulphur, 0.06 or under; manganese, 0.83 or over, not to exceed 1.00.

The great lesson I would once more emphasize is that until you get the joints perfect you need not worry about the quality of your steel.

Anything in the shape of steel—the very cheapest you can buy will last longer than the joints will permit you to keep your rails in the track.

(Concluded on page 187.)

COST OF ELECTRIC POWER FOR STREET RAILWAYS AT THE SWITCHBOARD.*

By R. W. Conant.†

It is my privilege to be able to communicate to you facts and figures bearing on the operation of 44 power stations located at the important street railway centers throughout the country. These figures cover for the most part the operation of the stations during the past year, and include the experience on the roads in Boston. The aggregate capacity of power stations represented is 98,387 K-W., or 134,800 electrical horse-power. The total actual cost of operations for the production of power alone from these stations during the past year has been $1,825,000, and if the power had been produced by all at as low a cost as it was in a number of the more economical stations the savings for the year would have amounted to $443,300.

There is a great variety of opinion as to what should be included in the cost of power, and also as to whether the basis of comparison should be the car-mile or kilo-watt hour, this latter being due to the fact that up to within a few years there has been no reliable instrument for the measuring of station output. The car-mile basis is not a fixed standard. A car-mile up hill takes a great deal of power, while a car-mile down hill should take none and may be a source of power.

In the analysis of costs of operation of power stations of various sizes and types, it is first necessary to adopt a standard for the unit of power. We have seen that the car-mile is unreliable. Recording watt-meters are at present constructed which will measure the output in kilo-watt hours within a very few per cent. This statement is abundantly verified by actual experience and is gradually becoming universally recognized. It is no doubt difficult for one who has been accustomed to figure cost of power production on a car-mile basis to reconcile himself to the kilowatt hour. It should, however, be very easy for the steam engineer who is accustomed to deal with horse-power, since the kilo-watt hour equals 1.34 electrical HP. hours.

It was evidently the idea of your executive committee in limiting the title of this paper to cost at the switch-board to abolish the car-mile and adopt the K-W. hour as the unit of power. In comparing the costs from the various stations I shall use this unit, and for the benefit of those who are accustomed to considering the costs per car-mile it will be interesting to know that on many roads a car-mile takes just about 1 K-W. hour. This is not true where grades and equipments are extremely heavy, for in such cases two or three times this amount may be required.

In the costs of power, whether it is produced by steam or water, should be included the fixed charges, as well as the cost of operation. Under fixed charges are interest, depreciation, insurance and taxes on the capital invested in the land, buildings and machinery of the power station. Under operating expenses are fuel, labor, supplies, repairs, superintendence and general expenses.

In both the fixed charges and operating expenses the component items vary between widely different limits, and it becomes impossible to construct a law that will predict the cost under all circumstances.

On the other hand, for one who has had experience it is comparatively easy to predict what the power ought to cost under a given set of conditions. What it will cost must, of course, depend on management.

In view of the variety of the circumstances governing these costs, I have deemed it advisable to establish for purposes of comparison a standard plant whose conditions are fixed. There is no intention to imply that the performance or equipment of this "standard" station is ideal, or could not be bettered, but rather to assume equipment and performance based on facts obtained from stations in actual commercial operation for some time.

This station may seem to border on the ideal, and there is no question but that its performance is consequent on favorable circumstancmes, very nearly we may say test conditions.

The station is assumed to be located on the water front, the exact spot is unimportant. The building and chimney are brick, erected on firm ground, requiring but little piling or filling. The capacity is assumed at 3,600 K-W.

For equipment three cross-compound condensing engines, cylinders 28-in. and 56-in. by 5-ft. stroke, are selected; speed 80 revolutions per minute; 150 lbs. steam pressure. There will also be 3-1,200 K-W. direct connected generators, 6 water tube safety boilers 500 HP. each; economizers and exhaust fed water heaters, electrically driven feed pumps and coal handling apparatus. Such a station would cost to install as follows:

Building, foundations for engines and boilers, chimney, coal handling apparatus, etc.	$120,000
Engines and condensers, heaters, separators and piping	91,800
Feed pumps and economizers	18,000
Boilers and flue connections complete	61,000
Generators and Switch-board complete	73,800
Land and docking facilities	17,000
Engineering and sundries	5,000
Total	$386,600

This gives about $107 per K-W. capacity.

To obtain the figure for fixed charges, I assume interest at 6%, insurance and taxes 3%, depreciation 2%, total 11%, which makes an annual fixed charge of $42,526.

I shall assume that this station produces 10,500,000 K-W. hours per annum, dividing the annual charge by this figure gives 0.4 cents per K-W. hour for the fixed charges. The depreciation is not intended to cover repairs which will be included under operating expenses. The 2% assumed for depreciation is to establish a sinking fund against the time when the station will have to be entirely replaced by one of more modern and economical design. The time of replacement is taken at 50 years,* although a few years ago this time should have been assumed much shorter, owing to the imperfect design of power station apparatus then existing. But with the present advanced state of the art, improvements cannot be expected to develop as rapidly.

In making comparisons between stations of different sizes and types, the cost of labor is the most perplexing item.

Some stations operate with two shifts, others with three. Some have engineers paid at different rates, and men which appear on the records of some are in a capacity which in others is absent or replaced by men of another class and rate of pay. I therefore give the following method of analysis of the labor item which gives satisfactory results when applied to station operation. The method can be illustrated and at the same time the operating expenses can be derived by applying it to our standard station. It is assumed that this station operates with three shifts of men, the duration of each shift being 8 hours. This makes the shift hours per day 24 or 8,760 for the year. The same number of shift hours would of course be obtained by two

*Condensed from a paper read at the annual meeting of the American Street Railway Association held at Boston.

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*A sinking fund contribution of 2% per annum if placed at interest at 4% would equal the entire investment in only 28 years. See Wellington's "Railway Location," p. 82.—Ed. Eng. News.

TABLE 1.—COST OF OPERATION OF VARIOUS STREET RAILWAY POWER STATIONS.

Stations.	Capacity in 1,000 K-W.	Type. Engines.	Type. Generators.	Type. Belted or D. C.*	Type. Simple or compound.	Type. Non-condensing or condnsg	Period avgd, days.	Load factor, %.	Labor. No. of shifts.	Labor. Length of shift, hours.	Labor. Total shift, hours.	Labor. No. of men pr 1,000 K-W.	Labor. Rate of pay, pr hour.	Labor. Output pr K-W. hour.	Fuel. Lbs. per K-W. hr.	Fuel. Price pr net ton.	Fuel. Anthracite or bitu.	Fuel. Cost per K-W. hr.	§General expenses per K-W. hr.	Total operating expenses, per K-W. hr.	Fixed chrgs.
Standard	3.6	3	3	D. C.	C.	C.	365	33⅓	3	8	8,760	1.94	$0.27	$0.157	2.2	$3.00	B.	$0.33	$0.093	$0.58	$0.405
10	0.4	2	2	D. C.	S.	N.	1	24	..	..	.....	7.5	.18	...	...	2.00	.5 A.†	...	...	1.50	...
11	1.4	5	8	B.	S.	N.	365	23	2	12	8,760	3.7	.20	.32	6.7	2.24	A.	.75	.33	1.40	...
12	1.0	3	7	B.	C.	C.	365	23	2	12	8,760	3.7	.20	.31	4.3	2.93	B.	.63	.11	1.05	.44
13	2.6	4	4	D. C.	S.	N.	365	42	2	12	8,760	3.0	.22	.16	6.5	1.44	B.	.47	.09	.72	.24
14	1.6	4	4	Both.	S. C.	N. C.	365	19	2	12	8,760	1.87	.15	...	...	....	....	...	...	...	...
15	1.6	10	16	B.	S. C.	N. C.	183	41	2	12	4,380	6.3	.16	.25	6.5	2.10	B.	.68	.14	1.07	.24
16	1.6	8	8	B.	C.	C.	365	33	3	8	8,760	3.7	.20	.23	5.0	3.30	B.	.83	.09	1.15	...
17	0.8	2	4	B.	C.	C.	365	24	2	12	8,760	3.7	.18	.28	5.0	1.43	B.	.36	.06	.70	...
18	0.4	2	3	B.	S.	N.	365	..	2	12	8,760	3.7	.12	...	...	.75	B.	...	...	...	...
19	3.0	6	6	D. C.	....	....	31	..	2	12	744	3.0	.17	...	...	.60	....	...	...	.68	...
23	0.6	3	3	B.	C.	C.	183	16	2	12	4,380	3.3	.25	.51	6.0	3.44	B.	1.03	.16	1.70	1.00
25	4.0	10	19	B.	S.	N.	365	33	2	12	8,760	...	...	...	5.6	1.05	....	.29	...	.56	...
26	0.8	7	12	B.	S.	N.	365	19	2	12	8,760	...	...	...	6.8	1.15	....	.39	...	1.20	...
28	1.4	4	8	B.	S.	C.	31	23	2	12	744	5.0	.17	.37	7.0	1.63	....	.57	.08	1.02	...
29	1.9	5	5	B.	C.	C.	365	27	2	10	7,300	3.2	.21	.25	3.9	2.80	....	.55	.23	1.03	...
30	1.7	5	5	B.	C.	C.	365	23	2	10	7,300	3.0	.21	.27	3.3	3.00	B.	.49	.15	.91	...
31	0.9	3	3	B.	C.	C.	365	32	2	10	7,300	4.5	.21	.29	4.4	2.84	B.	.62	.19	1.10	...
32	5.3	5	30	B.	C.	C.	365	31	2	12	8,760	3.5	.20	.23	3.5	3.00	B.	.52	.09	.84	...
33	1.5	4	12	Both.	C.	C.	365	16	2	12	8,760	5.0	.20	.62	4.3	3.08	B.	.66	.22	1.50	...
34	2.0	4	4	D. C.	C.	C.	183	57	2	12	4,392	5.0	.20	.18	5.3	1.00	B.	.27	.12	.57	...
35	1.2	1	1	D. C.	C.	C.	365	37	2	12	8,760	2.1	.26	.15	4.7	1.24	B.	.29	.04	.48	...
37	1.5	3	11	B.	S. C.	N. C.	151	11	2	12	3,624	8.0	.16	1.10	7.3	1.75	.5 A.†	.63	.12	1.85	...
40	9.2	6	6	D. C.	C.	C.	365	36	3	8	8,760	2.7	.23	.17	3.0	1.60	A.	.24	.11	.52	...
42	1.8	3	6	B.	C.	N.	365	45	3	8	8,760	5.0	.26	.29	5.7	1.60	A.	.45	.18	.92	...
43	3.3	5	10	Both.	C.	C.	365	15	2	12	8,760	3.7	.16	.39	3.7	2.70	.6 B.‡	.50	.14	1.03	...
44	6.0	6	12	B.	C.	C.	365	30	3	8	8,760	3.3	.24	.26	3.5	1.60	A.	.28	.15	.69	...
45	1.0	4	7	Both.	C.	C.	30	28	2	10	600	3.0	.15	.16	4.7	1.90	B.	.45	.05	.66	...
47	0.75	4	4	D. C.	C.	C.	183	20	2	12	4,380	8.0	.12	.41	5.1	2.12	.5 A.†	.54	.21	1.16	...
48	0.6	2	2	D. C.	C.	C.	365	35	2	10	7,300	6.7	.15	.29	3.3	2.75	B.	.45	.28	1.02	...

*D. C.—Direct-connected. †.5 anthracite and .5 bituminous. ‡.6 bituminous and .4 anthracite. §Includes repairs, all supplies other than coal, superintendence and office expenses.

shifts of 12 hours each, as is the east with some stations. For the three shift station, the first two probably would have the full complement of men, while the third would not, as the station might be shut down on that shift. But as there is considerable inspection, cleaning and overhauling, this shift requires almost as many men, though their rate of pay may be less. The highest rates of pay would be on the shift of heaviest load. The crew to operate the standard plant would be about as follows: Two engineers, 1 oiler, 1 helper, 2 firemen, 1 coal passer, a total of 7 men per shift.

The average rate of pay per man is taken at 27 cents per hour. This would be calculated from an actual station by dividing the total amount paid for wages, including the chief engineer's salary, by the product of the number of men operating with the hours each has worked. The number of men per shift for this station (7), divided by 3.6, which is the figure expressing the capacity in 1,000 K-W. units, gives 1.94 as the number of men per shift per 1,000 K-W. capacity. This figure will vary with the type and size of station, as we shall see later. Multiplying 1.94 by the rate of pay (27 cents) gives 52 cents as the cost of labor per hour per 1,000 K-W. capacity. This multiplied by 3.6, the number of 1,000 K-W. capacity, gives $1.87 as the total cost of labor required to operate the station per hour.

It will further aid in the analysis of the labor item to introduce the load factor. As this term is sometimes employed in a different sense from that used in this paper, I shall define it to be that per cent. which, when multiplied by the capacity of the station in kilo-watts and by the shift hours for the period gives the K-W. hours output for the time considered. In this case the average load factor for the year is taken as 33⅓%. The kilo-watt hours output of the station was given at 10,500,000, which is 33⅓% of 3,600 K-W. multiplied by 8,760, the shift hours per annum.

It has been shown above that $1.87 is the average cost of labor to operate the station for one hour, and if we obtain the average K-W. during the hour, which is K-W. hours for that period, a simple division will give the figure for the cost of labor per K-W. hours. The load factor gives the means of obtaining the K-W. hours, and by multiplying 3.6 by 1,000 and 33⅓% gives 1,200 as the average K-W. for the hour, or K-W. hours for that period. Dividing $1.87 cost of labor to operate the station per hour by 1,200 gives 0.157 cents as the cost of labor per K-W. hour. As 3.6, the figure representing the station capacity, was used as a multiplier in obtaining both the cost of labor $1.87 and 1,200 K-W. hours, it, therefore, disappears in the division and the expression for the cost of labor per K-W. hour is made independent of the capacity of the station to that extent. The rule then for obtaining the cost of labor per K-W. hour for any station is: Multiply the rate of pay of the men by the number of men per 1,000 K-W. capacity, and divide by the product of the load factor and 1,000.

The diagram, Fig. 1, gives the results of this expression for cost of labor for all usual rates of pay, load factors and men per 1,000 K-W. This diagram is based on a rate of 27 cents per hour, and there is also given a reduction table which gives the per cent. to be added or subtracted for other rates than this. To illustrate its use, suppose we have a station whose equipment requires five men per shift per 1,000 K-W. capacity. During a month of high output it might operate at a 30% load factor. On the diagram, following 5 up to 30 gives cost of labor at 45 cts. per K-W. hour. In a lighter month the station might operate at a 15% load factor. Following 5 up to 15 gives 0.90 cts., or twice as much for labor per K-W. hour.

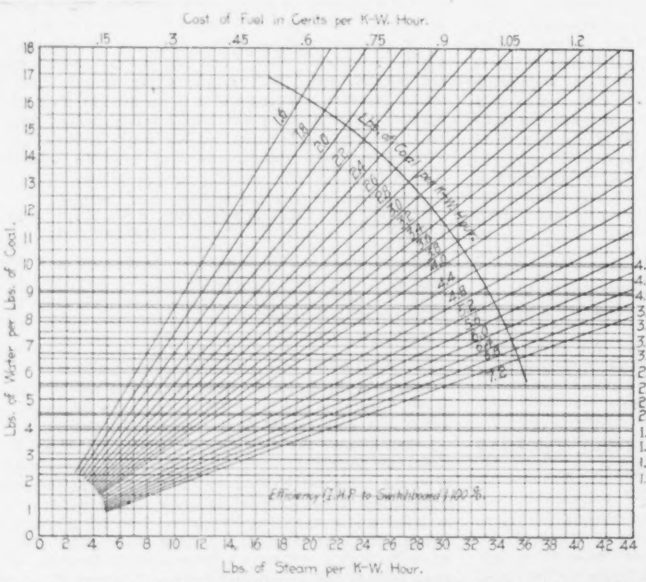

FIG. 2.—DIAGRAM FOR FINDING COST OF FUEL PER K-W. HOUR OF TOTAL OUTPUT OF A STREET RAILWAY POWER STATION, THE PRICE OF COAL, THE BOILER, ENGINE AND DYNAMO EFFICIENCY BEING KNOWN.

The diagram (Fig. 2) is calculated for 100% efficiency; for any other efficiency, add value given in right-hand column opposite that efficiency.

Plant efficiency.	Per cent. To be added to cost of fuel per K-W. hr.	Plant efficiency.	Per cent. To be added to cost of fuel per K-W. hr.	Plant efficiency.	Per cent. To be added to cost of fuel per K-W. hr.
60	67	82	22	92	9
65	54	84	19	94	6
70	43	86	16	96	4
75	33	88	14	98	2
80	25	90	11		

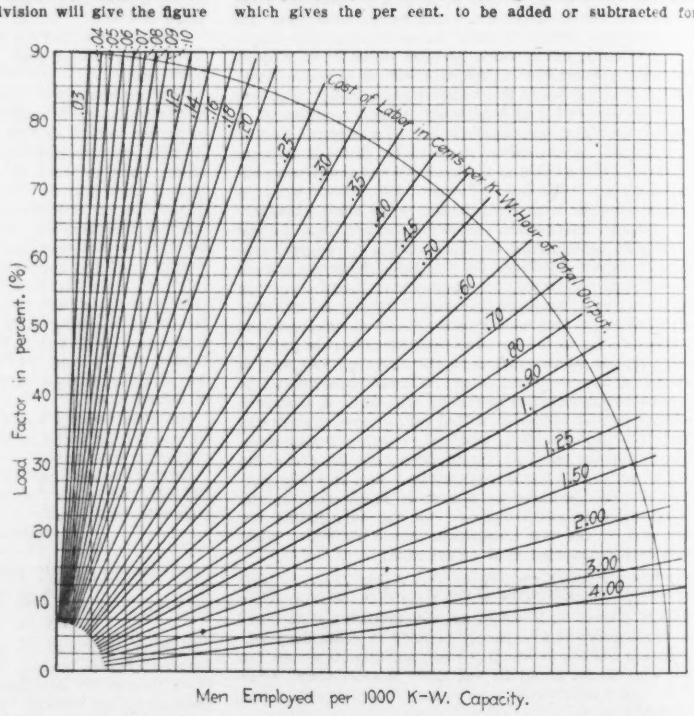

FIG. 1.—DIAGRAM FOR FINDING COST OF LABOR PER K-W. HOUR OF TOTAL OUTPUT OF A STREET RAILWAY POWER STATION, THE NUMBER OF MEN PER 1,000 K-W. CAPACITY, THE LOAD FACTOR AND THE AVERAGE RATE OF PAY BEING KNOWN.

