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RECENT TESTS OF HIGH DUTY PUMPING ENGINES have been made at Chicago on a 30,000,000-gallon engine at the 14th St. pumping station, and at Wilkinsburg, Pa., on an engine for the Pennsylvania Water Co. The Chicago engine was built by the Lake Erie Engineering Works, Buffalo, N. Y., and was tested by Messrs. J. C. McMynn, of R. W. Hunt & Co., Newcomb Corbin, of Buffalo, and F. W. Catlin, of Minneapolis. The duty attained is said to have been over 150,000,000 ft. lbs. per 1,000 lbs. of dry steam. The Pennsylvania Water Co.'s engine was built by the Nordberg Mfg. Co., of Milwaukee, Wis., and was tested by Prof. R. C. Carpenter, of Cornell University. The test developed a duty of about 162,000,000 ft. lbs. per 1,000,000 heat units.

A GOVERNMENT ICE-PLANT FOR MANILA is to be built at a cost of about $250,000 for the use of the troops in the Philippines. The plans are being made by Frank L. Strong, late Chief Engineer, U. S. N. The full capacity of the plant will be 5,000 dressed cattle, 7,000 dressed sheep, 200,000 lbs. bacon, 100,000 lbs. butter, 200,000 lbs. vegetables; it must also make 8,000 lbs. of ice daily and 200,000 lbs. of distilled water.

TRACTION ENGINES involving some novel features of design have been built for service in Cuba by the O. S. Kelly Co., of Springfield, O., and one of these machines is reported to have a paying load of 60 tons at the rate of five miles per hour upon the natural soil of the country. The engine has three high-pressure cylinders, mounted on top of the boiler, and driving the rear wheels by a single reduction gear. The wheels are each composed of steel plate disks, cut away to form spokes, and having angle iron rings to which the broad steel tire is riveted. The spokes of the two disks are connected by transverse web plates, the front wheels having single webs (forming spokes of I section), while the driving wheels have double plates (forming spokes of box section).

PAVING STATISTICS FOR NEW ORLEANS, LA., form the subject of a paper presented to the Louisiana Engineering Society by Mr. A. C. Bell, and printed in the "Journal of the Association of Engineering Societies" for February, 1899. A tabulated statement shows that in August, 1898, 194.62 miles of streets were paved out of a total of 700 miles of streets open to use; 72% being unpaved. Of the paved streets, 42.6 miles were gravel; 40.6 miles, plank; 40.5 miles, cobblestone; 26.2 miles, square block; 21.8 miles, shell; 12 miles, asphalt. The remainder covers Belgian block, vitrified brick, wood block (only .06 miles) and chert roads. While the total area in the incorporated limits of New Orleans is 196¼ sq. miles, 39 sq. miles are protected from overflow by levees. The estimated unit cost of the above classes of street pavement was as follows, per sq. yd.: Plank, 56 cts.; cobblestone, $2.00; square block, $5.00; Belgian block, $4.25; vitrified brick, $2.50; asphalt, $3.10; wood block, $3.40; shell, $1.00; gravel, $1.50; chert, $1.75. Plank roads are made by bedding 4 x 8-in. subgrade stringers, 4 ft. apart and laid longitudinally with the street; across these are spiked 2-in. or 3-in. yellow pine or cypress planks. The "square blocks" are granite, 10 x 14 x 8 ins., with ¾-in. to 1-in. joints, laid on a rolled subgrade covered with 4 ins. of sand. Belgian block includes 6 ins. of concrete and 2 ins. of sand; vitrified brick is laid on the same base.

THE MOST SERIOUS RAILWAY ACCIDENT of the week occurred on the Pittsburg, Cincinnati, Chicago & St. Louis Ry., a short distance east of Richmond, Ind., on March 30. The accident, in which one man was killed, resulted from a fast mail train running into the rear of a freight. Both trains were westbound.

THE SINKING OF THE STEAMER "STELLA" of the London & Southwestern Ry. Co., on March 30, in the English channel, resulted in the loss of 80 lives. The vessel sailed between Southampton and the Channel Islands, and on this occasion carried an excursion party which was bound for the Channel Islands to spend the Easter vacation. Owing to the foggy weather the vessel struck Casquet Rock and sank almost immediately. Of the 220 persons on board, all but 80 succeeded in getting into the boats, which were successfully launched.

THE CORROSION OF GIRDERS supporting the great Smithfield Market, in London, where the underground railways pass under the market, has reached such an extent as to call for radical repairs and reconstruction. There are three or four tracks, carrying an enormous traffic, the number of trains exceeding 60 per hour during the busy part of the day. Brick side walls supporting brick arches are being built effectively to protect the ironwork from the gases from the locomotives, and the masonry will form a support of the new girders, etc., which will gradually replace those damaged by corrosion.

A 10-IN. COAST-DEFENCE GUN, of the 1895 pattern, burst under test at Sandy Hook on March 29. The first test charge was 141 lbs. of Dupont smokeless powder with the regular projectile of 575 lbs. The pressure developed was 34,000 lbs. per sq. in. The second test was intended to increase this pressure to about 35,000 lbs., and the powder-charge was "increased by a few pounds." As a result the breech of the gun was totally destroyed and the breech-tube and block, the latter weighing about 500 lbs., were hurled to the rear with such velocity that it penetrated the hombproof behind the gun and killed the record clerk, Mr. H. B. Murphy, and wounded two gunners who were with him. When the testing-gage was picked up from the wreck it registered 70,000 lbs. pressure, and this may not have been the full extent of the pressure. This is the first of the 10-in. guns that has failed; and the breech-jacket, which presumably gave way first, is said to have been shrunk on by a new process. The ordinance officers present expressed no opinions; but the abnormal pressure recorded would point to a seeming detonating effect in the smokeless powder, from some cause unknown. To explain this supposition, it is only necessary to point out that smokeless powder ordinarily burns but does not detonate like common powder, but that under certain conditions, according to experts, a portion of the nitro-glycerin entering into its composition may remain uncombined or free in the form of minute globules which detonate when the powder is fired. The bombproof penetrated was made of two rows of heavy timbers driven into the sand, 4 ft. apart, and filled with sand.

THE COAST-DEFENCE SCHEME of the United States, says Col. Henry M. Roberts, Engineer Corps, U. S. A., includes 1,000 new rifled mortars, 700 new rapid-fire guns, and 500 new high-power guns, as planned by Gen. John M. Wilson, Chief of Engineers. Of these 312 mortars are in place or are being constructed; emplacements are huilt for 254 of the rapid-fire guns and 79 are in place; and 288 of the high-power guns, of 12, 10 and 8-in. caliber, are provided for. and 261 are in place or under construction.

THE ARMY TRANSPORT SYSTEM seems at last to be undergoing some development, and for the longer voyages, at least, the fitting-out of the ships seems to leave little to be desired. Though in the list of nine transports said "to be thoroughly remodelled and refitted as army transports" we find the "Port Victor," now renamed the "McClellan," about which one of our correspondents, from personal experience, tells a very sad tale of bad management under an army quartermaster. But the three transports intended for conveying troops to the Philippines, the "Grant," "Sherman" and "Sheridan," appear to be well fitted for transport service. They are each something over 5,000 tons gross tonnage, and each can carry 90 officers, 2,200 men and about 120 horses and mules. They have four decks, and 24 staterooms for officers, or four to a stateroom. The hospital has 64 separate hospital bunks, besides the dispensary and stores, and surgeons' room and staterooms for hospital stewards. The soldiers' "between deck" is fitted with patent folding hunks, made of canvas and gas-pipe, arranged in tiers, two men deep. Four steam fans provide ventilation, and air is distributed through air-coolers and a system of pipes; by forcing the air over steam coils it can be heated. About 50 additional sideports were cut in each ship, and an electric system of 550 lamps was introduced. Toilet-rooms, about 100 enamelled wash-basins, baths and shower baths are supplied to each ship. These transports are managed by a Division of Transportation in the U. S. Quartermaster's Department, U. S. A.

NAVAL AND MERCHANT MARINE STATISTICS are given in a paper presented to the Civil Engineers' Club of Cleveland: O., by Mr. William B. Cowles, and published in the "Journal of the Association of Engineering Societies." These statistics are "accurately condensed" from Brassey's "Naval Annual," from the "U. S. Naval Register" and from the "Statesman's Year Book," all for 1898:

Sea place.	Country.	Modern naval vessels over 1,000 tons displacement,* 1898-'99. No.	Displcmt, tons.	Merchant vessels,† statistics 1895-'97. No.	Register tonnage.
1.	Great Britain	287	1,810,050	8,522	6,284,306
2.	France	129	741,531	1,235	503,667
3.	Russia	96	546,112	522	205,649
4.	Germany	84	422,549	1,126	889,960
5.	United States	77	395,406	5,551	2,183,512
6.	Italy	63	330,970	345	220,508
7.	Japan	39	205,518	827	213,221
8.	Austria.	33	125,339	202	146,098
9.	Netherlands	39	109,188	172	196,824
10.	Brazil.	16	44,313	189	75,283
11.	Denmark	17	41,107	445	176,845
12.	Argentine	12	39,797	75	21,613
13.	Chili	9	39,000	42	29,931
14.	Sweden	14	33,906	118	93,653
15.	Norway	12	25,797	237	262,950

*Built, building, or proposed.
†Excluding river steamers and small craft.

In addition to the above the United States, on July 1, 1898, had 47 auxiliary vessels in its navy, aggregating a displacement of 255,000 tons.

THE NEW COMPANIES INCORPORATED AT TRENTON, N. J., during the month of March numbered 250, and the total capital authorized aggregated $1,111,750,000. The average capital stock for the 250 companies is $4,447,000; and the incorporation fees paid to the state of New Jersey amounted to $126,000. Among the larger trusts thus organized were the following relating to engineering trades: U. S. Cast-Iron Pipe & Foundry Co., $30,000,000; American Shipbuilding Co., $30,000,000; International Steam Pump Co., $27,000,000; New England Electric Vehicle Co., $25,000,000; United Electric Co. of New Jersey, $20,000,000; Indian-Egyptian Compress Co., $15,000,000; Compressed Gas Capsule Co., $15,000,000; Park Steel Co., $10,000,000; American Brick Co., $10,000,000; Continental Cement Co., $10,000,000.

THE STREET RAILWAYS OF DETROIT, MICH., under an act of the Legislature just passed, may be acquired and operated by the municipality. The bill was strenuously opposed by a number of interests, but was passed and signed by Gov. Pingree. The Governor maintains that the people of Detroit favored such municipal ownership; and declares that if the proposed experiment should not prove a success, the people, meanwhile, will have the benefit of low fares and the property can be returned to private ownership without loss to the city. The provision exciting most opposition is that authorizing a commission to purchase the roads without permitting the people to vote on the proposition. But negotiations for purchase are said to be now under way.

TYPHOID FEVER IN PHILADELPHIA shows some signs of abatement. The number of cases for the week ending April 1 was 405, against 563 for the preceding week, but there were 43 deaths last week against 38 the week before. During the first three months of the year the cases numbered 4,864 and the deaths 485. If this death rate were kept up through the year it would give 1,940 deaths. Assuming a population of 1,200,000, this would be at the rate of 162 deaths per 100,000. Yet in view of these figures the new Mayor, in his inaugural address on April 3, says he is "far from believing that there exists a typhoid epidemic in our beloved city," and that he believes the doctors are confusing typhoid with "enteric or intermittent fevers." As typhoid and enteric are used interchangeably, the physicians of Philadelphia are at a loss to know what the Mayor really means. As to an excessive number of cases being reported, it is well said that if it were cut in half the record would still be appalling.

HYGIENE AND SOCIAL ECONOMY at the Paris Exposition will form two classes of exhibits, for each of which 1,000 ft. of floor space has been granted to the United States. Under hygiene there will be exhibits relating to the sanitation of cities, public buildings and homes. Under social economy there will be exhibits illustrating the social and economic conditions of the laboring classes and efforts to improve these. Safety devices for workshops, libraries and dwellings will be included. Books, reports, drawings, photographs and models are desired. For full information address Mr. Richard Waterman, Jr., Assistant Director Education and Social Economy, Auditorium Building, Chicago, Ill.

NOTES ON COLORADO RAILWAYS.

(With two-page plate.)

The railway system of the state of Colorado offers many points of particular interest to the locating engineer, as well as to engineers in charge of operation, since it includes main lines and mining branch lines built in and through a difficult mountainous country. From notes gathered by a member of the editorial staff of Engineering News during a recent trip over several of the most interesting lines, the present article has been prepared, and we are able to give some interesting profiles showing the different character of the location on lines within the same region. Fig. 1 is a sketch map showing the several lines whose profiles are given.

Denver & Rio Grande R. R.—The most famous railway whose name is associated with Colorado is the Denver & Rio Grande R. R., which was in its early days one of the great exponents of the narrow-gage system, and was noted not only on account of its being a narrow gage trunk line, but also on account of the engineering difficulties successfully overcome in its construction. When, later on, the officers of this road found it an isolated narrow gage line touched by standard gage connections, it was wisely decided to convert it into a standard gage line, and so provide facilities for through traffic. As a result of this the road is now one of the important links in three or four transcontinental routes. The standard gage line, however, does not follow entirely upon the old route, but from Salida to Grand Junction an easier line was found (over Tennessee Pass) than the original route over Marshall Pass and through the Gunnison River valley. Both lines are operated and there are other narrow gage lines in the extensive system of the D. & R. G. R. R. From Denver to Salida and Leadville, there is a three-rail mixed gage track to accommodate the trains of the narrow gage divisions and the narrow gage ore cars which run from the Leadville mines to the Pueblo smelters. Particulars of the history and construction of the road and of its track were given in our issues of Sept. 2 and Oct. 15, 1896.

The standard gage line is essentially a valley line, following the waterways, and getting through the mountains with but one summit, as shown by the profile in an article on "The Profiles of Transcontinental Railways," in our issue of June 10, 1897. It has an unbroken succession of ascending grades on the eastern slope, and a similar succession of descending grades on the western slope. The grades are mainly 1 to 1.42%, with curves of 10 and 12°, though on both sides of the summit pass there are short lengths of 3% grades, and there are also a few curves of 20°. It will thus be seen that the location is comparatively favorable for a mountain line. Between Denver and Pueblo there is a summit at Palmer Lake, but this is not in the mountains. Passing Colorado Springs, the line continues south to Pueblo, which is a very important point from a traffic point of view, as it gives the road a very large business in ore from the mines to the Pueblo smelters, and in rails and other products from the Pueblo steel works for western distribution. The line then turns west, and into the valley of the Arkansas River, which it follows all the way to Leadville, or nearly to the summit elevation. On the west side of the summit the road follows the valleys of the Eagle River, and its confluent the Grand River, all the way to Grand Junction. On this line is the noted Calumet branch, with a grade of 7%, which is operated by ordinary locomotives of the adhesion type.

The narrow gage line has also a "valley" location, but with a more broken profile, as shown in Fig. 2. It follows the route already described from Denver by way of Pueblo and the Arkansas River valley to Salida, but then turns south, and, after crossing the Continental Divide, enters the valley of the Gunnison River, which it follows nearly all the way to Grand Junction, crossing and recrossing the river at various points. Between Salida and Grand Junction very heavy work is encountered, with 4% grades and 24° curves on the main summit of the Continental Divide (10,856 ft.) and the Cedar Creek Divide (7,968 ft.). At Gunnison there is a connection with the Denver, Leadville & Gunnison Ry., which is described further on. Profiles and information respecting the D. & R. G. R. R. have been furnished by Mr. E. T. Jeffery, President and General Manager, and Mr. M. M. Rogers, Chief Engineer.

From Denver to Pueblo the track is laid with 85-lb. rails (Eng. News, Oct. 15, 1896); thence 65-lb. rails to the foot of Marshall Pass, 52-lb. rails over the pass, 65-lb. rails from Sapinero (the foot of the pass) to where the line leaves the Gunnison River, 45-lb. rails over the Cedar Creek Divide, and 40-lb. rails from Montrose to Grand Junction. The Rio Grand Western Ry., which is used by the Denver & Rio Grande and Colorado Midland railways, from Grand Junction to Ogden, Utah, attains a maximum elevation of 7,465 ft. in crossing the Wahsatch range, and then descends into the Salt Lake basin by long steep grades.

FIG. 4.—VIEW OF THE COLORADO MIDLAND RY., IN THE HAGERMAN PASS.

Colorado Midland Ry.—There is still a third route between Denver and Grand Junction, by way of the Colorado Midland Ry., and this line affords an interesting comparison with the others. While the two lines of the Denver & Rio Grande R. R. are located almost entirely as valley lines, this newer road is laid out across the mountains. The Colorado Midland Ry. proper extends from Colorado Springs to New Castle, running its trains over the Atchison, Topeka & Santa Fe Ry., between Colorado Springs and Denver, and over the Denver & Rio Grande R. R., between New Castle and Grand Junction.

From Colorado Springs the line runs west to Manitou and starts boldly into the mountains, having ascending grades of 3 to 4%, to the first summit, on the Hayden Divide, as shown by the profile in Fig. 3. Beyond this there is a sharp decline to the 11-mile canyon, followed by easy ascending grades over the rolling country of the South Park to the second summit at Trout Creek Pass. On the west side of the pass are descending grades of 1.43 to 1.65%, followed by steep ascending grades to the main summit of the Continental Divide, at Hagerman Pass, 11,500 ft. above sea level. From this summit there is a continued descent, with long grades of 2.42 to 3.3%. On the eastbound trip, a passenger train of five cars is taken up the mountain division by two ten-wheel engines, the head engine being cut off at the summit.

Passenger trains ordinarily run into Leadville, but freight trains avoid the heavy grade on this loop by a cut-off, as shown on the profile. Passenger trains that are late also use this cut-off, a shuttle train making connection for Leadville passengers. The scenery along the line on each side of the Hagerman Pass is most striking, and on the east slope the line descends by a zigzag, forming four or five lines along the mountain side. One of the curves by which the train changes its direction is carried upon a long high trestle, there being no way of carrying the line upon solid ground. This part of the line is shown in Figs. 4 and 7. There are several snowsheds, and at the summit is the Hagerman tunnel, 2,064 ft. long, which begins just beyond the upper line of the railway at the left hand of Fig. 4. At Busk and Ivanhoe are the approaches to the Busk tunnel, which saves 500 ft. of elevation, as compared with the "outside" line over the pass, but there is nothing to call attention to this great work, the approaches being covered by inartistic snowsheds to prevent the approach cuts from being filled in by drifts. From Arkansas Junction to Buena Vista the line parallels the Denver & Rio Grande R. R., and beyond Wild Horse, when the train is ascending the Hayden Divide by a steep and circuitous route, it is curious to notice the direct down-grade line of the D. & R. G. R. R. in the broad flat bottom of the valley far below.

For the profile and other information respecting this road we are indebted to Mr. George W. Ristine, President and Manager, and Mr. W. F. Bailey, General Passenger Agent.

A general summary of the profiles of these three routes is given below:

Denver & Rio Grande R. R. (Standard Gage).

	Elevation, ft.	Distance, miles.	Grade. Max., per ct.	Grade. Direction.
Denver	5,198	....	....	......
Palmer Lake	7,237	52.3	1.42	Up.
Colorado Springs	5,992	22.9	1.42	Down.
Pueblo	4,668	43.4	1.00	Down.
Tennessee Pass	10,433	165.0	1.42*	Up.
Glenwood Springs	5,758	83.1	3.00	Down.
Newcastle	5,562	12.3	1.00	"
Grand Junction	4,594	76.9	1.00	"
Total		455.9		

*2½% on spur to Leadville.

Denver & Rio Grande R. R. (Narrow Gage).

	Elevation, ft.	Distance, miles.	Grade. Max., per ct.	Grade. Direction.
Denver	5,198	....	....	......
Palmer Lake	7,237	52.3	1.42	Up.
Colorado Springs	5,992	22.9	1.42	Down.
Pueblo	4,668	44.4	1.00	Down.
Salida	7,050	96.9	1.42	Up.
Marshall Pass	10,856	25.7	4.00	Up.
Buxton	8,794	12.3	4.00	Down.
Gunnison	7,681	35.8	1.30	"
Crystal Creek	6,851	38.9	1.00	"
Cerro Summit	7,968	7.1	4.00	Up.
Fairview	6,165	11.7	4.00	Down.
Grand Junction	4,594	77.0	2.1	Down.
Total		425.0		

Colorado Midland Ry.

	Elevation, ft.	Distance, miles.	Grade. Max., per ct.	Grade. Direction.
Denver	5,196	....	....	......
Palmer Lake	7,238	51.4	1.42	Up.
Colorado Springs	5,992	22.6	1.42	Down.
Hayden Divide	9,198	27.8	4.00	Up.
11-Mile Canyon	7,950	13.2	3.0	Down.
Bath.	9,528	44.6	2.0	Up.
Wild Horse	8,081	18.6	1.6	Down.
Hagerman Tunnel	11,528	48.3	3.0	Up.
Glenwood.	5,782	68.7	3.0	Down.
Newcastle	5,574	12.3	1.0	"
Grand Junction	4,594	77.0	1.0	"
Total		384.5		

Denver, Leadville & Gunnison R. R.—Fig. 5 is an interesting profile, representing the line from Denver to Baldwin (touching the D. & R. G. R. R.

narrow gage line at Gunnison) and its branch from Como to Leadville. This is a narrow gage line (3-ft. gage), with a very irregular profile, abounding in grades of 3 to 4%, and curves of 15 to 24 and even 28°. On this line is the famous Alpine Tunnel, 11,596 ft. above sea level, on a grade of 3.2%. On the High Line Division (to Leadville), there is a branch to Keystone, which point (9,157 ft. elevation) is but a few miles from the Graymont terminus of the U. P., D. & G. Ry. (9,771 ft.), and the closure of this gap would give a line between Leadville and Denver more direct than those of the Denver & Rio Grande R. R. and Colorado Midland Ry., but less favorable from an operating point of view.

The following particulars of the engines used and the train loads hauled on this narrow-gage road have been furnished by Mr. M. F. Egan, Superintendent of Motive Power of this line and of the U. P., D. & G. Ry.

Service.	Type of engine.	Cylinders, ins.	Driving wheels, ins.	Weight— Drivers, lbs.	Weight— Total, lbs.	No. of cars haul'd
	Canyon Division: Denver to Como.					
Passg'r.	Mogul.	14×18	40	55,300	61,300	5
Freight.	Consol. ...	15×18	37	54,600	62,900	6
	Gunnison Division: Como to Baldwin.					
Mixed.	Consol.	15×18	37	54,600	62,900	5
Mixed.	Consol.	16×20	37	66,000	76,000	6
	High Line Division: Como to Leadville.					
Passg'r.	Mogul.	15×18	38	52,000	60,300	4
Freight.	Consol	16×20	37	66,000	76,000	5

Union Pacific, Denver & Gulf Ry.—This road has a number of lines and branches, of both 3 ft. and 4 ft. 8½ ins. gage. Fig. 6 is a profile of the Graymont Division (3 ft.) which for many miles follows the bottom of the narrow and winding Clear Creek Canyon. Near the upper end of the line is the famous "Georgetown loop," by which the line is developed to such a length (4 miles) as to keep within a grade of 3½% in making the difference of elevation between Georgetown and Silver Plume (700 ft.), these places being only about a mile distant in a direct line. Fig. 7 is a plan of the loop, and of the Hagerman Pass portion of the Colorado Midland Ry., showing the direct tunnel line and the zigzag lines over the pass.

