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THE FIRST INTERLOCKING PNEUMATIC SWITCHboard applied to a street railway power plant was recently erected at the new power house of the Consolidated Traction Co., of Pittsburg, Pa., by the Westinghouse Electric Co. In a paper describing this station, read before the Engineers' Society of Western Pennsylvania, at its December meeting, this switchboard was described, as follows:

All the machine and feeder switches and circuit breakers are controlled by air valves on ornamental iron stands on a platform raised above the engine room floor. The bus bars, switches and other apparatus are in the vault below, and the air valves interlock in such a way that mistakes in manipulation are hardly possible. Each generator has a generator stand on the upper platform provided with an ammeter, hand wheel for regulating the potential; a volt meter connection, a tell-tale lamp for showing when circuit breaker is out, and the two air valves, one controlling the main switch, and the other the circuit breaker. Each feeder stand has a similar equipment, with the exception of the rheostat and volt meter connection. In addition, there is a volt meter stand and an ammeter stand, each carrying three Weston instruments.

A NEW TYPE OF INCANDESCENT ELECTRIC LAMP has been attracting attention abroad, and, according to Mr. James Swinburne, of London, England, who read a paper on the subject at the meeting of the Society of Arts on Feb. 8, it foreshadows a revolution in the method of electric lighting. The lamp is the invention of Professor Walther Nernst, of the University of Gœttingen, Germany. In this lamp a rod of magnesia, thoria or some similar refractory oxide, the exact nature of which is a secret, is heated by some external means, such as a Bunsen burner or a coil of platinum wire until quite hot. Current is then turned on, and owing to the property of the material to conduct electricity when heated it rapidly becomes incandescent and remains so until used up. The life of the incandescent rods is at present about 500 hours. The complete lamp of small size consists of a rod of the material about 1-16-in. in diameter and 1 in. long, which is held between suitable platinum terminals. The rod is exposed to the air and requires no vacuum bulb. The efficiency is high, and it is claimed that this lamp requires only 1.5 watts per candle-power against 3.5 watts in the case of the ordinary glow lamp. In addition it appears that the lamp can be arranged to operate on any voltage, even as high as 1,000 volts, and that the slight variation in pressure usually causing such annoying flickering has no appreciable effect upon the steadiness of the light.

DIFFICULTY IN OBTAINING WATER was experienced by both the Niagara Falls Power Co., and the Niagara Falls Hydraulic Power & Mfg. Co., both of Niagara Falls, N. Y., during the intense cold weather of the recent blizzard. Ice accumulated in the canal of the former to such an extent that dynamite had to be employed to keep the channel free enough to furnish water for three wheels. The Hydraulic company, whose power house is at the bottom of the gorge, was practically shut down owing to ice which backed up into the tail race. As soon as the flow in the two great penstocks (7 and 10 ft. in diameter) ceased the water began to freeze, and before the managers realized what was happening, the water in the penstocks was practically frozen solid. Several days of warm weather were required to thaw them out and put the plant in running order.

AN INJUNCTION AGAINST THE USE OF UNDERground water by the Borough of Brooklyn, New York city, has been granted by Justice Wilmot M. Smith, of one of the divisions of the New York Supreme Court. The plaintiff, Mr. Benj. E. Forbell, a florist and market gardener of Queens Co., was also awarded $6,000 damages for the diversion of water from his land. The land is near the Spring Creek pumping station of the Brooklyn waterworks, where water is drawn from driven wells. The Judge is reported as saying that property rights in surface water are no more sacred than those in underground water. It is said that hundreds of suits of like nature will follow. If so, it would appear that New York will have to choose between extinguishing these water rights and developing an additional supply elsewhere, provided the decision noted is sustained by the upper courts.

SITES FOR A NEW STORAGE RESERVOIR for the water supply of Newark are being investigated by Mr. M. R. Sherrerd, M. Am. Soc. C. E., Engineer of the Street and Water Board. The one most favored seems to be at or near Great Notch, practically on the pipe line built by the East Jersey Water Co.

THE LUDLOW RESERVOIR of the Water-Works of Springfield, Mass., is to be emptied and its bottom carefully examined to determine, if possible, what can be done to prevent the tastes and odors due to organic growths for which this reservoir has long been notorious.

