ENGINEERING NEWS AND AMERICAN RAILWAY JOURNAL.

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THE SOULANGES CANAL was opened on Oct. 9, completing a 14-ft. waterway between Montreal and the Great Lakes, though it will hardly be used this season. This canal replaces the 9-ft. Beauharnois Canal, on the other side of the St. Lawrence River, and connects Lake St. Francis and Lake St. Louis, between which so-called lakes the St. Lawrence River falls 82½ ft. in 16 miles in the four rapids of Couteau, Cedars, Split Rock and Cascades. This fall of 82½ ft. is overcome by four locks; three, near the Cascades, of 23½ ft. each, and the fourth about three miles from the entrance. Heavy guard-gates are located about 1,000 ft. above Lock 4, and a guard lock, at the upper end, can be used as a lift lock when the lake rises above mean stages. The lockages are to be made in 12 to 15 minutes, giving a capacity of 20,000,000 tons of freight in an ordinary season. This canal has cost about $5,000,000, and it will be operated and lighted by electricity generated by turbines developing 640 HP. for operating the generators.

A DEEP WATERWAY CONVENTION was held at Peoria, Ill., on Oct. 10 and 11, attended by delegations from Chicago, St. Louis and the cities and towns along the Illinois River. The work of the convention was summarized in the following resolutions:

1. That we reaffirm and approve the action of the convention held in Peoria in October, 1897, in favor of a deep waterway and the general legislative acts in harmony therewith.
2. That the advanced stage of the work on the sanitary and ship canal of Chicago justifies the immediate cooperation of Congress with a view to the early completion of the waterway between the lakes and the Mississippi.
3. That we urge the supreme utility of this waterway, and that the large flow of water from Lake Michigan is necessary to its adequate development.
4. That we renew and emphasize the request repeatedly made by various bodies of our citizens, and by the general assembly of the state, for the early removal of the federal dams in the lower Illinois River, provided that such work shall be carried out with due regard to the maintenance of existing navigation.
5. We hereby petition and request our senators and representatives in Congress to use their best efforts to secure such appropriations and provide such board of engineers as may be deemed essential for the purpose of making surveys and examinations from Lake Michigan to the Mississippi River, prepare plans and estimates and execute the work of improvement named in these resolutions.
6. Be it further resolved, the great importance of the Mississippi River as a commercial highway, the vast extent of the interests dependent upon and affected by it, and its influence on the general prosperity of the entire country are all such as to deserve the most liberal treatment at the hands of the general government, to the end that its improvement may be made so complete that it will furnish at all times an unobstructed outlet to the sea for the surplus products of the Mississippi valley.

NAVAL CONSTRUCTION is reported upon by Rear-Admiral Hichborn, Chief of the Bureau of Construction and Repairs. The most interesting part of this report relate to the valuable results of our late war experience, as effecting the design and fittings of warships. Sheathed ships have proved their strategical and tactical advantages over unsheathed ships; the combustible material on board ships must be restricted to the lowest limits, and fire-extinguishing apparatus must be of the best type. The general sanitary conditions on board ships exposed to hot climates proved very satisfactory, but some defects were brought to light, particularly in the ventilation of some of the earlier vessels. The presence of steam pipes in living quarters is condemned, and the tendency is to replace steam by electric power for the various auxiliaries; and on 36 vessels the Bureau has already installed 320 electric motors for turning turrets, hoisting ammunition and operating ventilation blowers, deck winches and boat hoists. A better method of handling and stowing anchors is demanded. As to navy yard plants, better and more docking facilities are urgently required; and this is especially the case at New York and Norfolk. During the last fiscal year, at New York, Dry-dock No. 1 was occupied 336 days; No. 2, 190 days, and No. 3, 204 days; and the last is the only dock there capable of taking a ship larger than the cruiser "New York." At Norfolk, the largest dock can only take the "Texas" class on light draft; but one of these docks was occupied 285 days and the other 292 days. The number of battleships will be doubled in the near future, and docks must be provided for them. Marine railways for the docking of torpedo boats are recommended for New York, Portsmouth, N. H.; League Island, Pa.; Norfolk, Va.; Port Royal, S. C., and Mare Island, Cal. Admiral Hichborn also calls attention to a much needed increase in the Corps of Naval Constructors in the near future.

THE BATTLESHIP "KEARSARGE" has been officially reported upon by the naval board of inspection in charge of her late trial trip. The true mean speed was 16.816 knots, on a run of 3 h. 55 m. 14.2 s. over a course of 66 nautical miles, or 65.929 knots with tidal corrections. The mean draft of the "Kearsarge" was 23 ft. 6 ins. and she displaced 11,550 tons of water. On the outward run the average steam pressure was 180.2 lbs. with 116.5 and 117 revolutions for the starboard and port engines; on the return run the steam pressure was 116.4 lbs. and the average revolutions for both engines was 111. The loss of pressure was due to leaks in the feed-water heater and some of the boilers. She steered and manoeuvred excellently, and was practically free from structural vibration. The unfinished condition of the superimposed turrets prevented a test of their working; but the forward turret was turned slowly through 180°, and meanwhile the helm was turned from hard-to-starboard 35° to hard-to-port 70°, with a resulting heel to the ship of 4 to 5°.

THE STEAMSHIP "KAISERIN MARIA THERESA" is now being lengthened 66 ft., by the Vulcan Co., of Stettin; and is at the same time being converted from a single to a twin-screw vessel. Her engine-power is being increased from 11,500 to 16,000 I. HP.

A 25-MILE RAILWAY, FOR THE PHILIPPINES, is packed in the hold of the steamship "Glenogle," at San Francisco; complete except for the ties. It is said that this material will be used in extending the 30 miles of railway now controlled by the American troops. The Engineer Corps will handle the material, build bridges, etc.

AMERICAN COAL MINERS AND SHIPPERS have an opportunity to obtain a large contract for coal in Paris. The Eastern Electric Tramway Co. desires to make yearly contracts for 2,000 tons per month of steam coal delivered at Havre or Rouen, and wishes proposals from American coal producers. Particulars can be obtained from Mr. Gus. C. Henning, M. Am. Soc. M. E., St. Paul Building, New York city.

THE MOST SERIOUS RAILWAY ACCIDENT of the week occurred near Granite Canon Station, on the Union Pacific R. R., on Oct. 16. The east-bound fast mail train ran into a stock train. The wreck caused the death of two men.

THE STEAMER "NUTMEG STATE," plying between Bridgeport, Conn., and New York city, was burned to the water on Oct. 14, while near Glen Cove, Long Island. Fire was first discovered near the stack, and the vessel was immediately beached, but not before all except the forward part was in flames. Great excitement prevailed with the passengers and crew, and both life boats were capsized in launching, or shortly thereafter. Ten persons are known to have lost their lives, six by fire and four by drowning.

THE PROPOSED NEW EAST RIVER BRIDGE, at Blackwell's Island, New York, for which surveys have been in progress for some months, will be a cantilever structure, according to the preliminary plans which have just been approved by Bridge Commissioner John L. Shea, of New York city. According to these plans, the new bridge will be 150 ft. wide, and from the East River shore of Manhattan to the opposite shore of Long Island its length will be 2,710 ft. It will accommodate two elevated railroads, two double tracks for trolley lines, paths for bicycle riders, walks for foot passengers, two roadways for heavy teams and also roadways for lighter vehicles. The foundations, which will be concrete and stone, will rest on solid rock. The main pier in Manhattan will be 115 ft. high, and the height of the piers on Blackwell's Island will be 118 ft. If the present plans are carried out the approach to the bridge on the Manhattan side will be in 60th St., from Second Ave. On the Long Island side the bridge will terminate at the shore line between Rogers and Babbitt Sts., in Ravenswood. Additional approaches can be built, one from Astoria and another from Hunter's Point. The estimated cost of the bridge is as follows:

Condemnation of land in Manhattan	$1,485,000
Condemnation of land in Queens Borough	573,000
Main bridge	1,392,000
Approach in Manhattan	930,000
Approach in Queens Borough	1,360,000
Total	$5,740,000

If the construction of the bridge is begun simultaneously on the Manhattan side, on Blackwell's Island and on the Long Island side, it is expected that it can be finished in two years. Commissioner Shea states that construction will begin just as soon as Corporation Counsel Whalen has determined whether the Board of Public Improvements or the Municipal Assembly has the final approval of the work before it goes to the Secretary of War. The latter, it is understood, has practically approved all the features of the bridge already.

THE HUDSON RIVER TUNNEL is being pumped out at the New Jersey entrance. This property was sold last June, under foreclosure proceedings, and the pumping out is supposed to be an indication that the English projectors have secured capital for continuing the work. It is more probable that it is being done to inspect the present conditions of the tunnel and provide material for estimating the probable cost of resumption of work.

THE CHICAGO RIVER TUNNELS, which will have to be lowered, as described in our issue of Oct. 12, will require an expenditure of somewhat less than $1,000,000 for the work. Some papers have given the cost as $3,000,000, and even more, but we are officially informed that these estimates were simply the guesswork of the reporters, and that the actual estimated cost is less than $1,000,000, as above stated.

FORTY LOCOMOTIVES AND 500 COAL CARS have been ordered by the New York, New Haven & Hartford R. R. Co. The Schenectady Locomotive Works will built the engines; five of which are for passenger work, 25 for freight and 10 for switching purposes, all to be delivered by July 1, 1900. The American Car & Foundry Co., of Buffalo, Detroit and St. Louis, will build the coal cars; and the estimated cost of locomotives and cars is $500,000. The Canadian Pacific Railway Co. is also said to have placed orders in the United States for 30 or 40 locomotives. This action was forced by the strike in the company's shops at Fort William, says a Montreal item.

A RUSSIAN ORDER FOR 700 LOCOMOTIVES, says "Bradstreet's," is reported as going a begging among European and American manufacturers. They are wanted for the Trans-Siberian railway, and the great shops are so full of orders that none will undertake to deliver the locomotives in the time which the Russian government considers reasonable.

AN INTERESTING INCIDENT IN THE WATER-supply history of Philadelphia is the reported sale for rent of the office furniture of the Quaker City Water Co., the alleged successor to the Schuylkill Valley Water Co. The latter company seemed sure of securing a contract for a filtered water supply for the city in 1897, when charges of bribery were made against it. The charges were not established in the court, but their effect was sufficient to kill the proposed contract. We understand that the people of Philadelphia will vote next month on a $12,000,000 loan for water-works improvements, to be made, it is supposed, in accordance with the recommendations of Messrs. Hering, Wilson and Gray for filtration plants, as reviewed in our issue of Oct. 5. Some of the newspapers of the city have shown anxiety because the loan ordinance does not mention filtration, merely stating that the money is to be used for water-works and water-works improvement purposes. While it is not too late for some old or new scheme for private water supply to come to the front again, its success would seem to be unlikely, in view of the temper of the people after these many years of delay and scheming, combined with the expressed policy of the Mayor and other executive officers of the city and the recent report of the water supply commission.

PRIVATE RIGHTS IN UNDERGROUND WATERS have been confirmed by the Court of Appeals of New York state. The plaintiff in the case was Mr. Walter R. Smith, of Freeport, Queens Co., N. Y., who claimed damages for the alleged diversion of water from a pond on his premises, following the sinking of wells and the construction of a collecting conduit for the water supply of the former city of Brooklyn. Some of the details of this case were given in our issue of Aug. 19, 1897, in an editorial on "Riparian Rights in Underground Waters." In our issue of March 2, 1899, there appeared a brief note (p. 129) stating that another riparian owner in the drainage area of the Brooklyn water-works had secured an injunction against the diversion of water from his land and an award of $6,000 damages. In the Smith cases, noted above, damages to the amount of $1,800 were given in a jury trial, and, we understand, have been confirmed by the highest court of the state. The significance of these decisions is that they seem to put riparian claims to underground supplies, in New York state, on the same basis as those to surface supplies.

A CONCRETE AND IRON BRIDGE AT OCONOMOWOC, WIS.

The use of steel and concrete for arch bridges is becoming quite extensive, and we illustrate this week a small but interesting bridge of this type which has been built at the summer home of Mr. P. D. Armour, Jr., at Oconomowoc, Wis. The bridge connects the mainland with an artificial island in the lake. It has a clear span of 21 ft., and a rise of 6 ft. 8 ins. The total width is 15 ft., and the thickness of the arch is 5 ins., reinforced by three ribs on the underside, 2 ft. wide and 4 ins. thick. The clear headway at the center is 8 ft. At each end of the bridge the parapet and haunches are curved outward and downward to form wing walls. The structure was designed by Mr. Charles F. Hall, now of the Western Engineering & Construction Co., 901 Unity Building, Chicago, and was built by Stamsen & Blome, contractors for concrete work, Unity Building, Chicago. We are indebted to Mr. Hall for blue prints and photographs, and to the contractors and their superintendent for particulars of the execution of the work.

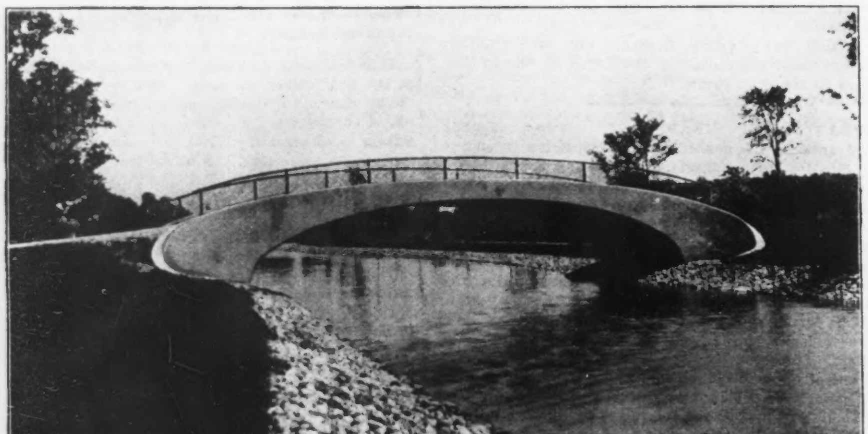

FIG. 1.—CONCRETE ARCH BRIDGE FOR MR. P. D. ARMOUR, JR., AT OCONOMOWOC, WIS.
C. F. Hall, Engineer; Stamsen & Blome, Contractors.

At the shore end, hard pan is reached at a depth of 4 to 6 ft., but at the island end there are 18 to 20 ft. of soft mud. Seven piles were driven vertically at each end, but this was done by the owner. The contractors had to take the risk of their stability, and would have preferred brace piles to take the thrust of the arch. A cofferdam of bags filled with earth was built around the piles, and the water pumped out. The piles were then cut off 2 ft. below low water, and concrete was filled in around their heads for a thickness of 12 ins. They were then capped by oak timbers, 3 × 12 ins., and the concrete foundations were brought up to the water level, being stepped or benched so as to form a shoulder for the superstructure. For the centering, two piles were driven at each end of the bridge, 6 ft. from the springing line, and were driven down by 6-ft. followers, which were afterwards removed so as to leave a clear channel. The piles (or followers) were cut off at the water line, and each pair was capped with a timber 6 × 10 ins. These caps carried six light timber trusses, extending beyond the caps, as cantilevers. Upon these trusses was the form or mold for the concrete, including the arch and parapet, the form being of matched stuff 2 × 6 ins.

This being completed, the ironwork was next put in place. At each side are two flat bars, ⅜ × 3½ ins., one near the top of the parapet and the other level with the arch proper. These are carried down into the abutments and connected to horizontal anchor plates, as shown. The lower bars are connected by ½-in. round rods, hooked over them and extending from side to side, these rods being about 18 ins. apart and ½-in. above the centering. Across these rods was drawn expanded metal of No. 16 gage, 2½-in. mesh, lapped and wired at all edges. The iron hand railing was then set up at proper height and braced in position.

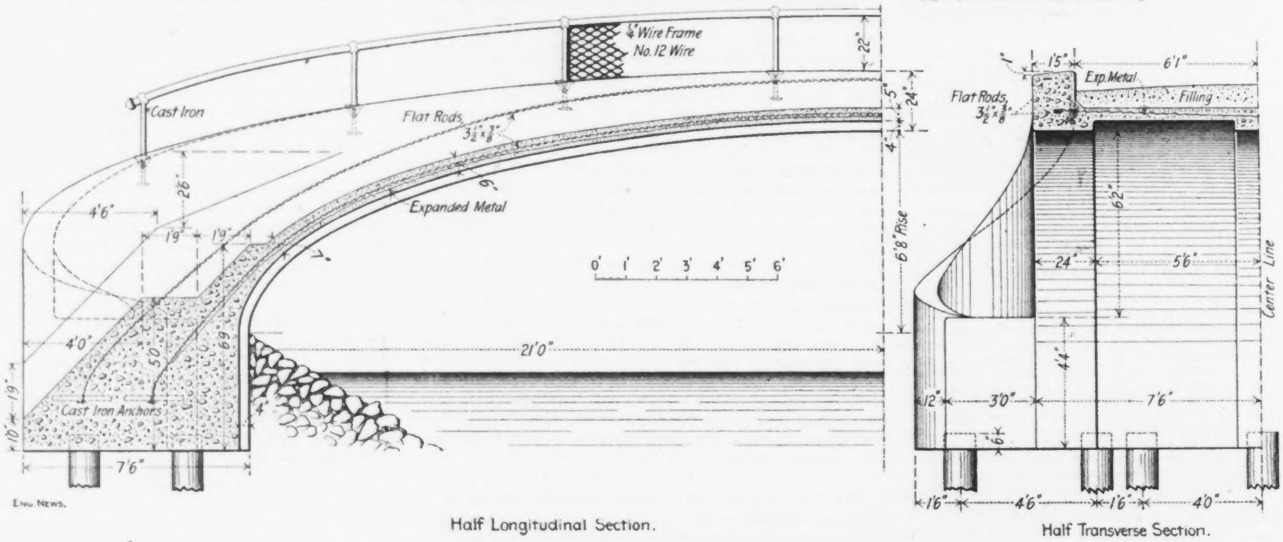

FIG. 2.—DETAILS OF CONCRETE ARCH BRIDGE AT OCONOMOWOC, WIS.

As the concrete could not all be laid in one day, it was divided into three sections, the dividing lines being at an angle of about 30° with the vertical, so that the central section forms a key. This central section was laid first, in order to guard against settlement of the piles supporting the centering. Several holes were bored in the planks forming the ends of the section, and through these were passed ¾-in. round rods, 2 ft. long, extending 12 ins. on each side of the boards, so as to form dowel connections between the central and side sections. Each of the three sections was built in one day.

The concrete was composed of 1 part of Vulcanite Portland cement, 3 parts of bank torpedo sand obtained on the ground, and 4 parts of [illegible] crushed limestone. Great care was taken in mixing, the materials being turned three times dry and twice after wetting. The finishing coat was composed of 1 part of the above cement, 1 part of granite screenings and 1 part of torpedo sand, well mixed and passed through a No. 4 sieve. This coating was spread on the centering to a thickness of 1 in. before the concrete was laid, and in ramming the finish became homogeneous with the concrete. The molds for the parapets were also plastered with 1-in. of this finish, before the concrete was filled in. On the second day after completion, the parapet molds were removed, and the surface was rubbed with a soft rubbing stone and water.

Under the specifications, the arch centering was to remain in place 21 days after the completion of the bridge, but as the owner became impatient it was removed in nine days. The bridge was then used by the owner for hauling earth across to form the approaches on the island side.

THE PURIFICATION OF DRINKING WATER BY THE USE OF OZONE.*

By George A. Soper, B. S., M. A.†

It is a matter of common experience that where electric sparking takes place in the presence of air there is formed a characteristic and unpleasant odor. This was observed by Marum in 1785, and in 1840 Schonbein began to publish notable memoirs upon the subject, ascribing the odor to the presence of a new form of matter which he named ozone. Schonbein found that ozone could be produced by the electrolysis of dilute sulphuric acid and by the slow oxidation of phosphorus. In 1845 Marignac and De la Rive found that pure oxygen could be completely converted into ozone, and Andrews, Soret, Brodie and Tait contributed facts which demonstrate that ozone from all sources is identical, and that it is an allotropic form of oxygen, with the formula O_3.

Ozone has been made in quantity by the electrolysis of acidulated water, by the slow oxidation of phosphorus and by the discharge of electric currents. The most approved method is by the use of the silent discharge of electricity, which may be defined as the transference without sparking of a current of high potential and small volume across a space between two electrodes. Under properly regulated conditions, the silent discharge is accompanied by the phenomenon of a distinctly violet-colored flame. In the presence of the flame pure oxygen, or oxygen con-

*Submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, in the Faculty of Pure Science, Columbia University. (Slightly condensed.)
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...ed in the atmosphere, is in part converted into ozone; ...t 15% of the oxygen being altered, according to Pro... Armstrong. Practical experience with large ...zers indicates this figure to be too high, and that ...ore than 1% of the oxygen of the air can be safely ...d upon. From the fact that ozone is supposed to be ...stituent of the atmosphere, possessing germicidal ...ties, attention has been directed to means for its ...ion in simple apparatus for the disinfection of hos... wards, etc. The reaction due to the slow oxidation ...osphorus has generally formed the basis of such de... but the beneficial effects of treating foul air with ...factured ozone have not received scientific confirma... The occurrence of ozone in the air is still a matter ...spute, according to Professor Ramsay in his "Gases ...e Atmosphere."

...e chemical properties and reactions of ozone indicate ...its general action is that of a strong oxidizer. It ...ars to have no effect on dry metallic gold, platinum, ...er, aluminum or silver, although in the presence of ...ture its characteristic test is the oxidation of the last-...ed element. Ozone is capable of throwing iodine out ...mbination with potassium, in potassium iodide, with ... formation of caustic potash; a reaction which has ... rise to a method for the quantitative estimation of ... Ozone oxidizes ammonia and nitrites to nitric acid, ...ks India rubber and is a strong bleaching agent, es...ally in the presence of chlorine, destroying vegetable ...oring matters, and I find that foul odors of organic ...gin are removed by it. The presence of ozone is usually determined by paper saturated with KI (potassium iodide) and starch, but Professor Shenstone points out that such tests are conclusive only in the absence of chlorine and oxides of nitrogen. Houzeau used paper treated with faintly acid litmus and potassium iodide. When exposed to ozone, the litmus turned blue by the formation of KOH (potassium hydroxide). Traces of nitrogen compounds and H_2O_2 will not affect the result. The method of estimating ozone, which I have adopted in connection with my apparatus for producing a continuous current of ozone, depends upon the dissociation of potassium iodide; 100 cu. cm. of a 5% solution of KI, free from iodate, is placed so as to catch the continuous stream of ozonized air to be examined. The ozone is bubbled through the potassium iodide which quickly absorbs it, iodine being liberated at the same time. In order to take up the KOH formed, a constant stream of small bubbles of CO_2 is passed through the KI solution. After a sufficient quantity of air has passed through the apparatus it is disconnected, and the iodine solution titrated with a fresh hyphosulphite of soda solution of such strength that 1 cu. cm. corresponds to 0.25 mg. of oxygen. Starch solution is used as an indicator. The method is taken from Mohr's "Titrirmethode," sixth edition, revised by Classen.