Fig. 8 is an interesting profile, differing from the others in that it is a north and south line, representing the course of the standard gage line of the U. P., D. & G. Ry., from Orin Junction, Wyo. (on the Fremont, Elkhorn & Missouri Valley Ry.), to Texline, Tex., where connection is made with the Fort Worth & Denver City Ry. The heaviest grades range from 1% to 1.7%, with one short piece of 2%, and the curves are from 3° to 6°. For the profiles of this road and the D., L. & G. R. R., we are indebted to Mr. T. F. Dunaway, who is General Superintendent of both roads. Some idea of the relative difficulties of operating the several divisions of the road may be gathered from the following particulars of the engines used and trains hauled, which have been furnished us by Mr. M. F. Egan, Superintendent of Motive Power:

Service.	Type of engine.	Cylinders, ins.	Driving wheels, ins.	Weight— Drivers, lbs.	Weight— Total, lbs.	No. of cars haul'd
	First Division: Julesburg to La Salle (4 ft. 8½ ins.)					
Passg'r.	8-wheel ..	18×24	69	62,300	101,300	6
Freight.	10-wheel ..	19×24	51	103,400	131,200	30
	Second Division: Cheyenne to Orin Junction (4 ft. 8½ ins.)					
Mixed...	8-wheel ..	17×24	61	49.700	81,000	10
Mixed...	10-wheel ..	18×24	56	65,900	93,400	.12
	Third Division: Denver to Greeley (4 ft. 8½ ins.)					
Passg'r.	8-wheel ..	17×24	61	49,700	81,000	7
Freight.	10-wheel ..	19x24	62	103,400	131,200	18
Freight.	Consol. ...	20×24	50	110,000	122,000	28
	Fourth Division: Denver to Graymont (3 ft.)					
Passg'r.	Mogul.	14×18	34	55,300	61,300	6
Freight.	Mogul	15½×20	31	70,500	80,500	10
	Fifth and Sixth Divisions: Denver to Pueblo and Pueblo to Trinidad (4 ft. 8½ ins.)*					
Passg'r.	10-wheel ..	19x24	62	107,600	131,200	18
Freight.	Consol.	19x26	51	126,700	141,800	24
	Seventh Division: Trinidad to Texline (4 ft. 8½ ins.)					
Passg'r.	8-wheel. ...	17×24	61	49,700	81,000	5
Freight.	Mogul	19×24	55	87,300	105,000	16

*The freight trains have helpers from Parkers to Hill Top (8 miles, 2% grade), and from Franceville to Falcon (13 miles, 2% grade).

It may be noted here, that since the preparation of this article, the Union Pacific, Denver & Gulf Ry., and the Denver, Leadville & Gunnison Ry. have been consolidated, under the name of the Colorado & Southern Ry.

Manitou & Pike's Peak Ry.—This is the only rack railway on the Abt system in this country, the other railways of this character having the older and less efficient Marsh system of rack. The latter consists of two side bars connected by short bars (usually of circular section) which form the cogs for the gear wheel on the engine. In the Abt system, the rack is built up of two or more sets of bars having teeth formed in the upper edge, the bars being set with the teeth staggered, to coincide with staggered teeth on the gear wheels. This results in a much shorter pitch and a much easier meshing of the gears.

The ascent of high mountain peaks has always had an attraction for tourists, but comparatively few persons can stand the fatigue of climbing. With the growth of tourist travel, many of the peaks in Europe and in this country have been made accessible by rail. In 1884, a project was started for a line up Pike's Peak in Colorado, with a developed length of 30 miles in order to limit the maximum grade to 5%. Nothing came of this, however, but in 1888 the surveys were made for a direct line, to be operated on the rack system. Construction was commenced in 1889 and completed in October, 1890. The road is 47,992 ft. (nearly nine miles) in length, and overcomes an elevation of 7,520 ft., its summit being 14,147 ft. above sea level. The average grade is 16%, the maximum grade being 25%, and the sharpest curves 16°. There are no trestles and only four small plate girder bridges.

In regard to the summit elevation of 14,147 ft. it may be of interest to note that the Alpine tunnel on the Union Pacific, Denver & Gulf Ry. is 11,596 ft. above sea level, and that the Colorado Midland Ry. attains an elevation of 11,500 ft. in the Hagerman Pass, while the Denver & Rio Grande R. R. attains elevations of 10,856 ft. and 10,433 ft. on its narrow and standard gage main lines. In Peru, however, the Lima & Oroya Ry. and the Arequipa & Puno Ry. attain elevations of 15,670 ft. and 14,666 ft., respectively.

The track of the Pike's Peak railway is of standard gage, laid with 40-lb. rails, having square, three-tie joints, spliced with six-bolt angle bars. here are 18 ties to a rail length, and the ballast is of disintegrated granite, which is an excellent material for the purpose. Extensive tie renewals have been made this year. The rails show but little wear, and this is undoubtedly due to the fact that the engines have no adhesion driving wheels. At intervals on the heavy grades, the track is prevented from creeping by inclined anchor timbers butting against the ties and having footings in the rock of the sub-grade. There are about 146 of these anchorages, placed from 200 to 1,400 ft. apart. For the same purpose, the ties are connected by lines of planks on each side of the rack, but many of these are rotted away and should be renewed. The road is kept in good line and surface and its curves are in good condition. The width of roadbed is from 15 to 22 ft.

As to the lines of "creeping boards" spiked to the ties, we are informed that they were used originally in order to prevent the creeping of the track and the shifting of the ties. A test extending over two years, however, has shown that even without these planks no perceptible creeping of the rails or shifting of the ties on the heaviest grades has occurred. This is also true of places where the anchors have been taken up. The reason is said to be that the sharp disintegrated granite used for ballast (which resembles fine gravel) becomes packed together into what is practically a solid mass. It would be better, for appearance sake at least, to remove or renew the rotten planks, as they give passengers the impression that the road is neglected and in bad condition.

The rack consists of two bars, placed side by side, 1⅝ ins. apart, with the teeth staggered. The bars are 6 ft. 8 ins. long, 4⅝ ins. deep over the teeth, and from ⅞ to 1¼ ins. thick. The teeth are 2 ins. deep, with sides inclined 1 in 4, and top corners of 1-16-in. radius. The length of tooth on the pitch line is 2.35 ins. At the root, the sides of the teeth are undercut to allow a clearance for the teeth of the cog wheel when the surfaces have become worn. The teeth of the rack show but little wear, but are slightly burred on the edges. The chairs are of rolled steel, 12½ × 7½ ins., 9-16-in. thick, and are placed on every other tie. Each chair has a central rib with a seat on each side for a rack bar, the bars being secured by bolts through the bars and rib. Lugs fit over the edge of the tie and prevent the chair from slipping. The details of the rack and chairs were illustrated in our issue of April 19, 1890.

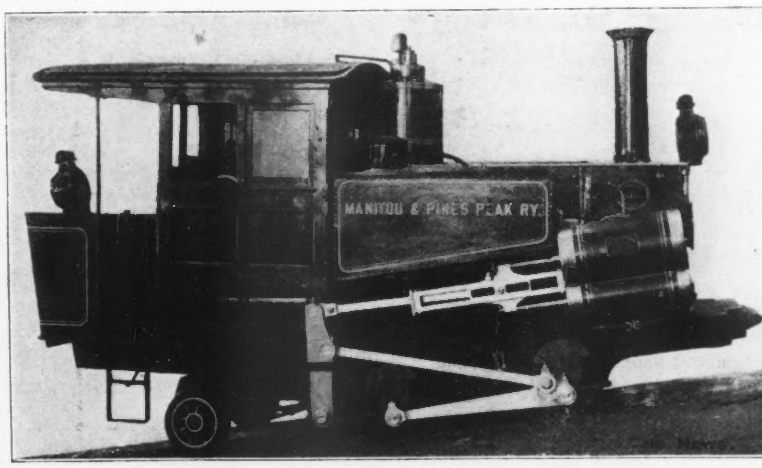


FIG. 9.—LOCOMOTIVE OF THE MANITOU & PIKE'S PEAK RY. (ABT RACK SYSTEM).
Baldwin Locomotive Works, Builders.

The equipment includes five tank locomotives and six passenger cars, and each train consists of one engine and car, the engine being at the rear and not coupled to the car. The thrust is taken by a horizontal roller on the bumper beam of the engine and a vertical roller on the end sill of the car. This arrangement allows for the lurching and vibration of the engine, but is not entirely successful, the car body having a horizontal swinging or "nosing" motion which is at times quite unpleasant, and which probably causes some irregular pressure of the wheel flanges against the rails. This motion is not due to any defect in the track, and a device intended to stop it is to be applied before the next season of traffic commences. The cars are long, each seating 50 persons, and being carried on two axles. Each car is equipped with a gear wheel for braking purposes, and a brakeman stands continually at the brake handle on the front platform, although the bad practice of the conductors in putting favored passengers on the platform usually crowds the brakeman so that he could not act promptly in an emergency. The ascent occupies about an hour.

The first locomotives were two-cylinder simple engines (Eng. News, Oct. 4, 1890), but all those now in service are Vauclain four-cylinder compounds, of the type shown in Fig. 9. They have each two double gear wheels, the teeth of which are staggered to coincide with the position of the rack teeth, and these wheels usually last about two seasons. They were first made of forged steel.

This superheater, which is illustrated in Figs. 1 and 2, consists of a series of U-shaped 1½-in. tubes expanded into wrought steel rectangular boxes or manifolds. Opposite the end of each group of four tubes in the manifold is a handhole cover. Steam is received into one of these manifolds through two 4-in. tubes from a perforated "dry-pipe" placed in the upper portion of the steam space in the boiler. This dry-pipe acts as a separator, delivering dry steam to the superheater. The steam flows through the tubes of the superheater and is delivered through the lower manifold into two rising pipes, which convey the superheated steam to the steam pipe above the boiler, as shown in Fig. 2. A water pipe connects the lower manifold with the water space of the boiler, by means of which pipe, when both valves in it are opened, the superheater may be flooded with water when steam is being raised and when the steam stop-valve is shut. The lower valve in this pipe being opened and the upper valve shut, allows the superheater to be drained after flooding.

It will be noticed that the superheater is so located in the gas passages of the boiler that the temperature of the gases by which it is heated is reduced, by passing through the forward ascending passage through the front portion of the boiler, to such a degree that there is no danger of burning out the superheater tubes so long as steam is passing through them, but yet that temperature is so high that the superheating surface is far more effective than if it were placed in the flue leading to the chimney. When the boiler is working under full draft and the gases passing the superheater are the hottest, the quantity of steam passing through it is the greatest. When the draft is checked, and the steam generation is lessened, the temperature of the gases also is lower, so that whenever the boiler is steaming, the superheater is practically self-regulating, both as regards the amount of superheat given to the steam and as to provision against burning out. When leaving the boiler at night with banked fires, the superheater may be flooded, but when this is not done, harm will not result if the steam is circulated through the superheater after putting on the draft, the steam stop-valve being opened before the fire becomes too fierce.

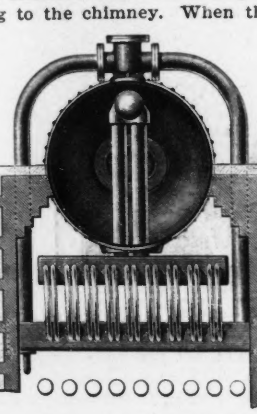


Fig. 2.—Cross-Section of Boiler and Setting, Showing Superheater in End Elevation.

The flooding device should be used when steam is being raised from cold water.

Concerning the practical operation of the superheater, the London office of Babcock & Wilcox, Ltd., under date of Feb. 23, 1897, writes:

We have in every case where we have installed superheaters, tested the temperature and found that we easily get 150° of superheat, and that the temperature does not fluctuate more than about 20°F. Our experience of two years' night and day working shows that the durability leaves nothing to be desired.

Two tests of a Babcock & Wilcox boiler of 1,098 sq. ft. heating surface, with a superheater of 184 sq. ft., at the Czanyer Mill, Czaney, Hungary, gave respectively 162° and 181° F. of superheating. The fuel used was Putnoker brown coal, containing 26.21% moisture and 14.10% ash, having the exceedingly low heating value of 6,468 B.T.U., after deducting the heat required to evaporate the moisture. The water evaporated per pound of coal in the two tests was 4.267 and 3.975 lb., the former figure giving an efficiency for the combined boiler and superheater of 73%.

In July, 1898, a test of a Babcock & Wilcox superheater was made by the Steam Boiler Inspection Society of Saxony, at Chemnitz, with the following results. The boiler has 1,938 sq. ft. of heating surface, and the superheater 334 sq. ft. The boiler pressure was 102 lbs. per sq. in. The temperature of the gases in contact with the superheater was 842°F. The superheating of the steam was 101°F. The steam pipe leading to the engine was about 460 ft. long, and the superheat was almost entirely lost in this long pipe, but the steam was delivered in an absolutely dry state, whereas without the superheater it carried a considerable quantity of water. Notwithstanding the unfavorable conditions, the results obtained from the fuel, which was accurately weighed, showed a saving in coal of 11%.

At the steam-engine works of G. E. Bellis & Co., Limited, Birmingham, Eng., the following results were obtained with a 300-HP. engine, using steam of 120 lbs. pressure and a vacuum of 26 ins.:

	Temperature of steam. At boiler.	Temperature of steam. At engine.	Water consumed, electrical HP.
Superheater off........	346°F.	346°F.	22.90 lbs.
" partly off ..	517°F.	355°F.	21.00 "
" full on ...	Not taken.	436°F.	19.75 "

The economy due to a very slight degree of superheating was about 6%, and when the steam was superheated 90° at the engine it was nearly 14%.

A series of experiments made in Bavaria on a 500-HP. Sulzer compound engine using superheated steam is summarized in an article in "The Engineer" (London) of Dec. 11, 1896. The superheater had 14 vertical cast-iron tubes with external ribs, and a total heating surface, including the ribs, of 1,237 sq. ft. It was provided with a furnace of its own, being located in a separate building between the chimney and engine-room, and as near as possible to the latter. Steam was furnished at 95 lbs. pressure from three Lancashire boilers of a total heating surface of 2,356 sq. ft. The principal results of the tests were as follows:

	Steam superheated.			Not superheated.
Steam temperature:				
Entering superheater, ...	334°F.	334°F.	334°F.	...
Leaving superheater	486 "	489 "	559 "	...
In engine valve chest....	439 "	446 "	498 "	325°F.
Loss of temperature pr ft. run of covered steam pipe.....	0.9	0.88	1.19	0.13
Lbs. steam, I. HP. pr hr., lbs.	15.8	15.4	14.0	18.7
Economy, %: Steam compared with saturated steam...	16.1	18.45	25.88	....
Of coal	2.24	4.03	10.95	....
Coal used by superheater, % of coal used by boilers	10.21	7.14	10.0	....
Efficiency: Boiler	61.1	61.7	61.9	67.0*
Superheater,† apparent ..	38	57	54	....
" assuming 5% moisture in steam entering superheater	61	91	83	....

*Four boilers were used in this test.

†Per cent. of heat utilized by the superheater compared with the heating value of the coal burned under it. The actual efficiency of the superheater could not be determined, as the moisture in the saturated steam entering it was not ascertained.

Probably the most remarkable result ever obtained by the use of superheated steam is that described by Prof. Schroeter, of Munich, in Zeitschrift des Vereines Deutscher Ingenieure, Band XXXIX, and translated by Mr. F. Ganz in the "Stevens Indicator" of April, 1895. In one test the water consumption was only 10.16 lbs. per I. HP. per hour. In this case the boiler, the superheater and the engine were all of unusual types. The engine had two tandem single-acting cylinders, respectively 12.3 and 27.1 ins. diameter, each 1.64-ft. stroke, the smaller cylinder set directly above the other without an intervening stuffing-box, with a trunk-shaped differential piston, so that the annular space around the trunk constituted the low pressure piston. Instead of the lower end of the low pressure cylinder being open to the atmosphere, it was closed by a head with a stuffing-box, the space thus gained serving the double purpose of a receiver and of a third and larger cylinder. The engine developed 75 HP. at 117 revolutions per minute. The boiler, an internally-fired vertical flue boiler, had a water-heating surface of only 96 sq. ft., a first superheater, exposed to very hot gases from the boiler for drying the wet steam furnished by the boiler, of 64.6 sq. ft., and a principal superheater of 350 sq. ft., which received the furnace gases from the first one. Above this superheater there was a coil feedwater heater by which the gases were further cooled. The following are the principal results of two tests:

Average boiler pressure gage.........	168 lbs.	170 lbs.
Temp. of steam at this pressure......	373.8°F.	374°F.
Average actual temp. of steam.......	662°F.	675°F.
Degrees of superheating	288.2°F.	301°F.
Coal used per hour..................	98½ lbs.	96⅜ lbs.
Water evaporated per hour	777 "	766 "
Per lb. coal, from and at 212°F.	10⅕ "	10⅜ "
Average brake horse-power..........	61.7	62.2
Average indicated horse-power........	71.25	75.37
Friction	14.0%	18.0%
Coal used per hr. per brake HP.......	1.60	1.55
" " " I. HP...........	1.38	1.28
Water used per hr. per brake HP......	12.60	12.30
" " " I. HP..........	10.90	10.16

The increased friction on the second test is believed to have been caused by a small amount of sand which was found around the high pressure piston.

The paper of Prof. Schroeter is well worthy of study by those interested in the study of unusual forms of engine. The type of engine, however, seems in no way to account for the high economy, which is undoubtedly due to the high degree of superheating. The figures obtained are especially remarkable, since the engine developed only 75 HP., and no doubt they could be considerably reduced with a large compound or triple expansion engine using steam of the same temperature.

THE COMPARATIVE MERITS OF TIMBER AND MASONRY DRY-DOCKS.

The report of Admiral M. T. Endicott to Secretary Long on the above subject was printed in our issue of Feb. 9, and a brief report of the discussion which took place upon it at the meeting of the American Society of Civil Engineers on Feb. 10 was printed in our issue of Feb. 16. The detailed report of this discussion is now printed in the Society's "Proceedings" for March, and from it we make the following abstract of the most important points brought forward in the discussion:

To begin with, the history of dry-docks in the United States, Admiral Endicott said that the first were commenced in 1828, at Boston and Norfolk, on plans made by Loammi Baldwin, of Boston, Mass., who made a trip to Europe to study structures of this class. These docks were completed in 1834 and cost about $677,000 for the Boston dock, and $943,000 for the Norfolk dock. They were both substantially founded on piles, built entirely of stone and faced with cut granite of the finest quality and workmanship. The granite dry-dock at the Brooklyn yard, completed in 1854, was the next built, at a cost of $2,000,000; and then came the Mare Island concrete dock lined with stone, finished in 1891. In the interval 1834-1891, the government built several floating docks of wood, which were used with more or less success.

The first timber graving dock in this country was built in 1840 for lake service, at Buffalo, N. Y.; others followed, and wooden docks of this type are now located at Buffalo, Cleveland, Chicago, Detroit, Port Huron and other places. Though they differ in detail the general design is the same as those later built upon the Atlantic coast. In 1854 the first timber dry-dock on the Atlantic coast was constructed at Boston by J. E. Simpson & Co.; and the same company soon after built others of the type now known as the "Simpson" dry-dock.

About 1886, the creation of a new navy called for more government dry-docks, and the advocates of timber presented the attractive arguments of cheapness, quick construction, and greater accessibility and more light and air. A negative advantage urged before the Naval Committee, says Admiral Endicott, was the statement that timber "would last 40 years, and that is long enough for anything to last." These arguments were successful, and in 1887, appropriations were secured for two timber dry-docks, one at New York and the other at Norfolk. These were followed by the League Island timber dock, finished in 1891; the Port Royal timber dock, finished in 1895; the Puget Sound timber dock with masonry entrance, completed in 1896, and dry-dock No. 3, at New York, completed in 1897.

The last Congress provided for four timber dry-docks, one each at Portsmouth, N. H.; Boston, Mass.; League Island, Pa., and Mare Islhaving an ultimate tensile strength of 103,000 lbs., with an elastic limit of not less than 45% of the ultimate strength, and an elongation of 20% in 2 ins. In 1897 the original rods and working parts were replaced by new parts made of Krupp steel, and during the past winter new cog wheels of Krupp steel have been applied to all the engines. Each connecting rod drives a vertical rocker, from which a return rod runs to the axle of the forward pinion, the rear axle being driven by a coupling rod. The carrying wheels are mounted loosely on the axles of the gear wheels. The boiler is pitched forward, so as to be level on the grades, and the firebox is supported by a trailing pony truck.

A back-pressure brake is used, the usual Le Chatelier brake valve being arranged with an attachment for introducing oil and hot water into the cylinders. This is for lubrication only. The exhaust is so arranged as to be diverted from the smokebox to the open air, and a relief valve (under the control of the engineman) is attached to the cylinders. To operate the brake, the exhaust is diverted from the stack and is discharged into the open air. The valve motion is reversed and pressure allowed to accumulate, the speed being regulated by the relief valve when the pressure in the cylinders becomes too great. All the engines were built by the Baldwin Locomotive Works, of Philadelphia, Pa., and we are indebted to the builders for the following particulars of the latest and largest engine, shown in Fig. 9:

Driving gear wheels, diameter on pitch line	22.468 ins.
Wheelbase, driving	5 ft. 7 "
Wheelbase, total	12 " 3 "
Weight on driving wheels	57,920 lbs.
Weight, total	48,320 "
Cylinders, h. p. (2)	10 × 22 ins.
Cylinders, l. p. (2)	15 × 22 "
Boiler, diameter	3 ft. 6 "
Firebox, length	3 ft. 11-16-in.
Firebox, width	4 ft. 3⅜ ins.
Tubes, (176), diameter	1½ "
Tubes, length over tube plates	7 ft. 6 "
Capacity of two side tanks	600 galls.

The road was built under the direction of Mr. T. F. Richardson, as Chief Engineer; while Mr. Wm. Hildenbrand, of New York, the American representative of the Abt system, designed the rack and gearing and superintended the construction. For particulars respecting the road we are indebted to the Manager, Mr. C. W. Sells, of Manitou, Colo.

RECENT PRACTICE IN STEAM SUPERHEATING.