The diagram (Fig. 1) is calculated on a basis of 27 cts. per hour as an average rate of pay. For any other rate add the percentage given in the right-hand column of the table opposite the rate employed.

Rate of pay per hour, cts.	Per cent. to be added or subtracted.	Rate of pay per hour, cts.	Per cent. to be added or subtracted.	Rate of pay per hour, cts.	Per cent. to be added or subtracted.
15	−44.4	24	−11.1	29	+7.4
17	−37.0	25	−7.4	30	+11.1
19	−29.6	26	−3.7	31	+14.8
21	−22.2	27	0.0	33	+22.2
23	−14.8	28	+3.7	35	+29.6

The cost of fuel is the next item to be considered in the operating expenses of the standard station. Considering coal as the fuel used, its cost per K-W. hour depends on the price per ton and on the efficiency of the station, which is best expressed in pounds of coal consumption per K-W. hour. The coal for standard station is assumed to he clear bituminous, costing $3 per short ton delivered.

As to the efficiency, I am able to quote from tests on a station of the same size and similar equipment. The duration of the test was 45 hours, made under actual conditions of railroad service during the day, and at night the load was kept on the station hy means of a water rheostat. The average efficiency of transformation, I. HP. to E. HP. at the switch-board, was 90%. The steam consumption of the engines was 14.5 lbs. per I. HP. hour. The boiler evaporation was 9.4 lbs. water per lb. of coal from actual conditions. The coal used was New River bituminous. The economy of the station, represented hy the coal consumption in lbs. per K-W. hour was 2.3. I have therefore assumed 2.2 for this figure for the standard station.

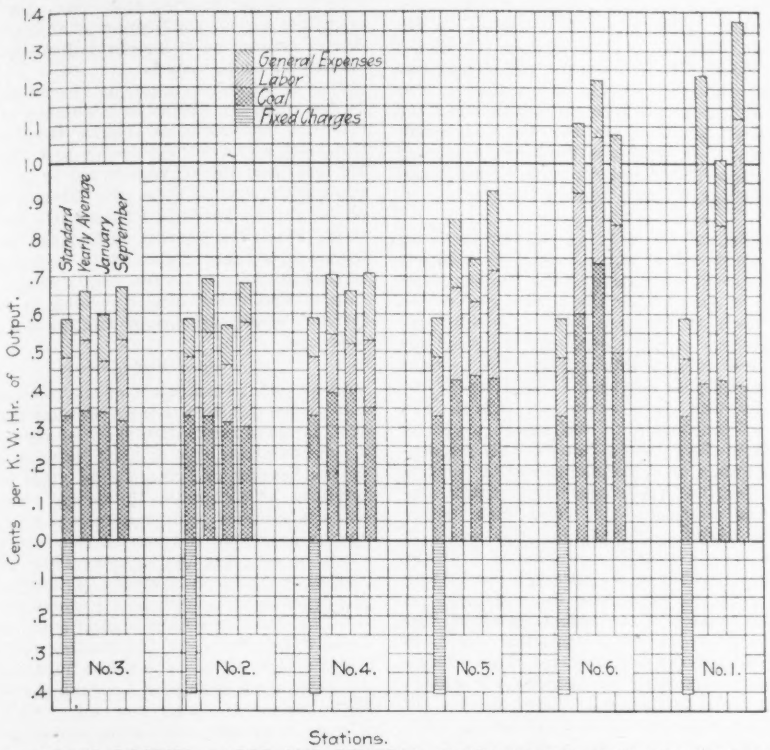

FIG. 3.—COSTS OF FUEL, LABOR AND GENERAL EXPENSES PER K-W. HOUR OF TOTAL OUTPUT IN SIX STREET RAILWAY POWER STATIONS.

(In each group of four lines, the first line gives the operating expenses (and fixed charges plotted helow the base line) of the "standard" station, the second gives the average for the year's output for the station under consideration, the third is for a month of the heaviest load (January), and the fourth for a month of the lightest load (September).

Reducing price per ton to price per pound and multiplying by 2.2 gives 0.33 cts. as the cost of coal per K-W. hour. This appears in table I. under cost of fuel. As an illustration of what the cost would have been had the engines required more steam, say 26.6 lbs. per I. HP. load, as might be the case with a non-condensing engine, referring to the fuel diagram, Fig. 2, and considering the electrical efficiency boiler evaporation and price of coal to remain the same, 26.6 to 9.4 lbs. water per lb. of coal gives 3.8 lbs. coal per K-W. hour. Following this line down to horizontal $3 coal line and verticaly upwards from this point to cost of fuel in cts. per K-W. hour, we obtain 0.57 cts., were the efficiency of transformation 100%, but since it is assumed to be but 90%, 11% has to be added to this cost, as shown in the reduction table. This gives the cost of coal per K-W. hour 0.63 cts., as against 0.33 for the condensing engine.

There remains to be included in the operating expenses for this station water, oil, small supplies, repairs, superintendence and general expense, which I have estimated at 0.093 cts. per K-W. hour. The total operating expense foots up to 0.58 cts., which, added to the fixed charge of 0.4 cts., makes the total cost power from standard 0.98 cts., or very nearly 1 ct. per K-W. hour.

The application of water power to street railways has the following points of advantage. In plants operated under any but very low heads the generating machinery may be installed at a less cost than for steam. Also the fuel expense disappears, as well as a portion of the cost of repairs. A part of the labor expense will be saved, inasmuch as no engineers, firemen or coal handlers are required.

Water power produced in various parts of the country varies greatly in its cost. It is reported that the electrical energy so produced costs from $14 to $32 per annum per K-W., continuous output. This expense is largely made up of fixed charges, which increase rapidly as the expense of making the necessary improvements is greater. The standard steam plant produces power with $3 coal for $29, and with 80-ct. coal for $22 per K-W. per annum, which compare very favorably with the above for water power.

There can be no general rule given that will determine whether it is more advantsgeous to use water or steam power. Each case must he figured hy a competent engineer, and decided on its merits.

I have compiled and classified the data of a number of representative street railway plants throughout the country which are given in Tahle I. In this, the numhers at the top, 10, 11, 12, etc., indicate the several stations, while the figures in the vertical columns are the data for each station derived from records extending over some time. The first column, headed S, refers to the standard hypothetical station above described. The left-hand column explains itself, the first portion describing the plant equipment, the number and kind of engines and generators, etc., the remainder giving labor, fuel and general expenses, the latter including repairs, supplies other than coal—that is, water, oil, waste, lamps and miscellaneous, as well as superintendence.

As a supplement to the table, in order to more clearly illustrate the relation of the costs, I have constructed diagrams (Figs. 3 and 4), in which the principal items of cost are plotted and the costs in the different stations are more readily comparable. In Fig. 3 the variations in the cost in the same plant at different seasons is also shown. The third line in each of the groups represents the operating expenses for January, a month of heavy load, and the last column, that for Septemher, a light month. The first line in each group shows the operating expenses and fixed charges for the standard station. It will he seen that in general the fixed charges are approximately equal to the coal cost. Labor is roughly about half the coal, and general expenses about half the labor. These proportions are simple and easily rememhered.

The author describes in some detail the equipment of the six stations, whose expenses are set forth in Fig. 3, showing the causes for increased or decreased expenditures over those of the standard station, as indicated by the diagram. To illustrate the utility of this form of diagram, and these in particular, we select two examples. The first is a large direct-connected plant and the second a small belted station, of which the author says:

Group 4 (Fig. 3) illustrates a large station including 6 1,200-K-W. generators direct connected to triple condensing engines, 2 1,500-K-W. generators direct connected to compound condensing engines, and an auxiliary plant of 40 62-K-W. generators belted to compound non-condensing engines and only used in case of emergency. Economizers, heaters and electric feed pumps complete the important part of the equipment. Group 4 indicates the costs for this station. The yearly average shows that we are approaching standard figures in labor. This item is not much less as the units are only slightly greater capacity. Load factor, rate of pay and men per 1,000 K-W. correspond very closely with staudard. The general expense and coal bring the total somewhat higher. General expense is high on account of the heavy repair account. The station is about eight years old and repairs are heavy, due to replaciug of worn out parts. The decrease in efficiency, as shown by the pounds of coal per K-W. hour, might he shown hy a test to he due to old boilers.

Group No. 6 represents the costs for a belted plant of about one-fifth the capacity of the standard. Its equipment is 12 generators belted to 4 simple high-speed non-condensing engines. There are feed water heaters, hut no economizer. High coal consumption is the feature of this diagram. The cost of fuel alone for the year is equal to the total operating expenses for the standard. Labor is also high, and the total cost of power per K-W. hour is nearly double the operating expense of the standard. This station furnishes a good illustration of the effect ou the cost of power of a simple nou-condensing belted equipment. It is to he remarked also that this plant has the henefit of a high load factor.

The diagrams given in Fig. 4 are plotted in the same way as those given in Fig. 3, the difference being that only the yearly average is given in each case. In examining the different stations represented the same method of analysis is followed. The author takes up each station separately, calls attention to the large or small expenditure for any one item, and traces this back to determine the cause. The equipment is in most cases outlined and other information given which can be obtained from Table I. It will be noticed in Fig. 4 that the lines representing stations 34, 35 and 40 are shorter than the standard, showing that the standard plant so fully outlined by the author is well within possible practice. In referring to the diagrams for these stations, the reason for the remarkably small operating cost is briefly explained as follows:

Station No. 34 operated at a lower cost than standard on account of the high load factor, 57%, reducing the cost of labor, and the low price of coal, $1 per ton. No. 35 is a one unit plant of 1,200 K-W. capacity. It operates with 2.1 men per 1,000 K-W., and a load factor of 37%, using coal costing $1.24 per ton. Its costs are quite a little lower than standard. No. 40 has a capacity of 9,200 K-W. It is direct connected, has economizers and compound condensing engines. Anthracite coal is burned, costing $1.60 per ton. This plant operates at less than standard figures. No. 37 is a record breaker in the opposite sense. It is of slightly greater capacity than 35, but has 3 engines and 11 generators, which require 8 men per 1,000 K-W. capacity. It has a load factor of hut 11% during 151 days, from Jan. 1 to May 31, 1898. The effect of this on the cost of labor is very apparent. The cost of coal in this case is greater than the total operating expense for standard. This station pays but $1.75 per ton, but it uses 7.3 lbs. per K-W. hour, while No. 35, about the same size plant, pays $1.24 for coal, and uses hut 4.7 lhs. per K-W. hour. Labor is easily 7 times as large in 37 as in 35. The load factor of 11% as against 37% would make this item three times as great, and 8 men per 1,000 K-W. as against 2.1 would again increase the cost of labor three times. The higher rate of pay in plant No. 35 prevents the discrepancy being greater.

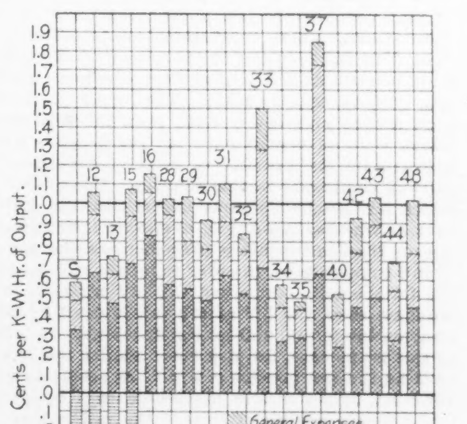

Fig. 4.—Costs of Fuel, Labor and General Expenses and Fixed Charges per K-W. hour of Average Yearly Output, in Various Street Railway Power Stations.

(Plotted from Figures in Table I.)

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In the report of the meeting of the New York Street Railway Association, in another column of this issue, will be found an interesting paper by Mr. A. J. Moxham, Assoc. Am. Soc. C. E., describing tests to determine the proper composition of steel rails to secure the best wearing qualities. The conclusions he reaches as the result of actual test of rails in the track are that high carbon rails wear better than low carbon rails, but that rails of high carbon with low phosphorus wear better than either. These conclusions are in entire accord with the opinions of the majority of expert metallurgists at the present day, who have given this subject consideration. That rails of fairly high carbon give better wear than the soft rails which were advocated some ten years ago is now attested by the practice of most of the leading railway companies in this country. The question which Mr. Moxham's paper leaves unsolved, however, is whether it will pay to specify lower phosphorus than the ordinary Bessemer practice gives in rail compositions, in order to secure still longer life for the rails. In street railway practice, Mr. Moxham says, the life of the rail is fixed by the wear at the joints, and he concludes that so long as this is the case, the Bessemer quality rail is as good as the low phosphorus rail. It seems to us, however, by no means impossible that by putting a better quality of steel in the rail, a longer life might be secured for the joints. The joints get low because the splice bars wear the under side of the rail head, and fail to give it the support it should receive. Now, if low phosphorus steel reduces the wear on the top of the head, there is good reason to suppose that it might also reduce the wear at the joints, especially if a similar grade of steel were used for the splice plates. Again it will be noted that the wear which Mr. Moxham measured in his experiments was the wear upon rails laid on a tangent. On steam railway lines, however, a large proportion of the track is on curves, where the wear is much more rapid. If, therefore, by paying $2 per ton more for a rail of lower phosphorus, its resistance to wear can be increased some 70 per cent., the matter is one which managers of both steam and street railways will do well to carefully investigate.

Mr. Moxham's estimate of $2 per ton as the extra cost of a rail of .050 phosphorus over a rail of .097 phosphorus, is, we presume, based on the acid process, using a higher grade of ore in the blast furnace. It is quite among the possibilities, however, that in the near future it may be possible to secure basic steel rails with even less phosphorus than that above specified, and at an increased cost little or no greater than the $2 per ton estimated by Mr. Moxham for 0.50 phosphorus acid steel. Such rails should safely take a considerably higher percentage of carbon than the rails tested by Mr. Moxham, and the final result should be a rail of maximum hardness, combined with high elastic limit and ultimate strength and entire safety against breakage in the track.

The widening of the gage of railway track on curves is discussed at some length in a report made by a special committee of the Roadmasters' Association of America, at the annual convention held last week at Denver, Colo., and fully reported elsewhere in this issue. As many of our readers will remember this subject was brought up anew about a year ago by the committee of the American Railway Association on wheel and track gages. According to the report made by this committee (Eng. News, Oct. 14, 1897,) a considerable number of railways, including several well known for the excellence of their track construction, had abandoned or else had never adapted the practice of widening the gage on curves. On the other hand, a number of railways widened curves as flat as 1°, although hardly any two roads used the same rule for widening. A more notable feature of the report, however, was not only the great variety of practice that was shown to exist but the fact that the ideas of railway managers regarding the reasons for widening the gage were as diverse as their practice. In discussing this report in our issue of Dec. 2, 1897, we pointed out that while many railways did not widen the gage on curves this was due in a great many cases to the fact that the maximum curves on those roads were not sharp enough to demand theoretically that the gage should be widened in order to pass the locomotives and cars in common use. In the same issue we published and discussed at some length a paper by Mr. Wm. H. Searles, M. Am. Soc. C. E., which presented clearly the mechanical reasons for widening the gage on curves, and gave a number of simple formulas for calculating any special case which might occur in ordinary practice. The committee of the Roadmasters' Association which reported at Denver last week, it will be noted, indorse with slight modifications the argument and formulas given by Mr. Searles in his paper published in our issue of Dec. 2, 1897. For practical use by trackmen, however, the committee recommends the inclusion in these formulas of a factor of safety to allow for the failure of the swing motion of locomotive trucks to work perfectly, and also for irregularities in wheel gages. The amount of this factor of safety and the method of including it in Mr. Searles' formula are clearly stated in the abstract of the committee report published elsewhere, and will not be restated here. The report of the committee is on the whole an excellent one, and it must be admitted, we think, that it is very timely. As we pointed out in our issue of Dec. 2, 1897, there is no theoretical or practical reason for such diversity of opinion and practice as now exists among trackmen in this problem of curve construction. By setting this fact clearly before trackmen and giving them a simple and reliable standard of practice for all conditions of curvature and locomotive wheel base, the committee of the Roadmasters' Association has done a commendable piece of work.

One of the most serious sources of complaint in the present war has been the treatment which the soldiers received on board the transports, while en route to Cuba and Porto Rico and on the return journey. From authentic reports it appears that in many cases the soldiers were subjected to conditions beside which the steerage accommodations on a merchant vessel may be considered palatial. The reason for this was that at the outbreak of the war, the Government had not a single vessel at its command fitted up as a troop transport. The best that could be done was to take merchant vessels and fit up such temporary bunks, etc., as time permitted. The absence of proper ventilation systems, sanitary conveniences and cooking arrangements on the vessels made the voyages upon them a severe ordeal even for men in robust health; and was doubtless responsible for no small amount of illness and for deaths among the sick and invalids who had to be carried on these vessels.

This great defect in our army system is now to be remedied by fitting up a number of the Government transports as regular troop ships with the most approved appliances and conveniences. No less than eleven vessels are to be thus fitted up, and the first of these, the "Mobile," is already at the Cramp yards in Philadelphia for that purpose. From the present outlook the transport of troops to and from Cuba, Porto Rico and the Philippines is likely to be frequently necessary in the future; and the fitting of vessels to carry comfortably large numbers of soldiers is a most sensible one.

