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THE NEW YORK UNDERGROUND RAPID TRANSIT railway was formally placed under construction on March 24 and actual construction was begun by one of the subcontractors on March 26. The formal opening of the work on March 24 consisted in the digging of the first shovelful of earth by Mayor Robert A. Van Wyck, the fixing of a memorial tablet to mark the spot and the reading of speeches by the Mayor and Mr. Alex. E. Orr, President of the Rapid Transit Commission. Actual work was begun on March 26 by Mr. James Pilkington, who has the subcontract to lower the large main sewer crossing the line of the road at Bleecker St., from its present depth of 14 ft. to a depth of 21 ft. The length of sewer to be altered will be 900 ft. At the meeting of the Rapid Transit Commission on March 22 a resolution was passed authorizing the President and Secretary of the Commission to issue to the contractor all directions and permits for opening the streets in prosecuting his work. At the same meeting the Chief Engineer reported that the cost of pipe galleries in Elm St., from Worth St. to Astor Place, would be about $425,000. Following this report a resolution was drawn up notifying the contractor,

that this Board requires from the contractor the performance of additional work and the furnishing of additional material as follows: The construction along Elm St., extending from the lower side of Worth St. to the north side of Astor Place, of galleries for the accommodation of the pipes, wires, sewers, and other subsurface structures necessary to be removed or disturbed in the course of the construction of the Rapid Transit Railroad along such part of Elm St., such galleries to be constructed pursuant to the general plan and the detailed plans and specifications to be furnished by the Chief Engineer of the Board, as hereinafter provided; that the Chief Engineer is ordered further to prepare detailed plans and specifications for such galleries, which shall be approved by this Board before such requisition from the contractor, and copies of which shall be transmitted to the contractor therewith.

Owing to the absence of three of the members of the Commission action on this resolution was postponed until the next meeting.

THE TUNNEL UNDER THE EAST RIVER at New York city, which is planned by the New York, Brooklyn & Jersey City Rapid Transit Co., is now before the New York Municipal Assembly in the form of an application for a franchise, and already one public hearing has been held at which the applicants for the franchise have presented their case at some length. The character and scope of the project is stated by Mr. George Wilson, the President and Chief Engineer of the company, as follows:

Commencing at a point under West St., Borough of Manhattan, near Cortlandt St., the tunnel will run thence under West and Liberty streets, Maiden lane, the East River, to Brooklyn, private property, City Park and Cranberry St., and private property to bridge plaza, thence back under Middagh St., City Park, private property, the East River, Maiden lane, and Cortlandt St. to the place of beginning. It is intended to be operated by electricity. It will be of standard gage with double tracks, through a single or two separate tunnels. The fare for a single journey between any points of the railroad will be 5 cts. The charge for the conveyance of property will be that allowed by law. We shall tunnel by the Greathead system at a maximum depth of 85 ft., and, when completed, the tunnels will resemble the new Central Underground Ry. of London. We have already entered into an agreement with the Secretary of War that in passing under the East River there shall be at every point at least 60 ft. between the roof of our tunnel and the surface of the water. As a matter of fact, we shall tunnel at a depth of 80 ft. from the river level. At all stations we shall have not only stairways, but elevators, capable of carrying 100 passengers at one time. It is expected to have at Canal and Elm streets, and at Broadway, between Cortlandt and Liberty streets, stations used in common by our railway and those of the Rapid Transit Commission, our tunnel passing beneath theirs. Our financial arrangements are simple and have already been completed. A syndicate of bankers and contractors has formed a company, which will build the entire system of tunnels, taking shares and bonds in payment. Who they are I cannot divulge at present, but I will say that they are distinct from the Belmont group. I have estimated that the cost of the construction will be between four and five million dollars a mile, and as our system will have a length of six miles, the total cost will be between twenty-four and thirty millions.

THE CHICAGO RIVER TUNNELS are to be lowered by and at the expense of the street railway companies, if an ordinance passed by the City Council on March 19 is accepted by the companies. If not, the city will try to have the matter submitted to arbitration, and if that fails, it is intended to carry the case at once to the courts. The three tunnels are to be lowered so as to give a depth of at least 21 ft. 6 ins. above the roofs, while it is specified that the roofs must be 3 ft. thick. The work is to be done by March 1, 1901.

THE CHICAGO RIVER is to be widened by excavating the west bank, between the P., Ft. W. & C. Ry. bridge and the 18th St. bridge. The Drainage Board has purchased a strip of land between the bridges, establishing a new dock line, and widening the river 10 to 65 ft. Where the width is now 117 ft., it will be increased to 127 ft., and a projecting angle will be cut off, giving a straight channel with a width of 175 ft., instead of a crooked channel with a minimum width of 110 ft. This will greatly facilitate navigation past the bridges.

THE EXTENSION OF THE POSTAL TUBULAR Service, in New York city, is being urged at Washington. The promoters of the project claim that such extension is justified by the enormous business done by the New York Post Office, and produce statistics to show that in 1890-98 inclusive the expenses of the office were $26,072,870, while the net revenues was $40,074,616. They say that the postal tube to Brooklyn has reduced the trips of the mail wagons 17,500 miles annually; and that to the Produce Exchange, 10,000 miles a year. They show that by a system of tubes to the branch stations, the present "special delivery" would be beaten by from 16 to 36 minutes, according to the location of the branch station.

THE PAVED STREETS OF GREATER NEW YORK, says Commissioner of Highways Keating, aggregate 1,720.12 miles, with Brooklyn leading with 547.96 miles, and Manhattan standing third with 405.10 miles. In this aggregate of the five boroughs, macadam streets have a length of 745.94 miles; granite, 339.18 miles; cobble, 238.25 miles; asphalt, 234.16 miles; trap, 84.29 miles; Belgian block, 45.33 miles; brick, 19.08 miles; gravel, 13.68 miles, and wood, only .08 miles.

THE PUBLIC HIGHWAYS OF NEW JERSEY, built since 1893 under the State Aid Law, now aggregate in length a little over 440 miles. The total amount expended by the State for these roads has been $715,826, or an average of $1,627 per mile. To this must be added the expenditure by the county, or others interested, of twice as much more; since the State only pays one-third of the cost of such roads.

THE MOST SERIOUS RAILWAY ACCIDENT of the week occurred on the Plant System near Ozark, Ala., on March 19. A mail train running at about 50 miles per hour went through a trestle 40 ft. high. The train was pulled by two locomotives, which passed over the trestle in safety. Two persons were fatally injured and 15 others were more or less hurt.

THE FALL OF A FREIGHT ELEVATOR at the works of the Blakely Printing Co., 126 Market St., Chicago, on March 21, caused serious injuries to 19 men and slight injuries to 10 others. The night shift was leaving work, and 30 men on the third floor crowded on the elevator, which has no regular operator at night. The city elevator inspectors report that the breaking of the cast-iron studs and bolts on the drum-shaft bearing of the inner standard released the drum and internal gear, which resulted in stripping the teeth from the pinion. As the cable was still attached to the drum, the car did not fall fast enough to operate the governor and safety device. The elevator had a capacity of 3,000 lbs., but was not licensed or designed to carry passengers. The inspectors recommend the use of steel instead of cast-iron for the drum attachments, and also recommend the more general use of the air-cushion system.

A FIRE TEST OF GIRDER COVERINGS was made at the plant of the British Fire Prevention Committee on Nov. 15, 1899. Two girders were tested, both being 7-in. I-beams. One girder was wrapped with expanded metal and this wrapping was itself wrapped with brown paper, tied on with a string, to prevent the protective composition from touching the metal. The composition was in liquid form, and according to the manufacturer consisted of "a mixture, by means of water, of plaster, hydraulic lime, some sort of neutral material, such as coke, or sand, and a fireproof material, such as asbestos, with an addition of sulphuric acid." This mixture was poured into a boxing built around the I-beam, in which it hardened into a rectangular section 9 × 15¼ ins. The other girder was wrapped like the first with expanded metal, but not with paper, and was covered with a plaster of secret composition, sufficiently thick to make a rectangular section 12¾ × 4¾ ins. The firing lasted one hour, during which time the temperature was raised from 500° F. to 1,800° F., and was followed by the application of a stream of water for two minutes. The following observations were made after the test in respect to the beam of larger section: There was a longitudinal crack on the soffit of the protecting material for about half the length. There were fine hair cracks on all surfaces of the protecting material. The lower arrises of the protecting material were damaged. The protecting material was very sodden from the applied water, and was very soft and easily impressed. The composition remained attached all round, and the girder was not affected by the test. The following observations were made after the test in respect to the beam of smaller section: A layer of the protecting material to the soffit of beam of about ⅝-in. thickness had become detached and had dropped off. The sides of the protecting material showed vertical cracks, and the surface of the material showed fine hair cracks on all faces. There was a longitudinal crack in the protecting material on the top surface. The protecting material was sodden with the applied water, and was soft and easily impressed.

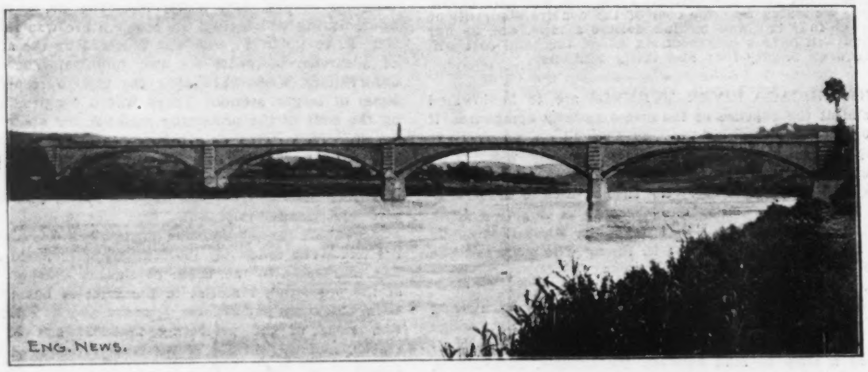
THE FILLING OF A HIGH TRESTLE on the Burlington & Missouri River R. R. was described briefly in our issue of Feb. 8, and we have since received some further information as to this work from Mr. J. R. Phelan, Superintendent of the B. & M. R. R. R. The trestle was 126 ft. high and 720 ft. long, made from light material, well bolted together and well braced. Before filling the structure, a concrete culvert 370 ft. long was built, of capacity sufficient to carry the drainage. It required about 280,000 yards of earth to make the fill. The earth was loaded with a steam shovel by Kilpatrick Bros. & Collins, the contractors, and unloaded from the cars from the top of the trestle by means of the Lidgerwood rapid unloader. Aprons were placed on each side of the bridge, attached to the stringers and ties, and aprons were also placed on the sides of the cars, in order to throw the dirt far enough away from the top of the trestle so as not to interfere with traffic. A good deal of trouble was experienced after 80 ft. of filling had been put in, because of the weight of the dirt breaking braces and pulling the structure out of line in different directions. However, by a close watch and constant repairs by competent bridgemen, while the work was being done, the road was able to complete the work without any accident. Mr. Phelan states that he would recommend to any railway company having similar work to do to use wider aprons on the sides of the trestles, throwing the dirt farther out and letting it roll toward the center, rather than dropping it so close to the center, as was done in this case, and allowing it to slide out. The fill was put in on the basis of a slope of 1½ to 1.

A NEW STEAMER of the North German Lloyd line, the "Kaiserin Maria Theresia," arrived at New York on March 22, completing her first voyage across the Atlantic. The new vessel was built from the hull of the old "Spree," which was wrecked on the Lizards a year or more ago. The hull was cut in two and lengthened, the whole interior of the vessel was rebuilt and new machinery was installed, making practically a new vessel. The length over all is 546 ft., the beam is 52 ft. and the displacement 13,600 tons. The propelling machinery consists of two four-cylinder triple-expansion engines of 17,000 I. HP. driving bronze twin screws 18 ft. 4½ ins. in diameter. The cylinders are 43½, 67, 72 and 77 ins., with 63 ins. stroke, and the shafting is of nickel steel. Nine double-end boilers and four single-end boilers are in place, each 15 ft. 4 ins. in diameter, giving a total heating surface of 50,700 sq. ft., and a grate surface of 1,531 sq. ft. The steam pressure is 156 lbs. Natural draft is used, and the top of the funnels is 92 ft. above the grates. There are three of these funnels, each 11 ft. 7 ins. in diameter. The hull is divided into compartments by watertight bulkheads, but the size of the propelling machinery made it impossible to carry a fore-and-aft central bulkhead through the engine and boiler rooms, as is done in most twin-screw vessels. The vessel is expected to equal in speed the performance of the "Kaiser Wilhelm der Grosse" of the same line, which now holds the Transatlantic record.

THE LAUFENBURG FALL OF THE RHINE, says a German contemporary, is to be turned to a useful purpose by putting in a turbine plant connected with electric generators. A dam is to be built across the Rhine, covering the turbine-chambers and power-house; and it is estimated that with 18 turbines 30,000 HP. can be developed at low-water.

HINGED CONCRETE ARCH BRIDGE OVER THE NECKAR RIVER AT KIRCHHEIM, WURTEMBERG.

One of the most notable bridges of the hinged concrete arch type, which has recently been constructed in Europe, is the highway bridge crossing the River Neckar between the towns of Kirchheim and Gemmrigheim in Wurtemberg. The accompanying general view, reproduced from "Annales des Ponts et Chaussees" for the second quarter of 1899, shows this handsome structure from a point of view which sets off its simple and graceful form very perfectly. Each of the four arches has a clear span of 38 m. (124.64 ft.), and a rise of 5.5 m. (19.04 ft.). The thickness of the arch ring at the crown is in each case 0.8 m. (2.62 ft.), and the thickness at the springing line is 0.9 m. (2.95 ft.). Each arch has three hinges, one at the crown and two at the springing lines, each consisting of two blocks of cut stone separated by a sheet of lead. The strength of the arches was calculated for a uniform superimposed load of 400 kg. per sq. m., and for a specific gravity of 2.4 for the concrete. The interiors of the spandrels are composed of three tiers of small arches. The concrete used in the main arches was composed of 1 part Portland cement, 2½ parts sand and 5 parts gravel. The width of the bridge between the metal guard rails is 5.5 m. (19.04 ft.), divided into a carriage way 4 m. (13.12 ft.) wide and two sidewalks each 0.75 m. (2.46 ft.) wide. The total cost of the bridge was about 233,000 francs, $46,600.



HINGED CONCRETE ARCH HIGHWAY BRIDGE OVER THE RIVER NECKAR AT KIRCHHEIM, WURTEMBERG.

TEN-WHEEL PASSENGER LOCOMOTIVE; NORTHEASTERN RY. (ENGLAND).

(With two-page plate.)

The use of locomotives having more than four driving wheels in passenger service is a distinct innovation in English railway practice, and we illustrate this week an exceptionally large and heavy engine of the ten-wheel type, which has recently been put in service by the Northeastern Ry., of England, for hauling its fast and heavy passenger trains. The engine is interesting for its size and weight, as well as for its being the first of a new type of passenger engines, although ten-wheel freight engines are used on two or three roads. In our issue of Nov. 9, we illustrated and described some ten-wheel engines of the Lake Shore & Michigan Southern Ry., which are the largest and heaviest ever built for passenger service, and the following table gives a comparison of the leading features of the heaviest English and American passenger engines. From this it will be noted that while the former ranks second at every point it is especially inferior in boiler capacity, for with cylinders of very nearly the same size as the latter, its boiler, firebox and heating surface are very far below in proportion:

	N. E. Ry.	L. S. & M. S. Ry.
Driving wheels	6 ft. 1¼ ins.	6 ft. 8 ins.
Truck wheels	3 " 7¼ "	3 " 0 "
Wheelbase, driving	14 " 0 "	16 " 6 "
" truck	6 " 6 "	6 " 0 "
" total	26 " 0½ "	27 " 4 "
Weight on drivers	103,600 lbs.	133,000 lbs.
" total engine	139,776 "	171,600 "
" eng. and ten.	226,240 "	283,600 "
Cylinders	20 × 26 ins.	20 × 28 ins.
Boiler, diam	4 ft. 8 "	5 ft. 6 "
Boiler pressure	200 lbs.	210 lbs.
Firebox	87½ × 38½ ins.	121 × 41 ins.
Tubes, number	204	345
" diam	2 ins.	2 ins.
" length	15 ft. 4⅛ "	15 ft. 0¼ "
Heating surf, tubes	1,638.86 sq. ft.	2,694 sq. ft.
" " firebox	130.00 " "	223 " "
" " total	1,768.86 " "	2,917 " "
Grate area	23 " "	33.6 " "
Water in tank	4,440 gals.	5,000 gals.
Coal in tender	11,200 lbs.	19,000 lbs.

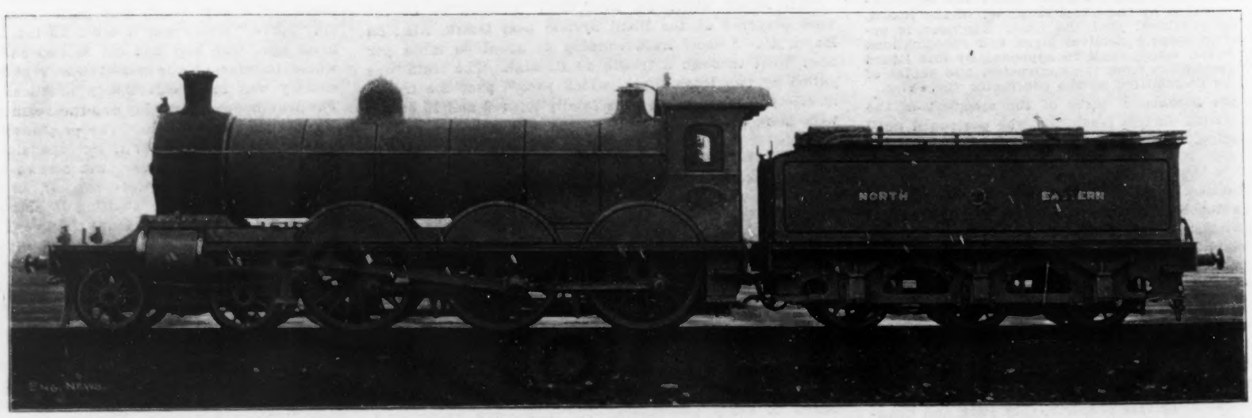
The American engines were built to take trains of 14 cars at a speed of over 50 miles per hour, and their train loads range from 350 to 500 tons behind the tender. The grades are from 0.33% (4½ and 5 miles long) to 0.58% (¾-mile long). The run is between Cleveland and Buffalo, 183 miles, with an average schedule speed of 41 miles per hour, including stops, but in actual service the speeds run up to 60 and 65 miles per hour, and even 75 miles when the trains are late. The longest run without stopping is 95 miles, but for most trains it is only 54 miles.

The English engines were designed specially for hauling the heavy express passenger trains between York and Edinburgh, and to make the run of 124½ miles at 53 miles per hour, without any intermediate stops. The maximum grade is 1 in 96 (approximately 1%) for a distance of 5 miles, and there are other grades of 0.66, 0.60 and 0.50%. The weight of train, for which the engines were designed, varies from 350 to 375 gross tons, so that the total weight of the train would be from 451 to 476 tons, but we are informed that such weights are never yet reached in practice. The engines, however, are intended to haul any train without double-heading. The engines were designed by Mr. Wilson Worsdell, M. Inst. C. E., Locomotive Superintendent, to whom we are indebted for plans and other information. They were built at the company's shops at Gateshead.

The middle or main pair of driving wheels has blind tires 5½ ins. wide (while the American engine has all tires flanged), and the distance between the back of the tires of all the wheels is 53⅜ ins. The driving wheel tires are secured by retaining rings bolted through the cast steel wheel centers. The driving springs are all underhung, and are not equalized, the leading and main driving axles have a pair of helical springs under each box, while the trailing axle has semi-elliptical springs. The truck wheels are larger than those used in this country, which feature of English practice was discussed in our issue of June 9, 1898. The lateral motion of the truck is controlled by a pair of elliptic springs embracing the truck-pin. The truck has plate frames of ¾-in. steel, 2 ft. 8 ins. apart, rigidly connected by platform plates. The main frames of the engine are of 1-in. steel plate and are 4 ft. apart, except near the front of the engine whre they approach somwhat closer. The center of the trailing axle is 16 ins. from the front of the firebox. The driving axles have bearings 8 × 9 ins., 3 ft. 10 ins. c. to c., and wheel seats 9 × 6⅞ ins.; the diameter at the center is 7¾ ins. The truck axles have bearings 6 × 9 ins., 3 ft. 7 ins. c. to c., and wheel seats 7½ × 7¼ ins., while the diameter at the center is 5¾ ins. The main crank pins have bearings 5 × 5 ins. for the connecting rods and 3½ × 5¾ ins. for the coupling rods, while the crank pins in the coupled wheels are 4¼ × 3 ins.

The cylinders are outside, slightly inclined, and have the slide valves placed vertically inside the frames, which involves the use of long steam passages. The pistons are of steel, with 4-in. piston rods and 2½-in. tail rods. Two-bar guides are used. The connecting and coupling rods are of I-section, the latter having solid ends. The ordinary form of slide valves are used, and are fitted with tail rods. The eccentrics are on the middle axle, and their rods are offset to clear the front driving axle. The rods are 8 ft. 6½ ins. long, and the valve rods are connected directly to the links, no rocker connections being required. The links are counterbalanced by weights. These valve rods have long bushed bearings just in front of the links. A screw reversing gear is used.

The boiler is straight, 15 ft. long in the barrel, and 4 ft. 9 ins. outside diameter, with shell plates 9-16-in. thick. The diameter over the jacket is 5 ft. ½ in., and the height from rail to center line is 8 ft. 2 ins. The circumferential seams have butt joints and encircling rings. Near the middle of the barrel is the dome, fitted with the English



TEN-WHEEL PASSENGER LOCOMOTIVE; NORTHEASTERN RY. (ENGLAND).
Wilson Worsdell, Locomotive Superintendent.

gridiron form of throttle valve, while just in front of the cab is the fitting for the Ramsbottom duplex safety valves, almost invariably used on English locomotives. The smokebox is 3 ft. 3½ ins. long inside, and has a smokestack only 25 ins. high, 14½ in. diameter at the base and 16½ ins. at the top. The stack extends down into the smokebox, and has a short petticoat pipe. The firebox is of copper, fitted between the frames, and has crown bar supports for the crown sheet. The grate is horizontal above the rear axle, and then slopes down to the front water leg. The box is quite shallow, and the brick arch is but about 2 ft. above the grates.

The cab affords a fair amount of shelter, and is of a pattern adopted by this road some years ago. The tender is of the usual English type, having six wheels, with outside bearings carried in the deep plate frames. The tender is 20 ft. 7 ins. long over the sills, and has four plate frames. The inside frames are ½-in. thick, 4 ft. 1 in. apart; while the outside frames are ⅞-in. thick, and 6 ft. 2¾ ins. apart. A water scoop is fitted, for taking water from the track tanks. The engine is fitted with the Westinghouse driving wheel brakes and Westinghouse and vacuum train brakes. The leading dimensions are given below in our standard form:

Dimensions of Ten-Wheel Passenger Locomotive; North-eastern Ry. (England).