It is coming to be generally understood by American engineers that the next great improvement in the economy of the steam engine will be made through the use of superheated steam, a line of development which was long ago brought forward, but which was dropped after many trials on account of the practical difficulties encountered. Within the past ten years or so, however, superheating has been taken up abroad, especially on the Continent, and has been made a practical and commercial success. The Continental builders of stationary engines are now well in advance of either England or the United States in the attainment of high fuel economies, and it is unanimously agreed that their advance is largely due to the use of superheating. Three years ago, at the May, 1896, meeting of the American Society of Mechanical Engineers (Trans. Am. Soc. M. E., vol. xvii.), Dr. R. H. Thurston, of Cornell University, rounded up the whole subject of superheated steam in an exhaustive paper discussing both the theoretical and the practical side of the subject and drawing deductions relative to the direction of improvement in apparatus and methods, and to the probability of a greatly increased use of superheating in the future.

The principal conclusions reached by Dr. Thurston were the following:

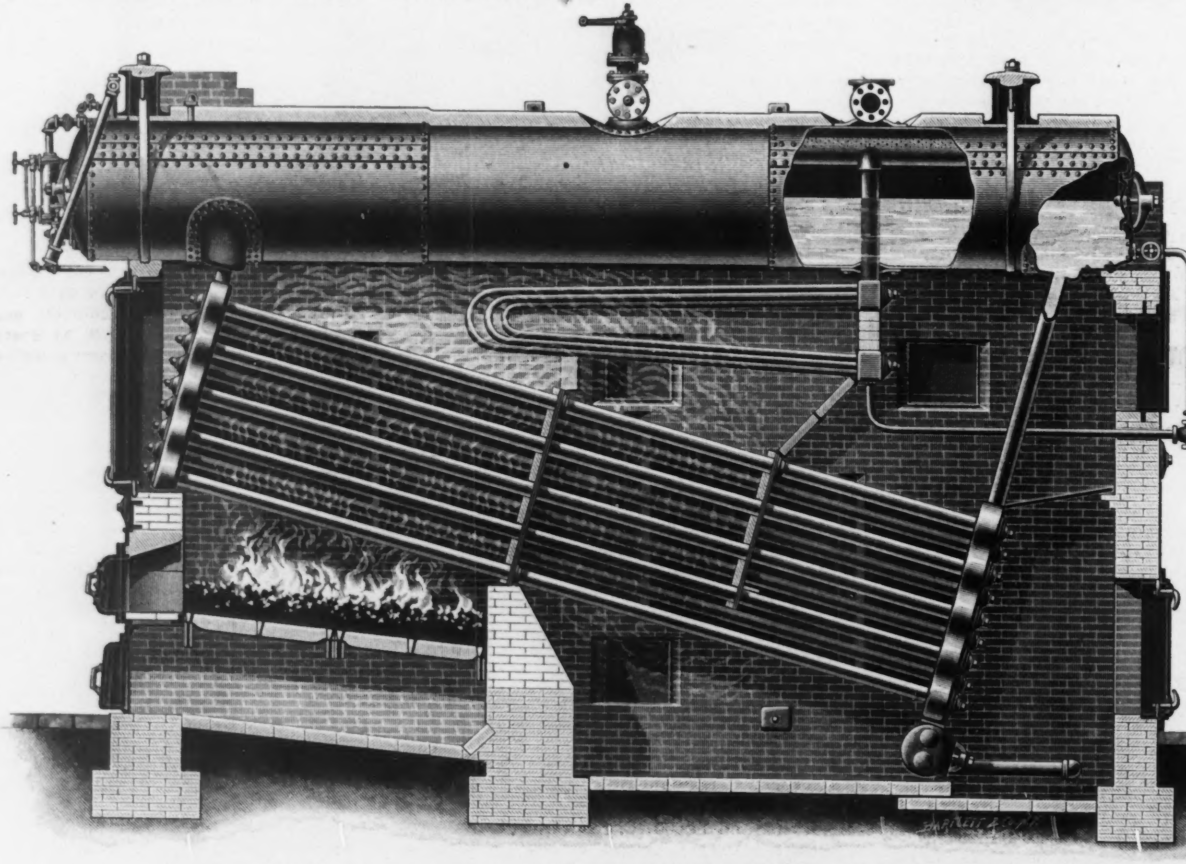


FIG. 1.—SECTIONAL ELEVATION OF BABCOCK & WILCOX BOILER, WITH STEAM SUPERHEATER ATTACHMENT.

1. Superheated steam, as hitherto employed in the steam engine, has absolutely no thermodynamic value. It neither raises the upper limit of temperature or depresses the lower limit. On the other hand, could any way be found of practically working superheated steam, safely and with economy in its production, it would permit a thermodynamic gain limited only by the extent to which the temperature range, $T_1 - T_2$, would be thus expanded.

2. Superheating has for its sole purpose and result, in the steam engine to-day, the extinction or reduction of the internal thermal wastes of the engine, consequent upon the phenomenon known as an initial or "cylinder condensation." Here it is extraordinarily effective, and a small quantity of heat expended in superheating the entering steam effects a comparatively large reduction in the expenditure of steam in the engine. The average of 52 cases observed by the writer gives a gain of 26% with a superheat of 105°F.

3. Superheating is superior to any other known means of reduction of internal waste.

4. No trouble need now be found at the engine with sufficient superheating under usual conditions of operation, to annihilate cylinder condensation.

5. The more wasteful the engine, the larger the promise of gain by superheating, and small engines will profit by it more than large, slow engines more than fast, and single engines more than the multiple-cylinder systems.

6. The larger the waste to be checked in the engine, the farther should the superheating be carried.

One principal hindrance in the past to the general introduction of superheating has been the lack of an apparatus the cost of which was not out of all proportion to the benefits obtained, and which was easy of management and regulation, safe and durable.

The three methods of superheating hitherto adopted were thus classified by Dr. Thurston:

1. Direct superheating, consisting in the exposure of the steam pipes to the direct action of the hot furnace gases.

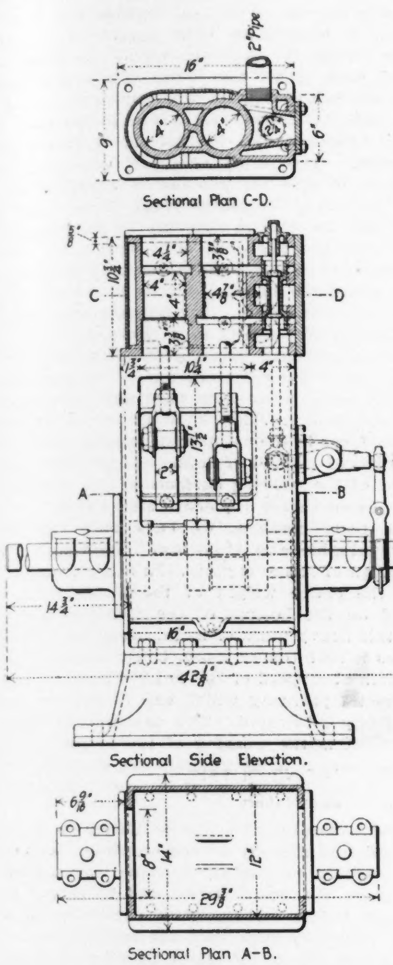
2. Indirect superheating, consisting in the expansion of steam from a higher pressure to that at which it is to be employed, or "wire-drawing."

3. Superheating by mixture, or "adheating," where highly heated steam is introduced into the saturated steam coming from the boiler, en route to the engine.

Of these three methods, the first is the one most frequently used, and the one which seems likely to be most used in the future. There are several subdivisions of this method, such as 1, superheaters in the flues between the boiler and chimney; 2, sending the furnace gases through tubes in the steam space of the boiler; 3, superheaters built in a structure separate from the boiler and provided with a separate furnace; 4, superheaters built in a chamber in the setting of a boiler where they receive the gases after their passage over a portion of the heating surface of the boiler, where they are at a temperature of perhaps 800 to 1,000° F, and before they pass over the remainder of the heating surface.

A superheater of the last described class has within the past three years been introduced extensively in Europe by Babcock & Wilcox, Ltd., of London, and is now being introduced in this country by The Babcock & Wilcox Co., of New York, to whom we are indebted for the following description and the accompanying illustrations, and for an inspection of numerous records of tests, some of which we abstract herewith. The superheater is especially designed for water-tube boilers of the Babcock & Wilcox type, but it is also in use in other forms of boiler, such as the Lancashire, in which latter it is placed in the chamber at the rear end of the boiler so as to receive the gases after they pass through the flues and before they return along the shell.

ite. Considerable areas of the inner surface of this dock have scaled off and have been replaced with "blue brick; but this failure may be accounted for by the fact that much of this work was built under the most unfavorable conditions as to storms, frost and storage of cement. Adjoining parts of the main walls are standing well.



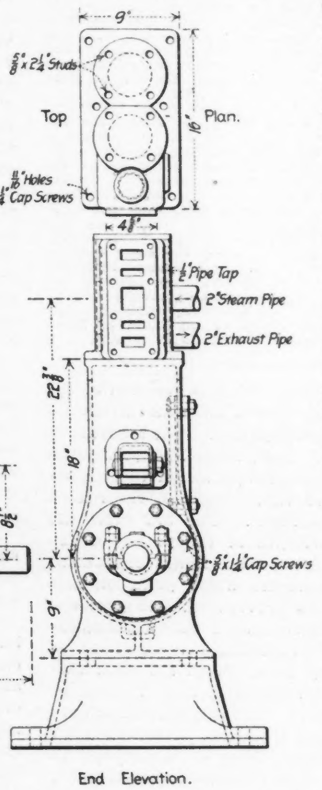


FIG. 2.—DETAILS OF THE ENGINE.

The No. 3 graving dock at Glasgow, designed by Mr. Deas, Engineer of the Clyde Trust, has walls almost wholly of concrete. This dock is 880 ft. long, 115 ft. wide at top and 32 ft. deep from floor to coping. It is divided into two sections by gates. The side walls are made entirely of concrete, with a thin backing of brickwork against the sheet piling. The whole inner face is built of granolithic concrete blocks, separately molded, hardened and then laid like ashlar masonry. To half the height the altars are 3 ft. 6 ins. high by 20-in. tread; and above that they are 18 ins. high by 14 ins. tread; one course of blocks forming an altar. An older concrete dock in England is that at Newport, completed in 1890. It is 350 ft. long and 30½ ft. deep and cost only $121,500, although built on a difficult site.

A COMPACT ELECTRIC GENERATING OUTFIT.

A novelty in the way of a generating set is presented in the accompanying perspective view, Fig. 1, and shown in detail in Figs. 2 and 3. It will be seen that both engine and generator are entirely enclosed, thus avoiding the collection of dust and dirt, the chief danger incident to electric apparatus, and also permitting the machine to be located in places where the ordinary open type of engine and generator would fail.

The engine and generator stand upon a single cast-iron Y-shaped base plate, Fig. 1. The engine, shown in detail in Fig. 2, is a 4 × 3-in. double enclosed automatic engine with cylinders cast in one piece together with the steam chest, in which operates a single balanced piston valve, regulating the steam admission to both cylinders. This valve is operated through a rocker from the eccentric, the position of which is in turn under the influence of the action of the governor.

The cylinder casting is bolted to the top of a closed frame having openings on the front and back for ready access. Ring oiler journal bearings are bolted to the sides of the frame in such a manner as to close the openings, through which the double crank is removable. The cranks are set at an angle of 180°, thereby practically balancing the reciprocating parts. The lower part of the engine frame forms a reservoir to catch all drip and oil, and is provided with a drain pipe.

As will be seen in Figs. 1 and 2, the engine frame encloses the crossheads, crosshead guides and all working parts. A large, close-fitting door on the front, however, affords ample room for inspecting the interior. To the top of the frame is bolted the casting containing the two cylinders and steam chest. The method of lubricating all running parts from one central oil reservior is also shown in this figure. The governor is mounted on the inner side of the flywheel and is of the usual shifting eccentric type common to high speed engines. With a steam pressure of 90 lbs. this engine turns the armature of the generator to which it is attached 650 revolutions per minute.

This generator, shown in Fig. 2, is completely enclosed, and except for the hemispherical end cases, is of substantially the same construction as the standard M. P. 4 generators made by its manufacturers. To the steel magnet ring are accurately fitted and bolted the hemispherical cases, which not only completely enclose the internal mechanism, but also act as supports for the journal bearings. These bearings are of the ring oiling, self-aligning type, and are like the engine bearings, practically dust proof.

The doors in the front case, Fig. 1, allow of ready access to the commutator and brushes. The armature is of the regular barrel-wound, ventilated type, with air ducts and radial vanes between the laminæ of the core. When in operation the armature acts as a centrifugal blower, causing a strong current of air to circulate through the armature core, and over the entire interior surface of the generator. Although this air is confined, it is constantly in motion, passing and repassing through the armature, and meantime coming in contact with the large internal surface of the case, to which it imparts its heat.

The high efficiency of this machine reduces to a minimum the energy wasted in heat, and the radiating surface of the machine is so proportioned with respect to the amount of heat dissipated that the temperature rise, after a continuous run of 10 hours, rarely exceeds 75°F., on either armature or the field.

The armature conductor has an area equivalent to 500 circular mils per ampere, and has a total resistance when hot of 0.052-ohm. The commutator is designed for a brush contact surface of 1 sq. in. for every 25 amperes carried by the brushes, and as the commutation of these machines is practically perfect, very little heat is developed at this point.

The iron losses in the armature are kept low by using a superior quality of annealed steel for the disks, and having them punched, finished and mounted in such a manner as to give the core an exceptionally high resistance across the laminæ. The core density is also kept as low as possible, never exceeding in this machine 50,000 lines per sq. in., while the mean tooth density approximates 80,000 lines per sq. in. The air gap densities are also low, not exceeding 30,000 lines per sq. in.

Perfect commutation is aided by having few turns per coil on the armature, and by proportioning the cast-iron pole shoes so that the pole horns will be practically saturated, thereby preventing the shifting of the field.

The internal temperature rise having been limited to 75°F., the problem presented was to provide sufficient transmitting and radiating surface in the case, and allow the heat generated to pass to the atmosphere. From the conditions of the design, the number of watts to be dissipated was about 950. On the assumption based upon the experiments of Peclet, Mayer and Leslie, that the loss per hour per sq. ft. of surface of the case would be about 160 B. T. U., the exterior surface of the case was made about 20 sq. ft. Subsequent experience with this construction has shown the accuracy of this assumption.

This type of combined engine and generator is made in three sizes with outputs of 3,750, 6,250 and 11,000 watts; the weights of the outfits being 1,550, 2,400, and 3,800 lbs., respectively. This gives 2.4, 2.6 and 2.9 watts output per lb. weight.

For the drawings and data from which this description was prepared, we are indebted to the B. F. Sturtevant Co., Boston, Mass., who are the makers of these equipments.

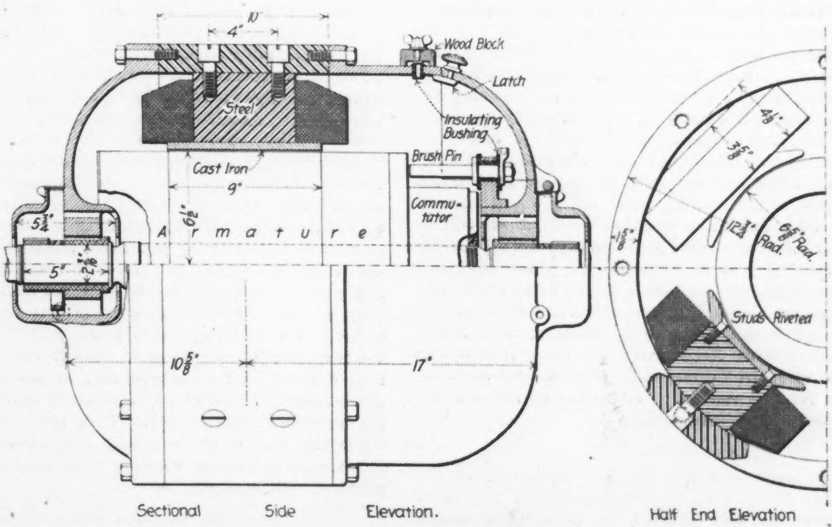


FIG. 3.—SECTIONAL ELEVATIONS OF GENERATOR, SHOWING DETAILS OF FIELD MAGNET AND ARMATURE BEARINGS.

and, Cal. But as the bill provided that the Secretary of the Navy, in his discretion, might build one of these of granite, with a limiting cost of $1,025,000, he exercised this authority in the case of the Boston dock, and decided that it should be built of concrete, lined with granite. Plans were accordingly prepared and bids were opened on Jan. 31, 1899, with the result that such a dock can be completed for about $1,000,000, or within the limit set by Congress. Prior to the final passage of the act above referred to, the Navy Department had strongly urged upon the Senate Naval Committee the use of concrete and granite for all these docks, as the Board of Dry Docks, appointed by the Navy Department in 1897, had reported recommendations which practically favored masonry for this use. While the ultimate action of Congress was substantially adverse to this advice, a change in the present policy is expected, from the fact that timber docks are beginning to show that they are temporary and unsafe structures, and the Boston bid shows that a substantial masonry dock can be built for a reasonable sum, and at only a moderate increase, over the cost of timber construction.

Admiral Endicott went on to show that a timber dock is necessarily a temporary structure, that may last from 20 to 25 years, according to the kind of wood used and the local influences. While the first cost is small, compared with masonry, the rapid deterioration of the wooden structure results in very considerable expenditure. The records of the stone docks, on the other hand, show comparatively small repair bills; and these were largely due to the use of Rosendale cement, permitting the action of frost and leakage from springs. The large original cost of the old stone docks may be charged to several causes; they were built by days' work by navy yard employes, and not by contract; the materials were purchased or contracted for piecemeal; and the appropriations by Congress were intermittent, causing long delays and unnecessary expenditure for maintenance and repair during the periods of idleness. The timber docks were all built by contract and pushed through with the utmost dispatch; and as a consequence no fair comparison of cost between the two types of dock construction was possible, until the bids were received for the concrete and stone dock for Boston. These bids show that a dock of this type, with all accessories complete, can be built for about 25% in excess of the limit fixed by Congress for each of the timber docks, authorized at the same time for $825,000 each. It must be admitted that this is a fairer and more accurate comparison than that previously made, when the contract price of a timber dock, at $600,000, was set off against the $2,000,000 for the Mare Island concrete and stone dock, and $2,750,000 for the all-stone New York dock.

In weighing the relative merits of stone and timber docks, Admiral Endicott said that the two are equally convenient for use. Timber docks are usually of great width at the top; as the slope taken is usually that natural to the soil, as near as possible, so as to avoid undue horizontal thrust against the sides. The altars used to line these sides form a continuous stairway, and the great width at top freely admits light and air. Stone dry-docks are generally much narrower at the top and the altars are too high to form easy steps, and stairways must be introduced. But the materials of a masonry dock lend themselves to any form, and the dimensions generally adopted result in no inconvenience or disadvantage to the work carried on in the dock. If this had been so, the form of masonry docks would have been changed long ago; and in fact, the Mare Island dock very closely approximates the cross-section of a timber dock. The disadvantage of a dock wide at the coping is that it necessitates cranes with very long arms for handling material; and this is a ruling objection in European dock construction. In a stone dock there is nothing to obstruct light and air except the ship itself; and even when the cross-section of the vessel approximates that of the dock, this condition only exists amidships.

In the matter of stability, the conditions to which the two types of dock are subject are practically the same, so far as the ability to resist the weight of the ship is concerned. But the condition involving most danger in a dry-dock is not that of the weight of the vessel, but the pressure of the water in the soil below high-tide level, which tends to lift the bottom and force in the sides of the dock. Herein the two types differ very materially. In a timber dock the weight of structure is a very small element of stability; and its integrity depends on the tightness of the sides and the holding-down power of the piles under the docks and to which it is secured by bolts. Such a structure is not well designed to resist inward and upward hydrostatic pressure; and this point is admitted in the common practice of providing timber docks with relief inlets through which the water in the soil may enter, to find its way to the pump-well and there be lifted to the harbor level. This hydrostatic pressure is particularly severe at the entrance, where it is greater, the slopes steeper, and the thrust from the soil is increased. Leaks in such docks may carry silt or soil with them and endanger the whole structure by undermining, as was the case in Dry Dock No. 3, at Brooklyn. A masonry dock, on the other hand, is designed to resist these forces by its own inherent weight; it can be made watertight, and any leak due to a faulty joint is not attended with the same danger as in the case of a timber dock. An experience with stone docks extending over 65 years shows that such leaks as did occur from bad joints involved no instability or danger, and the docks fully preserved their usefulness without any interruption. Finally, the present demand for docking warships costing several millions each requires absolute safety of such structures. The government cannot afford a doubt of any kind when the safety of such a vessel is considered.

Admiral Melville spoke in much the same strain, though he was naturally most concerned in the danger to battleships that might result from cheap, or unsafe dock construction. After pointing out the present condition of our wooden dry-docks, he remarked that it was only the great care and skill exercised by those in charge of these weak docks that had averted financial loss, and perhaps appalling loss of life as well. He condemned timber for the new dry-dock at League Island, as the old dock penetrates a compact water bearing stratum of sand and gravel that has always caused excessive leakage, and the erection of duplicate pumps to get rid of the water. Admiral Melville called these pumps costly monuments to the timber folly. As to the site of the proposed timber dock at Portsmouth, N. H., borings show that the government would there propose to blast this dock out of solid granite and then line this excavation with wood! The advocates of timber could ask no deeper devotion to their theories and interests, than this.

Mr. Wm. Ledyard Cathcart, in his discussion, showed that the British government owned or controlled 62 graving docks, and only one of them was of timber; France has 36, Germany 11, and Italy 12 graving docks; all built of masonry. Germany lately declined to subsidize a corporation dry-dock unless it were built of masonry. Mr. Cathcart took up in detail the cost of repair and maintenance of the principal government stone and timber dry-docks in the United States, and combated the published comparisons of cost presented to Congressional committees by interested parties. He contended that many of the items used in these statements were erroneous, or simply estimates; and in considering the cost of repairs to timber dry-docks, the naval docks, cited as examples of the small expense of maintenance, ranged in age from 2 to 10 years. They were thus practically new, and decay had not advanced sufficiently to give a true appreciation of the cost of repair over any considerable period. These comparisons also omitted some items like the $64,000 just appropriated for the repair of the League Island timber dry-dock.

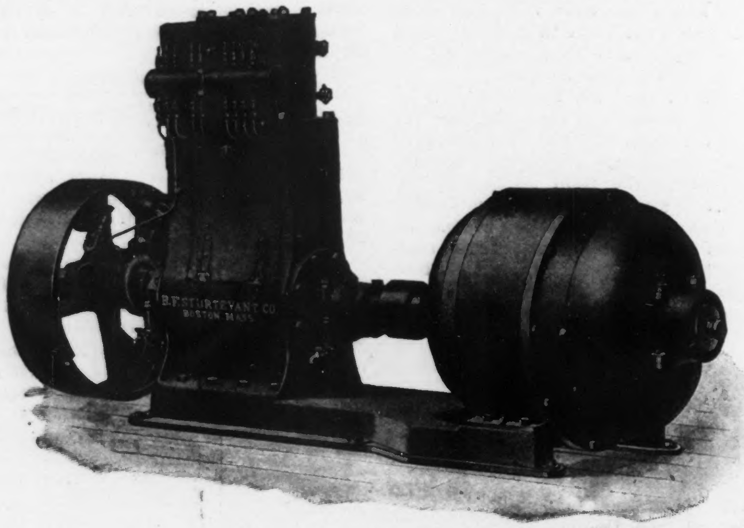


FIG. 1.—A COMPACT ELECTRIC GENERATING OUTFIT.
The B. F. Sturtevant Co., Boston, Mass., Makers.