An excellent illustration of the fact that it costs much more to heat the fresh air that must be supplied for good ventilation than merely to maintain the temperature of a room or building is afforded by the heating and ventilating plant of the new buildings of Columbia University. These buildings are supplied with enough direct steam radiators to overcome the loss of heat through walls, windows, etc., and the entering fresh air for ventilation is blown over stacks of heating pipes so that it enters the rooms at a temperature of about 70°. The buildings have a total cubic contents of about 9,700,000 cu. ft., the heating surface in the direct steam radiators is about 56,000 sq. ft., and the ventilating system is designed to furnish about 50,000,000 cu. ft. of air per hour. When the outside air is at zero, the steam consumption of the plant is estimated as follows, in horse power. Condensed in direct heating radiators, 560 HP.; condensed in heating stacks in connection with blowers, 2,205 HP.; power required for electric motors operating blowing and exhaust fans, 635 HP. In other words, the heating and distribution of the fresh air for ventilation takes about six times as much coal as is required to simply maintain the inside temperature of the buildings. In a lecture describing this plant, delivered before the Engineering Society of Columbia University,* Mr. G. A. Suter, under whose direction the plant was constructed, gives the following useful figures from the experience with this plant:

1 HP. of steam supplies 100 sq. ft. direct radiating surface.

1 HP.-hour of steam supply heats 20,000 cu. ft. of air from zero to 70° F.

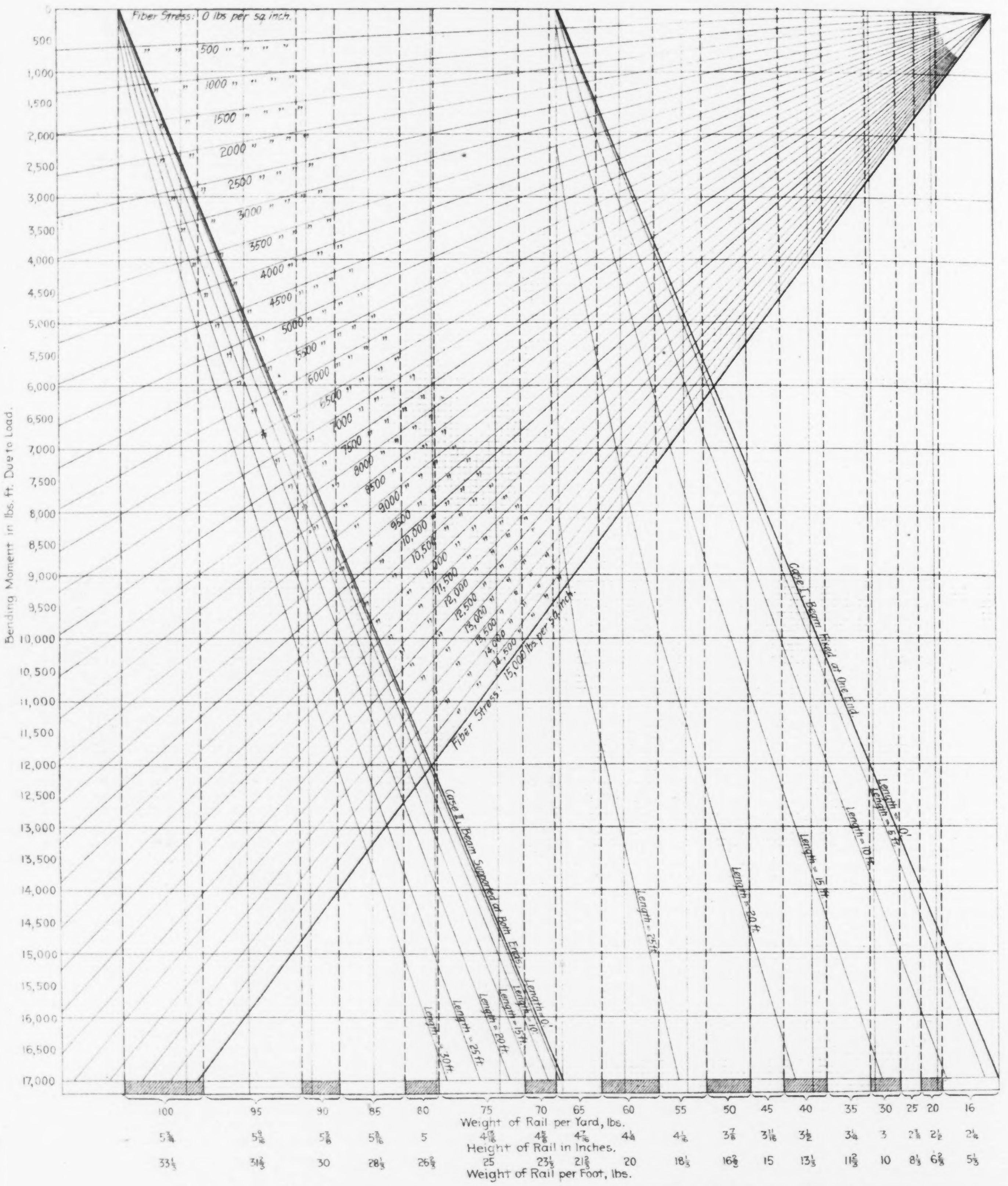
1 HP. on the shaft of an electric motor driving a blower will move 75,000 cu. ft. of air per hour into and out of the rooms.

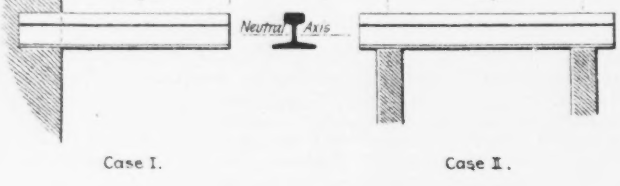
The very large amount of power required for moving the air will be, we presume, a surprise to many engineers; but it is to be remembered that as all the exhaust steam is utilized for heating and the power applied to the air, for the most part, also appears as heat, the fan system of heating and ventilating is really not so expensive in operation as might at first sight appear.

TYPHOID FEVER IN THE ARMY.

If one were asked what topic had been uppermost in the minds of the American people during the past few weeks, there could be but one answer, the condition of the returning troops. It is, or was, a common idea that army service is calculated to toughen a man. The trooper who left home pale and stoop-shouldered was expected to return from a season of drill and camp life bronzed and straight, with muscles hardened, and constitution fitted to endure hardship and fatigue. This is the ideal. The reality is that a wofully large percentage of the men who left home in perfect health and passed a medical examination of great rigor are now returning as

*The lecture is published in the "School of Mines Quarterly" for July, 1898.



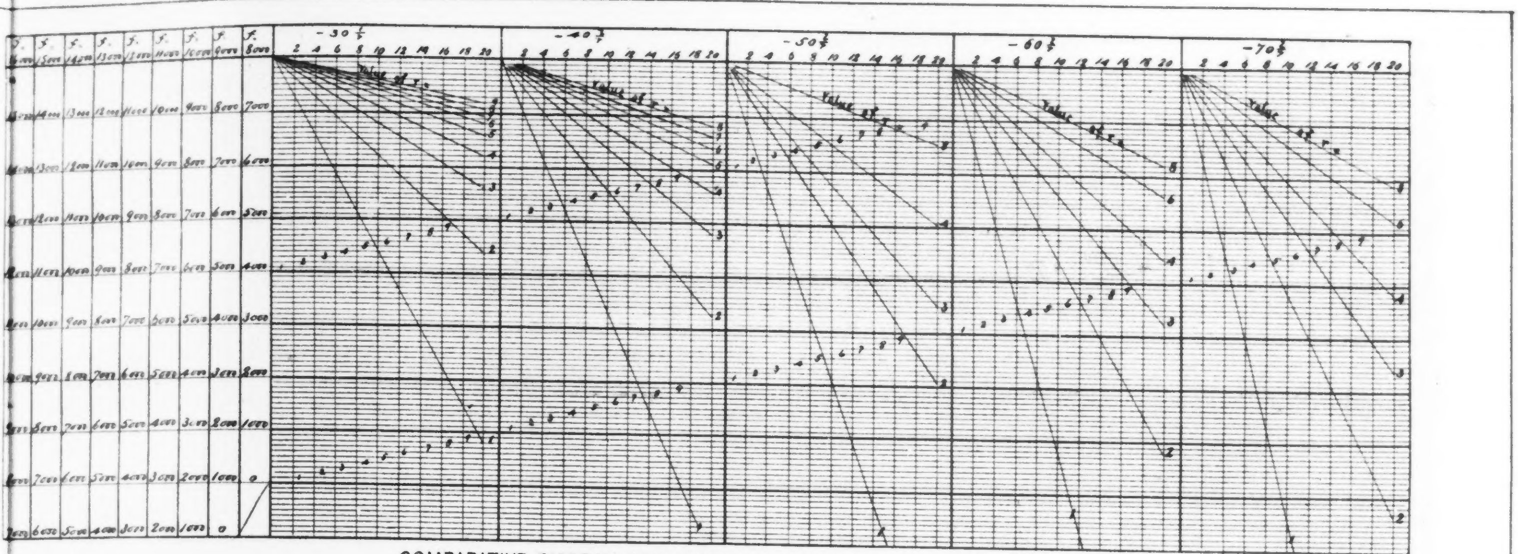


Case I. Case II.

DIAGRAM FOR FINDING THE TRANSVERSE STRENGTH OF RAILWAY RAILS.

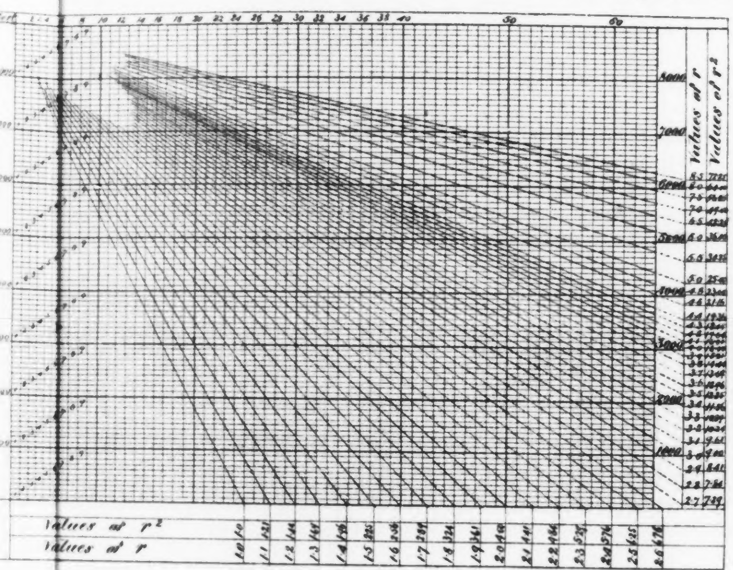
Compiled by W. M. Wickham,

Braddock, Pa.

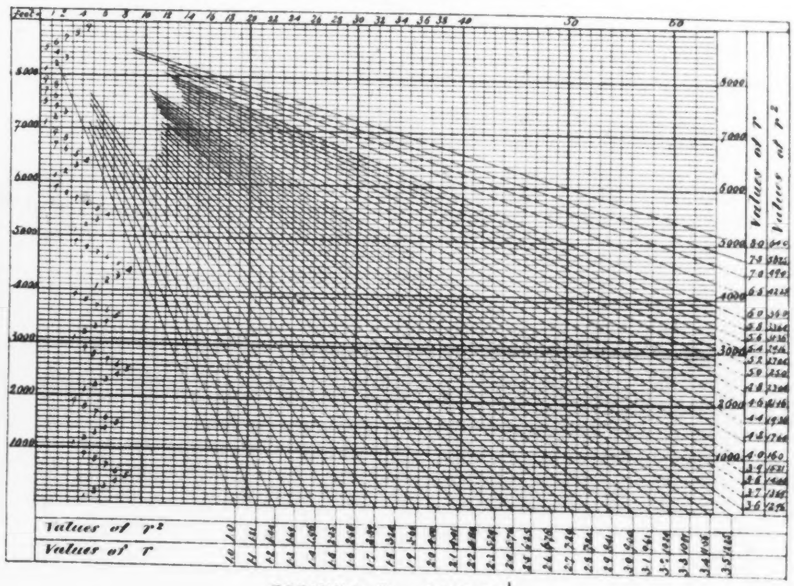


COMPARATIVE DIAGRAM FOR DIFFERENT VALUES OF f AND b.

Values of f — 8,000 to 16,000 lbs., Including Each in Combination with Values of b of 30, 40, 50, 60 and 70.



FORMULA, $P = 9{,}000 - 30\frac{l}{r}$



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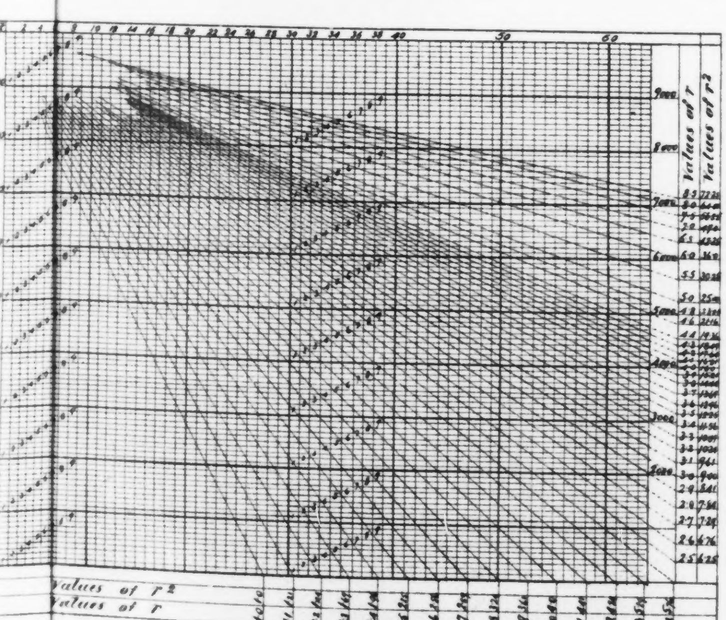

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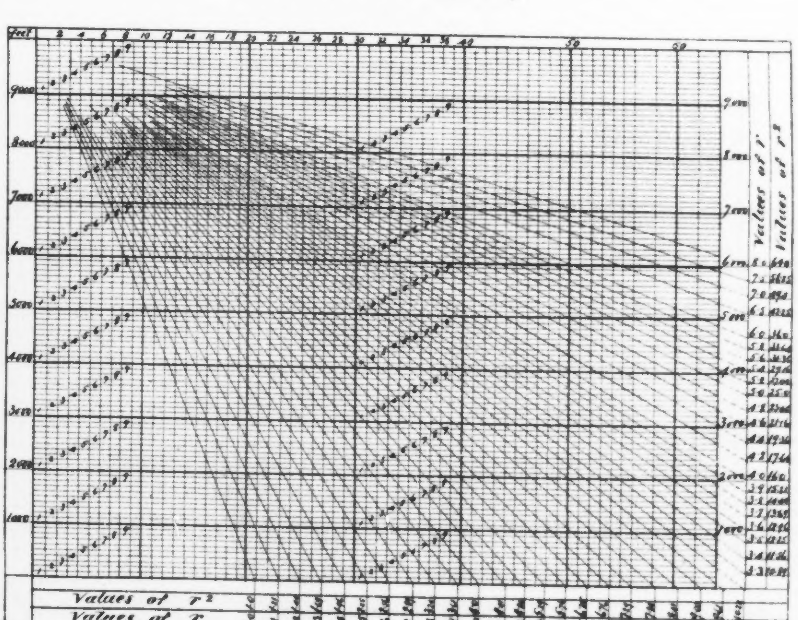


FORMULA, $P = 10{,}000 - 40\frac{l}{r}$

DIAGRAMS OF JOHNSON'S STRAIGHT LINE FORMULAS FOR DETERMINING THE STRENGTH OF COLUMNS FOR COMPRESSION MEMBERS FROM 12 INS. TO 64 FT. LONG.

CHAS. HART, LITH., 36 VESEY ST., N. Y.

helpless invalids, and many more of those who stayed in the home camps have fallen victims to typhoid than all who were killed by Spanish bullets in Cuba.

The question that is now agitating the American people is, where does the responsibility lie for this vast loss of life and this great amount of sickness and suffering? They will not accept any assurances that this was all a necessary feature of army service; and they are right. Other countries assemble great numbers of troops every year in camps for practice manoeuvers; and their ranks are not decimated by typhoid. Of course when troops are engaged in actual campaigning, care for the health of the men must often be a secondary consideration. Strategic positions must be held in the face of the enemy though troops lie in pools of water in the trenches, and camps have to be made in fever breeding swamps. There is little fault finding heard because of the sad condition in which the captors of Santiago came home. There would have been none at all except that the loss of health by the soldiers who never left the home camps gives ground for belief that all was not done that might have been done to care for and restore the health of those who suffered from wounds and pestilence at Santiago.

That, however, is a matter by itself. The fact to which we desire to call especial attention is that the sickness and deaths from typhoid have been the one great blot on the administration of army affairs in the campaign just closed. Compared with that, all the other delinquencies and shortcomings complained of in the administration of army affairs are trivial. Deduct the deaths and illness from typhoid, and the hospital record for the past four months would be little worse than must inevitably be expected when an army is hastily assembled, chiefly from the Northern states, and is put into semi-tropical camps, in a region where malaria is more or less prevalent, at the beginning of midsummer.

The fact that the public desires to learn more than any other is, where does the blame lie for the great prevalence of typhoid in the army camps, and how is similar illness and mortality to be prevented among the troops that must soon be sent away to garrison Cuba, Porto Rico, and, perhaps, also the Philippines? Certainly, if it were generally believed that new regiments would suffer from typhoid as did the troops at Chickamauga and Camp Alger, it would be a difficult matter to find volunteers to fill them.

In the voluminous criticisms of the War Department which have been current during the last few months a great deal has been said concerning the unfitness of the camp sites selected. It has been alleged that the selection of this or that or the other location as the site for a camp was due to "political influence." The soil, the water-supply and the atmospheric environment of almost every camp have been denounced in the public press. One camp was in a barren desert of sand, where the heat was excruciating; another was a malarial and fever-breeding spot, and was inundated at every heavy rain. One was supplied with water from a running stream, which became so foul that its use was well-nigh impossible; another relied on driven wells, whose pollution, according to the reports, was a matter of certainty.

How much or how little truth there may have been in these criticisms as to particular camps, we shall not take space to discuss; but the fact that typhoid has been seriously prevalent at every large camp that has been established, except those most recently opened in the Northern states, is good proof that it was not the camp sites that were responsible in the first place for the epidemic that prevailed in them. It is easy to condemn a camp site after an army has lived upon it for weeks and scattered its debris over it; and it is easy for an unthinking man to say, as was so many times said: Why was such a site chosen when thousands of better sites are to be found in every state? Few appreciate the requirements that must be met in selecting a site for the encampment of an army of fifty thousand or more, such as that at Chickamauga. Military considerations, at the time the camp sites were chosen, were of the first importance. The army had to be gathered in camps large enough to enable brigades and corps to be formed so that there might be some practice in the movement and handling of large bodies of troops. These camps had to be located within quick rail communication of the points on the seaboard from which a forward movement might be made, and rail communication with the principal markets and supply depots was essential. The water supply of a large camp is a most difficult problem. Lakes in the South are few, and an army camped on the shore of any lake of small size would soon seriously pollute it. Running streams in the South are generally very muddy; and besides, an army of considerable size camped along a stream will quickly foul it. Under these circumstances, underground supply from driven or bored wells seems practically the only source from which an army of 50,000 men or more can derive a reasonably pure supply of water; but every sanitarian knows that such wells are liable to surface contamination unless great care is taken. For general sanitary reasons a sandy soil is the best on which to locate a camp; but wells in such a soil are more liable to surface pollution than those driven through clay.

When one bears in mind the limitations with which at the opening of the war the choice of camp sites was hedged about, it is hard to believe that Chickamauga, for example, was selected with any other idea than that it was the best adapted for the purpose. It is located in a high mountain region, the coolest and most salubrious in the South. Its railway communications with the North and East are better than those of any other center in this mountain region, and its rail communication with the seaboard is also excellent. Besides this, its proximity to Lookout Mountain, a natural sanitarium, would seem to make it a place where troops should have been kept in excellent health. It is now said, we are aware, that the soil at Chickamauga was too stony to make it a sanitary camp site; but while it is doubtless more difficult to keep a camp healthful on a rocky or clay soil than on sand, it can be done nevertheless.