A STATE SCHOOL OF PUBLIC HEALTH is proposed by a bill introduced in the New York legislature. Instruction would be given in public sanitation.

NEW DUMPING PIERS FOR GARBAGE, ASHES and refuse are proposed for New York city. Provision would be made for sorting and saving refuse of commercial value and burning the combustible portion. The ashes, street sweepings and garbage would be dumped onto scows for removal. The whole plant, including the scows, slips and docks, would be enclosed. Mr. Jas. McCartney, 346 Broadway, is Commissioner of Street Cleaning. Bids are to be received by the department March 10 for receiving and disposing of the street sweepings, ashes, garbage and refuse of the boroughs of Queens and Richmond.

THE LONG ISLAND RAILWAY CO.'S TUNNEL on Atlantic Ave., Brooklyn, is again before the Cities and Railway Committee of the New York Senate. A franchise for a greater period than 25 years is wanted, as such a limited time would not warrant the expenditure necessary. The purpose of the tunnel is to promote rapid transit between Brooklyn and New York. No action has yet been taken on the proposed amendment.

A NEW FOOTWAY TUNNEL UNDER THE THAMES, at Greenwich, is proposed, and the Bridges Committee of the London County Council has recommended the acceptance of the bid of J. Cochrane & Sons for this work, at $547,500. After some controversy the recommendation was passed on Feb. 14.

THE MOST SERIOUS RAILWAY ACCIDENT of the week occurred on the Pennsylvania R. R. at West Philadelphia, Pa., on Feb. 24. The accident was due to an open switch which permitted an inbound accommodation train to cross over and collide head on with an outbound express. One person was killed and 13 were injured.

AN EXPLOSION OF DYNAMITE in the Eiger tunnel of the Jungfrau Ry. occurred on Feb. 25, killing 6 men. A description of this railway was given in Engineering News of Dec. 15, 1898.

A BREAK IN A 20-IN. CAST-IRON WATER MAIN forming part of the system conveying water from Belleville, N. J., to the high-service reservoir on Jersey City Heights, N. J., occurred on Feb. 17. The main was laid in 1857. Mr. C. A. Van Keuren, Chief Engineer of the Board of Street and Water Commissioners of Jersey City, says:

The point at which the break occurred is on the Salt Meadows, just east of the Hackensack River. This locality is over three miles distant from the vicinity in which electrolysis was found. (Eng News, Feb. 2, 1899.) The cause of the break was due entirely to ice in the pipes. We lost no water to speak of, and the repairs to conduit are nearly completed. The pipe was considerably corroded, but still not seriously to impair its strength.

RAISING THE "GERMANIC," of the White Star Line, which sank at her pier in New York city, on Feb. 13, was accomplished on Feb. 23, after ten days of the hardest kind of work on the part of the Merritt & Chapman Derrick & Wrecking Co., and the Baxter Wrecking Co. All openings were closed by divers, cofferdams were built about the hatches, and pumps installed on her deck, and on the wrecking tugs. Three or four trials were made, each time increasing the number of pumps. The work was finally accomplished by 18 pumps, capable of discharging about 2,500,000 gallons of water per hour. It is stated that the work of raising the vessel cost the steamship company $5,000 per day, or a total of $50,000. She will be docked at the Erie Basin for temporary repairs and sent to England for a complete overhauling.

THE JAPANESE CRUISER "CHITOSE," built at San Francisco, Cal., made a trial speed of 23.76 knots for short distance runs, and her average was 22.87 knots. This slightly eclipses the trial run of the "Minneapolis," which made 23.7 knots.

ARMOR PLATE for the new battleships now nearing completion is not to exceed in cost $445 per ton of 2,240 lbs., including all royalties, according to the terms of the Naval Appropriation bill, as passed by the House on Feb. 23.

TWO LARGE STEEL RIVER BOATS, "built after the style of Mississippi River boats," says the "Weser Zeitung," are being constructed at Bremen for use between Shanghai and Hankow, China, a distance of 600 miles. They are designed to serve the very considerable Chinese passenger traffic between these and intermediate cities on the Yangtse. They will have twin screws and triple-expansion engines, with a speed of 12 knots loaded. Excepting that they have high deck houses and light draft, the resemblance to Mississippi steamers is not apparent.