Captain Asserson, in discussing his experience in the repair and maintenance of timber docks, said that it was not generally known that in timber dry-dock No. 2, at the Brooklyn Yard, in driving home the wedges at the ends of the shores, in docking a ship, the dock would spread on both sides 4 or 5 ins. This happens even now in that dock, and it is only a question how long the diagonal timbers will bear this continual thrust. The soil, which should pack against the back of the timbers, is of such a nature that it falls away from the altars and diagonals, and the sides of the dock are left without any other support than the piles. It is a disturbed soil that takes a natural slope of 35°. He placed the cost of timber docks at $1,000 per lineal foot in round numbers; while he estimated stone and concrete at $1,500 per lineal foot. Though at one time in favor of wooden docks, he now advocated concrete faced with stone. In regard to protecting wood by creosoting, he said that his experience was that a good, heavy, dead-oil creosote, injected under a pressure of 100 to 120 lbs. per sq. in., would protect timber for from 10 to 15 years; after that, it failed. The estimated cost for a 750 ft. concrete dock, lined with 3 ft. of stone, at Norfolk, Va., was $1,100,000. For a timber dock of the same size and built as strong as possible, the estimate was $700,000. The plan for the masonry dock called for stone abutments, a steel caisson and a slope of 30 to 33° for the sides; or, a very wide topped dock.

Mr. John Kennedy, as Chief Engineer of the Montreal Harbor Commission, has lately visited all the dry-docks from Halifax to Norfolk and on the lakes. He reported the timber docks, both private and government, as generally failing and being largely repaired by concrete, especially in the parts out of water. He favored concrete lined with masonry, and believed it would be well to consider how much further this concrete might be carried, where economy is of prime importance. The Halifax dock of 1886-89, 580 ft. long, is all concrete, except the faces for the caisson gate, the coping course of the altars and main walls, and the stairways and material slides; these are all gran-

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The American Railway Engineering and Maintenance of Way Association, whose provisional organization at a meeting held in Chicago, Ill., last October was noted in our issue of Nov. 3, 1898, has completed its permanent organization, as recorded in our department of society proceedings in this issue, by adopting a constitution and electing officers. The task which this new society has undertaken is one of great importance, although it will require good judgment and thorough work not to interfere with or to duplicate the work of other and older railway engineering organizations, and to substantiate the reasons which have been given for its separate existence. Fortunately the association starts on its career with a set of officers of exceptional reputation and professional ability, and we have no hesitation in saying that if the members will stand by these officers and support them with hard and earnest work, there will be every reason to expect a prosperous career for the new society. It is by its work alone that any engineering society obtains the right to claim recognition and encouragement from engineers, and if the American Railway Engineering and Maintenance of Way Association can show a record of needed work well done, at its next annual meeting, it will find no reason to complain of the manner or extent of this recognition.

In our issue of March 24, in commenting on the Windsor Hotel fire, we remarked that the story that the fire was started by a burning match thrown against a lace curtain was absurd on its face, when the almost instantaneous spread of the flames was taken into consideration. Our statement to this effect was supported by Mr. Edward Atkinson, from whose letter to the Boston "Herald" we quoted last week; and we are now in receipt of a letter from Prof. A. D. F. Hamlin, of the School of Architecture of Columbia University, in which he states that he arrived at the same conclusion shortly after the fire. We quote as follows from a contribution by Prof. Hamlin to the New York "Times:"

> Since your issue of March 25 calling attention to the theory of Engineering News regarding the origin of the Windsor Hotel fire, it has been asserted with some positiveness that the Fire Marshal's report would indorse the conclusion that the fire started with the accidental burning of a lace curtain on the second floor. I agree with Engineering News in believing this conclusion to be absolutely unwarranted.
>
> The readiness with which the public has accepted the lace-curtain theory is surprising. I hold this theory to be preposterous as an explanation of the fire. All the photographs I have seen militate against this theory, and some of the testimony, at least, points to the existence of fire and the discovery of smoke from the outside some time before the curtain was seen to blaze.
>
> I believe the fire originated unnoticed in the basement, perhaps some hours before it broke out above, and ate its way at first slowly in the hollows of the ceiling in several directions laterally, and then crept up the studding and furring of several walls and partitions at the same time, catching the joists of each floor as it worked upward, and spreading slowly through the floors from each of these points; a smoldering fire, with but little flame, the smoke escaping into the roof through the unstopped hollows of the furring; and that the whole smoldering mass burst into flame at nearly the same moment on every floor and in every part of the house. Undoubtedly one or perhaps two curtains blazed up, catching not from a match, but from a flame breaking through cracks in the window casing from the internally burning walls, and thus giving the first notice of the burst of flame which was soon to follow with such awful results.

A bill for the protection and improvement of the waters of the State of New York was introduced in the legislature a few days ago. The measure is a most excellent one. Its passage, supplemented by an ample appropriation to make it thoroughly effective, would be of vast benefit to the health and prosperity of the State. The bill vests the general care and oversight of the purity of the waters of the State in the State Board of Health; authorizes it to investigate water pollution and devise remedies for its prevention; and provides for the co-operation of the Board with municipalities and individuals "in making investigations or experiments necessary to ascertain the most efficient, economical and feasible means" to stop or diminish water pollution. All this is most admirable. The co-operative feature deserves high praise. It allows single cities or individuals to secure the help of the Board in experimental work, the expense to be divided, by agreement, so the State need not bear the expense of work of purely local value, while the municipality or individual will be relieved of the cost of that part of the work by which other communities or persons may profit. A separate bill appropriates $10,000 for the expenses entailed by these new duties. Three times this amount has been appropated yearly for similar work in the much smaller State of Massachusetts for some ten years past, with results that have become famous the world over. Ohio has been working along this general line for several years, and the recent New Jersey legislature took some important steps to the same end by entrusting the sanitary supervision of the water supplies of the State to the State Board of Health and providing for a State Sewerage Commission, in addition, to give specific advice regarding sewage disposal. A bill for the appointment of a permanent State Sewerage Commission is also before the Connecticut legislature, with good prospect of passage. The legislatures of Pennsylvania, Illinois, and Wisconsin, yielding to the influence of manufacturers who blindly put their temporary financial interests before the lives of their employees and neighbors, and to a conservatism born of sanitary ignorance and backwardness, have smothered or killed the bills to prevent water pollution, which we reviewed in our issue of March 16. There is still a hope that Pennsylvania, at least, will do something to retrieve its reputation and to assist its typhoid-stricken cities. Thus far, New Jersey leads the way in the sanitary legislation of 1898. It remains to be seen whether New York and Connecticut will outstrip her.

THE DESIGN OF ENGINES TO USE SUPERHEATED STEAM.

On another page of this issue we illustrate and describe a new apparatus for superheating steam, and in connection therewith we have given some account of the remarkable progress which has been made in Europe in the use of superheated steam in large mill engines. We have noted from time to time in past volumes of this journal the reports of high duty tests of the steam engines built by Continental establishments; and it now seems clear that our American engine builders must turn their attention to the work which their European competitors are doing, if they propose to keep pace with them.

The secret of the great success which the European engine builders have attained is very simple. It lies in the use of vertical engines with poppet valves in connection with superheated steam. Those whose recollections extend back to the period, many years ago, when superheating was given an extensive trial, will remember that the chief difficulty found with it was the burning up of the lubricant and the cutting of valves and cylinders. It required very few experiences of this sort to give the practice of superheating a very black eye. No matter what claims might be made for theoretical economy in superheating, those who had heard of mills shut down while injuries were repaired which engines had received while superheated steam was on trial were in no mood to investigate further an innovation which promised to give rise to such troubles.

Thus it happened that superheating was abandoned, and it has remained for the studious Germans to again bring it forward and demonstrate its practicability. They have got rid of the rubbing surfaces in the cylinder by making the cylinders vertical instead of horizontal, and they have got rid of the rubbing surfaces of the valves by using poppet valves in place of slide valves.

Both these changes, we have long held, are really valuable and important improvements in the design of steam engines. In a horizontal cylinder the entire weight of the piston must be carried on the bottom of the cylinder, and we have this heavy mass of metal, weighing in large engines a half ton or more, being dragged back and forth at a speed of 500 to 1,000 ft. per minute on a metal pathway which can at best be very imperfectly lubricated. The natural and inevitable result is the wearing of the bottom of the cylinder until it is measurably out of round, and more or less leakage of steam past the piston occurs.

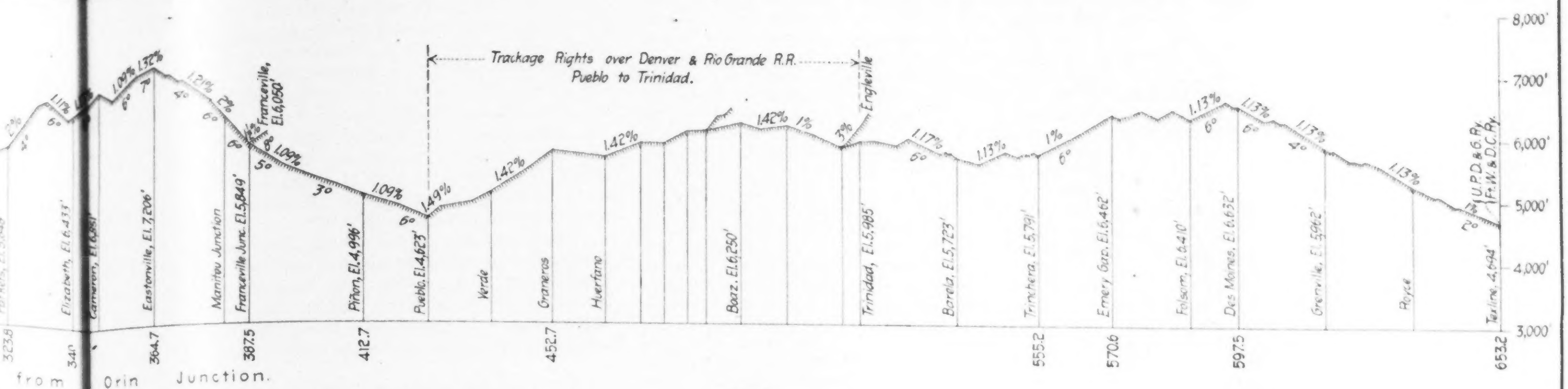
In the vertical engine, the weight of the piston is transferred directly to the crank-pin, and operates merely to slightly increase the pressure upon it on the down stroke and to relieve the pull upon it to a corresponding extent on the up stroke. The only wear upon the barrel of the cylinder is that due to the piston packing rings, and the difficulties with uneven wear and heating of the glands and packing around the piston rod are likewise overcome.

It is noticeable that the tendency of recent practice, both in this country and abroad, is toward the vertical type of engine. In electric power stations, for example, it has been rapidly gaining ascendancy over the horizontal engine for some years. From the above discussion, it seems clear that this is a change in the right direction.

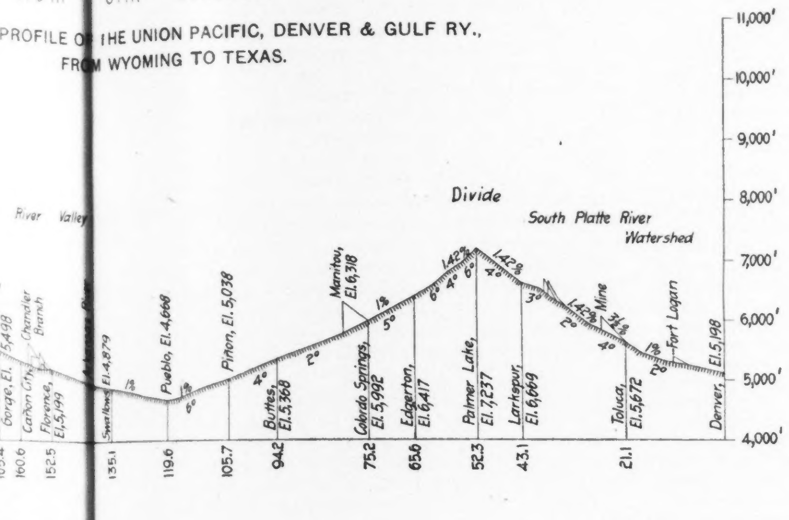
Even more important than the use of the vertical engine is the adoption of the poppet valve. The piston presses with only its own weight upon the cylinder, as it sweeps back and forth; but the slide valve is loaded with a steam pressure often equivalent to a weight of several tons.

The work done in operating a poppet valve is very much less than that required to operate a slide valve, for the load upon the poppet valve is relieved as soon as it is started from its seat, while the slide valve is loaded all the time. Further, the wear upon the slide valve begins as soon as it is put in operation, and continues with the rapidity to be expected where two hot metal surfaces rub against each other under high pressure and with very imperfect lubrication. The wear upon a properly designed poppet valve, on the other hand, is very slight.

It may seem strange that these manifest advantages have not brought the poppet valve into more extensive use as a competitor of the slide valve; but there are evident reasons for its neglect. In the first place, the design of a valve-operating gear which will promptly open and close a poppet valve and do it without jar or shock, is a problem by no means easy of solution. Some form of cam gear is almost essential to effect this, and American engine builders, and



PROFILE OF THE UNION PACIFIC, DENVER & GULF RY., FROM WYOMING TO TEXAS.



GAGE LINE.

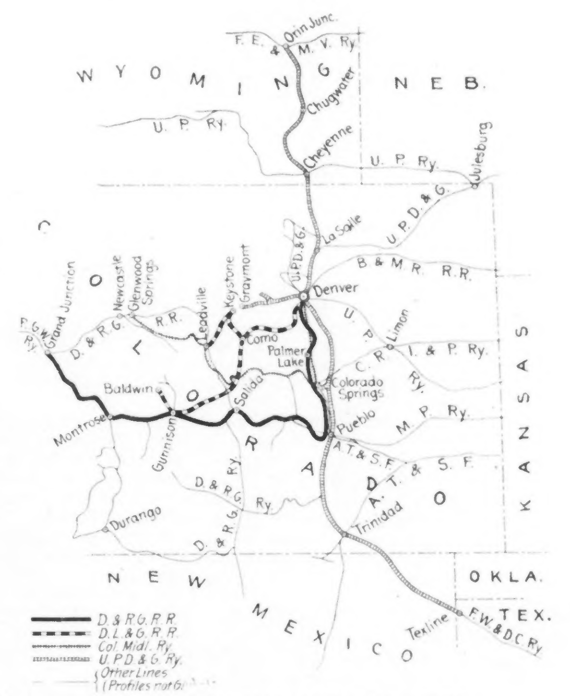
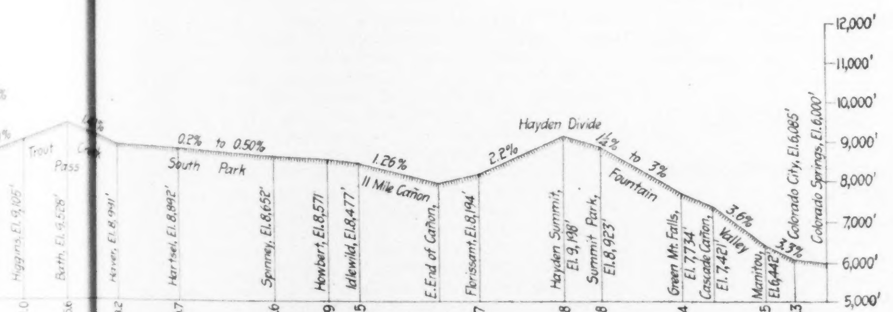
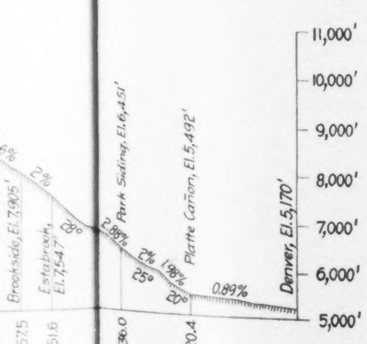


FIG. 1.—SKETCH MAP SHOWING LINES WHOSE PROFILES ARE GIVEN.





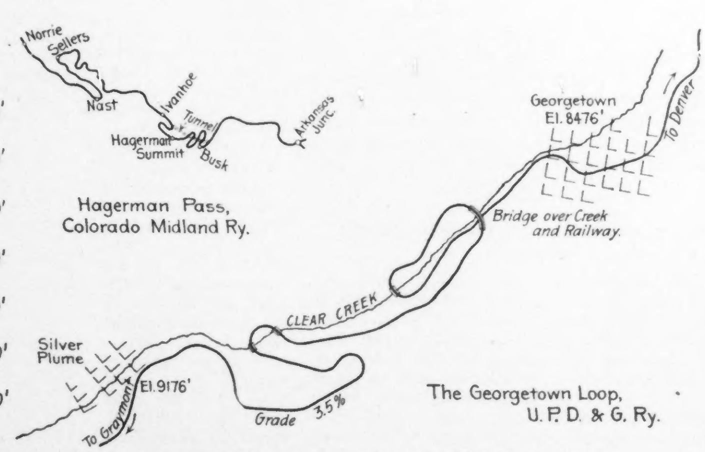


FIG. 7.—PLANS OF THE HAGERMAN PASS AND THE GEORGETOWN LOOP.

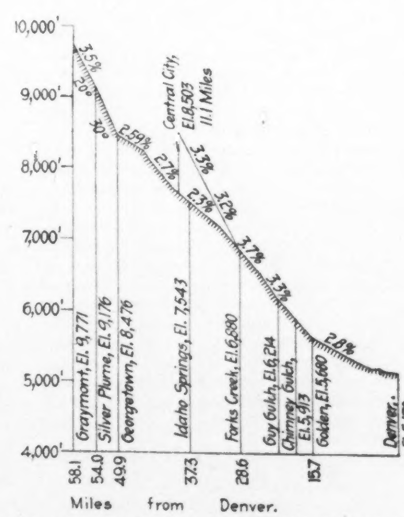


FIG. 6.—PROFILE OF GRAYMONT DIVISION; U. P., D. & G. RY.

HE ROCKY MOUNTAINS IN COLORADO.

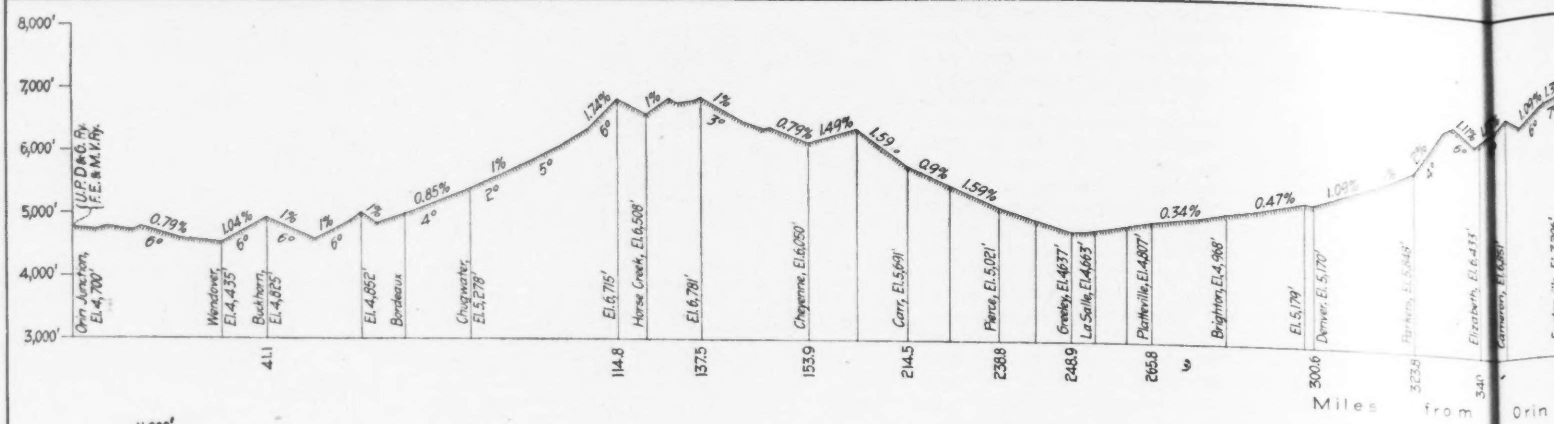


FIG. 8.—PROFILE OF THE UN...
FROM WYOM...

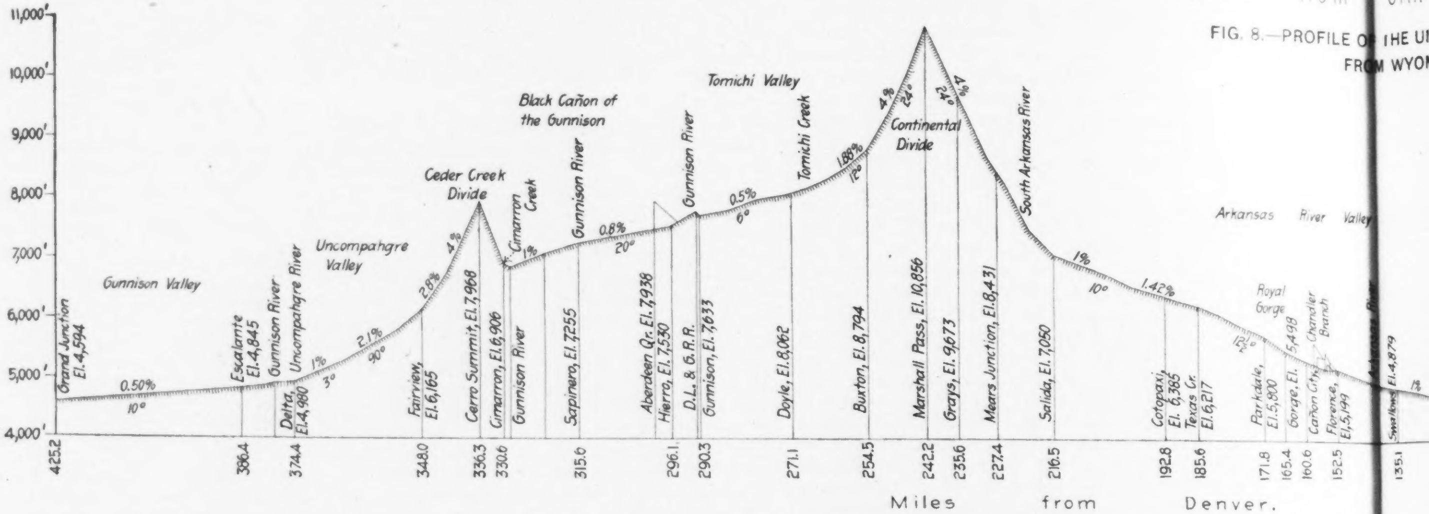


FIG. 2.—PROFILE OF THE DENVER & RIO GRANDE R. R. (ORIGINAL NARROW GAGE LINE).