Again, the fact that typhoid has raged at Chickamauga, at Camp Alger, at the Presidio, at Camp Black, at Jacksonville, and at various other camps proves not only that the camp sites were not the original cause of the trouble, but that it was not due to the mistakes of any one particular commander, or the inefficiency of the officers in any one camp or locality. The wide prevalence of the disease proves that something was wrong with the system as a whole. Just what that something is it will be the most important task of the President's proposed investigating commission to find out. At present we can only say, without pretense of having made an exhaustive inquiry, that all the information at hand inclines us to believe that the main source of trouble was, first, the ignorance and inefficiency of the officers in immediate charge of the volunteer troops; and, second, the system under which army affairs are administered. Almost all of the officers appointed to the volunteer regiments were absolutely without experience in the making or policing of army camps; and it is safe to say that in the minds of nine-tenths of them, sanitary matters were given little attention. Those who were industrious and faithful had their minds chiefly set on drilling their men into soldiers. Those who were not, paid as little attention to the sanitary condition of their men as they did to their other duties.

It may be said with truth, however, that this is no explanation of a typhoid epidemic. Decaying garbage and uncared-for sinks about a camp may offend the eye and the nostril, and these and similar unsanitary conditions may produce malaria, bowel troubles and such disorders. But to propagate typhoid, a germ from the discharges of a typhoid patient must be taken into the alimentary canal. To prevent the spread of typhoid, therefore, all that is necessary is to disinfect or absolutely kill the germs in the discharges of every typhoid patient, and this is the most important duty of the nurse in charge of a typhoid fever case, while the responsibility is the attending physicians to see that it is done. With this single precaution the disease is not contagious at all. Without it, a single patient may, under favorable conditions become a center of infection for hundreds.

Now there is good reason to believe that in their zeal to show a good health record and to keep men from "playing sick" to escape discipline or drill, the medical staff have tried to keep men out of the hospitol who ought to have been in it. The men themselves, too, in nine cases out of ten, were never willing to go to the hospital while they had any strength left; especially after the regimental hospitals were abolished and transfer to the division hospital meant leaving everyone they knew.

Of course in gathering thousands of men together, all of them traveling long distances and drinking all sorts of water on the way, some cases of typhoid are certain to occur; and a considerable percentage of these cases, there is little room to doubt, were not taken to the hospital until they had been ill for many days; in fact it is likely that not a few light cases were never in the hospital at all. As evidence of this neglect to identify typhoid in its early stages and to keep the patients in the hospital where their discharges can be disinfected, we find in the current "Medical Record" the testimony of a prominent New York physician, who diagnosed, on Sept. 5, 17 cases of pronounced typhoid fever among soldiers in the Presbyterian and Bellevue hospitals in New York city. Most of these patients were from Camp Wikoff, and not one of those who came from there had been in the hospital at all. The physician, from whom we quote, after sarcastically commenting on "the new army treatment of typhoid fever by prescribing thousand-mile railroad journeys," calls attention to the danger to the public health in the following vigorous words:

> A patient having six or a dozen diarrhœal enteric stools a day, using the ordinary closet of a railroad car travelling, say, thirty miles an hour, distributes a trail of fæces along the track, to be washed by the first rain into neighboring streams, and sets a rather bad example of hygiene to the country at large.

But besides the infection of the camps and their water supplies, by the cases of "walking typhoid," it is by no means certain that the hospitals were so conducted as to remove the danger of infection from the discharges of typhoid patients. The same physician from whom we have just quoted describes the methods of disinfection which he witnessed at Camp Wikoff as "obsolete, inefficient and farcical." On the other hand, Dr. Benjamin Lee, of Philadelphia, who visited the camp at about the same time and published a report of his visit in the Philadelphia "Public Ledger," said: "In the hospitals great care is taken in the disinfection of the excreta of typhoid patients." Here is a disagreement of doctors. The truth probably lies between the two extremes. It would be equally wrong to draw a wholesale indictment of the sanitary conduct of the hospitals or to declare that they were all conducted in a faultless manner. Knowing, as we do, that the nurses were largely men inexperienced in the care of the sick, that frequently both doctors and nurses had twice as many patients as they could properly care for, and that medical supplies were too often found inadequate to the demands, bearing these facts in mind, it seems altogether probable that at many, if not all, of the camps, at times, the discharges of typhoid patients in the hospital have been thrown out untreated, and the germs in them have been scattered broadcast by rains, dust and flies, have polluted food and water supplies by the wholesale, and thus have caused the remarkable spread of the disease that has been witnessed.

We view the vast total of death and suffering, the grief and anxiety in thousands of homes, and wonder that it was not foreseen and guarded against. But it is no wonder after all. Who, among sanitarians even, would have predicted six months ago that some carelessness in permitting cases of "walking typhoid" to stay outside the hospital and more carelessness in neglecting the well-known sanitary precautions in the care of typhoid patients in the hospitals, would have produced such terrible results? It is easy to be wise after the event. In the light of our present knowledge, we can easily say that vigilance in isolating and caring for cases of typhoid should be the very first duty of those in charge of troops; but who appreciated to the full importance of this precaution six months ago? Some did, unquestionably. The army surgeon in charge of one of the hospitals at Chickamauga is quoted as saying that it was an ideal site for a camp; that its soil and sanitary surroundings were excellent, and that the sole cause for the epidemic of typhoid which has raged there was the disregard, by those in charge of the troops, of the rigid sanitary regulations which the medical staff of the army promulgated at the opening of the campaign.

Experience shows, however, that not all the surgeons in charge by any means were sufficiently well posted in sanitary matters to appreciate and insist upon the care necessary to stamp out and prevent the spread of typhoid. Even when surgeons were competent and faithful, their efforts, it is feared, were often neutralized by lack of co-operation on the part of line officers and lack of military discipline and strict obedience to orders on the part of the soldiers who had to do the actual work of keeping clean the camps and hospitals.

The fact is that the nation improvised an army on short notice from a mass of raw recruits, some of whom knew something of military drill, but nothing else of the things which an efficient private soldier must know. The officers over these men were for the most part as ignorant of military matters, aside from the mere matter of tactics, as their men. Camp sanitation, camp cooking, and the provision of food, clothing and other supplies to large bodies of troops in camps or traveling from point to point by rail or transports, was a matter in which all alike were wholly inexperienced. To what extent this condition has been aggravated by the selection of inefficient youths as officers, because of political influence exerted on their behalf, we cannot say; but it would be strange, indeed, if in selecting some thousands of officers, a large percentage of incompetents did not manage to secure sufficient backing to enable them to creep in.

The inexperience of the officers alone, however, is quite sufficient to account for all the soldiers have suffered in the way of bad rations, improper clothing, and illness and death from bad sanitary conditions. In fact some contrasts in the condition of regiments which had the good fortune to have an experienced soldier at their head and those in charge of volunteer officers furnishes additional proof as to where the fault lies for the illness and loss of life in the war from what are well called "filth diseases."

We are aware that a great deal has been said about "military red tape" being a chief cause of the troubles experienced in the army. But it is too often overlooked that "red tape," as it is commonly called, is an absolute necessity in any large organization, civil or military. There must be a definite system for the performance of duties, and a definite assignment of duties and responsibilites throughout every grade of the service, in order to secure proper co-operation, and the orderly prosecution of business. It is probably true, however, that too many hampering and embarrassing restrictions have been embodied in the army regulations, and it should be one of the earliest duties of an investigating commission to determine to what extent those restrictions can be removed and the army routine methods can be amended so as to promote efficiency. The tendency in the framing and amending of such rules is all the time to prevent the wrong thing being done, and to overlook the fact that it is more important after all to ensure that the right thing is done. Rules should be found to facilitate action and not embarrass it.

In conclusion, then, we would emphasize the fact that the illness and deaths from typhoid in the army have been primarily due, not to the camp sites as has been alleged, but to the neglect of simple sanitary precautions on the part of those in charge of the troops, chiefly through ignorance of their importance.

With the dearly bought experience that the nation has now had, such epidemics of typhoid as have raged in the army should hereafter be impossible. The means of preventing the spread of this and similar filth diseases are so simple and so widely known that they should be familiar to the officers in every grade; and their neglect should receive punishment proportionate to the loss of life and suffering which such neglect will cause.

LETTERS TO THE EDITOR.

Moving Electric Cars Across a Weak Bridge.

Sir: Your issue of Sept. 15 contains a short article on "A Plan for the Safe Movement of Electric Cars Across a Weak Bridge," according to which, after an examination and report by me on Sept. 3, 1897, in which the structure was pronounced unsafe and after a further examination and report by an unnamed engineer representing the Capital Railway Company, whose tracks crossed the bridge, in which it was declared to be safe, the final result was "that the railway company has now obtained a permit to construct a double-track trolley line over the bridge." The clear inference of the article is that a difference of opinion between the District Engineer Department and the Capital Railway Company as to the structural sufficiency of the Navy Yard Bridge was resolved by the issuing of a permit to the railway company in accordance with their expert's contention that the bridge would safely carry the loads, and in contradiction of the office's contention to the contrary. The circumstances really are that the company received the charter right to cross this bridge with its cars from Congress prior to the date of my investigation and report which you quote. This right could not be denied them, and has been exercised by them for some time past, the cars being hauled across the bridge by horses. By subsequent legislation of Congress the right to construct a trolley on the bridge to supplant the horse traction, subject to approval as to details by the Commissioners of the District, was granted the company, and the permit for putting up these wires is the one your article refers to. The details employed in this trolley construction were calculated to accomplish the result of preventing cars passing on the bridge, but to publish the circumstances as they appear in your article without such an explanation as the foregoing would make a presentation unfair to the Engineer Department of the District of Columbia and to myself.

Very respectfully,

C. B. Hunt.

Office of the Engineer Commissioner of the District of Columbia, Washington, D. C., Sept. 17, 1898.

(We did not intend, in the article referred to, to imply that in the disagreement between experts, the railway company's expert was sustained. On the contrary, it was our understanding (and the above letter makes it entirely clear), that the exact opposite was the case. We regret that some of our readers may have been misled by the ambiguous wording of the article referred to. It appeared to us that the engineer had contrived a very ingenious scheme for preventing the bridge being overloaded by two cars crossing in opposite directions at the same time, and our readers will now understand what was not clear before, why a double-track was laid across the bridge.—Ed.)

Tests of the Stress in Plate Girder Stiffeners.

Sir: I have read with considerable interest the discussions which have appeared in several of your recent issues on the subject of web stiffeners in girders. It seems to me that there are two distinct conditions of a girder to be kept in mind: First, a girder in which incipient failure, by buckling or otherwise, has not even begun; and, second, a girder in which certain parts have partially or wholly failed. The model shown by Mr. Wilson exhibits the girder in the second condition, and I agree with "E. M.," and with Mr. Buel, that from the behavior of such a model, correct conclusions cannot readily be drawn as to the stresses which exist when the same is in perfect condition.

I take it that the question of chief interest relates, however, to a girder in the first-named condition. In such a girder with vertical stiffeners, it appears to me that the character of the web stresses are, so far as the intermediate stiffeners are concerned, exactly the same as in a girder without stiffeners; and for the following reasons. 1. In a girder without stiffeners (assuming no buckling to occur), the web is subjected to stresses which are tensile or compressive on surfaces inclined at 45° with the axis, and pure shearing stresses on surfaces parallel to, or at right angles with, the axis. 2. Granting 1, it follows that in such a girder the longitudinal distortion of a vertical strip of the web is zero, there being no tensile or compressive components in a vertical direction. 3. An angle riveted to a vertical strip of the web in which there is no longitudinal distortion produced will not itself be distorted, and therefore will receive no strain.

The above may be objected to on the ground, that, while it may apply to girders with thick webs, it may not apply to those with thin ones; but I see no reason why the general distribution of stress should be any different in girders with thin webs and stiffeners, than in those with thick webs and stiffeners, provided always that incipient failure has not occurred. End stiffeners, and others attached in the vicinity of heavy concentrations, will receive more or less stress; as the tensile and compressive stresses in the web at such points vary more or less from a 45° inclination.

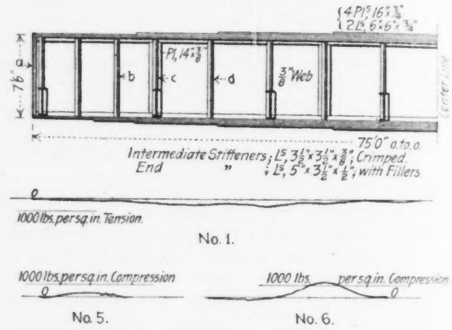
In applying Professor Johnson's proposition regarding the distribution of a load over several paths, there appears to be some confusion in the use of the terms "rigidity" and "strength." A web plate, no matter how thin, is just as rigid in compression as in tension so long as buckling does not actually take place, though it is of course ultimately not as strong. In a girder, then, in which buckling is prevented, there is as much reason to suppose that the web stresses follow down the web and up the stiffeners, as in a Howe truss, as to suppose that they follow the lines of a Pratt truss. The stresses are, indeed, all provided for without distorting the stiffeners at all, as I have attempted to show.

The behavior of a girder after partial failure has occurred is very clearly illustrated by Mr. Wilson's model; and it is readily seen that as soon as buckling begins and the distortion of the web in compression is greater than in tension, compressive stresses will be developed in the stiffeners and total failure cannot take place by the buckling of the web alone.

I have recently made some observations on the stiffeners of a through girder of 75-ft. span by means of a Fraenkel extensometer, and the results are given herewith, together with a sketch of the bridge, on which are indicated the position of the stiffeners tested. Stiffeners b and d were on the inside, as shown, while a and c were on the outside of the girder:

No. of experiment.	Stiffeners tested.	Observed max. stress. (Lbs. per sq. in.)	Calculated shear on girder. (Approx.) (Lbs.)
1	d	500, tension	50,000
2	c	600, "	57,000
3	b	300, compression	62,000
4	b	300, "	62,000
5	b	300, "	62,000
6	a	1,200, "	72,000

The extensometer was adjusted in each case to measure the distortion of a meter's length of the stiffener about mid-



Extensometer Curves from Stiffeners on 75 ft. Plate Girder Bridge.

way between top and bottom. The calculated shears are for sections taken at the stiffeners in question; they indicate what the small column, consisting of two stiffeners and a narrow strip of web, would have to carry under the assumption that the web acts as a Pratt truss.

The small stresses actually observed in the intermediate stiffeners, some tensile and some compressive, are, no doubt, secondary stresses due either to the effect of local loading or to some slight lateral bending in the girder. The considerable compression in the end stiffener shows the effect of concentrated loads.

I enclose also a tracing of three of the curves obtained. No. 1 was caused by the passage of two locomotives and caboose, while Nos. 5 and 6 were in each case produced by a locomotive running light. The diagrams were drawn from left to right.

Yours truly,

F. E. Turneaure.

University of Wisconsin, Madison, Wis., Sept. 14, 1898.

Notes and Queries.

Concerning the casting of large size wheels for locomotive and car trucks, discussed in our issue of June 9 and Sept. 8, Mr. Andrew J. Vaughan, of Providence, R. I., who was at one time foreman of the old Hinkley Locomotive Works at Boston, writes us that chilled wheels as large as 42 ins. were successfully cast at those works.

E. D. S. asks whether brass pipe laid underground would be affected by electrolysis, or would be liable to corrosion from other causes?

It is now definitely established that pipes of any material, or metal covered cables are subject to electrolysis when in the vicinity of electric street railway systems or lighting plants using a ground return. Corrosion occurs independent of any electrolytic action in nearly all localities, and especially in cities and places where the soil contains chlorides, sulphates and nitrates, together with any moisture. Temperature of the pipe also plays a part in the corrosive action, there being what may be termed a "critical temperature" at which the action is most rapid. In other words, a pipe conveying steam will be corroded more rapidly than one carrying water.

Regarding the amount of eating away by either electrolytic action or corrosion, or both, of brass pipe in comparison with other materials, such as iron, copper or lead, we know of no positive data. A study of the chemical equivalents of the various metals used in underground construction will, however, indicate that common brass pipe, containing about 70% of copper and 30% of zinc, would suffer from electrolysis somewhat more than iron pipe and not so much as lead. Approximately, a current of one ampere flowing steadily from an iron plate of ample proportions will remove about 20 lbs. of iron per year. Under the same conditions 75 lbs. of lead could be removed and brass would suffer a loss somewhere between these figures.

MUNICIPAL ASPHALT PLANTS are recommended by Mayor Van Wyck for New York city, to meet an alleged combination among asphalt paving companies. This resolve is a result of the late bidding for laying asphalt strips for bicycles on streets connecting the Borough of Queens and Long Island City. The engineer's estimate was $22,000, but the bids received were $14,000 in excess of this estimate. The comparative narrowness of the strips may have something to do with the excessive price.

THE ORIGINAL PAIGE TYPE-SETTING MACHINE, one of the most ingenious and intricate pieces of mechanism ever invented, has been presented to the museum of Sibley College, Cornell University, by Mr. P. P. Dodge, President of the Merganthaler Linotype Co. of New York city. The Paige machine was the invention of a mechanic in Hartford, Conn., and while it was a marvel of mechanical ingenuity, it was so complicated and of such delicate and intricate and expensive construction that it never had a chance of commercial success. The patent upon the machine is one of the most voluminous that was ever granted by the U. S. Patent Office, and it is said that the patient attorney who prepared the specification and claims was made insane by the work. Over $2,000,000 is said to have been sunk in developing the invention. The chief contributors were business men of Hartford, Conn., among them being Mr. Samuel L. Clemens (Mark Twain).

THE THREE BATTLE SHIPS ordered by the last Congress were let on Sept. 14, one each to the Cramps, Newport News Shipbuilding Co., and to the Union Iron Works of San Francisco. These contracts call for ships of 12,500 tons displacement, a coal capacity of 2,000 tons and a speed of 18½ knots. Within the next few weeks contracts will be let by the Navy Department for four coast-defence monitors; 12 torpedo boats and 16 torpedo boat destroyers. Commodore Watson announced to the Navy Department that the Spanish cruiser "Maria Teresa," sunk at Santiago on July 3, will be floated. Ten 6-in. rapid-fire guns have already been removed from this vessel and placed on the collier "Leonidas."

ANNUAL CONVENTION OF THE STREET RAILWAY ASSOCIATION OF THE STATE OF NEW YORK.

(Concluded from page 181.)

A paper, by Mr. D. F. Carver, Brooklyn Heights R. R., Brooklyn, N. Y., was the next on the list, and from it we have taken the following points of interest:

Track Construction.