Application of Ozone.

Notwithstanding the strongly oxidizing properties of ozone and the abundant supply of oxygen from which it may be produced, no successful attempt seems to have been made until recent years to manufacture it upon a commercial scale. To-day there is but one economical method for its production, and its application in the various chemical processes to which, from speculative reasons, it might seem adapted, is extremely limited. Ozone is rather regarded as a curiosity of chemistry than as a reliable oxidizing agent, and the U. S. patents for making it indicate that its supposed disinfecting properties constitute its chief value. Recently, however, the oxidizing properties of ozone have attracted attention, and companies have been formed to manufacture ozone and apply it to various industrial purposes. Among such companies may be mentioned the Commercial Ozone Syndicate of Great Britain, an account of whose operations I have recently had the honor to review before the Chemical Society of Columbia University. Among the industries in which ozone is claimed to be successfully employed may be mentioned the ageing of spirits and wines, the preserving of coffee, the seasoning of wood for pianos, the purification of oils and the bleaching of linens and other fabrics. Within a few years ozone has been used to sterilize water. The process has been developed by Baron Henry Tindal, of Amsterdam, Holland. Mr. Tindal's plants and the experiments which led up to them, represent the only attempts ever made, so far as I am aware, to sterilize large volumes of water except by the familiar methods of filtration and evaporation. I have visited the Tindal plants at Blankenberg, on the Belgian coast, and Paris, and have been able to collect first hand many of the facts here presented relating to the process.

The Tindal Experiments.

It has been claimed by Mr. Tindal that the purification of water by ozone is a natural process. Wherever water lies exposed to the influence of the air and sunlight there is a purifying effect which he considers must, in part at least, be attributed to the agency of ozone. The idea of improving the quality of drinking water by this supposed constituent of the atmosphere is therefore not novel. The novelty of the Tindal process lies in the arrangement of artificial conditions whereby the beneficial effects ascribed to ozone may be produced in a thorough and reliable manner.

The first experiments with the Tindal system were undertaken at Oudshoorn, near Leyden, Holland, in 1893. It had been shown by Froelich, during the course of investigations made by him for the engineering and contracting firm of Siemens & Halske, of Berlin, that ozone produced by subjecting a current of atmospheric air to the action of a silent discharge of electricity possesses the important property of destroying micro-organisms, and that its action is most effective in the presence of moisture. In this respect Froelich's research confirmed those of Kowalowski and Krukowitsch, of Russia, and Christmas, of Paris, who investigated the germicidal action of ozone and whose results appeared at about the same time. Froelich's investigations, however, are believed to furnish the first practical suggestions of the value of a satisfactory system of ozonizing water. In a paper contained in "Electrotechnische Zeitschrift," No. 26, 1891, and in "Gesundheits-Inginuir," XIV., 543, 1891, Froelich states that ozonization probably sterilizes water, converts ammonia into nitrites and nitrates, precipitates iron as hydroxide and destroys sulphuretted hydrogen; he further suggests the important fact that ozonization must follow, and not precede, filtration. Froelich's efforts were especially directed to the development of an effective and economical apparatus for the production of ozone which might be used in various industries, and the hygienic applications of ozone were not conclusively worked out by him.

The sterilizing action of ozone was left for Ohlmueller to investigate officially for the Imperial Board of Health of Germany. His report is entitled "Ueber die Einwerkung

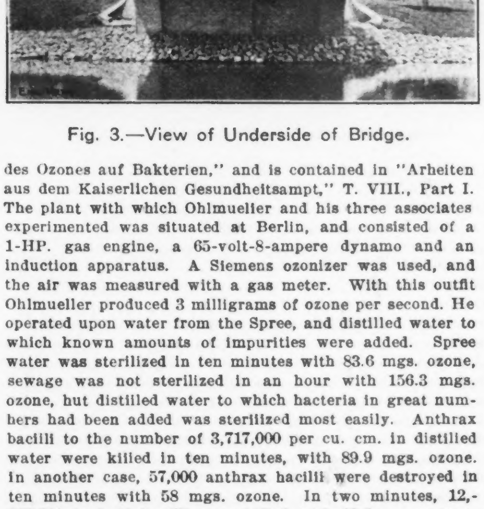


Fig. 3.—View of Underside of Bridge.

des Ozones auf Bakterien," and is contained in "Arbeiten aus dem Kaiserlichen Gesundheitsampt," T. VIII., Part I. The plant with which Ohlmueller and his three associates experimented was situated at Berlin, and consisted of a 1-HP. gas engine, a 65-volt-8-ampere dynamo and an induction apparatus. A Siemens ozonizer was used, and the air was measured with a gas meter. With this outfit Ohlmueller produced 3 milligrams of ozone per second. He operated upon water from the Spree, and distilled water to which known amounts of impurities were added. Spree water was sterilized in ten minutes with 83.6 mgs. ozone, sewage was not sterilized in an hour with 156.3 mgs. ozone, but distilled water to which bacteria in great numbers had been added was sterilized most easily. Anthrax bacilli to the number of 3,717,000 per cu. cm. in distilled water were killed in ten minutes, with 89.9 mgs. ozone. In another case, 57,000 anthrax bacilli were destroyed in ten minutes with 58 mgs. ozone. In two minutes, 12,247,000 typhoid bacilli were killed with 19.5 mgs. ozone; and in still another case, in two minutes, 2,791,000 cholera bacilli were destroyed with 16.5 mgs. ozone. Ohlmueller's conclusion was that where waters were not too contaminated with solid organic impurities, ozone exerts a destructive action upon bacteria.

The Tindal plant at Oudshoorn was the object of an investigation by Professor Van Ermengem, of the University of Ghent, whose research was carried on at the request of the Government, and whose report was tendered to the Minister of Agriculture and Industries, of Belgium, July 30, 1895. An abstract of the paper is to be found in the "Annales de l' Institut Pasteur," Vol. IX., p. 673. The water used in the Oudshoorn experiments was drawn from the Old Rhine, which at this point is a little more than

	Directly from the river	From the cistern.	After filtration.	After ozonization.
Residue on evaporation, ...	0.222	0.220	0.284	0.291
Chlorine, ...	0.035	.0.046	0.049	0.019
Albuminoid Ammonia, ...	0.00027	0.00015	0.00009	0.00006
Free Ammonia, ...	0.00010	0.00010	0.0003	0
Nitrites, ...	0	0	0	0
Nitrates, ...	0.0006	0.0008	0.0014	0.0012
Permanganate, ...	0.024	0.016	0.010	0.006
Microbes per c.c., ...	10,802	18,991	385	0
Color, ...	yellow	yellow	pale yellow	no color
Odor, ...	faint	faint	faint	faint
Taste, ...	?	?	?	?
Appearance, ...	turbid	turbid	turbid	clear

Table I.—Analyses of Old Rhine Water at Oudshoorn Before and After Treatment.
(Parts per 1,000,000.)

a drain for the polders and factories and towns in the vicinity. The quality of the water was variable, with much organic matter, a disagreeable odor and a distinct brown color. In order to remove suspended matter, which would interfere with the process, the water was first stored in a small cistern and then filtered at the rate of 2,500,000 gallons per acre per day through a slow filter. The water was then ozonized by having a current of cold, dry air, which had been subjected to the silent discharge of electricity, bubbled through it. The quality of the water of the Old Rhine at Oudshoorn at each stage of its purification may be observed in Table I. The results of many analyses of the water before and after ozonization are conveniently summarized in Table II. In order to comprehend the latter table fully, it should be understood that bacteria of known species were occasionally planted in known numbers in the untreated water, and that the numbers of such bacteria found in the effluent were compared with them. Ptomaines, toxalbumins, and other poisonous products of bacterial activity were also added to the water on several occasions, with the result that their presence was never discovered in the water after ozonization.

The apparatus employed at Oudshoorn for the production of ozone was, like the apparatus of Froelich and Ohlmueller, adapted to the silent discharge of electricity. In the presence of the silent discharge, pure oxygen, or the oxygen contained in atmospheric air, is in part converted into ozone, while in the spark discharge of electricity compounds of oxygen and nitrogen are believed to be formed also. In the Siemens and Halske experiments, dielectrics had been used between the electrodes, the purpose in interposing such non-conducting surfaces having been to regulate the current so that the discharge might be uniform and constant. With sufficient potential in the electrodes, currents of opposite sign are induced by dielectrics and the discharge takes place, in most forms of ozonizers, between walls of glass, the electrodes consisting of sheets of metal foil. By passing a current of air through the space formed between the dielectrics, a continuous supply of ozone may be produced. At first, a large Siemens tube with celluloid dielectrics was employed by Mr. Tindal, but it was impossible to insure satisfactory working with it at very high voltages. Froelich and Ohlmueller found that there was danger of rupturing glass dielectrics with electrical pressures above 4,000 volts.

Credit is due to Schneller, an electrician in the employ of Mr. Tindal, for devising means whereby solid dielectrics may be dispensed with. By substituting a liquid cell of known resistance for the solid dielectrics usually employed in ozonizers, Schneller opened the way for currents of higher electro-motive force than had thus far been experimented with, and the result is claimed to have been an increased yield of ozone. The cell consisted of a thin glass tube of 60 cm. (24 ins.) long, filled with a mixture of glycerine and alcohol and fitted at each end with wire connections. It was suspended directly above the ozonizer, to whose positive electrode it was electrically attached. The ozonizer consisted of a positive electrode, composed of a series of pieces of thin platinum foil, inclosed in a metallic box, from which it was separated at all points by a space of 2-3 mm. (0.08-0.012 ins.). The box was in electrical communication with the earth and thus served as a negative electrode. The electrical discharge took place between the sheets of foil and the metallic box. Air forced through this apparatus was ozonized. In order to supply the high potential desired, Mr. Schneller designed two step-up transformers which were operated in series, taking current from an alternating cur-

Serial No.	Date.	Type of Sterilizer.	Kind of Water.	No. of colonies of Bacteria per c.c. before ozonization	Mgr. K MnO4 before ozonization	Mgr. ozone per liter of air	Length of contact	Results, samples sterile. In all	per ct
I	29 XI 94	Experimental	Filtered Water.	862	—	0.058	—	7 in 8	86.5
II	29 XI 94	"	Filt. Water and Bacillus Fluorescens.	3,893	—	0.045	—	10 in 10	100.0
III	2 V 95	Improved.	Filtered Water	4,090	0.32	0.042	4 min	5 in 15	33.0
do	3 V 95	"	" "	670	0.32	0.042	4 min.	7 in 12	58.3
do	4 V 95	"	" "	258	0.35	0.045	4 min.	6 in 17	35.2
IV	7&18 V 95	"	" "	1,270	0.40	0.039	7-8 min	16 in 17	94.1
V	17 V 95	Large Apparatus.	" "	"	—	—	—	—	—
VI	15 V 95	Experimental.	Filt. Water and B. Ramosus.	28,000	—	—	—	12 in 13	92.3
VII	15 V 95	"	Filt. Water, B. Subtilus and B. Rubiginosus.	32,000	—	—	—	17 in 18	94.4
VIII	15 V 95	Improved.	Filt. Water and B. Coli.	7,830,000	0.027	0.039	10 min	12 in 12	100.0

Table II.—Old Rhine Water at Oudshoorn.

Results stated in parts per million.	Sample collected Sept. 18, 1896.		Sample collected Sept. 19, 1896.		Sample collected Sept. 20, 1896.	
	Before.	After.	Before.	After.	Before.	After.
Residue on Evaporation	242	240	241	242	256	248
Loss on Ignition, ...	24	20	24	24	28	24
Sulphate of Lime, ...	48.8	36.1	39.6	37.3	42.0	37.3
Carbonate of Lime, ...	103.6	107.8	128.9	127.1	112.5	101.8
Carbonate of Magnesia,	8.4	6.8	7.8	7.2	6.2	5.7
Chloride of Sodium, ...	41.0	41.0	29.3	29.3	29.3	29.3
Free Ammonia, ...	0.271	0.36	0.196	0.086	0.147	0.101
Albuminoid Ammonia,	0.364	0.202	0.536	0.198	0.287	0.205
Nitrous Acid, ...	0.0	0.0	0.0	0.0	0.0	0.0
Nitric Acid, ...	.142	.202	.71	.54	.274	.221
Phosphoric Acid, ...	0.0	0.0	0.0	0.0	0.0	0.0
Permanganate, ...	4.29	2.11	3.98	1.77	2.64	1.44

Table III.—Seine Water.

TABLES II. AND III.—EFFECT OF TREATING FILTERED WATER WITH OZONE.
(Parts per 1,000,000.)

Before ozonization.	Collected Aug. 26, 1897.	Collected Sept. 2, 1897.	Collected Sept. 4, 1897.	Collected Sept. 6, 1897.
Colonies per c.c. after 8 days,	916	1056	1728	612
Organic matter,	0.035	0.043	0.038	0.039
Chlorine,	0.012	0.018	0.018	0.017
Color at a depth of 60 centimeters,	yellow, slightly opalescent.	id.	id.	id.
Taste,	good.	id.	id.	id.
Smell,	good.	id.	id.	id.
After ozonization.				
Colonies per c.c.,	14 samples give an average 20 colonies.	10 sterile samples.[1]	12 sterile samples.[2]	10 sterile samples.
Organic matter,	0.022	0.028	0.028	0.016
Chlorine,	0.012	0.019	0.018	0.0175
Nitrites,	0	0	0	0
Color at a depth of 60 centimeters,	bluish, absolutely transparent			
Taste,	good.	id.	id.	id.
Smell,	good.	id.	id.	id.
Conditions under which the experiments took place,	Discharge: 300 liters per min.	id.	id.	id.
	Voltage: 85	110	90 to 100	90 to 100
	Contact: 5 min	id	id.	id.
	Concentration of ozone: 0.0025 to 0.003	0.0042	0.004	0.004

[1] One tube gave a single colony of *Bac. fluor. liq.* probably arising from the air.
[2] Three tubes gave some colonies of the same microbe.

Table IV.—Analyses of Brussel's Water Before and After Treatment with Ozone. (Parts per 1,000,000.)

rent dynamo giving 100 volts and 14 amperes and transforming it to 50,000 volts. It was found advantageous to subject the air to several ozonizations. This was done by forcing it through a battery of ozonizers. The air, however, was first freed of dust by filtration through cotton, then dried by passing through desiccators containing calcium chloride and sulphuric acid, and finally refrigerated by the aid of an ice-making machine. The air was further chilled on its passage between the ozonizers.

On leaving the ozonizers the ozonized air was forced by a pump to the sterilizers. Two models of sterilizer were tried; in one a rain of water met an atmosphere of ozone and the other the ozone was bubbled through a column of water. The bubbling system appears to have been the more economical, and it is the one subsequently preferred by Mr. Tindal.

Unfortunately, Professor Van Ermengem's report does not deal with the economic questions involved in Mr. Tindal's plant at Oudshoorn. It concerns itself only with the qualitative efficiency of ozonization.

The first public demonstration of the Tindal system of purifying water by ozone was made at Paris, at the Hygienic Exhibition on the Champ de Mars, in 1896. The plant was tested as to its capacity for sterilizing the water of the Seine, by Dr. Marmier and Dr. Repin, of the Pasteur Institute. A memoir by Dr. Repin, entitled "Sterilization de l'eau par l'ozone," appears in Rev. Gen. des Sciences, Vol. VII., p. 596. The line of investigation was similar to that pursued by Van Ermengem at Oudshoorn, and the qualitative results were much the same. The electric current used for the ozonizers was taken from an electric light alternating current machine of 120 volts, 10 amperes, which was transformed to 50,000 volts for the silent discharge. The ozonizers consisted of a series of glass-lined boxes, 25 × 35 × 60 cm. (10 × 14 × 24 ins.). Supported in each box, and insulated from it, was a rectangular package of platinum foil sheets. Opposite the edges of the platinum, and upon the glass, were fastened sheets of gold. Glycerine-and-alcohol resistance cells, similar to those already described, were suspended above the boxes. The silent discharge took place between the platinum and the gold. All other apparatus was substantially such as had been used at Oudshoorn. The sterilizers brought about a contact between the ozone and water by bubbling. The water was filtered through sand before ozonization. The effect of the process was satisfactory, and in Table III. may be seen the results of three chemical analyses of Seine water before and after ozonization. Dr. Repin says that where water does not contain more organic matter in solution than is represented by 0.004 gram permanganate per liter, 5 cu. m. may be purified by the expenditure of 600 watts (about 0.6 HP. per 1,000 gallons.)

The third installation of the Tindal system was constructed at the Brussels International Exhibition in 1897, where it was made the subject of investigation by Professor Van Ermengem and Prof. Leon Gerard, of the University of Brussels. The research was made in order to secure information which would assist in improving the sanitary condition of towns on the Belgian coast whose water supplies are well known to be frequently inferior in quality. At first the water treated at Brussels was that of the general city supply, which is obtained from infiltration galleries. Later, with smaller apparatus, samples of 200-250 liters (52 to 65 gallons) collected elsewhere, were ozonized. Mr. Tindal's apparatus at the Brussels Exhibition had a capacity of 432 cu. m. (114,000 gallons) of treated water per day. The plant was essentially like those already described. The consumption of energy per gram of ozone produced, was 244-252 watts (0.3 HP.). The electrical energy per cubic meter of water sterilized, was 75-95 watts (about 0.5 HP. per 1,000 gallons). The cost of ozonizing water containing 0.1 gram organic matter per liter was less than 1 centime per cu. m. (about ⅕ ct. per 1,000 gallons). The experiments at Brussels confirmed the favorable reports already made upon the Tindal system and demonstrated that some highly polluted waters may be satisfactorily purified upon a commercial scale when they do not contain organic matter in suspension. The effect of ozonizing Brussels water may be seen in Table IV. Experiments with water from the Ostende supply, from the canal of Plaschendael and the canal of Bruges, two possible sources of water supply, are indicated in Table V. Interesting details concerning the energy absorbed in producing ozone by the Tindal process may be seen in Table VI.

	Water from the Ostende Water Supply.	Purified Water from the Ostende Wat. Sup.	Water from the Canal at Plaschendael.	Water from the canal at Bruges.
Before Ozonization.	Collected Sept. 2, 1897.	Collected Sept. 2, 1897.	Collected Sept. 15, 1897.	Collected Sept. 15, 1897.
Colonies per c.c.	6,528	6,848	389,280	1,430,000
Organic Matter	0.0985	0.0361	0.080	0.102
Chlorine	0.280	0.298	0.124	0.208
H_3N saline	mgr. 0.66	0.06	0.01	0.9
H_3N albuminoid	mgr. 0.35	0.21	0.18	0.31
Nitrites	0	Trace.	Trace.	Trace.
Nitrates	Trace.	Trace	Trace.	Trace
Resid. on Evap.	0.742	0.896	0.556	0.696
Loss by Calcin.	0.80 blackened	0.108 blackened	0.120	0.108
Color	yellowish, muddy	id	yellowish.	dirty green, brownish
Taste	muddy	id	id	very dirty green
Smell	marshy	id	id	very dirty green
After Ozonization				
Colonies per c.c.	10 sterile samples	10 sterile samples.	10 sterile samples.	10 sterile samples
Organic Matter	0.0635	0.022	0.052	0.055
Chlorine	0.268	0.271	1.104	0.184
H_3N saline	0	0	0	0.1
H_3N albuminoid	mgr. 0.01	0.06	0.04	0.18
Nitrites	0	0	0	0
Nitrates	Trace.	0	Trace.	Trace.
Resid. on Evap.	0.728	0.610	0.475	0.736
Loss by Calcin.	0.082	.060	0.120	0.080
Color	null bluish	id	id	Slightly pinkish after having been greenish.
Taste	good	id	id	id
Smell	good	id	id	id
Conditions under which the experiments took place.	Discharge: 1.5 liters P. M.	id	2 liters.	2 liters.
	Voltage: 90.	id	100	100
	Contact: 5 min.	id	6-8 min.	6-8 min.
	Concentration of ozone: 0.004	0.004	0.00374	0.00374

Table V.—Analyses of Water from Ostende and the Canals of Plaschendael and Bruges Before and After Treatment with Ozone.

There are in Europe at the present date two municipal sterilization plants operated upon the principles just outlined. Both were constructed by private enterprise, subject to the examination of competent scientific experts, and upon the demonstration of their capacity for purifying the water supplied to them, they were accepted and paid for by the municipalities. The first plant referred to is situated at Blankenberg, on the Belgian coast. It receives canal water filtered by the Howatson process, which in America would be considered a crude system of mechanical filtration.

The second municipal plant is situated at Joinville le Pont, in the environs of Paris, for the sterilization of Marne water, after filtration through slow filters. Details of the cost of sterilizing this water are as follows:

Energy required for ozonizer	3.0 HP.
" " " air pump	1.5 "
" " " water pump	12.0 "
Total energy	16.5 HP.
Cost per day, at 2 cts. per HP. hour	$7.90
Other daily expenses are:	
Salaries of three men at $200 per month	$6.66
Interest charge of 3½% upon $20,000 (cost of plant)	1.94
Interest charge of 4% upon $20,000 (to cover depreciation)	2.22
Total salaries, etc.	$10.82
Cost of energy	7.90

Capacity of plant, 3,170,000 gallons per 24 hours. Operating (total.—ed.) expense, $18.72 per day. This is at the rate of $5.90 per million gallons.

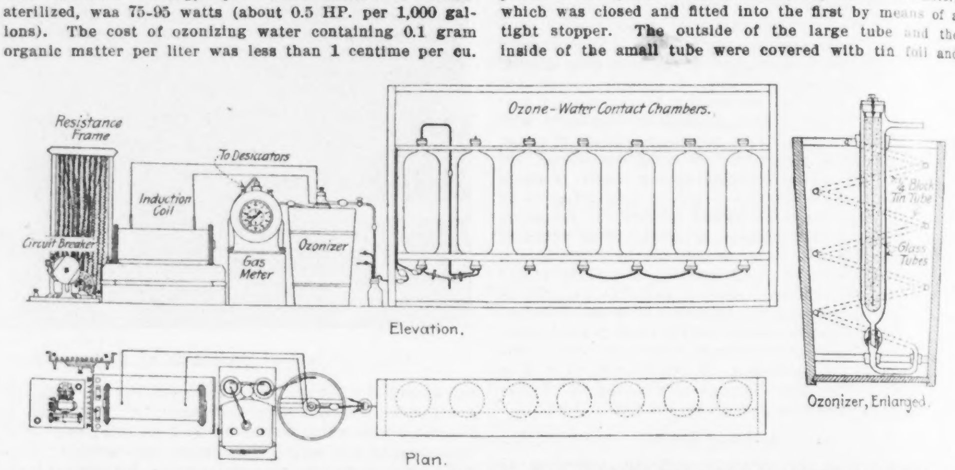
Current supplied to Transformers.			Liters of air ozonized per minute.	Grams of ozone per hour.	Grams of ozone per cm. of air.	Total [illegible] consumed [illegible] Watts.	Watts per gram of ozone.
Amperes.	Volts.	Watts.					
22.6	73.64	1665.26	39.875	7.35	3.07	1858 H. P. [illegible]	252
28.55	80.50	2298.28	41	10.578	4.3	2568 H. P. [illegible]	244

Table VI.—Details Concerning the Production of Ozone by the Tindal System at the Brussels Exposition.