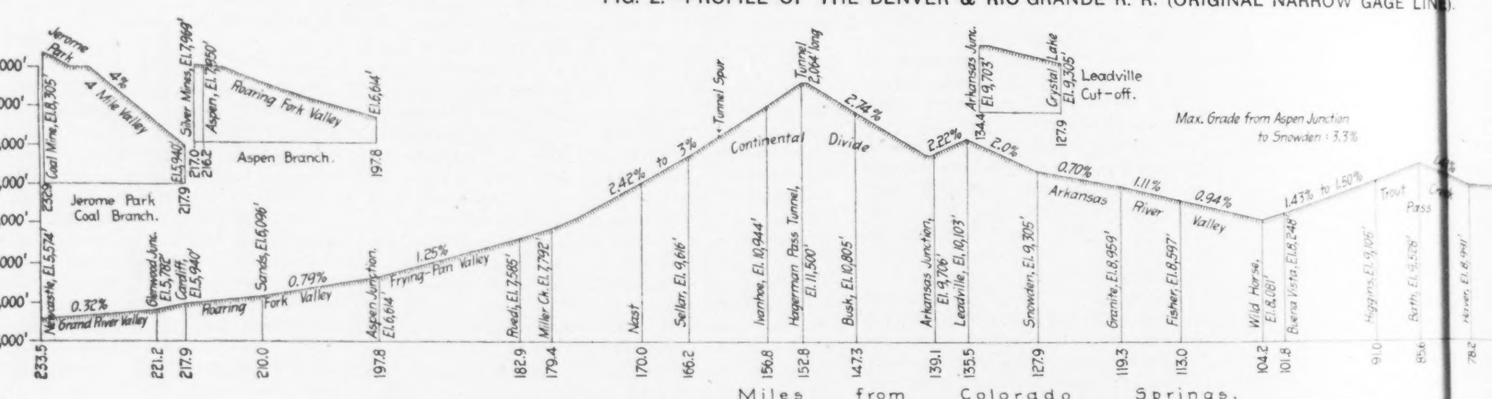


FIG. 3.—PROFILE OF THE COLORADO MIDLAND RY.

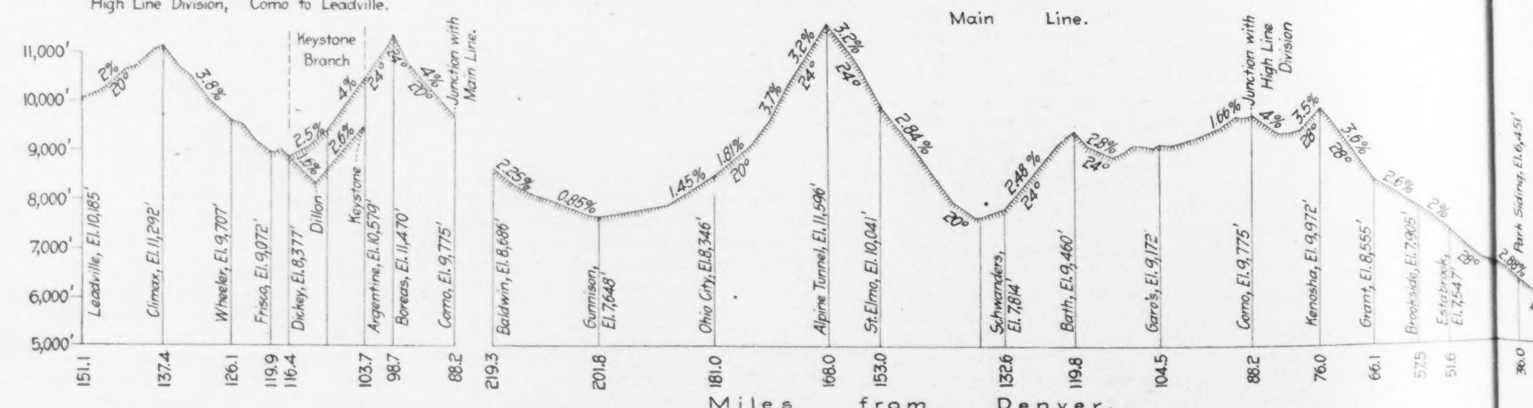


FIG. 5.—PROFILE OF THE DENVER, LEADVILLE & GUNNISON RY.

PROFILES OF RAILWAYS CROSSING THE ROCKY

users as well, have never looked with much favor on cam gears, notwithstanding the high economy which has been obtained by their use.

Simplicity has always been the cry of American mechanical designers; and it certainly has saved them from the production of some such complicated extravaganzas of mechanism as have become notable in France and Germany. On the other hand, it must be said that sometimes a device is discarded as too complicated when the complication exists in the mind of the designer, who prefers some mechanism with which he is more familiar. There are poppet valve gears, for example, if we mistake not, which are much less complicated than some of the slide valve mechanisms which have been developed in the attempt to secure a slide-valve which shall be relieved of steam pressure, and which shall give prompt and full port opening and release under all conditions of cut-off.

The results which are being attained by the Continental steam engine builders are already exciting the attention of American steam engine users. We know of one large electric lighting company, for example, which has for years been trying to obtain engines which would give higher fuel economy. They have had engines designed by their own engineers and built to their own drawings and specifications. They have also tried the plan of asking engine builders to submit their own plans with inducements to offer high guarantees of economy. Recently a committee of the company's managing officers was sent on a European tour, to study foreign practice in steam and electrical engineering. They returned strongly impressed with the great advances which have been effected there through the use of superheated steam.

A piece of additional evidence as to the interest which superheated steam is arousing in this country is furnished by the remarks of Mr. Elihu Thomson, the well known electrical engineer, at a recent meeting of the American Institute of Electrical Engineers. Mr. Thomson, it appears, has recently been turning his attention to steam engineering design, and the results of his work were stated by him as follows:

Engines as small as 4 HP. can be made to develop a brake horsepower (not indicated) on about 20 lbs. of water per HP. hour. I make that statement advisedly because I have been experimenting for a year in that direction. Engines of this kind can be turned out in any machine shop without any particular difficulty, being as easy to make as any simple engine. I find curiously enough, after doing a certain amount of work in this direction, that M. Serpollet of Paris has recently published a statement concerning a steam engine as applied to horseless vehicle work, and I find further that his engine is about the same as mine. This goes to show that we have been thinking pretty much in the same groove. I need make no secret as to what the engine is, because M. Serpollet has published it, although our own patents are pending. But it is so simple that it is astonishing that something of the kind has not been used or at least experimented with before. My reasoning was this: That the gas engine is an efficient engine and that I must run my steam engine on the same principle as the gas engine. In other words, I must imitate the cycle of the gas engine in steam, and then I would get high efficiency, with other advantages. If I represent an ordinary steam cylinder as an open-ended cylinder in Fig. 1, and put a piston P in that cylinder, well packed by rings, and either use a straight piston rod and guides in the ordinary way, or a connecting rod jointed to the piston, we have the type of engine as it stands. Now instead of reversing the motion of the steam as it enters back of the piston and throwing it back to the heated surfaces in exhausting, we are careful never to throw it back, but always let it go forward. We make an exhaust consisting of a number of holes uncovered by the piston at the extreme outward portion of its stroke as at E. The piston is moving slowly when it is near E, and there is plenty of time, if the holes are made around the piston, to discharge all the steam. In order to use superheated steam and not burn the valves or injure the engine, we use a poppet valve V which is raised by proper valve mechanism in time with the rotations of the crank. Now, suppose the engine cylinder has been exhausted of steam at E to atmospheric pressure. If we construct an indicator diagram, Fig. 2, calling base line atmospheric pressure, we reach the end of our stroke at e. Instead of letting the piston go all the way up to the end of the cylinder we can allow a clearance space similar to the clearance space in a gas engine. We can thus allow a certain compression; and the compression can nearly equal the boiler pressure, or it may fall below it. This seems to make but a slight difference. We have, therefore, adiabatic compression with a slight heating during the compression line along e d, Fig. 2, because the steam left in the cylinder is being driven up towards hot surfaces, those that have been heated by the live steam. Then we have valve V opened suddenly, and pressure rises to boiler pressure g. The valve V stays open but a very short time, and expansion takes place from g to e. The diagram resembles a gas engine diagram. What is left in the cylinder is again driven up and compressed. Now what is the result? There is a temperature gradient from one end of the cylinder to the other. The steam always coming in hot, cools off by expansion; by the time it gets to E it is ready to go out. It sweeps out all water condensation, and what steam is left in the cylinder is driven back on hot surfaces, dried and superheated; the poppet valve opens and makes as it were an explosion of steam; remains open but a small time and expansion brings the pressure down again, and so on. The engine with four cylinders 2½ ins. in diameter, 3-in. stroke, has given the result of 20½ lbs. of water per HP. hour, at 160 lbs. to 200 lbs. pressure.

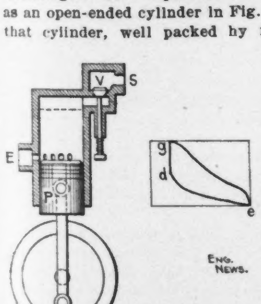


Fig. 1. Fig. 2.
Vertical Single-Acting Engine for Superheated Steam with Typical Indicator Card.

This small engine does not condense at all; the escape is outwardly to the air. We made careful brake tests, driving a dynamo and loading the dynamo, and against the results of test is the transmission by a chain and the bearing on which the dynamo ran. That is, we really ought to allow about 5% more, which would bring the steam down to about 19½ lbs. per brake HP. hour. With a large engine I see no reason why it should not go down to something like 15 or 16 lbs. Surely we ought to gain something with increase of size.

Again, notice the conditions. There is no re-traversing of passages, no re-traversing of even the cylinder portion. The steam enters, goes forward and out, and it is running steadily forward. Thus we have a temperature gradient from one end to the other of steam cylinder. We use superheated steam, highly superheated if we please, because the engine is like the gas engine which can use flame. We have run it at all degrees from moderate superheating up to red heat. The engine has been operated with the steam pipe red hot right up to the engine, but our tests were made when it was at a moderate superheat.

LETTERS TO THE EDITOR.

Against a Perpetual Franchise for the New York Rapid Transit Ry.

Sir: I hope that you or someone else will take the lead in organizing a movement to oppose to the last a perpetual grant of the franchise for an underground tunnel in New York city to any private corporation. The tunnel must be the city's, whatever method of building it may be adopted.

Yours sincerely,
John Franklin Crowell.

201 West 56th St., New York city, March 31, 1899.

(That public opinion in New York city is decidedly opposed to the grant of a perpetual franchise for the Rapid Transit road has been made evident during the past week. Various public organizations have taken strong ground against it, and it seems on the whole improbable that either the legislature or the Rapid Transit Commission will go counter to manifest public opinion.—Ed.)

Efficiency of Pelton Water-Wheels with Deflecting Nozzles.

Sir: We have read with much interest, in your issue of March 9, a description by your correspondent of the long-distance transmission power plant in the Santa Ana Canyon, installed by the Southern California Power Co. of Los Angeles, as also your deductions therefrom. There are some inaccuracies in the latter that, in justice to us, should be corrected.

In making some calculations as to the probable efficiency of the entire plant, you assume that of the wheels to be 70%, accounting for what you term this rather low efficiency from the fact that the methods of governing required the use of deflecting nozzles on the wheels on account of the high head under which they operate.

The fact is that deflecting nozzles were used in this case, not on account of the high head, nor solely for purpose of regulation, but from the fact that the water was required below the station for irrigation and a constant flow from the wheels was therefore necessary. The same degree of regulation could have been obtained, with more economy of water, by the use of our nozzle cut-off device, with perfect safety, many being in use under much higher heads than these wheels are working under. Further, even with the deflecting nozzles, it is admitted that the wheels in this plant show a working efficiency of something over 80%. A revision of your calculations on this basis would show a material gain in net results.

Yours truly,
The Pelton Water-Wheel Co.,
A. P. Brayton, President.

San Francisco, Cal., March 16, 1899.

Measuring Dead Oil in Creosoting Timber.

Sir: I would like to find through your correspondence column the general practice for measuring dead oil of coal tar for treating timber by the Bethel process. In inspecting work done at a certain creosoting works I have found the following practice in vogue: The capacity of the empty cylinder in gallons is known. Then by reducing the cubical contents of timber to be treated and cars holding same to gallons, and substracting this from the capacity of the empty cylinder the unoccupied space in the closed cylinder in gallons is found. To this the number of gallons of oil required for the treatment is added and this amount plus a variable quantity is put in the cylinder. It is found that sappy timbers will soak up as much as 6 lbs. of oil per cu. ft. during the treatment without the application of pressure from the force pump; and that the closer the fibers in the timber, the less oil it absorbs. It is also found that when just the exact amount as computed by the above plan is used, it seldom leaves just the required amount of oil in the timber. On measuring the amount of oil run out, the quantity left in the timber will be found less than what was required; and this has led to the practice of putting in an extra amount of oil over and above the calculated amount, with the general result that too much oil is left in the timber. If this extra amount is too small, then the oil has to be put into the cylinder the second time, in which case more oil is put into the timber than is required, causing a loss due to the value of the extra oil used as well as the loss of time in use of the cylinder, etc. The uncertainty is all due to the variation in the amount of oil the timber will soak up and always leaves the Superintendent between two dilemmas, either of which is expensive. Does anyone have a practice where the amount of oil the timber retains can be determined before the cylinder is emptied into measuring tanks? K.

The Darien Route for a Ship Canal.

Sir: I have noted in your issue of March 23 the admirable article on "The Appointment of a Commission to Investigate Isthmian Canal Routes," which I have carefully read with much interest. It appears then that the President of the United States has been given full authority to investigate all of the isthmian canal routes, which he should do, and employ competent engineers for the purpose. You may have noticed from my book entitled "Isthmus of Panama, Nicaragua, Canal Routes, etc.," that I have advocated a route for a ship canal across the Isthmus of Darien, in the United States of Colombia, from Caledonia Bay or Port Escosces on the Atlantic side to the Gulf of San Miguel on the Pacific side, distance about 39 miles. I advocate this route because it appears to have good harbors, a comparatively good climate, short distance and low elevations, which will permit of a sea-level canal. There are no lakes on the route which might prove troublesome, and I do not think there will be many rivers encountered. The Savana River will form a part of the Pacific end of the canal.

I am aware the United States government sent Commander Selfridge, U. S. N., and Lieutenant Sullivan, U. S. N., to investigate this route, but I am not at all satisfied to take the reports of these gentlemen as conclusive evidence against its practicability. Still less am I inclined to regard Lieut. Strain, U. S. N., as a competent witness. Nor do I regard the report of Mr. Lionel Gisborne, the British engineer, who investigated the Darien route for Sir Charles Fox, as conclusive.

There is much in the explorations of Commander Prevost, R. N., and Dr. Edward Cullen, F. R. G. S., and Dr. Caldwell, of the U. S. frigate "Independence," and Adjutant Miller, of the Spanish service, to encourage me in the belief of the practicability of this short Darien route.

Very respectfully yours,
Thomas W. Hurst.

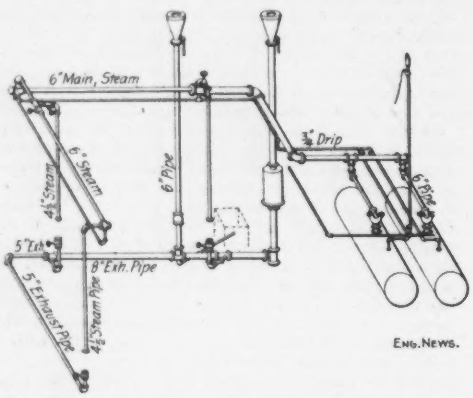
Chicago, March 27, 1899.

A Case of Vibration in Steam Piping.

Sir: Can any of your readers suggest a remedy for a curious throbbing or pulsation in our steam pipes? The steam plant originally consisted of one 72-in. return tubular boiler and one 75-HP. high speed engine. These were connected by a large steam main with every opportunity for expansion, there being not less than six turns between engine and boiler, with at least one length of not less than 10 or 15 ft., both vertically and horizontally. With this original plant no trouble was experienced.

To this plant has been added one new boiler of the same size as the old, viz., 72 ins. × 18 ft., and two new engines of the same size as the former engine, viz., 12 × 14 ins. The new engines and boiler are placed on the outside of the old—that is to say, the new boiler is placed at the side of the old one opposite the engine, and the steam pipe which supplies the original engine is continued further from the boiler to supply the two new engines. The accompanying sketch will show the arrangement of the piping.

Since this was put in there has been noticed a marked vibration or pulsation when both boilers are in service and two or more of the engines are running. This pulsation does not synchronize with the motion of either of the engines. It is not perceptible in the pipe near the engines. It is most evident in the second or new boiler, and is felt most strongly when standing on the side of the new boiler. There is no variation in the water level of



either boiler as shown by the glass, nor is there any variation in the steam pressure shown by the gage. The vibration is continuous whether the steam pump which supplies the boiler is running the boiler or not. The steam main across the boilers is 8 ins., diminished to 6 ins. between the first and second engine and 4 ins. between the second and third. The vibration apparently is the same whether the engines are running light or driven to their full capacity, and apparently is not affected materially by changes in the steam pressure. The wall of the new boiler has been shaken loose. The wall of the original boiler remains firm and solid.

We shall be glad to know if the experience of any of your readers covers this case.

Yours truly,
"Erecting Engineer."

March 17, 1899.

(The "symptoms" would indicate that the trouble was somewhere about the new boiler. Just where, it would probably require some "feeling of the pulse" to determine.—Ed.)

Engineering Notes in Porto Rico.

II.

Sir: In one week I have made a horseback journey southeastward from San Juan, leaving the railroad at Carolina and journeying by a rugged trail into the heart of the Sierra Luquillo. I returned thence to San Juan, traveling by army ambulance over the celebrated military road, 80 miles long, which connects San Juan with Ponce, the commercial metropolis, near the southwestern extremity of the island.

In order that you may better understand the conditions surrounding engineering construction and especially road building, I would first say that the area of Porto Rico is but 3,670 sq. miles, or about 1,200 sq. miles less than that of Connecticut; its average width is 35 miles and its length 105 miles, or about that of Long Island, though it has about three times the land area of that island.

Crowded, however, into this small area is about as great a diversity of topographic form and of climatologic change as can be found in any equal portion of the inhabited world.

On the authority of Professor Mark Harrington, ex-Chief of the U. S. Weather Bureau, and now in charge of our climatologic service in the West Indies, the Spanish records show for a period of twelve years an average annual precipitation in San Juan of 59.5 ins. This is fairly well distributed throughout the year, the greatest monthly mean occurring in November, of 7.62 ins., though this amount is approached during the entire rainy season from April to November, inclusive. During the remainder of the year the mean monthly precipitation ranges down to 1.8 ins., in February. Clearly as this indicates uniformity of rainfall throughout the year, this is still more accentuated by the fact that the least precipitation recorded in any month was 0.3 ins. in March of one year, and the greatest 17.1 ins. in August of another year. Though these figures give a fair index to the range of precipitation on the northern and northeastern side of the island, they form no criterion for the relative amounts of precipitation falling anywhere upon other portions of the island. Thus, at Hacienda Peria, only about 15 miles east and a little south of San Juan, reliable records extending over the two years of 1897 and 1898 show there a mean annual precipitation of 123.4 ins.; the maximum, occurring in 1897, being 136.2 ins.; while the distribution was approximately as at San Juan, the minimum being 2.5 ins. in February and the maximum monthly precipitation 32.9 ins. in May. During this time the greatest rainfall in twenty-four consecutive hours was 8.4 ins., occurring in August. Such great differences in amount of precipitation between those recorded at San Juan and at Hacienda Peria, which is but a few miles south of Luquillo, can be partly explained as follows:

From its position Porto Rico receives the first breath of the trade winds as they come heavily loaded with moisture from the tropic ocean and impinge suddenly against the high mountains. These winds are compressed and their capacity to carry moisture is suddenly reduced; they are squeezed like a sponge and deposit a large portion of their moisture. Hacienda Peria is on the slopes of the Luquillo mountains under El Yunque, the highest peak on the island, the elevation of which is about 3,750 ft. This mountain rises from sea-level in a distance of scarce seven miles, and the effect of the banking up of the trade winds against the summit is to cause the greatest precipitation at this point. San Juan, on the other hand, is on the coast; back of it is comparatively low land, for a distance of eight to ten miles, and thence the country rises, gradually, to the highest summits at the headwaters of the La Plata and Loiza rivers, a distance of at least 20 miles from the city. It therefore feels in much less degree the effect of pressure on the trade winds. Further inland, to the south and west of San Juan, close under the summits of the main mountains in the neighborhood of Cayey, Aibonito and Adjuntas, the precipitation is greater than at San Juan, because these points being both more elevated and nearer the mountain crests, feel more directly their effect upon the trade winds.

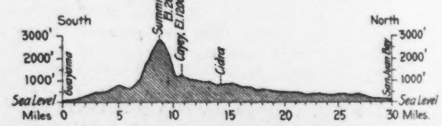
Along the south and west mountain slopes the precipitation is so much less in quantity than on the northern slopes that these coasts have semi-arid, in fact, in places, arid climates as distinguished from the moderate and often great humidity found on the northern slopes. The average annual precipitation on the southern coast is only in the neighborhood of 20 ins. There is said to be an authentic record for the year 1893, that at Guayama, immediately south of San Juan, during 13 months, not a drop of rain fell. In fact, the Spanish records go so far as to indicate that in one period of three years not a drop of rain fell at Cabo Rojo, the most arid place on the island and at its extreme southwestern extremity. This transition from humid to arid conditions is due to the sudden expansion of the trade winds, which, blowing over the tops of the main summits, are released and expanded and are thus given greater power to carry the moisture they contain.

The effect of such great changes in precipitation on any form of engineering construction will be appreciated, and it results in making road maintenance on the northern slopes a most difficult problem, as well as imposing difficulties in construction; while fairly good dirt roads may be easily maintained in good condition on the southern slopes, such roads on the northern slopes become at once impassible. Irrigation is superfluous on the north coast for the reasons given, whereas on the southern coast it is and will be more generally resorted to in order that the soil may produce to the fullest measure of its capacity. Drainage, however, even on the north slope, is rarely necessary as an aid to agriculture, because of the rugged outlines of the topography and the steep slopes of almost every portion of the land which furnishes correspondingly good natural drainage.

The temperature has but little bearing upon engineering works, other than in the matter of sanitation and as showing the conditions under which manual labor has to be performed. The average annual temperature during twelve years, as recorded at San Juan, is 78.9° Fahr.; the lowest mean monthly temperature was 75.7° in February of one year, and the highest 81.5° in June of another year. The highest temperature ever recorded was 100.8°, occurring in the month of May, and the lowest was 56.1°, occurring in the month of December. Rarely, however, has a temperature lower than 57° been recorded, and rarely a temperature above 97°. It will thus be seen that the island is not subject to any excessive heat, nor is the temperature at any time low; the extreme ranges recorded being but 44°, while that recorded in Washington, D. C., is about 140°.