A MODEL OF THE CHICAGO DRAINAGE CANAL is to be exhibited at the coming Paris Exposition, by resolution of the Engineering Committee of the Trustees of the Sanitary District of Chicago. The model, it is stated, will be 40 ft. long on a scale of 10 ins. to one mile, and the cost is estimated at $3,000. Chief Engineer Isham Randolph and a committee of three trustees will decide upon the details.

ERIE CANAL CONTRACTORS will receive the pay due them, without allowances for prospective profits; according to the reported late conference of state officers. An effort to learn on what basis the canal contractors would quit, is said by an Albany item to have resulted as follows: Eight of them will accept $133,000 for work done, but want $214,000 for damages for plant purchased, etc.; 25 will accept $436,000, the amount due them for work; and four contractors have not yet communicated with the state officials.

THE NEW NEW YORK RAPID TRANSIT BILL was introduced in both houses of the New York legislature on Feb. 22. It makes a great number of changes in the old Rapid Transit law, the most important of which is an amendment which abandons the old and admittedly unworkable plan of selling the franchise for constructing and operating the road to a private corporation, and permits the commission either to build the road outright with the city's funds, as the Boston subway was built, or to dispose of the franchise to a railway corporation, either one now operating a railway in the city, or one organized for the purpose of leasing the franchise.

100,000 TONS OF PIG IRON were reported sold on Feb. 17, by the Tennessee Coal, Iron & R. R. Co. This is No. 2 Foundry, and is intended for export. The price, $9.25 per ton, is $1.75 per ton higher than the price of a year ago. For the 18 months prior to Jan. 1, only 293,996 tons of pig iron had been exported from the Birmingham (Ala.) district.

PLATINUM HAS BEEN FOUND IN THE YUKON, according to United States Consul McCook, of Dawson City, who says that the black sand of that region is rich in platinum. A quantity of this sand was examined by Dr. Willis E. Everette, who found it to contain 75% black magnetic iron oxide and 25% of some other material. Upon furnace testing it was determined that 1 ton of this non-magnetic black sand contained $102 of gold, 96 ozs. of platinum, some iridium and traces of tin. The platinum at $8 per ounce, would amount to $768, or the total value of a ton would be $870.

FURTHER KITE EXPERIMENTS were conducted at Bayonne, N. J., on Feb. 22, by Mr. Wm. A. Eddy. In these experiments a Leyden jar was sent up using three kites 7 ft. in diameter. The outside coating of the jar was connected to a bare copper wire, which ran down the main kite cable. The end of this wire was held within 4 ins. of an iron spike driven into the ground. When the jar reached an elevation of 100 ft. a spark was drawn between the terminals. There was a constant brush discharge between the end of the wire and the spike, accompanied by the usual hissing sound. When the terminals were separated to 5 ins. the action ceased. With a gap of 1-in. a large spark occurred, which was preceded by the "crackling of countless small sparks." The experiments were conducted in connection with an investigation of military signaling. An elevation of 1,100 ft. was reached, requiring over 2,000 ft. of line.

The upper end of the canal enters the reservoir in 20 ft. of water. Here are six gates, with 120 sq. ft. of opening, discharging through a convergent section of the canal between baffle boards into a weir chamber 16 ft. wide, 17.7 ft. deep and 45 ft. long. At the lower end of the chamber is a weir of 12 x 12-in. timbers braced. This weir is removable at will, and may discharge into a 4 x 4-ft. waste tunnel, carried longitudinally through the partition wall, and emptying below the dam, or into the canal direct. The quantity of water passing the weir for any experiment may be carefully fixed, while the discharge is through the waste tunnel, and at the proper moment suddenly turned into the canal by tripping a weighted gate closing the tunnel. The lower end of the canal discharges over a 60-ft. cliff, mingling its waters with those of Trip Hammer Falls below. At this end is a weir or dam of 12 x 12-in. timbers, with appliances for removing and replacing them. At the north side, 6 ft. from the lower weir, are two discharge gates, each with an opening of 18 sq. ft. Immediately opposite, similar gates open into an auxiliary canal, which, in turn, discharges into the top of the 6-ft. steel stand-pipe, resting at the base of the cliff. A measuring weir is placed in the auxiliary canal near its intersection with the stand-pipe.