My Laboratory Experiments.

The apparatus employed by me for the production of ozone and its application to the purification of water consisted of a motor-circuit-breaker producing 4,000 breaks per minute, an 18-in. Ruhmkorff coil, a Siemens tube, a gas meter, and some glass-chambers in which the ozone and water were brought into contact. Current was taken from the electric light installation of the University grounds, and the water operated upon was usually the Croton supply, previously filtered through "Continental" rapid filters, containing charcoal and sand. Most of the electric current was cut out by a resistance frame and shunt, and only a small portion was allowed to enter the Ruhmkorff coil. The spark obtained from the latter under these conditions was 5 ins. long.

The ozonizer placed at my disposal was an old Siemens tube 18 ins. long and 1¾ ins. outside diameter. One end of the tube tapered to a ⅜-in. tube, 2 ins. in length, and at the other end there was a tubulation of the same diameter. Within the large tube, and separated from it by pieces of cork, was a second tube, 1⅛-ins. in diameter, which was closed and fitted into the first by means of a tight stopper. The outside of the large tube and the inside of the small tube were covered with tin foil and



SKETCH OF APPARATUS USED IN EXPERIMENTS ON THE TREATMENT OF WATER BY OZONE.
Geo. A. Soper, Engineer and Chemist.

suitably arranged with separate wire connections. Eventually the inner foil was replaced by tin filings. The whole rested on a wooden stand, in a horizontal position. Air was passed into the annular space between the glass walls of the two tubes, through the side tubulation and ozonized by contact with the silent discharge of electricity which took place when the wire connections of the ozonizer were joined to the poles of the Ruhmkorff coil. It was soon found in practice that the ozonizer thus operated became very hot, and that some means for cooling the air and reducing the temperature of the ozonizer were needed. Various plans and several ozonizers were tried, with the result that an ozonizer of the following description was adopted. A ¼-in. block tin tube was fastened in the form of a worm about the inner walls of a cedar bucket 19 ins. high and 13 ins. in diameter. The lower end of the worm passed through a permanent false bottom, downward at the periphery and upward at the center. Here it was joined to the old Siemens tube, whose pointed end was hermetically sealed to the block tin pipe. The upper end of the Siemens tube projected slightly above the top of the bucket so that the side of the tubulation was conveniently connected to tubes supplying the sterilizers. The bucket was then filled with water. As desired, a freezing mixture or a current of cold water was maintained in the bucket, with the result that the air feed was kept at a low temperature and the ozonizer was prevented from heating. It is believed that this arrangement is novel. The air to be ozonized was first filtered through cotton to remove dust particles, then measured through a gas meter, passed through a scrubber of pumice stone and potassium hydrate to remove carbon dioxide and finally through a scrubber of pumice stone and sulphuric acid to dry it, whence it proceeded to the ozonizer. The air was kept in motion by an aspirator attached to the sterilizer, which produced a negative pressure in the whole apparatus.

The water experimented with was at first held in eight-gallon tincture bottles, and ozonization was effected by pasing bubbles of ozonized air through six gallons of water thus contained. Difficulties with temporary connections, however, made it impracticable to continue the

		Parts per million.	
		Before.	After.
Turbidity,		none	none
Color,		2½	1
Odor	Cold,	none	none
	Hot,	none	none
Chlorine,		4.	4.
Residue on Evaporation,		54.	54.
Loss on Ignition,		33	30.
Nitrogen as	Albuminoid Ammonia,	170	.090
	Free Ammonia,	060	.056
	Nitrites,	trace	none
	Nitrates,	75	.800
Bacteria per c.c. after 48 hours in gelatin,		416	41

Table VII.—Analyses of Croton Water Before and After Treatment by Ozone, March 16, 1899.

use of bottles. Another plan of ozonization consisted in atomizing a small stream of water with a current of ozone, and for this purpose the bottles described were turned upside down and atomizing devices attached through the stoppers. By properly regulating the supply of ozonized air and water, the bottles could be filled with a fine spray or heavy rain. This collected upon the sides of the bottles, ran down and was carried off by an exhaust. Atomization made it necessary to provide a second bottle to catch the product, and with such an arrangement it was difficult to determine the interval of contact between the water and ozone. A cylinder of stout glass, 25 ins. long and 6 ins. in diameter, abruptly tapering at the ends and fitted with stoppers, was then selected to replace the bottles, because of the facility with which water and ozone connections could be made at its top and bottom. With this form of sterilizer arranged as an atomizer, several interesting tests were made.

A dark-brown infusion of tobacco leaves was prepared and filtered. Of this filtered infusion enough was added to a quantity of distilled water to produce a color corresponding to six of Hazen's platinum-cobalt standard scale. After atomization the color was reduced to three of the standard. A second atomization reduced the color to one. The total reduction of color was, therefore, 83.3%. Subsequent tests gave results similar to the foregoing, but it was found, when Croton water was substituted for distilled water, that the product became opalescent. In all cases the last traces of color were slow to disappear.

With the idea of testing the effect of ozone upon disagreeable odors, such as occasionally give rise to complaints against water supplies, the following series of experiments were arranged. Nearly equal weights of herring, onion, geranium leaves, cinnamon and putrid beef were soaked in separate bottles of distilled water for 48 hours, and then filtered off. The odors absorbed by the water were very pronounced. Each sample was then atomized with ozonized air, and the odor again noted. The reduction was considerable in each case. After a second treatment there was scarcely any odor perceptible in the herring, beef and onion waters. The geranium and cinnamon samples smelt slightly of ozone, but whether they had absorbed enough ozone to make the odor noticeable or whether it was due to a mechanical admixture of ozonized air was not apparent. Upon aerating the water the smell of ozone disappeared.

In the color and odor experiments it was observed that a definite time interval was required in order to insure a proper reaction with the ozone and that no matter how intimate the contact, purification was not instantaneous. Supposing it might be more important to provide for a long exposure than a particularly intimate one, apparatus was devised whereby a fairly intimate contact could be maintained for a longer period. The plan had the further advantages of requiring less power to keep the water and air in circulation. Into the top of the cylinder described was set a small glass aspirator. Water to be treated was furnished to the aspirator under suitable pressure, and as it passed through the aspirator it entrained ozone. Ozone and water then passed into the cylinder, where the water fell upon a plate and spattered to the sides. It was found that the use of the aspirator required too much water for the quantity of ozonized air entrained.

The next form of sterilizer used consisted of a series of seven cylinders like the one already described, arranged in a row in a permanent wooden case. The battery of cylinders was first connected at the bottom by block tin piping, ⅛ in. in diameter, in such a way that ozonized air and water which was made to enter the first, would pass in succession through each cylinder. The outlet end of each tube was reduced, to give force to the water leaving it. When the system was in operation, a continuous spray was formed through all the cylinders. Experiments were made with various coloring agents in this apparatus.

Date. 1899	Period of Contact.	Permanganate.			Bacteria per c.c.			Color.		
		Before.	After.	Percent. Dif.	Before.	After.	Percent Dif.	Before.	After.	Percent. Dif.
Mar. 14.	10 min.	1.8	1.7	5.5	560	320	42.8	1.50	1.00	30.00
" 21.	15	1.9	1.6	15.7	721	91	87.5	2.00	1.00	50.00
" 28.	20 min.	1.9	1.5	20.5	3,938	512	86.9	2.00	1.00	50.00
Apr. 7.	10	1.7	1.6	8.5	13,018	2,373	81.9	2.00	1.75	12.50

Table VIII.—Analyses of Croton Water Before and After Treatment by Ozone.

Very dark infusions of dried leaves, darker than the color of any water which would be likely to be considered fit to drink, were completely bleached by this system. Solutions of red and blue litmus, indigo and alizarine were also decolorized. It was evident that such thorough and protracted contact would probably not be required for any drinking water to be met with in practice, and there were practical difficulties in the way of using the battery as permanent atomizers. Air pressures were difficult to manage in so many large chambers.

The second form of adjustment of the cylinders was as follows: Cylinders Nos. 1 and 2 were connected at their bases so that either could be filled or emptied readily, and a free communication opened between them. From the top of cylinder No. 1 to the bottom of cylinder No. 2, a glass tube was fitted. Further, there were tubes for the ozonized air to enter at the bottom of No. 1, and escape at the top of No. 2, where an aspirator was connected. Between the ozonizer and sterilizers was a series of cocks for regulating the quantity of water, ozone and air which it might be desired to draw into the cylinders. This was the final adjustment of the apparatus. The water to be treated is ordinarily run into sterilizers Nos. 1 and 2, until they are two-thirds full. Cylinder No. 3 is filled at the same time and kept closed in order that its contents may serve as a comparison. The other cylinders are permanently out of service in this adjustment. When the preparations indicated have been made, the electricity is turned on and the aspirator opened. Ozonized air bubbles up through the first and second cylinders until their contents are sufficienty purified. In operating the apparatus with a continuous supply of water, the water is admitted at the bottom of No. 1 and withdrawn at the bottom of No. 2. If a case should arise in which further ozonization was desired, other cylinders could be connected to Nos. 1 and 2, in the manner described for Nos. 1 and 2.

My chemical analyses of Croton water before and after treatment by this system have shown a notable degree of purification. Nitrites disappear, albuminoid ammonia and free ammonia are oxidized, and a considerable reduction in color effected. As previously indicated, odors are destroyed by ozone and the water after treatment is attractive to the sight and taste.

It was found that the sterilizing power of ozone is a difficult question to investigate in a laboratory not especially suited to the refinements of bacteriological technique. My bacteriological results show a decided reduction in the number of bacteria after ozonization, which agrees with the partial removal of color and organic matter already alluded to.

Conclusions.

A consideration of the facts here presented leads to the conclusion that drinking water can be sterilized, and that unpleasant colors and odors arising from organic impurities can be removed by ozone. It remains to be shown what class of waters are best suited to the treatment and the conditions under which ozonization may be successfully carried on.

The action of ozone in the artificial purification of water is a chemical one. It is unlike other methods in that no mechanical or biological actions contribute to the result. By ozonization, chemically active oxygen is brought into contact with oxidizable impurities, which thereupon suffer transformation into more stable compounds. No suspended matters are removed or destroyed, except the bacteria, and in this respect the ozone treatment differs from the more familiar methods of filtration and sedimentation. Consequently, the class of waters susceptible of purification by ozone are generally free from organic particles. Such, for example, are clear, colored or foul-smelling surface or ground waters and the effluents of improperly acting filters.

The claims made for the ozone treatment of water are distinct and its functions are as clearly defined as are those of filtration and sedimentation. Ozonization aims to eliminate bacteria from water and to destroy unpleasant colors and odors of vegetable origin. From a consideration of all obtainable data I am led to the conclusion that this result is possible.

The function of ozonization puts at a discount the possible ignorance and carelessness of filter keepers and places the responsibility for pure water in the hands of electricians and enginemen whose familiarity with machinery makes them competent to manage the mechanical details of the process. There is no cleaning of apparatus in the ordinary case, no stopping and little regulating to be done. The proper dose of ozone is known by the presence or absence of its peculiar odor when observed at the top of the water column.

Ozonization is in no sense a straining process, and from its nature could not be expected to sterilize waters containing large quantities of matter in suspension. Consequently for the proper treatment of water by ozone, filtration is in most cases indispensable, but the kind of filtration which may be termed a simple straining, is as effective as any other in preparing the water for ozonization.

Of special importance is the completeness with which ozone destroys unpleasant odors in water. When filtered water or ground water is exposed to heat and light, forms of vegetation are apt to grow and cause trouble. Films or cloudy masses of algæ appear under such circumstances, and frequently cause fishy, pungent, aromatic or disgusting tastes and odors in the water. It seems certain that ozonization of such a water, previously filtered to remove the objectionable organisms, etc., would restore it to its former acceptable condition.

I desire to make suitable acknowledgment to Professor C. F. Chandler for the privilege of using his private laboratory and lecture apparatus for the purposes of my experiments, and for his kindness in furnishing me with literature, sometimes taken from his personal library.

MANUFACTURE OF THE CAST STEEL VOUSSOIRS FOR THE ALEXANDER III. BRIDGE, PARIS.

(With two-page plate.)

Manufacture.

The foundry methods adopted in casting the 510 steel voussoirs and pedestal castings composing the 15 arch ribs of the new Alexander III. Bridge, now under construction across the River Seine, in Paris, were of an unusually interesting character. Five well-known steel works were employed in the task, and the work was divided between them as follows: Forges de Chatillon et Commentry, four arches, including the two exterior ones; Forges et Acieries de la Marine et des Chemins de Fer (Saint Chamond), four arches; Forges et Acieries du Creusot, three arches; Forges et Acieries de Saint Etienne, two arches, and Acieries et Forges de Firminy, two arches. Each of these establishments was allowed, with certain restrictions, to carry out the work in its own way, and naturally there was considerable variation in the methods adopted. The principal details of these methods are illustrated in the accompanying cuts, and are fully described in "Annales des Ponts et Chaussees," for the first quarter of 1899, from which we abstract the following facts.

The main structural features of the Alexander III. Bridge have already been described in Engineering News of April 21, 1898, and May 25, 1899, but a brief summary of such details as relate to the foundry work will enable it to be more clearly understood. The bridge is a three-hinged arch, with a span of 107.5 m. (352.6 ft.), c. to c. of end pins, and a width of 40 m. (131.2 ft.). The arch ribs composing the bridge are 15 in number, spaced equal distances apart, and, as indicated above, are composed of voussoir-shaped steel castings bolted together to form a continuous rib. For æsthetic reasons the two outside ribs were made different from the 13 intermediate ribs. In elevation this difference is but slight, but the section of the outside ribs was made channel-shaped, and that of the intermediate ribs, I-shaped. Each arch rib was divided into 32 voussoirs proper and two pedestal or shoe castings. The end and two center voussoirs of each rib are designed to carry the pins and are somewhat complex in shape, but the others are forms of either I-beam or channel section flanged on all four sides, with the flanges braced to the webs by brackets, and are made wedge-shaped exactly like the ring stones of a masonry arch. Complete details of the arch rib construction were published in Engineering News of May 25, 1899, which can be consulted for further information.

Assembling Floors.—The first work to be done preparatory to the casting operations was to calculate the dimensions and exact contour of the voussoirs. This being done, full size drawings were furnished to each of the steel works under contract to furnish the castings, together with a standard double meter measure provided by the contractors for the erection. Each steel works was also required to provide a special laying-out floor or platform upon which the arch rib castings could be assembled in the exact positions they were to occupy in the completed bridge. At the Firminy and the Saint Chamond works, concrete floors covered with iron plates were employed, the outlines of the assembled voussoirs being traced on the iron plates. At the Creusot works, a heavy timber platform was built. Upon the floor of this platform were placed iron plates at the lines of the joints and connections of the vertical supports for the roadway; and at the lines of the extrados, the intrados, the medium curve and the chord to the medium curve were set strips of U-iron, the contours being traced upon these metal surfaces. At the works of the Chatillon & Commentry, a series of isolated marble pedestals at the joints of the voussoirs were employed instead of a single platform. One reason for this was that in assembling the outside ribs it was necessary to get underneath the voussoirs where they were laid out in order to get at all of the connections. This firm also arranged to lay out two half-arches at once, the two lines of supports being arranged side by side, as shown by Fig. 1. The marble caps to the pedestals were mounted upon steel rails planned to a level and arranged so that shims could be inserted to correct changes in level which might take place in any of the 17 pedestals during the interval elapsing between the assembling of successive arches. The necessary contours were traced on the marble tops to the pedestals. At the Saint Etienne works the assembling platform used resembled those employed at the works of Chatillon & Commentry. After the contours had been traced on these platforms by the respective works they were verified by the Government engineers.

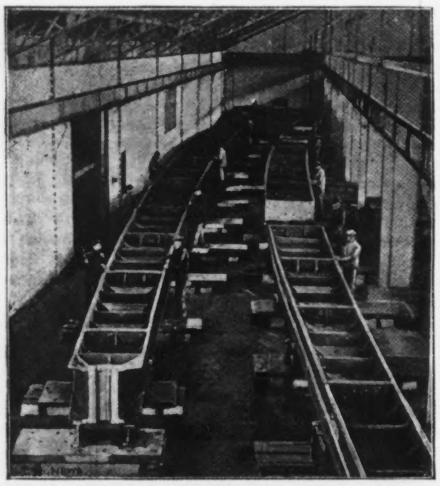
The reasons for these great precautions to avoid error were considered by the engineers of the bridge to be justified by the peculiar nature of the work. In ordinary structural work, such precautions are rendered unnecessary by the fact that each member goes through so many different measurements in performing the shop work that any error in the dimensions originally marked off is pretty sure to be discovered and corrected before the work has gone far. Furthermore, in case an error is made, it does not require a great length of time or much labor to replace the useless member with a new one. In the preparation of one of the cast steel voussoirs, however, from the time the model was received until the piece was ready for assembling, required two months, making the shipping of a piece having wrong dimensions a somewhat serious matter, considering that the time allowed for erecting the bridge arch was restricted to the shortest possible time in which the work could be done by the necessity of not disturbing navigation any more than could be helped.

Models.—Timber models were made for each voussoir of a half-arch rib in each works having the casting of the intermediate arches, and also for an entire exterior arch rib in the Chatillon & Commentry works, which cast the two exterior arches. The slight changes necessary in these models to make them suitable for the opposite half-arch to those for which they were particularly designed were accomplished by fastening thin strips of the necessary form to the extrados of the original models. A shrinkage of 18 mm. per 1 m. was provided for in making the models.

Molding.—The method of molding was similar in all of the five works, the voussoirs being molded lying flat, and the mold consisting of a bottom section, and intermediate section or cope embracing the full width of the flask, and a top or cover carrying suspended the upper cores. The cope was sometimes made in two parts, to facilitate the removal of the models. The cores were constructed of a crust of sand enveloping a mass of coke, and were supported either by metal skeletons, or iron bars, or by trellis work of iron straps. In some of the works the parts of the mold in contact with the metal were made of pulverized crucible dust. The molds, when finished, were taken to the drying stoves, where they remained 36 hours subjected to a temperature of 250° C. to 300° C. Upon removal from the ovens the molds were finished up by stopping up all the fissures produced by the drying, and by coating the surface with a liquid mixture of refractory clay and graphite, which was dried by flame. In order to ensure a smooth surface to the exposed webs of the exterior arch voussoirs, they were molded with the web of the channel section at the bottom. This necessitated unusually large suspended cores, which required unusual care in the molding.

Position of the Molds for Casting.—Each of the different steel works placed the molds in an inclined position for casting, but the angle of inclination adopted and the number and positions of the rising heads varied considerably. At the Chatillon & Commentry works the mold was given an inclination of 10 cm. per 1 m. (1 in 10), with two rising heads placed as shown by Fig. 2. At the Cruesot works the inclination of the mold was 0.175 m. per meter, and the number and arrangement of the rising heads were as shown by Fig. 3. At the St. Etienne works the inclination of the molds was 10%; at Firminy, 43%; and at St. Chamond, 173%, or 60°, Figs. 4, 5 and 6. These illustrations also show the position and dimensions of the rising heads. The method of arrangement for the hinge voussoirs naturally varied from that described. Fig. 7 shows the arrangement adopted by the Chatillon & Commentry works.

Casting.—The voussoirs were exposed to two sorts of danger during the casting and cooling. The first of these was the prevention of free shrinkage by the binding of the mold. For instance, the stiffeners of the web, if prevented from following the shrinkage of the web to which they are attached, might separate from it at the joint. The second danger was the formation of shrinkage cracks by unequal cooling. Various plans were adopted by the different steel works to avoid these possible dangers. At the St. Chamond and the St. Etienne works the metal was poured rapidly at first, and then more slowly, in order to permit it to settle thoroughly and to allow the gas to escape. At the St. Jacques works the casting was allowed to harden for 15 mins., and then the rising heads were removed and the flask fastenings were loosened. At the Creusot works the casting was removed from the mold the day after it was poured, and put into an annealing furnace, where



View Showing Manner of Assembling the Arch Ribs at the Works of Chatillon & Commentry; Alexander III. Bridge, Paris, France.

it was allowed to cool slowly from 800° C. At the St. Chamond, Firminy and St. Etienne works the castings were allowed to remain in the molds for from 48 hrs. to four or five days.

Annealing.—All the castings were annealed to destroy the cooling strains and prevent interior crystalization, but the length and character of the annealing process varied in the different works. At the St. Jacques works the operation lasted 98 hours, the temperature being raised during 30 hours to 950° to 1,000° C., and maintained there for 6 hours, and the cooling continuing for 62 hours. At St. Chamond the temperature was raised in 24 hours to 1,000° to 1,050° C., and maintained for four hours. The casting was then left to cool to 600° for 12 hours with the furnace hermetically sealed, and then for 12 hours more with the furnace open. The total operation took 52 hours. At St.Etienne the temperature was raised in 36 hours to from 1,000° to 1,100° C., and then maintained for six hours. The cooling occupied from 30 to 36 hours, and the whole operation took from 72 to 80 hours. At the Firminy works the temperature was raised in from 35 to 40 hours to 900° C., and then suddenly reduced to 600° C., by opening the furnace. The furnace was then sealed and the casting allowed to cool gradually for 45 hours. The total operation thus lasted from 80 to 85 hours. At the Creusot works, besides the preliminary annealing already mentioned, the temperature was raised during twelve hours to 1,000° C., and maintained there for two hours. The casting was then quickly cooled to 700° C., and then, with the furnace sealed, cooled slowly for 12 to 14 hours. The total operation was thus only from 26 to 28 hours. After the annealing a rough finishing took place, and the metal was tested.

Tests.—The tests made to determine the quality of the metal in the voussoirs consisted of both tensile and impact tests, and their nature was fully described in our issue of May 25, 1899. Careful notes were also taken of the physical appearance of the casting, chemical analyses were made, and the process of manufacture, which each test piece had undergone, was recorded. Only a brief summary of this information is possible here. The average strength, elongation, specific gravity of the steel tested were as follows:

	Lbs. per sq. in. Elastic limit.	Lbs. per sq. in. Tensile strength.	Elongation, %.	Specific gravity.
Arches, A, H, L, O	35,841	75,951	16.8	7.768
" B, F, J, N	32,855	68,413	20.4	7.782
" C, G, M	51,487	93,446	16.2	7.774
" D, O.	37,122	71,542	19.7	7.798
" E, K	46,225	81,355	12.9	7.730

Shop Work.—After the castings had been roughly dressed they were taken to the shops and the direction and plane of each joint accurately marked off by means of gages or templates. The bearing surfaces were then planed, and, in some cases, ground, to a true fit. The boring of the bolt holes and assembling of the voussoirs on the laying-out platforms followed, and here all contours and dimensions were verified for the last time. This finished the shop work, except the weighing, painting and numbering of each casting ready for shipment. While the shop work called for care, it will be seen that it presented very little that was unusual in character.