As the island has been shown to be divided climatologically into two distinct portions, so is it divided hydrographically, and by the same causes, viz., the trade winds and the configuration or topographic form of the surface. The controlling factor in this division is a chain of mountain ranges extending from the northeastern extremity of the island southwestwardly near the eastern coast, thence westward and near the southern coast to the western extremity of the island. These consist, first, of the Sierra de Luquillo, a spur of which runs from El Yunque westward a short distance towards San Juan, while the main range, with altitudes of from 1,500 to 3,750 ft., extends to near Guayama, and is distant from the eastern coast but five to seven miles. This mountain system merges into the Sierra de Cayey, which extends westward to Aibonito Pass with elevations of from 1,800 to 3,000 ft., and is distant from five to ten miles from the southern coast, and from 15 to 30 miles from the northern coast. West from Aibonito Pass this mountain system is continued as the Cordillera Central, a more massive mountain group reaching with well sustained elevations well toward the northern coast, and being nearer the center of the island, distant perhaps 12 to 15 miles from the southern coast, and 15 to 20 miles from the northern coast. The elevations in this mountain mass are not great, none exceeding 3,300 or 3,400 ft.; yet none fall below 2,200 or 2,300 ft. Beyond Adjuntas Pass the Cordillera culminates in El Guilarte, the second highest peak on the island, with an altitude of 3,610 ft., and thence the main mountain system is divided into several prominent spurs, which reach the western coast to the north and south of Mayaguez. The effect of this great divide is to throw two-thirds of the drainage of the island toward the north coast and about one-third of it toward the southern coast. The slopes toward the north are more gentle and uniform than those to the south, which are very abrupt and precipitous; yet the same difference in elevation is encountered in but five to ten miles on the southern coast, as is passed in from 15 to 25 miles on the northern slope. As a result of this and the greater precipitation on the northern slope, it is natural that the rivers flowing to the north and those also flowing to the west, are much longer, drain a greater area, and carry a much larger and more uniform volume of water than do those flowing to the south and east. The former have fairly well maintained discharges, even in the dry or winter seasons, while the latter expose their dry beds during a large portion of the year, discharging considerable volumes only in the rainy season, and then sudden freshets of great volume.

The only bit of railway that I have seen thus far is the seven miles of steam tramway running from San Juan city to Rio Piedras and paralleling the military road, and the 15 miles of narrow-gage railway built and owned by the French, paralleling the tramway as far as Piedras, and extending eastward to Carolinas. The tramway is not unlike some of the old steam dummy lines once seen in the suburbs of Brooklyn, a dwarf engine and a couple of little cars run over a track with a gage scarcely 2 ft. wide. The railway encounters no difficulties in construction of any kind. It runs below the foothills surrounding the flat country, bordering the coast and the valley of the Rio Loiza. The deepest cut scarce encounters any rock and is not much over 10 ft. in depth. There are no fills any greater than this. The only bridge of importance is a good steel plate, single span deck bridge, over the narrow gut which separates the island



Profile Across the Island of Porto Rico from San Juan South.

of San Juan from the mainland of Porto Rico. There are no grades worth mentioning, and the curves are fairly good. The gage is about one meter. The engines are well constructed, of the French type, as are the cars, little box affairs capable of carrying but trifling loads, and the trains drawn rarely exceed three or four cars; though freight trains of greater size are occasionally run over the road. The ties are of wood and the ballast is the dirt, gravel or soft coral encountered along the line. The rails are light and the roadbed is in such comparatively poor condition and the rolling stock so inferior, that only very slow time can be made and only light loads hauled. There is no doubt that this inferior railway will, as a result of American competition, either soon disappear or be converted into an electric railway of substantial construction.

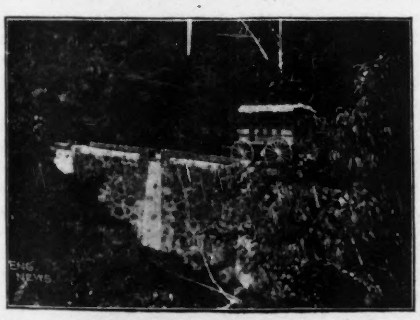
As I will point out later and in more detail the problem of inland transportation is a serious one upon this island, one which can only be easily solved by electric traction from power generated by the boundless water supply which is everywhere available. It will cost little more, perhaps no more, to construct electric railways, than macadamized roads which must be sufficiently substantial to withstand the erosive action of the superabundant rainfall. It will cost less to maintain them than such highways. Such roads as may be put in passable condition hereafter, while numerous, will be only those necessary to act as feeders for main systems of electric freight and passenger railways.

From San Juan to Carolinas and thence eastward to Rio Grande, about two-thirds of the distance to Fajardo, there is an excellent military road. This consists of a well-graded, well-alined, well-drained and well-surfaced road about 60 ft. wide, of which about 15 ft. are macadamized. The side gutters are deep, the under drainage good, and the surface is maintained in excellent condition in spite of the heavy traffic and the high erosive action of the rain. All side drainage is carried under the road in substantial masonry culverts, but no streams of any size are encountered, except the Rio Loiza, which is crossed about a mile to the east of Carolinas, and the Rio de Canovanas, which is crossed about half way between Carolinas and Rio Grande by a substantial arched masonry bridge. The Rio Loiza, which is the largest river upon the island, unless it be the Rio de la Plata, has to be forded, the water being at low stage between 2½ and 3 ft. in depth; if higher, it can be crossed only by the animals swimming, passengers being taken over in row boats, which are scarcely safe even in moderate flood rises. This river has at the crossing a surface width of about 220 ft., and an average depth of nearly 3 ft., at low water; the approximate lowest depth is 2½ ft., and its minimum discharge is 16 cu. ft. per second. In flood its discharge probably reaches maxima as high as 15,000 to 20,000 cu. ft. per second.

Considerable progress has been made toward bridging this river, in point of work done and in point of time. Thus the earth approaches consist of a high embankment extending about 500 ft. on the east side, and with an altitude of 30 to 40 ft., and a graded cut on the west approach, both of which are completed. The masonry approaches and abutments on both sides are also practically completed. This work is said to have been in progress under the Spanish administration for about 25 years, and at the same rate it would probably have taken them 25 years longer to have completed it. I look upon this as an exaggeration, however, and believe from extraneous information that this work has not been under way more than five or eight years as this seems to have been the length of time during which the military road has been under construction. Between the masonry abutments the river is to be spanned by steel plate-girders. Practically all of the material is now on the site. There is a large amount of Portland cement under a shed, and the larger portion of the metal work of the bridge is either at the site of the bridge, or at the mole in San Juan. When I visited this structure some little work was being done upon the earth approaches under the present American regime and the prospects are that when the government of the island becomes more settled this work will be rapidly pushed to completion. It is well planned and what has been done has been substantially executed.

Between San Juan and Rio Piedras the change in elevation is scarcely 25 ft. At Carolinas the elevation is about 65 ft., and at Rio Canovanos it is 70 ft., so that the grades for railway construction are evidently matters of no moment.

From Rio Piedras over the main military road toward Ponce the grade is rather steep for the first two miles. Thence there is a gradual descent from the divide separating the Rio Piedras from the drainage of the Rio Guainabo, a branch of the La Plata. The lowest point reached at the masonry bridge which spans this river is 250 ft. Thence to Caguas, a total distance of 15 miles to San Juan, the country is rolling, the highest elevation reached being 375 ft., on the divide separating the drain-



Bridge Over Small Stream, Between Caguas and Cayey, on Military Road, Porto Rico.

age of the La Plata from that of the Loiza, the headwaters of which flow through the Caguas Valley, which has an altitude of 230 ft.. On this portion of the military road the grades are light, the width of the roadway is 30 ft., of which 20 ft. is well macadamized, well-drained and splendidly surfaced. The Americans are keeping up the road repairs excellently, following the Spanish plan under the civil government of the Department of Public Works. Repairs are made by native roadworkers, or "camineros," as they are called, each of whom has a stretch of about two kilometers to care for. These camineros live in nice little houses, the property of the government. They are uniformed to the extent that they wear caps that are numbered and lettered. They frequently employ help, as many as a half a dozen to a dozen workmen being engaged sometimes in keeping up repairs on one section of the road. This is because during the interim between the Spanish and American governments the road repairs were allowed to run down, and it is therefore necessary now to do much more to get them in good condition. Over the camineros are overseers, each of whim has charge of about ten kilometers.

Near Caguas no heavy grades are encountered,the heaviest being such as will permit the native ponies drawing the mail coaches to trot at a fair gait. The first important bridge on this road is that over the Rio Cana, about two miles north of Caguas. This is a substantial structure of two arched spans and most artistic appearance. The bridge over the Rio Caguita, a branch of the Loiza, at Caguas, is one of the longest and most substantial on

Street in Cayey, Porto Rico, Showing Paving and Gutters.

the road between San Juan and Ponce. It is of iron plate-girders supported on masonry piers well founded, well protected by excellent wing-walls, and well built. Even the smallest side-streams, such as we would bridge with a couple of wooden stringers and a plank flooring are bridged by substantial masonry culverts of such height as to permit the road to be maintained at a comparatively uniform grade, and thus avoid the descents and ascents required in our more common road building in crossing ravines.

Leaving Caguas the road meanders through a wide, open, agricultural valley for several miles and finally climbs at kilometer 50 to Las Cruces Pass, elevation 1,310 ft.; this pass, separating the headwaters of the Rio Loiza from those of the Rio Plata. Thence the route of the highway is over more rugged country. It descends in the next four kilometers to an elevation of 1,080 ft. about Las Vegas or the Plains, and keeps thence a comparatively uniform elevation along the headwaters of the Plata River to Cayey at kilometer 60, elevation 1,180 ft., and to kilometer 77, elevation 810 ft., where the valley of the Plata is left. Thence the ascent is rapid, the road climbing in the next 12 kilometers a height of 1,050 ft. to a summit elevation of 1,860 ft., just above Aibonito. Here some beautiful views are had of the Plata Valley, and there is some extremely heavy road construction, far heavier in fact than anything which I have ever seen in any portion of the United States. In one place, the road winds for several miles along steep hillsides, the roadways having been blasted out of a hard volcanic tuff, the upper face of which has been excavated to a height of 60 to 70 ft. In places, while the lower side is upheld by retaining walls of substantial masonry, often 25 to 50 ft. in height. From the summit there is a slight descent to Aibonito, elevation, 1,725 ft.

In addition to constructing substantial bridges, excavating and blasting great masses of earth and rock in order to obtain uniform grades, and good drainage by numerous ditches, culverts, and underdrains, the lower slopes are protected frequently by masonry parapets, and every curve in the road is defended by a cylindrical post of stone firmly buried in the earth as a guard against which the wheels of vehicles and carriages may make the sharp turns on the steeper grades. In interesting contrast with this magnificent road is a short tour in any direction over the numerous cart roads and trails which connect the people living in the country on either side with the main thoroughfare.

The surface of the mountains of this portion of Porto Rico is covered with a deep red sandy clay which clings tenaciously to the mountain slopes and to which vegetation clings with equal tenacity. Disintegration of the volcanic rocks is extremely rapid under the heat and moisture which prevail throughout the year. As a result of the sticky and unguent character of this soil, the mountain slopes are densely covered with cultivated and natural flora of all kinds, where they would otherwise be washed into barren rocky wastes. Cart roads or trails constructed over such material without macadamizing and where the rain is abundant are necessarily little more than mud ponds. An attempt to walk a little over a mile from Aibonito to the Spanish trenches was abandoned after over half an hour of effort, during which time scarcely a quarter of a mile had been made on comparatively level slopes.

The three cities passed thus far are very similar in their general characteristics. The stores, churches and municipal buildings are all built of brick, stuccoed with plaster, or of rubble masonry. Gypsum is abundant toward Juana Diaz, and this makes an excellent low grade of plaster for stucco work. Fine flagstone and hard black limestone are found in great quantities near the summit between Caguas and Aibonito, alternating in layers with volcanic tuff, and these furnish an abundance of good road metal immediately adjacent to all portions of the road, as well as excellent flagstones, paving-stones and building materials. Volcanic boulders and lumps of porous white limestone, as well as massive quarry limestone, are abundant everywhere, and are used in bridge construction and in the rubble work of residences. Clay also being abundant, bricks of a very fair quality, but not great durability, are found everywhere.

The small cities of Aibonito, Cayey and Caguas have respectively 2,200, 3,900 and 4,800 inhabitants; yet each is provided with its little public square, its municipal government, and the main street, defining the line of the military road, is of course well macadamized, and has fairly good sidewalks. The side streets are also paved or macadamized, the gutters paved with cobblestones, and there is a fair brick walk on either side of the street. They all have gravity water supplies, which are piped into them from streams on the hill sides. The distribution system is of the crudest kind; the water is carried through 1-in. iron piping, and is only taken into a few of the most prominent buildings and public places; to the latter the inhabitants go to fill their water jars. There is no sewerage, surface drainage carrying off the rain-water through the open gutters; while the house sewage and drainage is discharged into cisterns in the interior courts or directly into the streets. H. M. W.

Ponce, Porto Rico, Feb. 7, 1899.

Notes and Queries.

In the article on "A Gasoline Pumping Plant for the Water-Works of Toms River, N. J.," in our issue of March 30, the cost of the pumping plant should have been $3,700, instead of $4,450, divided as follows: Two 20-HP. Nash gasoline engines, $1,500; two 8 × 10-in. Goulds triplex pumps, $1,700; setting and connections, $500.

DAMAGES FOR POLLUTING THE PASSAIC RIVER are asked by two persons who conducted an ice business below the city of Paterson. These persons claim that the discharge of sewage into the river has ruined their business, and are suing for $100,000 damages. It is said that a similar suit, for $50,000 damages, will be brought by other parties soon.

A TWELVE-WHEEL FREIGHT LOCOMOTIVE of exceptional size and power is being built by the Brooks Locomotive Works, of Dunkirk, N. Y., for experimental work in heavy freight service on the Illinois Central R. R. It will be a simple engine, with the Player-Belpaire boiler and the Brooks piston valve, these features being used in a large number of engines built at the Brooks works. The firebox will extend over the frames. All the driving wheels will be flanged, and the engine will be fitted with the Westinghouse brake and the Thurmond M. C. B. coupler. The leading dimensions are as follows:

Driving wheels (8)	4 ft. 9 ins.
Truck wheels (4)	2 " 6 "
Tender wheels (8)	2 " 9 "
Driving wheelbase	15 " 9 "
Engine wheelbase	24 " 6 "
Engine and tender wheelbase	55 " 0 "
Weight on driving wheels	195,600
" total engine	214,000
" of tender, loaded	106,000
Cylinders	23 × 30 ins.
Boiler barrel, diameter	6 ft. 8 "
Working pressure	210 lbs.
Firebox	11 ft. × 3 ft. 6 ins.
Crane stays	1⅛-in. direct stays
Tubes, No. 424; diameter inside	2 ins.
" length	14 ft. 8⅜ "
Capacity of tender tank	5,000 gallons
" " coal space	12 tons

PROPOSED RAILWAYS IN BRAZIL are reported on as follows from Rio Grande do Sul: A German firm is about to build a railway, from the navigable river Uruguay, to open up and promote the colonization of the fertile forest lands of Southern Brazil. The road will connect at Tupaceretan with the terminal station of a railway already in operation, and extend northwest. A party of engineers has also been studying the projected railways for Santa Catherina, and report that they have gathered a large amount of statistical information; that the state is badly in need of railway connection with the coast, and that the present traffic is sufficient to warrant the expenditure. The engineers engaged in both of the above surveys were sent out by the firm of Arthur Koppel, of New York and Berlin.

A RAILWAY IN FORMOSA, from Teckham to Takow, 175 miles, is to be built by the Japanese government, says U. S. Consul Davidson, of Tamsui. The leading agent in this enterprise is H. Yamashita, of Taipeh, Island of Formosa, who especially desires information regarding American locomotives.

RUSSIA, TO AID PRIVATE RAILWAY COMPANIES, has created an international financial syndicate which will issue 50,000,000 roubles of 4% stock for this purpose, says a St. Petersburg item.

timated cost of $250,000,000. The number of messages annually transmitted over them is about 6,000,000. These connect with 835,000 miles of land telegraph, with 3,500,000 miles of single wires; and over these 365,000,000 messages are sent annually, or 1,000,000 per day. Of the 170,000 miles of submarine telegraph, about 150,000 belong to 35 companies operating 320 commercial cables; the remaining 20,000 miles is represented by short lines controlled by governments, connecting forts, lighthouses, signal stations, etc., aggregating 1,150 separate lines.

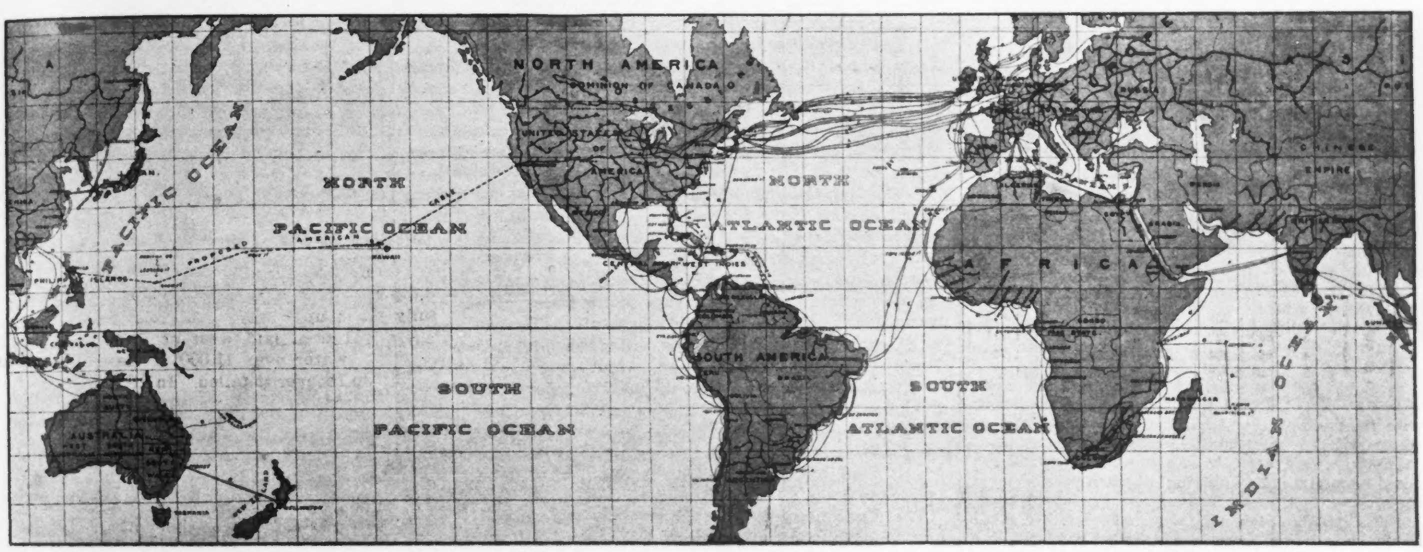
The chief obstacle in the past to the construction of a trans-Pacific line was that mid-ocean resting places could not be satisfactorily obtained or arranged for, as no single government controlled a sufficient number of these landing places. But with Hawaii, Wake Island, Guam and the Philippines now available, a cable can be built from the United States to Asia with no section of cable having a length equal to that now in daily operation between France and the United States; this line is 3,250 miles long, counting from Brest to Cape Cod. The greatest distance on the proposed Pacific cable would be the 2,089 miles between San Francisco and Hawaii; from the latter point to Wake Island is 2,040 miles; from Wake Island to Guam, 1,290 miles; from Guam to Manila, 1,520 miles, and from Manila to the Asiatic coast the distance is 630 miles. The greatest depth of water between San Francisco and Hawaii is 18,300 ft., and between Hawaii and Manila the greatest estimated depth is 19,600 ft., though this statement is now being tested by actual soundings. A cable has recently been laid in 18,000 ft. of water between the Windward Islands and Haiti. Otto Krummel puts the mean depth of the Pacific Ocean at 2,160 fathoms, against 2,040 fathoms for the Atlantic.

The development in constructing, laying and operating submarine cables has kept pace with their extension. There are now 50 steamships especially equipped for laying the improved cables, or picking up and splicing lost or broken cables; the speed of transmission has increased to 30 words per minute, and more than that by an automatic transmitter now coming into use, and by duplexing the cables their carrying capacity is doubled. From a cost of $100 per message, originally charged in the trans-Atlantic cable, the rate from New York to London and the Continent has fallen to 25 cts. per word; the time of transmission has so fallen that messages were sent from Washington to the battlefield of Santiago, in Cuba, and a response received, in 12 minutes; and a message was sent from Washington to London and a reply received in 13½ minutes.

The rapid development of international commerce is largely due to this ready and inexpensive method of transmitting messages throughout the civilized world. In 1866 our commerce with Europe amounted to $652,232,299; in 1876, to $728,959,053; in 1886, to $896,911,504; in 1896, to $1,091,682,874; and in 1898, to $1,279,739,936. Our commerce with the whole world has increased from $783,671,588, in 1866, to $1,847,531,984, in 1898. The Bureau argues from this that a direct cable to Asia should bring proportionately large returns. The commerce of the countries of Asia and Oceanica, commercially adjacent to the Philippines, is now more than $2,000,000,000 annually, with imports of $1,200,000,000 per annum. Of this enormous market the United States now obtains less than 6%, though the imports are largely composed of the classes of articles produced in the United States.

Under the head of miscellaneous information we find that Mr. Charles Bright, F. R. S. E., of England, estimates the present cost of submarine cables, per mile, at $750; to which must be added the average cost of laying per mile, or $375. The present rate of speed of transmission, without duplex, is 25 words per minute; by automatic system, without duplex, it is 50 words; duplexing increases the use of the wire by 90%. There are now 16 cables across the North Atlantic, of which 13 are working. The average life of a submarine cable is put at 25 years. The length of the present cable route from Washington to Manila is 14,000 miles, as follows: To New York, by land; to Valentia, Ireland, by cable; to Brighton and Havre, by cable and land; Havre to Marseilles, by land; to Alexandria, cable; to Suez, by land; to Aden and Bombay, by cable; to Madras, by land; to Singapore, Saigon, Hong Kong, by cable; to Bolonao, Philippine Islands, by cable; to Manila, by land. The cost of a message from New York to Manila is $2.35 per word.

The International Cable rules require every address to contain two words, to insure delivery; all that the sender writes for transmission is charged for; messages may be written in any language that can be expressed in Roman letters; code words must not be longer than ten letters each; but they must be taken from the English, German, Spanish, French, Dutch, Italian, Portuguese or Latin languages—other languages are not allowed. Cipher language is formed of groups or series of figures; and in such messages each five figures is counted "a word," plus one for any excess. In plain messages—those not containing code words or cipher groups, 15 letters or less are counted one word; and words of over 15 letters at that rate; in a message made of code words entirely, ten letters count one word. Messages made up of mixed plain and code words or cipher groups, are rated in accordance with the above rates. A sender may pay for a reply up to 30 words; and by paying an additional 25% he can have his message repeated.