The gates are wood faced, have openings 2 to 3 ft. wide, and are raised by rack and pinion apparatus, operated by a loose bar, except that in each set one is brass faced and is operated by a worm screw and wheel. On the berms are 20-lb. steel rails, carrying an electrically-propelled car, spanning the canal, and which can be regulated closely to fixed speeds.

The water which finds its way through the rock in which the canal excavation is made is prevented from forming a head against the canal lining by the insertion of seepage channels of gravel sewed into tubes of burlap placed vertically between the rock and the back of the canal lining. These channels are carried under the canal into a drain excavated in the rock under the canal, and along the center line throughout its length. This latter drain is entirely cut off from the interior of the canal by the concrete bottom.

At the south end of the dam proper, near its intersection with the canal, is a gate chamber with a screen and a 48-in. circular gate leading to a 48-in. steel riveted pipe. This pipe parallels the canal throughout its length, and is to be continued down stream for 1,600 ft. to the proposed new power-house. A 30-in. branch is taken from this pipe to the auxiliary canal as an independent feed for the laboratory stand-pipe when it is undesirable for any reason to use the main canal for this purpose.

Near the lower end of the canal, between it and the stream and under the 48-in. main, which is here carried on high supports, is a house containing four duplex water motor pumps. The average size of the pumps is 10-in. stroke, 17-in. power piston and 6½-in. pump plunger. The normal combined capacity of the four pumps is about 1 cu. ft. per sec. They take water from the 48-in. main, under a head of 32.7 ft., normally, and pump into the distributing reservoir 144.6 ft. above the pumps. This reservoir is used for the University campus supply and incidentally for experimental purposes, as hereinafter described. It has a capacity of 1,000,000 gallons.

Fig. 2.—View of Fall Creek Gorge in its Original Condition. Laboratory Site Under Cliff at Foot of Lower Falls; New Dam Site Just Below Old Dam.

The cliff at the site of the stand-pipe overhangs 25 ft. in a height of about 85 ft. Under this cliff, and built against it about the base of the pipe, is a laboratory building, shown by the view, Fig. 5, and the plan and section, Fig. 6. The building is of heavy construction, as it must needs be to withstand the load of ice which may rest upon it in the winter formed from the spray of the nearby falls; the roof is of especially heavy construction, with intermediate supports, which are removable, leaving a room unbroken by obstructions for the greater part of the year. The walls are of heavy rubble, 30 ins. in thickness, laid in 2 to 1 Portland cement mortar. The building was designed as appropriately to its position as its purpose would permit; and the suggestion of a cliff-dweller's stronghold which it conveys does not mar the wild scenery of its surroundings. It is roughly 70 x 30 ft., with a ceiling height of 12 ft. At one corner is a 40,000-lb. scale, set in a pit 3 ft. deep. The floor of the building and the pit lining throughout is of concrete, so graded as to give rapid drainage. A portion of the building extends over a bay in the pool below the falls, and is carried on 20-in. steel beams. The depth of water is here 20 ft., and the solid rock to this depth has been cut out by the grinding boulders, which have come over the falls and have been churned about in the cauldron below. A view of the laboratory taken on Feb. 11, 1899, is shown by Fig. 7. After the plant is in full operation there will not be so much ice attached to the cliff as shown in this view, owing to a better control of waste waters.

The stand-pipe is 72 ins. in diameter, and is of 5-16 and ⅜-in. steel plate. The upper end is curved through 90°, and connected with the auxiliary canal through a massive concrete collar. It has one 12-in. opening about midway of its height, a 6-in. opening just under the ceiling of the laboratory building and a 6-in., a 12-in. and a 36-in. opening near the level of the floor within the building. These openings are of flanged cast-iron specials, made ready to receive any kind of connections which may be desired. From the center line of the horizontal lead of the pipe, connecting with the auxiliary canal, to the center of the 36-in. opening, is 60 ft., giving an available head of that amount.