Erection.

The general method of erecting the arch ribs for the Alexander III. Bridge was described in our issue of May 25. Briefly summarized, a steel truss or traveler resting on carriages on the opposite banks of the river was built to span the whole length of the arch. This traveler carried two trolley systems for handling the voussoirs, and from it was suspended the centering for the arch ribs for a distance of 50 m. (164 ft.) at the center of the stream. On each side of this 164-ft. center space the centering was built on permanent falseworks. Fig. 8 is a cross-section showing the method of suspending this movable centering from the traveler above, and Fig. 9 is a longitudinal section showing the same thing.

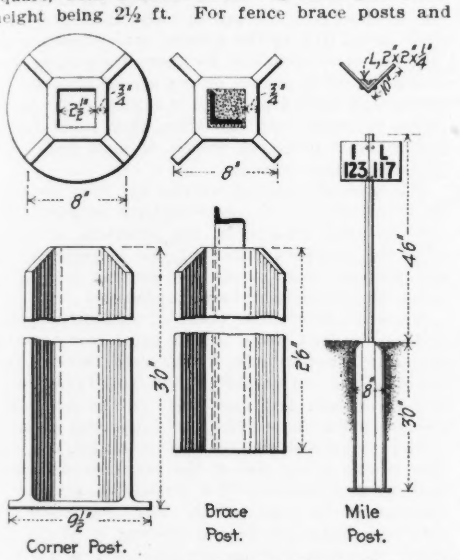
The suspension rods from each panel point of the overhead traveler carried a cross beam of two channels fastened back to back, and on top of these successive cross girders were placed two pairs of I-beam longitudinals spaced so as to come directly under the arch ribs being erected. The cross girders were also braced together by timbers, and the whole was floored over to make a working platform. Figs. 8 and 9 show this construction. It will also be noted that the suspension rods are hinged at both ends, and are provided with turnbuckles. This construction not only made perfect adjustment possible, but allowed of individual rods being removed when they were in the way of the erection work. The castings were picked up at the shore ends of the traveler and carried to their positions in the arch ribs by means of the trolleys. As shown by Figs. 8 to 11, inclusive, these trolleys were moved longitudinally by means of endless chains operated from the shore. The lifting and lowering movements were obtained by means of a fall-block held in the loop of a wire rope running from the shores over and down between sheaves on the trolley carriage.

By means of the trolleys all the voussoirs for an arch rib were first placed in position upon the centering, and then the adjustment and connection of the separate voussoirs were completed, beginning at the abutments and working toward the crown. The adjustments and connections being completed, the work of striking the center is begun. This is accomplished by raising the arch ribs slightly by means of jacks (Fig. 12), removing the blocking, and then easing up the jacks until the rib swings clear. The jacks employed were dynamometer jacks, so that the engineers were able to calculate just what proportion of the weight of the arch rib each should carry according to its position, and to give it exactly that weight at all times during the process of raising and lowering the rib. The object of this careful manipulation was evidently to prevent the wrenching of the voussoir or ring joints which would tend to result if the weight of the rib fell unequally upon these isolated points of support.

As indicated by the drawings, the arch ribs were erected in pairs, and the average time consumed in erecting each pair of ribs was 20 days. Considering the structure as a whole, the first pair of arches was swung clear on Dec. 3, and the last pair on the following May 19.

AN IRON AND TILE POST FOR TRACK SIGNS AND FENCES.

The use of some more permanent material than wood for the posts of railway signs and fences is becoming quite extensive, and we illustrate herewith a style of post which is being introduced for railway and general work. The post is of iron, set in a base of vitrified clay, of the form shown, the height of the base being from 2½ to 4 ft., and the top being a little above the ground. For sign posts, the base is 8 to 10 ins. square over the arms, with a central hole 2½ ins. square, and its height is 3 to 4 ft. For fence posts, the base is 6 ins. square, with a central hole 1½ ins. square; the height being 2½ ft. For fence brace posts and



A Permanent Post for Railway Track Signs and Fences.
Indestructible Post Co., Makers.

corner posts, the base is made 8 ins. square and 3 ft. high, with a disk 9½ ins. diameter at the bottom. The thickness of the clay is from ½ to ¾-in. The post itself is of angle-iron for fences, and of angle-iron or T-iron for signs, according to the size and style of the sign. It extends to the bottom of the clay base, and is secured by a filling of Portland cement. The system can be adapted to any kind of plain or ornamental post.

These posts have been used for 40 miles of right-of-way fencing on the Chicago Junction Ry., and 2,000 fence posts have been supplied to the Cleveland, Cincinnati, Chicago & St. Louis Ry. The cost of the clay bases ranges from 10 to 25 cts. each, according to size. The posts, with or without signs and fencing, are supplied by the Indestructible Post Co., of Brazil, Ind.

HEAVY TRAFFIC ON THE CHICAGO LOOP.

The heavy local traffic in Chicago on Chicago Day, Oct. 9, was something exceptional, even for that city of parades and gatherings. Besides being a general holiday, the President was present to lay the corner-stone of the new Post-Office, and there were two elaborate processions or parades, one by night and the other by day. These attractions brought crowds of visitors from neighboring cities, to swell the crowds of Chicago people. The three elevated railways carried 452,000 passengers during the day, and as all these trains had to pass round the loop terminal, special means had to be taken to prevent any blocking of the traffic.

At each of the signal towers at the four corners of the loop, a man was placed on the roof of the tower, where he could see the line plainly, while another man at the foot of the tower was provided with a pad of special train orders. When the man above saw the track clear for two or three stations, he signaled the man below by means of an electric bell. The latter at once filled out an order and handed it to the motorman of the next train, directing him to run to a certain station, omitting all immediate stops, and thus enabling the next train behind to run to one of these intermediate stops. When the man gave a train order of this kind, he telegraphed the movement to the man at the next signal tower, so that the latter would not pass the same train or round the loop without a stop. The trains were handled entirely by special orders, and were kept moving as above described, so that they were loaded or unloaded and passed around the loop as rapidly as possible.

This did not always meet the passengers' convenience, but is was evident that if all trains were stopped at all stations on the loop, the traffic would be hopelessly blocked, especially as two of the lines were liable to be shut off from the loop occasionally by open drawbridges. A very short delay of this kind would suffice to produce a long line of trains waiting to cross as soon as the bridge was closed, and by running the trains ahead, as above described, they were got out of each others' way and unloaded as rapidly as possible. In this connection it may be interesting to note that a few days before, one of the bridges had been kept open 15 minutes. In order to prevent blocking the whole loop, trains for the line crossing the bridge were run on around the loop, thus allowing the trains of other lines to reach their junctions and pass off the loop. One train made the circuit of the loop four times before it could get across the bridge and proceed to its destination. This delay was, of course, exceptional, but indicates one of the difficulties to be encountered in operating the heavy traffic on the loop line.

Some idea of the traffic on the loop on Oct. 9 may be gathered from the fact that from 7 a. m. until midnight the number of trains was from 60 to 91 per hour. The greatest rush at the stations on the loop came between 9 and 11 p. m., when the night parade was over and everybody wanted to get home at once. During the two hours tickets were sold as follows: Metropolitan Ry., 21,162; South Side Ry., 15,708; Lake St. Ry., 10,712; total, 47,582. The following table gives a statement of the hourly traffic from 7 a. m. until midnight, as taken from official records, for which we are indebted to Mr. S. S. Neff, Superintendent of the Union Elevated Ry.:

Traffic on the Union (Loop) Elevated Ry., Chicago, Oct. 9.

Time.	Elevated railways: Metropolitan. Trns.	Metropolitan. Cars.	South Side. Trns.	South Side. Cars.	Lake St. Trns.	Lake St. Cars.	Total trains per hr.
7 a.m. to 8 a.m.	40	160	21	91	17	51	78
8 " " 9 "	30	120	24	120	22	66	76
9 " " 10 "	49	205	24	120	18	54	91
10 " " 11 "	40	185	24	120	19	57	83
11 " " 12 m...	40	191	26	129	20	60	86
12 m. " 1 p.m.	38	182	27	135	21	77	86
1 p.m. " 2 "	41	190	27	134	18	62	86
2 " " 3 "	40	183	27	135	20	72	87
3 " " 4 "	40	179	23	115	13	39	76
4 " " 5 "	40	184	25	125	12	36	77
5 " " 6 "	27	128	23	115	18	70	68
6 " " 7 "	23	107	22	110	17	55	62
7 " " 8 "	27	124	23	115	18	69	68
8 " " 9 "	31	139	26	130	25	87	82
9 " " 10 "	33	151	29	145	18	66	80
10 " " 11 "	28	128	18	90	24	87	70
11 " " 12 "	29	132	17	85	14	53	60
Total	596	2,688	406	2,014	314	1,061	1,316

	Trains.	Cars.
Metropolitan Elevated Ry.	596	2,688
South Side Elevated Ry.	406	2,014
Lake St. Elevated Ry.	314	1,061
Total	1,316	5,763

The movement of passengers per hour, from noon to midnight, at the eleven stations on the loop was as follows:

Time.	Elevated railways: Metropolitan.	South Side.	Lake St.	Total.
12 to 1 o'clock....	2,522	2,956	911	6,389
1 " 2 "	2,689	2,033	878	5,600
2 " 3 "	1,937	1,946	926	4,809
3 " 4 "	3,441	2,558	1,787	7,786
4 " 5 "	7,777	6,366	3,856	17,999
5 " 6 "	14,951	7,828	6,572	29,351
6 " 7 "	6,327	3,955	1,994	12,276
7 " 8 "	2,711	2,833	997	6,541
8 " 9 "	3,862	4,252	1,537	9,651
9 " 10 "	7,628	5,426	4,356	17,410
10 " 11 "	13,442	10,210	5,755	29,407
11 " 12 "	4,536	3,724	2,055	10,315
Total	71,823	54,087	31,624	157,534

The parade passed under some of the stations, and these were temporarily closed, as people alighting from the trains could not get into the streets. Special doors were put up and electric buttons were placed on the passenger bridge crossing the street below the floor of the station. Special policemen were on duty on these bridges, and when they saw that the streets and stairways were packed, they signaled the station agent and closed the doors as soon as the passengers from the last train were clear of the platforms. The platform man then displayed a sign, "Station closed, do not stop," and all trains then ran on to the next station.

It is estimated that after the night parade 216,000 persons were carried homeward by the elevated and surface lines, distributed as follows:

Metropolitan Elevated Ry.	55,000
South Side Elevated Ry.	48,000
Lake St. Elevated Ry.	38,000
Cottage Grove Avennue cable line	12,000
State St. cable line	20,000
No. Clark St., Lincoln St. & Clybourne cable lines	21,000
Madison St. and Milwaukee Ave. cable lines.......	12,000
Blue Island and Halsted St. cable lines...........	5,000
Electric lines having downtown terminals	5,000
Total	216,000

The total local traffic of the day is estimated at over 1,700,000 persons, about one-fourth of whom were carried by the three electric elevated railways. In order to handle the crowd at night after the parades, empty trains were run as expresses to the loop, the traffic to the city at that time being very small. The distribution of the day's traffic was about as follows:

Metropolitan Elevated Ry. (official)	187,000
South Side Elevated Ry. (official)	170,000
Lake St. Elevated Ry. (official)	95,000
Chicago City St. Ry.	450,000
West Chicago St. Ry.	325,000
North Chicago St. Ry.	225,000
Various steam lines	250,000
Total	1,702,000

As to the outside traffic, it is estimated that the railways brought 180,000 persons into the city in the morning from outlying towns and from places as far distant as Milwaukee, Detroit and Toledo. Of these, 150,000 were taken back the same night.

A QUICK METHOD OF CALCULATING THE WEIGHTS OF ELECTRIC CONDUCTORS.

L'Industrie Electrique describes the following method for comparing the costs of different materials, such as copper, iron or aluminum, for transmission lines. For a line of given length and resistance the weight of the conductor is proportional to the product of the specific resistance and the specific gravity of the material used. This product for iron is 78, for copper 14.24, and for pure aluminum 7.54. Thus we see that if aluminum costs about twice as much per pound as copper the cost of the line will be the same for these two materials. The actual weight of a line will be:

$$W = 0.000205 \frac{L^2 r S}{R},$$

where W = weight in lbs.,
L = total length of wire in ft.,
r = specific resistance in microhms per cu. cm.,
S = specific gravity,
and R = resistance of line in ohms.

THE AUXILIARY FIRE SYSTEM OF WHITE HAVEN, Luzerne Co., Pa., was devised by Mr. A. B. Dunning, civil and mining engineer, of Scranton, Pa., and is now in successful operation. This borough owns a second-class Silsbee fire engine, but the streets are so steep that delay followed any attempt to get it to a fire. It is therefore utilized as a stationary engine, as follows: At the engine house, in a central part of the town, a small reservoir is located holding about 1,800 gallons of water at all times and connected with the city mains. From this engine house radiate three separate lines of 4-in. pipe covering the town area, with hydrants at intersecting streets. In case of fire the fire engine is connected with this pipe system, the suction is dropped into the reservoir, and the valve opened admitting water to the reservoir from the city mains. A hose-cart, with 500 ft. of hose, is run to the hydrant nearest to the fire and connected, and is at once ready to operate. Waste-gates drain any water from the pipe system after use, and thus freezing is prevented. Automatic relief valves regulate the pressure on the pumping mains. The system is effective in this small town, and the cost does not exceed $6,000 for one mile of iron pipe, the hose-carriage and hose and pump and boilers.

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

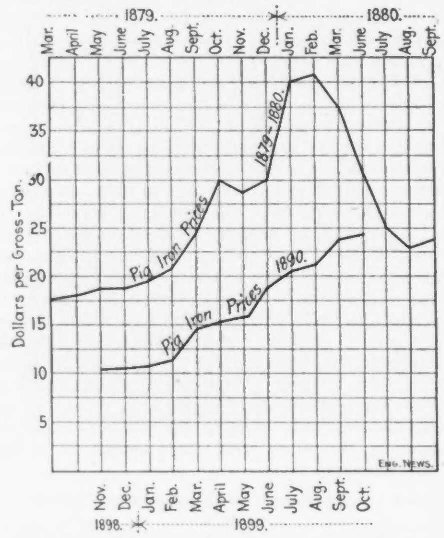
The treatment of water by ozone has been given some attention on the continent of Europe during the past few years. The work done by several investigators in this field is concisely reviewed elsewhere in this issue by Mr. Geo. A. Soper, who also gives an account of some experiments of his own, which, while conducted on a small scale, under great difficulties, are in some respects broader than the studies made heretofore. The European experiments indicate that water may be sterilized by ozone, provided it is free from suspended organic matter, the ozone not only having little or no effect on such matters, but its effect on bacterial life being reduced or nullified by such matter in suspension. Mr. Soper's experiments are not so conclusive as the foreign ones regarding sterilization, partly due to imperfect facilities for making bacterial examinations; but he is convinced that high colors and strong odors may be destroyed by treating water with ozone. He ventures no opinions, based on his own experiments, regarding the cost of destroying bacteria, color and odor in water, but does give figures for the cost of sterilization alone, at Joinville le Pont, in the environs of Paris. Here a municipal plant, of 3,170,000 gallons daily capacity, treats Marne water which has previously passed through slow sand filters. Allowing 3½ per cent. interest and 4 per cent. depreciation on a cost price of $20,000, the ozone treatment costs $5.90 per 1,000,000 gallons treated.

Until this figure can be materially lowered, or the necessity for previous filtration obviated, it seems very questionable whether the process will be generally practicable for city water supplies. To be sure, the filtration may be rapid, but even then there will be several dollars to add to the $5.90 for the ozone treatment. In addition, there is the marked disadvantage of having a complex plant to operate. Either slow sand or mechanical filtration will easily remove 98 to 99 per cent. of the bacteria from any water that does not require previous sedimentation, and where the latter is necessary without, it is even more necessary with, the ozone treatment. Some waters low in suspended matter, but of suspicious bacterial character, might possibly be rendered nearly or quite sterile with ozone alone, more advantageously than if brought to a high degree of purity by filtration alone, but this has yet to be demonstrated. However, work along this line should be encouraged, for few problems are more urgent today than that of obtaining pure water supplies from sources which with the increase in density of population are constantly being subjected to greater and greater pollution.

PIG IRON PRICES AND PRODUCTION.

The increase in tonnage and in prices of all iron and steel products, which began about a year ago, still shows no signs of having reached its climax. The latest monthly report of production of pig iron, from the statistics collected by the "Iron Age," shows a rate production of 278,650 gross tons per week on Oct. 1, against 215,635 tons on Oct. 1, 1898. The present price of Bessemer pig at Pittsburg is $24 per ton, against $10.50 per ton a year ago, and $9.25 per ton in July, 1897, the lowest monthly average figure on record.

The stocks of pig iron at furnaces, sold and unsold, not including holdings of steel works producing their own iron, on Oct. 1, amounted to only 120,541 tons, which is equal to only three days' production of the furnaces in blast. Notwithstanding the great increase in production and



Two Boom Periods in Iron Production and Prices.

in prices, there has been a steady shrinkage of the stocks on hand for several months.

A notable feature of the present statistics of production is that the average rate of production per blast furnace is considerably less than it was at the beginning of the year. On Jan. 1, 200 furnaces were producing 278,650 tons per week, or at the rate of 1,216 tons each, while on Oct. 1, 265 furnaces were producing 243,576 tons, or at the rate of only 1,052 tons each. In other words, the 65 more furnaces put in blast during this year produce only 35,074 tons per week, averaging 540 tons each, while those already in blast at the beginning of the year averaged 1,216 tons each. These figures mean that it is only the smaller furnaces, those which usually remain idle during periods of low prices, which have been put in blast during this year, a few new furnaces probably excepted.

The figures of production and prices of pig iron since June, 1897, are shown in the following table and in the accompanying diagrams:

As to reserve capacity of furnaces, which may be relied upon to meet the continually increasing demand, and to check the advance of prices, there is almost none. The furnaces in blast are undoubtedly being driven to the utmost capacity of which their blowing engines and steam boilers are capable. Those not in blast, not including small charcoal furnaces, which are practically out of the race for lack of fuel, are only 70, scattered all over the country, with a weekly capacity of

Date.	Furnaces in blast.	Capacity per week in gross tons.	[illegible]
Oct. 1, 1899	265	278,650	[illegible]
Sept. 1	257	267,335	[illegible]
Aug. 1.	244	267,672	[illegible]
July 1.	237	263,363	[illegible]
June 1	220	254,062	[illegible]
May 1.	217	250,095	[illegible]
April 1.	205	245,746	[illegible]
March 1.	192	228,195	[illegible]
Feb. 1	195	237,639	[illegible]
Jan. 1.	200	243,516	[illegible]
Dec. 1, 1898.	195	235,528	[illegible]
Nov. 1.	196	228,935	[illegible]
Oct. 1.	192	215,635	[illegible]
Sept. 1.	186	213,043	[illegible]
Aug. 1.	187	206,777	[illegible]
July 1.	185	216,311	[illegible]
June 1.	190	225,398	[illegible]
May 1.	194	234,163	[illegible]
April 1.	194	233,339	[illegible]
March 1	193	234,430	[illegible]
Feb. 1.	184	228,338	[illegible]
Jan. 1.	188	226,608	[illegible]
Dec. 1, 1897	191	226,024	[illegible]
Nov. 1.	183	213,159	[illegible]
Oct. 1.	171	200,128	[illegible]
Sept. 1.	161	185,506	[illegible]
Aug. 1.	152	165,378	[illegible]
July 1.	145	164,064	[illegible]
June 1	146	168,380	[illegible]

45,135 tons, or 645 tons each. One-quarter of this capacity, or 11,540 tons, is in 12 furnaces in Alabama.

It thus appears that if all the furnaces now out of blast could be put in blast, they would add only about 16% to the present rate of production. But this is not possible, for there are always some furnaces out of repair, others are dilapidated and practically abandoned, and if capital could be secured to repair and run them they could not be put in blast until the period of high prices will probably have passed.

The present position of the pig iron producer is, therefore, one of extraordinary strength, and almost every feature in the situation seems to offer the prospect either of the maintenance of the present high prices for several months to come, or of their still further advance.

When or where the point of maximum prices will be reached, from which point there will be probably a sudden and a very great decline, is a thing no one can predict. That it will come some day is certain, and that day will be just when the statistics show that the producing capacity of the furnaces has caught up to the demand, and that stocks of pig iron at the furnaces are beginning to accumulate. The demand itself may be checked by the high prices. The supply will certainly increase, not by the blowing in of old and small furnaces, but by the new and larger furnaces which are now being built. New ore and coal mines will be opened, new mining machinery will be installed, more and larger vessels will be built on the lakes, and more 100,000-lb. steel cars will be built to carry the ore. New boilers and engines will be put in some of the older furnaces, enabling them to be driven faster.

It may be interesting to compare the course of prices this year with that of the famous boom year 1879-80. We give below the prices of anthracite No. 1 pig at Philadelphia during that boom period, as found in the reports of the American Iron and Steel Association, together with recent prices of Bessemer pig at Pittsburg, as given in the "Iron Age" reports:

Date.	Anthracite pig at Phila., pr gross ton.	Date.	Bessemer pig at Pittsb'g, pr gross ton.
March, 1879	$17.88	October, 1898.	$10.36
April	18.00	November	10.15
May	18.50	December	10.58
June	18.75	January, 1899.	10.87
July	19.25	February	11.60
August	21.00	March	14.59
September	24.25	April	15.03
October	30.00	May	16.20
November	28.00	June	18.50
December	30.50	July	20.60
January, 1880	40.00	August	21.70
February	41.00	September	23.30
March	37.50	October	24.00
April	31.00		
May	25.00		
June	23.00		
July	23.50		

In the boom period of 1879-80 the price of pig iron advanced from $18.00 in April, 1879, to $41.00 in February, 1880, or 127% in 10 months, while in 1899 it advanced from $10.87 in January to $24.00 in October, or 120% in 9 months. The advance in six months, from August, 1879, to February, 1880, was from $21 to $41, or 95%, while that in six

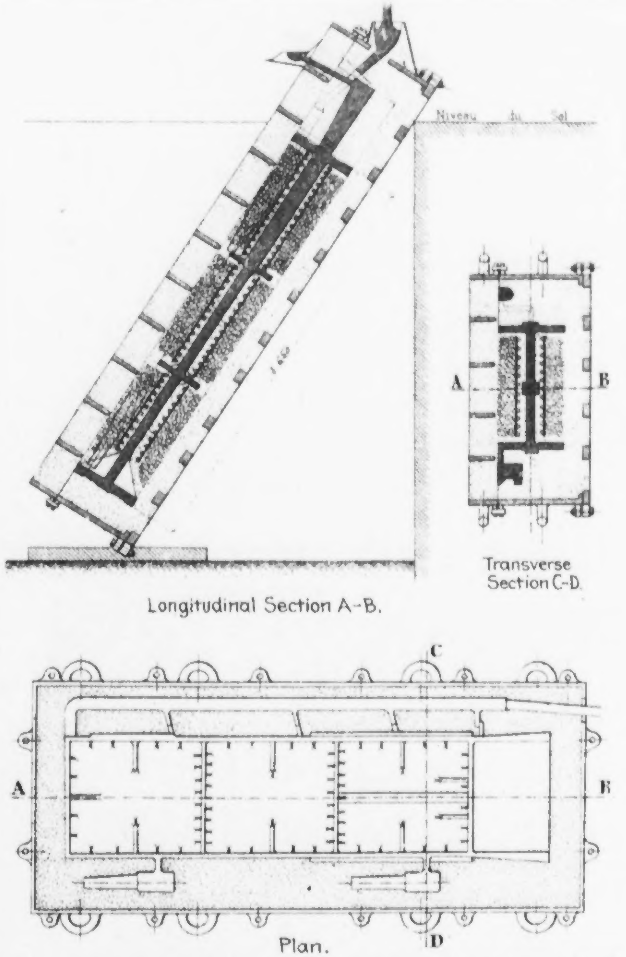


FIG 6. ARRANGEMENT OF MOLDS FOR CASTING INTERMEDIATE ARCH RIB VOUSSOIRS: ST. CHAMOND WORKS.