MAP OF THE WORLD, SHOWING LINES OF SUBMARINE CABLES AND PRINCIPAL LAND LINES.

THE MASSACHUSETTS RULES FOR THE PROVISION OF FIRE STOPS IN BUILDINGS.

In our comments on the origin and rapid spread of the Windsor Hotel fire in our issue of March 24, we referred to the use of fire stops as a most important adjunct in retarding the spread of fire in buildings, and urged that their use should be made obligatory wherever buildings of ordinary combustible construction are permitted to be used for public purposes.

Since that publication our attention has been called to the fact that in Massachusetts the use of such fire-stops has been required by law since 1894, and the law is enforced by the District Police of the State, under the Department of Inspection of Factories, Workshops and Public Buildings.

The statute of 1894 provides that every public building, institution, school-house, church, theater, public hall, place of assemblage or public resort; every building of more than two stories, and designed to be used above the second story as a manufactory or mercantile establishment, with accommodations for ten or more employees; and every building of more than two stories for use as a hotel, apartment house, boarding house or tenement, with ten or more rooms above the second story, must have its plans and specifications for its construction filed with and approved by the district inspector of factories and public buildings before the construction can be proceeded with. These plans must especially show the methods of ventilation to be employed, and the means of egress in case of fire.

The inspector may require that proper fire-stops shall be provided in the floors, walls and partitions of such buildings and may make such further requirements as may be necessary or proper to prevent the spread of fire therein, or its communication from any steam boiler or heating apparatus; and no pipe for conveying hot air or steam shall be placed nearer than 1 in. to any woodwork unless protected to the satisfaction of the inspector by suitable guards or casings of incombustible material, and no wooden flue or air duct for heating or ventilating purposes shall be placed in any such building. * * * Every story above the second of such buildings shall be supplied with means of extinguishing fire, consisting either of pails of water or other portable apparatus, or of a hose attached to a suitable water supply and capable of reaching any part of such story; and such means of extinguishing fire shall be kept at all times ready for use and in good condition.

The most important feature of the above act is not its specific requirements, but the means provided for securing the enforcement of the law. In another column of this issue we have received the annual report of Rufus R. Wade, Chief of the District Police of Massachusetts. Through Mr. Wade's courtesy, we have been furnished with a copy of the specifications issued by his department, covering the requirements which have been fixed upon by it for means of preventing the spread of fire in buildings, and have printed them in full below. It should be said that these re-

LINE CONSTANTS FOR POWER TRANSMISSION CIRCUITS.*

Constants for use in the calculation of alternating current transmission lines are given in the accompanying table, which is employed by the engineering department of the General Electric Co., of Schenectady, N. Y. The meanings of the letters at the head of the column are as follows:

r = Ohmic resistance.

L = Inductance in milhenrys per 1,000 feet of conductor.

C = Capacity in microfarads per 1,000 feet of conductor.

LINE CONSTANTS FOR POWER TRANSMISSION CIRCUITS.

	SIZE OE WIRE.B.&S.G.	WEIGHT.	DIAMETER.	AREA IN CIRCULAR MILS.	RESISTANCE AT 75° F.	INDUCTANCE IN MILHENRYS.	CAPACITY IN MICROFARADS.	CHARGING CURRENT.	REACTANCE AT 25, 40, 60, 125 CYCLES. IN OHMS.				SIZE OF WIRE.B.&S.G.	
	No.	Lbs.	Mils.	C.M.	r	L	C	i_0	x25	x40	x60	x125	No.	
PER 1000 FEET OF WIRE.	0000	639	460	211600	.049	.282	.00388	.0244	.0443	.0708	.1062	.221	0000	PER 1000 FEET OF WIRE.
	000	507	410	167805	.062	.290	.00378	.0238	.0455	.0727	.1090	.227	000	
	00	402	365	133079	.078	.296	.00368	.0232	.0465	.0743	.1113	.232	00	
	0	319	325	105592	.098	.303	00358	.0226	.0476	.0761	.1141	.238	0	
	1	253	289	83694	.124	.310	.00351	.0220	.0486	.0775	.1166	.243	1	
	2	201	258	66373	.156	.317	.00342	.0215	.0498	.0796	.1194	.249	2	
	3	159	229	52633	.197	.324	.00334	.0210	.0509	.0814	.1220	.254	3	
	4	126	204	41742	.249	.332	.00326	.0205	.0521	.0832	.1248	.261	4	
	5	100	182	33102	.314	.339	.00320	.0201	.0532	.0850	.1277	.266	5	
	6	79	162	26250	.395	.346	.00313	.0197	.0543	.0867	.1301	.271	6	
	7	63	144	20816	.499	.352	.00306	.0193	.0553	.0885	.1327	.276	7	
	8	50	128	16509	.629	.360	.00300	.0189	.0565	.0904	.1355	.283	8	
	9	40	114	13094	.792	.366	.00294	.0185	.0575	.0920	.1380	.288	9	
	10	31	102	10382	.999	.373	.00288	.0181	.0585	.0936	.1405	.293	10	
PER MILE OF WIRE.	0000	3376	460	211600	.26	1.489	.02046	.1286	.234	.374	.561	1.167	0000	PER MILE OF WIRE.
	000	2677	410	167805	.33	1.529	.01993	.1255	.240	.384	.576	1 199	000	
	00	2123	365	133079	.41	1.562	.01943	.1223	.245	.392	.588	1.225	00	
	0	1685	325	105592	.52	1.600	.01892	.1191	.251	.402	.602	1.257	0	
	1	1335	289	83694	.65	1.636	.01854	.1163	.257	.409	.616	1.283	1	
	2	1059	258	66373	.83	1.674	.01806	.1135	.263	.420	.630	1.314	2	
	3	840	229	52633	1.04	1.711	.01765	.1110	.269	.430	.644	1.343	3	
	4	666	204	41742	1.31	1.750	.01722	.1085	.275	.439	.659	1.379	4	
	5	528	182	33102	1.66	1.788	.01689	.1060	.281	.449	.674	1.403	5	
	6	419	162	26250	2.09	1.826	.01651	.1038	.287	.458	.687	1.431	6	
	7	332	144	20816	2.63	1.860	.01617	.1018	.292	.467	.701	1.459	7	
	8	263	128	16509	3.32	1.901	.01584	.0997	.298	.477	.715	1.492	8	
	9	209	114	13094	4.18	1.934	.01552	.0977	.304	.486	.729	1.519	9	
	10	166	102	10382	5.28	1.968	.01521	.0956	.309	.494	.742	1.544	10	

i_0 = Charging current at 100 cycles and 10,000 volts to neutral, that is, in a 20,000-volt single-phase and a 17,300-volt three-phase line.

$i_0 = 2 \times \pi \times \text{frequency} \times C \times E \times 10^{-6}$; where E is the Electro Motive Force between a line and neutral.

x = reactance $= 2 \times \pi \times \text{frequency} \times L \times 10^{-3}$.

The E. M. F. consumed by resistance r, of the line, is = Ir, and is in phase with the current I. The E. M. F. consumed by the reactance x, of the line, is = Ix, and is in quadrature (at 90°), with the current at I. The E. M. F. consumed in the line is neither Ir nor Ix, but depends upon the phase relation of current in the receiving circuit. The loss of energy in the line is $= I^2r$, and hence does not depend upon the reactance, but only upon the resistance. Two wires in parallel have the same resistance and about half the reactance (if strung on separate insulators and intermixed), of a single wire of double cross section. Thus replacing one No. 0000 wire by two No. 0 wires, the resistance, weight of copper, etc., will remain the same, but the reactance will be reduced practically to one-half, so where lower reactance is desired the use of several conductors strung on independent insulators and intermixed is advisable. The values given for L, C i_0 and x are calculated for sine waves of current and E. M. F.

*Circular C-1328, June 15, 1898.

THE DEVELOPMENT OF THE SUBMARINE CABLE.

The U. S. Bureau of Statistics has just issued "The Chronology of Submarine Telegraph Construction Throughout the World, and the Development of Submarine Telegraphy." From this the following abstract is made:

Salva, a Spaniard, is credited with first suggesting submarine telegraphy, in 1795, to the Barcelon Academy of Sciences. In 1803, Aldini, a nephew of Galvani, experimented in transmitting electric signals under the sea, near Calais; in 1812, Schilling ignited gunpowder by electricity transmitted by a subaqueous conducting wire under the Neva, near St. Petersburg; in 1839, the Director of the East India Co.'s telegraph system transmitted telegraph signals through insulated wires under the River Hugli; in 1842 Professor Morse sent messages through an insulated wire laid between Castle Garden and Governor's Island, in New York harbor, and in 1843 he suggested submarine electrical communication between the United States and Europe. In 1845 Ezra Cornell and Professor Morse laid and successfully operated submarine copper wires in the Hudson River, between New York and Fort Lee, N. J.; and in 1847, a section of the New York and Washington telegraph system was laid through the waters of a narrow creek by J. J. Craven, of New Jersey, thus demonstrating the practicability of actual submarine telegraphic service. In 1850, a telegraph cable was laid across the English Channel, and signals were exchanged, though without further success. In the following year, a cable containing four copper wires, insulated with gutta percha and protected by spirally-wound galvanized iron wires, was laid across the Channel and put into successful operation.

The first attempt to lay a cable across the North Atlantic was made in 1857 by Cyrus W. Field, of New York, and Charles Bright, J. W. Brett and others, of England. This cable was to extend from Valentia, Ireland, to Newfoundland, an estimated distance of 2,500 miles. The construction of the cable was similar to that across the English Channel; but when 255 miles had been laid west of Valentia the cable broke and work was abandoned. In 1858 the attempt was renewed by the same men, and the U. S. frigate "Niagara," and the English ship "Agamemnon," each carrying half the cable, proceeded to midocean and there joined the ends of the two cables. On July 29 they sailed eastward and westward, laying the cable, and on Aug. 5 they reached Valentia and Newfoundland, respectively, and established electrical communication between the two continents, over 2,050 nautical miles of cable. Congratulatory messages were exchanged, but in less than one month the cable ceased to work, and was never again operated or recovered in any part. During its operation, however, 730 messages, or about 10,000 words, passed over it. Its total cost was $1,256,250.

In 1859, a submarine cable to connect England with India was laid through the Red and Arabian seas to Murracheo, in India; it was 3,043 nautical miles long, but had several intermediate landings. Some parts of the line worked satisfactorily for 30 days, but it soon proved a complete failure. In 1860, a committee of the British Board of Trade made an elaborate study of the entire subject of submarine telegraphy, and decided that the service would be successful if sufficient care were exercised in making, laying and managing the cable.

In 1861 a telegraph cable, made with great care, was laid from Malta to Alexandria, with landings at Tripoli and Benghazi. This cable was made of seven copper wires stranded together, covered with several coatings of gutta percha alternating with other non-conducting and waterproofing materials, and then protected by 18 iron wires wound spirally about this core. This cable was a permanent success; and the speed of transmission—which was three words per minute on the Atlantic cable, was brought up to ten words on each separate section; but still only three words on the continuous line of 1,331 miles. In 1861-1862 a cable was laid from France to Algeria, but was a failure. In 1864, The England-India line was relaid, with an improved cable, with a length of 1,450 miles through the Arabian Sea and Persian Gulf, with three landing places. This line connected with Calais by land lines and was successful.

In 1865, Cyrus W. Field and his associates again contracted, for $3,000,000, to lay another Atlantic cable on the Valentia-Newfoundland route. This cable contained seven copper wires surrounded by numerous coatings of gutta percha and other materials, and protected by ten Bessemer steel wires, each separately wound with pitch-soaked hemp yarn; this was the first use of Bessemer steel for this purpose. The shore-ends were further protected by 36 heavy iron wires wound about the completed cable. The "Great Eastern" was carefully fitted up to lay this cable; but after 1,186 miles had been laid west of Valentia the cable broke in water over 11,000 ft. deep, and all attempts to recover it failed. In 1866, Field and his partners renewed their efforts to lay a cable, and formed a new company with $3,000,000 capital. The "Great Eastern" left Valencia on July 13, 1866, and payed out the new cable on a line 25 miles to the north of the old one, and safely arrived at Newfoundland in 14 days out from Valencia. Electric communication was at once established with England, and has never since been more than temporarily interrupted. The "Great Eastern" returned to the spot where the cable of 1865 was lost, and after 18 days' work she picked up the end of the cable, made a splice, and on Sept. 8 she landed the American end at Newfoundland, and thus completed the second successful line. The distance from Valencia, Ireland, to Trinity Bay, Newfoundland, is given as 2,143 miles; and the rate of transmission began at 8 words per minute and increased to 15 words.

After this date progress became rapid in the work of laying submarine cables. In 1868 a second Malta-Alexandria line was laid; in 1869 a cable was laid from France to Nova Scotia, and another from Suez to Bombay; in 1871 a cable was laid along the eastern coast of Asia, connecting with land lines already built across Siberia and Russia. These latter lines had been constructed after the failure of the first Atlantic cable in the hope of connecting Europe and America by way of Siberia, Behring Straits, Alaska, British America and the United States; but the success of the Atlantic cable of 1866 killed this scheme, and the Siberian line was utilized as above. In 1873, South America was connected with the United States by cable, and thence with Europe; in 1875 cables were laid along the coast of Africa, connecting with Europe and America; in 1880, cables were laid across the Gulf of Mexico, across the Isthmus of Panama, and down the west coast of South America. In the Indian and Pacific Oceans, lines have been constructed extending among the islands to Australia, and from Australia 1,200 miles to New Zealand, and 800 miles to New Caledonia; but the Pacific proper is not yet spanned by a cable connecting Asia with the Americas.

There are now 1,500 separate cables, with an aggregate length of 170,000 miles, laid at a total es-

"Well, we have applied for patents in every country in the world which issues patents; and in countries which do not issue patents we are applying to the potentates thereof for patent protection."

This wholesale method of procedure was rather startling to us, and we ventured to inquire how long it would probably be before this multitude of patents would be issued. "Not for some time yet," replied Mr. Burns. "You know it takes about two years to get a German patent." We did not know it; but we did not venture, of course, to dispute the word of a patent attorney on such a matter; and we trust that other members of Mr.

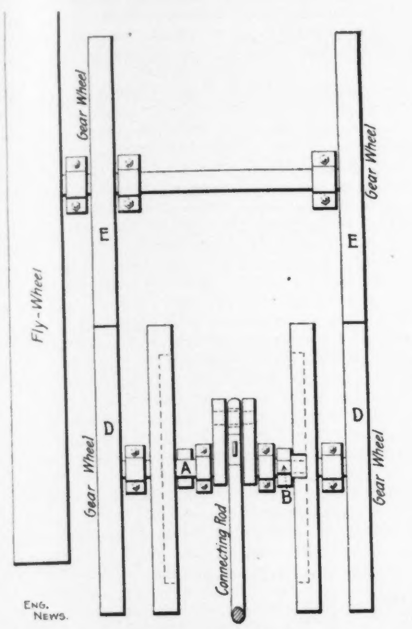


Fig. 1.—Plan of Alleged Power Multiplying Device.

Burns's profession may be interested in the information.

We will next describe the alleged "power multiplying" device by which the power is conveyed from the primary driving shaft to the fly wheel shaft. The mechanism is really ingenious. It performs the functions of making the fly wheel shaft rotate twice while the crank shaft rotates three times. It does exactly what a pair of gear wheels connecting the two shafts would do if the gear on the crank shaft had two-thirds the number of teeth of the one on the fly wheel shaft. It has the great advantage over gears, however, of being more complex and somewhat difficult to understand, which is a most important matter in a perpetual motion device.

Referring to the cut, Fig. 1, the crank shaft A A, which is driven by the engine, carries at each extremity a crank, B B, these two cranks being 180° apart. The pin of each of these cranks carries a small hardened steel roller which rolls on the inner surface of an internal cam, C C, carried on a rotating disk which is journaled not in line with the driving shaft but about ½ in. below it, the length of the crank from the center of its shaft to the center of the pin carrying the roller being 1½ in. This disk is more clearly shown in Fig. 2. It is a flat disk with three projections, or cams, on the edges of which the roller presses as it rotates. The space between the cams forms three channels for the cam to roll in, located 120° apart. When the driving shaft rotates the right hand crank through 180° it presses on the edge of one of the cams on the right hand disk and causes the disk to move through 120°.

It is then disengaged and communicates no motion to the disk through the other 180° of rotation. But while this is disengaged the left hand crank is in like manner moving the left hand cam through 120°. The shaft at each disk carries at its outer end a gear wheel, D D, which meshes into a gear wheel, E E, of the same size, on the fly wheel shaft. The motion of the engine shaft is thus transmitted during 180° of its rotation through the right hand disk to the engine shaft, and during the other 180° through the left hand disk, the fly wheel shaft thus making two-thirds of a revolution or 240° while the crank shaft turns through 360°.

By this reduction of speed of the fly wheel shaft its torque is increased 50%, which would, if the mechanism were frictionless, cause it to lift 50% greater weight than if the engine were coupled directly to the fly wheel shaft, but of course at only two-thirds of the speed. Since the 150 lbs. lifted by the "triple power" engine is lifted only a short distance, and since the lift is undoubtedly assisted by the momentum of the heavy fly wheel, it is quite possible for the triple power engine to lift three times as much as the plain engine.

The idea of the inventor of the above described curious contraption appears to have been that he could gain something by giving the crank of his engine a longer leverage than that due to the length of the crank itself. He failed to comprehend that the turning movement gained in this way would be exactly offset by the reduction in speed, so that the net horse power delivered to the fly wheel would be exactly the same as if the engine turned the fly wheel directly, except for the greater losses in friction by the complicated apparatus employed.

We were curious to know what the inventor and his attorney expected to do with the device in a commercial way. From the replies to our questions we gathered that they proposed to organize a company and sell stock. This company would attach its "power multiplying device" to engines of all classes, "thus enabling a manufacturer whose engine or boilers are too small for their work to supply such power as he requires without buying new engines or boilers."

"But why do you take up such small business as this? If your power multiplier will do what you say it will, why not do away with engines entirely and get power for nothing?"

"Well, we know there might be some prejudice if we should make too great claims for our invention, so we think it best to be moderate at the start. As soon as we are established we will then proceed with arrangements by which the engine will furnish its own power."

Since the date of our visit we have learned that actual attempts to interest capitalists are being made by the inventor and his attorney, with what success, however, we are not informed.

A Philadelphia Scheme for Multiplying Power.

Some months ago we received through the mails a small leaflet issued by the "The Power Multiplying Engine Co., 14 South Broad St., Philadelphia." It was headed: "Important to Capitalists," and among its contents was the following:

Many years of practical experimenting has enabled the inventor to harness, as it were, an element, and to get from it almost unlimited power by the use of a very small quantity of steam and coal.

For instance, while working in pneumatics, he has discovered what we will call the power multiplying engine, which furnishes phenomenal power at the most trifling cost. A steam boiler, requiring scarce half a ton of coal per day, operating a pump upon our principle, will show at least thirty times the initial power; and large mills, locomotives and steamships requiring hundreds of tons of coal per week to operate them, by this method can be run at the incredible outlay of three or four tons of coal weekly.

To obtain sufficient money to build an extensive plant to exhibit and convert the whole world to the truth of our statements, the company will offer for sale a limited number of shares of stock at a very low figure.

It will be seen from this circular that while the New York inventor only proposed to multiply his power by 3, the Philadelphian expected to multiply it by 30.

A visit to Philadelphia by two members of the editorial staff of this journal afforded a convenient opportunity to investigate the above described curiosity. At the time of our visit the General Manager of the company, one C. H. Goebel, was not present; and a Mr. Leake, explained the "invention" to us and exhibited to us copies of U. S. patents upon the engine which was claimed to multiply power. The scheme is delightfully simple. Some readers of Engineering News may recall in our issue of March 22, 1890, a description of a curious revival of the old pneumatic railway, which in the early part of the century was a rival of the locomotive as a means for the mechanical traction of cars upon railways. The apparatus consisted of a continuous iron tube or conduit about 8 ins. in diameter laid between the rails. A piston is attached to the car and travels in this conduit, being forced forward by air pressure behind it. A slot extends along the whole length of the conduit to accommodate the shank connecting the piston to the car body, and this slot is automatically opened and closed as the car passes along.

In 1890 the C. H. Goebel above referred to had a railway of this type 80 ft. or more in length on exhibition in a building on Chestnut St., Philadelphia, and was selling stock—or attempting to sell it—to exploit the scheme on a large scale. Apparently the stock did not prove very salable, for nothing further was ever heard of the invention.

Turning now to the "power multiplying engine," we find it to be nothing more nor less than the old compressed air conduit, bent up into a circular form. A shaft at the center of the circle carries an arm which is connected to a piston that travels in the circular conduit. Of course some "abutment" is necessary in the conduit, else the air pressure would scoot around and press on the front side of the piston as much as on the back side. The inventor has provided such abutments, consisting of sliding shutters, which form partitions in the conduit and are arranged to jump back out of the way when the piston comes around to them. The slot on the interior of the circular conduit and the mechanism for opening and closing it are practically identical with those used on the old street car propulsion scheme of ten years ago. It is perhaps hardly necessary to say that this remarkable mechanical conception has never taken any more concrete form than a patent drawing.

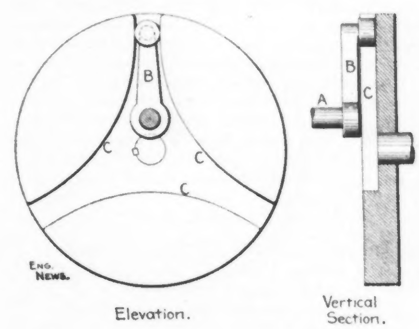


Fig. 2.—Disk with Internal Cams for Increasing Effective Length of Working Crank.

The reader who has followed the above description will now be curious, as we were, to know where the power multiplying came in. We ventured to suggest to Mr. Leake (a very appropriate name, by the way, for a compressed air promoter) that while the mechanical construction of the invention was reasonably clear to our minds, we failed to understand why it was expected to multiply power by it, or indeed why they should get as much power out of the apparatus as the air compressor to run it would require. Mr. Leake bestowed upon us a benign and pitying smile. "Why, don't you see? The natural power of the air runs it," said he. We didn't see; so he proceeded to explain that air had a natural tendency to exert pressure when enclosed in a pipe. To illustrate this he stated that he was himself the patentee of a system of pneumatic transmission. In 1891 or 1892 he had an exhibition plant in operation at some place in New Jersey, and they found that the carrier could be sent back and forth at high speed without the air being compressed at all! The pipe was open at both ends, and the "natural force of the air" was all they needed to propel their carrier!