Running Gear.
Driving wheels (6), diameter .... 6 ft. 1¼ ins.
Truck wheels (4), diameter .... 3 " 7¼ "
Tender wheels (6), diameter .... 3 " 9¼ "
Driving whel centers .... cast steel
Tires .... steel; width on tread .... 5½ ins.
" thickness on tread .... 3 "
Driving wheel tires secured .... By shrinkage and retaining rings
Engine truck .... Rigid center
Journals, driving. 8 x 9 ins.; truck, ... 6 x 9 ins.

Wheelbase—Driving ..... 14 ft.; Truck ..... 6 ft. 6 "
Total engine .... 26 " 0½ "
Tender .... 12 " 0 "
Engine truck-pin to c. of lead. driv. wheel. 8 " 9½ "
Wheels having blind tires .... Middle (main) drivers

Weight in Working Order.
On driving wheels .... 103,600 lbs.
On truck wheels .... 36,176 "
Engine, total .... 139,776 "
Tender, loaded .... 86,464 "

Cylinders—Number .... Two
Diameter and stroke .... 20 x 26 ins.
Distance, center to center .... 6 ft. 3 "
Center of cylinder to valve face .... 1 " 11 "
Cross-head .... 15 ins. long; Guides ...... Two-bar
Connecting rod, length between centers .... 10 ft. 6 ins.
Side rods .... Solid ends.

Valve Gear: Type .... Stephenson link.
Ports, steam ... 1½x18 ins.; Ports, exhaust .... 4x18 ins.
Eccentrics .... 7½"
Slide valves, maximum travel .... 4 21-32 "
" " lap ... 1⅛ ins.; lead .... ⅛-in.
" " c. to c. of stems .... 2 ft. 5½ ins.

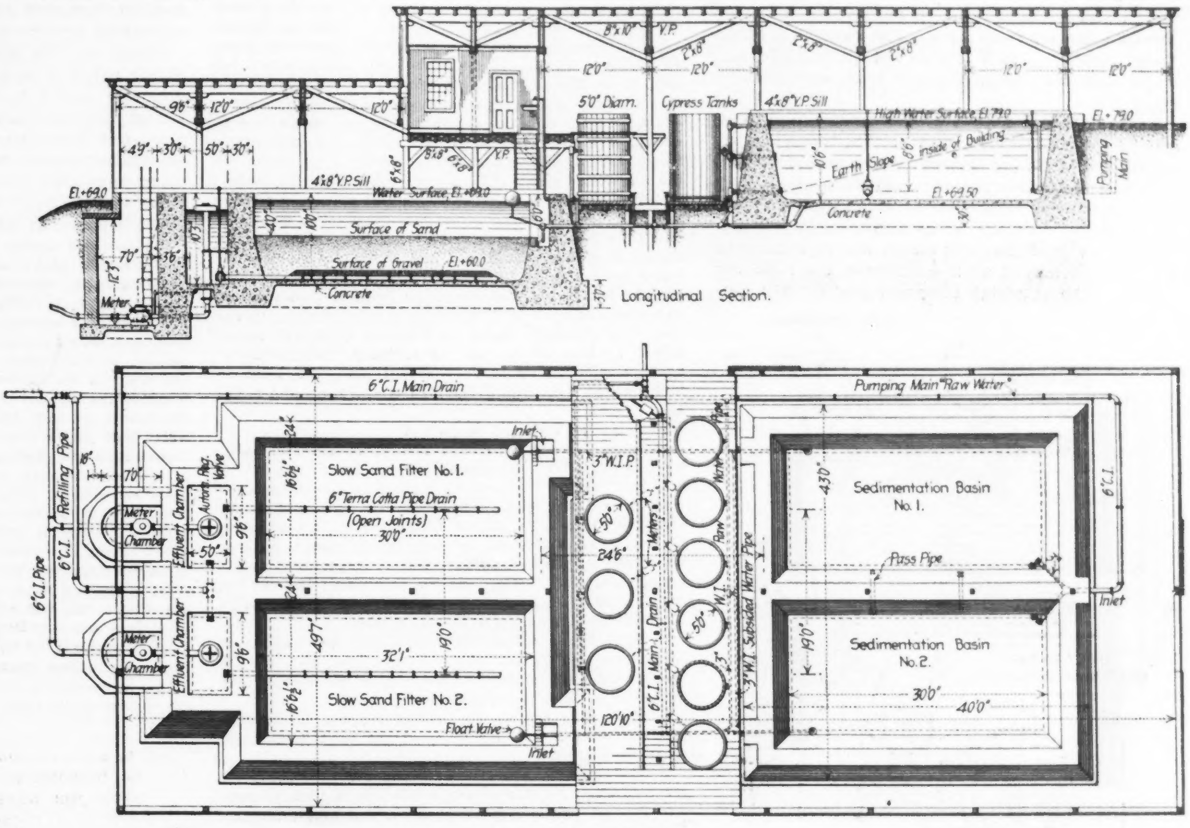
Boiler: Type .... Straight top.
Barrel, diameter, inside .... 4 ft. 7⅞"
Dome, diameter, inside .... 1 " 9 "
Thickness, barrel plates .... ⅝ and 9-16-in.
Thickness smokebox tube-plate .... 1 in.
Height from rail to center line .... 8 ft. 2 ins.
Smokebox, length .... 3 " 3½"
Form of spark arresting device .... None.
Working steam pressure .... 200 lbs.

Firebox .... Copper.
Length, inside 7 ft. 3⅛ ins.; width inside .. 3 ft. 2½ ins.
Depth, front ... 5 " 8 " ; depth, back .... 4 " 8 "
Thickness of crown plate .... 9-16-in.
Kind of crown stays .... Crown bars.
Is fire-brick arch used? .... Yes.
Stay bolts ... copper; diameter ... 1⅛ ins.; pitch ... 4 ins.

Tubes: Steel; Number 204
Diameter, outside ... 2 ins.; thickness ...... No. 12 W.G.
Length over tube plates .... 15 ft. 6⅛ ins.

Heating Surface and Grate Area:
Heating surface, tubes (interior area) .... 1,638.86 sq. ft.
" firebox .... 130.00 "
" total .... 1,768.86 "
Grate area .... 23.00 "

Miscellaneous:
Exhaust nozzle, single, diameter .... 5 ins.
Exhaust nozzle, distance above center line of boiler 1 in.
Smokestack, diam. top, 16½ ins.; at base .... 14½ ins.
Smokestack, height of top above rail .... 13 ft. 1 in.
Capacity of tender tank and well .... 4,440 U. S. galls.
Capacity of coal space .... 11,200 lbs.



PLAN AND LONGITUDINAL SECTION OF EXPERIMENTAL WATER PURIFICATION PLANT, PHILADELPHIA, PA.

EXPERIMENTAL WATER PURIFICATION PLANT AT PHILADELPHIA.

The accompanying plan and section show the experimental water purification plant at Philadelphia, a contract for which was let a few weeks ago. The plant will be located close by the Spring Garden pumping station, on the Schuylkill River. The plan includes two small sedimentation basins, two slow sand filter beds, and a number of filter tanks. Each basin has a capacity of 25,000 to 30,000 gallons. The filter beds have an area of about 0.01 acre each, and the filter tanks are 5 ft. in diameter. Valves, meters and regulating devices are provided to control and register the operations of the various parts of the plant.

The object of the plant, we are informed by Mr. Wm. C. Haddock, Director of Public Works, is to investigate

the detailed action of Schuylkill River water upon a slow sand filter and also to test the various sands which will be submitted in order to determine which is the best for our purpose.

Chemical and bacterial laboratories will be provided for the purposes of the investigation, each about 15 x 24 ft., housed in the same building. Besides the approval of Mr. Haddock, the blue prints from which our illustrations are prepared bear the signatures of Mr. Geo. S. Webster, Chief Engineer, and Mr. Samuel T. Wagner, Assistant Engineer of the Bureau of Surveys.

The investigations form a part of the work preliminary to the design and construction of a water purification plant or plants for Philadelphia, recommended by the expert commission last fall (see Eng. News, Oct. 5, 1899), and for which large sums have been voted.

WATER DISTILLING PLANT AT THE DRY TORTUGAS.

The "still" is among the oldest of mechanical devices, but until very recent times its use was almost wholly confined to the production of alcoholic liquors from fermented ones. Modern manufacturing processes, however, have created a great variety of uses for distilling and evaporating machinery, and have led to great changes in its design.

The old-time "still" was merely a vessel to whose exterior the heat of a fire was applied. The liquid to be distilled was placed inside, the top of the vessel was closed, and the vapors were led off through a spiral coil of pipe or "worm" kept cool by a water spray or bath. Machines of this primitive form are still in use; but in all plants of any size, machinery more complicated and far more economical has long replaced the primitive still.

The two most prominent uses of distilling and evaporating machines to-day are found in the manufacture of sugar and in the production of distilled water. In many other manufacturing industries, evaporation and distillation processes are in use; but the volume of product is small compared with the product of sugar. The distillation of water on a large scale is a matter of recent date. On land it has become important in connection with the manufacture of artificial ice, and to some extent in connection with the supply of water to points located where an abundance of salt water, but no fresh water is obtainable. At sea, distilled water has come into demand through the increase in boiler pressures, and the use of surface condensers, rendering the use of fresh water in the boilers advantageous. In the navy the introduction of water-tube boilers has given a strong impetus to the use of fresh water in boilers, and to the installation of distilling plants on board the larger vessels. As many of our readers will remember, the U. S. Navy has a special distilling ship, the "Iris," which is now in service at Manila. For drinking and culinary purposes on board passenger vessels, too, distilled water has largely replaced water carried from port to port in tanks.

Turning now to the construction of modern distilling apparatus, the principal points in which it differs from the primitive "still" are in the use of steam instead of fire as the heating agent, and in the use of so-called "multiple effects." The advantages of using steam instead of direct heat from a furnace for any operations involving distilling and evaporating are so obvious that they need not be set forth here. The operation of the "multiple effect" is a matter not generally understood, and of sufficient interest to be worth a little explanation.

Suppose that we have a vessel containing a liquid to be evaporated, and in this vessel an arrangement of piping through which steam may be admitted to furnish the heat. If we now set such an apparatus in operation as an evaporator, and use steam of ordinary boiler pressures in the piping, it is evident that this steam will be condensed and being removed as it condenses, the resulting water will be at a high temperature, and will contain a large amount of heat which will be thrown to waste. Further, in the operation of distilling sea water the concentrated brine must from time to time be discharged, or its solid contents will be deposited as scale on the heating surface of the apparatus. The heat contained in this brine is of course a further source of loss.

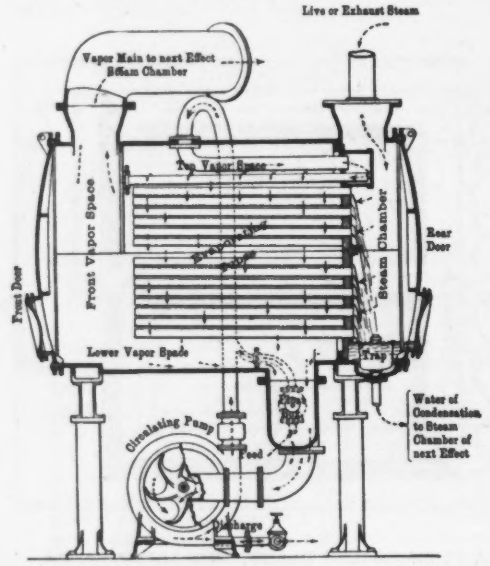


Fig. 1.—Vertical Longitudinal Section of a Lillie Evaporating "Effect."

The object of the multiple-effect evaporator is to reduce the losses due to the discharge of heat in the condensed water and in the concentrated solutions, thus increasing the economy of the apparatus. This it does by carrying on the operation in successive stages, so that the product is finally discharged at a low temperature, and the heat loss due to this cause is reduced to a minimum.

During the past year a large multiple-effect distilling plant has been erected at Fort Jefferson, on the Dry Tortugas, Fla., to furnish water for the naval station and barracks at this place, and to such vessels of the navy as may make port at that point in need of fresh water supplies. The plant has a guaranteed capacity of 60,000 gallons of distilled water in 24 hours, and has been tested to an output 50% in excess of this. It was furnished and erected by the Sugar Apparatus Mfg. Co., of 328 Chestnut St., Philadelphia, working under the patents of Mr. S. Morris Lillie.

A six-day test of the above described distilling plant was carried on from Jan. 13 to Jan. 20, 1900, and the results are described in a paper by Lieut. R. K. Crank, U. S. N., published in the "Journal of the American Society of Naval Engineers" for February. The plant is described in this paper as follows:

In this "multiple-effect" system, the sea water to be evaporated is first passed through heaters which are supplied with steam from the boilers or from the pressure-reducing tank. The temperature of the sea water is raised to about 300° or more in the heaters. The heated sea water then passes to a pressure-reducing tank, in which a pressure of from 10 to 15 lbs. is maintained. A portion of the water becomes steam on account of the low pressure and high temperature. The exhaust steam from all the auxiliary machinery of the plant also goes into this tank. The steam from the pressure-reducing tank is almost all employed to heat the first heater through which the sea water is passed. The unevaporated portion of the sea water in the tank then goes into the first effect (or evaporator), passing first through a centrifugal circulating pump, by which it is showered over the outside of the evaporating tubes. Live steam from the boilers, supplemented by steam from the pressure-reducing tank, is admitted to the inside of the evaporating tubes. A portion of the sea water is converted into steam; this steam passes into the evaporating tubes of the next lower effect, where it aids in evaporating the salt water in that effect. The unevaporated portion of the sea water falls to the bottom of the first effect, whence it is drawn by the centrifugal pump and again showered over the evaporating tubes of this effect, the loss from evaporating being automatically supplied, through a float valve, by fresh feed from the pressure-reducing tank. This action is continued in each of the effects, the constantly moving sea water increasing in density as it passes in turn through the effects. In the last effect, the brine is drawn off at any desired density at a temperature corresponding to the very low pressure (below atmospheric pressure) maintained in this effect. In an ordinary "single-effect" evaporator, such as is used aboard ship, the brine is blown off at a comparatively high temperature and much heat wasted.

The plant at Tortugas consists of:

1. Three Babcock & Wilcox boilers, of 125 HP. each, built to carry 160 lbs. pressure per sq. in.

2. One "Lillie" triple-effect, comprising three effects, or evaporators, with surface condenser 30 ins. in diameter and 12 ft. long, with duplex vacuum pump (air pump) 9 ins. by 12 ins. by 10 ins., for maintaining vacuum in third effect, and for condensing vapors from same; four centrifugal, circulating pumps, one for each effect and one for the condenser, all four on one shaft driven by a directly-coupled Westinghouse 8 × 8½-in. engine.

3. Three Blake duplex, double-plunger feed pumps, of which two are 7½ ins. by 4 ins. by 6 ins., and one 7½ ins. by 4¼ ins. by 10 ins., which may be used to feed boilers or to force sea water through heaters.

4. Three pipe heaters for heating the sea water, each provided with a trap for trapping the condensed steam from the heaters.

5. One pressure-reducing tank, fitted with float valve, for regulating the flow of salt water into it from heaters.

6. Two automatic regulating valves and tanks, respectively for regulating feed to boilers and feed of sea water to the plant.

The evaporators or "effects" used in this plant differ radically from the older forms of multiple effect evaporators.

The accompanying illustrations, Figs. 1 and 2, show sectional views of a single "effect" of a Lillie evaporating plant. The steam, whose heat causes the evaporation, enters at the top and passes downward to the steam chamber. One side of this steam chamber is formed by a heavy tube plate some 3 ins. thick, and into this the tubes are expanded (without annealing). The other end of the tube is closed by a plug, but is left free, and not confined in any way. Thus the tubes are supported by the tube plate alone, and are entirely free to expand and contract with changes of temperature. The tubes are given a slight inclination toward their open ends, so that the water, as it condenses on the interior, drains out and falls to the bottom of the steam chamber. To facilitate freeing the tubes of air in starting up the evaporator and to keep them free while evaporation is in progress, a brass plug is screwed into the cap, which closes the end of the tube, and through this plug is drilled a 1-32-in. hole. The condensed water as it collects is discharged through a trap to the steam chamber of the next effect, where a part of it vaporizes by reason of the lower pressure and gives up its heat in the tubes of that effect.

Referring now to the longitudinal section, Fig. 1, it will be seen that the liquid to be evaporated is raised by a centrifugal circulating pump and discharged through a pipe which enters the top of the chamber, and empties into a manifold at the right-hand end of the effect. From this manifold lead a number of tubes, each of them with an open slot along its upper side. The effect of this arrangement is to discharge the liquid to be evaporated in a series of thin cascades directly over the bank of tubes, as shown in Fig. 2. As the tubes are staggered, the film of liquid flows from tube to tube, and the tube surface is cooled in a most effective manner. Any liquid not evaporated in its passage over the tubes falls to the bottom of the chamber and drains into a sump, which leads it back to the circulating pump.

The vapors from the bank of tubes escape to the vapor spaces at their sides, top and front, and finally through the outlet pipe at the top. It will be seen that with the thin film covering the tubes there is no chance for priming or foaming to occur, and a free escape of the vapor from the liquid is assured, which is an important point in the concentration of certain liquors.

There are 106 seamless drawn copper evaporating tubes in each effect, each of them 3 ins. in diameter, and 5 ft. 2½ ins. in length. The circulating pump of each effect has a 2-in. discharge pipe, and from the last of these discharge pipes the concentrated brine passes off, its density being regulated by the amount of opening of a valve in this pipe. We quote further from Lieut. Crank's paper as follows:

The salt-feed supply to the first effect (from the pressure-reducing tank) enters this first effect through a balanced valve, which is controlled by a float in the float box of this effect. This valve maintains the salt water in the effect at a constant level. Now, since the discharge from each effect is the feed to the next lower effect, the amount of feed water that passes from the third effect (as vapor to the condenser and as discharged brine) determines the amount of sea water that is admitted from the second (or next higher) effect to the third; and this water that passes from the second effect to the third is replaced by the discharge from the first effect, which, in a similar manner, is replaced by fresh feed from the pressure-reducing tank, entering through the automatic float valve of the first effect.

The sea water is thus constantly passing through the effects, being circulated in each, its density increasing as it passes from one effect to the next lower. Thus, the level of the sea water in each effect, the amount of feed admitted to the first effect from the tank, the movement of the sea water from effect to effect, are all (automatically) determined by the opening of the discharge valve of the circulating pump of the third effect.

This triple-effect portion of the plant was built originally for concentrating sugar solutions, and had been actually erected in a sugar refinery. The contract for supplying and erecting the plant was made during the war with Spain and was a hurry order. As this was the only "Lillie" triple effect immediately available, it was used, by permission of the Department, in filling the contract. Its construction would have been slightly different had it been built purposely for distilling sea water.

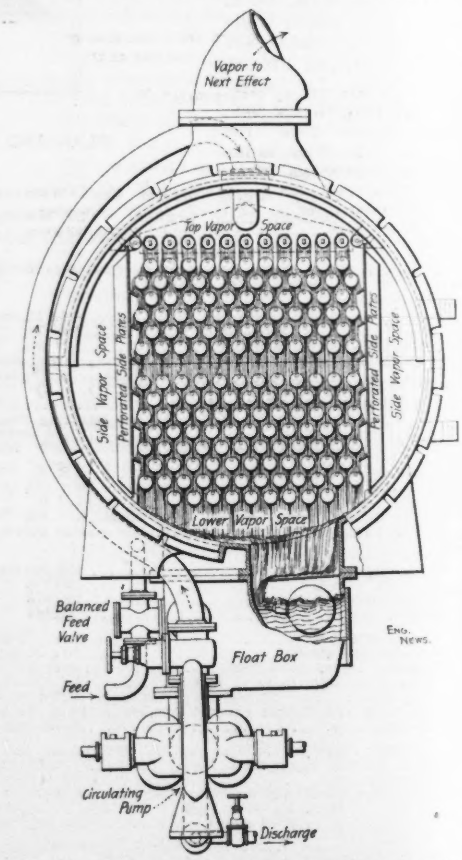


Fig. 2.—End View of Lillie Evaporating Effect, Showing Circulation of Liquor.

The pressure-reducing tank serves as a receiver for the heated salt water that comes from the heaters at a temperature of over 300°. If this heated water were sent directly to the first effect, much of it would at once vaporize at the low pressure in this effect, and would pass directly to the second effect as vapor. This vaporization, however, takes place in the tank. As the volume of water in the tank is large in comparison with the amount passing to the first effect as feed, and hence is not in rapid motion, some of the solid matter in the sea water (salts that are insoluble at the high temperature above 300°) has time to settle and is blown off; the pressure maintained in the tank varies from 10 to 15 lbs. above atmosphere. From one end of the tank (below the lowest water level) a feed pipe leads to the automatic valve in the float box of the first effect. From the top of the tank part of the steam (exhaust from the pumps and steam from the heated salt water) passes through a pipe to the steam chamber of the first effect. The greater part of the steam formed in this tank is used, however for heating in the first or low-pressure heater. Live steam from the boilers is also admitted through a 2-in. steam pipe to the steam chamber of the first effect. This is the only boiler steam that is admitted to the effects. The condensation from the traps of the second and third (or high-pressure) heaters also goes into the steam chamber of the first effect. The condensation from the first or low-pressure heater goes into the steam chamber of the second effect.

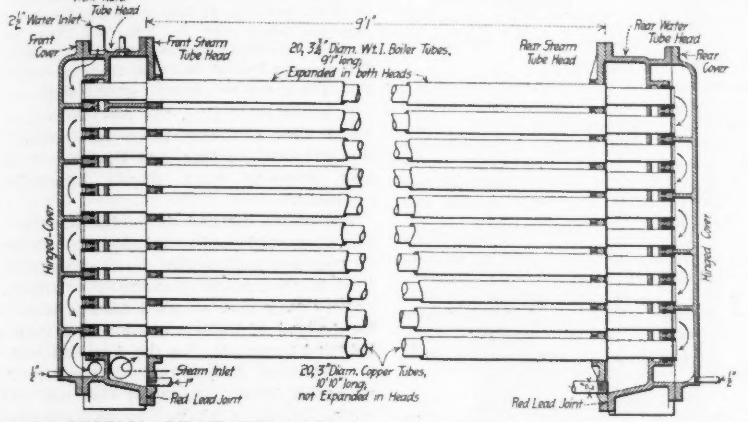


FIG. 3.—SECTION OF HEATER USED IN DISTILLING PLANT AT DRY TORTUGAS.

The heaters (see Fig. 3) each contain 20 wrought-iron steam tubes, 4 ins. in diameter by 9 ft. in length. Passing through each iron steam tube there is a 3-in. copper water-tube, 10 ft. 10 ins. in length, secured at its outer ends in outer tube sheets. The water enters the tubes at the top of the heater and flows back and forth through each of the water tubes, traveling 108 ft. in its passage. The steam for heating is in the annular space between the steam and water tubes. In the second and third (or high-pressure) heaters, this steam comes from the boilers.

As has been said, steam from the boilers is admitted (through a Dinkle reducing valve) to the steam chamber of the first effect, and also some steam from the pressure-reducing tank.

The piping is so arranged that chemical solutions may be circulated through the entire system for cleaning the tubes of the heaters and effects. It was found after the six-day run that there was only a light scale on the tubes of the heaters, varying from 1-64-in. in the first to 3-64-in. in the third. The tubes of the first and the second effects were practically clean. In the third effect the incrustation was 5-16-in. thick. By operating the plant in a slightly different way, as was done experimentally prior to this test, Mr. Lillie found no heavier scale in the third than was found in the first and second effects. At the end of the third day of the test the plant was shut down for several hours to permit the removal of this heavy scale from the third effect. In all cases the thickness of scale was greatest on the lower tubes and on the bottoms of the tubes.