The development of street surface railways from their operation by animal power to their operation by cable or by electric power has made many changes in track construction a necessity. The first essential of good track construction and good pavement is a good foundation. In a majority of cases this exists naturally at the depth at which ties are laid. If the natural foundation is not suitable, it can be made so by the use of broken stone or gravel. The ties should be of the best quality of yellow pine, sawed four sides, and of a size sufficient to give a bearing on foundation of not less than 4½ sq. ft. per tie. A very excellent and economical spacing has been found to be 24 ties to a 60-ft. rail. All ties should be thoroughly tamped near the rail, and the joint ties tamped throughout their lengths. The dirt under the base of the rail should also be thoroughly tamped, otherwise there will be a settlement which will allow the paving stones next the rail to be forced down.

The rail used should be of hard steel, and of a section that will give it great stiffness. The tread should be either level, or, as is becoming common practice, should bevel, so that the wheels will have a bearing for the width of the tread. This latter arrangement gives greater contact for traction and stoppages, and also causes less damage to wheels that are skidded in an emergency stop. As the lightest section of 9-in. rail is more than amply strong to stand the strain of carriage, provided, of course, that every tie has a first-class bearing, it has been found desirable to roll the web down to the thinnest section possible, and accept the small losses due to rails splitting along the web from the tension caused by the very unequal distribution of metal. The breakage above referred to has been found to be, throughout a year's work, about 0.25% of all rail laid.

The problem of the rail-joint has been a very trying one, but it is fast approaching a successful and satisfactory solution, the essential features of which are either a welded joint, which makes a rail practically one continuous mass, or the mechanical joint, which avails of the bearing surfaces beneath the head and tram, and beneath the base, and of the upper surface of the base of the rails which it connects. Either joint, to be entirely successful, however, must be laid with tight joints, so that passing wheels will have a continuous bearing.

This method of construction will, in time, force the track out of line, and where the line is curved to any extent will push the curve out of line; and also in renewing any portion of the track in warm weather, it will be found almost invariably impossible to put in new pieces of the same size as the old removed, because the great compression strain closes up the opening. Still, with all these objections, the added length of life of joints gained, is of decided advantage.

In paving the street, the portions outside the outside rail and between the tracks should be paved and thoroughly rammed before the sections between the rails are paved. This prevents the crowning of the stones between the rails from forcing the track out of gage.

A bed of concrete between ties has been tried to prevent the paving blocks from sinking, but such experience as the writer has had with this construction has not been very satisfactory, and as its first cost is great, and also as the interest on this extra investment is, in many cases, greatly in excess of the maintenance charges which it is intended to prevent, he is led to doubt very greatly its utility.

The question of track bonding was considered in a paper presented by Mr. R. P. Brown, Electrical Engineer, Brooklyn Heights R. R., Brooklyn, N. Y., which is abstracted as follows:

Track Bonding.

Several systems of track bonding have been tried upon the Brooklyn Heights R. R. since its operation by electricity. Originally the familiar supplementary ground wire with branches to the track and copper ground plates were employed, no dependence being placed upon the rails for returning the current.

The next step was to install return feeders with frequent taps to the supplemental wires. Increasing traffic caused an excessive return feeder outlay, and in 1895, when it became necessary to relay the tracks, it was decided to use the rails for at least part of the return circuit. The bond adopted was a short cast-copper plate (5 x 1-16-in.) the full width of the base of the rail, with about 12 sq. in. contact between the bond and the end of each rail.

The connecting piece of metal was curved so as to allow for expansion. To secure good connection, a re-enforcing plate of cast iron was placed underneath the area of contact and the bond pressed firmly against the rail by ½-in. bolts passing through the base of the rail. No machine work was necessary other than grinding the contact face on the bonds and removing the scale from the rail where the bond was to be applied by grinding with a portable emery wheel.

Recent tests show these bonds to be practically of the same resistance as when first installed, three years ago. The cost of these bonds was not greater than that of the No. 0000 bond going completely around the fish-plate, and having two or three times the electrical resistance of this connection. The difficulty of attaching a bond underneath the base of the rail, however, was considerable, requiring careful supervision to insure good results. This trouble led to further investigations, with the result that a bond electrically brazed to the rail was adopted the following year. This bond was somewhat cheaper than the plate bond and good work was more easily obtained on account of the better chance of inspection.

At present the bond which has been adopted as standard on all lines of the system having heavy traffic is made in two parts and brazed on the rails before they are removed from the yard. The shape of this bond depends on whether it is to be placed on the web of the rail, so as to come underneath the fish-plate, or as they are now applied, on the base and upper flange of the rail, outside of the joint plate. All forms of the bonds, however, are made up of 10 or 12 leaves of 1-64-in. soft copper, the carrying portion of the bond being 1¾ ins. wide, and the brazed contact having an area of about 1 sq. in. Soft spelter, with suitable flux, is used in brazing the copper to the steel rail. The bond is divided longitudinally into three parts, so as to give greater flexibility. When the rails are in position, the ends of these bond leaves are interlaced and fastened together by rivets and also by solder. The length of the bond between center of contacts is 5 ins., and its cross-section is equal to 350,000 circular mils.

On the lines having light traffic the short "horseshoe" bond has been placed underneath the fish-plate. These bonds are 3¼ ins. in length, of 0000 cross-section, and have ¾-in. diameter terminals. As a measure of safety, as well as to lower the resistance of the joints, all rails are double-bonded whether the brazed or horseshoe bonds are used. The holes for these bonds are drilled by the makers of the rail, and they are reamed out with emery paper to remove the rust that may have formed during shipment. If care is used in compressing the terminal of those bonds, there is no necessity for drilling or reaming of holes on the ground, as any slight irregularity in the drilling fills up when the soft copper is thoroughly upset.

Curved rail, switches and other special work are often difficult to bond satisfactorily in the yard, and the joint plates are of such section that the bond cannot be placed underneath. In such work long bonds going round the fish-plates are used. On account of the excessive wear on special work the joints are particularly liable to loosen, so that the bond must be extremely flexible.

It has been found that if a simple bond is used, it should be placed at the center of the web of the rail if sufficient contact can be obtained at that point. If contact is made at either the base or upper flange, the length of the circuit is increased by the height of the rail.

Contrary to the former practice of tinning the bonds and supplementary wire, the bonds and their exposed copper surfaces are carefully coated with an insulating paint, so that if there is any flow of the current in the track to the surrounding soil it must leave from the steel and not from the copper. This prevents the bonds being destroyed by electrolysis or other corrosive action.

To guard against imperfect workmanship, a system of testing bonds has been practiced. Usually only the joints on one line of rail are tested, though in sections of high current density, as in the vicinity of power houses, the resistance of each joint is obtained. The test is a simple comparison of the fall of potential across the joint and on a measured portion of an unbroken rail. Two Weston milli-voltmeters, with scales ranging from 0.001 to 0.3 volt are used; the readings being taken simultaneously. Contact is obtained by pressing hardened steel points on the surface of the rails. These points are set in wooden blocks and placed 6 ins. apart if used on the joints and 2 ft. apart for tests on solid rail. The distance on the rail is taken for 2 ft. instead of 1 ft., on account of the small amount of current flow in the rail on some of the lighter lines. These testing terminals are provided with handles of convenient length so that the person using them can stand upright and apply the necessary pressure with one foot. Two men can test joints very rapidly with this outfit. The current density of some of the rails was too low to give reliable readings with these instruments, so a portable resistance was arranged on a wagon and the necessary current readily obtained from the trolley wire. This resistance allowed about 300 amperes to flow from the line to the rail, and as it could be very quickly applied, rendered it a comparatively easy matter to test the joints in any section of the city.

Although the bonds are less than 6 ins., that length was selected for the distance between terminals of the voltmeter used in testing joints, because it gives a convenient fraction to subtract from the length of each rail in arriving at the total resistance in line of track. The drop on this 6 ins. was considered as increasing the length of the rail by an amount proportionate to the drop in the rail itself. From this the percentage that the rail of any line approached the conductivity of the solid steel rail could be easily determined.

The following results were obtained from different joints:

—Drop in volts.— Rail.	Joint.		% of conductivity of solid rail.
1 ft.	1 ft.	Falk Joint.	
0.00215	0.00355	(30-ft. rail)	98%
		(60-ft. rail)	99%
		Double Brazed Bond.	
0.00725	0.00758	(30-ft. rail)	99.8%
		(60-ft. rail)	99.9%
		Johnson Bond.	
2 ft.	6 ins.		
0.00364	0.00342	(30-ft. rail)	95.6%
		(60-ft. rail)	97.8%
		Plate Bond.	
0.0109	0.0233	(30-ft. rail)	89%
		(60-ft. rail)	94%

It will be seen by the foregoing that it is a comparatively easy matter to get a conductivity of over 90% of a continuous steel rail. As high as 600 amperes can be safely carried on any of the bonds mentioned, and the cost of double bonding in a satisfactory manner should not exceed 75 cts. per joint. The conductivity of steel varies with the amount of carbon in its composition, but, generally speaking, it is about ⅙ of the conductivity of commercial copper. Bearing these facts in mind, it will be readily seen that it is much cheaper to make the return circuit wholly of well-bonded steel rails, supplementing the track in the vicinity of the power house with worn-out rails carefully bonded.

Other papers of interest were read on "Individual Fare Boxes: Are They Practicable," T. J. Nicholl, Rochester, N. Y., and "The Relation Between the People and the Street Railways," J. T. Little, Jr., Metropolitan St. Ry. Co., New York.

After the close of the afternoon session, the visiting railway men were treated to a special exhibition of fireworks at 8 o'clock, which included several special features. Immediately afterward the banquet was held in the dining-room of the Manhattan Hotel, with Hon. Tom L. Johnson as toastmaster.

The morning session on Sept. 14 was devoted to the consideration of such topics as "The Repair Shop," "Municipal Ownership," "The Care of Dynamos," "General Track Construction," "The Use and Abuse of Transfers," "Pointers on Store-Room Accounts," "Long-Distance Power Transmission," "Pleasure Resorts: Are They Profitable?" "The Use of Air and Power Brakes on Street Cars."

At 11 o'clock, the members and visitors took trolley parlor cars at Sheepshead Bay bound for the navy yard, where some time was spent. Later, a steamer was taken, which left from the Bridge Dock and sailed down New York Harbor, up the Hudson, through Spuyten Duyvil and down East River to the Battery landing. On the way luncheon was served, and the following officers were elected to serve for the ensuing year: Pres., G. Tracy Rogers, Pres. Binghamton R. R. Co., Binghamton; First Vice-Pres., W. Caryl Ely, Pres. Buffalo & Niagara Falls Ry. Co., Buffalo; Second Vice-Pres., Albert L. Johnson, Pres. Nassau R. R. Co., Brooklyn; Secy. and Treas., Henry A. Robinson, Solicitor Metropolitan St. Ry. Co., New York; Members of Executive Committee, H. H. Vreeland, Pres. Metropolitan St. Ry. Co., New York; John W. McNamara, Treas. Albany Ry., Albany; Henry M. Watson, Pres. Buffalo Ry. Co., Buffalo; Clinton L. Rossiter, Pres. Brooklyn Heights R. R. Co., New York.

ANNUAL CONVENTION OF THE ROADMASTERS' ASSOCIATION OF AMERICA.

The sixteenth annual convention was held at Denver, Colo., Sept. 13, 14 and 15, the headquarters being at the St. James' Hotel. The meetings were held in the hall of the Chamber of Commerce, and the exhibits of the Road and Track Supply Association were in an adjoining building. It was a very successful meeting, and the attendance was exceptionally large. The opening session was called to order at 9 a. m. on Sept. 13, when the president, Mr. A. M. Hawkins (Norfolk & Southern R. R.) delivered a brief address. A few brief remarks were then made by Mr. Burnett, the founder of the association, after which the Secretary and Treasurer, Mr. J. B. Dickson (Chicago & Northwestern Ry.) read his report. The financial report showed the following summary: Receipts, $2,287; expenditures, $1,523; balance on hand, $764. The Hon. Alva Adams, Governor of the State of Colorado, then delivered a short address of welcome, in which he referred to the important relation of railways to the development of the country, and spoke of George Stephenson as having been the original "railway man," as he was at once a civil engineer, mechanical engineer, locomotive engineman, roadmaster and superintendent. Another short address by Hon. T. S. McMurray, Mayor of Denver, closed the formal part of the procedings.

The election of officers was next taken up and resulted as follows:

President, T. Hickey, Michigan Central R. R.; First Vice-President, J. M. Meade A., T. & S. F. Ry.; Second Vice-President, C. B. Teller, Denver, L. & G. Ry.; Secretary and Treasurer, J. B. Dickson, Ch. & Northwestern Ry.; Member of Ex. Com., C. E. Jones, C., B. & Q. R. R.

A paper on "Discipline, in its Practical Application to Track Forces," by Mr. H. W. Church (Lake Shore & Michigan Southern Ry.), was then read by the Secretary. Its object was to advocate the so-called "Fall Brook" or "Brown" system. The paper was printed, slightly condensed, on page 173 of our last issue. In the discussion two or three members reported the system as in use in the track departments of their roads (including the Toledo & Ohio Central R. R.), taking in the roadmasters, supervisors and foremen. It was further stated that a roadmaster ought to try to educate his men and make something of them, instead of arbitrarily punishing them by suspension or dismissal.

The first business of the afternoon session was the discussion of a proposed amendment to the constitution changing the name of the association to the "Railway Maintenance of Way Association," but this amendment was lost by a vote of 24 to 45. Two minor amendments were adopted, one referring to the rights of honorary members and the other giving associate members (former members who have left railway service), the right to speak on the floor only by permission of the chair.

The report of the committee on "The Best Method of Preventing the Creeping of Rails," (p. 171 of the last issue of Eng. News), was then read, and brought out a little desultory discussion in which a few members presented their individual experience.

The next committee report taken up was a very long and elaborate discussion of the merits of tie-plates, and was, it may be remarked, one of the most complete studies of the subject that has appeared in engineering literature. We condense it as follows:

Tie Plates—Benefit and Results Obtained by Their Use.

This Committee was called upon to report on:

Tie Plates; The Benefits and Results Obtained from Their Use; which is the best, most easily applied, and most effective; a tie-plate having a projection which runs parallel with the grain of the wood, or one which has a projection which cuts across the grain of the wood; and that as many plates of each kind as have been in use be obtained, and also a portion of the ties in use, be brought to the meeting for actual observation, not removing the tie from the plate.

We feel that this committee has been asked to decide upon too much; for, in connection with "tie-plates, the benefits and results obtained from their use, etc.," must be considered the conditions as to differences in the kind of ballast and of the tie, the weight and the size of the rails used, the number and effectiveness of track men to a certain section, the various climatic conditions; besides, also the amount and weight of traffic and the kind of motive power and rolling stock. All these different conditions and forces have to be taken into consideration in each case, both individually and severally, and in different parts of the country. It is thus clear that a large number of facts and conditions, in each case, must be collected, segregated and analyzed, to obtain the facts as to which is the best plate, and each case must then be considered in relation to the other cases under consideration, and as this entails a vast amount of labor and careful study it is clearly beyond the ability of any body of busy railroad men to so consider these cases in one year as to point out positively and definitely to one plate and say, "That is the best plate." This is made the more difficult also from the fact that through the experience gained by manufacturers in the use of their plates they are enabled from time to time to improve them, which necessarily means a constant change in the form and type of the tie-plate. However, considering the cases which have come under the personal observation of this committee in connection with the answers to inquiries which we have sent out to many experienced railroad men who have used the various types of tie-plates, we beg to submit recommendations as to the general construction and use of tie-plates, which we herewith submit, with the facts and general information from which we have drawn these recommendations:

1. That tie-plates be used always in preference to rail braces for greater safety and higher economy.
2. That tie-plates be used on all ties where the life of the tie is limited by the cutting or sawing action of the rail.
3. That tie-plates be used on all ties whose life is limited on account of the destruction caused by spike killing.
4. That tie-plates with soft ties be used in preference to hard ties without any plates, when the natural life of the soft tie is equal to or greater than the natural life of the hard tie, cost being equal.
5. That the only plate used be one which becomes practically part of the tie.
6. That as a tie-plate is intended to prevent the cutting action of the rail flange across the wood fibers of the tie, the plate used should not itself cut such fibers and should prevent the rail from cutting them.
7. That a tie-plate having sufficient thickness to resist buckling, sand wear and rust, during the natural life of the tie, should be used.

General Considerations.—A tie-plate is a thin piece of metal placed beneath the rail and on top of the tie, with the object of preventing the latter being destroyed by the action caused by the movement of the former. It is not a rail chair, but is distinguished from the latter in being thin and light and often having a less bearing surface on the tie than the base of the rail would did it bear on the tie. The chair is a heavy piece of metal supporting the rail, and gives a greater bearing on the tie than the rail would if it rested on the tie.

In 1871 the first patent on a tie-plate proper was obtained. This was circular and had three teeth below it, but it did not come into extensive use. Several other patents were issued from time to time, but none of them, so far as we are aware, was ever put into practical use. In the '80's the first Servis tie-plate was invented and shortly afterwards put into use on a small scale.

This was abandoned for an improved one, and this latter was soon put into use on the Manhattan Elevated R. R., in New York, where such a device was badly needed to preserve the expensive ties in use and to economize the difficult tie renewals. Later came the C. A. C. Then the Goldie two-flanged. And shortly afterwards the Servis four-flanged, and the shoulder plate was put on the market. Then the Goldie claw, the Wolhaupter arch and girder tie-plate, and the Fox tie-plate were put into commercial use. Many patents have been secured on tie-plates, but the aforementioned plates are those which have been in use extensively, or are now in practical use.

The forces and strains to which plates are subjected are as follows:

1. As a wheel rolls over a rail each tie is loaded consecutively, and the ballast is compressed. The rail bends and takes an undulatory, wavy motion, or lever motion; the

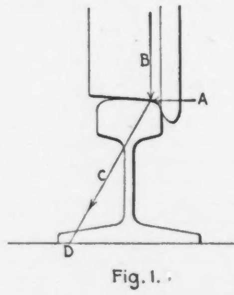


Fig. 1.

portion ahead and behind the wheel being higher than at the wheel. When the loads are heavy and the rails light, and ballast poor, the action is excessive.

When the wheel is between two ties having plates on them, one edge of each plate is loaded. This has a tendency of raising or loosening the other edge of the plate, and at the same time causing the tie to churn—the wider the plate the greater this tendency is—and it is, therefore, apparent that a narrow plate is the best to resist these forces. This rising and falling of a light rail on a plate allows also small particles of sand to enter between the rail and the plate, which thus become an abradant, producing an injurious action on both rail and plate, if continued for any long period, and it would, therefore, appear that particularly where the rails are light some means should be provided for the excluding of this sand.