We were minded to ask him whether the "natural force of the air" was accommodating enough to push the carrier in either direction at the will of the operator; whether they were able to sell enough stock to pay their office rent and living expenses; why it was not as easy for them to multiply power by a hundred or thousand as by thirty; and a multitude of other questions; but our informant was so bland, so frank and so genial, and withal apparently such an implicit believer in his quirements do not apply to theaters, for which special additional precautions and requirements are required by law and by the regulations of the department. Neither does it apply to the city of Boston, which has its own building laws and Building Inspection Department. With these exceptions, it covers all the buildings mentioned in the list above, located anywhere in Massachusetts:

1. All elevator wells and light shafts, unless built of brick, must be filled in flush between the studs with fireproof materials, or lined with metal or plastered on metallic lathing, as may be directed by the inspector. Elevator doors and casings to be lined with tin plate, lock-jointed.

2. Where floor beams rest on partition caps or on girders, wall girts or on wooden sills, fill in between such beams, from the caps, girders, girts or sills to the lining floor above, solid with brick and mortar or other fireproof material.

3. When floor beams in frame buildings rest on ledger boards, fire-stop thoroughly at each floor with brick and mortar resting on bridging pieces cut in between the studs, or, where practicable, on the ends of lining floor.

4. In brick buildings the space between the furrings on the outside walls or brick partition should be filled flush with mortar for a space of 5 ins. in width above and below the floor beams of each story.

5. Where basement or other flights of stairs are enclosed by partitions of brick or wood, the spaces between the studs or wall furrings must be so fire-stopped with brick or mortar as to effectually prevent any fire from passing up between such studs or furring back of the stair stringers.

6. The soffits of all such enclosed stairs, and also partitions on stairway side, must be plastered on metal lathing.

7. Where a building is occupied above the first floor for any purpose which renders it subject to the provisions of chapter 481 of the Acts of 1894 (the law quoted from above), and the lower story is occupied for stores, or other purposes not connected with the upper floors, the stairways leading to such upper floors must be enclosed with brick walls or with wooden partitions filled solid with brick laid in mortar, or other fireproof material, and plastered on both sides on metallic lathing, and all doors in such partitions lined with tin plate, lock-jointed.

8. All long flights of stairs to have two smoke-stops in each flight properly constructed.

9. No pipes for conveying hot air or steam can under the law be placed nearer than 1 in. to any woodwork unless protected, to the satisfaction of the inspector, by suitable guards or casings of incombustible material.

10. No wooden flue or air-duct of any description can be used for heating or ventilating purposes.

11. A space of at least 1 in. to be left between all woodwork and the chimneys, also around all hot-air, steam and hot-water pipes; these spaces around chimneys and pipes, where they pass through floors, to be stopped with metal or other fireproof material, smoke-tight. Steam and hot-water pipes to have metal sleeves. All channels and pockets for gas, water and soil-pipes to be made smoke-tight at each floor.

12. The space around all metal or brick ventilating ducts must be fire-stopped at each floor with metal or other fireproof material, as approved by the inspector.

13. All chimneys to be plastered with one good coat of brown mortar, on the outside of brickwork, from cellar to roof.

14. The ceiling over furnaces or boilers and over indirect radiators must be plastered on metal lathing, said plastering to extend at least 6 ft. in front of feed door and 2 ft. on each side of furnace or boiler casing. There should be not less than 1 ft. in height of open air space between the tops of furnace or boiler casing and the ceiling.

15. The entire cellar ceilings of school houses and other buildings used for public purposes should be plastered on metallic lathing.

Other provisions than those herein specified, to prevent spread of fire, may be required by the inspector if deemed by him to be necessary.

In planning buildings to be used for school rooms, or places of assemblage above the first story, provision should be made for at least two stairways, and such stairways should be as far apart as practicable. No such stairways should be less than 4 ft. wide in the clear, and winding steps should be avoided. No flight of stairs should have more than 15 steps between landings.

The main stairways from places of assemblage should have a width of not less than 26 ins. for every 100 persons accommodated therein. Such stairways should be railed on both sides. All outside doors to such buildings should open outwardly.

The detailed report of the inspection, in the annual report above alluded to, gives additional information respecting the placing of fire-stops. For example, the report of Inspector Ansell J. Cheney, of District No. 8, says:

As the laws requiring fire-stops in buildings leave it entirely to the judgment of the inspector as to what they shall consist of and where they shall be located, I have from year to year required more and more, until to-day I have the architects and owners so educated up to the necessity and importance of cutting off all channels and pockets where fire might spread through a building that there is but little trouble in getting specifications properly drawn to warrant me in putting in all the fire-stops needed.

I have so impressed owners, architects and contractors with the importance and advantage of this method of construction that there is not the trouble now that there has been in years past in getting fire-stops properly put in. Nevertheless, I am constantly on the watch, and visit the buildings as often during their construction as I can find time to do so. I have also instructed the contractors not to cover up any of the fire-stops until I have been notified and have inspected the work. In this way I am able to give the occupants of these buildings in the future much better protection against fire than could be given in years past.

TWO POWER MULTIPLYING ENGINES.

Of the many schemes for attaining the unattainable in engineering, those which have for their object the increasing of the power of a steam engine beyond that of which it is possibly capable, are among the most fascinating to mechanics whose imaginations are not limited by the law of the conservation of energy, and are also among the most likely to attract the attention of confiding investors.

We were recently informed that an engine was on exhibition in this city which was claimed to develop three times the power of an exactly similar engine having the same size cylinder and furnished with steam of the same pressure. Such a curiosity was worth examining, especially as it was only a few blocks distant from the office, and therefore two members of the editorial staff of this journal went "incognito" on a brief visit of inspection.

Following the directions of our informant, we found on the lower floor of the Liberty Building, at the corner of Liberty and Greenwich Sts., in this city, a small room with the words "Triple Power Engine" on the entrance door. On a table in the room there were two plain slide-valve steam engines, apparently exactly alike in size, with cylinders about 1¼ ins. diameter and 2½ ins. stroke. One of these engines had an ordinary shaft and fly wheel, while the other had an ingenious and somewhat complex mechanism between the crank and the fly wheel shaft, by means of which, it is claimed, the power of the engine is "multiplied by three." This mechanism will be described later.

There were two men in the room at the time of our visit, one of whom was introduced as Mr. Klein (it may be Clyne, as the spelling of the name was not given), the inventor of the "triple power" engine, and the other introduced himself as Mr. Burns, presenting a card showing him to be a member of the firm of "Vowles & Burns, 237 Broadway, New York, and 707 8th St., N. W., Washington., Solicitors of Patents and Claims; special attention given to patent litigation in Circuit Courts and in the Supreme Court of the United States," to quote verbatim from their business card.

Mr. Klein appeared to be a fairly intelligent mechanic, with none of the signs of a perpetual motion "crank" about him, and Mr. Burns would not be suspected, from his appearance or from his profession as patent attorney, to be capable of believing in a mechanical fallacy. Both men were quite communicative and explained the operation of the engines and their claims for them at much length.

A single ¼-in. steam pipe entered the room, conveying steam from a boiler in the basement, and this could be connected to either engine at will. Both engines discharged through short connections into a common exhaust pipe which led out of the room, so that the character of the exhaust could not be seen. As both engines were stated to be exact duplicates of each other, valve motion and all, it was assumed that the two cylinders would each develop the same power when running at the same speed. To test the power exerted at the fly wheel shaft, each shaft was provided with a drum about 1 in. diameter, on which could be coiled a slender wire rope. The wire rope from each drum passed over a pulley held by a standard which elevated it about 18 ins. above the table, and thence to a set of weights resting on cushings on the floor. The weight hung on the rope running from the plain engine was said to be 50 lbs. and that on the other rope 150 lbs. and as the heavier weight was said to be raised by the "triple power" engine, it was therefore claimed to be proved that it exerted three times the power of the plain engine.

No means were provided for testing the speed of the raising of the weights, nor of recording the speed of the engines during the time the weights were being raised. In fact, on account of the short distance between the pulley and the floor the weights could not be raised more than 2 ft. A more complete test of the engines was being prepared for, apparently, as there was a small dynamo on the floor and a countershaft with pulleys was bolted to the ceiling of the room, from which the dynamo could be driven by a belt, but this apparatus was not in condition to be run at the time of our visit.

If there had been any intention of actually proving what the engine could or could not do, the means provided were ridiculously inadequate. No engineer would consider for a moment that the equal size of the cylinders and the equality of steam pressure were any proof that the cylinders developed the same power, and the raising of the weights is no proof of the power developed at the shaft when there is no way of measuring the speed at which they were lifted, nor of finding what was the influence of the momentum of the fly wheels in assisting the lifting. It may be noted here that the fly wheels were not of the same size, the one on the shaft driven by the "triple power" engine being probably three times the weight of the other, and since the engines were brought up to a good speed before clutches were thrown to couple the drums, the momentum of the fly wheels must have had much to do with raising the weight.

These criticisms of the inadequacy of the proof of the power of the engines, however, are such as would not be apt to be made by any one but an engineer versed in the art of testing power. The ordinary layman would not think of them, and to him the equal size of the engines and the evidence of the raising by one of a weight three times as great as that raised by the other would be sufficiently impressive, especially when reinforced by the statements of the exhibitors that the engine "had been reported favorably upon by many distinguished mechanical experts." The names of some of these experts were stated, but to us they were unfamiliar names.

The engine having been thoroughly explained by its exhibitors, a few questions were asked the inventor, and his replies were, to say the least, highly entertaining. The questions and answers were in substance about as follows:

Q. You claim that the power of this engine at the fly wheel shaft is three times that developed by the steam in the cylinder and communicated by the connecting rod to the crank pin? A. Yes.

Q. Then if 1 horse power were developed at the crank pin, 3 horse power could be obtained at a dynamo driven from the fly wheel, friction of the mechanism and loss in conversion at the dynamo of course excepted? A. Yes.

Q. Instead of driving the crank pin by the steam engine, it might be driven by a small electric motor, of say one horse power, could it not? A. Yes.

Q. Now if we got 3 HP. of current from the dynamo, we could take 1 HP. of it to drive the motor, could we not? A. Yes.

Q. Then we would get the other 2 HP. for nothing? A. Well, you are the first man that has ever seen the engine that has put it that way. But you are right. That is exactly what we would get after the engine once got started; but we would have to start it first.

By this means the inventor was led to admit that he had a perpetual motion machine after all, although he did not call it by that name. All he claimed for it at any time was that it would multiply power three times.

We then proceeded to question Mr. Burns on the subject of the patents on the "invention." The patent in the United States was allowed, he said, but its issue was delayed pending the applications for foreign patents.

"How many foreign patents are you taking out?"

own scheme, that we hadn't the heart to betray to him our scepticism, and we left him under the impression that we were just a couple of ordinary "suckers," who might yet come back and swallow the bait.

THE METRIC SYSTEM is to be introduced into the Russian Empire by 1900; and the Minister of Finance is now making the necessary arrangements.

CANADIAN CANAL ENLARGEMENT, to 14 ft. navigation, is reported upon by the Chief Engineer of Railways and Canals. Excepting the Cardinal section of the Galops Canal, the 14-ft. navigation will probably be open this spring throughout. Work on the Cardinal section is progressing favorably, and up to Dec. 1, 1898, 1,450,000 cu. yds. out of 1,964,470 cu. yds. had been excavated by Wm. Davis & Sons, the contractors. This work was to have been completed by May 1; the approximate value of the whole work being $1,264,129. The Iroquois section will probably be completed by May 1. The work includes the building of crib entrance piers and an 800-ft. masonry lock, valued altogether at $1,066,759. The upper entrance enlargement, valued at $1,420,000, will be ready for this season. The enlargement of the Rapid Plat Canal, at a cost of $1,876,400, is now completed to 14 ft. The Farran Point Canal enlargement, costing $670,000, will probably be made ready by hard work; the 11-mile Cornwall Canal is now enlarged to 14 ft., at a cost of $2,720,000. The work on the Soulanges Canal is encountering difficulties from the nature of the soil; but Messrs. Onderdonk & Hogan hope to have it finished for this season. The work includes one guard and four lift locks on a total rise of 82½ ft.; the locks being 270 ft. long, 45 ft. wide and 14 ft. deep on the sills; the estimated cost is $5,250,000. The enlargement of the Lachine Canal is about completed. During the fiscal year ending June 30, 1898, the sum of $3,207,249 was expended on canal enlargement account.

THE DUTTON PNEUMATIC LOCK for canals is to be exploited on a large scale. On March 27 the organization was completed of a new corporation to be known as "The Maritime Improvement Co.," which will succeed to the business of the Dutton Pneumatic Lock & Engineering Co. The new corporation has an authorized capitalization of $3,000,000, and the directors are: Messrs. Chas. H. Cramp, Amzi L. Barber, Gustav Lindenthal, E. F. C. Young, Chauncey N. Dutton, W. W. Gibbs, Henry W. Cramp, Geo. Thayer and Geo. S. Graham. The officers are: President, Chas. H. Cramp; Treasurer, Henry W. Cramp; Secretary, Edwin F. Glenn; Chief Engineer, Chauncey N. Dutton. The new corporation proposes to build hydraulic and pneumatic installations, including canals, pneumatic locks, differential pneumatic dry-docks, regulating dams, etc.

THE NEW YORK RAPID TRANSIT COMMISSION has had another offer to build the Rapid Transit railway. The offer is made by the Metropolis Contract Co., through Frederic B. Esler. It is proposed to construct the entire length of road according to the plans of the Rapid Transit Commission for the sum of $33,000,000, and to complete it in two years and six months from the signing of the contract. The company will agree to pay the interest on the bonds issued by the city to pay for the construction, and in addition will create a sinking fund which will pay off the principal of all the bonds before their maturity, and the road and tunnel will then become the property of the city free of incumbrance. It also offers to build a tunnel under the East River from New York to Brooklyn at the same time, and transfer passengers to and from Brooklyn for a single fare of 5 cts. It also offers free transfers to and from the surface street railways on Manhattan Island to be included in its fare of 5 cts., and to pay 5% of the gross receipts from the operation of the road into the city treasury. The work of building the tunnel would be under the direction of Mr. Chas. Sooysmith, M. Am. Soc. C. E.

THE CHESAPEAKE & OHIO CANAL, or at least the interest in it held by the state of Maryland, is wanted by the Baltimore & Ohio R. R. Co. The state investment, made between 1824 and 1834, represents $788,724 in common stock, $4,375,000 in preferred stock and $2,000,000 on mortgage loan of 1834. In 1890 an act was passed authorizing the sale to the Washington & Cumberland Ry. Co. of all the states' interest in this canal in consideration of $15,000 a year annuity, redeemable at the option of the railway company for $300,000. At the time of passing this act the canal was so damaged by the floods of May and June, 1889, that its repair and use as a waterway were deemed impracticable. The terms of purchase by the railway company included the payment in full of the principal and interest of the $590,000 canal bonds of 1878; and the payment of $427,375 on the $4,250,000 bonds of 1884. The holders of the latter bonds refused to sell on these terms; took possession of the canal under decree of the courts, and spent about $450,000 in repairs; also taking up the bonds of 1878. They have ever since maintained and operated the canal. But the state of Maryland receives nothing for its interest; and must either hold it indefinitely, without hope of realizing a dollar, or sell it for what it can get. The value of this state interest to those holding similar interests is that it is a monument of title justifying the expenditure needed for new boats and better traffic facilities, and herein comes the interest of the Baltimore & Ohio R. R. Co. The state has received assurances that it will be maintained and improved as a public waterway for the benefit of the citizens of the state. But the people demand bonds to guarantee the maintenance of the canal.

THE SAMOAN ISLANDS, about which there is so much discussion just now, says the U. S. Bureau of Statistics, are 2,000 miles south and 300 miles west of Hawaii, and 14° south of the equator. They lie slightly south of the direct steamship line which would connect the Philippines and the Nicaragua ship canal, and almost directly on the steamship line between San Francisco and Australia. They would thus be important coaling and repair stations. The group of twelve islands—two uninhabited—has an aggregate area of about 1,700 sq. miles and an estimated population of 36,000; with a foreign population of 200 British, 125 Germans, 25 Americans, 25 French and 25 of other nationalities. Cocoanuts form the most important product, in the form of "copra," which is the dried kernel of the cocoanut and from which cocoanut oil is made. In 1896 these islands exported 12,565,909 lbs. of copra, valued at $231,372. The present government was formed in 1889 by the terms of a treaty between the United States, England and Germany, guaranteeing the neutrality of the islands and giving the citizens of these countries equal rights and recognizing the independence of the Samoan government. One Supreme Court judge appointed by the treaty powers decides in all civil suits. The harbor of Pago Pago, in the island of Tutuila, the southernmost of the group, was ceded to the United States in 1872 for a naval and coaling station; and this cession was confirmed in 1878 and the harbor was occupied in 1898.

THERMOMETER RECORDS FOR DAWSON CITY, on the Yukon, are officially reported as follows for January, 1899, as taken by the Canadian Government: The lowest record is 45° below zero, on Jan. 25; and the highest was 2° above zero, on Jan. 21. On Jan. 1, 5 and 6, the records touched 41° below zero. The U. S. Weather Bureau reports as follows on the temperature in the mountains 75 miles south of Circle City, Alaska, in 65°, 30′ north latitude, 144° west longitude: The average for the month of January, 1898, ranged from 6.2° below zero, to 28° above zero; with − 31 and + 28 as the extreme readings. The observer, Mr. J. O. Holt, mentions, however, that the thermometer stands from 15° to 20° higher in the colder parts of the winter in the mountains, than it does at the same time on the flats at Circle City, or along the Yukon River. But in summer the thermometer reads higher on the lowlands. One reason given is that the coldest weather is perfectly still, and a brisk wind will run the temperature up 30° in three hours.

ANOTHER ROADWAY TUNNEL UNDER THE Thames, says "The Engineer," of London, is being considered by the London Council. It will be eastward of the Tower Bridge and run between Shadwell and Rotherhithe, with a total length of 6,825 ft. in tunnel and approaches. The termini will be Union Road, on the south, and Commercial Road, on the north. The tunnel will have a 17-ft. roadway and two 4-ft. 2-in. sidewalks. The estimated cost is £2,198,250, including £798,250 for property damages and rehousing the working classes displaced by the proposed scheme.

BOOK REVIEWS.

ANNUAL REPORT OF THE CHIEF OF THE MASSACHUSETTS DISTRICT POLICE for the Year ending Dec. 31, 1898.—Rufus R. Wade, Chief of District Police. 8vo.; cloth; pp. 452; illustrated. Address Office of Chief of District Police, Boston, Mass.

As most of our readers are aware, Massachusetts has taken the lead in the supervision by state officers of industry, commerce and municipal government. The work of her Railway Commission and of her Board of Health is well known to all engineers; but we believe very few know what an important class of engineering work is being conducted by the department known as the District Police. The public is too often accustomed to connect the duties of police solely with the detection and prevention of crime and disorder; but in the report before us only a dozen pages are devoted to reporting the work of the detective department. Of the entire force under Chief Wade, 23 are engaged in the inspection of factories, workshops and public buildings, 2 in inspecting ready-made clothing, 10 in the boiler inspection department, and 13 in the detective department.

The first of the departments above noted inspected 7,166 manufacturing and mercantile establishments during the year, and 1,490 elevators.

One important branch of the work is the inspection of all plans for new school buildings and of the buildings themselves during construction, to the end that proper heating, ventilation and sanitation may be secured and danger from fire may be reduced. The report contains detailed plans of three different school buildings, showing the general arrangement of each floor and the details of the heating and ventilating apparatus. These detailed plans will be found of much value by any of our readers who are interested in building construction or in heating and ventilation. In the detailed report of the inspectors we notice that the placing of fire stops and the provision of better means of egress in case of fire was one of the most common changes recommended by the inspectors. The buildings inspected included schools, churches, libraries, public halls, clubs, banks, factories, tenements, apartment houses, hotels, lodging houses, asylums and jails.

The inspectors reported a vast improvement during the past two years in the provision of means of ventilation for school buildings, and the plans nearly always now contain some provision for this, so that the inspectors' work is in correcting errors of detail. It is noticeable that a great part of the inspectors' work consists in seeing that statute requirements are complied with. For example, the law requires that suitable fire-stops shall be placed in wood building construction, and that rope fire escapes shall be placed in hotels and lodging houses. In many states laws like these are passed and then left to enforce themselves, and thus gradually become dead letters. We know of no state which has provided so effectively for enforcing the laws which are placed on its statute book as Massachusetts.

Turning to the department of factory inspection, we find a long list of repairs and safety appliances recommended by the inspectors. Belts, flywheels, shafts and set-screws are ordered to be guarded, elevators are ordered repaired and sanitary arrangements are ordered improved.

The report of the boiler inspection department is one of the most interesting in the book. One of the duties of the department is the examination of engineers, who are required to hold a license from the department. In the Boston district, where the greatest number of applicants are examined, a small boiler and four different styles of engines have been set up, and the applicant for a license must prove by his adjustment of the valve-motions, etc., of this machinery that he understands his business and is practically competent to perform his duties. The fact that not half of those applying for licences were granted them indicates that the examination is a thorough one.

The detailed reports of the defects found in boilers fills many pages of the report, and some very curious examples of dangerous treatment of boilers are found.

One of these worth putting on record is as follows:

An interesting case occurred in my district at the beginning of the year. It was the explosion of a house boiler, and, although not under my jurisdiction, an investigation was made by me, at the request of the owner. This boiler was located in the cellar, for heating the house, and was in charge of a man who had the care of the stable and did general work about the place. It was blown into fragments; the floor above was badly wrecked and a lady severely cut about the face. I found the safety valve outside of the house and stuck fast on its seat. The steam gage was located in the dining room, and the pointer on the wrong side of the pin. The owner said they carried about 2½ lbs. pressure, but had paid no attention to the gage lately as it did not register. I brought the gage to Boston, and we found that the spring had expanded until it buckled in the center. An exact duplicate gage was tested, and it required 245 lbs. pressure to put the spring in the condition of the old one. This case shows the necessity of some knowledge of steam in handling even small low-pressure boilers.

Another inspector found a safety valve in use in which the bushing which formed the seat for the valve would lift with the valve in case of over pressure, so that no opening was made for the steam to escape even when the lever lifted.

Both the boiler inspection law and the law requiring the examination and licensing of engineers seem to meet with public approval, and owners of boilers are generally ready to accept every recommendation made by the inspector.

Under the heading, "Reports of Accidents in Manufacturing and Mercantile Establishments," statistics are given of the accidents reported during the year. The law requires written notice to be sent to the police of every accident to employees which causes death or such bodily injury as to prevent the person injured from returning to work within four days. The whole number of injuries reported during the year was 1,061, of which 417 were accidents in which the person injured was not engaged at the time in operating any kind of machinery. Of the accidents due to the use of machinery, 180 occurred to operatives who were attempting to clean machinery in motion. Elevators and elevator wells caused 35 injuries, and belting and pulleys 32.

On the whole, the report is an admirable exposition of what is doubtless the most important experiment in the state supervision of industrial establishments and the protection of public safety that has been undertaken anywhere in the United States.