Mr. Lillie uses the following method of cleaning: A solution of carbonate of soda is run through the heaters and effects (being heated at the same time). This Na_2CO_3 acts on the insoluble scale (which is mostly sulphate of lime), and soluble sulphate of soda and carbonate of lime are formed, the last being soluble in hydrochloric acid. The $NaSO_4$ passes off in the water. A dilute solution of hydrochloric acid is then run through the heaters and effects. The remaining carbonate of lime reacts with the acid, forming soluble calcic chloride, carbon dioxide and water. All soluble salts formed pass off with the solutions. Only practical tests will demonstrate fully the efficiency and practicability of this method of cleaning.

In this trial only fresh feed (which was a part of the output of the plant) was used in the boilers. The plant was at first fitted to be worked on a sea-water system. The proposed system for this is as follows: The sea water is passed through heaters and its temperature raised to that point at which the sulphates (scale-forming elements) become insoluble. The water then passes to a large settling tank in which the now insoluble sulphates are deposited. From the settling tank the water passes to the boilers. Only enough is to be evaporated in the boilers to furnish steam for the pumps, etc. (say about 25%), the remaining 75% goes to the pressure-reducing tank and thence to the effects for evaporation. The boilers were thus to act more as heaters, and even if the scale-forming sulphates were not all deposited in the settling tank, and much remained in suspension (not in solution) it was thought that little or no hard scale would be formed in the boilers owing to the fact that the sulphate of lime was not in solution in the sea water (only in suspension), and to the other fact that 75% of the feed to the boilers was constantly running away from the same. As the effectiveness of the settling tank had not been demonstrated, and as scale would prove very destructive to the boilers, this method was abandoned. As 35% of the total output goes for feed to the boilers, the capacity of the plant would be greatly increased if the salt-water system could be successfully used.

The contract required that the plant should prove itself capable of making from sea water 60,000 U. S. gallons, net, of distilled water per 24 hours for six days of each week. This allows one day out of each week for cleaning, and it is thought that this will prove ample, even with heavy incrustations in the third effect. With the Yaryan system, as used in the plant at Key West, when running only eight (8) hours each day, five days out of every forty are required for cleaning; running 24 hours each day, 20% of the time would be required for cleaning. In the Yaryan system the sea water passes through the tubes, and the scale formed is less readily removed.

The results of the six-day test of the "Lillie" plant are given below. From the table it will be seen that, for the total or gross output of the plant, 21.58 lbs. of water were distilled per pound of coal; for the net output, after deducting the feed for the boilers, 13.98 lbs. of water were distilled per pound of coal:

Duration of test in hours	144.
Number of boilers in use	3.
Mean temperature of the atmosphere	68.29
Mean temperature of sea water	69.58
Mean temperature of water from condenser to heater	89.83
Mean temperature of water leaving heaters	306.7
Mean temperature of discharged brine	140.42
Mean temperature of feed water	120.3
Mean temperature of distilled water	109.3
Mean density of sea water entering first effect	1.$^{44}/_{32}$
Mean density of discharged brine, degrees B.	8.58
Mean pressure in boilers, lbs. per square in.	115.92
Mean pressure in reduced-pressure tank	11.12
Mean pressure in first effect	10.79
Mean vacuum in first effect	0.
Mean vacuum in second effect	5.42
Mean vacuum in third effect	24.23
Total water distilled, cubic feet	73,318.
Feed water in cubic feet	25,783.
Net output in cubic feet	47,535.
Total water distilled, gallons	548,418.64
Feed water used in boilers, gallons	193,856.84
Gallons per 24 hours	59,260.3
Net output in gallons	355,561.8
Total water distilled, lbs.	4,568,327.
Feed water used, lbs.	1,606,497.48
Net output of distilled water, pounds	2,961,829.79
Percentage of total water used for feed	35.16
Total coal expended, lbs.	211,677.5
Refuse, ashes, lbs.	28,275.
Combustible, lbs.	183,402.5
Percentage of refuse	13.35
Lbs. of water distilled per lb. of coal	21.58
Lbs. of water distilled net per lb. of coal	13.98
Lbs. of water distilled per lb. of combustible	24.98
Lbs. of water net output per lb. of combustible	16.14
Lbs. of water evaporated in boilers per lb. of coal	7.58
Lbs. of water evaporated in boilers per lb. of combustible	8.65
Ratio of evaporation in the multiple-effect system to the evaporation in the boilers per lb. of fuel	2.84
Same ratio for the net output	1.84

The principle upon which multiple-effect evaporators act is not generally understood owing to the type being somewhat uncommon, and, indeed, at first glance, it appears to be something of a phenomenon to obtain 21.58 lbs. of fresh water from the $7\frac{1}{2}$ lbs. of steam produced by the combustion of 1 lb. of coal in the boiler. A short explanation, therefore, of the theory is not amiss in completing this report, and it will be of interest to all engineers who have noted the output of such plants, but have deferred the work of tracing the steps of the operation.

The figures given below are approximate only, and merely to show the theoretical possibilities. No account is taken of loss by radiation or discharge of heat with the brine mixtures, while the "total heat" of the brine in the several effects is taken as that of pure water. Also the water is supposed to be fed to each effect at the sensible temperature due to steam at the pressure in each, to simplify explanations. Peabody's tables have been used in the calculations.

The steam chamber and interior of tubes of each effect is here called the steam side, and the outside of tubes or salt water and vapor space is called water side, for brevity's sake:

The pressure in the water side of first effect 0 lbs. = 14.7 lbs. absolute.

Total heat in 1 lb. of feed water at 14.7 lbs. (absolute) .... 180.8 units.
Total heat in 1 lb. of sea water at 69.58 degrees Fahrenheit .... 37.7 units.

Total heat to be supplied to 1 lb. feed in first effect .... 143.1 units, . (a)

The pressure in the water side of second effect = 5.42 ins. vacuum = 12.1 lbs. absolute.

Total heat in 1 lb. of feed water at 12.1 lbs. (absolute) .... 171. units.
Total heat in 1 lb. of sea water at 69.58 degrees Fahrenheit .... 37.7 units.

Total heat to be supplied to 1 lb. feed in second effect .... 133.3 units, . (b)

The pressure in the water side of third effect = 24.23 ins. vacuum = 2.8 lbs. absolute.

Total heat in 1 lb. feed water at 2.8 lbs. (absolute) .... 106.7 units.
Total heat in 1 lb. of sea water at 69.58 degrees Fahrenheit .... 37.7 units.

Total heat to be supplied to 1 lb. feed in third effect .... 69. units, . (c)

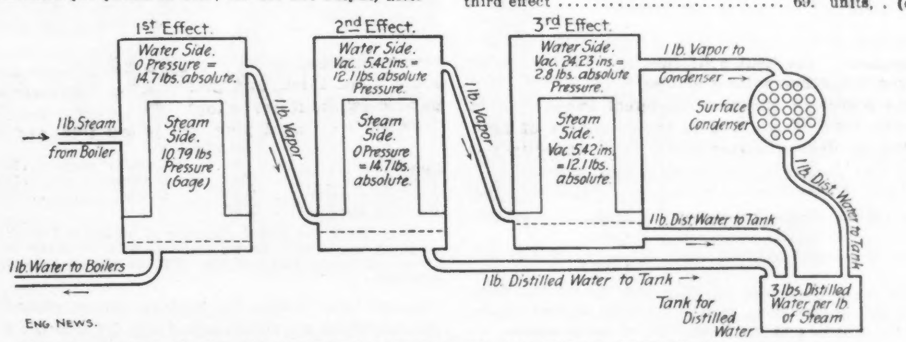


FIG. 4.—DIAGRAM TO ILLUSTRATE THEORY OF MULTIPLE EFFECT EVAPORATORS.

Now let us trace the course of 1 lb. of steam from the boiler entering the steam side of the first effect.

The heat in this pound of steam is first utilized to evaporate the water in the water side of the first effect until the pound of steam condenses to a pound of water at 10.79 lbs. pressure (gage). This pound of water then passes over into the steam side of the second effect, and as the amount of heat thus utilized is the difference between the total heat in the pound of steam at the boiler pressure and that in the pound of water to which it is reduced, we have:

Total units of heat in 1 lb. steam at 115.92 lbs. pressure (gage) .... 1,188.
Total units of heat in 1 lb. water at 10.79 lbs. pressure (gage) 210.1

Units of heat supplied to feed water in first effect. 977.9

In order to find out how much water these 977.9 units will vaporize in the water side of this effect, we first ascertain the total heat units necessary to vaporize 1 lb. of the feed therein. From the test record we know the vapor pressure in the water side of first effect is 0 (gage), and that the feed comes in from the reducing tank at 11.12 lbs. (gage), so that to vaporize a pound of this feed to steam at 0 pressure, we have:

Total heat units in 1 lb. vapor at 0 lbs. gage	1,146.6
Deducting units in the 1 lb. feed at 11.12 lbs. gage	210.8
Heat units necessary to evaporate 1 lb. feed in first effect	935.8

Hence with the available heat supplied for this as above we can vaporize here

$$977.9 \div 935.8 = 1.045 \text{ lbs.}$$

Second Effect.—Following the course to the second effect we have delivered to the steam side of this, both the 1.045 lbs. of vapor (at 0 pressure, gage) from the water side of first effect, and the 1 lb. of water from the steam side of first effect (at 10.79 lbs. pressure, gage) and which was condensed from our original 1 lb. of boiler steam.

The heat of this mixture is now utilized for evaporating feed water in the second effect and is

1 lb. of water, at 10.79 lbs. press. containing	210.1 units.
And 1,045 lbs. vapor containing 1,045×1,146.6	1,198.2 units
Being a total of 2.045 lbs. mixture containing	1,408.3 units.

As the pressure in the steam side of this second effect is 0, this heating mixture evaporates feed of the second effect until the mixture becomes water at 0 lbs. pressure (gage), when it passes to the steam side of the third effect.

Total heat units in 2.045 lbs. water at 0 lbs. (gage), or 14.7 absolute, is $2.045 \times 180.8 = 369.7$.

Subtracting this from the total heat in the mixture, 1,408.3 units, we have 1,038.6 units available for evaporating feed in this second effect.

As in the case of first effect, we now ascertain how much feed water in second effect these 1,038.6 units will vaporize:

Total heat units in 1 lb. of vapor in water side of this second effect at 12.1 lbs. pressure absolute (b)	1,143.7
Heat units in 1 lb. feed at same temperature	171.1
Total heat units to be supplied to 1 lb. feed in this second effect to vaporize it	972.6

Hence the total pounds of feed water evaporated in this effect by the 2.045 lbs. mixture in steam side = 1,038.6 ÷ 972.6 = 1.07 lbs.

Third Effect.—This 1.07 lbs. of vapor passes to the steam side of the third effect together with the 2.045 lbs. of water from the steam side of second effect, and we have in the setam side of the third effect the following heat units:

2.045 lbs. × 180.8 units (14.7 lbs. pressure absolute)	369.7 units.
1.07 lbs. × 1,143.7 units (12.1 lbs. pressure absolute)	1,221.3 units.
or 3.1 lbs. total mixture with	1,591. units.

To vaporize 1 lb. of feed water in this effect, we require:

Total heat units in 1 lb. vapor in water side third effect at pressure of 2.8 lbs. absolute (c)	1,124.2
Heat units in 1 lb. feed at that pressure	106.7
Total heat to be supplied, units	1,017.5

The heat in the mixture 3.1 lbs. in steam side of the third effect is utilized to vaporize the above feed water until the mixture becomes water at 5.42 ins. vacuum or 12.1 lbs. absolute.

Total heat units in 3.1 lbs. mixture at 12.1 lbs. absolute	1,591.
Total heat units in 3.1 lbs. water at same pressure, 3.1 × 171.1	532.
Heat units available for evaporating feed	1,059.

$$\text{Water evaporated in third effect} = \frac{1,059.}{1,017.5} = 1.04 \text{ lbs.}$$

This, when condensed, together with the 3.1 lbs. from steam side of this effect, goes to the tanks as fresh water, or 3.1 + 1.04 = 4.14 lbs. from 1 lb. of boiler steam.

Total heat units in 1 lb. steam from boiler	1,188.
Total heat units in 1 lb. feed at 120.3° F.	88.
Total heat units supplied by boiler to 1 lb. water	1,100.
Water evaporated per lb. coal	7.58
Total h't units supplied by 1 lb. coal (1,100 × 7.58)	8,338.

Heat units supplied to make 4.14 lbs. fresh water:

Heat units of 1 lb. of steam	1,100.
Heat units of 1.03 lbs. of feed, first effect, 1.033 × 143.1	148.
Heat units of 1.07 lbs. of feed, second effect, 1.07 × 133.3	143.
Heat units of 1.035 lbs. of feed, third effect, 1.04 × 69	72.
	1,463.

$$1 \text{ lb. of fresh water requires, therefore, } \frac{1,463.}{4.14} = 353$$

heat units, and

$$1 \text{ lb. coal would produce } \frac{8,338}{353} = 23.6 \text{ lbs. fresh water}$$

under the conditions assumed.

In connection with the above test it may be of interest to present some data regarding the distilling machinery in use on the two special distilling vessels of the Navy, the "Iris" and the "Rainbow," together with a test of the former vessel.

According to a description in the "Journal of the American Society of Naval Engineers" (Vol. 10, p. 793), the "Rainbow" has twelve evaporators or "effects," four condensers and three feed and two brine pumps. The evaporators have cylindrical steel shells 5½ ft. diameter and 6 ft. 2½ ins. between heads, with straight brass tubes 1½ ins. in diameter, and a total heating surface of 350 sq. ft. They may be worked in either single, double or triple effect. There are three feed heaters, each with 52 sq. ft. of heating surface, consisting of three coils of copper tubing. The "Iris" has practically the same equipment, and was designed by Past Asst. Engineer Emil Theiss, U. S. N., to have a capacity of 60,000 gallons per day when operated in multiple effect, and an economy of 20 lbs. of water per pound of coal was expected.

Results of a test of the "Iris" are given as follows in the last annual report of the Bureau of Steam Engineering:

The Bureau is well pleased with the efficiency of this distilling ship, and believes such a type of vessel to be a most essential addition to any squadron.

After the arrival of the "Iris" at Manila, in the early part of May, 1899, a 24-hour trial performance of the plant was held with the following results, which indicate the ability of the plant to produce readily about 200 tons of water per day.

Owing to insufficient steam supply from the main boiler in use at the time, the maximum performance was not attained. One of the regular evaporator machinists being ill at the time, his place had to be taken by one comparatively inexperienced in taking care of the plant with all sets in operation. The weather was very warm which naturally interfered with getting the best attendance from the men stationed on the evaporators.

Results.

Duration of trial, hours	24
Grate area in use, sq. ft.	70
No. of sets of evaporators in use (all)	4
Total quantity of water distilled, gallons	58,897
Total quantity of coal consumed, lbs.	40,314
Unnecessary machinery in operation	Flushing Pump.
Water distilled per lb. of coal consumed, lbs.	12.14
Per lb. coal consumed for distilling, lbs.	12.88

Excepting two condensers, which gave signs of leaking, all the machinery of the distilling plant operated satisfactorily. The affected condensers were cut out, and the distillation continued without total stoppage of the plant, two condensers doing the duty of four.

Data Taken During the Trial.

	Steam pressures, lbs. by gage.			
Tubes of first effect	64.3	58	62.5	63
Shell of " "	39	40	41.5	40
Tubes of second "	38	38	39.7	37.5
Shell of " "	16	22	19	17
Tubes of third "	14.7	20	19	17
Shell of " "	1	1.5	1	1.3

Concentration of Water in Shells.

	Set A.	Set B.	Set C.	Set D.
First effect	3½	3½	3⅛	3
Second effect	2⅝	3⅛	3	3¼
Third effect	2¾	2⅞	3⅛	3¼

Temperatures.

Sea water	85°	Evaporator room	121.8°
Feed water	184°	Highest	125°
Discharge water	115°	Lowest	100°
Distilled water	125°		

Note.—With the initial pressure of steam and object in view, it was found to be impracticable to carry lower pressures in the shells of the third effects on account of priming.

In the table below, the leading figures regarding the two tests are summarized side by side for convenient comparison. It may be noted that the coal used in the test of the Dry Tortugas plant was of poor quality and the boiler evaporation was consequently low, only 7.58 lbs. of water per pound of coal, or 8,338 heat units per pound. The evaporative performance of the boilers used in the test of the "Iris" plant is not at hand; but it will be evident that if a better record than this was made, the difference of economy above shown between the two plants would be still greater in favor of the Tortugas plant.

Comparison of Sea Water Distilling Plants.

Location of plant	Dry Tortugas.	Steamer "Iris."
Type of plant.	Lillie.	Submerged tube
Character of evaporators	Triple effect.	Triple effect.
Heat'g surf., evaporators	1,320 sq. ft.	3,840 sq. ft.
Surface in heaters	507 "	156 "
Total heating surface	1,827 "	3,996 "
Duration of test	144 hours.	24 hours.
Pressure:		
Steam: First effect	10.8 lbs.	64 lbs.
Vapor, from third effect	— 12 lbs.	1 lb.
Total, distld water, 24 hrs.	91,403 galls.*	58,897 galls.
Per sq. ft. heatg surf.	50 galls.	14.75 galls.
Relative efficiency of surf.	3.4	1.0
Total distilled water per 1 lb. of coal: Expected	22.8 lbs.	20.0 lbs.
Total distilled water per 1 lb. of coal: Obtained	21.6 lbs.	12.8 lbs.

*Average for 144 hours.

NEW STANDARD METHOD OF TESTING PAVING BRICK; NATIONAL BRICK MANUFACTURERS' ASSOCIATION.

In our issue of Feb. 22, we noted that the National Brick Manufacturers' Association, at its recent convention at Detroit, modified the "N. B. M. A." standard method of testing paving brick in an important particular, by deciding to use cast-iron shot in the rattler. The standard method which was adopted by this Association in 1897 was essentially as follows:

The standard rattler shall have a diameter of 28 ins., and shall be 20 ins. in length. It shall be built of cast-iron, a 14-sided polygon in cross-section, and shall make 1,800 revolutions at a rate of 30 per minute. The charge shall consist of bricks only (one kind at a time), enough being taken to equal in their united volume about 15% of the cubic contents of the rattling chamber. They shall be clean and dry, as nearly as possible in the condition they are taken from the kiln, and their loss in weight shall be calculated in percentage of the original weight. The average loss of two such charges shall constitute an official test, and be reported as one result.

In addition to this, the Association, in 1897, advised that the absorption test should be abandoned as misleading, and that the cross-breaking and crushing tests should be omitted as unnecessary.

The above method of conducting the rattler test has been subjected to criticism on the ground that it may not sufficiently distinguish inferior brick; that is, that brick of manifestly inferior value as pavers may give as good results in the rattler as hard brick of known value and reputation. Prof. Edward Orton, Jr., for the Association's committee on Technical Investigation, recently completed a thorough investigation on this and other points which led to a change in the standard method. Two other rattler methods were also investigated by Prof. Orton: The Talbot (or University of Illinois) method, and the Jones method. Prof. A. N. Talbot, of the University of Illinois, has since 1895 used a mixture of large sized cast-iron shot, weighing between 7 and 8 lbs. each, and a small size weighing about 1 lb. each, and in his criticism of the standard method adopted by the National Brick Manufacturers' Association he held that the method using this mixture of large and small shot showed up soft and brittle brick and that the standard shot were easily duplicated, while without shot the rattler might fail to detect inferior brick. In this connection it may be said that the paving brick commission of the National Brick Manufacturers' Association in its tests in 1897 experimented with small shot and with large shot, but not with a mixture of the two. The second method included the use of a rattler designed by Mr. Gomer Jones, of Geneva, N. Y., which had pockets in the cast-iron staves. The bricks to be tested were clamped in these pockets, and a charge of 150 lbs. of cast-iron cubes with 1½-in. edges was used to cause the abrasion. The brick were thus worn principally on one surface only, and it was held that this wear was quite similar to that received in the street.

The results of the investigation of these methods were submitted to a committee appointed by the President of the National Brick Manufacturers' Association which met in Chicago on Jan. 27, 1900. The committee was made up as folows: Prof. J. B. Johnson, Dean of the College of Engineering, University of Wisconsin, Chairman; Prof. A. N. Talbot, Professor of Municipal and Sanitary Engineering, University of Illinois, Secretary; H. A. Wheeler, Mining Engineer, St. Louis, Mo.; Gomer Jones, M. E., formerly City Engineer of Geneva, N. Y.; D. V. Purington, President of the Purington Paving Brick Co., Chicago; Prof. Edward Orton, Jr., Director Department of Clayworking and Ceramics, Ohio State University. This committee reviewed the data presented by Prof. Orton and others and formulated a report. The committee found that for some makes of brick the rattler test without shot gave as low losses for soft brick as for superior brick, and that while it had some advantages and did bring out structural defects, it could not always be relied on to detect inferior brick. In general, it did not make a sufficient distinction between the different grades of brick. The University of Illinois test, with standard shot, proved more trustworthy in selecting soft brick and gave results which agreed with the grades of the brick. The Jones test was quite sensitive in nearly every case, but failed with one make of brick and was unduly and unfairly severe with brick as compared with blocks, besides having some minor defects of design. It was felt that this machine had some promising features and the committee recommended that its design be modified and further experiments made upon the improved rattler. The committee recommended that pending the completion of these experiments, the conclusion of which is uncertain, the standard method of the Association be amended on the following points, the proportion of large to small shot being such as had been found to give best results with a 28-in. rattler with a speed of 30 revolutions per minute.

1. The brick to be thoroughly dried before rattling.

2. Steel staves to be used preferably in place of cast iron, as the latter peens and ultimately breaks under the wearing action of the charge.

3. The speed to be between 28 and 30 revolutions per minute.

4. The charge to consist of from nine paving blocks to twelve paving bricks, together with 300 lbs. of shot, as described below.

The National Brick Manufacturers' Association, at its annual convention at Detroit, in February, adopted the report of this committee and made provision for continuing the investigation of these methods of making rattler tests, as well as of other processes which may be brought before its Committee on Technical Investigation. This work will be under charge of Prof. Orton, who conducted the other tests. Engineers generally will commend the brick makers for investigating the criticisms passed upon the rattler test proposed by them and for so promptly adopting the recommended modifications.

The following is the text of the method of testing adopted by the National Brick Manufacturers' Association as it stands since amendment:

1. Dimensions of the Machine.—The standard machine shall be 28 ins. in diameter and 20 ins. in length, measured inside the rattling chamber. Other machines may be used, varying in diameter between 26 and 30 ins., and in length from 18 to 24 ins., but if this is done a record of it must be attached to the official report. Long rattlers may be cut up into sections of suitable length by the insertion of an iron diaphragm at the proper point.

2. Construction of the Machine.—The barrel shall be supported at either end; in no case shall a shaft pass through the rattling chamber. The cross section of the barrel shall be a regular polygon, having 14 sides. The heads shall be composed of gray cast iron, not chilled or case hardened. The staves shall preferably be composed of steel plates, as cast iron peens and ultimately breaks under the wearing action of the inside. There shall be a space of ¼-in. between the staves for the escape of dust and small pieces of waste. Other machines may be used having from 12 to 16 staves, with openings from ⅛-in. to ⅜-in. between staves, but if this is done a record of it must be attached to the official report of the test.