2. Another loading comes directly from the rail, and is of a compound nature, which is the chief source of tie destruction. This load is illustrated in Fig. 1.

The wheel flange is bearing sideways against the rail head, caused by the centrifugal force when it passes around a curve, or from the sway of the train. This force is shown by arrow marked A. The tread of the wheel is also bearing vertically down upon the head, shown by arrow marked B, and these two forces applied to the head of the rail produce a resultant force, shown by arrow marked C, through the rail which strikes the plate at a point marked D, near the outer edge of the rail flange. At D it is resolved into its two components again, with the result that there is a lateral force equal to A tending to slide the rail on the plate and widen gage, and with the vertical force B tending to press the plate into the tie and crush the fibers. This vertical force, B, will be found to be always much greater than the lateral force A.

Considering now the relative merits of a tie-plate and a rail brace to withstand these forces on a curve, it will be seen that in the case of the rail brace the small lateral force against the head is resisted by the upper portion of the rail brace and is taken care of by it, but as the vertical force is applied near the edge of the outer flange of the rail, this flange soon cuts into the wood and abrades it and allows the outer flange to become lower than the inner one and carries down with it the upper edge of the rail brace, tilting up the outer end, as shown in Fig. 2. It will be, therefore, seen that while a rail brace may take care of a small lateral force, it does not take care of the greater vertical force applied near the edge of the outer flange of the rail.

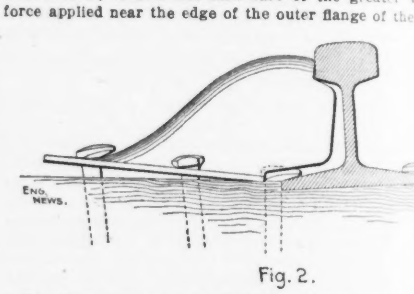


Fig. 2.

Considering now a properly designed tie-plate in place of a rail brace, we find that the great vertical force applied near the edge of the outer flange of the rail is taken care of by the plate and distributed over the tie beneath the plate and prevents the outer flange from cutting into the tie and canting the rail; but it is clear that to properly distribute this loading from the edge of the outer flange there should be more metal in the plate beyond the outer flange than beyond the inner one. The small lateral force causes the rail to slide outwardly on the plate, but this is prevented by the spike or shoulder outside of the rail, and as the plate ties the inside spike to the outer one the inside spike therefore also resists this tendency of the rail to widen gage; consequently, if there are as many spikes through the tie-plate as there would be through the rail brace, the tie-plate will prevent this lateral motion of the rail just as thoroughly as the rail brace would; but, as shown above, it also prevents the rail canting, which the rail brace cannot do. It is, therefore, very clear that a tie-plate is much better than a rail brace, and a tie-plate with more metal beyond the outer flange than beyond the inner one, is better than one which is equal at both ends. It is evident, of course, that the more metal, or shoulder, there is placed on top of the plate outside the outer flange of the rail the longer such metal will resist the wear from the lateral force, and as a continuous flange from edge to edge of the plate will give the most metal, such a flange would appear to be the most desirable, other things being equal, than a single spike, or even two spikes, particularly where the lateral force is extreme. However, there are many millions of plates in use, doing excellent service, without any shoulder, and there are difficulties, also, in shimming such shoulder plates in winter.

The above excellent features of a tie-plate on a curve also exist on tangents, but to a smaller degree. On tangents there is not only the great vertical force from the wheel, but there is more or less lateral force produced by the swaying of the train, trucks skewed out of level, etc., so that the tendency of all rails on tangents is to take an outward cant as well as on curves. This outward cant means widening of gage. This again means increased sway of the train, which again reacts upon the rail. If rail braces are used the tie must be constantly adzed to bring the rail to the perpendicular, thus destroying the tie and destroying the compact bed of the ballast. The rail brace must be removed and again respiked, thus spike-killing the tie, and all necessitating the spending of a great deal of time and labor.

Reports from Practical Experience.—In order to obtain, as far as possible, reports from practical experience, of the comparative merits of the different tie-plate used side by side in track, as well as the general experience with the use of any one kind of tie-plate, a circular letter was sent out to a large number of roadmasters and supervisors of our important railways in different portions of the country.

The following were the questions asked and answered:

1. Kind of tie-plate in use? 2. How long in use? 3. How do you apply them? 4. What is the average cost of applying a plate? 5. Have you the different kinds of plates under nearly the same traffic? 6. Kind of tie used? 7. Do you use them on curves only: if so, give the minimum of curvature? 8. Do you use them on every tie? What is your practice in regard to this? 9. Do they move longitudinally; if so, under what conditions? 10. What kind lengthens the life of the tie the most? Remarks.—Under this head state the amount of labor saved in respiking and other work incident to cutting ties, including any other information of interest.

We received a report from only one supervisor who had all of the different types of plates in use, but as this supervisor has nearly three-fourths of a million plates of the different kinds in use, about half of them having flanges across the grain of the wood and the other half with flanges parallel with the grain of the wood, and "has been using plates for the last six years," and as he has been studying them with care, his report is of great value. These plates were used on "yellow pine, chestnut and cedar ties," and he "drives them home with a heavy sledge," and says the cost of application varies from ⅜ to 9-16 ct. per plate. The plates are all used under the same kind of traffic and on curves "from two degrees up," and on "every tie on curves." They do not move longitudinally. His experience is that the plate which lengthens the life of the tie most "is the one with longitudinal flanges." Under "remarks" he states that at some curves where it was necessary to roll the rail and regage the track each year, "since plates have been put on these curves they have been kept in perfect gage and it has not been necessary to roll the rail in the last two years, and the rail lays perfect at the present time." "I have just as good results without a shoulder as with one. A plate with a longitudinal flange adheres to a tie better than one which cuts across the grain." In addition to this report he writes further as follows:

I have had experience with the plates for the last six years under almost all conditions and have found that most of the talk about the spike shearing when it is not protected with a shoulder, is all nonsense. I find that if you keep the rails level so that they conform to the wheel base there will be no spread track, with or without shoulders. I have found that a tie-plate will lengthen the life of yellow pine ties from two to three years, and cedar and chestnut from three to five years. On curves where fast and slow trains are run the tie-plate will double the life of any kind of a tie, and when plates are properly applied they will stop the rolling of the rail, thus saving the adzing of ties to roll rail to gage and level. The plate should be so formed that the track can be shimmed without removing the plate. It should not be removed until the tie or rail is changed. I find that the plate with longitudinal flange adheres to the tie better than plates which cut across the grain. It should be formed so that it will adhere to the tie and become part of the same without injuring the fibers of the wood, and when once applied should not become loose and rattle. At the present time I have found none but the ones with long longitudinal flanges would adhere closely to the tie after they have been in track for a few years. The others will adhere to the tie for a short time, but will soon become loose and rattle.

He also writes relative to plates used in a heavy switch yard:

These plates have been in track for eight months and have saved one set of ties. Before we used plates on this track it was necessary to renew the ties once every year, and some of them every six months. The cause of ties cutting out so fast is on account of the yard being damp and quite a lot of sand being used. Since tie-plates have been used in this track the ties are good for three or four years. This is one of the cases where plates pay if they wear out every six months, but the longer they last the better they pay.

2. A division engineer who has used some of the Servis, Wolhaupter and Goldie plates, writes as follows relative to his experience with thes different styles: He used them on every tie on curves of 6° and over, and at road crossings, and they are under the same kind of traffic. The ties are white oak and he applies them by "pulling the spike and raising the track high enough to allow adzing of tie level. Place plate under rail and spike to gage. Put plates into tie by striking lightly on edge of plates. After a few trains have passed over, tighten down spikes." In this manner it costs him between 1¼ and 2 cts. to apply these plates, and he finds they do not move longitudinally and "he has not noticed any difference to amount to anything," as to which kind lengthens the life of the tie most.

3. A roadmaster who is using Servis and Goldie tie-plates reports as follows: He uses them on white oak bridge ties only, and drives them into the wood with a 12-lb. sledge, which costs "about 1 ct. per plate." They are used "on every bridge tie," and "do not move longitudinally." He finds that the labor saved is about 50%, and says that he considers the Goldie lengthens the life of the tie most and gives better service than the Servis. The latter buckles.

4. An old, experienced roadmaster, who has about 70,000 Servis plates in track, reports as follows: He has used them on "2½° curves with oak, on cedar switch sets, and on center joint ties, where three ties are used." He applies them "by the aid of Ware's tie-plate surfacer and gage," and cost of applying is ½-ct. in ties out of track and less than 1 ct. when ties are in track. Oak ties used in both cases. He uses them on every tie, and finds they do not move longitudinally, and does not know which plate lengthens the life of the tie most. Under "remarks" he says:

Having had 45,000 in use since 1892, on oak ties and on curves of 5° to 7½°, have not had to regage any part of it, and as the surface of the plates has not gone below the surface of the tie, and work of surfacing and regaging, caused by the rail cutting into the ties, has been entirely eliminated by their use. As an element of safety they are invaluable.

5. A division roadmaster, who is using the Wolhaupter and Servis plates, reports as follows: He has used these plates on white oak ties, on curves, since 1893-4, and he applies them by "pulling the spikes on every other tie, adzing the tie, and then driving the plate under the rail, which partly beds the plate in the tie. After a few trains pass over I then go back and apply them on the other ties." He says the average cost of applying them is "about 1 ct. per tie-plate." He uses them on curves "only 5° the minimum; under same traffic over both kinds of plates." He says, "I have had no trouble with them moving longitudinally." As to which lengthens the life of the tie most, he says, "The Wolhaupter Arch and Girder will give the best satisfaction. The Servis plates I have in use buckle; that is, turn up at sides of the rail." Under "remarks," he says: "I have used the plates on 5° to 10° curves. Before I put plates on these curves I had to adze the ties and regage the track once a year. Cost of doing this work, about 2 cts. per tie. I have had tie-plates on part of these curves for the last four or five years, and have not had to regage the track since the plates were put in. Before using the plates on these curves the ties would last four to five years, but by using plates we can get the full life of the tie, eight and nine years."

An engineer who has a large number of Servis and less than 100, each, of Wolhaupter and Goldie plates, says he uses the plates under the same kind of traffic and on oak and cedar, and merely "lays them on the tie." The cost of application is "practically nil." He uses them on both curves and tangent, on curves up to 18°. As to longitudinal movement, "under light rails and heavy traffic they move."

7. A railroad man who has a few of both Goldie and Servis plates in use on oak and pine ties, on joints only, states that they do not move longitudinally; that he prefers the Goldie, and that he finds considerable labor saved in the course of a year in re-spiking, adzing, etc.

8. Another roadmaster who is using a few of the Goldie and quite a number of the Servis, says he uses them on every tie, white oak, and on curves from 3° to 7°; that he applies them by "adzing to true gage, put heavy plate on top of tie-plate and sledge to close." The average cost to apply, "about 4 cts. per tie, when we have twenty to thirty trains in working hours, for the Servis, and about half that price for the Goldie." They do not move longitudinally "until the life of the tie is about gone." As to lengthening the life of the tie, "both kinds on a curve give longer life to a tie, neither kind will lengthen the life of a white oak tie on tangent." Under "remarks" be says, "The Goldie is a good, strong tie-plate, but will get loose on the tie sooner than the Servis, but the life of the Goldie will be much longer than the Servis. On a 3° curve and over, one-third labor is saved when the curve is well plated and the curve is safe. Our trains make 60 miles per hour on these curves. We use them under 80-lb. rails; 5-in. base. Have used Servis plates seven years. Like the last style of pattern best; it has a good outside lug that saves track spike and do not crack, but all plates will buckle when placed on poor ties."

9. An engineer of maintenance of way of a large traffic line, which has been one of the most extensive users of tie-plates for years, writes: "We have been using Servis tie-plates for several years past," and says, "that a great saving in the cost of tie renewals, and consequently in the expense of track maintenance, will be secured by their use. The kind of ties particularly used by us are redwood, the natural life of which (under heavy traffic) is seven years. With the use of tie-plates we hope to at least double this period."

10. A superintendent, who has had extensive experience with the use of different kinds of tie-plates, writes: "I am of the impression, however, that the Wolhaupter plates and well treated ties, with chloride or zinc solution, should give at least 30% of increase in life."

11. A superintendent of a road which uses plates extensively writes: "We believe that tie-plates materially lengthen the life of the ties, where ties are destroyed by the cutting of the rail, or by frequent spiking to maintain gage. With ties of soft wood, such as pine and chestnut, tie-plates are essential to secure the full life of the timber, and are especially so for bridge ties or switch ties. The gage is maintained easier and much better when tie-plates are used, and we can maintain much firmer bearings between rails and ties than would be possible without the use of tie-plates. Tie-plates practically eliminate the labor of regaging or adzing to turn rail. Where sand is used freely the particular damage is due to softening of the wood, caused by the moisture held by the sand around the ties at the rails. In order to get the full benefit of the plate at such places it is important that the sand be kept below the base of the rail and the top of the tie be kept dry"

It might be well, before closing this report, to state in general the benefits to be obtained from the use of tie-plates:

(1) They prevent the tie from being cut by the rail and thus preserve the tie. a. Renewals in ties are reduced. b. Level of track is maintained. c. Adzing to maintain rail vertical is avoided. d. Cost of track labor is reduced.

(2) The rail is held vertical, and thus—a. Safety of operation is increased. b. Gage is maintained.

(3) The inside spikes help to maintain gage in addition to the outside spikes. a. They dispense with rail braces. b. Prevent the rail rolling. c. Maintain gage by preventing the rail rolling.

Thus, in general, it will be seen that a properly constructed tie-plate maintains good track and thus makes a large saving in the labor of track maintenance and in the cost of repairs to rolling stock through the more perfect track which it produces. It increases the life of the tie and thus decreases the cost of tie renewals. It saves in the cost of operating, through the possibility of carrying heavier loads with the same amount of motive power.

W. J. Prindle, J. L. Single, Henry Ware, Edward Marshall, committee.

In previous years the tie-plate report has provoked much discussion; but this year the report was received with little objection, and the seven recommendations of the committee, given above, were formally approved by the association.

In the afternoon and evening there were trips to the Elitch Gardens, a pleasure resort, where a theatrical entertainment was provided.

The morning session on Wednesday was called to order at 9.30 a. m. There was no report from the Committee on Rail Joints, but Mr. Hickey exhibited a model of the joint with an inverted piece of rail for a base support, invented by Mr. A. Torrey, Chief Engineer of the Michigan Central R. R., and recently described in our columns.

Two reports were presented by the committee on "The Advisability of Increasing the Length of Rails, and the Advantages to be Derived from the Use of Rails with Miter Cut Ends." Both the majority and minority report were printed on p. 172 of our last issue. The discussion turned largely on the expansion and contraction of light and heavy, long and short rails, and the opinion was expressed that heavy long rails take up more of this movement in themselves by internal stresses, while they take longer to heat up to high temperatures. Both reports were accepted as information, on the ground that comparatively few roadmasters have had experience with long rails or miter joints, and cannot therefore vote intelligently upon their wants. The report of the committee on "Widening Gage on Curves" was then read and was probably the report of greatest practical value read at the convention. We print it substantially in full as follows:

Widening Gage on Curves.

The question of widening gage on curves naturally divides itself into two heads: First, the reason, if any, for widening; and, second, the proper amount that the gage should be widened. There is no question but that the majority of roads in the past have widened the gage on curves too much, and without any thought of the reasons for doing so. The present method of gaging wheels gives a clearance of from ⅝ to ⅞-in. on tangent, and it is evident that no good reason whatever can be assigned for widening the gage on the curve, so long as there is sufficient clearance between the flange of the wheel and the rail to permit of the wheel taking a natural position in going around a curve. In other words, so long as the wheel is not forced out of normal position by the rail, or so long as the rails are not disturbed or forced out of their position by the wheels of the truck in passing around. If this be the case, then the second part of the question is simply to find out at what degree of curvature this play would be absorbed by reason of the sharpness of the curve. As in all questions of this nature, there are two factions who do not agree upon the fundamental principles involved in a mathematical discussion. The only two authors who have ever discussed this question thoroughly are Trautwine and Searles. Trautwine's discussion of the problem is based upon the theory brought out by the late A. M. Wellington, whose experiments upon a kindred subject involving the action of trucks in passing around curves, are very elaborate, being made with large-sized models and full-sized trucks. The theory deduced by him from these experiments upon the action of a truck in passing around a curve would be expressed as follows: In any truck system the flange of the forward wheel is invariably pressed hard against the outer rail, all the other wheels standing away from the rail and the rear axle always being normal to the curve except when forced out of that position by the rear inner wheel coming in contact with the inside rail, as shown in Figs. 1 and 2.

The followers of Mr. William H. Searles oppose the Wellington theory and hold his proposition is not proven. Mr. Searles takes the position that when a truck is passing around a curve, the flange of the forward wheel is invariably pressed hard against the outer rail and that the other wheels ordinarily stand away from the rail, and that the rear axle may or may not assume a normal position. Various positions are shown in Figs. 1, 2, 4, 5 and 6. When a truck has but four wheels the other three flanges are not usually in contact with the rails, the rear wheels dividing the play between in some unknown ratio. The sharper the curve the nearer the flange will approach the inner rail, and when by reason of the sharpness of the degree of the curve the rear inner wheel comes in contact with the rail, then the middle ordinate to twice the

wheelbase will be just equal to the play allowed in setting the flanges. The rear axle will then be normal to the curve at the point of contact with the rear wheel. The sharpening of the degree of the curve beyond this point will force the rear axle into a position as shown in Fig. 2, and the flange of the rear inner wheel will then be grinding against the inner rail. In a six-wheeled truck, all flanged and with equidistant axles, the same is true as in the four-wheeled truck, up to the time that the rear inner wheel comes in contact with the rail, as shown in Fig. 4. If the curvature is then sharpened, the track will finally assume the position shown in Fig. 5, and the truck will then be wedged tight in the track, the points of contact being the outer front and rear wheel and the middle inner wheel. This happens when the middle ordinate to the chord of the wheelbase equals the play originally allowed in setting the wheel, and of course would indicate

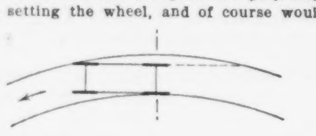


Fig. 1.

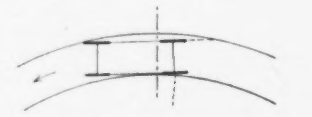


Fig. 2.

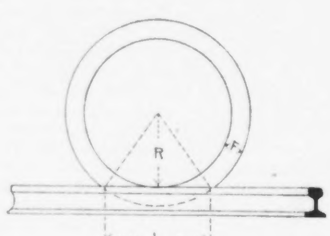


Fig. 3.