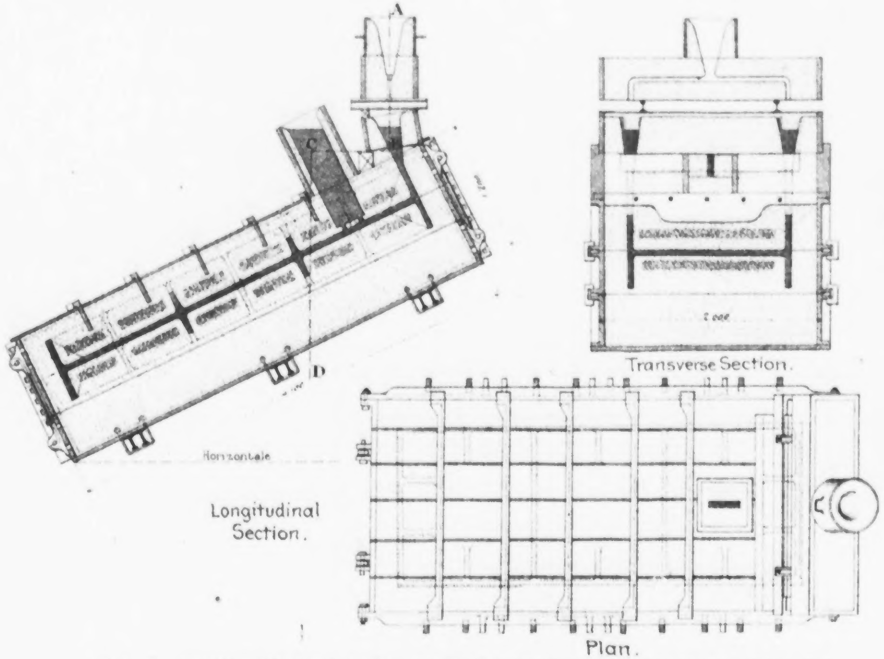


FIG 5. ARRANGEMENT OF MOLDS FOR CASTING INTERMEDIATE ARCH RIB VOUSSOIRS, FIRMINY WORKS

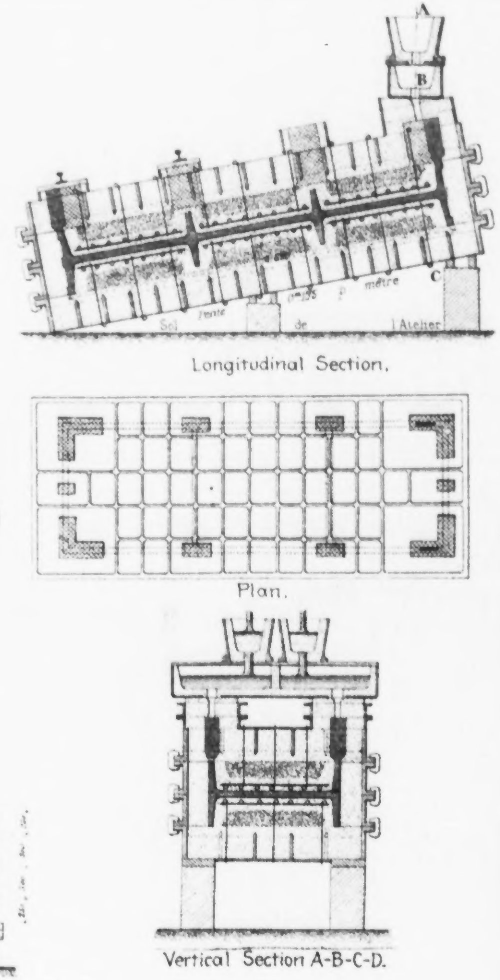


FIG. 3. ARRANGEMENT OF MOLDS FOR CASTING INTERMEDIATE ARCH RIB VOUSSOIRS, CREUSOT WORKS.

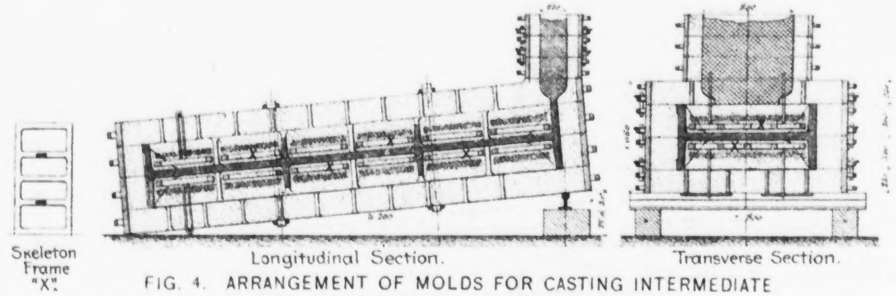


FIG. 4. ARRANGEMENT OF MOLDS FOR CASTING INTERMEDIATE ARCH RIB VOUSSOIRS; ST. ETIENNE WORKS.

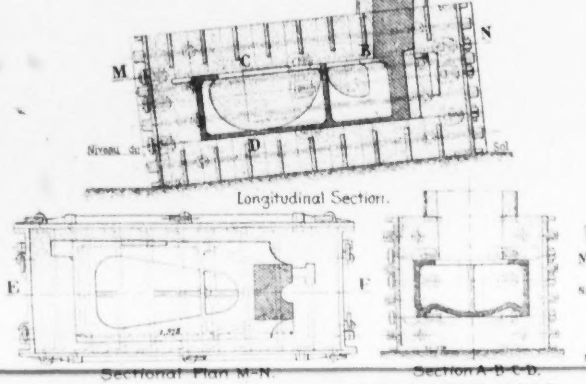


FIG 7. ARRANGEMENT OF MOLDS FOR CASTING HINGE VOUSSOIRS, CHATILLON & COMMENTRY CO.

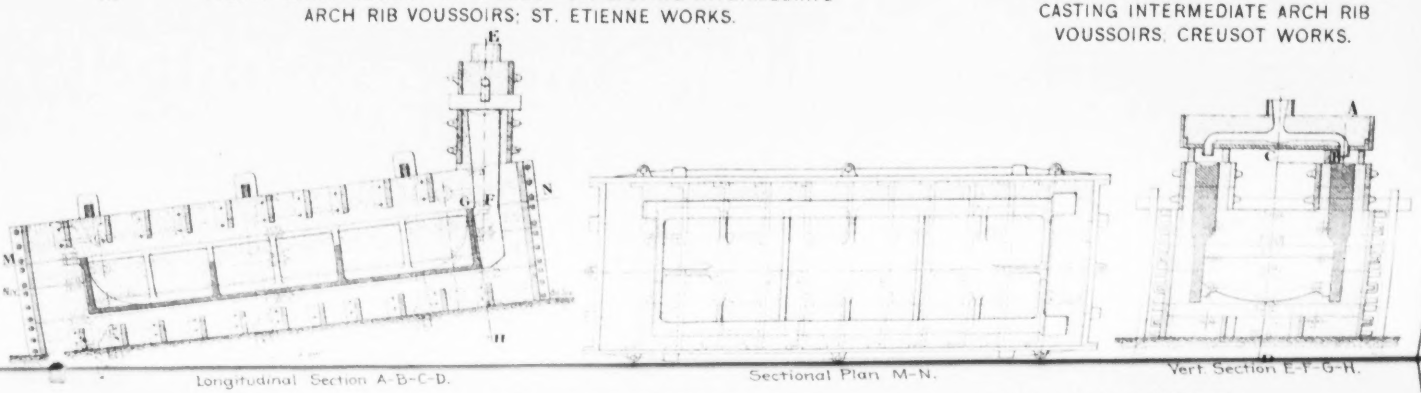


FIG 2. ARRANGEMENT OF MOLDS FOR CASTING EXTERIOR ARCH RIB VOUSSOIRS, CHATILLON & COMMENTRY CO.

FIG. 7. ARRANGEMENT OF MOLDS FOR CASTING HINGE VOUSSOIRS, CHATILLON & COMMENTRY CO.

FIG. 2. ARRANGEMENT OF MOLDS FOR CASTING EXTERIOR ARCH RIB VOUSSOIRS, CHATILLON & COMMENTRY CO.

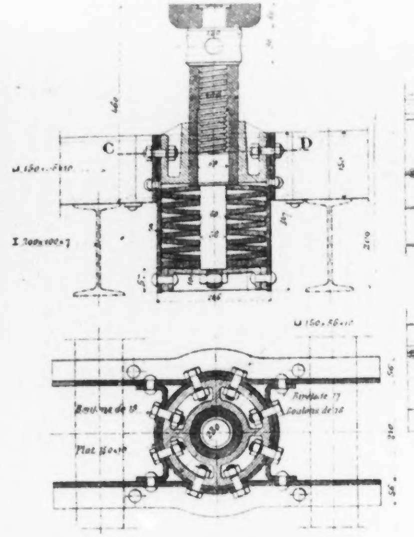


FIG. 12. DYNAMOMETER JACK USED IN STRIKING THE CENTERS.

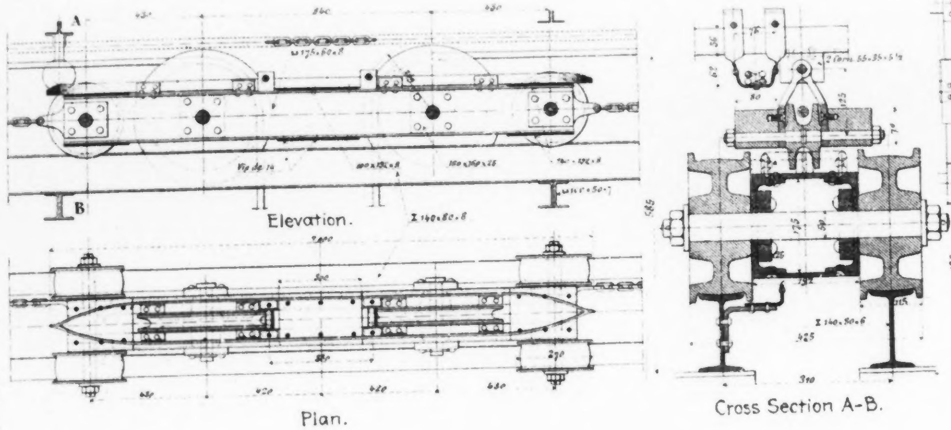


FIG. 10. DETAILS OF TROLLEY CARRIAGE.

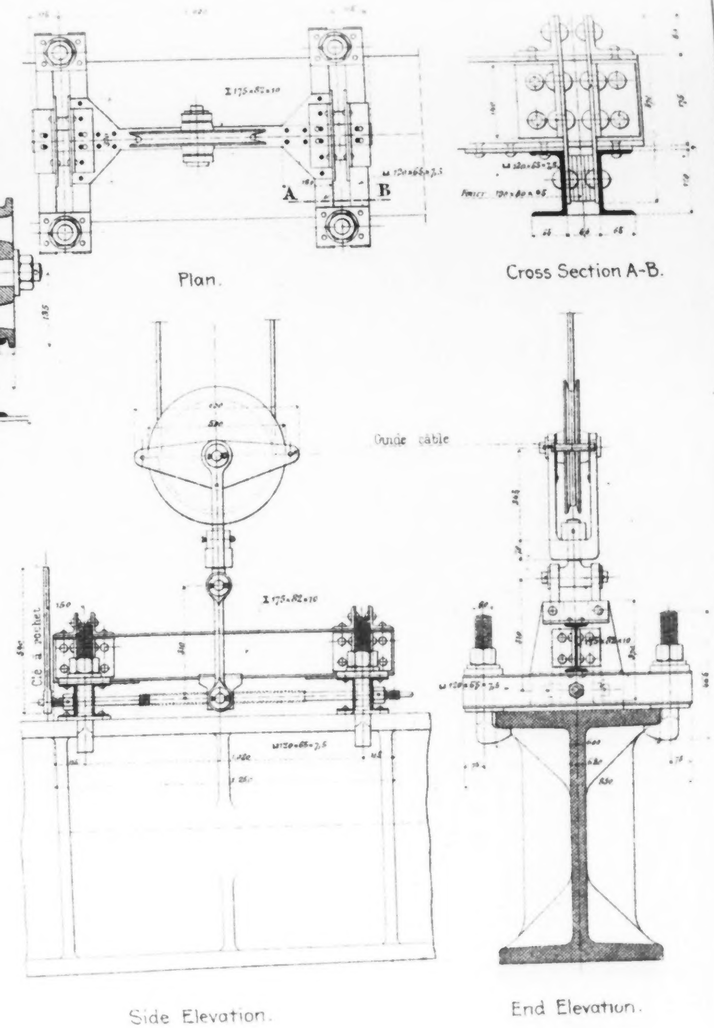


FIG. 11. DETAILS OF GRIP FOR HANDLING THE VOUSSOIRS.

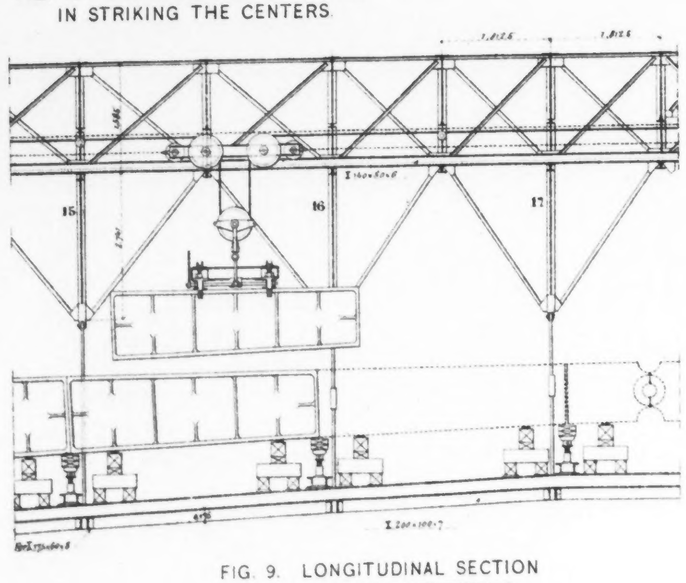


FIG. 9. LONGITUDINAL SECTION OF SUSPENDED CENTERING.

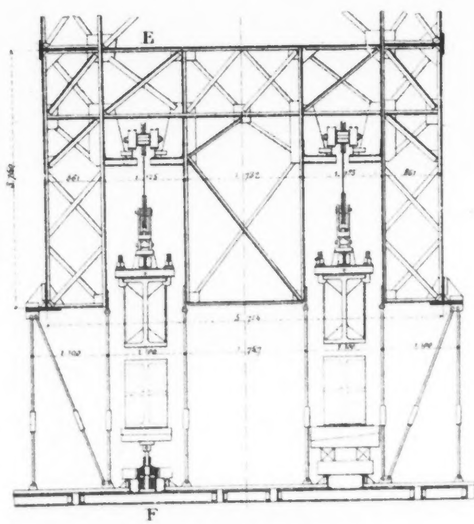


FIG. 8. TRANSVERSE SECTION OF SUSPENDED CENTERING.

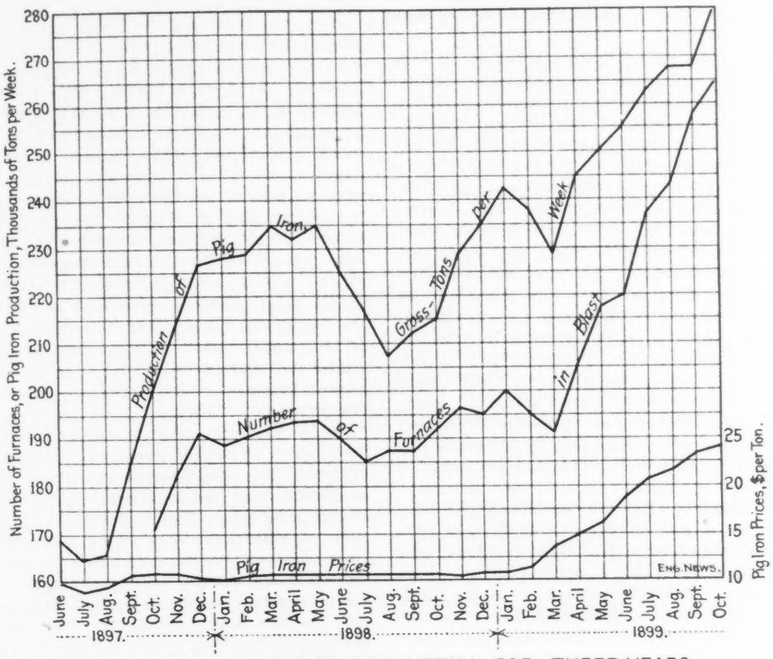
ALEXANDER III. BRIDGE, PARIS, FRANCE.

Casting and Erection of Steel Voussoirs.

..onths, from April to October, 1899, was from 15 to $24, or 60%. The course of prices in the ..o periods is also graphically shown in the ac-..mpanying diagram.

The peak of the diagram in 1879 was at $41 per ..n in February, from which point the price de-..ined in four months to $23, or nearly 44%. ..here the peak of the 1899 diagram will be the ..ture will reveal.

Like causes produce like effects. The cause of ..e sudden advance of prices in 1879 was that the ..emand had increased beyond the producing ca-..acity of those furnaces which could make pig iron at low cost. When consumers had awakened to the fact that there was an actual scarcity of pig iron, a rush to place orders for future delivery began, and this caused prices to mount higher and higher. The same causes are acting this year, with the same effect.



THE COURSE OF PIG IRON PRODUCTION FOR THREE YEARS.

The scarcity of iron and the advance in prices in 1879 and 1880 gave a tremendous impetus to the building of new furnaces and coke ovens, and to the devopment of mining. Many new furnaces were blown in late in 1879 and early in 1880, and soon the producing capacity was equal to any possible demand. Then the reaction came, and prices dropped 44% in four months.

The same causes which led to the culmination and the decline of the boom in 1880 are operating now. The new furnaces, new cars and vessels, new machinery at mines, and new coke ovens will at some date, probably not far distant, enable production to exceed the demand. Stocks of pig iron will then begin to accumulate, and a large and rapid decline in prices will then follow.

THE ORGANIZATION OF RAILWAY ENGINEERING AND MAINTENANCE OF WAY DEPARTMENTS.

In the organization of the engineering departments of railway service there is great diversity of practice, the department having a broad range of authority on some lines, while on others it is much more limited. In the maintenance of way department there is equal diversity, the work of this department being in some cases directly under the engineer, in other cases directly under the superintendent, while in still other cases there is a division of authority. Thus, the roadmasters, who are the men in actual charge of the track forces, may report direct or through an engineer to the superintendent, or may report to an officer who in turn reports to the chief engineer. The same remarks hold good as to the signal department, a matter which we discussed some little time ago. The jurisdiction of the signal engineer sometimes includes all kinds of signals (train-order, switch, block and interlocking), while in other cases it includes only block and interlocking signals, and in still other cases it includes all but the block and interlocking signals. The arguments are strongly in favor of the first system, with undivided authority, and they are also strongly in favor of having the signal department as a branch of the engineering or maintenance department. In the same way, it would seem decidedly the better plan to have the maintenance of way department under the direction of the engineering rather than of the operating department.

This general subject was discussed to some extent in a paper on "The Organization of the Maintenance of Way Department," which was read by Mr. E. E. Russell Tratman, Assoc. M. Am. Soc. C. E. (Associate Editor of Engineering News), at the recent annual meeting of the Eastern Maintenance of Way Association, held at Portland, Me. An abstract of this paper is given below, but somewhat modified as to that part which deals with examples of the different systems of organization, while some additional information has been added in regard to the engineering department. It was pointed out that under present conditions of railway operation, where the aim is to effect the most rigid economy consistent with efficient service, the system of organization of any department becomes of special importance.

Before proceeding with the abstract of the paper it may be well to present some examples of the organization of the departments in question, as now in force on some of the leading railway systems.

Atchison, Topeka & Santa Fe Ry.—On this great system, the Chief Engineer has under his direction (1) an Assistant Chief Engineer; (2) a Bridge Engineer, in charge of iron and steel bridges; (3) an Inspecting Engineer, who is supposed to keep the Chief Engineer and the Assistant Chief Engineer posted as to the progress of the work under construction; (4) seven Resident Engineers, one on each operating division of the road, who have charge of all construction work. In addition to this, if any entirely new lines are under construction, an engineer is put in charge of the work and reports directly to the Chief Engineer. The Engineering Department is entirely independent of the Operating Department, and the Chief Engineer reports to the General Manager.

All new construction, replacing of temporary bridges with permanent bridges or culverts, extensive repairs of bridges, and important improvements of grade or changes of line, are in the hands of the Chief Engineer, as are also any new buildings, the replacing of old buildings with more permanent structures, or the establishment of new water supply.

The Maintenance of Way Department is in the hands of the General Superintendent, who reports to the General Manager. Repairs of track, reballasting, and repairs of wooden trestles are also under his direction. The maintenance of way includes signals, bridges, buildings and water supply. The Signal Engineer reports to the General Superintendent, but is in charge only of block and interlocking signals. The train-order signals are attended to by the Bridge and Building Department. Roadmasters report to the division superintendents, except on the Chicago division, on which there is a General Roadmaster, to whom the roadmasters report, and who in turn reports to the Division Superintendent. On each operating division there is a General Foreman of Bridges and Buildings, who reports to the Division Superintendent, and who has charge of the maintenance of trestle bridges, and the repairs of buildings and water service. Carpenters and painters report to this foreman.

Erie R. R.—On this line the whole organization is based upon the division system, as distinct from the departmental system, the Division Superintendents being supreme within their own domains, and subject only to the orders of the General Superintendent. They have charge of Maintenance of Way, maintenance of motive power, and transportation (Eng. News, Jan. 9, 1896). The Chief Engineer reports directly to the President and Vice-President. He has direct charge of all construction work, and of bridges and buildings. He has also indirectly charge of the maintenance of way, in so far that he establishes all the standards relating to track and signals, and none of these standards can be changed without his consent. The Engineer of Maintenance of Way has direct charge of the maintenance and reports to the General Superintendent. On the Erie Division, each division superintendent has a Roadmaster, who has an assistant engineer and rodman under him. On the Ohio Division, the roadmasters are called assistant engineers. Under the roadmasters are the supervisors, track foremen, carpenters, masons, and all mechanics and laborers necessary for the maintenance of way.