3. Composition of the Charge.—All tests must be executed on charges containing but one make of brick or block at a time. The charge shall consist of nine paving blocks or twelve paving bricks, together with 300 lbs. of shot made of ordinary machinery cast iron. This shot shall be of two sizes as described below, and the shot charge shall be composed of one-fourth (75 lbs.) of the larger size and three-fourths (225 lbs.) of the smaller size.

4. Size of the Shot.—The larger size shall weigh about 7½ lbs. and be about 2½ ins. square and 4½ ins. long, with slightly rounded edges. The smaller size shall be cubes 1½ ins. on a side, with rounded edges. The individual shot shall be replaced by new ones when they have lost one-tenth of their original weight.

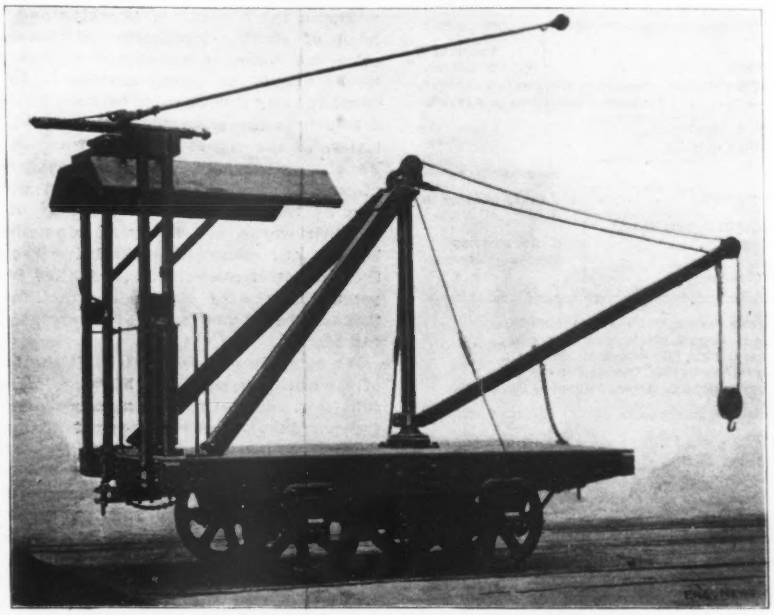
5. Revolutions of the Charge.—The number of revolutions of a standard test shall be 1800, and the speed of rotation shall not fall below 28 nor exceed 30 per minute. The belt power shall be sufficient to rotate the rattler at the same speed whether charged or empty.

6. Condition of the Charge.—The bricks composing a charge shall be thoroughly dried before making the test.

7. The Calculation of the Results.—The loss shall be calculated in per cent. of the weight of the dry brick composing the charge, and no result shall be considered as official unless it is the average of two distinct and complete tests, made on separate charges of brick.

A LIGHT ELECTRIC LOCOMOTIVE CRANE.

We illustrate in the accompanying cut a light locomotive crane operated by electricity which has been recently built by the J. G. Brill Co., of Philadelphia, for use about their own works. The convenience of locomotive cranes for loading and unloading heavy materials about a manufacturing plant is pretty well known, and the present machine has the advantage over the steam-driven cranes that it can operate inside shops and enclosed spaces without creating a nuisance from the escape of steam or gas. It has, on the other hand, the objection that it is limited in its movements to tracks over which trolley wires are stretched, and for that reason its chief use will probably be about the shops and yards of street railway companies. For work where freedom of movement is essential and a network of overhead wires is not strung, a machine operated by storage batteries would be preferable.



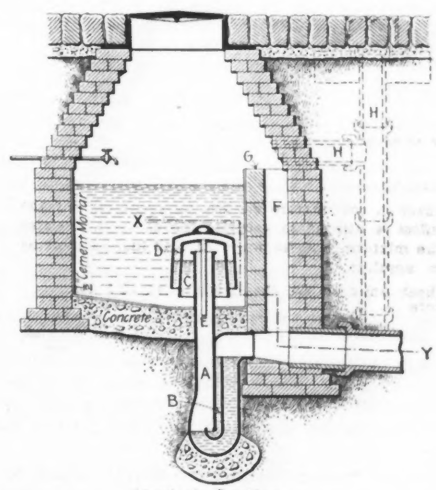
LIGHT ELECTRIC LOCOMOTIVE CRANE.
The J. G. Brill Co., Philadelphia, Pa., Builders.

The machine illustrated has a 5-ft. wheel-base. The mast is of iron, and the hoisting rope passes down through it to the winding drum underneath the car floor. An important advantage of the machine is that it is equally useful as a locomotive and as a crane. The use of electric locomotives to operate the industrial railways about manufacturing plants has become widespread. A machine of this sort fills all requirements as a locomotive, and in addition is always available to lift a heavy weight in loading or unloading, hoist a derailed car back on the track, or do any similar service within the limit of its capacity. The latter can be made of course almost anything that the conditions require, by increasing the wheel-base of the machine and adding to its ballast, the power of the motors and the size of the mast and hoisting machinery.

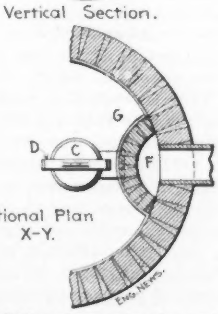
AN AUTOMATIC FLUSHING TANK.

In the automatic flush tank siphon, which we illustrate herewith, the special features claimed are a compound trap and a secondary siphon. The former allows the water to commence discharging with a full flow, and the latter ensures the main siphon being recharged with air. It does not, however, admit air to the main siphon until the tank has been emptied, as such admission would diminish the flow.

The trap (A) is of cast iron, with the smaller trap (B) formed within it. The dome or bell (C) is also of cast iron, fitting over the top of the trap and secured in position by brackets cast in the dome. The secondary siphon is formed on the dome, and consists of two passages (D) which extend up the sides and across the top, connecting with the pipe (E) which enters the top of the trap. The water flowing into the tank first seals the dome and then seals the secondary siphon. As the water rises, it exerts a pressure on the air confined within the dome and trap, and forces down the water in the leg of the trap until it gets below the opening of the small trap, the water in which trap is then blown out and the air escapes from the dome. This allows the water in the tank to begin discharging, and as the air escapes through the smaller trap the water is discharged in a full flow through the main trap. When the tank is emptied, air enters under the dome and through the secondary siphon, thus recharging the siphon with air. The cut shows a vent (F) formed within the tank, by means of the segmental wall (G), which has the advantage of giving a large ventilating shaft. An outside vent may be used if preferred, as shown by the dotted lines (H), in which case the inside vent and wall



Vertical Section.



Sectional Plan
X-Y.

are omitted, and the sewer pipe is continued to the mouth of the siphon.

This device is patented, and is manufactured by the Walker Flush Tank Co., 916 Baltimore Ave., Kansas City, Mo. It has been used in Kansas City, Mo.; Los Angeles, Stockton and Santa Ana, Cal., and at the U. S. barracks at Benicia, Cal. In all these case the city engineer or other authority has reported favorably upon the device, especially in regard to its reliability in continuous operation.

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ADVERTISING RATES: 20 *cents a line. Want notices, special rates, see page XXI. Changes in standing advertisements must be received by Monday morning; new advertisements, Tuesday morning; transient advertisements by Wednesday morning.*

The decision of a Pennsylvania court in an injunction suit to close the garbage reduction works at Pittsburg, given in another column, is a strong contrast to the summary manner in which the legislature of New York State has ordered the closing down of the garbage reduction works at Barren Island, Greater New York. The Pittsburg plant is in a populous section of the city, yet the court refused to order it closed, holding that if properly operated it was little or no more of a nuisance than ordinary manufacturing establishments in the vicinity. The court also held that the city authorities really had the sanitary control of the plant in their own hands, since under the contract the works must be operated in a sanitary manner, and the contract had only a year or so more to run.

The conditions governing the Barren Island reduction works are much the same, in that the city authorities have sanitary control of the plant and the contract expires in about two years; but the location of the plant at which the garbage of Greater New York is treated is much more remote from populous districts than the Pittsburg works. Notwithstanding all this, the New York legislature brushes aside the city authorities, the State Board of Health and the courts, to all of which complainants have access, and in response to the demands of a mere handful of people, compared with the total population affected, virtually orders the Barren Island plant closed, by an act prohibiting the treatment of garbage by boiling or rendering processes within the borough of Brooklyn. As an amendment, a provision was inserted that the local board of health may extend the date the act shall go into effect, provided the extension is not more than 22 months, thus enabling the city authorities to decide for themselves whether the works shall be closed before the termination of the contract under which they were built and are being operated.

The probable effect of this bill, if approved by the mayor and governor, will be to increase very largely the future cost of garbage disposal in New York city, for when new contracts are let the city is not only cut off from the advantageous bid the present contractors might make, through having a plant fitted to do the work already in operation, but it is also liable to be cut off from all competition between proprietors of reduction processes and those controlling garbage furnaces. This liability is due to the prohibition of reduction works in the borough of Brooklyn and the likelihood of similar legislative prohibition against other boroughs, if suitable localities for such works should be found elsewhere. In such an event the city must choose between cremation and a return to the practice of dumping at sea. The latter, in the light of past experience at New York and elsewhere, would be a long step backwards. Thus the city might be left with cremation as the only practicable means of disposal. In other words, practically all competition might be shut off, reduction works being excluded and the number of concerns in the United States competent to take so large a contract for garbage furnaces being very small at present, so far as we can learn.

We strongly suspect that if all the forces back of the anti-Barren Island bill were marshalled in full view, some of the strongest cohorts would be those in favor of one or two patented systems of garbage cremation. But if such legislative interference as this is to go on unchecked, what is to prevent the promoters of garbage reduction systems, whenever they can rally sufficient strength, from taking advantage of the local sentiment sure to develop against garbage furnaces, wherever they may be located, and securing from some future legislature a prohibition of garbage furnaces in the borough in which they are located? As we pointed out in our issue of Feb. 1, the whole question of garbage disposal in New York city, or any other city, is so purely one of engineering and finance it should be left for the respective cities to settle each for itself, trusting to local and state boards of health to protect the health and property of the citizens, who are or think they are injuriously affected. For any legislature to try to settle such questions offhand is not only a violation of home-rule principles, but is an attempt to try to convert a heterogeneous body of men from all the various walks of life into a sort of joint board of sanitary engineers and high court of justice, an attempt that is bound to result in a sanitary farce and a miscarriage of justice.

The —— syndicate and allied interests have, it was announced yesterday, practically completed their arrangements for a consolidated air power company with a capital of $200,000,000. The amalgamation will take place in all the large air power companies in this country.—New York Tribune, March 21.

In the old-fashioned arithmetics it used to be laid down that "ought and ought is ought."

No such prosaic mathematics are current with the modern promoter. In his transcendental computations the result of addition is multiplication. The process of division comes later.

In connection with the discussion of the Hall or Chisholm gas process as exploited in San Francisco, in our issues of Dec. 7 and Feb. 15, we note the following in the current issue of our contemporary, "The Journal of Electricity, Power and Gas," which is published in San Francisco:

The gas mains of the Equitable company are being gradually introduced into most of the best down-town thoroughfares. This is the company which is using the almost universally denounced Hall process, and it is worthy of note that at present the works of the Equitable company are being remodeled for the generation of water gas after a standard process so that the ensuing few weeks will undoubtedly terminate the unsatisfactory career of the Hall process in the works of the Equitable Gas Light Company of San Francisco.

We also learn that the application of Dr. Chisholm and his associates for a franchise to supply gas to Passaic, N. J., has been withdrawn.

One of the most striking differences between European and American locomotives in external appearance is the absence of the pilot on the former and its universal presence on the latter. Probably if somebody had owned a patent on the use of pilots and it had been worth while to push their use abroad, all foreign locomotives would by this time be as well supplied with pilots as those in this country. As matters stand, however, no one has had any interest in seeing that foreign railway managers were educated to perceive the benefits of the pilot, and the inertia and conservatism of the average locomotive superintendent have been sufficient to prevent anyone from taking up the question in a proper manner. Probably most foreign railway officers labor under the impression that the "cowcatcher" is used on American railways merely because trespassing live stock is more frequently encountered here.

We have noted recently, however, two serious accidents on English railways, each of which would in all probability have been prevented entirely had the locomotive been equipped with a pilot. In one of these a light baggage truck rolled off the platform of a local station just as a fast express train was approaching. The train was derailed with serious casualties.

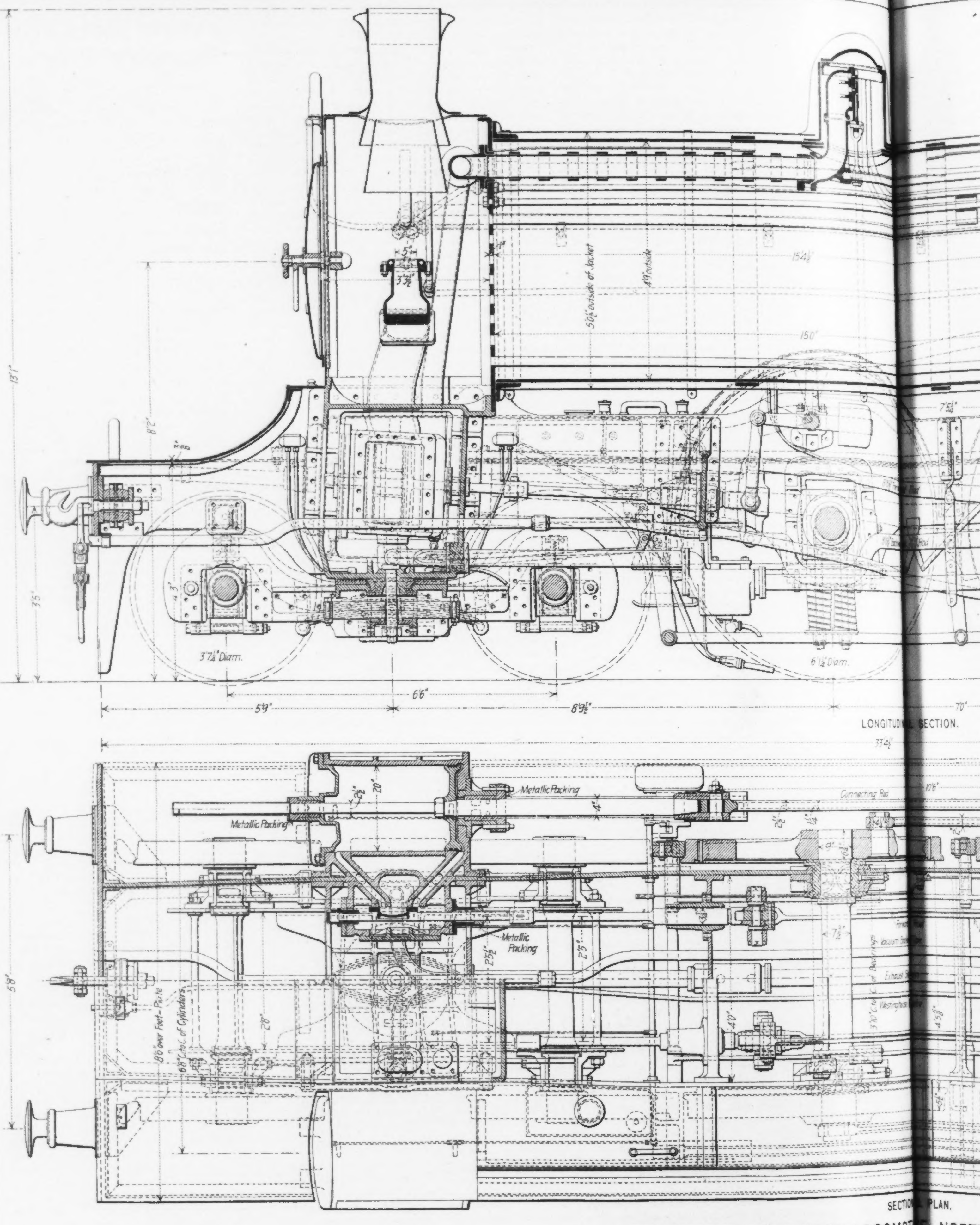
A still more recent accident occurred to the Irish Mail train on the London & Northwestern in December last. A bale of cloth fell off an open freight car upon the express track. The locomotive and four cars of the Irish Mail train passed over without injury, but the fifth car was derailed by it and ran on the ties for three-fourths of a mile until it struck a switch, when it was thrown across the parallel freight track. A freight train close behind on this track ran into this car, and the rear cars of the mail train also ran off at the switch and were struck by the freight train. One passenger was killed and several were severely injured. The Board of Trade Inspector lays the whole blame for the accident to carelessness in loading the bale of cloth. That the practice of carrying such light and shifting freight on open cars, protected only by a tarpaulin covering, was in any way objectionable does not seem to have occurred to anyone.

A third accident which is of some interest in this connection is described in our correspondence column this week by a personal participant. In this case a Pullman car standing on the main track was struck by a freight train running at full speed. The pilot of the locomotive and the car platform absorbed the force of the collision and the two passengers in the cars were uninjured.

THE WEAR OF WHEELS ON SHARP-CORNERED RAILS.

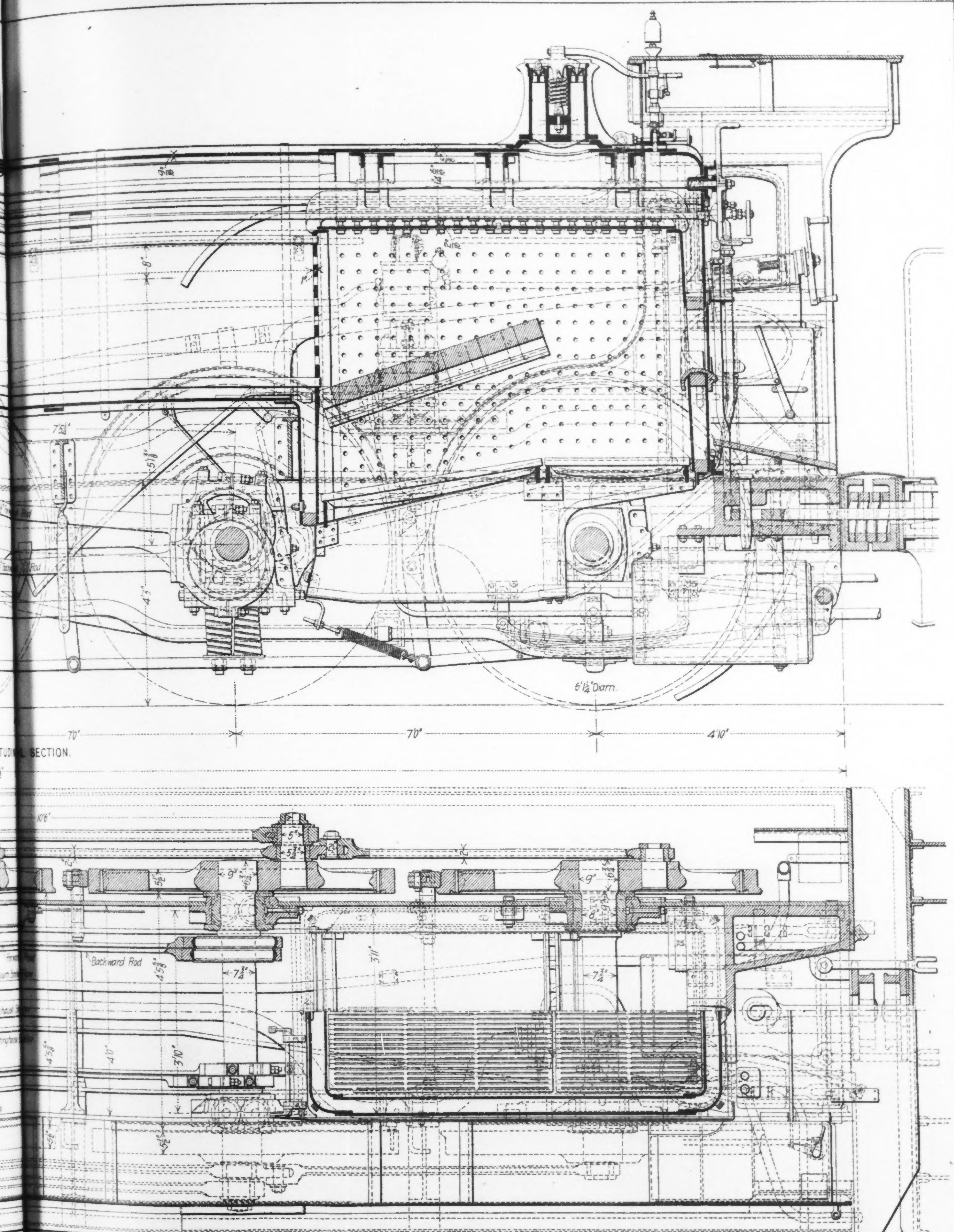
The type of rail section recommended by a committee of the American Society of Civil Engineers in 1893 has now been adopted as standard by a majority of the large railways in this country; and this is a strong proof of the merits of this section, since its adoption has involved the rejection of many varying sections, including a number of sections of special individual design. We believe, however, that it is quite generally forgotten that this type of section was designed as the result of some years of investigation by another committee (composed in part of the same members) into the proper relation of railway wheels and rails. In other words, an investigation was made to determine what section of wheel tread and flange and what section of rail head would give the best results in regard to the wear of both wheel and rail. At the time of that investigation there were many engineers and others who favored a rail with a top corner of large radius and an outward flaring head, fitting the contour of the wheel flange. This type of section, however, has been proved to be very objectionable, but as it has now almost entirely disappeared it need not be discussed here. We refer to it only to show the two general propositions which had to be considered by the first committee: (1) Should the rail have a round top corner and a head flaring outward from the top, so as to conform to the outline of the wheel flange and fillet? or, (2) should the rail have a sharp top corner and vertical sides to the head, in order to keep the flange away from the wheel as long as possible?

It will suffice to say here that the evidence presented and the principles discussed were overwhelmingly in favor of the latter design. It was originally proposed to give the top corner of the rail a radius of ¼-in., but in the design finally adopted, partly to effect a compromise, this was increased to 5-16-in., which is the present standard. While this has been satisfactory and there is probably little practical difference between sections with the two radii, we are inclined to be-



TEN-WHEEL PASSENGER LOCOMOTI[...]E; NORTH

W. Worsdell, M. Inst. C. E., Locomoti[...] Superinte



OCOMOTIVE; NORTHEASTERN RY. (ENGLAND.)

, Locomotive Superintendent, N. E. Ry., Designer.

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

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lieve that on the whole it would have been better to adhere to the original design and use a corner radius of ¼-in. That, however, is out of the question now, and any such change would be most undesirable (in view of its slight importance), since one of the principal objects of preparing the design was to establish a uniform standard section, and so to save time, money and labor in rail manufacture, as well as to improve the rail section in itself.