Parallel to this larger pipe, and attached to it, is a 10-in. pipe connected with the distributing reservoir. It has one opening in the laboratory building, which is 189 ft. below the overflow level of the reservoir, giving an available head of that amount.

The masonry construction throughout, with the exception of the walls of the laboratory building, is of concrete. The argillaceous shale of the country makes fair concrete material, and is generally unsuited for hydraulic constructions in the form of rubble masonry. There are ledges in the neighborhood of Ithaca which, with a large amount of stripping and waste, afford layers from which small rubble stone could be obtained, but if used in the case of the dam it would have been necessary to face the structure with stone imported by rail from some remote place, and if used for the lining of the canal a facing of fine masonry or concrete would have been required to provide the smooth surface necessary to the purposes of the canal. In short, the use of rubble masonry not only would have made a backing more expensive than concrete, but would have required a facing of fine masonry, the slight advantages of which would have wholly unwarranted the excessive cost as compared with concrete.

Watertightness without a large sacrifice of strength was a prime quality demanded in the concrete; the large proportion of cement in concrete necessary to insure a good degree of impermeability, made the use of Portland too ex-

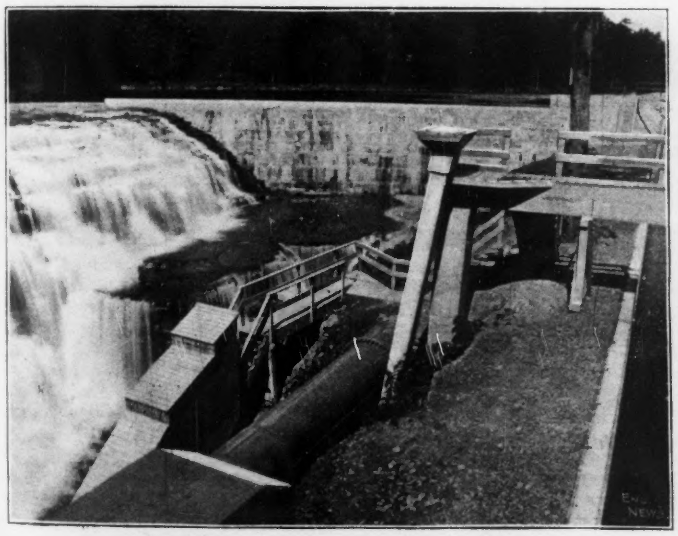

FIG. 3.—VIEW OF NEW DAM AND SPILLWAY.

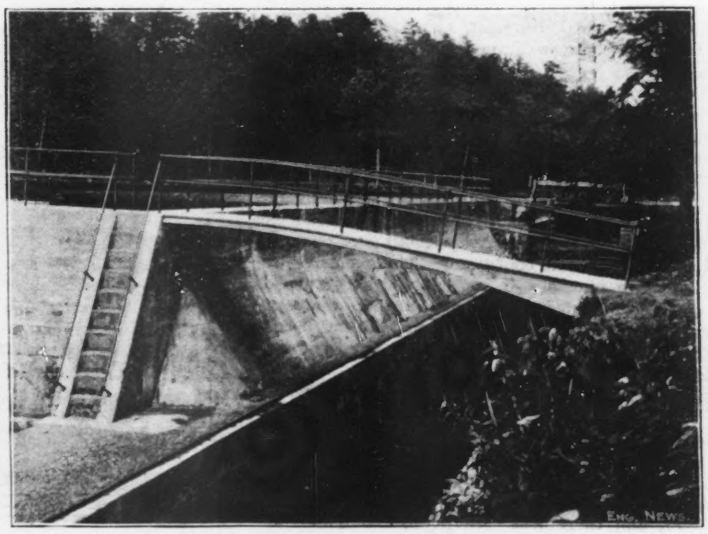

FIG. 4.—VIEW OF CANAL, WING DAM AND BRIDGE OVER CANAL.

THE HYDRAULIC EXPERIMENT STATION OF CORNELL UNIVERSITY.