Illinois Central R. R.—Here the Engineering Department is in charge of maintenance of way, but the Operating Department is in charge of the Chief Engineer, who reports to the Assistant Second Vice-President. He has under him an Engineer of Bridges and Buildings, and a Signal Engineer. He looks after both construction work and maintenance of way, and, in fact, the entire physical property; including track, bridges, buildings, water supply, turntables, interlocking and block signals, etc. The construction and maintenance of the interlocking plants are in the hands of the Signal Engineer, but the operation of the signal devices and interlocking plants is under the direction of the division superintendents, so far as the government of trains is concerned.

The Engineer of Bridges and Buildings has under him a Superintendent of Bridges, an Architect and a Master Carpenter. The former looks after all special consruction and renewals of bridges, the ordinary maintenance being in the hands of the roadmasters, subject to the inspection of the bridge department. The Architect looks after the designing of new buildings and the remodeling of old ones. The Master Carpenter has charge of special construction and large renewals of buildings, their maintenance being looked after by the roadmasters. Painters are employed by the Master Carpenter, the Superintendent of Bridges or the roadmaster, as required by them.

The track supervisors, who have charge of about 100 miles of track, report to the roadmasters, whose divisions are for 250 to 500 miles in length. The latter report to the division superintendents who have charge of operation and maintenance of way, and who in turn report to the two Assistant General Superintendents, one for lines north and the other for lines south of the Ohio River. These report to the Chief Engineer on all obstruction and maintenance of way matters, and to the General Superintendent on transportation matters. Half of the Roadmasters are engineers, and this proportion is gradually increasing.

A system of track apprenticeship for the training of young engineers in the track forces, was adopted some years ago, by Mr. John F. Wallace, M. Am. Soc. C. E., Assistant Second Vice-President, who was then Chief Engineer. As dscribed to us by Mr. Wallace, the idea is to take young engineering graduates, and place them with section gangs for a year or two, then make foremen of them, then supervisors, and finally roadmasters. By this means it is hoped to have always plenty of good available material to draw upon for the better positions in the maintenance of way department, from among men who are engineers with a practical knowledge of track work. While these young men are working as apprentices on the track, their engineering knowledge is also called into play, as they look after the division engineering work, thus gaining experience in both engineering and track work. This system was established about three years ago, and though many of the young men have not had the pluck to tackle a section laborer's work, and though some of those who do try it drop out of the ranks, yet the results have in the main been satisfactory, and the majority of these who started as track apprentices are still with the road. Owing to the large amount of new work which has come up every year since this system was inaugurated, it has been necessary to withdraw nearly all these young men from the apprentice ranks and to place them in the engineering corps. Mr. Wallace, therefore, has not been able to follow out this system as closely as he would have liked, but the system will be continued. He believes that the maintenance of way department offers the best future for young engineering students, as there is always an opportunity for the right man to work his way up.

Michigan Central R. R.—On this road the Engineering Department is entirely independent of the Operating Department, and the Chief Engineer reports to the President, who is also the General Manager. He has entire charge of all new construction, track, bridges, buildings, water supply, signals, interlocking plants, and real estate, and no work of construction, track or bridge renewal, reballasting, etc., is done without his authority. The roadmasters are not under the authority of the division superintendents, but report to an officer known as the Superintendent of Tracks, who is practically a general roadmaster, and who reports to the Chief Engineer. The Signal Engineer is at the head of the Signal Department, immediately under the Chief Engineer, and has charge of block signals, interlocking plants, and train-order and switch signals and lamps. This is a much better system than to have the care of different classes of signals distributed among different officers or departments. Under him are the signal inspectors. Masons and bridge carpenters report to the division foremen of bridges, while carpenters and painters report to the division foremen of buildings and water supply. Under the roadmasters are the assistant roadmasters, who in turn have foremen of repairs under them. The general organization of the department is as follows:

Prin. Asst. Engineer....	Reports to....	Chief Engineer.
Bridge Engineer	"	" "
Signal Engineer	"	" "
Supt. of Tracks.......	"	" "
Supt. Bldg & W. Sup....	"	" "
Assistant Engineers ...	"	Prin. Asst. Engineer
Roadmasters	"	Supt. of Tracks.
Div. Foremn of B.& W.S.	"	Supt. B. & W. S.
Assistant Bridge Engrs..	"	Bridge Engineer.
Div. Foremen of Bridges	"	" "

New York Central R. R.—The scope and authority of the Engineering Department are very similar to the arrangement on the Michigan Central R. R., except that only the switch signals are included. The department is independent of the Operating Department, and has entire charge of all construction and maintenance work, no such work being planned or carried out without the knowledge and authority of the Chief Engineer, who reports to the President. The Signal Department, however, is under the Operating Department, each division superintendent having an assistant superintendent of signals. The general organization is as follows:

(1) Chief Engineer.
  (2) Office Engineer (contracts, accounts, correspondence, etc.).
  (3) Engineer of Bridges (bridges and buildings).
  (4) Assistant Engineers (contract work of magnitude and special investigation).
  (5) Division Engineers (one on each of the seven divisions).
(5) Division Engineers.
  (6) Roadmasters.
  (7) Supervisor of Buildings.
  (8) Supervisor of Bridges.
  (9) Assistant Engineer (surveys, etc.).
(6) Roadmaster.
  Section foremen and section men; ballast and special gangs, pump men, etc.
(7) Supervisor of Buildings.
  Carpenters, painters, water supply and scales men.
(8) Supervisor of Bridges.
  Iron bridgemen, masons, pile-driver gangs, bridge painters and carpenters.

For the past six months, young men with engineering education and training have been employed in a subordinate capacity, with a view to their working up from the ranks, and so far the results have been satisfactory. We learn that the principal difficulty is in finding young men who unite with their technical training and education the fund of so-called "horse-sense" which is so necessary for success in the maintenance of way department.

New York, New Haven & Hartford R. R.—On this road, the maintenance of way comes under the jurisdiction of the operating department: The Chief Engineer, as head of the Engineering Department, reports to the General Manager. He has charge of all construction work, and supervisory authority as to all changes and renewals of roadway, buildnigs, bridges and docks. He decides upon the kinds and style of materials to be used, approves all plans adopted, and furnishes all standards used in construction and maintenance. Wherever it is considered that any work can be done by the company's employees who are under the Operating Department, such work is done under the supervision of the engineer by a notice given to the Operating Department that such work is required. There is practically no maintenance of way department, separate from the Operating Department, although in all cases the Engineering Department is consulted for what is necessary.

The Chief Engineer has two assistants, or District Engineers, one in charge of the Eastern District (east of Willimantic and New London), and the other in charge of the Western District (west of these points). Each has charge of about 1,000 miles. The districts are subdivided into engineering divisions, the Division Engineers having about 300 miles of line each, and reporting to the District Engineers. They have charge of all the general work, as well as of the construction work where it is not of such extent as to require an engineer specially to take charge of it. In the latter case, the engineer in charge reports to the Chief Engineer, and has charge of preparing the plans for new bridges and repairs of old bridges, as may from time to time be necessary, with the approval of the Chief Engineer. The erection of new bridges, and the repairs of old bridges, are carried out by the district engineers in accordance with the directions of the Bridge Engineer.

Roadmasters, bridge supervisors, and signal engineers report to the division superintendents, and the General Superintendent reports to the General Manager.

Pennsylvania R. R.—On this road there is a sharp distinction between the engineering (construction) and maintenance departments, but both classes of work are under the direct charge of engineers. The Engineering Department has two separate divisions, for construction and maintenance. The Chief Engineer has charge of the construction of new lines, changes of lines and the designing of bridges; he reports to the Second Vice-President. The Engineer of Maintenance of Way is one of the four staff officers of the General Manager, and has general charge of the road (including track, bridges, buildings, turntables, water supply, the installation and maintenance of signals, etc.), after the various works have been completed in construction and turned over to the Operating Department. He is the head of the signal department, and in his office are prepared the plans, which (after being approved by him and authorized by the General Manager), are carried out by the division officers, unless it is an extended piece of work which is done by contract.

The General Manager is the head of the Operating Department, and to him report the General Superintendents in charge of the Grand Divisions. Each General Superintendent has a Principal Assistant Engineer, and each Division Superintendent has an Assistant Engineer. Each superintendent's division is divided into supervisors' divisions of about 25 miles in length. The Supervisors (who occupy the positions of roadmasters on other roads), are educated engineers, and they report direct to the assistant engineer of the division. Each division has a Master Carpenter, who looks after general repairs to bridges, buildings, etc., and there are also masons on each division to look after repair work in their line.

Southern Pacific Ry.—The organization of this great railway system resembles that of the Pennsylvania R. R. in that the engineering construction and the maintenance of way are under separate departments, but under the charge of engineers. The Engineering Department is entirely independent of the Operating Department. It is organized for the construction of new lines of railway, and beyond the construction of the more important changes in lines of existing roads it does not include maintenance or betterments and addition to operated lines. The Chief Engineer reports to the President. The Maintenance of Way Department is a distinct department, and includes track, bridges, buildings, signals, turntables, water supply, etc. This department, on each of the two systems into which the road is divided (the Atlantic System and the Pacific System), is under the charge of an Engineer of Maintenance of Way, who reports to the General Manager on all matters relating to standard plans and methods, while in all other matters he works in harmony with the managers. The Signal Department is a branch of the maintenance of way department, and includes all classes of signals. It is headed by a Signal Engineer, who reports to the Engineer of Maintenance of Way.

Track foremen and bridge-and-building foremen report to the roadmasters. On one of the two systems, the roadmasters report to the resident engineers, and resident engineers to the division superintendents. The latter report to the Engineer of Maintenance of Way in maintenance of way matters, particularly as to standard plans and methods. On the other system, however, there are no resident engineers, and the roadmasters report to the superintendents. In this case, the bridge-and-building foremen report to a Superintendent of Bridges and Buildings, who reports to the Engineer of Maintenance of Way. It is considered that, as a rule, it is well to have roadmasters who are engnieers, instead of men of purely practical experience. No systematic steps have been taken to train engineering students in the track gangs or the maintenance of way department, but such students applying for employment are generally advised to go to work on the track or carpenter gangs. One of the roadmasters and one of the resident engineers began in this way.

We now proceed to give some extracts from the paper above referred to:

In Europe, the maintenance of way is usually strictly under the Engineering Department. On the Great Northern Ry. of England, the Engineer in Charge and the Assistant Engineer are at the head of the department, and the line is divided into five divisions, each having a Resident District Engineer, with inspectors and track foremen (or gangers) under him. The foremen report to the inspectors and the inspectors to the District Engineer. The inspectors answer to the old-fashioned roadmasters in this country, being as a rule appointed from among the foremen. Their divisions vary from 2¼ miles near London, to 30 miles in the open country, and there are usually 4 men to a gang. The London & Southwestern Ry. (with three main divisions), has practically the same system of organization, but there is a Superintendent between the Inspector and the District Engineer. Foremen of ability are promoted to be Inspectors, and Inspectors can become Superintendents, if they possess the necessary qualifications. Of course, those Superintendents have nothing to do with operation, but are equivalent to General Roadmasters.

On the London & Northwestern Ry. there is a Permanent-Way Engineer, who is an assistant to the Chief Engineer, and reports jointly with him to the directors of the company on all matters concerning the maintenance of the railway. Under the Permanent-Way Engineer are nine Divisional Engineers. Each of these is in charge of the maintenance of track, buildings, and all works on his division, including, in some cases, docks, harbors, sea defences and canals. Under him is a Chief Bridge Inspector and a Chief Permanent-Way Inspector. Under the latter are the sub-inspectors, whose districts are 30 to 40 miles in length. They are selected from the most intelligent and experienced foremen. The sub-inspector is in immediate control of the section foremen. The section gangs average 4 to 5 men, including the foreman, and they have on an average two miles of double track and one mile of single siding, with frogs and switches.

On the Netherlands State Railways, there is a Chief Engineer of Way and Works, who is in charge of everything pertaining to construction, renewal and maintenance of road, bridges, buildings, etc., on the 992 miles of railway. Under him are 8 Division Engineers, whose divisions average about 124 miles. They are engineering graduates from the Polytechnic School, and each has 5 to 7 Supervisors or Roadmasters under him, in charge of 15½ to 28 miles. Each Roadmaster in turn has 4 to 7 section laborers' gangs, each in charge of a foreman, whose section is thus about 4 miles in length. The Roadmasters are of three classes, and to be appointed to the lowest class they must have some school education and some experience as carpenters or on public works, and must also pass a special examination.

But to return to practice in the United States. On many roads there is an engineer and a roadmaster to each division, and the question has come up for discussion whether the two positions can be combined, with a reduction in expenses and no corresponding reduction in the efficiency of the work. The fact is very evident and very generally recognized that there is an increasing demand for engineering skill in the position held by the roadmaster. Under such conditions it becomes impracticable to fill vacancies from the ranks of the section foremen however skillful these men may be in practical work. The two main objections which have been urged against the placing of engineers in charge of the maintenance of way forces are as follows:

(1) That the engineer has not the practical training and experiences to enable him to direct and judge track work.

(2) That the engineer is a man of theory and for handling instruments, and is not a "practical" man.

(3) That the engineer is not accustomed to handling or directing men, and is not familiar with traffic conditions.

The first objection has some force and truth in it. The others are based mainly on inaccurate ideas and lack of knowledge. The railway engineer is not a mere surveyor and draftsman. He is essentially a man of wide experience and liberal ideas, but until recent years he has not entered the domain of the roadmaster, whose work has been largely looked upon as that of a superior grade of section foreman. Engineers in charge of construction, reconstruction, changing grades and alinement, renewals of bridges, etc., etc., have to organize their forces, to handle and direct large bodies of men, and to make provisions for carrying on their work with the least possible interference with traffic.

The question may then be asked, where can the railway look for a supply of men with practical and theoretical knowledge of both engineering and track work. To this it may be answered that they will do well to train such men in their own service. One source of supply of raw material is the engineering school, whose graduates have some foundation education in engineering and railway work, including economics. Of course, nobody proposes that young men fresh from college should be put in responsible positions in the track department, over the heads of experienced foremen. They enter the department to learn, not to govern, and they are to learn general practice and methods of work, and not to aim at becoming simply expert section men. It is sometimes objected that college graduates are so afflicted with a sense of their importance and knowledge that they will not work efficiently, even if they consent to begin as low down in the service as to join the section gang, bridge gang or work train forces. This is true to a certain extent, but there are probably plenty of men with good sense who are willing to make such a beginning if they are given proper encouragement as to promotion. In view of the steady development of track work on scientific principles, and the valuable kind of officers obtained by such a combination of scientific and practical training, the railway management can well afford to give such encouragement.

LETTERS TO THE EDITOR.

A Mercury Extraction Process Not Laid Down in the Books.

Sir: In Engineering News of Oct. 5 there is an article in regard to a company formed for the purpose of extracting gold from anybody, or anything, by the cold process.

This recalls to mind an organization that was projected (at least on paper) about thirty years ago. The business of this company was to extract mercury by a somewhat novel process. This company consisted of a couple of promoters, and they had an inventor "in their midst." The business of this company was primarily to give baths. As in other cases, water was the principal element. To this was added a secret and mysterious preparation. Some part of the bather, or apparatus, was then connected with an electrical current. There were no dynamos or dry batteries in those days, so they used a common wet battery, which was perhaps the most appropriate anyway for a bath. This bath was expected, on general principles, to be in itself of advantage to the company and the bather; but the great profit was in the by-product. We now know, what these able men then foresaw, that in some cases what was a by-product is the most profitable part of a manufacturing business—as it was to be in this case. This "by-product" was nothing less than mercury. Now mercury is as old as mythology and as certain kinds of sin. They say that a dalliance with the most beautiful of the goddesses was followed by companionship with the most swift footed of the gods.

Years ago doctors were lavish in the use of minerals; calomel and blue mass were the mainstay, and jalap the spinnaker of the profession. It was therefore claimed by the inventor of this process that every human being contained a certain amount of mercury, which might have entered his system by his own free agency or by the law of inheritance. It was further claimed that this process would eliminate the mercury, and from it the company working the process would obtain a handsome profit. Whether this mercury was to be found in pockets like the appendix vermiformis or in mercury-bearing sand was not stated.

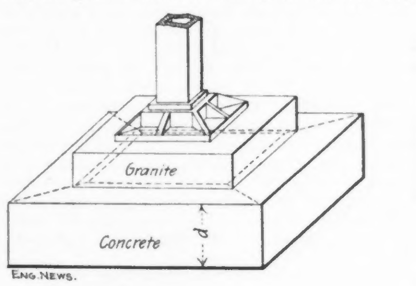
When the promoter was asked in what form this mercury was eliminated, he said, "in little, round, shiny drops, the kind you can't pick up." Now, a foolish question may sometimes confound the wise; and so, when suddenly asked: "If you can't pick them up, how do you get them?" he answered: "You don't have to pick them up; they float on the top of the water and you just skim them off." G.

Perth Amboy, N. J., Oct. 10, 1899.

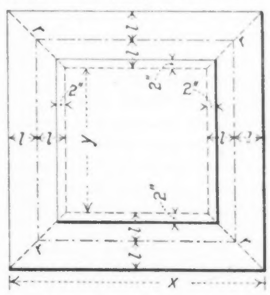
("Good wine needs no bush," and our correspondent's story is so delicious that comment on it would be superfluous. We may add, for the benefit of the skeptical, that our correspondent, who is a well-known engineer, accompanies the above communication by a personal letter in which he vouches for his story as an absolute fact.—Ed.)

Computing Strength of Concrete Footings.

Sir: Will you or some one of your readers state the proper method of figuring the thickness of a concrete base like the one shown herewith, or tell me in what publication rules and formulae for such calculations can be found? I have often had such footings to proportion and have made an approximate calculation by assuming that failure would take place by breaking along a line somewhat inside the granite block as well as at the four corners on



Isometric View.



Plan of Base.

the diagonal line (indicated by dotted lines in the sketch). In other words, I have made the moment of resistance of the concrete block along the line just mentioned equal to the upward bending moment produced by the load, in the following formula:

Let W = load per sq. ft. allowable on soil.
S = permissible cross-bending strain per sq. in.
Then is

$$\frac{W\,(x^2-y^2)\,l}{\dfrac{d^2\,4\,(y+r)}{6}} = S = \frac{\text{bending moment}}{\text{moment of resistance}}$$

By calling the attention of your readers to this you will greatly oblige, Yours truly, W. C. Lyon.

Treasury Dept., Washington, D. C., Oct. 9, 1899.

(The requirement of the new building code of New York city, for concrete footings is given below. We shall be glad to hear from any of our readers concerning the proper method of making the computation asked for by our correspondent.—Ed.)

The footing or base course shall be of stone or concrete, or both, or of concrete and stepped-up brickwork, of sufficient thickness and area safely to bear the weight to be imposed thereon. If the footing or base course be of concrete, the concrete shall not be less than 12 ins. thick. If of stone, the stones shall not be less than 2 × 3 ft., and at least 8 ins. in thickness for walls; and not less than 10 ins. in thickness if under piers, columns or posts; the footing or base course, whether formed of concrete or stone, shall be at least 12 ins. wider than the bottom width of walls, and at least 12 ins. wider on all sides than the bottom width of said piers, columns or posts. If the superimposed load is such as to cause undue transverse strain on a footing projecting 12 ins., the thickness of such footing is to be increased so as to carry the load with safety. For small structures and for small piers sustaining light loads, the Commissioner of Buildings, having jurisdiction, may, in his discretion, allow a reduction in the thickness and projection for footings or base courses herein specified. All base stones shall be well bedded and laid crosswise, edge to edge.

(In the same code the safe extreme fiber stress for transverse stress in concrete is set at 20 to 30 lbs. for Portland cement concretes, according to the composition, and 10 to 16 lbs. for Rosendale concretes.—Ed.)

Engines for the Glasgow Electric Power Station.

Sir: As a subscriber to the Engineering News, I note with pleasure the very impartial remarks regarding the above subject, in which I am deeply interested, and which I know is of great interest to the majority of your readers. Such being the case, I trust I shall not be trespassing on your space in making the following suggestions:

The remarks suggested in "Engineering," viz., that Mr. Parshall should have made designs for these engines, were surely not meant to be taken seriously; for, while granting Mr. Parshall to be one of the foremost electrical engineers of the day, I believe I am correct in saying that he does not claim to have had special experience in the design of engines of this class.

I do not, however, quite agree with your suggested means (Engineering News, Sept. 21st) of overcoming what is undoubtedly a grave difficulty.

As anyone acquainted with the design of engines is aware, all first-class engine builders have certain features in the design of their particular engines which experience has proved to them is the best for the class of work for which these engines have been built; and in these particulars most engine builders differ, each, of course, claiming their own to be the best.

It is well known that all first-class firms employ engineers with considerable experience and technical ability to design any engine they may be called upon to build, and it seems to me that if a commission of such engineers was formed, as is common practice with important engineering subjects in America, to draw up a report upon the subject, I think there would have been some chance of getting a really first-class engine in every detail. The commission could be formed as above of, say, two or three English, American and European engineers. Each engineer would have his experience to act upon which could be illustrated with designs of engines already constructed, and their performance while working.

It would be possible to settle all matters in detail, i. e., horizontal versus vertical engines, steam pressure, diameter and number of cylinders, etc., with their various details; also the best position to place the dynamos and flywheel with respect to the engines themselves. Drawings could then be prepared and finally approved by this commission, and each of the firms represented asked to quote for the construction of these engines.

To surmount the difficulties of freight expenses, each manufacturer should quote delivery at his own works, and the purchasing corporation would pay freight in every case, so as to place all on an equal footing.

In the event of any firm not represented on the commission being manufacturers of parts of engines, controlled by patents, which were admitted to be superior to similar items manufactured by any of the firms represented and bidding for the work, it could be decided upon for all bidders to include such items in their prices.

I am strongly of opinion that such a procedure would have settled a very vexed question once for all. Each firm would possess designs for an engine with which to work upon in the future, also all firms would be represented at the trials and furnished with full data in regular working. By this means Glasgow would have obtained the experience of the engine builders of the world, also each builder would have the benefit of the experience of the several other builders.

The expenses in connection with the commission should be borne by the corporation for whom it was appointed, to the direct advantage of both the corporation and each firm represented. Such expenses may be put down roughly at £2,000, including compensation to the firms represented for their engineers' services while the commission was sitting, which would certainly have been a very economical means of obtaining much valuable information.

In the event of their being no latitude with the several prices, the contracts could be given out to the firm naming the lowest time limit, or to those firms who possess the best appliances for the manufacture of such engines.