It will be remembered by those who followed the discussion on the committee's investigation as to the advantages and disadvantages of various rail sections, that the advocates of a round-cornered rail claimed that a sharp-cornered rail would cut the wheel flanges and cause a dangerous and expensive proportion of sharp flanged wheels. This matter was thoroughly investigated, with the result that the claims were proved to have but a very slight foundation in fact, and this theory has now been very generally abandoned. The Sayre rails of the Lehigh Valley R. R., with ½-in. corners and heads flaring 5° and 10°, and other similar sections (but not carried to such extremes) have given place to the section recommended by the Am. Soc. C. E. committee. One of the most recent changes of this sort has been made on the Canadian Pacific Ry. The former standard was a 72-lb. rail of the Sandberg round-cornered section, with a top radius of 6 ins., top corners of ½-in. radius, and vertical sides to the head. The present standard is the 80-lb. of the so-called Am. Soc. C. E. section, with a top radius of 12 ins. and a top corner radius of 5-16-in. It may be noted that the rail of this weight and section is the one now most generally adopted as standard on American railways.

One other point which has been very generally forgotten or overlooked in recent discussions on rail sections is that the rail committee's report expressly stated that the form of rail section presented had been designed particularly for the tangents and easy curves which compose by far the greater part of the railway system. It would thus be reasonable to expect that some modification of the section might be made to give more satisfactory results on lines having a large percentage of very sharp curves. Such modifications have been made in a few instances, but as a matter of fact the committee's form of section is also used with success on lines of this character.

Appended to the report of the rail committee (Trans. Am. Soc. C. E., 1892, Vol. 28) was a collection of letters showing the individual preferences and practices of different roads. From this it appears that many important roads were then using sharp-cornered rails and considered them satisfactory. Among these were the Boston & Maine; Buffalo, Rochester & Pittsburg; Erie; Duluth & Iron Range; Lake Shore & Michigan Southern; Louisville & Nashville; Michigan Central; New York Central; New York, Chicago & St. Louis; Norfolk & Western, etc. The opposite extreme was represented by the Florida Central & Peninsular R. R., whose Chief Engineer, Mr. Burwell, advocated a top corner radius of 7-16-in. When the sharp-cornered rails were first introduced on the Louisville & Nashville R. R., the Superintendent of Machinery thought they were causing sharp flanges on the wheels of the locomotives, but further investigation led to the conclusion that the sharp corner was not detrimental to the flanges of engine wheels. This point is referred to further on. The New York Central R. R. had used radii of ¼-in. and 5-16-in., and Mr. Dudley considered that the former should be used for rails having heads up to 2¾ ins. in width, and the latter for rails with wider heads. The Fitchburg R. R. and the Atchison, Topeka & Santa Fe Ry. were then using rails with ⅜-in. corners, but both these roads have now adopted the Am. Soc. C. E. section. The Burlington & Missouri River R. R. reported against the sharp-cornered (¼-in.) rails, because such rails on the Deadwood line wore to a round corner and a flaring head, after which the train loads could be materially increased. This line, however, has curves of 16° and, as we have already pointed out, the Am. Soc. C. E. section was not specially designed for sharp curves. As a matter of fact, the result of the experience on the Deadwood line was the adoption of the 5-16-in. corner radius recommended by the Am. Soc. C. E. committee. On other parts of the B. & M. R. R. R., with easier grades and curvature, no such effects were found with the rails having ¼-in. corners. Even the Lehigh Valley R. R., formerly the leading advocate of the round-cornered flaring head, has now adopted the Am. Soc. C. E. section as its standard. In 1892, Mr. Thomas Rodd, Chief Engineer of the Pennsylvania lines, favored a sharper top corner radius than that of the standard rail section of the Pennsylvania R. R., and it may be noted that the Am. Soc. C. E. rail section is now used on the Pennsylvania lines west of Pittsburg. As the Pennsylvania R. R. proper is one of the few remaining roads which uses a round-cornered rail, it may be appropriate to explain that in 1892 Mr. W. H. Brown, the Chief Engineer, stated that the 7-16-in. radius adopted for the new 85-lb. rail was a compromise between the Engineering Department and the Motive Power Department; the former favored ¼-in. and the latter ⅝-in., and 7-16-in. was the compromise. This is still retained

As a practical example of the wide recognition of the advantages of the type of rail section designed by the Am. Soc. C. E. committee, it may be noted that a recent investigation which we have made shows that out of 44 leading railways (representing 104,700 miles of road), 33 railways (with 81,566 miles) have adopted this form of rail as standard. Of the others some use sections "nearly the same," or "modified Am. Soc. C. E.," while the officers of one road are discussing the matter and are expected to adopt the Am. Soc. C. E. section. Very few of the roads have sections differing radically from this section. Of course this does not mean that 81,000 miles of track are laid with rails of this section, but it does mean that the section has been adopted as standard, is already in use, and will be used in future to the exclusion of other sections.

The foregoing presentation of the history and development of the Am. Soc. C. E. rail section has been suggested by a letter which we have recently received from Australia, which brings up again the old question of the wear of wheels on sharp-cornered tires. This letter is as follows:

Sir: Prior to 1891 all the rails used on the railways in this province were rolled with large-radius top corners. In that year I introduced an 80-lb. rail with top corners of ¼-in. radius, and since then have used the same radius on all new rails.

My new rails (illustrated in your journal of Oct. 31, 1891, p. 408) came into use just prior to the issue of the progress report of the American Society of Civil Engineers' committee upon "Standard Rail Sections," and when the final report was published in 1893, I found that my rail was strangely like the standard section recommended.

I have now received from our Locomotive Engineer, for the first time, a complaint that the tires of engines running over these sharp-angle rails are very seriously worn. He goes so far as to say that while engine No. 72, which was used on the old-fashioned rails, ran 70,942 miles; engine No. 120, used upon the rails with sharper angles, ran only 35,205 miles when showing the same wear, and he endorses the statement that this wear was due entirely to the class of rail the engine was run on. The Locomotive Engineer informs me that the tires were all of equal quality and of Krupp's manufacture.

May I ask you to let me know whether a similar or approximately similar wear of engine tires has come under your notice as having been observed on the railways of the United States, as the result of the adoption of the pattern of rail recommended by the committee of the American Society of Civil Engineers.

I am, sir, yours faithfully,
Alex. H. Moncrieff, Engineer-in-Chief.
Adelaide, South Australia, Dec. 22, 1899.

It will be noted that although the rails complained of were first introduced in 1891, and their use has been extended and continued up to the present time, this is the first complaint that has been made. Nothing is said as to the character of the steel in the two types of rails, nor is anything said as to the respective shape or outline of the tires, the respective types and wheelbase of the two engines, or as to whether they were run on the same part of the line. It would not be at all unreasonable if an old light engine with light traffic on an easy portion of line with soft or low carbon rail, should give a greater mileage for a set of tires than a heavier engine with longer wheelbase working heavier traffic on a more difficult part of the line, laid perhaps with harder rails. Any one of these conditions alone would exert some influence. The general design of the engine and the general condition of the track (irrespective of the form of rail) would also have an important influence on the wheel wear. In fact, on the Mobile & Montgomery Division of the Louisville & Nashville R. R. the greatly improved wear of wheels on the new sharp-cornered rails of the Am. Soc. C. E. section is attributed in part to the fact that the road has been ballasted with slag as well as relaid with these rails. On this division engine tires make 64,000 miles before it is necessary to turn them off, while formerly (with rails of 7-16-in. corner radius) they had to be turned after running 36,000 miles.

In order to reply to Mr. Moncrieff's inquiry as to American experience and opinion in this matter, we have made inquiry among some engineers and superintendents of motive power who have given attention to this question of the relation of rails and wheels to one another, and present below some of the answers received. These substantially support all the claims made for the sharp-cornered rail. There is one, however, from Mr. E. H. McHenry, Chief Engineer of the Northern Pacific Ry., which states that excessive wheel wear has been caused by sharp-cornered rails. The position advanced by Mr. McHenry is one which has not, we believe, been presented by any other writer on the matter of wheel wear. This proposition is in regard to the relation of rail ends at joints to the wear of the wheels. In his letter to the rail committee (1892) the matter was presented as follows (Transactions American Society of Civil Engineers, Vol. 28): "I wish to assert my belief that a large part of the excessive wear observed on both wheels and rails on new track is due to the chisel action of the sharp-cornered rail at the joint cutting the flanges of the wheels and scoring them in such a manner that the reaction upon the rail is in turn equally destructive."

Following are the letters above referred to, which reply to our enquiry as to the conditions mentioned by Mr. Moncreiff:

While we have no absolute data as to the relative tire wear on rail sections of the Am. Soc. C. E. type in comparison with more antiquated rail sections of greater side-head bearing surface, I am inclined to the opinion that the larger rail wear is due to some difference in the engine construction, such as increasing weight on driving wheels and longer wheelbase. It is undoubtedly true that the heavier sections of rail, as now rolled, are inferior in quality to the smaller rail in use a few years since.

J. M. Graham,
Chief Engineer,
Baltimore & Ohio R. R.

I am of the opinion that there will not be as much flange wear with ¼-in. radius on the side of the rail head as there would be if the radius was larger, for the simple reason that the larger the radius the greater surface of flange would be exposed to rubbing contact, with consequent abrasion. Careful observations extending over a number of years would indicate to me, that there is no perceptible difference due to the change in the radius as mentioned above. Theoretically I would look for less wear.

So far as the Australian engines Nos. 72 and 120 are concerned, to which reference is made, a description of the two engines might point to a much more definite reason for the flange wear of the same than in variation of the section of the rail.

J. N. Barr,
Mechanical Superintendent,
Baltimore & Ohio R. R.

Our road used some of this sharp-cornered steel Am. Soc. C. E. standard on our Deadwood line, where our maximum curvature is 10 to 16 and a large percentage of line curved. We found that the rail on that line cut our flanges, and that our flanges cut off the sharp corners of rail very rapidly, and after the corner was cut off the cutting of wheel flanges was much less rapid, and that our engines would haul bigger train loads. The result was that the corner radius was changed from the Am. Soc. C. E. standard to 5-16-in. All this occurred seven or eight years ago, and we have no definite figures to quote at this time.*

I. S. P. Weeks,
Chief Engineer,
Burlington & Missouri River R. R.

*As we have noted above, the Am. Soc. C. E. section was designed with special regard to tangents and easy curves. The top corners of the Am. Soc. C. E. section, however, are of 5-16-in. radius (although originally proposed to be ¼-in.), and as the B. & M. R. R. R. adopted the 5-16-in. radius after its experience with a sharper radius, it would seem that the Am. Soc. C. E. section is suitable even for lines of this character. Mr. Weeks is, it will be seen, mistaken in saying that the corner radius was changed "from the Am. Soc. C. E. section to 5-16-in.," since this latter radius is the Am. Soc. C. E. standard. In a later letter Mr. Weeks states that the rails originally had a corner radius of ½-in.—Ed.

We have not been using the Am. Soc. C. E. standard rail long enough to notice any increased wear on our wheels. These rails, you will understand, have only been laid over short sections of our line between old 56-lb., 60-lb. and 72-lb. rails. In no place have we a stretch of as much as ten miles of the American Society rails yet laid in any one place.

I am very much inclined to doubt the statement that the Am. Soc. C. E. standard rail has caused an increased wear on the wheels. If such is the case, the wear should be very near the flange, and very much deeper than at any other point. I think it would be well to get from Mr. Moncrieff a cross-section, or templet of the tire of Engine No. 72 running over the old round corner rail, and also a cross-section or templet of the tire of Engine No. 120, used upon the rails with sharper angles.

P. Alex. Peterson,
Chief Engineer,
Canadian Pacific Ry.

We have no definite data on this matter by which we could say with absolute certainty that a straight sided rail and with a corner radius of ¼-in. had increased the trouble with sharp flanges. Our records of wear of car wheels would certainly seem to show nothing of the kind, as wheels give more miles of service now than formerly, but we know this is largely due to the better quality of wheels. Of course we have more or less trouble with flanges of locomotive tires wearing sharp, and this is especially true with long framed engines, but as the number of engines of this class has increased in recent years, it would not be fair to compare the results with former years. The design of hanger on front trucks, whether single (pony) trucks, or double (four-wheel) trucks, will of course affect the question of the flange wear on front drivers. This is a matter to which we have given considerable study, with a view of making the leading truck do more efficient work in guiding the engine.

In substance, about all that can be said on this subject, in this country, will, I think, be largely a matter of opinion. Some men consider that the sharp-cornered rails, as they are called, are responsible for the flange wear, while my position (and the opinion of others with which I agree) is that the best way to limit the wear is not to allow the flange to come in contact with the side of the rail head. Just as soon as the wear of the rail and flange have permitted this, as of course occurs on the outside of curves, there is a rapid abrasion of both the wheel flange and rail head, and it is not uncommon to find long slices or shavings of rail steel, which have been sheared off in this manner.

F. A. Delano,
Superintendent of Motive Power,
Chicago, Burlington & Quincy R. R.

After a thorough investigation of the matter, I find that there is, on our railway, no increase in the wear of wheels since the introduction of rails of the Am. Soc. C. E. section.

C. W. Buchholz,
Ch. Engr., Erie R. R.

In regard to wear of driving wheel tire flanges on rails of the Am. Soc. C. E. pattern, our Superintendent of Machinery states that while he is not prepared to give an expression regarding wear of tires on the different types of rails, he does not think flanges of wheels are being worn to any greater extent than formerly except on account of larger engines and higher speeds.

David Sloan,
Chief Engineer,
Illinois Central R. R.

Relative to the wear of locomotive driving wheel tire flanges, since the adoption by this company of the Am. Soc. C. E. type of rail section, I will say that on account of the great difference in the sizes, as well as the service of engines since this section of rail was adopted, as compared with those operated on rails previously used by this company, I am scarcely able to give an opinion as to whether the increased wear of tires recently is caused by the service or by the rail section.

W. Renshaw,
Superintendent of Machinery,
Illinois Central R. R.

Our Motive Power Department has not made any complaint with regard to the Am. Soc. C. E. section of rails with sharp corners. I forwarded your letter to our Superintendent of Machinery with request that he give me the average number of miles run by engine tires prior and subsequent to 1890, when we adopted rail with sharp corner (¼-in. radius), which we used until the adoption of the Am. Soc C. E. section some three or four years later, and suggested to him that the engines run on our Mobile & Montgomery Division would probably be the best for the comparison. In his reply he does not give me this information, for the reason, he says, that it shows altogether too favorably for the sharp-cornered rail, which he attributes to the fact that the road has been ballasted with slag as well as being relaid with the Am. Soc. C. E. section of rail. He informed me that engine tires now run on the Mobile & Montgomery Division 64,000 miles before it is necessary to turn them off, where formerly, with rail of 7-16-in. corner radius, they had to be turned off after running 36,000 miles. Tires are turned when grooved ¼-in. deep.

R. Montfort,
Chief Engineer,
Louisville & Nashville R. R.

With regard to flanges of engine wheels wearing more rapidly on the Am. Soc. C. E. section of rail, which has a radius on top corners of 5-16-in., I have no reason to change the advice that I gave the Chief Engineer in 1892 relative to this matter. In fact, if anything, I am more strongly confirmed in my opinion that it has no effect upon the wear of the tires than I was at that time, and I flatter myself that this opinion is based upon as close observation as has been given to the subject matter by anyone.

In the first place, if this sharp radius is destructive of wheels, why should it not make a corresponding radius at the root of the flange? So far as I am able to ascertain, it is not a fact that it does so, and wherever I have found engines with a tendency to wear the flange of the wheel I have looked to the engine itself for the cause, and have not ascribed any part of it to the form of the rail. On some mogul and consolidation engines, the forward driving tires will wear the flanges on both wheels, but I have always found that either the radius bar to the pony truck was too long, or the suspension links of the truck were not set at the proper angle. In other words, the truck itself did not have proper guiding action, and consequently the forward drivers had to do the guiding to a greater extent than they should; but in every case I have found that the root of the flange still maintained approximately its ⅝-in. radius. I can neither explain, nor fully understand, why this should be, but that it is a fact can be proved by looking at any engine that has flanges worn in this manner. In fact, in my opinion, wherever excessive flange wear is found there is some cause outside of the shape of the rail, as the flanges themselves have but very little to do with the guiding of an engine. This may be considered a wild assertion, but if you will take observations from any engine that has started out to track exactly right, and has continued to do so until there is a track line worn in the wheel to the depth of say ⅛-in., you will find that there is no mark on any of the flanges, not even on the truck wheels; that as far as the driving wheels are concerned the tool marks will be on the flanges after they have been run long enough to need re-turning. This matter of track wear influencing the engine has led me to the belief that under ordinary circumstances, of a reasonable curve and wheelbase, there is no necessity whatever for blind tires. If you will notice either a mogul, consolidation or ten-wheel engine, you will find that the impression of track wear on the blind tire is not wide enough ever to have reached the flange if there had been any on that tire. I certainly should not undertake to base an opinion, or complaint, on account of two engines of the same character and of supposably the same tire, showing an extraordinary wear on one section of the rail as against the other. Even on the same division and (so far as it is possible to know) under the same conditions, tires of the same make showing the same analysis and apparently the same metal so far as can be judged in turning them, will show an extraordinary difference in the wearing of the tire.

In regard to the Mobile and Montgomery Division. If I should undertake to make a comparison there, it would be an absolutely unjust one, as that division is now fully ballasted, and the wear of the tire is not nearly as excessive as it was previous to such ballasting, so that a report based on this division would be entirely in favor of the sharp-cornered rail. A tire on the Pensacola Division will not run half as many miles under the same engine as on the M. & M. Division on account of the sand. The same can be said as regards an engine in the hands of two different men; one may use a great deal more sand than the other and such a man almost always will do a great deal more slipping than another. In my opinion, the records as regards the turning of tires would not be reliable evidence, as we have been continually increasing our tonnage very extensively. When an engine used to start out with a train, the size of which was established by the heaviest grade, and consequently was not working anywhere near its capacity for a great percentage of the mileage, now, under the system of turn-arounds, and the reducing of such grades as establish the size of the train, the engines are almost all the time working to a far greater per cent. of their capacity from end to end of the line. So it resolves itself down to a great extent to an opinion, and that opinion is that the adoption of the Am. Soc. C. E. rail section has not injured us to such an extent that we have any reason for complaint, if it has injured us at all.

P. Leeds,
Superintendent of Motive Power,
Louisville & Nashville R. R.

Mr. Bronner, our Superintendent of Motive Power, has sent me a statement in regard to sharp-flanged wheels found in the last four months of 1888 and 1899 and has requested me to forward it to you, in regard to the inquiry as to wear of wheels. I feel averse to making extensive remarks as to the sufficiency of the evidence which perhaps appears, so far as it goes, to indicate that the Am. Soc. C. E. section, which has grown more popular in the last decade, is responsible for the indicated situation. No evidence is given in the table that any particular portion of the wear was accomplished on the road. It seems to be the best information, however, that we can present and as such it is submitted.*

Previous to Jan. 1, 1899, no rails of the Am. Soc. C. E. section were used on the Michigan Central R. R., but since that year no other section has been laid on the main line between Kensington and Buffalo.

A. Torrey,
Chief Engineer,
Michigan Central R. R.

Statement Showing Sharp Flange Wheels Changed Under Michigan Central R. R. and Foreign Freight Car Equipment in 1888 and 1899.

Month.	Total No. pairs changed.	Divided as follows.	Sharp flanges: No. of wheels.	Sharp flanges: Total No.	Sharp flanges: Per cent.
Sept., 1888..	895	M. C. 421	M. C. 103	220	25
		For. 474	For. 117		
Oct., 1888..	864	M. C. 376	M. C. 121	267	31
		For. 488	For. 146		
Nov., 1888..	589	M. C. 278	M. C. 69	146	25
		For. 311	For. 77		
Dec., 1888..	653	M. C. 315	M. C. 89	190	29
		For. 338	For. 101		
Sept., 1899..	1,105	M. C. 430	M. C. 187	415	38
		For. 675	For. 228		
Oct., 1899..	890	M. C. 423	M. C. 191	413	46
		For. 467	For. 222		
Nov., 1899..	924	M. C. 434	M. C. 176	365	39
		For. 490	For. 189		
Dec., 1899..	774	M. C. 334	M. C. 125	278	36
		For. 440	For. 153		

I have found no reason to change my opinion as to the cause of abnormal wheel wear, as expressed to the Rail Committee of the American Society of Civil Engineers in 1892. On the contrary, all my subsequent experience seems to confirm this, the sharp corners of the rail acting as a cutting tool or chisel on the tire, unless the rail ends are perfectly alined. This effect is most marked on sections of small corner radius. The difficulty usually disappears after a few years' use of the track, as notwithstanding the great wear first experienced, we now receive no complaints.*

I believe it is also a fact that abnormal wear of rails and flanges invariably results, as a temporary condition, from the replacement of steel, even with rails of the same section, and the difficulty is much increased when the section is changed. On the Northern Pacific Ry., the replacement of the old section of 56 lbs. per yd. by new sections of 66 and 72 lbs. per yd. was followed by an abnormal wear on the outer edge of the head or ball of the rail. This was due to the fact that all engine tires and car wheels had worn to fit the narrower head of the old 56-lb. rail, and when a rail of broader head was substituted, undue weight was concentrated on the outer margin of the new rails representing the additional width.

The difficulty on the South Australian Railways, as reported by Mr. Moncrieff, will doubtless disappear with time and may be greatly lessened by effecting a more perfect alinement of the rails at their ends, particularly of the outside rail on curves.

E. H. McHenry,
Chief Engineer,
Northern Pacific Ry.

This company has not laid any sharp-cornered rails, and I am unable, therefore, to give you any data as to the wear of the rail and of the car wheel where such rail is used, as compared with that where the round-cornered rail is used. I do not think that any definite conclusions can be reached through experimentation in the laying of sharp-cornered rails, except so far as the wear of the rail itself is concerned, as compared with the wear of a round-cornered rail, as the treads and flanges of car wheels in service present conditions ranging from new wheels to those worn out and ready for removal. The quality and suitability of the metal of which the wheel is made, the load which it carries, and the alinement of the track are such potent factors that I regard it as impossible to determine the relative effect of the shape of the corner of the rail upon the wheels, as differentiated from those other defects.

I believe that the final conclusion in this matter must come through careful observation, continuing over a long period, of wheels running over rails of the Am. Soc. C. E. section and of others running over rails with the corners more rounded; the wear of the wheels being taken as a whole, that is, the tread as well as the flange. As rails of the Am. Soc. C. E. section are being laid in large quantities it would be well to urge the roads that are laying such rails to observe carefully the wear of car and locomotive wheels.

The determination of the relative wear of rails of the two sections is a simple matter, rails of each section being rolled from the same heat and laid contiguous to one another.

Theo. N. Ely,
Chief of Motive Power,
Pennsylvania R. R.

It has been my observation that when our heavy 100-lb. rail was first laid, the tire wear increased considerably but after being in service for some time the wear again returned to normal and at present I do not think it is any more than with the other rail.

E. B. Gilbert,
Master Mechanic,
Pittsburg, Bessemer & Lake Erie R. R.

*This statement it will be seen refers to freight car wheels, and not to locomotive driving wheels, which formed the subject of the original inquiry.

*This theory has been discussed above.—Ed.

As our cars run over rails of all widths and sections of head, it is impossible to get any data on this suhject as yet. In fact, if the wheels do wear out more rapidly than a few years ago, the question as to the character of wheel and chill, and also as to the heavier load per wheel and speed of trains would he quite an important one.

W. S. Lincoln,
Chief Engineer,
Wahash R. R.

In reference to wear of wheels on sharp-cornered rail heads, etc., owing to the short time which has elapsed since new rails were laid, it is hardly sufficient to give us a comparison of the wear of wheels as hetween the old and new rails. 1 have, however, made up a tahle from five engines with the following results.