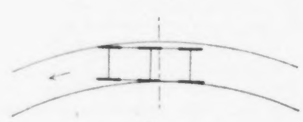


Fig. 4.

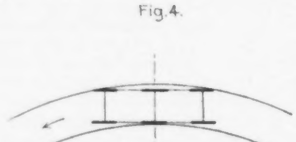


Fig. 5.

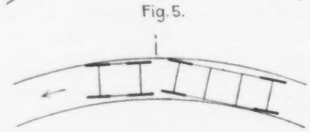


Fig. 6.

the limit of curvature of track at which the truck would go around without spreading the rails. This limit of curvature is expressed by the following formula propounded by Mr. Searles:

$$D = \frac{3825\,p}{l^2}, \qquad (1)$$

in which D = the degree of curve sought, p = the original flange play in inches, and l = the rigid wheelbase in feet.

If the middle axle is not equidistant from the others, let the distances be expressed by a and b in feet, then the formula becomes:

$$D = \frac{956\,p}{a\,b}. \qquad (2)$$

This is a general formula and applies to trucks of eight wheels, all flanged, as well as six wheels or more, and consequently is true for rigid locomotive wheelbases. Applying this formula to an engine with ⅝-in. clearance and maximum rigid wheelbase of 22 ft. 6 ins., the point at which gage should be widened is 5° 30′ curve; but if the swiveling device in the leading truck of locomotive is to be called into play in passing around a curve, Mr. Searles proposes the following equation:

$$D = \frac{956}{a\,b}\left(p + \frac{b\,s}{a+b}\right) \qquad (3)$$

in which b is the driving wheelbase, a the distance from the center of the forward driving axle to the center pin of the pilot truck, s the side motion of the center pin in inches, and p the play allowed by the flanges in inches, D the same as in the other equations. **Use coefficient 955 up to 16°. For D = 20° use 960; for D = 30° use 966,** and intermediate degrees in proportion.

This formula is based on the conditions that the center pin has exhausted its full side motion. The forward flange driving wheel is in flange contact with the inner rail, and the rear driving flange is in contact with the outer rail. Taking the same example as in the preceding problem, and supposing that the leading truck has a side motion of 1¾ ins., that the distance a is 7 ft., then b would be 15½ ft., and applying the equation (3) we find that D is equal to 16° 12′. With all the conditions assumed in this problem then, the gage would not have to be widened for such an engine up to a curve a fraction over 16°. If it were wished to determine how much a given sharper curve should be widened, it is only necessary to solve equation (3) for p, but write P to indicate the total clearance required, and then

$$P = \frac{D\,a\,b}{956} - \frac{b\,s}{a+b}, \qquad (4)$$

which, if the original clearance is subtracted, will give the amount that the gage should be widened for a given wheelbase.

A question which Mr. Searles has not taken into consideration is that the point of the flange where the wheel would come in contact with the rail in passing around a sharp curve is not vertically under the center of the wheel, as he assumed, but is a point on the wheel flange which is $\sqrt{(R+F)^2 - R^2}$ distant from the vertical through the center of the wheel. This, of course, for small wheels, could be ignored, but for large drivers on sharp curves it becomes an important factor.

Experiments having been made by your committee, they find that curves up to 6° can be laid to gage. Also, that allowance has to be made for the swiveling device on the pilot truck, owing to the fact that in a great many cases the full play is not secured. From tests this should be taken at one-half the amount. Owing to the great variety of wheel gages which pass over a road, allowance has to be made in gaging the track, consequently your committee does not recommend taking up the entire amount of clearance on curves, but rather of allowing one-half inch for any variation. Therefore, your committee would modify the Searles formula and recommend formula (3), modified as follows:

$$D = \frac{956}{a+b}\left((P - \tfrac{1}{2}) + \frac{\tfrac{1}{2}\,b\,s}{a+b}\right) \qquad (5)$$

and in place of formula (4) the following:

$$P = \left(\frac{D\,a\,b}{956} - \frac{\tfrac{1}{2}\,b\,s}{a+b}\right) - \tfrac{1}{2}. \qquad (6)$$

In view of the fact that allowance has been made for variations of wheel gage, your committee does not consider it necessary to take into account the formula

$$\sqrt{(R+F)^2 - R^2}.$$

The limit of widening the gage, in the committee's opinion, should be 1 in.

As the various roads have different clearances and a variety of wheelbases, it is impossible to give a table which would be applicable everywhere; but by substitution in the formula given, a series of tables could be gotten up by the different roads which would meet all their requirements.

As an example, in the use of formulas 5 and 6, a New York, New Haven & Hartford consolidation locomotive is taken, of which the following are the figures to be used:

Wheelbase equals 22½ ft., of which 7½ ft. is the distance from the center of the forward driving axle to the center pin of the pilot truck, and equals a in the formula. The rigid wheelbase is 15 ft., and equals b. The side motion of the center pin in inches equals 1¾ and is represented by s. The play allowed by the flanges in inches equals ⅝, and is represented by p. D equals degree of curve after which widening should begin. Substituting in formula (5), we have:

$$D = \frac{956}{7.5 \times 15}\left((\tfrac{5}{8} - \tfrac{1}{2}) + \frac{\tfrac{1}{2} \times 15 \times 1\tfrac{3}{4}}{7.5 + 15}\right)$$

$$D = \frac{956}{112.5}\left(\tfrac{1}{8} + \frac{13.125}{22.5}\right) = 8.5\,(\tfrac{1}{8} + .583).$$

$$D = 8.5\,(.708) = 6.018 = 6^\circ\ 1'.$$

or widening should begin on curves of over 6°.

Substituting in formula (6) and calculating for a 16° curve,

$$P = \left[\frac{16 \times 7.5 \times 15}{956} - \frac{\tfrac{1}{2} \times 15 \times 1\tfrac{3}{4}}{7.5 \times 15}\right] - \tfrac{1}{2} =$$

$$\left[\frac{1{,}800}{956} - \frac{13.125}{22.5}\right] - \tfrac{1}{2} = (1.883 - .583) - \tfrac{1}{2} =$$

1.3 − .5 = .8-in., or, for all practical purposes, P = ¾-in. In other words, from 6° to 16° the widening will be ¾-in., for the example in question.

If D equals 18° 30′, we have by substitution in formula (6),

$$P = \left[\frac{18.5 \times 7.5 \times 15}{958} - .583\right] - \tfrac{1}{2} =$$

$$\left[\frac{2{,}081.25}{958} - .583\right] - \tfrac{1}{2} =$$

(2.172 − .583) − ½ = 1.589 − .5 = 1.089 ins., or, for practical working, P = 1-in.

As previously stated, it is impossible to give one table which would cover all roads; but your committee would suggest for use on those having engines about of the type mentioned in the examples, a table which is practically taken from the above results:

Degree of curve.	Amount of widening, ins.	Gage of curve, ft.	ins.	Degree of curve.	Amount of widening, ins.	Gage of curve, ft.	ins.
1	0	4	8½	10	¼	4	8¾
2	0	4	8½	11	⅜	4	8⅞
3	0	4	8½	12	½	4	9
4	0	4	8½	13	½	4	9
5	0	4	8½	14	⅝	4	9⅛
6	0	4	8½	15	¾	4	9¼
7	⅛	4	8⅝	16	¾	4	9¼
8	⅛	4	8⅝	17	⅞	4	9⅜
9	¼	4	8¾	18	1	4	9½

Therefore for types of engines as mentioned, the widening of the gage should begin on curves of over 6°, and increases 1-12-in. for each degree of curvature over 6°.

F. R. Coates, A. S. Westin, R. P. Collins, J. W. Shanks, H. B. Dick, Committee.

In the afternoon of Wednesday the concluding session was held. The last report presented was that of the committee on "The Latest Improvements in Frogs and Switches" (Eng. News, Sept. 15, p. 173). There was but little discussion and the report was accepted.

The vote on the place for holding the next convention resulted in the selection of Detroit. After this, resolutions of thanks to local committees, etc., were passed, and the new officers were installed.

During the afternoon there was an electric railway trip of some 20 miles for the ladies, and in the evening Mr. C. M. Hobbs, of the Denver & Rio Grande R. R., delivered a lecture on "Switzerland and Colorado," illustrated by beautiful stereopticon views.

On Thursday there was a trip over the narrow gage Union Pacific, Denver & Gulf Ry. to Georgetown and around the famous "Loop" to Silver Plume, where the railway winds up both sides of the valley, crossing from side to side, and rises 700 ft. in four miles.

On Friday the party left Denver at 7.30 a. m. for Colorado Springs and Manitou, visiting the Garden of the Gods and ascending Pike's Peak by the Abt rack railway. The night was spent at Manitou, and on Saturday there was a trip over the Denver & Rio Grande R. R. to the Royal Gorge, returning to Pueblo for dinner. In the afternoon the party visited the works of the Colorado Coal & Iron Co., after which they returned to Denver.

The Road and Track Supply Association, made up of the supply men in attendance upon the convention, elected officers as follows: President, Wm. Goldie (Dilworth & Porter Co.); Vice-President, J. A. Ingalls (Buda Foundry & Mfg. Co.); Secretary J. A. Brown (Pocket List Publishing Co.); members of the Executive Committee, Messrs. Bray and Fisher.

ANNUAL MEETING OF THE TRAVELING ENGINEERS' ASSOCIATION.

The sixth annual meeting of the Traveling Engineers' Association was held at Buffalo, Sept. 13 to 16. President D. R. McBain, in his address, said that the competition of electric railways must be met by greater economy in locomotive operation. He believed hard steaming locomotives to be the most fruitful source of waste in the motive power department.

The report of the Secretary showed a total membership of 235 railway companies. The receipts were $1,246 and the expenses $1,196. The first committee report was on the question:

What is the Best Method to Be Pursued by Traveling Engineers in Giving Air Brake Instructions While on the Road?

The report was a very long and detailed one. Space permits an abstract of only a few points touched upon. Holding the brake set too long on passenger trains at the instant of stopping gives a disagreeable surge to the train, and may throw passengers off their feet.

When coupling an air brake engine to her train, the auxiliary pressure on engine and tender can be held down close to the train pipe pressure on the train by not charging auxiliaries up to the full pressure after each release of the engine brake, till hose is coupled ready for air to pass back to train. This will allow you to move the engine if it is necessary to do so to make any more couplings in the train. Do not test the brake until you have the standard pressure. Then make the reductions for a station stop; the first one just hard enough to be sure that all the leakage grooves are covered, and successive light ones afterward, till the train line pressure is reduced 20 to 25 lbs. On no account make an emergency reduction when testing the brake unless it is especially called for after the first test.

Take up the matter of listening for the length of the train pipe exhaust so as to judge of the number of car lengths of train pipe attached to the brake valve, and thus be able to judge whether they have all the angle cocks open. A partially closed angle cock can be detected by the intermittent flow of air from the train pipe discharged at the first reduction. A partially closed angle cock will allow the brakes behind it to set with a service application, but unless all the triples are in good order, some of them will be sure to release slow enough to jerk the train or stick altogether.

In coupling up hose, the angle cock next engine should be opened first so that the hose will be filled with air from the engine instead of from train pipe of the rear cars. Never open the angle cocks suddenly when the train pipe and auxiliaries are charged with air. It is certain to set all the brakes on that side of the empty hose with the emergency action. If the cocks are opened gradually so air will fill into hose and empty the train pipe, it is only a few seconds before it will equalize with the air in the already charged cars, and then the angle cock can be opened full. Show the trainmen how to couple onto an uncharged car or cars in a siding, and at the same time leave brakes on head end of train free, so that they can at once pull out to couple on the train and utilize the time while moving out of the side track to charge up the empty cars. In the majority of cases the last cars taken on will be fully charged by the time the stop is made for coupling on, and the test of brakes may be made then.

Take up with the trainmen the proper method of using the hand brakes in connection with the air brakes on a partially equipped train. Show them that the hand brakes should be set on the cars immediately behind the air braked cars, as that is the place where the slack in the train can be most easily taken care of, whether air or hand brakes are set or released. When releasing air brakes after hand brakes have been set on rear cars of train, it is absolutely necessary to have hand brakes next the air let off last of all. When backing out of a siding, show that hand brakes should be set on rear cars to hold the slack.

A very important point to take up with the engineers is the wasting of air in the auxiliaries by repeated applications and releases, and the still greater waste by setting the brake full on and then still further reducing the train pipe pressure below the proper amount. On a long train this may become criminal carelessness and cause a wreck by getting out of air on a bad hill.

If an engine is fitted with independent driver brakes, do not tolerate using this for bunching slack in train prior to use of train brakes, especially with all or nearly all air braked cars. These independent engine brakes should only be used independently when releasing the train brakes at slow speeds (when handling freight trains) or in bunching slack in train when going over uneven roads, "hog backs" and sags in track.

The use of pressure retaining valves on driver brakes of freight engines avoids lots of rough handling and prevents breaking in two. When stops are made for stations, water tanks and coal chutes, should the engineer see that he is going to stop too soon, and has to release the brakes, he turns up the pressure retaining valve before doing so, and thus holds the train bunched, as the retaining valve prevents the engine and front cars from running ahead. When the second application is made, there is very little chance of breaking the train in two and very little shock is felt at the rear end.

How Can the Traveling Engineer Best Instruct and Assist the Fireman in the Economical Firing of the Locomotive?

In this report stress was laid on the selection of men of some intelligence and ambition for firemen. In endeavoring to secure economy of fuel, it must not be allowed to interfere with the requirement that the engine shall hold its load and make its time. Good results can be secured by giving firemen elementary treatises on combustion, and seeing that they study and understand them. It is absolutely necessary to economy of fuel that the engine runner and the fireman should work in harmony, and the Traveling Engineer should have authority in the making up of engine crews to see that this is effected.

The Uniformity of Cab Fittings and Their Arrangement with a View of Accessibility and Utility.

The great variety in locomotives which now exists makes uniformity impossible; but whatever the type of locomotive, no pains should be spared to arrange the cab fittings where they will be most convenient for the engineer. A combination stand or turret supplied from a dry pipe in the dome, and fitted with an inside closing valve, was favored. The convenient location of the brake valve is the most important matter. It should not be so close to the boiler that the heat will injure the gaskets, and the handle should be where the engineer can reach it when he has his head out of the window looking for signals. The grouping of gages is an excellent plan, and uniformity in the diameter and graduation of the same gages on different locomotives in the same "pool" is much to be desired.

Lubrication of Locomotives; the Best Method of Reducing Hot Bearings to a Minimum with the Least Amount of Oil.

The report on this subject gave a large number of practical hints of much value, including answers to a long list of questions sent out by the committee.

The Use of Water on Hot Bearings of Engines and Tenders. Is it Advisable, and to What Extent Used? In Using Water for Hot Driving or Engine Truck Boxes, is it Used on Top or Side of Boxes?

It appeared from the report of this committee that on heavy locomotives in fast passenger service it has become quite common to fix pipes from the tender or injector pipe connections so that water can be turned on tender or engine truck journals or the driving boxes if they get hot on the road. On some roads, it is stated, that the fastest trains are only able to keep to their schedule by this means. One member stated that, besides his locomotive experience, he had been eight years in marine service, and had been in vessels where engines ran without stopping for 30 days with nothing but water as a lubricant in some of the heavier bearings.

Does the Location of Track and Station Signals in Any Way Affect the Safe and Economical Operation of Locomotives?

The following is an extract taken form the report of this committee:

Every time a train is stopped or its speed reduced, there is not only more fuel used, but there is also more strain on the machinery of the locomotive, and on the draft rigging of cars getting the train into speed again, than there would have been had the speed of trains not been checked. This means not only increased cost of fuel, but also greater cost for repairs. Track and station signals are intended to indicate to engine and trainmen whether the track ahead is clear or blocked. They should be so located that engine and trainmen can distinguish them at a sufficient distance without having to reduce speed if the track is clear or be in danger of overrunning the signal if the track is blocked. Signals located where they cannot readily be seen or distinguished, or placed where their meaning may be wrongly interpreted, are neither safe nor economical. They require every train that passes them to slacken speed and the extra expense this causes in the course of a year is a large item. In addition to this expense, there is also an element of danger connected with such signals that should not be overlooked. With the high speed at which trains are run, and the heavy tonnage hauled, engineers are compelled to take every advantage possible to keep their trains on time. With signals properly located they have no difficulty in doing this; but where signals are located obscurely, it is often a question with him whether he will reduce speed to a safe limit, or take chances on the signal showing clear track. He may do this for a number of times with safety, but sooner or later the inevitable will happen and the wrecking crew will be needed.

In addition to the reports abstracted above, the following report of a special committee appointed at the meeting met with general approval:

The bearing at the back end of main rods is a very important and often a very troublesome one, and it is necessary that the brasses of these bearings be carefully fitted—that is, filed so as to be free of bearing at the joints of brasses and for a distance not less than a ½-in. from that point. The fitting of brasses to back end of main rods should be done so as to leave them free from the pin at all points. The size of the oil hole in all rod brasses should be as large as the oil hole in the strap. When the temperature of a brass bearing has been sufficiently raised to cause a discoloration it will ever afterwards be found unreliable.

With proper mechanical conditions existing, engine oil is the proper lubricant for all rod bearings. In the event of a pin becoming heated, valve oil (owing to its higher fire test) should be used. Engine oil should also be used for the lubrication of eccentrics. These should be supplied through a cup similar to that used on rod bearings. There should be a cellar in eccentric straps, oil cups on rocker boxes, also packing in link block oil holes. A link motion judiciously oiled can safely be run from 75 to 100 miles with one oiling. Oil cups which can be shut off at the end of each trip should be used for the guides. Oil applied by hand is wasted.

It will be found a valuable aid towards keeping cylinders, pistons, piston rod packing, valves, valve seats and valve stems in good condition to keep the main throttle valve slightly open when going into stations or down long grades, as it overcomes the vacuum forming tendency of the main pistons and prevents the drawing into the cylinders and steam chests of the smoke-box gases.

It is a good practice to groove the face of the piston packing rings, with the object of reducing the area of the surface of the ring in contact with the cylinder surface, as well as forming a partial balance to the piston and a receptacle for oil. The best point to have oil reach the driving and engine truck journals will be found to be as near the horizontal center of the journals as is possible. The use of a driving box cellar which will permit of the inspection or renewal of the packing without taking the cellar down is advisable. Enginemen should be instructed not to stir up the packing on the top of driving boxes, as it has been found to result in the heating of those journals, owing to the dirt which accumulates there being carried with the oil into the oil holes and onto the journals.