I am, gentlemen, yours faithfully,
Ernest Halton,
Chief Assistant Engineer,
Birkenhead Corporation Electric Tramways.

Dallam House, near Warrington, Oct. 5, 1899.

AN ASSOCIATION OF CLEANSING SUPERINTENDENTS is one of the many societies devoted to engineering and sanitation in Great Britain. At the recent annual convention of the association at Glasgow delegates were present from 28 municipalities in England, Scotland and Ireland, and a number of papers on street cleaning, refuse collection and disposal were read.

A VIBRATORY CONVEYOR AND SCREEN.

An interesting form of conveyor which is now being introduced consists of a trough placed on a horizontal plane, and giving a longitudinal rocking or vibrating motion which causes the contents to travel along, even when the trough is inclined slightly upward. The trough is either suspended from above or supported from below by rocker arms, at intervals of about 10 ft. The trough is made in lengths of about 100 ft. For greater distances, two conveyors are used, the end of one trough lapping over the other, forming a continuous line, but each length being operated by its own driving mechanism.

The trough or conveyor is operated by a pitman or connecting rod attached to an eccentric or crank on a shaft driven by belting, and when the shaft is running at speed the upward and forward motion which it gives to the trough serves to drive the contents along. As the trough itself does not travel, it may be used for loading into bins, etc., being fitted with doors and chutes at any part of its length. The machine is now being used for handling gravel, sand and cement, and is equally well adapted for grain, coal, etc. At the packing works of P. D. Armour & Co., of Chicago, a conveyor of this kind has been put in for handling salt, and in this case the steel trough is lined with wood to prevent corrosion. It is also used in cement works for carrying hot clinkers, and in this case it is lined with fire brick, or water jacketed. Fig. 1 shows a portion of the trough, with the rocking supports and operating mechanism.

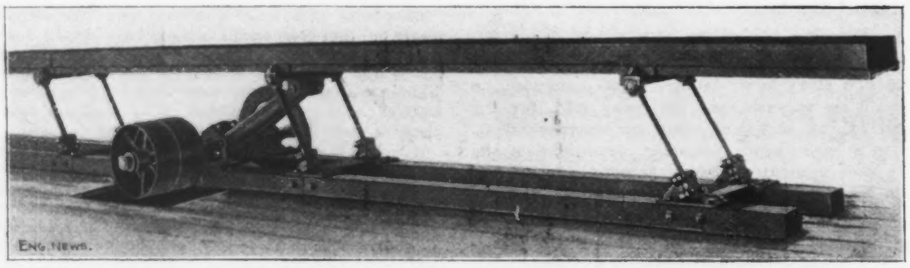


FIG. 1.—VIBRATORY CONVEYOR.
Western Machinery & Supply Co., Makers.

The same principle is applied to screening machines for stone, gravel, coal, etc. The trough of the screen is made of any desired width, and the perforations increase in size from the receiving to the delivering end, so that the output may be of any desired degree of fineness, and may be delivered directly into bins under the screen. A series of screens may also be used, placed one above the other, the tailings from the upper screen passing to the next lower screen, and so on. Where large quantities of material are to be dealt with, as at coal yards, a pair of troughs may be set side by side and operated independently, thus avoiding the objections to very wide screens, and enabling repairs to be made more readily. Fig. 2 shows the arrangement designed for a coal screening plant using three sets of screens and sizing the coal into four degrees of fineness. The coal from the mine can be delivered on screen (A), the tailings from which go direct to the car or bin, while the "fines" fall through to screen (B) and travel in the same direction. The fines from the second screening go to screen (C) and travel in the opposite direction. There is no violent motion which would tend to break the coal.

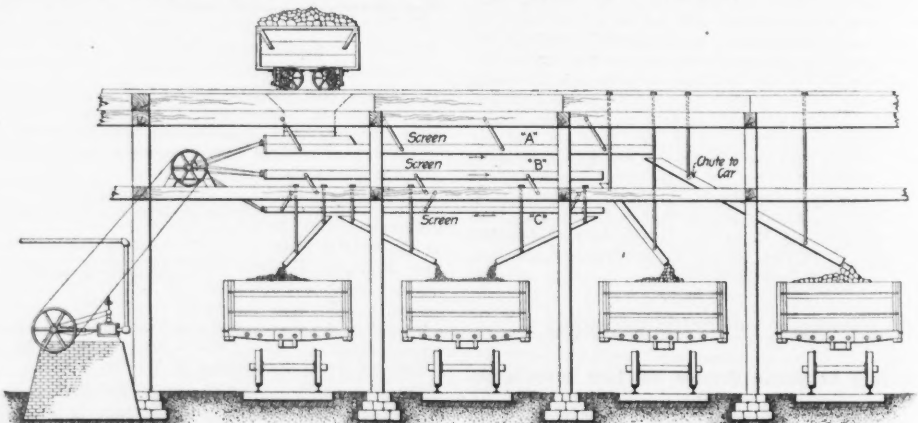


FIG. 2.—COAL SCREENING PLANT, WITH VIBRATORY SCREENS.

These devices are being introduced by the Western Machinery & Supply Co., 161 La Salle St., Chicago, Ill., and we are indebted to this company for plans and photographs.

A DERRICK SWINGING DEVICE, which is claimed to be unusually simple and efficient, is being applied to the new hoisting engines of the Lidgerwood Mfg. Co. This device consists of two small drums, which are placed inside the winch heads, and are operated by suitably arranged frictions actuated by cams, which can be thrown in and out by an auxiliary operating lever. The ropes from the bull ring of the derrick are wound on these drums, whose rotation in opposite directions thus serve to swing the derrick.

A UNIFORM SYSTEM OF REPORTING CHEMICAL analyses of water and sewage has been recommended by a committee of Section B of the British Association. The committee was composed of Prof. W. Ramsay, Chairman; Dr. S. Rideal, Secretary; Sir W. Crookes, Prof. F. Clowes, Prof. P. F. Frankland and Prof. R. Boyce. The results of all analyses should be expressed in parts per 100,000, except dissolved gases, which "should be stated as cubic centimeters of gas at 0° C. and 760 mm. in 1 litre of water." The nitrogen should be returned as (1) ammoniacal nitrogen from free and saline ammonia; (2) nitrites; (3) nitrates; (4) organic nitrogen (either by Kjeldahl or by combustion, the process to be stated); and (5) albuminoid ammonia. The total nitrogen will be the sum of (1) to (4), inclusive. In raw sewage and in effluents containing suspended matter it is desirable to determine the amount of suspended organic matter. Composite samples are suggested, in some cases made up from hourly takings proportioned to the rate of flow. The committee was unable to suggest a method of reporting bacterial results, likely to be acceptable to all workers.

THE INSTITUTION OF OPERATING ENGINEERS has applied for a charter in Philadelphia, and the incorporators are Charles G. Darrach, M. Am. Soc. C. E., President; John Frigar and William Hewittson, Vice-Presidents, with a board of directors also made up of prominent operating engineers of that city. The purpose of the new organization is to bring about closer relations between the consulting engineers, who design large buildings and mechanical plants, and the engineers who operate these plants when completed. The designing engineers, on the other hand, can also gather much information of practical value from the operating engineers. The predominating purpose, says one of the directors, is the education of both classes of engineers. For this purpose appropriate papers will be read and discussed—and published when deemed expedient; a library will be established and drawings and models collected. The membership will cover five classes; and to become a member the applicant must be qualified to take charge of an operating engineering plant; the junior member must be qualified to act as assistant engineer of such a plant, for elevators, electric lighting, steam heating, etc. The organization is to be national in its scope, and engineers in all parts of the United States will be eligible for membership.

THE BALDWIN LIBRARY, numbering about 2,000 volumes, and lately presented to the Woburn Public Library by Mrs. C. R. Griffiths, is largely made up of the books of the three brothers—Loammi, James F. and George R. Baldwin, the first-named being the famed early American engineer and the other two being also active engineers. As a result, the library is composed almost entirely of engineering works, many of them rare or important as contemporary records of public works. They are handsomely bound, and a special catalogue is being prepared. The sets of bound periodicals and the reports of early engineers form an especially valuable historical library in themselves.

THE SURVEY OF THE ST. CLAIR FLATS, says the "Free Press," of Detroit, has been ordered by Land Commissioner French, with the view of converting much of this territory into a public park. Considerable real estate has already been reclaimed from these flats by summer residents, clubs and others, and as the law limits such occupation to a strip 500 ft. back from the main channel on each side, there is room for some friction between the state and individual claimants. The survey is being conducted by Mr. Fred. Morley, C. E., formerly Professor of Civil Engineering at Purdue University, on plans outlined by Prof. Davis, of the University of Michigan. As the work is to be done in water from 1 to 3 ft. or more deep, small flat-boats are being constructed, with four spuds and lifting-tackle, which will be used to provide a solid base for the instruments. Other flat-boats, with a central well, will be employed in setting the gas-pipe stakes; and two house-boats will accommodate the party of about 30 men engaged in the work.

IRRIGATION DAMS IN ARIZONA, to be built by the Federal government, were advocated by Myron H. McCord, late Governor of Arizona, at the Irrigation Congress held at Missoula, Mont., on Sept. 26. He believed that millions of fertile acres could be created by building dams for great impounding reservoirs to hold the flood waters now going to waste. He contended that the money annually wasted in "improving" certain Western rivers, and in attempting to control their floods, would be much better expended in holding this water near the sources of these streams in such manner that it could be utilized in irrigation. He strongly advocated a national system of irrigation as the only means of properly developing large areas in the arid Western plateau. The Congress adopted resolutions in favor of government appropriations for irrigation works.

WATER STORAGE IN CALIFORNIA has been agitated during the last few months. The California State Association for the Storage of Flood Waters has been organized and a call has been issued for a convention to be held in San Francisco on Nov. 14. The object of the meeting is

to consider the bearing which the increase of the available waters of the state for agricultural, horticultural, mining and mechanical purposes will have upon its future growth and prosperity, and to devise plans and means whereby this important result may be attained.

The invitation to delegates includes state, county and municipal officers, representatives of the public press and of irrigation districts and companies. At the meeting which decided to issue the call for a general convention Chief Justice Beatty, of the Supreme Court, presided, and Mr. T. C. Friedlander acted as secretary.

DAY LABOR FOR SEWER CONSTRUCTION has been proposed in Chicago, on account of the continual trouble with contractors and the large sums demanded by the contractors for "extras." In some of the contested cases, the courts have decided against the city, and the mayor, Mr. C. H. Harrison, has refused to approve the award of contracts for the south side intercepting sewer, bids for which were opened in August. The city council has thus far declined to give the necessary authority for this work to be done by day labor, and, on the other hand, the mayor has declared he will not approve any contract as long as he holds office. The reason given for failure to permit the day labor system is that it would be used as a political weapon in the campaign next year. Until the sewer is built, the Hyde Park district, from 39th St. to 75th St., will discharge its sewage into the lake, in the neighborhood of the 66th St. intake crib.

AN INTERNATIONAL TRAMWAYS AND LIGHT railway exhibition is to be held in Royal Agricultural Hall, Islington, London, from June 30 to July 11, 1900, under the patronage of about 15 mayors of prominent cities of the United Kingdom. As the title indicates, street railway appliances and systems, power station equipment, rolling stock, etc., will form the bulk of the exhibits. The Managing Director is James W. Courtenay, Amberley House, Norfolk St., London, W. C., and the exhibition is promoted under the sole responsibility of "The Tramway and Railway World," of London.

EXPERIMENTS ON EARTH PRESSURE AGAINST RETAINING WALLS.*

By A. A. Steel.†

All theories of earth pressure against retaining walls, etc., in lack of experimental data, are based upon a number of more or less plausible assumptions. Since it seemed possible to test some of these, such as the direction of the pressure and its distribution over the wall, the following experiments were undertaken during the summer of 1898. As they were to determine the facts relating to earth pressure against actual walls, and as it seemed probable that the conditions existing within a mass of earth may vary with the pressure, the experiments were performed on a large scale even though this caused some loss in exactness of measurement. The maximum head was 14½ ft. This was obtained by digging a hole 8 ft. deep and building the wall across the middle of it. The earth for producing the pressure was placed in one-half of the hole and piled up against the wall 7½ ft. higher than the top of the hole, supported above ground by a bin of boards. The other half of the pit was occupied by the apparatus for measuring the pressure.

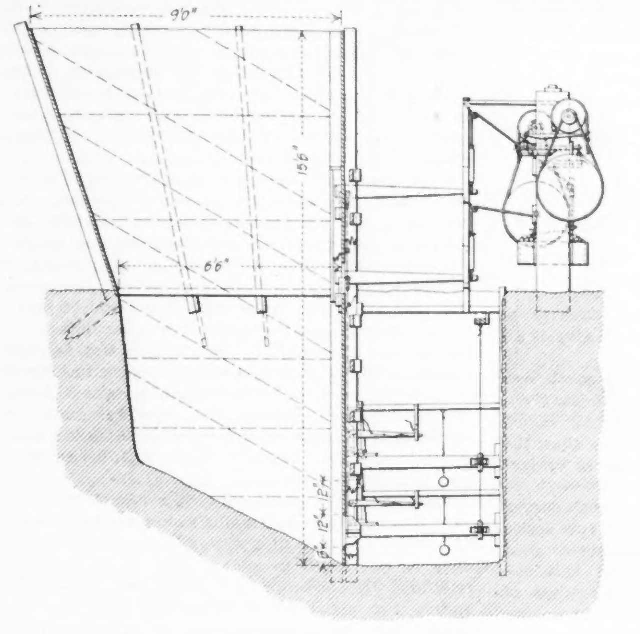
In the wall were two openings 12 ins. wide and 12⅛ ins. high, the lower edges being 6 ins. and 30 ins. above the bottom of the wall. These openings were closed by boards 12 ins. wide and 11⅞ ins. high. Thus, there was ¼-in. vertical play, but only enough sidewise clearance to prevent friction, and if the earth in front of a crack is supported equally by the two sides, the movable boards would each receive the pressure coming upon just 1 sq. ft. of the wall. The wall and boards were left unplaned just as sawed, so that the friction of the earth against them would be as great as possible. All these parts were painted twice before being finished accurately to size.

In the center of each board was braced normally a piece of 2 × 4-in. scantling about 4 ft. long. The forked end of this, shod with iron, rested against the knife edges of a lever for measuring the pressure. This lever would then receive the normal pressure, practically unaffected by any slight vertical movement of the board. To get the tangential component, each part was supported vertically by a number of carefully stretched wires from the clevis of a lever placed in a convenient position above. Since the wires could not well be arranged to act in the plane of the front face of the board on which the pressure acted, the attachments were so made that the apparent pressure was increased by one-fortieth.

The pressure reduced by the levers was taken by carefully calibrated spring balances. It was essential, of course, that each measuring board should remain exactly in the plane of the wall and the center of the opening. This was accomplished by the closing of an electric circuit by means of multiplying levers, whenever the board was pushed outwards or downwards. This released a brake on a mechanism, which increased the tension on the proper spring balance until the board was pulled back into position. The apparatus was so adjusted that there was no perceptible motion.

The hole for the dirt was 6 ft. wide at the bottom and 7 ft. wide at the top. The back of the pit was 6 ft. from the wall at the bottom and 6½ ft. at the top. The bin was uniformly 7 ft. wide, but sloped back to a distance of 9 ft. at the top. As shown hereafter, the width was amply sufficient to destroy any influence which the end walls might have on the earth at the center. The distance to the back of the hole was probably enough to prevent any error on that account. It was ample if we accept the theory of a plane of rupture, on which basis it was designed. The general arrangement of the apparatus can best be understood by reference to the accompanying drawings, Figs. 1 and 2.

The experiments were performed by adding the earth gradually. At intervals of 2 or 3 ft. the

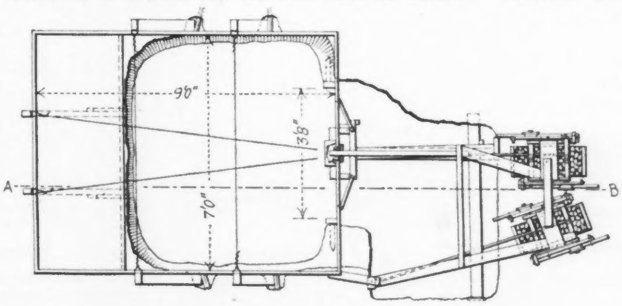


Longitudinal Section A-B.

FIG. 2.—SECTIONAL ELEVATION OF APPARATUS EMPLOYED IN EXPERIMENTS ON PRESSURE OF EARTH AGAINST RETAINING WALLS.

surface was carefully leveled up by reference marks around the walls, and the readings taken. Then more earth was thrown in so as to make the surface inclined upwards at an angle of 30° to the horizontal, and the readings again taken More earth was then added, until the surface was again level. In this way, with one filling, two series of readings were obtained. Usually, when the inclination of the surface was changed, enough earth was added to increase both components of the pressure.

To test the influence of the density and angle of repose of the substance producing the pressure, it was necessary to use more than one kind of material. It was intended to run through the series of experiments with fine earth in its natural damp condition, next perfectly dry and then as rather



Plan.

FIG. 1.—PLAN OF APPARATUS EMPLOYED IN EXPERIMENTS ON PRESSURE OF EARTH AGAINST RETAINING WALLS.

stiff mud. Since the dry earth most nearly meets the theoretical conditions, and it was desired to know the pressure on all parts of the wall, the original intention had been to change the lower board to an opening 5 ft. above the bottom of the wall, and repeat the experiments with dry earth, leaving the middle board in position, for a check. Afterwards, however, this plan was abandoned.

In most theories, it is assumed that, due to weathering, the earth will settle against a wall as though it had no cohesion. To bring about this condition as nearly as possible, all the earth was to have been passed through a piece of "hardware cloth" with three meshes to the inch, but after filling the hole in this way to a depth of 5 ft., it seemed that the great amount of labor required to sift the earth was not compensated by a sufficient gain in accuracy. So the earth was then simply thrown in after breaking all lumps more than 1 in. in diameter.

The angle of repose was determined from its tangent. Three straight strips of wood were carefully attached and braced, so that they should have three edges intersecting in a point, and mutually at right angles. Two of these edges were then made level, and the earth from a carefully selected sample slowly poured against the third and vertical edge. These edges had been carefully spaced off, and at intervals the vertical and horizontal distances from their intersection to the surface of the earth were read. For the sifted earth this gave very uniform results, with the mean value of 38° 22' for the angle of repose.

To determine the density, a strong box, holding just one-half a cubic foot, was filled with the earth. The box was then jarred against the ground, and the excess of earth removed with a straight edge. In this way the earth was as closely packed as possible without applying actual pressure, so that its condition would approximate that of the mass of earth in the pit. The average of several readings varying from 80 to 85 lbs. was 83½ lbs. per cu. ft.

The diagram Fig. 6 gives the results of the experiments with damp earth. It will be seen that the pressure against the upper measuring board increases much more rapidly than that against the lower one. For this reason the series was discontinued shortly after the upper balances indicated a greater pressure than the lower ones. It was supposed that this was due to the earth clinging to the sides of the pit, like the sand in a molder's flask, and not settling freely. To avoid this the cohesion was destroyed by spreading the earth upon an asphalt pavement. Here, by the aid of convenient draft it was completely dried in about two weeks.

The experiments were repeated with this dry earth, but again the pressure on the lower boards was less. This series of experiments required two days' time, and during the night the tangential component of the pressure on the upper board fell off about 60 lbs. This might have been due to a readjustment in the mass of the earth, but it seemed probable that it might have been caused by some meddlesome boy. To get a check on this and the difference in the pressure of the two boards, the series was repeated exactly, and a laborer engaged so that it could be finished in one day. The drop did not again appear, and at no other time was there any change in either the damp or dry earth noticed, although the apparatus frequently stood over night with the pit partly or entirely filled. Except for the drop, the results of the two series of experiments agree as well as could be expected of such an uncertain thing as earth pressure. The angle of repose of the dry earth, determined as before, gave a mean result of 35° 29', though more variable than that of the damp earth. The average weight was 78 lbs. per cu. ft., the limits being 77 and 79½ lbs.

The results of the dry earth tests are given in Fig. 5. The curve in the diagram, marked "theo-

*Abstract of a graduating thesis, University of Nebraska, Lincoln, Neb.

†1318 South 30th Ave., Omaha, Neb.

"retical pressure," is derived from the formula given by Prof. Merriman* for pressure inclined at any angle to the normal to the wall, substituting for this unknown angle the mean angle of 28° 10′ found by experiment, and which was fairly constant, as shown by the tests. The pressure on the lowest unit of surface, which is what is desired, is, according to the theory that supposes the pressure to vary directly as the head, twice the average pressure, or the total pressure divided by one-half of the height of the wall. In this way we

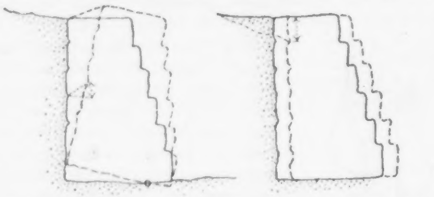


Fig. 3.—Sketch Illustrating Actions Resulting from Tipping and Sliding Forward of Retaining Walls.

eliminate from the theory all assumptions as to the direction of the pressure, and thus give it all the advantages possible.

The theoretical pressure of the damp earth was not computed, because it was known to have cohesion, so the angle of friction probably varied with the depth and was certainly greater than the angle of repose, since the angle of pressure against the wall often exceeded 45°.

The curves in the diagram are the smooth curves best coinciding with the results of the two series of experiments. These were thus drawn so that the indicated total pressure could be obtained by a planimeter, assuming that the pressure at any point of the wall is the same as that on the measuring board under the same head.

The dry earth was next removed and mixed with about one-fourth of its weight of water, giving a rather stiff mud. With this the first difficulty was to determine the angle of repose. This, of course, varied from 90° or more for small heights, to almost anything when piled higher. It did not even approach a constant value within the limits of the apparatus for determining it. Therefore the pit was filled with mud merely to see how much pressure would be increased when the earth was saturated with water. Fig. 6 gives the results obtained. It was found that over night the

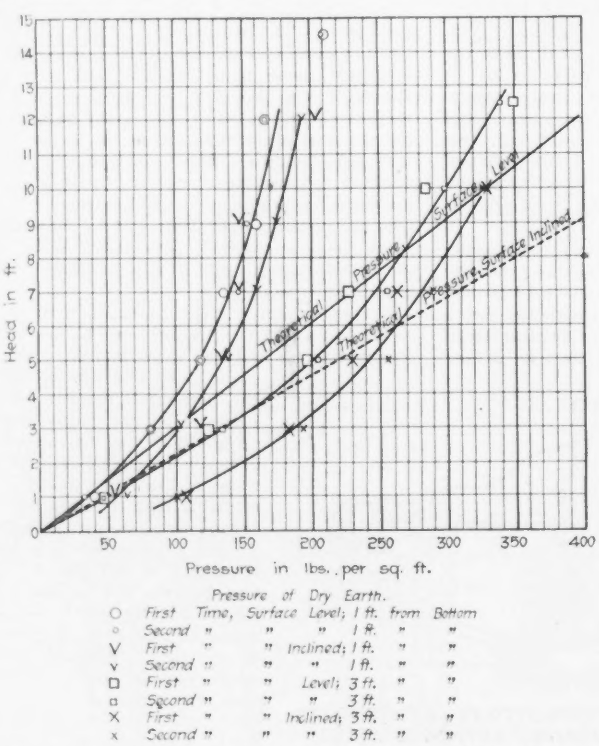


FIG. 5.—DIAGRAM SHOWING THEORETICAL PRESSURE AND PRESSURES, AS DETERMINED BY TESTS OF DRY EARTH AGAINST RETAINING WALLS.