Engines.	Times turned. Old rail.	Times turned. New rail.	Miles to 1-16-in. wear. Old rail.	Miles to 1-16-in. wear. New rail.
118	6	2	12,820	12,855
174	8	3	10,098	14,423
177	6	3	12,457	8,946
411	7	1	12,353	13,518
414	6	2	11,911	12,389

Of course in making up a statement of this kind we must take into consideration the fact that engines were running on one district hefore new rail was laid and on other districts after the new rail was laid, also class of service and schedules were entirely different hetween the two periods. Brakes on driving wheels have also heen improved very materially during the last three years and that would have a great effect on the tire wear. It would seem from the above figures, if there were no conditions to be taken into consideration, that the new rails were contributory to an increased wear of wheels.

J. B. Barnes,
Supt. Motive Power & Machy.,
Wahash R. R.

LETTERS TO THE EDITOR.

The Record Rainfall of the American Continent.

Sir: In a communication from Mr. Arthur P. Davis, Hydrographer of the Isthmian Canal Commission, which appeared in Engineering News of March 15th, it is suggested that the precipitation of 12.48 ins., which occurred at Greytown, Nicaragua, on Nov. 4, 1899, is prohahly the "record" for the American continent. My attention was called some time ago to a storm which occurred in Jewell, Md., on July 26-27, 1897, and to the surprising statement made that 14.75 ins. of rain fell in 18 hours. I took occasion to inquire regarding this at the office of our Weather Bureau and was handed a special report on this storm printed in the Climate and Crop Service Bulletin of Maryland for December, 1897, published hy the U. S. Weather Bureau, containing such evidence as had been obtained hy the observer, J. Phummer, who had been sent to Jewell from the office of the Weather Bureau for the purpose of investigating the matter. From evidence obtained by him the report was considered substantiated. Without being willing to vouch for the correctness of the reported precipitation I have thought fit to call attention to it from the fact that one of such magnitude is made a matter of record hy the Weather Bureau.

Yours truly,
Kenneth Allen, M. Am. Soc. C. E.
Baltimore, Md., March 16, 1900.

The Design of Columns for Sheds Exposed to Wind.

Sir: In my letter on "The Design of Columns for Sheds Exposed to Wind and of Concrete Bases for Columns," as printed in your issue of Feh. 1, 1900, there are two errata. The moments of inertia of the principal and stanchion are I and I_1, respectively. For these symhols d and d_1 have been substituted at one place and y and y_1 at another. The expression for the least work should he

$$L = \int_A^B \frac{N^2 \, ds}{2 E I} + \int_A^B \frac{M^2 \, ds}{2 E I}, \qquad (8)$$

and the expression for horizontal thrust should he

$$X = \frac{1}{h} \cdot \frac{\frac{3}{4} p h^2 \left\{1 + \frac{11}{18} \frac{I}{I_1} \frac{h}{l}\right\} - \frac{p_1 l^2}{12}}{1 + \frac{2}{3} \frac{h}{l} \frac{I}{I_1}}. \qquad (13)$$

Leopold Mensch.
11 Clifton St., Finshury Square, London, E. C.

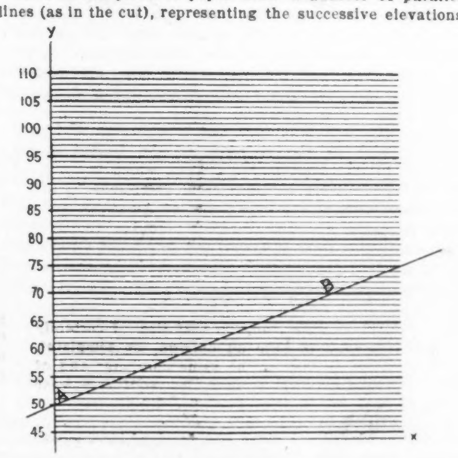
Sir: Your issue of Feh. 1 contains a communication from Mr. Leopold Mensch on the design of columns for sheds exposed to wind. He says "a structure of this kind will always deflect as shown at a (Fig. 1)." There is evidently an error in the sketch referred to marked "a." In my opinion the columns would hend so that the concave side would he toward the wind, and not the convex side, as shown in the sketch. An examination of Mr. Mensch's formulas (4) and (6), for the hending moment in the columns, indicates the same thing—that is, that the curvature of the columns would he in the opposite direction.

Yours truly,
Lightner Henderson.
New York, Feh. 1, 1900.

A Simple Aid in Plotting Contour Lines.

Sir: This method is simply a mechanical means of interpolation as an aid in plotting contour lines. It is assumed that a sufficient number of points have heen located, and their elevations noted on the map, and that contours of given elevations are desired. The following, then, is the method of procedure:

On a hlank piece of paper draw a number of parallel lines (as in the cut), representing the successive elevations



of horizontal planes cutting the surface of the ground. Distances along the X axis parallel to these lines will represent the horizontal distances hetween points on the map.

Suppose the elevation of a point A is 50 ft., and that of a point B is 70 ft., and that the position of a point hetween them on the 60-ft. contour line is desired. With the dividers lay off along the line of elevation 70 a distance equal to the distance hetween the 50-ft. and 70-ft. points on the map. Now, if this point is joined to a point on the Y axis at the elevation of 50 ft., then the distance along any line of elevation to this diagonal line will he the distance from the point A on the map to the contour of that particular elevation.

Practically a straight edge is suhstituted for the line hetween the points, and then the desired distances are taken off with the dividers. The distances can then he quickly transferred to the map in a simple mechanical manner and so make the work less trying and tedious.

University of Nehraska, March 1, 1900. C. E. Bedell.

Railroading as Practised in Colorado.

Sir: Early this morning a wreck occurred on the Rio Grande Western R. R., which was peculiar and interesting—at least to the writer.

The through Pullman car on the train arriving here at 1.15 a. m., was condemned on account of a flat wheel. The passengers were awakened and requested to dress and take the day coach forward, and the Pullman was hilled for the repair shop. While passengers and porter were carrying haggage to the forward car, by oversight or mismanagement the train pulled out, leaving two through passengers hehind, one of them the writer. The only thing to do appeared to he to tumble in and finish the night's rest while waiting for the next train. After sleeping some time the car was humped into and moved off slowly. The writer supposed it was heing switched to a siding, while in reality it had heen started on the down grade west of Grand Junction, and ran free and unnoticed for six or seven miles until it stopped on a stretch of track either level or slightly up-grade. Between 4 and 5 a. m. a west-bound freight train smashed into it, the engineer running almost onto the car hefore he saw it, as no lights were out. The engineer and front brakeman put on the brakes and jumped. The locomotive was a consolidation, pulling a train of about 16 cars, and running at a fairly high speed. As the engine struck the car it smashed the platform, broke the truck pin, and raised that end of the car body clear of the truck. The car was pushed forward hefore it came to a stop about 300 ft. from the point where it was struck, judging from the position of the brake and portions of the wrecked platform after the collision. The forward end of the sleeper was set on fire hy the headlight of the locomotive, but the fire was soon extinguished.

The car truck next the locomotive was knocked forward about 3 ft., but the front pair of wheels was not derailed, and the truck at the opposite end of the car remained on the track. The engine pilot was a complete wreck, and the smoke-hox was smashed in. The platform of the car was knocked all to pieces, but it was otherwise uninjured.

The porter of the sleeper was injured severely, hut the other occupants were uninjured.

The shock of collision seemed slight owing, no douht, to the raising of the car hy the pilot, and the small resistance to motion, since there was little weight on the partially derailed truck. Yours truly, C. Eng.

Grand Junction, Colo., March 18, 1900.

A Table for Determining the Buckling Resistance of Web Plates in Plate Girders.

Sir: I send you herewith a hlueprint of a table computed hy me for use in the design and detail of plate girders. This table gives the values in the formula

$$\frac{15{,}000}{1 + \dfrac{d^2}{3{,}000\, t^2}}$$

for resistance of weh plates to huckling stress for an assumed numerator of 15,000 lhs. per sq. in.; which is the value of the numerator in ordinary use for highway hridges and huildings. The range of the tahle up to and including 1-in. thickness of metal meets, I think, the ordinary run of requirements. As a rule the huckling formula is only used to test weh plates, which are often as thick as 1 in. Wheu that is done few of us go to the trouhle to figure out the exact strength of the stiffeners

TABLE SHOWING SAFE RESISTANCE OF WEB PLATES TO BUCKLING FOR AN ASSUMED NUMERATOR OF 15,000 LBS. PER SQ. IN.

Depth of web plate in ins.	Thickness of web plates. ¼-in.	5/16-in.	⅜-in.	7/16-in.	½-in.	⅝-in.	¾-in.	⅞-in.	1-in.
12	8,484	10,057	11,183	11,994	12,584	13,357	13,821	14,114	14,313
14	7,334	8,987	10,242	11,183	11,893	12,852	13,440	13,821	14,082
16	6,342	8,005	9,335	10,375	11,183	12,312	13,025	13,496	13,821
18	5,499	7,122	8,484	9,589	10,475	11,752	12,584	13,146	13,538
20	4,788	6,342	7,700	8,842	9,783	11,183	12,126	12,775	13,235
22	4,189	5,656	6,986	8,139	9,117	10,616	11,657	12,390	12,917
24	3,684	5,058	6,342	7,489	8,484	10,057	11,183	11,994	12,584
26	3,257	4,536	5,764	6,890	7,889	9,512	10,709	11,590	12,242
28	2,895	4,081	5,248	6,342	7,334	8,987	10,242	11,183	11,893
30	2,586	3,684	4,788	5,843	6,818	8,484	9,783	10,777	11,538
32	2,322	3,337	4,377	5,390	6,342	8,005	9,335	10,375	11,183
34	2,094	3,033	4,011	4,979	5,903	7,552	8,902	9,978	10,828
36	1,896	2,766	3,684	4,606	5,499	7,122	8,484	9,589	10,475
38	1,724	2,530	3,392	4,268	5,128	6,720	8,083	9,210	10,126
40	1,574	2,322	3,130	3,962	4,788	6,342	7,700	8,842	9,783
42	1,441	2,137	2,895	3,684	4,475	5,988	7,334	8,484	9,446
44	1,325	1,972	2,684	3,432	4,189	5,656	6,986	8,139	9,117
46	1,221	1,824	2,494	3,202	3,925	5,347	6,655	7,808	8,796
48	1,129	1,692	2,322	2,993	3,684	5,058	6,342	7,489	8,484
50	1,046	1,574	2,166	2,802	3,462	4,788	6,045	7,182	8,182
52	973	1,466	2,024	2,628	3,257	4,536	5,764	6,890	7,889
54	906	1,369	1,896	2,468	3,069	4,301	5,499	6,609	7,607
56	846	1,282	1,778	2,322	2,895	4,081	5,248	6,342	7,334
58	792	1,202	1,672	2,187	2,735	3,875	5,011	6,087	7,071
60	743	1,129	1,574	2,064	2,586	3,684	4,788	5,843	6,818
62	698	1,062	1,483	1,950	2,449	3,505	4,576	5,611	6,575
64	657	1,001	1,401	1,844	2,322	3,337	4,377	5,390	6,342
66	619	945	1,325	1,747	2,203	3,180	4,189	5,179	6,118
68	585	894	1,254	1,657	2,094	3,033	4,011	4,979	5,903
70	553	846	1,189	1,574	1,991	2,895	3,843	4,788	5,696
72	524	802	1,129	1,496	1,896	2,766	3,684	4,606	5,499
74	497	762	1,073	1,424	1,807	2,644	3,534	4,433	5,309
76	472	724	1,021	1,356	1,724	2,530	3,392	4,268	5,128
78	448	689	973	1,294	1,646	2,423	3,257	4,111	4,954
80	427	657	928	1,235	1,574	2,322	3,130	3,962	4,788
82	407	626	886	1,180	1,505	2,227	3,010	3,820	4,628
84	388	598	846	1,129	1,441	2,137	2,895	3,684	4,475
86	371	572	809	1,080	1,381	2,052	2,787	3,555	4,329
88	355	547	775	1,035	1,325	1,972	2,684	3,432	4,189
90	339	524	743	993	1,271	1,896	2,586	3,314	4,055
92	325	502	712	953	1,221	1,824	2,494	3,202	3,925
94	312	481	684	915	1,174	1,757	2,406	3,095	3,802
96	299	462	657	880	1,129	1,692	2,322	2,993	3,684
98	287	444	631	846	1,087	1,631	2,242	2,895	3,571
100	276	427	607	814	1,046	1,574	2,166	2,802	3,462
102	266	411	585	785	1,009	1,519	2,094	2,713	3,357
104	256	396	563	756	973	1,466	2,024	2,628	3,257
106	246	381	543	729	939	1,417	1,958	2,546	3,161
108	237	368	524	704	906	1,369	1,896	2,468	3,069
110	229	355	505	680	876	1,325	1,836	2,393	2,980
112	221	342	488	657	846	1,282	1,778	2,322	2,895
114	213	331	472	635	818	1,241	1,724	2,253	2,813
116	206	320	456	614	792	1,202	1,672	2,187	2,735
118	199	309	441	594	767	1,165	1,620	2,124	2,659
120	193	299	427	575	743	1,129	1,574	2,064	2,586

we thus find it necessary to use, but put them in by experience-taught rules rather than by the nice requirements of theoretical consideration. Personally, I figure these things out in most cases, because oftentimes in close competition for sales a slight difference in weight may influence the placing of contracts. In most cases, however, it is not so done. I believe that the publication of the table will prove of value to engineers. It has been very carefully checked and is believed to be accurate.

Very truly yours, R. B. Woodworth.

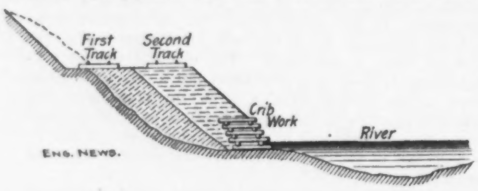
Bureau of Engineering, Carnegie Steel Co., Pittsburg, Pa., Feb. 6, 1900.

Making Railway Embankments by Filling Trestles.

Sir: Referring to the query of J. W. S. in the March 15, 1900, issue of the Engineering News, regarding the filling up of trestles, and leaving the timber in the same, I fully agree with you, that no anxiety should be experienced on this account. I know there are thousands of trestles on the railroads of this country which have been filled in in the manner described, and I have never heard of any bad results from this practice.

The most objectionable feature in filling trestles is when improper materials are used for this purpose, such as slack or refuse coal. There is always imminent danger from fire in these cases, unless the outer slopes are covered with a heavy layer of earth.

I recall an instance where an embankment was built of rock and coal mixed, the coal having been encountered in the construction of a tunnel. This embankment sub-



sequently caught fire and continued to smoulder for at least a year, I think, before it was extinguished. M. Am. Soc. C. E. in writing on this subject in your issue of March 22, 1900, speaks of the gradual decay of timber crib work in the bottom of a deep fill.

I recall the accident, caused by the failure of the crib work, but I think he is in error regarding the construction details. The railroad in question followed a river, and in building a double track, the embankment encroached on the river bed. To prevent this a retaining wall was built of old cross-ties and timber. The consequent rotting of this wall caused the embankment to give way just at the time of a passing train, causing a horrible accident. The accompanying cross-section shows the manner in which the second track embankment was partially retained.

Of course, this was very bad construction, but I regret to say that this very kind is being used even at the present day by many of our railways for economic reasons, with no thought of the direful results in case of subsequent failure.

In this connection, it may be of interest to many of your readers to know that the Pittsburg, McKeesport & Youghiogheny R. R. lately filled in the long iron viaduct at the north end of the Homestead bridge, across the Monongahela River, above Pittsburg, Pa., leaving in all the iron work except the girders. This viaduct was built in 1882, and was quite an expensive structure.

Buffalo, N. Y., March 26, 1900. Trestle.

The Ratio of Operating Expenses to Gross Earnings on English and American Railways.

Sir: Your article of March 8, 1900, on "Railway Maintenance-of-Way Expenses," contrasts the experience of 22 designated American railroads with that of 5 of the principal lines in Great Britain. It closes with this statement:

> As to the percentage of operating expenses to gross earnings there is not such a marked difference as is usually supposed. In fact, we believe that English railway men would be somewhat surprised to find that the percentage on American railways averages but little higher than that on English railways, instead of representing a great proportion of the earnings.

You overlook the fact that the percentages of operating expenses to the so-called gross earnings are, with respect to the American railroads, given without including taxes, while, with respect to the British railroads, taxes are included in the expenses. In this you do injustice to some, if not all, of the American companies named by you, and particularly to the Illinois Central. Its annual report for the year ending June 30, 1899, clearly states, at page 11, both that its "expenses of operation exclusive of taxes" consumed 64.746% of its receipts, and that its "expenses of operation and taxes" consumed 69.58% thereof. The reports of the other American companies must also have shown the payment of taxes.

That you should have fallen into this error is but natural, in view of the uniform practice of the Interstate Commerce Commission of exaggerating the profits of the railroads in the United States by, among other things, stating their individual, as well as their collective, "net earnings," or "net income," without either including taxes in operating expenses, or deducting them from what is left after paying such expenses.

The British Board of Trade and the British railways pursue a more straightforward course. Neither attempts to deceive itself by miscalling the money taken for transportation "earnings." They invariably denominate it "receipts." And both include in "working expenses," which corresponds to our term "operating expenses," all payments for taxes.

From the Railway Returns of the British Board of Trade for the year ending Dec. 31, 1898, now before me, it appears that the receipts of the British railways were (£1 being taken as equal to $5), $455,330,190; that their working expenses were 58.50% of the sum, or $266,377,330, and that, in those working expenses, there was included payments for taxes amounting to $18,659,165. The taxes thus included in working expenses amounted to 4.10% of the receipts.

The Interstate Commerce Commission's latest report on Statistics of Railways is that for the year ending June 30, 1898. I quote literally from the "Comparative Condensed Income Account," on page 72:

Gross earnings from operation............	$1,247,325,621
Less operating expenses	817,973,276
Income from operation	$429,352,345

On page 93 of the same report, the "percentage of operating expenses to operating income," is given as 65.58%.

As this happens to be the ratio of the operating expenses ($817,973,276) to the so-called gross earnings from operation ($1,247,325,621), we will be charitable and assume that this is what the Commission meant to say. It is, however, obvious from the context that taxes are neither included in the operating expenses, nor deducted before stating income from operation.

Anyone who will take sufficient trouble can find that the taxes paid by the railroads of the United States amounted, in that year, to $43,828,224, which is 3.51% of their so-called "gross earnings from operations."

To fairly contrast the experience of American and of British railroads, we must therefore take due note of this very considerable item of taxes, and this must always be kept in mind in dealing with reports made by the Interstate Commerce Commission, and those made by our railroads in the form required by that body.

As a matter of fact, it really costs, including taxes, 69.09% to operate railroads in the United States as against 58.50% in Great Britain. Our railroads only earn, even without allowing for fixed charges (viz. interest and rent), 30.91% of that which they receive from transportation, while the British railways earn 41.50%.

In other words, of any given sum received by the British railways, taken as a whole, there is left, after paying therefrom all expenses of operation, including taxes, somewhat over one-third more, as actually earned and applicable to fixed charges and dividends, than there is when a like sum is received by the American railroads, taken as a whole. Truly yours,

Stuyvesant Fish.

Illinois Central R. R. Co., 214 Broadway, N. Y., March 17, 1900.

(We acknowledge the justice of our correspondent's criticism as respects the relation between receipts and expenditures on American and on British railways. We find on examination, however, that in the table above referred to some of the figures for American railways did include the taxes in the operating expenses, although in most cases, as Mr. Fish suggests, the taxes were not included. To make a fair comparison we have compiled the following table:

Ratio of Operating Expenses to Gross Receipts.

American Railways.	Taxes in operating expenses — Included. Per ct.	Not incided. Per ct.
Chicago, Milwaukee & St. Paul..	62.55	59.20
Chicago, Burlington & Quincy....	64.84	61.18
Chicago & Northwestern	65.31	62.23
Chicago, Rock Island & Pacific..	66.17	61.75
Lake Shore & Michigan Southern.	67.11	.....
Illinois Central	69.58	64.74
Boston & Albany	71.60	63.50
Atchison, Topeka & Santa Fe....	71.61	68.14
English Railways.		
Lancas. & Yorkshire............	56.73	54.00
London & Northwestern	58.40	55.28
Midland	58.90	54.90
Great Eastern	59.79	55.10
Great Western	62.21	57.89

As to the question whether it is better practice to include taxes in operating expenses, as in England, or to place them under the same head as fixed charges, which is the American practice, everything depends upon the point of view. From the standpoint of the holders of railway securities, money paid for taxes has to be paid out of the gross income of the road just as much as the wages of trainmen, the repairs of locomotives or any other expenditure for operation and maintenance, and should, therefore, be classed with such expenditures.

On the other hand, one of the most important things for railway owners and managers to know is the degree of enterprise, good judgment and economy with which their property is being administered, as indicated, first, by the total receipts, and second, by the total expenditures incurred in carrying on the company's business of manufacturing and selling transportation. Both these qualities will vary with the general conditions of business, the volume of traffic handled and the character of the management. This is not true of taxes. No vigilance or economy of operating officials can affect these. They are a fairly constant charge upon the property, and to a certain extent represent a rental paid to the state by the company for the franchise which it exercises. If by the term "net earnings" is meant the sum available for returns to the owners of the railway, then taxes should be deducted in computing them. If on the other hand "net earnings" means the amount received from the sale of transportation over and above the cost of its manufacture, then the deduction should not be made.—Ed.)

Is the Trouble at the Austin Dam an Argument Against Municipal Ownership?

Sir: In an editorial in your issue of Feb. 22, after referring to the silting-up and leakage of the dam at Austin, Tex., and the use of this fact as an argument against municipal ownership, you say: "If there are any reasons why the very same engineers who built the Austin dam might not have been employed in the same capacity if it had been built by private capital, instead of the city, we should like to hear them. Or is nature itself against municipal ownership?"

As I have not noticed any further references to this in your columns I venture to take it upon myself to point out two reasons why the results at Austin show the disadvantage of municipal ownership: (1) Although it is true that private owners might have employed the same engineers as were employed by the city, and although I have no reason to doubt that the particular engineers employed in this case worked ably and honestly, I think it is generally the case that better and abler engineers will be employed by private owners who are going to pay the bills and be responsible for the losses, than will be employed by municipal councils and committees when the taxpayers pay the bills, while the majority of the constituents of the municipal committees or councils pay at most a poll tax. (2) Even when the municipal councils or committees employ the very ablest engineers there is always the possibility of accidents or mistakes causing heavy losses, such as have occurred at Austin. In the case of municipal ownership these losses must be paid by the municipality. In the case of private ownership the municipality is free of expense.

The higher rate of interest allowed on bonds and stocks of private companies is, in the opinion of private parties who invest in the same, no more than enough to allow for the risk that they must pay for mistakes or accidents, while if they buy municipal bonds the taxpayers must pay for such mistakes.

While it is undoubtedly true that a municipal plant which is honestly and ably managed, which suffers no accidents and makes no mistakes, is cheaper than the average of private ownership, yet in order to make a fair comparison between private ownership and municipal ownership it is only fair to compare the average cost under private ownership with the average cost of all municipal plants, including with the well-managed ones, the municipal plants that have been failures, such as that at Austin. It is not possible to state the average cost of all municipal plants including the failures, but considering the record of the many attempts at municipal ownership in the United States, it is by no means impossible that the true average cost of municipal ownership to the taxpayers is far greater than the true average cost of private ownership.