It is a necessary requisite for engine or car oils to be of such a consistency as will permit a free flow at atmospheric temperature. Tender truck journals should be lubricated by roundhousemen, who should be instructed to inspect these parts each trip to see that the packing is saturated with oil and kept in close contact with the journals. The best results are obtained by assigning this work to special men. Where engines are not equipped with a device which assures a constant feed of oil to the valves and cylinders of high pressure engines at all times, the enginemen should be instructed to vary the main throttle opening at intervals to permit the oil which has lodged in the oil pipes to flow into the steam chests.

Officers for the ensuing year were elected as follows: Pres., D. R. McBain (Mich. Cent.), Jackson, Mich.; First Vice-Pres., P. H. Stack (U. P.), Council Bluffs, Ia.; Second Vice-Pres., Charles Davies (Erie), Buffalo, N. Y.; Third Vice-Pres., C. P. Cass (St. L. & S. F.), Monett, Mo.; Secy., W. O. Thompson (L. S. & M. S.), Elkhart, Ind.; Treas., C. A. Crane (A. T. & S. Fe), Fort Madison, Ia. Executive Committee, J. R. Belton (C. & O.), Covington, Ky.; C. B. Conger (C. & N. W.), Grand Rapids, Mich.; I. A. Brown (C. & O.), Covington, Ky.

The next meeting will be held in Cincinnati, O., the 3d Tuesday in September, 1899.

Any of our readers desiring to secure the complete reports above abstracted should address Mr. W. O. Thompson, Elkhart, Ind., the Secretary of the Association.

ANNUAL MEETING OF THE NEW ENGLAND WATER-WORKS ASSOCIATION.

The seventeenth annual convention of the association was held at the Hotel Wentworth, Portsmouth, N. H., Sept. 14 to 16, inclusive. Mr. Willard Kent, President of the association, delivered an address after the usual opening exercises. He stated that the membership of the association had increased from 27 at its organization to 570 on June 1, 1898. During the past year the average attendance at the winter meetings was 84, the minimum having been 75. The report of the Treasurer showed a balance of $2,937, a gain of about $200 during the year. The Secretary stated that the 570 members were divided as follows: Active, 488; honorary, 5; associate, 77. The gain in membership during the year was 21.

Method for the Determination of Color and the Relations of Color to the Character of the Water.

The first paper read had the title given above, and was by Mr. Frederick S. Hollis, Biologist, Metropolitan Water Board, Boston. The author stated that the color of surface water varies with the amount of carbonaceous matter present. In unpolluted surface waters there is a pretty close agreement between the amount of color and the oxygen consumed, loss on ignition and albuminoid ammonia in solution. In contaminated waters there is no direct relation between the color and the chemical constituents. The color of water increases with stagnation. At the deepest part of Lake Cochituate the color at the surface has been observed to be 0.22, against 1.20 at the bottom. After standing, however, the color of the bottom sample increased to 3.70, by the oxidation of iron. The high color of this sample is no indication of the character of the whole lake, as the deep place from which the sample was taken has only a limited area. Much of the color of water is due to peaty materials, and much of that of surface water is caused by leaves. The author concluded his paper by describing the various color standards in use, including the Nesslerized ammonia of Leeds, the platinum-cobalt of Hazen and the device designed by FitzGerald and Force.

Some Things that Should be Done in Constructing a Distributing System of Water-Works.

This paper was by Mr. Wm. R. Hill, M. Am. Soc. C. E., Chief Engineer and Superintendent of the Water-Works of Syracuse, N. Y. Attention was first called to the necessity of rigid inspection of pipe during its manufacture, including both material and workmanship. The joining of three or four lengths of pipe before lowering into the trench may be a little cheaper, but there is liability of injuring the joints. A block of masonry should be built back of all bends, hydrants and ends of all lines more than 6 ins. in diameter, to take up the pressure. The pipe should be tested after it is laid, to a pressure at least 100 lbs. in excess of the ordinary pressure the pipe is to withstand in service. Good castings for corporation and curb cocks may be made from a mixture of 88 parts refined copper, 6 parts tin, 3 parts lead and 3 parts zinc, but the zinc should be omitted if there is alkali or salt in the soil, or corrosion will result. Regarding service pipes and the use of fire hydrants for filling sprinkling carts, Mr. Hill may be quoted in full, as follows.

Service pipes should be laid in straight lines at right angles to the axis of the street so that at a time of a leak the location of the corporation cock could be easily determined from the position of the curb cock. This, together with the fact that the main is laid at a fixed distance from the center of the street, will enable the repair to be made with the least possible disturbance to the pavement. If the service pipe is of lead all the solder joints between the main and curb should be made in a shop, as better work can be done there than in a trench. To one end of the pipe the tail piece of the corporation is soldered, while to the other end is the curb cock and a piece of pipe about a foot long is attached. The pipe is then coiled up and taken to the trench where it is to be used. The tail piece is attached to the corporation and the service is complete to a point one foot beyond the curb cock, where the joint connecting with the service to the building is made. None but the best of solder for the purpose should be used. The service pipe between the main and the curb should be made of one piece, and no unnecessary joints should be permitted. All short pieces of lead pipe can be melted up and used for calking joints in cast-iron pipe. A service pipe should not be laid in the same trench or close to a sewer. It would be hard to discover a leak should one occur in such a service, as the water would not appear on the surface of the ground, but would find its way to the sewer. Where a sewer or other trench is excavated crossing under a lead service pipe, the pipe should be properly supported, as when the trench settles it would carry the pipe with it and would be apt to cause a leak at the nearest joint.

Fire hydrants should not be used as fixtures to fill sprinkling carts with water, unless they are provided with a special valve and nozzle for that purpose. Such a valve and nozzle can be made in the dome or cap of the hydrant. During the season when sprinkling is done the drip is closed and main valve in the hydrant is slightly opened, so that there is a constant supply of water in the barrel of the hydrant. The men who sprinkle cannot interfere with the main valve or nozzles, as their wrench will not fit them. To use these hydrants for fire purposes the firemen first close the main valve with three turns of the valve rod. They cannot make a mistake and take off the upper nozzle, as that requires a smaller wrench. No one but a fireman or an employee of the water department should be permitted to have a wrench that will open the main valve. These special hydrants should be placed at points convenient for the purpose of sprinkling. In the city of Syracuse, N. Y., there are 200 that have been in use two years, and have been very satisfactory, both to the water and fire departments. A frequent cause of trouble with hydrants is because they are not properly drained to a sewer. If this connection were made with a lead or wrought-iron pipe there should be no liability of the hydrant becoming frozen.

In answer to questions Mr. Hill stated that the special nozzles for filling sprinkling carts, described above, are on Eddy hydrants. He liked to see the lead driven ⅛-in. inside the bell. If that is done and the pipe tested to 100 lbs. above what it is to bear, he felt safe. On the Skaneateles Lake pipe line, at Syracuse, no leaks have been discovered since the pipe was put in use, some four years ago, and it is patrolled daily.

Mr. Fuller stated that on some systems under heavy pressure he had used cast lugs and rods to hold hydrant in place, instead of masonry supports.

Mr. Crandall expressed the opinion, with which several members afterwards agreed, that very poor coating had been put on cast-iron pipe of late, and that, in general, the pipe has been of poorer quality since the fall in prices. Mr. Coffin thought one cause for the poor coating is that the pipe is not left long enough in the bath, owing, perhaps, to rush of work at the foundries. He had been considering the advisability of lining cast-iron pipe with cement. Theoretically, a 6-in. cast-iron pipe reduced to 5¼ ins. by a cement lining would discharge as much water after 15 years as a 6-in. cast-iron pipe at the end of that period. Mr. Richards thought it would be cheaper to make the cast-iron pipe larger at the start.

The Water-Works of Portsmouth, N. H.

An informal talk on these works was given by the Superintendent, Mr. Ayers. They were built in 1798, by a company, and sold to the city in 1890. The first supply was by gravity from a spring which is still in use, delivering 300,000 to 400,000 gallons a day. In 1798 there were 127 water takers, paying a total of about $700 a year for water. In 1840 there were 459 takers, paying $3,800, and in 1890, when the city took the works, some 1,900 takers paid $23,000 a year.

The last of the wooden logs laid in 1798 were taken up in the 70's, when it was found that the 5-in. bore had increased to 8 ins., save for projecting knots, and the interior was polished as smooth as mahogany. All sorts of service pipes have been used during the last hundred years, including 1½-in. cast-iron pipe lined with ½-in. glass tubes, and wrought-iron pipe, enameled inside and outside with glass.

The Occurrence of Cristatella in the Storage Reservoir at Henderson, N. C.

This paper was presented by Mr. Robt. S. Weston, C. E., of Brockton, Mass., who was called to Henderson last July to ascertain the cause of a bad odor in the water furnished by the Henderson Water Co. The source of supply for these works is from spring-fed brooks, impounded in a shallow reservoir having a maximum depth of 10 ft., while most of it is only 4 ft. deep. The drainage area is 2.32 sq. miles, composed mostly of arable and pasture land, with some swamps and peaty matter. There is a population of 509 in the drainage area, or about 220 per sq. mile. There are 87 privies in the drainage area, but none are within less than 100 ft. of any stream, and the soil is so sandy that all the water is subjected to natural filtration, except during freshets. The cristatella develops in the reservoir every year, between July 1 and Sept. 15, giving rise to an odor like heaps of old oyster shells. The organism is a polyzoan, or moss-like animal, which attaches itself to the sides and bottom of the reservoirs, grows only in the light, and spreads by a budding process. It occurs at Henderson in greatest numbers when the temperature of the water is at the maximum, which was 85° F. this year. The temperature of the water in the feeders was lower, and few or none of the organisms developed there. They grew in greatest numbers near the intake, where the water was shallow and the temperature highest. If the reservoir was deeper, so the temperature would not rise so high, doubtless there would be no trouble. To remove the odor, as well as the turbidity which occurs at times, Mr. Weston recommended aeration, with subsequent filtration through a Warren filter. The aerator is placed over a small settling tank. Water passes upward to and through a ball nozzle, above which is a hood which deflects the water downwards over four steps, or weirs, one above another, pyrimidal in form, the lower step being 5 ft. sq. The daily capacity of the plant is to be 300,000 gallons. The daily consumption averages about 75,000 gallons. The plant is now being built. Questions put to Mr. Weston by members brought out the statement that he believed mechanical filtration to be cheaper than slow sand filtration in this case, since for taking out these comparatively large organisms a higher rate of filtration was permissible than where bacteria are to be removed.

The Water-Works of Monson, Mass.

A description of these works was read by Mr. F. L. Fuller, M. Am. Soc. C. E., of Boston. The plant was built in 1894-5, with Mr. Fuller as engineer and Mr. E. E. Egice, of Flushing, N. Y., as contractor. The supply is taken from a large well located near a stream with a drainage area of about 6 sq. miles above the location of the well. The well is over 300 ft. above the village, thus giving a good gravity pressure, a very unusual thing for a ground water supply. The well has an inside diameter of 73 ft. at the top and 69 ft. at the bottom, the water generally being 19 ft. deep. Its storage capacity is about 675,000 gallons. The wall is of dry rubble, packed on the outside with broken stone, which gives some additional storage capacity. An iron roof covers the well. About 19 acres of land surrounding the well have been bought by the town.

Since these works were built the state of Massachusetts has built an extension of them to supply the Hospital for Epileptics, located in Monson. The chief feature of the extension is a distributing reservoir, 41 ft. in diameter at the top and 39 ft. at the bottom, having a concrete roof. A band of soft steel encircles the outer wall of the reservoir, to take up the thrust of the roof. The roof has a 4-ft. rise, and the concrete is 10 ins. thick at the springing line and 8 ins. at the top, the whole being covered with earth. The concrete is composed of 1 part Alsen's Portland cement, 2½ parts clean, sharp sand, and 4½ parts broken stone, not exceeding 2 ins. in size. Centering was placed for the whole roof, instead of for section after section. This method Mr. Fuller prefers for circular roofs. The reservoir has a concrete bottom 1 ft. thick, beneath which are drain tiles laid in broken stone, to prevent an upward thrust of the ground water on the bottom of the reservoir. In the driest weather there is some flow from the drains. Two small pipes extend up through the bottom of the reservoir. These are for the admission of ground water, in case of excessive pressure, and are provided with check valves to prevent loss of water from the reservoir.

Man's Imitation of Nature in the Purification of Water.

A paper with the above-named title was read by Dr. Gardner T. Swarts, Secretary of the Rhode Island State Board of Health, Providence, R. I. Slow sand filtration, the use of coagulants and subsiding reservoirs, the author showed, all have their prototypes in nature. These various systems were described by the author in an entertaining manner. Special inquiries addressed to health officers seemed to him to disprove the assertions sometimes made that the alum used in mechanical filtration is injurious to the human systems. Of 40 cities responding to his inquiries the health officers of only three or four stated that alum had been found in the filtrate. The amount of alum used in the various cities ranged from 0.1 to 7.0 grains per gallon of water. Dr. Swarts stated that slow sand and mechanical filtration may each be relied upon to give satisfactory bacterial results, but his remarks showed that he prefers mechanical filtration. Speaking of ordinary dug surface wells and of cemeteries located near sources of water supply, he said he thought the dangers from these had been overrated. Excavations near old cesspools and graves showed a discoloration of the soil for but a few inches from their limits. If the adjacent material had fissures the danger might be greatly increased.

Mr. Robt. Weston, having been asked to give some information regarding the Louisville experiments on water purification, said that the problem there, at times, was to remove 40,000 bacteria per cu. cm. and from 40 to 100 tons of mud from each day's supply. At New Albany, which is across the river from Louisville, and takes its supply from the same source, the Ohio River, the benefits of sedimentation are apparent. Although the water for New Albany receives the sewage of Louisville, which the Louisville supply does not, New Albany has only about 30 deaths from typhoid fever per 100,000, while Louisville has from 70 to 80. The New Albany water has about 30 days' sedimentation. Bids have already been received at Louisville for a filter house and clear water basin beneath it, but not for the filters themselves.

Results of Tube Well Experiments in Lowell, Mass.

These results, as set forth by Mr. Geo. Bowers, City Engineer of Lowell, are three driven well plants, with a combined normal capacity of about 10,000,000 gallons a day. The water is of good quality, and the quantity seems ample in view of the fact that the average daily consumption in 1897 was 6,594,000 gallons, and the average for January, the month of maximum consumption, less than 7,500,000 gallons. The third plant, recently completed by B. F. Smith & Bro., of Boston, as contractors, has a capacity of about 450,000 gallons a day. It includes 169 driven wells, each 2½ ins. in diameter and from 28 to 42 ft. deep, depending upon the thickness of the water-bearing stratum, the top of which is uniformly about 25 ft. below the surface of the ground. Lead pipe is used to connect the individual wells with the suction mains, as it can be made to conform more readily to the inevitable slight differences in elevation of the well tubing. The suction main and branches were tested with air in the field, and leaks were discovered where none were apparent on the water test. An air receiver is provided on the suction main, and there has been little trouble with air in the pipes thus far. The cost of the three plants has been about $265,000, or $26,500 per 1,000,000 gallons per day. Generally only two of the driven well plants are in operation, leaving one for emergency use or repairs.

Surface Water Supplies.

This paper was presented by Mr. John C. Haskell, of Lynn. It was devoted to the sanitary phases of the subject, calling attention to the dangers from typhoid fever due to sewage pollution and disagreeable tastes and odors caused by the lower forms of organic life in the water. Assuming that 400 microscopic organisms per cu. cm. will give rise to offensive tastes and odors, Mr. Haskell showed by figures from the report of the Massachusetts State Board of Health for 1896 that most of the surface supplies of the state were unsatisfactory during one-fourth of the year. The Laurence experiments show that surface waters may be made satisfactory in every respect by slow sand filtration; supplemented by aeration if necessary. A proper system of filtration, the author believed, is as necessary for surface supplies as are storage reservoirs. In conclusion, he expressed the belief that the surface waters of Massachusetts are as good as those of any other state, and with filtration may be made superior to underground waters.

Mr. Clark said he, agreed with Mr. Haskell regarding the advisability of filtering surface supplies, but even then they do not always have as good a color as ground waters. Regarding the Lowell well system, previously described at this meeting, no one knows how long it will be ample to meet the demands of increasing consumption, nor when iron will develop. He believed Lowell would eventually have to put in a filter plant, either to supplement the well supply from another source, or to remove iron from the water.

Mr. Richards pointed out the difference between disagreeable and dangerous waters. He thought it unfair to say that all surface supplies ought to be filtered, believing that some water from sparsely settled drainage areas was perfectly safe in its natural condition.

The Separate High Pressure Fire Service System of Providence, R. I.

In the absence of the author, Mr. Edmund B. Weston, M. Am. Soc. C. E., this paper was read by Mr. D. V. French, of Boston. In an appendix to the paper the author described a service used for thawing the ground to a depth of 12 to 24 ins. for trenching over 4,000 ft. in winter, the street being macadamized. Wooden boxes without bottoms were used, having a length of 72 ft. and a combined width of 4 ft. Steam from a boiler was admitted to the boxes. The boxes cost less than $20 and the thawing cost only 6.7 cts. per lin. ft. 4 ft. wide.

Mr. French said, in discussing the paper, that it was of great interest to insurance men, who were in favor of gravity supplies. A pressure of 100 lbs. is sufficient and preferable, except for high buildings. The proprietors of locks and canals at Lowell recently dug up some 12-in. uncoated cast iron pipe laid in 1849. It was so badly corroded that tests showed its carrying capacity to be no greater than that of a clean 8-in. main.

Tests of a Pumping Engine at Indianapolis, Ind.

A communication from Mr. F. A. W. Davis, of Indianapolis, was received and ordered printed, giving the results of a test of a Snow pumping engine. The test was made by Prof. W. F. M. Goss, and showed a duty of 150,000,000 lbs. on the British thermal units basis.

Closing Business.

The constitution was amended, without opposition, so as to permit meetings to be held outside of New England. There is a large membership in other sections of the country. An invitation to hold the next annual meeting at Syracuse, N. Y., was received from Mr. Wm. R. Hill, M. Am. Soc. C. E., of that city, and referred to the executive committee. The following are the principal officers elected for the ensuing year, all but the president being re-elected: President, F. F. Forbes, Brookline, Mass.; Secretary, J. C. Whitney, Newton, Mass.; Treasurer, Geo. E. Batchelder, Worcester, Mass.; Editors of the Journal, Jos. E. Beals, Middleboro, Mass., and Wm. H. Richards, New London, Conn.

Excursions.

On Thursday afternoon a boat ride was taken to the Portsmouth Navy Yard and around the harbor. On Friday, after the morning session, there was a drive about Portsmouth and vicinity.

Exhibits.

The exhibits by associate members were in charge of Mr. H. F. Jenks, of Pawtucket, R. I. A list of them is given under Industrial Notes.

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