Dr. A. M. Fairbairn, the Principal of Mansfield College, Oxford, England, wrote of Cornell University, after a visit to various American institutions of learning:

> Cornell is an example of a university adapted to the soil, bravely modern and industrial without ceasing to be ancient and classical or philosophical and historical. . . . It has instituted departments and organized them as excellent academic and scientific disciplines, while they are excellently adapted to the creation of the sort of citizens the State most needs—those qualified to discover, to use and develop the resources of the country. This was the classical idea of education; Plato and Aristotle held it; it was Milton's; it is surely the idea of every man who wishes to see the university serve the land in which it lives.

It was in keeping with this estimate of the University that its trustees two years ago prepared the plans, and appropriated the money, for a plant for making hydraulic experiments. Prof. E. A Fuertes, M. Am. Soc. C. E., Director of the College of Civil Engineering, presented to the Board of Trustees in 1896 a report upon the growth in number and importance of hydraulic problems in public works, and the serious lack of accurate knowledge of the laws governing many of these problems. The non-existence in any country of a plant or laboratory capable of practical experimentation upon these phenomena was dwelt upon, and attention was called to the natural facilities offered on the property of the University for the establishment of a hydraulic laboratory which could meet satisfactorily for many years the requirements of the hydraulic art. The report was accompanied by tentative sketches of the plant proposed. The Trustees viewed the project favorably and received early in 1897 from a special committee recommendations for the construction of a laboratory of greater scope than was originally suggested, providing at the same time for a water power plant, with electrical transmission, an improved water supply and a new sewerage system. The recommendations were accompanied by a report on the available drainage areas of the neighborhood, particularly of Fall Creek, upon whose banks it was proposed to build the laboratory; on rainfall and stream flow, together with sanitary surveys, chemical and bacteriological examinations of the waters and final contract, drawings, specifications and estimates of cost. The work was authorized, the money appropriated and the contract for practically the entire work, except the power development, was let to Mr. Ira A. Shaler, M. Am. Soc. C. E., in March, 1897. Mr. Frank S. Washburn, M. Am. Soc. C. E., a Trustee of the University, gave his services as Consulting Engineer. Mr. E. H. Hooker, now Deputy State Superintendent of Public Works, Albany, N. Y., was resident engineer during construction. We are indebted to Mr. Washburn for the information from which this article has been prepared.

The work includes a dam on Fall Creek, forming a reservoir of 50,000,000 gallons available storage, from which, as shown in the general plan, Fig. 1, leads a canal 400 ft. long, 10 ft. in depth and 16 ft. in width. From near the lower end of the canal is taken an auxiliary channel along the edge of a perpendicular cliff, discharging into the top of a 65-ft. stand-pipe, 6 ft. in diameter, which rests at the base of the cliff. The bottom of the pipe is enclosed in a one-story stone building, 30 × 70 ft. A 48-in. steel main leads from the reservoir and supplies the power station under a head of 150 ft. This main provides an independent supply for the stand-pipe already mentioned and furnishes water to the water motor pumps, which supply a distributing reservoir situated at some distance on high ground. The distributing reservoir delivers water to the laboratory building under the cliff, through a 10-in. pipe. Such in outline are the primary appliances to be used in whole or in part for experimental purposes.

Fall Creek has a drainage area, above the dam, of about 117 sq. miles, in which are living 7,500 persons, one-third of whom are in eight villages.