Since dictating the above your issue of March 15 containing Mr. Gerhard's letter is at hand. His whole letter is an excellent endorsement of my argument, that while municipalities can employ the best talent, yet that council whose constituents are to a large extent non-taxpayers, will not necessarily employ as good engineering talent as private owners who have to pay the bills in case of mistakes. Very truly yours, R. S. Hale.

31 Milk St., Boston, Mass., March 15, 1900.

(While we agree with some of the broad general claims advanced by our correspondent, we do not think that a private company would have employed better engineers than did the city of Austin; nor that consumers of water or light escape the burdens due to mistakes or accidents on the part of private companies, since consumers and taxpayers must foot the bills in the long run, under either private or public ownership; nor do we believe all that can be said against municipal ownership begins to offset its many and obvious advantages, some of which cannot be measured by mere dollars and cents.

As a class, the engineers employed by municipalities rank better in fitness for their work and the conscientious manner in which they do it, than is the case with most of the other municipal officials. No sane man disputes the proposition that a more rational method is generally employed in selecting the officers of private corporations than in choosing mayors and councilmen. But it should be remembered that both public and private undertakings are officered by men; that all men are more or less fallible; while the mere fact that a man is employed by a private company, instead of a municipality, is no insurance against the most fatal lapses in honesty, judgment and good business ability generally—else why should Bradstreet and Dun report so many private failures every week?

As to the last paragraph of Mr. Hale's letter we cannot do better than reprint the full report of Mr. Roger W. Babson upon the municipal plant at Austin, including the much maligned dam. Mr. Babson was sent to Austin by the holders of the Austin bonds. These bonds were issued by the city at the time of the construction of the works, and interest on them was defaulted on Jan. 1. The default appears to have been due to the work of a faction in the council which is trying to scale down the rate of interest on the bonds by withholding an interest payment.

Mr. Babson's report was published in the Austin "Evening News" for Feb. 21, referred to in the letter from Mr. Gerhard, in our issue of Feb. 22. The report is as follows, the postscript being included to show that Mr. Babson did not lack data:

Boston, Mass., Jan. 30, 1900.

Messrs. C. S. Cummings & Co., Boston, Mass.

Dear Sirs: At your request I visited Austin, Tex., and made as complete an examination of its water and light system as the time permitted.

Physical Condition.

The dam proper, or that portion of the masonry over which the water flows, is in perfect condition, and is most substantial and complete.

The headgate masonry has two slight defects. The penstocks should be lowered and there is a slight leak through the base. Some day these should be remedied, but they are not dangerous at present.

The power house and machinery are not modern, and should be rearranged to obtain the best economy. An auxiliary steam plant should some day be added. The machinery, however, is continually being improved, and is, as a whole, quite satisfactory.

The system of distribution is very complete and both the wiring and piping is beyond criticism. Moreover, this part of the work was constructed for much less than would be possible to-day.

Operation.

The gross receipts each year, if all bills had been collected, would amount to about $100,000. They, however, would be fully double this were it not for the ruinous competition between the city's plant and the old water company.

The legitimate operating expenses are very close to $35,000, and are subject to no criticism. There have been, however, extensive improvements costing each year about $40,000 which rightly should have been charged to capital. Instead, said improvements and extensions have been charged to operation, which reduced the net income to less than $25,000.

As the interest charges and sinking fund require about $105,000 yearly, this leaves a deficit of about $80,000, which greatly worries the newspapers of Austin.

Political Aspect.

The very best people of Austin, under the leadership of Mayor McCall, are violently opposed to the action of the city council and greatly in favor of paying the bonds, interest and principal.

There is, however, a strong opposition which is thoroughly organized and which, backed by wealth, is determined to put up a very aggressive fight to compel a reduction of interest to 4%.

This opposition is actuated by three distinct motives, and is thus divided into the following classes:

Heavy taxpayers striving for a reduction of taxes.

Disgruntled customers trying to embarrass the water and light commissioners, a most excellent body of men.

Friends of the old water company, who are endeavoring to force the city to lease the old water plant or sell to said old company the city's system, including the dam.

Conclusion.

All parties, however, including the leaders of the opposition, fully realize that the $1,400,000 5% bonds are valid, and that if the holders assert their rights, the council must assess $11.15 per thousand valuation, for their payment, principal and interest. They also realize that if the valuation is reduced, that the courts can order a still greater assessment. Although the bondholders have a perfectly clear case and will surely win in every court, nevertheless I suggest that before entering any suit that you consider certain other remedies which will be very effective. Respectfully submitted.

Roger W. Babson, C. E.

P. S.—I have full plans, elevations and specifications of the property, as well as itemized earnings and other data, and am prepared to give a minute description if necessary.

This report suggests a number of questions more or less closely related to the quotation from our issue of Feb. 22, given at the beginning of Mr. Hale's letter. We print the report partly as a matter of fairness to both sides of the controversy, since it contains arguments for both sides. Undoubtedly the city of Austin took a big contract in hand when it built so expensive a dam, and at the same time water and light plants to compete with those of the existing company. The mayor, however, in a message containing a strong plea against any semblance of repudiation, expresses himself as satisfied with the results obtained from this huge enterprise. It will be noted that Mr. Babson approves of the character of most of the construction, speaks highly of the water and light commission, and characterizes the movement for repudiation as largely the work of friends of the old company and small politicians.

Finally, to return to the direct question of municipal vs. private ownership of the so-called "public utilities" in city streets, our correspondent can find instructive object lessons nearer home. A comparison of the Boston water supply system with that remarkable institution known as Bay State Gas may be worth while. In New York an object lesson of how a private corporation may be mismanaged is furnished by the Third Avenue R. R. Co. We do not recall any municipal financiering anywhere which has resulted more disastrously.—Ed.)

THE OPERATION OF THE SEWAGE FILTER BEDS AT BROCKTON, MASS., IN 1899.

We have often commented on the care and skill shown in the construction and operation of the sewage filter beds at Brockton, Mass.* The annual report of Mr. Chas. R. Felton, City Engineer of Brockton, for the year 1899, contains a summary of the operations of the beds for that year by Mr. Geo. E. Bolling, Chemist-in-Charge. The results obtained by each bed have been determined by means of systematic analysis, and the information thus obtained has been of great value in regulating the dosing, raking and overturning of the material. Although the winter of 1898-9 included the longest cold spell since the plant was put in operation the beds continued to do good work. This was probably largely due to the system of ridging the surface of the beds before cold weather set in, the ice, which was several inches thick, being supported on the ridges and leaving channels for the sewage between them.

*For descriptior and notes, see Eng. News, Oct. 5, 1893, May 2 and 23, 1895, Feb, 27, 1896, May 20, 1897, and Feb. 2, 1899.

The daily average amount of sewage pumped (see foot note, Table I.) during the year ending Nov. 30, 1899, was 641,069 gallons, the pumps working, while in service, at an average rate of 3,845 gallons a minute, or 5,536,800 gallons in 24 hours. This rate was made possible by the storage afforded by the reservoir and force main. The number of sewer connections in service on Nov. 30, 1899, was 749, a gain of 106 during the year. Only a portion of the city is provided with sewers thus far.

The relations between rainfall, sewage flow and temperature, and between seasonal and day and night flows of sewage may be studied in Table I., but it will not be easy to account for some of the variations in flow by either the rainfall or temperature figures:

The purification of the sewage during 1899, expressed in percentages of ammonia and oxygen consumed removed, is shown by Table II. The 12-in. main underdrain serves the north and the 15-in. the south part of the disposal area, while the spring is supposed to represent that part of the effluent which does not reach the drains and has more purification on that account. The effluent from the 15-in. underdrain "is often collected within an hour from the time when sewage is applied to the surface of the sand," the report states, which may be taken to mean a less stay in the beds than is the case with the effluent from the underdrain. Analysis of the water of the Coweeset River, taken above and below the point where the effluent reaches the stream, and extending over four years, show "that in various respects the quality of the water flowing in the river is improved after the effluent mixes with it."

TABLE II.—Showing Per Cent. of Free Ammonia, Albuminoid Ammonia, and Oxygen Consumed, Removed from Sewage, at Brockton, Mass. (Calculated) as Represented by 12-in. and 15-in. Drains and Spring.

Month, 1899.	12-in. drain. Ammonia Free.	Albuminoid.	Oxygen consmd.	15-in. drain. Ammonia Free.	Albuminoid.	Oxygen consmd.	Spring. Ammonia Free.	Albuminoid.	Oxygen consmd.
Jan.	95.6	93.7	97.1	92.7	96.1	98.0	99.8	98.2	98.8
Feb.	94.0	95.8	97.1	90.1	96.6	97.4	99.9	98.6	98.9
Mar.	88.0	95.3	97.3	84.6	96.2	97.6	99.9	98.3	98.5
April	95.0	97.6	98.2	94.7	98.0	98.9	99.9	98.9	99.0
May	98.0	98.6	98.7	96.5	98.8	98.9	99.5	98.7	99.1
June	99.4	98.7	98.5	97.9	98.9	98.8	99.6	99.0	99.1
July	99.5	98.8	98.0	98.2	99.0	98.5	99.7	99.1	99.0
Aug.	99.7	99.2	99.0	99.4	99.3	99.1	99.7	99.5	99.2
Sept.	99.3	98.9	98.3	99.5	99.0	98.9	99.8	99.1	99.1
Oct.	99.6	99.0	98.4	99.7	99.1	98.8	99.9	99.2	99.0
Nov.	99.7	98.7	98.4	99.6	99.1	98.9	99.9	99.1	99.1
Dec.	99.7	99.0	98.9	98.4	99.1	98.6	99.9	99.4	99.4
Average	97.3	97.8	98.2	95.9	98.3	98.5	99.8	98.9	99.0

The report contains a table showing the cost of labor on the surface of each of the 23 beds by months, and another showing the monthly cost of all labor at the disposal area distributed between the following items: Care of surface of beds, tending gates, watchman, effluent, samples, snow, cleaning brook, banks and roads, swamp, lawn, miscellaneous. The value of the tables would have been greatly increased by adding the amount of sewage applied to each bed, and the total amount treated, each by months.

The area of the beds in use was about 23 acres, there being 23 beds with an average area of about one acre each. On this basis, and with an average of 641,000 gallons treated daily, the work done by the area averaged 27,850 gallons of sewage an acre 365 days in the year. The total amount of sewage, including sludge from the bottom of the reservoir, treated during the year was about 234,000,000 gallons. As the total cost of labor at the beds is given in Table III. at

TABLE I.—Monthly Rainfall, Sewage Flow as Shown by Recording Instrument at Reservoir, and Temperatures of Air, Sewage and Effluent, at Brockton, Mass.

Month.	Monthly rainfall, ins.	Average flow per 24 hrs.*	Flow per hr. Day, 7 a.m. to 9 p.m.	Night, 9 p.m. to 7 a.m.	Difference bet. day and night.	Temperature, °F. Air.	At reservoir.	At beds.	Effluent.
January, 1899	4.86	1,020,990	43,270	41,520	1,750	26.0	47.0	45.7	44.8
February, 1899	3.26	762,210	32,410	30,840	1,570	25.5	45.6	43.8	40.3
March, 1899	5.59	1,451,700	61,770	58,700	3,070	35.5	45.0	43.5	39.2
April, 1899	1.14	809,880	34,095	33,255	840	49.0	46.6	46.1	40.3
May, 1899	1.72	490,700	22,640	17,390	5,250	58.0	51.4	51.1	45.0
June, 1899	2.88	341,410	16,255	11,385	4,870	68.5	55.9	56.6	49.2
July, 1899	4.52	407,070	18,590	14,680	3,910	73.5	59.7	60.8	53.5
August, 1899	1.40	365,940	17,150	12,580	4,570	69.5	61.2	62.4	58.5
September, 1899	9.56	527,170	24,110	18,965	5,145	62.0	62.3	61.2	59.9
October, 1899	2.17	677,850	29,380	26,650	2,730	54.0	60.0	57.3	58.5
November, 1899	2.06	517,400	23,070	19,610	3,460	41.0	56.2	52.1	55.3
December, 1899	1.15	402,710	18,940	13,760	5,180	34.0	52.8	46.9	51.0

*These figures are not necessarily identical with the amount of sewage pumped to the disposal area, for (see Mass. State Board of Health, 1898) large quantities have been discharged into the river in previous years, without treatment, and may have been in 1899.—Ed.

TABLE III.—Distribution of Cost of Labor at Sewage Disposal Area, at Brockton, Mass.

Month.	Surface of beds.	Tending gates.	Watchman.	Effluent.	Samples.	Snow.	Cleaning brook.	Banks (r'ds).	Swamp.	Lawn.	Miscellaneous.	Total.
January	$20.89	$22.55	$6.67	$3.11	$5.44	$2.67	.....	.....	$48.89	.....	$12.11	$122.33
February	6.67	21.33	5.33	2.67	5.33	15.00	.....	$0.44	13.67	.....	33.56	104.00
March	105.11	25.67	5.33	5.22	4.00	.....	.....	3.56	19.45	$3.33	4.88	176.55
April	189.31	23.78	6.67	.67	7.78	.....	.....	4.66	.....	1.44	2.33	236.64
May	204.93	19.78	6.67	....	3.89	.....	.....	4.89	.....	....	5.44	245.60
June	184.85	15.56	5.33	....	2.44	.....	.....	10.33	.....	....	1.10	219.61
July	204.07	14.89	6.67	....	2.00	.....	.....	.....	.....	....	1.78	229.41
August	260.11	15.11	5.33	....	2.11	.....	$11.78	2.89	25.11	....	8.88	331.32
September	155.54	16.22	5.33	.67	1.89	.....	.....	29.00	22.33	....	3.00	233.89
October	199.15	21.33	6.67	1.44	2.78	.....	.....	.....	.....	....	.44	231.81
November	169.32	19.11	5.33	.45	2.78	.....	.....	6.66	.....	....	2.00	205.65
December	80.91	18.52	7.67	1.37	1.82	.....	.....	1.62	26.88	....	18.37	157.16
Total	$1,780.86	$233.85	$73.00	$15.60	$42.26	$17.67	$11.78	$64.05	$156.33	$4.77	$93.89	$2,494.06

$2,494, the cost per 1,000,000 gallons for labor alone was about $10.50.

The first column of Table III., labor on surface of beds, includes the separate items, sludge, weeds, crops and general. Table IV. gives these items for 1899 as compared with the two preceding years. It will be noticed that sludge and weeds are heavy and increasing items. The sludge, it may be added, is the heavier matter from the bottom of the storage reservoir. During 1899 there were 362 doses of this sludge, averaging 55,700 gallons each, applied to the beds. On an average these beds were raked after receiving 18 doses. The total deposit raked from the sludge beds during the year weighed 1,108.4 tons, or about an average of three tons per day, against 641,000 gallons per day of sewage.

TABLE IV.—Detailed Cost of Labor on Surface of Sewage Filter Beds at Brockton, Mass., 1897-9.

	1897.	1898.	1899.
Sludge	$262	$410	$560
Weeds	380	294	513
Crops	276	198	238
General	383	497	470
Total	$1,301	$1,399	$1,781

The average percentage composition of these rakings was as follows:

	Summer.	Spring and fall.
Moisture	4.10	45.04
Sand and mineral matter	85.20	39.22
Organic matter	10.70	15.74
Total	100.00	100.00

During 1899 all the rakings from beds were removed by farmers and used as fertilizers, instead of being burned in the open air as formerly. The fertilizing constituents of the sludge are nitrogen, phosphoric acid and potash. The drawback to the use of the rakings as a fertilizer is the large amount of worthless mineral matter they contain, averaging 85.2%. We venture the suggestion that some of the sludge heaviest in sand might be used for filling in the low land near the beds, in which event the balance might prove so attractive to farmers that they would continue to haul it away for some years to come. Unless some such plan is adopted the experience of other localities indicates that the "sludge problem" will soon be paramount again.

On the subject of crops raised on the beds we quote all the report contains, as follows:

The beds have been cropped as usual, four beds being planted with yellow and four with sweet corn, the latter planted to ripen at different times, with good results. The gross income from this source has exceeded any previous years by $11.66. The nominal profit on the produce was $51.46, but the actual gain to the department, if we consider the saving effected in the sludge removal, was $161.46. As regards the dosing of the cropped beds, the principle adhered to throughout the season was that the crops grown should be absolutely subservient to the proper purification of the sewage, but in practice it was found feasible to apply the sewage to the crop without detriment to the beds or disadvantage to the purification.

THE SPEED OF VESSELS IN SHIP-CANALS was touched upon in a late paper presented to the Institute of Civil Engineers, by Sir Charles A. Hartley, on "Engineering Works of the Suez Canal." The Commission to enlarge the Suez Canal, in 1881, made a series of experiments with the steamship "Austral," the largest ship then using the canal. The most striking result of this test was that with 45 revolutions the "Austral" only made 5 knots in the straight canal; while the same number of revolutions in the open sea gave her a speed of 11 knots, and 68 revolutions gave her 16 knots. These experiments took place before the section of the canal was enlarged.

GLASS VESSELS OF 18 CU. FT. CAPACITY are made at the P. T. Sievert Glass Works at Denben, near Dresden, by a new process, including the use of perforated iron plates, molds and compressed air. Cylindrical glass vessels, troughs, etc., of unusual size are made by this means.

THE ENGLISH MILITARY BALLOONS, says "Engineering," are made of gold beaters skin, and weigh only 100 lbs. for an envelope of 10,000 cu. ft. gas capacity. The cable is made of wire, and weighs 87 lbs. for 550 yds. The total weight of a balloon complete and capable of lifting two men, is less than 224 lbs.; but to this must be added the weight of the cable. Hydrogen is used for inflation, and this is carried compressed in steel bottles, as being more convenient than the generation of gas on the spot. To supply one charge of a balloon 2¾ tons of bottles are needed.

A NEW MAP OF INDIA, and "adjacent countries," has been commenced by the Survey of India Department. The scale selected is 1 in 1,000,000, or about 16 miles to the inch, and it will be issued in 100 sheets.

MOHAWKITE is a new mineral recently discovered forming a cross vein in the Mohawk mine near Houghton, Mich. According to the analysis, the new mineral has the general appearance and characteristics of the so-called Domeykite, which has been found from time to time in various localities in the same region. These analysis have been made by Dr. George A. Koenig, Professor of Chemistry and Metallurgy at the Michigan College of Mines, and gives the following composition for the new mineral: Copper, 61.7%; nickel, 7%; cabalt, 2.2%; arsenic, 28.8%, and a trace of iron. The atomic ratio is three to one, and the specific gravity is 8.07.

THE PAVING AND SEWERAGE OF HAVANA under the alleged contract between the old government and Mr. Michael J. Dady, of Brooklyn, N. Y., is not to be carried out. Instead, a commission will be appointed to determine the value of Mr. Dady's rights, and another commission, of three engineers, will be chosen to prepare plans for a sewerage system for the city.

THE PROGRESS MADE BY THE ISTHMIAN CANAL COMMISSION.

Gen. Peter C. Hains and Mr. Alfred Noble, of the Isthmian Canal Commission, have returned to the United States, leaving in Costa Rica Admiral Walker, Gen. Ernst and Messrs. Pasco, Burr and Johnson. Prof. Haupt is in Washington and Mr. Morison has been delegated to examine the Darien route. From interviews with Messrs. Hains and Noble, published in the New York "Journal of Commerce," we quote as follows:

General Hains said: "The present Commission's report will not only decide upon a practicable route for an Isthmian canal, but will demonstrate conclusively that the route selected is the most feasible one that could have been chosen. We have at present about 300 surveyors in the field, under the charge of competent engineers. They are going with the greatest care over the Nicaragua route, the Panama route, and all the other routes suggested by any of the former surveys. Besides this, we have a number of exploring parties out, in the hope of discovering routes that have been hitherto overlooked. Our object is to do the work with such thoroughness that our results cannot possibly be questioned at any future time. We have the reports of all previous surveys, but we shall cover every mile of ground through which we think it possible for the canal to be run. The country is varied, and the work of the surveyors is difficult and progresses slowly, especially in the section about Darien. It is impossible for this reason to set even an approximate date for presenting our formal report to the State Department. Unless Congress expressly requires one, we shall submit no preliminary report. Our report, we hope, will settle the whole question of an Isthmian canal, once for all."

Mr. Noble added: "I think the American people will want a route across the Isthmus, but the work of digging the canal on any route will take longer than anybody seems to think."

Mr. Noble was asked if the Commission had found the representations of the Panama Canal people, who were in Washington before the Commission left, to be true. "I think they have the number of men employed that they said they had," he replied. "The present Panama Canal Company has been spending its money mainly in making a narrow, deep cut through the great divide. The work is being well done. In regard to the Chagres River, we have found that the Panama people have a feasible way to manage that. We have a surveying party at this point now making the necessary survey of their plans."

The Commissioner verified the reports that the new route of the Nicaragua Canal, as proposed, was thought to be the best one if the Nicaragua route should be decided on. The new route from Greytown to the San Juan River was easy and cheap.

Mr. Noble said that if Greytown was used as a terminus a big jetty would have to be built and continual dredging done to keep the passage clear.

GARBAGE REDUCTION WORKS AT PITTSBURG AND ALLEGHENY, PA.

The garbage reduction works at Pittsburg were described in Engineering News for Oct. 3, 1895. The system of treatment first employed was that of the Consolidated American Reduction Co., of New York city, but it has been modified since. The original plant is located close by the Monongahela River and Baltimore & Ohio R. R. tracks, at the foot of a commanding bluff, but this plant is now used only as a receiving, drying and shipping station, the process of treatment being completed outside the city limits.

A contract for collecting and disposing of the garbage, offal, condemned meat and dead animals of the city was awarded to Mr. Chas. E. Flinn for four years from July 1, 1895, at $79,890 a year. Mr. Flinn organized a local company to build and operate the disposal works, known as the American Reduction Co. On the expiration of the contract it was renewed for a period of four years from July 1, 1899, at a price of $93,890 a year. The contract provides that all dead animals shall be removed from the city.

On the first visit of a representative of this journal to the plant, in August, 1895, only two of the digesters had been put in use. It was then said that the garbage was simply cooked with steam under 30 lbs. pressure to liberate the grease and dried in Bigelow driers, the grease being separated from the water before drying. In the latter part of 1896 a description of the works was prepared by Mr. Joseph B. Taylor for a special report on garbage disposal which appeared in the annual report of the Health Department of Brooklyn, N. Y., for 1896, and was also printed separately. From this account (see foot note, following quotation) it appears that the garbage was then being treated with sulphuric acid under some 20 lbs. of steam pressure; also that a complete, or commercial fertilizer, was being made of the tankage. The plant as it then stood, as well as the process employed, being in some respects unique, and this being the only plant, other than experimental ones, ever constructed on the system of the American Consolidated Reduction Co., a concern that was quite prominent a few years ago, we condense the description as follows, although it does apply to the present plant at Pittsburg:

The digesters are arranged in pairs, the conveyor passing between and above each pair. In the bottom of the conveyor trough are openings, one placed for each pair of digesters. The openings are provided with iron doors, operated by a rack and pinion. Beneath the conveyor is placed a two-rail track, upon which runs a hopper, terminating in a swivel spout. The spout is bent at an angle so as to bring the mouth over the charging doors of the digesters. By means of the track, the hopper being mounted on wheels, the hopper and spout can be moved to any of the numerous openings in the conveyor trough, and by means of the swivel motion the spout may swing to either of any pair of digesters. This feeding device enables any digester in the battery to be filled from the central conveyor.