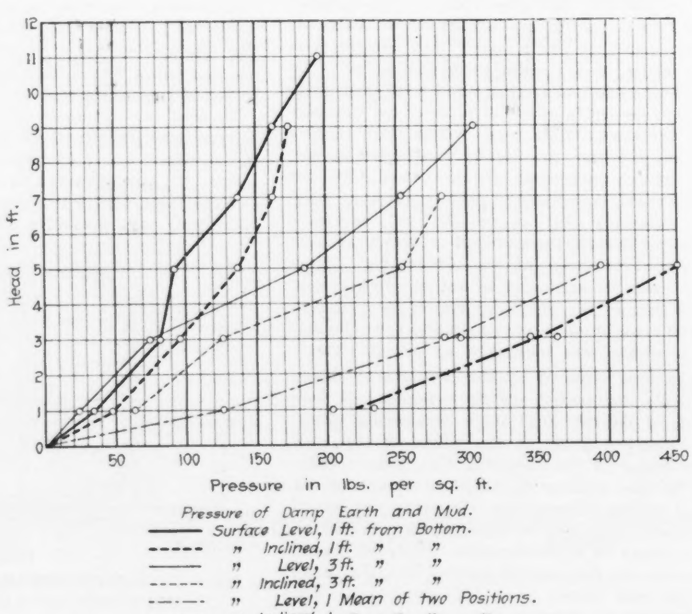


FIG. 6.—DIAGRAM SHOWING PRESSURE OF DAMP EARTH AND MUD AGAINST RETAINING WALLS AS DETERMINED BY TESTS.

mud shrunk away from the walls of the pit and partly consolidated, due to the draining away of the moisture. Hence it was deemed inadvisable to continue the experiments. The mud was then left in the pit for several days. The pressure on the lower board increased slightly, while that on the upper board diminished.

Although dry earth more nearly represents the theoretical conditions, the results with both damp and dry earth illustrate the same general facts. These are: that the pressure is not normal to the wall, but inclined at a fairly constant angle, which is practically independent of the inclination of the surface of the earth; that the pressure is not equal to a constant times the head; and that the nearness of the solid bottom has an unknown but large effect on the pressure of the earth.

Since the theory developed in Merriman's "Walls and Dams" seems to be the most generally accepted, it will be discussed in some detail. He favors the idea that the pressure is normal to the wall by stating that the wall may be considered as replacing a similar mass of earth, and since the pressure across any plane in a mass of earth will be normal to the plane, it will be normal to the surface of a wall in that plane. But against actual walls, the earth is either thrown in loosely or rammed, and in being compacted slides down the wall, which, unlike the replaced mass of earth, cannot settle or otherwise yield to the tangential pressure. Hence there will be friction and inclined pressure.

Also, as shown in Fig. 3, when a wall fails by overturning about any point not in its inner bottom edge, the face of the wall moves with reference to the earth in such a way as to produce friction. Or, assuming that incipient failure by sliding has occurred, the space occupied by the earth has been increased so that the surface of the ground sinks, and the earth slides down the wall, thus developing the full friction. When this is once developed, there is no reason for its subsequent disappearance.

As the experiments were conducted, this friction was produced by the settling of the earth. To measure the settling, a block of wood was placed in the earth opposite a mark on the wall about 4 ft. from the bottom. In the case of the damp earth it settled fully 4 ins. With the dry earth, one observation was lost by an oversight in removing the earth, but the other showed a settlement of ½-in. Thus, it is evident that since the settling actually occurred, the pressure must have made an angle with the normal equal to the angle of friction of the earth on the wood. The results show that this did not coincide with the angle of repose of the earth. In the case of dry earth it was much less, and, neglecting the case of very small heads, nearly constant. With damp earth, the angle of friction is very much greater than the angle of repose, showing that the coefficient of friction is much increased, due probably to cohesion.

Prof. Merriman, in deference to the opinion of some, works out another theory on the basis of pressure inclined at any angle to the normal of the wall, but in this also he accepts the common idea of the distribution of pressure. He assumes in accordance with most of the theories that the pressure is produced by a triangular prism of earth resting against the wall and the so-called plane of rupture. Now, since he assumes that this plane of rupture is fixed and immovable, it will act like another wall, and there is no reason to suppose that the distribution of the pressure over the plane differs from that over the wall. Since all his formulas give the total pressure as a constant times the square of the height of the wall, the center of pressure will be at a point one-third the distance from the bottom. Therefore, the weight of the prism of earth will be balanced by reactions through the lower one-third points of the wall and of the plane of rupture. Considering a unit section of this prism, the weight will act along the vertical through the center of gravity of the triangle. It is also a necessary law of statics that the lines of action of these forces shall meet in a point.

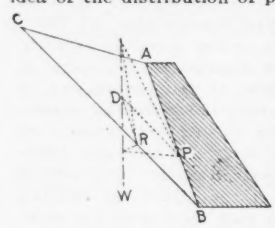


Fig. 4.—Diagram Illustrating Action of Earth Pressure on Retaining Wall Inclined Inward.

To show that these assumptions are not of general application, let us consider the special case of a wall inclined inwards. Let A B, Fig. 4, be the inner face of the wall, and B C the plane of rupture, P and R the one-third point, and W D the line of action of the weight. From simple geometry we know that R and P lie on the same side of W D, so that if W D is a resultant of two forces passing through P and R and meeting at any point D on W D, one of the forces must act towards D, so that, when all the forces radiate from D, the resultant will lie between the components. This means that the prism of earth will

*"Walls and Dams," p. 35.

exert a negative pressure either upon the wall or the plane of rupture. This is so absurd that we are forced either to reject the idea of a plane of rupture or conclude that the pressure at any point does not equal a constant times the head. The last was confirmed experimentally.

As a test of the theory of a plane of rupture, assuming that the reaction of the plane makes an angle of friction with the normal, it is a simple matter to work out a formula for the distance from the wall to the intersection of the plane of

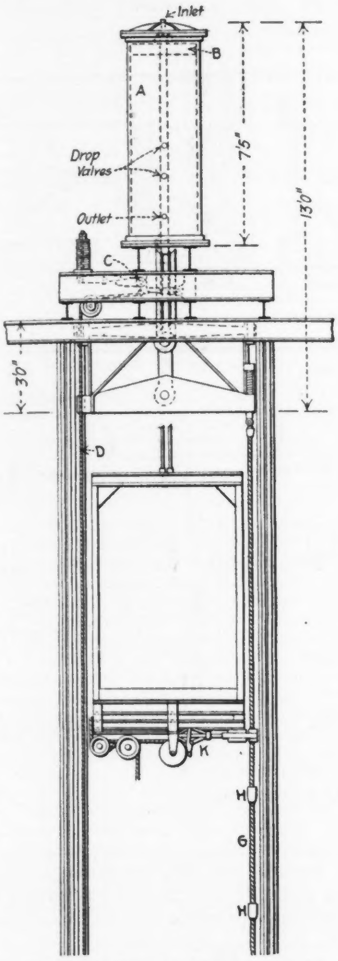


Fig. 1.—Elevation Showing Arrangement of Pneumatic Elevator Safety Device in a Building. John D. Griffin, New York, N. Y., Inventor.

rupture and the surface of the earth, in terms of height of the wall and known total horizontal and vertical pressures upon it. By using different heights, we could therefore see how nearly the position of the plane of rupture was constant. The pressures of dry earth against the upper measuring board, as most nearly meeting the conditions assumed by theory, were to be used, but when they were used it was discovered that within the range of the experiments they were a little greater than the theoretical pressure inclined at that angle. This fact gave distances involving the square root of minus one, or very appropriately indicated that the plane of rupture was imaginary.

To estimate the effect of the end walls of the pit, it is assumed that they only differ from a continued mass of loose earth in that they will not settle, and therefore the pressure against them will have a vertical component, which has the effect of supporting some of the earth. As the only apparent method of investigating this action, it is assumed that the pressure against the ends is equal to that against the retaining wall, shown by the upper measuring board where it is greatest. Further, assume that its vertical component holds up a triangular prism of earth (the most unfavorable form), then the distance from the wall to the further angle of this triangle can be readily computed. The maximum height of the earth above the upper opening was 12½ ft., and using the total tangential pressure coming upon the upper 12½ ft. of the wall, we find that the end walls will influence the earth 2½ ft. away. Since the end walls are nowhere less than 6 ft. apart, there is still 1 ft. of earth in the center of the pit unaffected by them.

Inclining the surface of the earth seems to introduce no new conditions, but merely causes an increase of the pressure such as we would expect from the addition of earth in any position, from which it could affect the wall. From the appearances of the curves, this increase is apparently a constant amount for all heads.

For the fact that the lower board did not receive as much pressure as the upper one, no adequate explanation can be offered. The pit was practically the same size at the bottom as it was 2 ft. higher. The dry earth, at least, had almost no cohesion, which was shown by the fact that in removing it, not even the lowest part would support itself in a vertical bank more than an inch or two high. The existence of this phenomenon seems simply to indicate that the conditions existing within a mass of granular material cannot be covered by any set of simple assumptions ignoring the influence of the solid bottom.

While the results of this investigation are mostly negative, it is hoped that they have indicated a fruitful line for further experiments, which may lead to some more scientific methods of proportioning retaining walls. In the meantime, we had best fall back upon rules like "make the thickness of the wall three-sevenths the height, plus a few inches for luck."

A NEW PNEUMATIC SAFETY DEVICE FOR HIGH-SPEED PASSENGER ELEVATORS.

We illustrate in the accompanying cuts the construction and operation of a pneumatic safety device for high-speed passenger elevators, which has given excellent results in a series of tests recently made by one of the large elevator companies. This safety is designed to combine the immediate action of the familiar clutch device with the gradual action of the air cushion for taking up the momentum of the falling car.

At present, as most of our readers are doubtless aware, high-speed passenger elevator cars are invariably equipped with clutches which automatically grip the guides at the side of the shaft in case the ropes supporting the car break or the car exceeds a predetermined limit of speed. With modern high-speed elevators, however, the difficulties of elevator designers have greatly increased. It will not do to set the safety clutches to trip at too high a speed, for in the stoppage of the car by the safety clutches risk is run that the guides may be wrecked or the passengers injured. If, on the other hand, the clutches are set to trip at a speed not much in excess of the operating speed, the chances are that cars will occasionally overrun their speed, throw the safety clutches and give the passengers a shock, physical and mental, from the sudden stoppage of the car, that will bring down curses on the head of the elevator engineer. It may be said that the clutches should be set to grip the guides with less force, but one cannot progress far in this direction without risk that the clutches may not certainly stop the car.

What is needed for an easy stop, apparently, is a resistance which will be applied with moderate force at the start, but which will continue to increase until the car is brought to a standstill.

The air cushion, which was in considerable use some years ago, effects just this sort of a stop; but with modern high lifts the air cushion at the bottom of the shaft is evidently unsuitable. A car

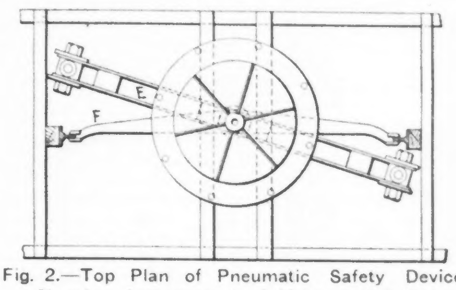


Fig. 2.—Top Plan of Pneumatic Safety Device, Showing Arrangement of Yoke and Guide.

falling freely down a 100-ft. shaft, for example, would acquire a velocity at the bottom of about 80 ft. per second, or 55 miles per hour, and unless a very deep shaft were made for the air cushion, the stop would be highly disastrous to the passengers.

The apparatus which is illustrated in the accompanying drawings has for its purpose the stoppage of the car by an air cushion at any point in the shaft, and the manner in which this is effected will be evident from the following description:

The construction in the building is shown by Figs. 1 and 2. Referring to Fig. 1, the air cylinder A is placed at the top of the hoistway or shaft, with the piston B held at the top of the cylinder by means of the balanced automatic lock C. This lock is released by the pull on the ⅝-in. steel rope D. The piston rod carries the yoke E and the cross guide F, which are shown more clearly in Fig. 2. To the yoke E at its ends are attached two cables G, provided with buttons or stops H, spaced about 4 ft. apart. On the bottom of the car is the safety device, operated by a centrifugal speed governor, and, also, by a hand lever in the car, and which has jaws which normally stand open and clear the cables G and the buttons H as the car passes. A second pair of jaws encircle the rope D, which operates the safety latch C.

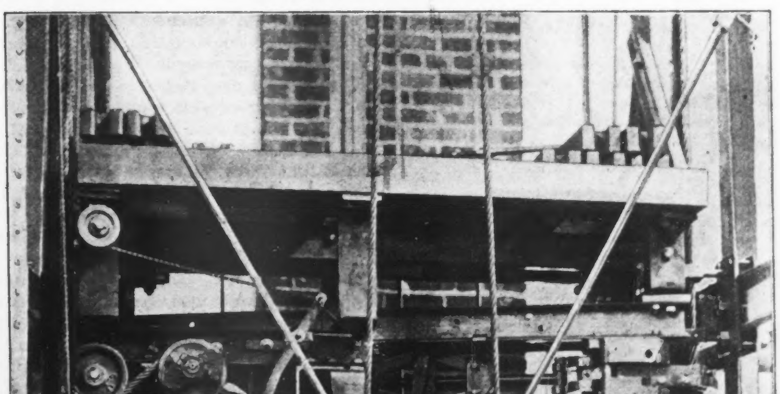


FIG. 3.—VIEW OF SAFETY GRIP ATTACHED TO ELEVATOR CAR.

The general appearance of the safety apparatus is shown by the half-tone view, Fig. 3, and the details of its construction are given by Fig. 4. Referring to the latter figure, A is the centrifugal speed governor, which operates the latch B, which in turn sets free the spring actuating the jaws C, which grip the lock rope B. Simultaneously with the closing of the jaws C, the spring actuates the bolt E, which rotates the wheel F. A three-fourths turn of this wheel sets free the latch which holds the spring G, which operates the grips closing on button cables. This delayed motion mechanism is a salient feature of the safety device, as will be explained more fully further on. First, however, the construction of the automatic lock (C, Fig. 1) needs to be explained. Fig. 5 is an enlarged drawing of this lock. It supports, as will be seen, the piston rod and everything attached thereto, which for a building 300 ft. high weigh about 5,000 lbs. Two 1,000-lb. capacity spiral springs balance this weight, with the advantage of six to one furnished by the lever system. A pull of 500 lbs. on the lock rope compresses the spring enough to release the lock fork and allow the piston to drop.

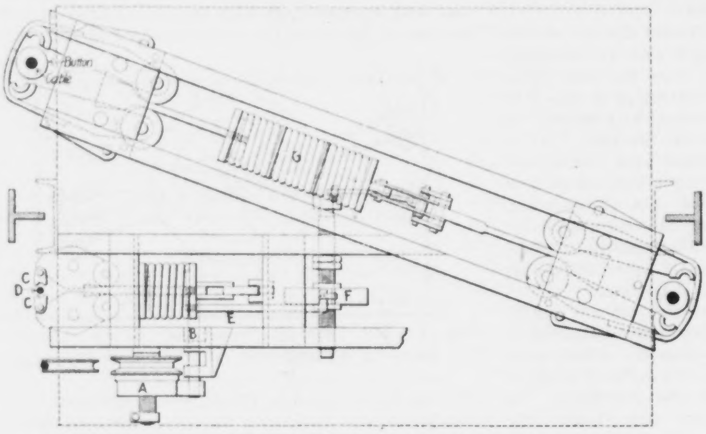


FIG. 4.—DIAGRAM EXPLAINING OPERATION OF SAFETY GRIP.

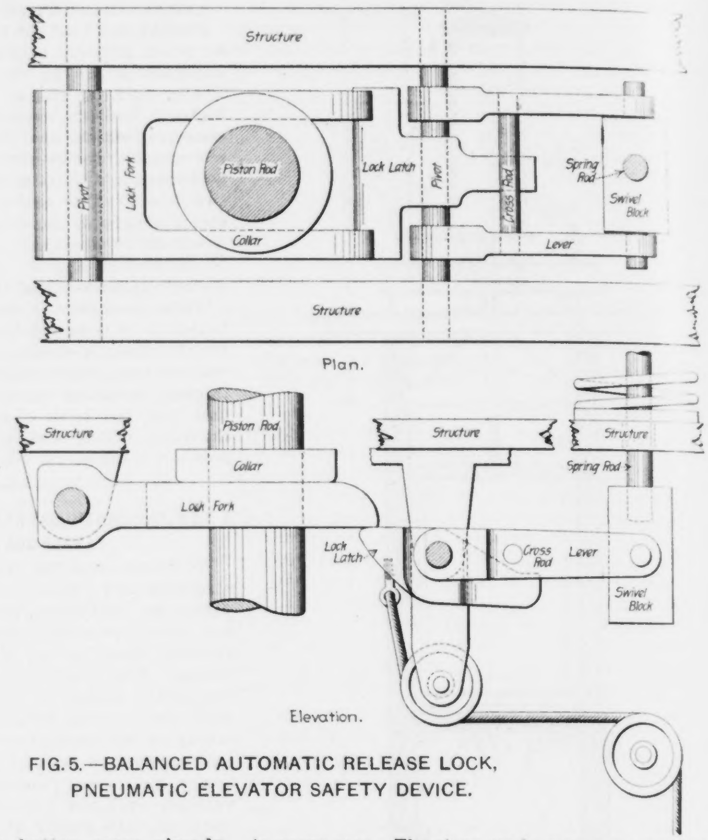


FIG. 5.—BALANCED AUTOMATIC RELEASE LOCK, PNEUMATIC ELEVATOR SAFETY DEVICE.

The operation of the whole device may now be explained as follows, by referring to Fig. 1: The car falls freely until a certain speed has been reached, say 600 ft. per minute, when the centrifugal governor acts by throwing in the clutch running on the lock rope D. This releases the lock C, which allows the piston rod and yoke with the attached button cables to fall so that when the safety grip proper closes about 1-5-sec. later it clutches on the bottom ropes already in motion in the same direction as the falling car, but moving at a slower speed. The significance of this will be understood best by assuming a concrete example. Supposing the centrifugal governor set to trip at 600 ft. per minute, to trip just below one pair of buttons and to catch on the next pair 4 ft. below. By this time the car would have acquired a speed equal to a free fall of 5 ft. 6 ins., which is 1,158 ft. per minute or 18.8 ft. per second. As the button cables, together with the parts to which they are secured, weigh more than the falling car, their inertia, supposing them to be at rest, could not be overcome by the car falling at the rate of 18.8 ft. per second without a serious shock to the passengers and severe strains on the apparatus that would call for such strength in all the parts as would add greatly to the mass, the inertia of which has to be overcome by the falling car. With, however, the button ropes already moving, when the safety grip catches, at a speed due to 1½ ft. free fall of the piston, the difference in speed between them and the car is not enough to cause any severe shock when the two engage and travel together. Then there remains the air cushion to absorb the momentum of the falling car and piston attachments, and to understand its action the construction of the piston cylinder must next be examined.

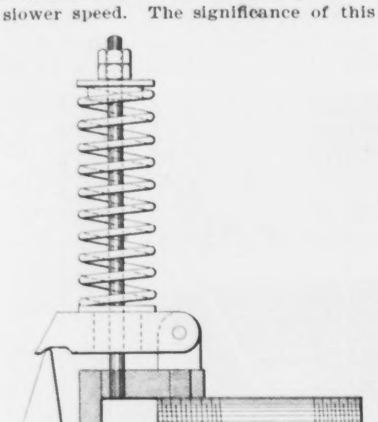


Fig. 6.—Release Valve for Cylinder of Pneumatic Elevator Safety Device.

The cylinder used in the tests was made of rolled steel, with an outside diameter of 30 ins., and a length of 7 ft. 6 ins., giving it a capacity of about 29¼ cu. ft. At the center of the top cover there was an inlet hole, 1¾ ins. in diameter, and at three different heights on the side were release valves of the construction shown by Fig. 6. The lowest of these vents was 6 ins. above the bottom of the cylinder. On the first part of its stroke the piston operates against a modified vacuum and a partial compression amounting together to about 5 lbs. per sq. in. of piston area. This prevents a too free drop of the piston and pendant cables before the car engages with them. In the example assumed above the fall of the piston up to the time the car clutch gripped the button cables would be about 1½ ft. This leaves 6 ft. of stroke in which to absorb the momentum of the falling mass, in a period of from ½ sec. to 1 sec. of time, the compressed air escaping from the three nut holes, as the piston descends. As already stated, the final vent is 6 ins. above the bottom of the cylinder, giving an air cushion to prevent shock. Referring to Fig. 6, it will be noticed that the gravity drop of the cover of this release valve gives instantaneously a relief area the full size of the vent, which could not be had with the ordinary pop valve construction. Fig. 7 gives the detail of the fixed buttons, which are on the safety cables. The buttons were threaded on the cable, and the strands opened up in the button by means of a right and left twist, and drawing together of the two caps of a special machine designed for the purpose. The interstices in the egg-shaped cavity of the button in which the strands of the cable were distended as described, were then filled with molten babbitt metal.

Tests of a full-size elevator equipped with the above-described safety device have been made at the shops of one of the principal elevator manufacturing concerns. The car was dropped about 100 times, and the safety operated satisfactorily in every case. The stops made were very comfortable, and tests showed that the average retarding force was equal to only 25% of the weight acted upon. The distance which the car was allowed to fall in these tests was from 3 ft. 6 ins. to 8 ft. 6 ins., with loads of 2,000 to 6,000 lbs.

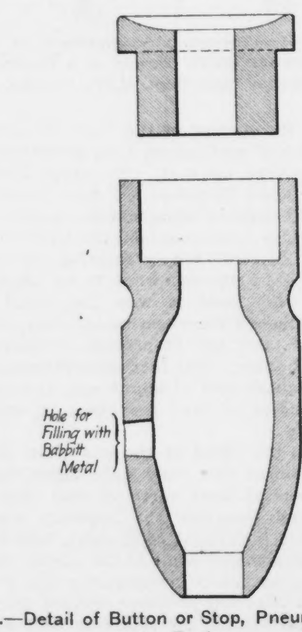


Fig. 7.—Detail of Button or Stop, Pneumatic Elevator Device.

For the information from which this description has been prepared we are indebted to Mr. John D. Griffin, 60 Broadway, N. Y., the inventor of the device.