The digesters are of unusual shape (see foot note.—Ed.), being larger in diameter than in length. They are built of boiler iron, and consist of a cylindrical portion 8 ft. in diameter and 4 ft. long, the lower end of the cylinder terminating in the frustum of a cone 4 ft. long. At the lower end of the cone is riveted a short cylindrical pipe which connects with a 12-in. gate valve, tightness being maintained by means of a gland. The top or cover of the digester is of cast-iron and dome-shaped, having the charging-door-seat and vapor outlets cast on. The cover is bolted on to a flange riveted to the cylindrical shell. On account of the acid used in the process it is necessary to line the digester with sheet lead; the lead is kept in place by pieces of flat iron riveted through the lead to the shell. The exposed pieces of flat iron are then covered over with pieces of sheet lead. At the junction with the gland the lead sheeting is turned under and held by a copper ring. The gland is packed with rope having a central core of rubber, and is drawn home by stud bolts in the gate valve flange. Four steam inlets are located in the conical portion of the digester, the joint being made by a flanged lead pipe with a blank flange for drawing up. Each steam inlet pipe is provided with a check valve.

Each pair of digesters is connected with a drier placed below; the connection being made by a pipe bolted at one end to the gate valve and at the other to the shell of the drier. The driers are cylindrical steam jacketed vessels, about 6 ft. in diameter by 16 ft. long. A shaft runs through the center of the drier, to which are attached mixing arms to cascade the material and facilitate liberation of the moisture. A spur wheel is keyed to the projecting end of the shaft, a pinion meshing with the wheel. They are belt driven from the pinion shaft, to which is also attached a friction clutch for starting and stopping. In the bottom of the drier and communicating with the inner shell is a discharging door, located above a flight conveyor. This conveyor passes in turn under the discharging door of each drier and empties in the tankage-room.

The modus operandi is as follows: After the digesters are filled, their capacity being about four tons of garbage, about 200 lbs. of concentrated sulphuric acid and 200 lbs. of water are poured in. (See foot note.) The doors are locked and steam at about 20 lbs. pressure is turned on and continued for about eight hours. At the end of this time steam is turned off, and the contents of the digester allowed to settle. After a time the grease separates out, floats on top and is skimmed off with dippers and emptied into pipes which carry it to the storage tanks. At this point we have a radical departure from the usual method in garbage reduction systems in that the tankage is converted into a complete fertilizer instead of being put on the market as a filler. The tankage in itself is too poor in ammonia, phosphates, etc., to be available for use directly on the soil, and to enrich it, Charleston rock, etc., are added in the proper amounts to give the desired analysis. The material in the digester is discharged into the drier by opening the gate valve. The valve is then closed and the digester is ready for another charge. The drying operation requires about eight hours, the material being discharged when dry into the conveyors, heretofore described, and screened and bagged.

While this report is intended to be mostly descriptive of the various methods and to avoid criticism where possible, it must be borne in mind that the commercial aspect is one of the most important factors which must be considered. Analysis seems to show that the commercial side of making a complete fertilizer by the above method has not received due consideration.

From the sanitary standpoint the system has some commendable features, and as the garbage is not exposed after delivery into the digesters except for the removal of grease, the process offers exceptional opportunities in this direction.

The foul gases generated during the digesting are led by pipes under the grate of the producer to be consumed. There is some annoyance experienced in this method in that the condensation of the water vapor in the gases, together with the condensation from a steam jet in the vapor pipe used to help circulation, causes trapping. These are mechanical features, however, which ought to be easily overcome and the burning of the gases is a desirable method of disposition.

For disposing of the gases from the driers a water condenser is located on the roof. This condenser is of the usual type, discharging to the sewer, but provision is made for a steam draft if necessary. Vacuum pumps are also used for drawing off moisture. It is the intention eventually to have all noxious fumes destroyed by fire.

This concern is experimenting, as have several others, with centrifugal machines for removing the grease rapidly from the digested garbage, on the principle of the cream separators now so largely used. Up to the present time, however, we believe that this method has not come up to expectations. (See foot note.)

This establishment is well kept up, and considerable effort has been put forth to meet sanitary requirements; but notwithstanding, the familiar caramel odor is discernible, and the discharge of unfiltered condenser water into the river militates against it.*

As already stated, the plant is not now operated along the original lines. The changes will be noted further on. Before the original plant was fully in operation complaints of bad odors were made by residents on the bluff above the works, and from early in 1896 to January, 1899, suits were pending to secure the closing of the works on the ground that it was a nuisance. The justice of the original complaints was admitted, but it was claimed that improvements had been and were being made which would put an end to the nuisance. On this, the court, in July, 1896, ordered the plant kept closed until the improvements were completed, after which it was to be given another trial.

In the latter part of October, 1897, the same general case was again before the court, but was postponed for six weeks on the plea of the defendants, although the complainants urged that a year had been allowed for preparing for the case. In January, 1898, Judge J. W. F. White dismissed the case, with an order that the garbage should be handled with as little exposure as possible, and the final product speedily removed. In view of many complaints and suits brought against other garbage disposal works, and especially of the recent legislative interference with a reduction plant so remote from centers of population as the one at Barren Island, Greater New York, we quote in full the very sensible opinion of Judge White, in which he discusses alleged nuisances of this sort and shows the similarity of such works to other manufacturing plants:

It is the duty of a large city like Pittsburg to make provision for gathering and disposing of the garbage of the city; it is indispensable to the health and comfort of the citizens. There is difficulty in finding a proper place for the disposal of the garbage of Pittsburg. There is no place within 20 miles of the city, on any of the rivers, where the garbage could be disposed of in the ordinary way without being regarded a nuisance in that locality; or no point within 20 miles of the city on any of the railroads where the garbage could be disposed of without being regarded a nuisance. To haul out the garbage by wagons into some remote portion of the county would be exceedingly expensive to the city; and perhaps no locality within the county could be got where it would not cause trouble. It is a serious question for a city located as we are, and yet it is the duty of the city to provide in some way for disposing of the garbage. This furnace is constructed on the most scientific principles, and is far superior to ordinary garbage furnaces.*

No doubt the city has the right to dispose of that garbage within the city limits, as provided by the ordinance, if a suitable place can be got. The location of this garbage furnace is, perhaps, in the most unobjectionable place that could be selected within the city limits. There is no evidence to the contrary. In selecting a place for a garbage furnace, a reasonable discretion must be allowed to the city authorities. There is no doubt that a garbage furnace anywhere may be to some extent a nuisance to citizens in that locality. As one witness in the case testified, the very thought of a garbage furnace will be an annoyance. So any large establishment, factory, rolling mill, furnace, glass works, and all these other large establishments, will be, to a certain extent, an annoyance to property holders in the immediate vicinity, and, in many cases, may even depreciate the value of property in the vicinity. These inconveniences and annoyances that some citizens may suffer are simply the incidents resulting from the growth and business of a large city. This furnace is constructed on the most scientific principles, and is far superior to ordinary garbage furnaces.

The Bluff, where these complainants live, was some years ago, probably the most delightful place about the city for residence; overlooking the Monongahela River and the hills beyond, a high bluff bank, almost perpendicular; but, in the growth of the city, factories and furnaces have been established along the bank of the river, and no doubt will increase with the years, and the smoke from these, the noise, the steam, the smells and the offensive odors from them, will affect the bluff as a place for residences. But, the onward march of the business of the city cannot be arrested because it may be an annoyance to some of those living on the bluff. In the course of a few years it will not be, perhaps, a desirable place for residences. It is just like many other portions of the city; years ago, the lower part of the city on Penn Ave., was the most delightful portion of the city for residences. In consequence of the large iron establishments and others it has almost ceased to be a place for residence; property for residences has depreciated in value, and the desirable places for residences are out in the suburbs of the city. The mere fact that those residing on the bluff are annoyed some little by the fact that a garbage furnace is down on the bank, and some little annoyed, perhaps, by the hot air that escapes from the building, does not make this a public nuisance. The offensive odors on the bluff arose from the garbage remaining too long in the pit. If the garbage brought into this furnace should be at once put into the digesters, and they kept tight, I believe there would be no offensive odors escaping from the garbage even in the building, and none, of course, to any appreciable extent, could extend up to the bluff.

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The contract with the defendant was made by the director of the department of public safety, and approved by councils and the mayor, and is only for four years. If, at the end of that period of time, only a year or so hence, this factory should be found to be a nuisance, the city authorities will not continue it, or, if they attempt to continue it then, there may be an effort made to stop it. It cannot be continued without the consent of councils and the mayor. It will not be any serious injury to these complainants to let this factory run on for the length of time provided for under the present contract if the garbage be at once put into the digesters. Of course the city cannot authorize or sanction a public nuisance. Under the testimony of the director of the department of public safety, and the officers of the bureau of health, I do not feel authorized to suppress this garbage furnace at this time, which would result, of course, in a great loss to the defendant. If the causes of the offensive odors as stated in my findings, cannot be removed, it will be the duty of the director of the department of public safety and of the officers of the bureau of health to stop this furnace, because the ordinance requires it to be conducted in a sanitary manner. It is their duty to visit it frequently, inspect it, and hear any complaints of the citizens on the subject; and, unless it can be conducted in a manner that will not be offensive to the neighborhood, or to the complainants living on the bluff, it would not be proper for the director of the department of public safety to renew this contract with the defendant, but he should make some other provision for disposing of the garbage of the city.

Let a decree be drawn requiring the defendant to dispose of the garbage as soon and as fast as it is brought to the pit, and at once conduct it into the digesters, they to be kept tight, and the residuum to be shipped off as speedily as possible; the defendant Charles E. Flinn to pay the costs. William Flinn and Philip Flinn having no interests in the establishment, as to them the bill is dismissed.

The case went to the Supreme Court, which sustained the decision just cited.

The remainder of this article is based on notes taken at the works located beneath the bluff, in the city, on Nov. 14, 1899, by a member of the editorial staff of this journal. The plant at the time was in the charge of Mr. James E. Flinn, Foreman, to whom we are indebted for the information given. We are also indebted to Mr. Crosby Gray, Superintendent of the Bureau of Health of Pittsburg, for courtesies shown at the same time.

The collecting wagons dump the garbage into a pit below the ground level. Here cans are picked out and put aside. About $10 a month is paid for hauling the cans to a furnace, in which a man melts out the solder for what he can make on it, the contractor furnishing the gas. From the pit a conveyor system takes the garbage to the tops of the original digesters, a lift of 40 or 50 ft., and dumps it into any one of 14 vertical tanks. These tanks were the original digesters, but are now used for storage only. From the storage tanks the garbage is dumped as desired into horizontal driers, of which there are seven; five made by the Bigelow Co., of New Haven, Conn., and two by Thos. Carlin's Sons, of Allegheny. The driers have a clear inside diameter of 5½ ft., are 18 ft. long, steam jacketed. A central shaft runs the length of each drier, on which there are five or six webs, at intervals, provided with arms coming to within ½-in. of the shell. These driers remove 60% of the moisture.

The tankage goes from the driers to an elevator, which lifts it about one story to a gangway running out over box cars, with four doors in the top of each for loading. These cars are hauled for some 25 miles over the Baltimore & Ohio R. R. to West Newton, on the Youghiogheny River. Here the grease is extracted with naphtha and shipped, some in barrels and some in tank cars. The tankage is made into a fertilizer. This secondary plant was built in 1896 and 1897. The American Reduction Co. informs us that this plant "was established to accommodate the fertilizer business, only. The cooking and drying is all done in the city, hence this West Newton plant had no connection with complaints or lawsuits." Mr. Crosby Gray, Superintendent of the Bureau of Health of Pittsburg, also confirms this statement, in a letter dated March 27, 1900.

At the city plant there are six boilers, with a combined capacity of 1,200 HP. The boilers are provided with automatic stokers from the Brightman Stoker Co., of Cleveland. One of the boilers is generally in reserve. The main use of the boiler plant is to supply steam to the driers, but there is a 250-HP. engine. Two vacuum pumps are provided for exhausting the gases from the driers. The condensed gas goes to the sewers and the uncondensed to the boiler furnaces.

In summer an average of 125 tons of garbage are collected and treated each day, but in November, 1899, about 90 tons were being handled.

The Allegheny Plant.

At Pittsburg and Allegheny, each, there was a Rider furnace in operation for many years; both plants were outgrown and replaced by reduction works. The Allegheny furnace was described briefly in an article entitled "Garbage Cremation in America," which appeared in Engineering News for Aug. 30, 1894. On July 1, 1897, there went into effect a four-years' contract for the collection and disposal of garbage, the contractor being Mr. Joseph Hastings, National Bank Building, Allegheny.

The Allegheny Garbage Co. was organized to carry out the contract. The contract calls for the collection and disposal of garbage from houses, markets, etc., the compensation being $28,— a year. Wholesale houses pay extra for having their garbage removed. The contract does not include ashes, street sweepings nor dead animals, a separate contract having been made recently for the latter, on the basis of $2,500 a year, the dead animals to be removed beyond the city limits.

*Since this was put in type we have been informed by Mr. A. Wedd, of the American Reduction Co., that probably the digesters described above were made by Thos. Carlin's Sons, Allegheny, Pa., after plans by Dr. Rismuller, for a temporary plant built by the Consolidated American Reduction Co., at Philadelphia; also that the experiments with centrifugal machines, mentioned in the next to the last paragraph, were made at the same plant. The capacity of the Pittsburg digesters was about 13,000 lbs. of garbage, to which was added sulphuric acid, phosphate rock and potash, proportioned according to the fertilizer formula being used. Mr. Wedd also says that the last paragraph was not applicable to Pittsburg, at the time it was written. It is evident, therefore, that Mr. Taylor's description was designed to outline the general process of the Consolidated American Reduction Co., rather than to describe a particular plant.—Ed.

*It will be noticed that the Judge clings to the word furnace throughout, instead of the proper term reduction works.—Ed.

The garbage contract contained no provision regarding the system of disposal to be employed, further than that it should be subject to the approval of the health department. Walker, Stratman & Co., bone fertilizer manufacturers, of Pittsburg, are interested in the disposal plant. The engineer for the works was Mr. W. E. Garrigues, formerly of Pittsburg, but with an address now given as Loomis, Wash. The above information was secured in Allegheny in November, 1899, from Mr. McLaughlin, Superintendent of Health. Mr. McLaughlin said he thought cremation was a more sanitary means of garbage disposal than reduction, but the commercial phases of the question favor reduction for larger places. No further information could be secured for publication.

Since the above was written we have been informed by Mr. A. Wedd, of the American Reduction Co., of Pittsburg, that the plant constructed by Mr. Garrigues was entirely destroyed by fire in May or June, 1899, and that a new plant is now in operation, on similar lines.

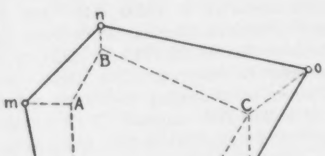
A METHOD OF MAKING A FARM SURVEY.

By G. B. Zahniser.*

From the time the bull's hide was cut into strips and used to measure off a parcel of land to the present, the art of land surveying has of right received its share of attention. No apology, therefore, is offered for this article on a method of making a farm survey. In making a farm survey today, either to determine its area, or to rerun its lines on the ground, the great majority of engineers, usually equipped with a transit and steel tape outfit, on account of brush, fences and other obstacles to the measurement of the actual lines, proceed to range out and measure auxiliary parallel lines and offsets. This method results in much field work and comparatively little office work. There is a better method, both for determining lines and area, which is best illustrated by a concrete example.

A good outfit consists of a transit whose plate is graduated from 0° to 90° each way from the North and South zeros, having stamped under each figure on the plate, the letters N. E.—S. E.—S. W. or N. W., as the quadrant requires. It may also have graduations running from 0° to 360°, but they are unnecessary for our present purpose. A 100-ft. steel tape is necessary, but instead of sight rods use three 6 or 8-oz. plumb bobs. An ax, tacks, note-books, etc., complete the outfit.

Suppose the farm to be surveyed is the shape shown in the diagram; with worm fences, brush, etc., along its lines.



On the ground the transit is set up at A, a point anywhere in the open near the corner m; a man is sent to drive a stake, B, anywhere near the corner, n; the line AB is laid down on the best ground available for chaining. When B is in, the rodman gives a "plumb bob sight" upon it. This "plumb bob sight" is given by holding the bob over the point, so that its string hangs down over the end of the rodman's thumb, extended from his closed hand. With the rodman's body for a back ground, if a handkerchief is wound tightly around the end of his thumb, it can be seen for a mile, even though the bob string is invisible; a green man soon gets the trick of it, and sight rods are done away with.

Now the transit at A is sighted on B and the magnetic bearing AB read. The vernier, marked as described above, is then set to this magnetic bearing and the transit is again set on B. The side shot A m is now taken, the vernier giving the calculated course at once, with no angle, right or left, to record, and no mistake possible in the calculations, for the vernier does the figuring. The reading from the vernier of the course A m can now be checked by a needle reading. The second rodman, or the engineer himself, where one rodman is used, then goes to B and the distance BA is chained back to the transit that stands at A as a range sight. Then a set up is made at B, vernier is set to the course BA; back sight taken on A, and another stake C driven any where on good ground near o, while side shot B n is taken. Then course BC is observed; read off the vernier; checked; recorded and measured, and so on around the farm, closing on AB. Where possible, of course, make a corner of the farm one of the points in the inside survey. Land marks, houses, etc., are easily and quickly tied into the traverse with side shots.

The advantages of this method of field work are: The best ground for chaining can be selected; the readings of the closed survey are taken almost as soon as a set up is made, and hence are more accurate; the side shots being short can be out three or four minutes without affecting the result. No calculation of courses is necessary, they being read off the vernier direct, and the reading checked for big errors with the needle. Quickness and hence economy in the field work result, and errors of closure are with ordinary care from 1:5000 to 1:9000. The closure in angle should be well within three minutes, this error being the uncompensated error of the instrument pointings, while the error in each reading of the vernier is not carried through the survey, as it is in the angle method.

The office work is as follows: Have printed on soft paper, two blank forms, form No. 1 having columns for course, distance, North, South, East and West; and form No. 2 has these same columns, and also columns for Lat. Dep. D. M. D. + area and — area; and both forms have a space at the top for the name of survey, date, file number, etc. The best reduction tables the writer has found, not excepting the minute traverse tables, are the Gauss Logarithmic Tables (German), costing about 65 cts.; the book is small and easy to handle.

Take from the notes of the farm survey above the closed survey A, B, C, D. E. and see if it closes within the proposed limit of error, say 1:50000. To do this quickly look up the log. sin and cos. of each course first, then the logs of the distances; add these respectively and look up all corresponding Lat. and Dep. This saves much leafing back and forth in your tables. Tabulate the results on Form No. 1; do the same now for all the side shots and tabulate the results also on Form No. 1. Now if the survey A, B, C, D, E, closed correctly, plot it with all the side shots and join up the corners. An 8-in. circular one minute protractor is of use here. Now with the two sheets of tabulated Lat. and Dep., one for the inside survey and one for the side shots, the final courses, m n, n o, etc., are quickly and easily calculated on sheets of Form No. 1. Perform all operations with logs and the table of squares. As each course of the final survey is calculated, check it on your map with scale and protractor and record it on Form No. 2. When all these final courses and distances are found it is then best and a check on the whole work, to calculate the final Lats. and Deps. from them (though of course you have them already), and see that they close.

From these final courses get your area. If the survey has been a survey to retrace old lines on the ground, you now have a plot, showing the courses and distances between all the "monuments" as they exist on the ground, which survey can be compared with the deeds or rerun on the ground with no uncertainty as to how it is coming out.

The H. C. Frick Coke Co., in their property surveys of the coke region, where land is often worth $1,000 per acre, and for their mine maps, necessarily accurate, use this method of land survey exclusively; and while the office work of this method may seem laborious, in a ten years' experience for himself, the writer has found it cheaper, quicker, more accurate and better for a permanent record of the work than any other.

*Civil and Mining Engineer, Newcastle, Pa.

GAGES FOR WEAR OF LOCOMOTIVE DRIVING WHEELS.

On most railways there are rules setting a limit to the depth of wear allowed for the tires of locomotive driving wheels, and when this is reached the tires must be turned down. In many cases, however, the measurements are more or less crude and unsystematic, and there is frequent complaint from the maintenance of way department as to the damage being done by deeply grooved or "false-flanged" wheels. We illustrate herewith two forms of gages used for the purpose of measuring the amount of the wear. The limit is usually ¼-in. as a maximum, but many roads claim that their wheels are not allowed to reach this limit.

The Chicago, Burlington & Quincy R. R. uses the gage shown in Fig. 1, which is adapted from the M. C. B. flange thickness gage, the lower edge be-

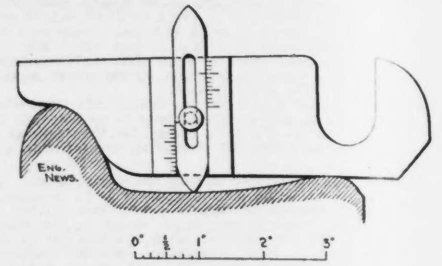


Fig. 1.—Gage for Worn Tires; C., B. & Q. R. R.

ing formed to the standard contour of an unworn tire. Across the plate of the gage is a slide, with scale graduations on the slide and plate. The gage is set upon the tire as shown, and the slide moved out until it touches the tire, the amount of wear being then indicated by the scale. The limits of wear are ⅜-in. for switching engines, ¼-in. for engines in ordinary freight or slow passenger service, and 3-16-in. for engines in fast passenger, fast freight and mail service.

The Chicago, Milwaukee & St. Paul Ry. uses the Keen patent gage shown in Fig. 2. This consists of two side plates, the bottom edges of which are shaped to the standard contour of an unworn tire. Between the plates is a row of pins of rectangular section which can be clamped tightly between the plates. The gage is set on the tire with the pins loose, so that they touch the tire across the full width of the tread. They are then locked in position by the clamping screw, and when the tool is

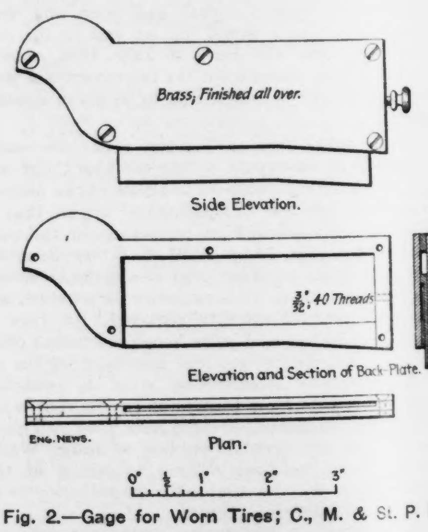


Fig. 2.—Gage for Worn Tires; C., M. & St. P. Ry.

removed the pins show the exact contour of the tire. The results of the measurements are reported monthly by the roundhouse foremen on a special blank sent to the District Master Mechanic, showing the thickness of the tire, the depth of wear, and stating if any flat spots exist. The information from this report is then tabulated in the office of the Motive Power Department, the engines being grouped by districts, and ten columns being given for the wear, varying from 0 to ⅝-in. by variations of 1-32-in. The limit of wear before turning is ¼-in.

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