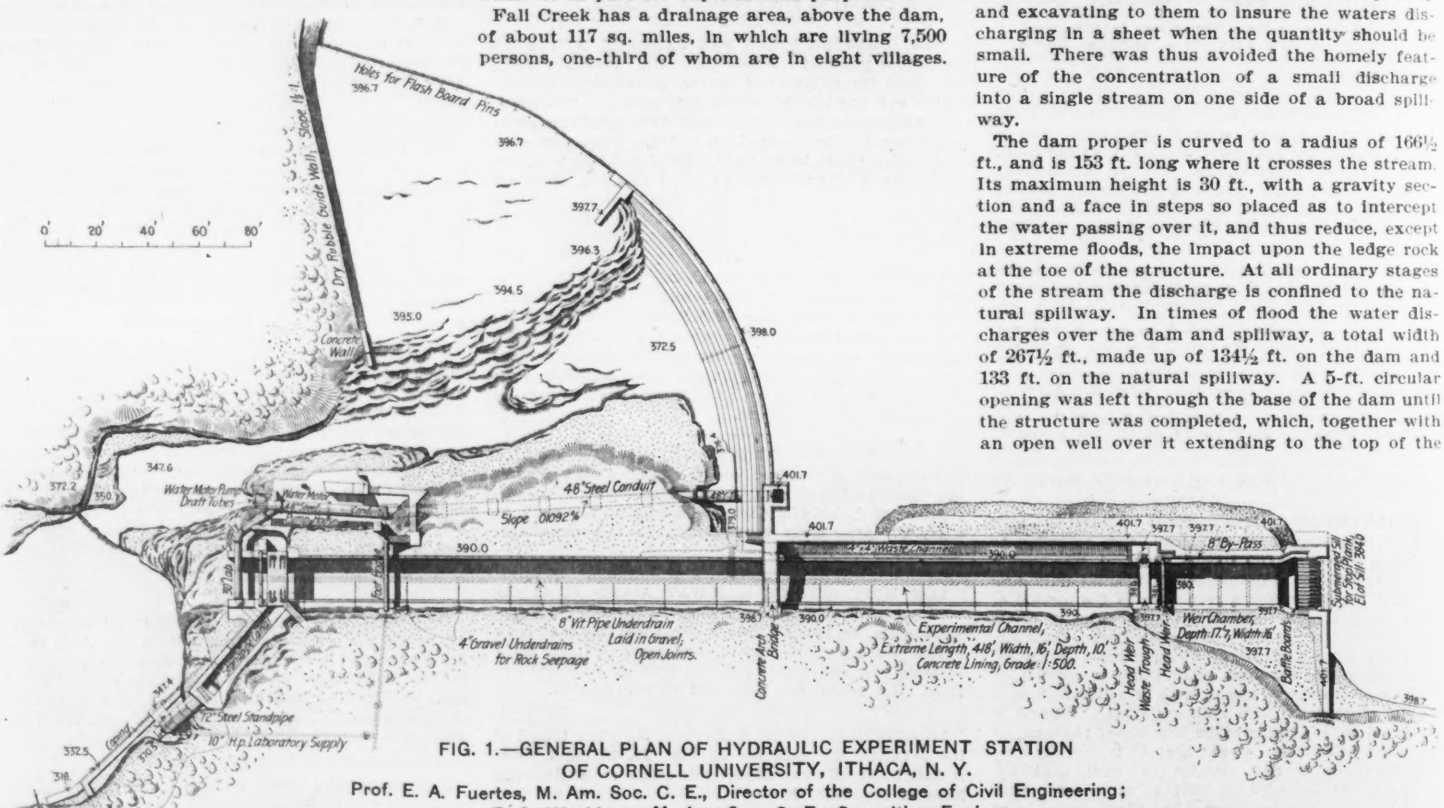

FIG. 1.—GENERAL PLAN OF HYDRAULIC EXPERIMENT STATION OF CORNELL UNIVERSITY, ITHACA, N. Y.
Prof. E. A. Fuertes, M. Am. Soc. C. E., Director of the College of Civil Engineering; F. S. Washburn, M. Am. Soc. C. E., Consulting Engineer.

The average rainfall at the western end of the drainage area from 1880 to 1897, inclusive, was 35.22 ins., the maximum being 46.39 ins., and the minimum 28.66 ins. The rainfall was first observed in 1879, and then showed only 20.04 ins. This is so abnormally low that, together with doubt as to the accuracy of the first year observations, it is not considered.

The monthly means during this period are as follows:

Months.	Ins.	Months.	Ins.	Months.	Ins.
January....	2.26	June........	3.75	November..	2.59
February...	2.16	July........	3.72	December...	2.39
March.......	2.39	August.....	3.40		
April........	2.19	September..	3.15	Total.....	35.22
May........	4.13	October.....	3.09		

The mean annual evaporation as determined from two years' observation is 22.55 ins., and the mean annual temperature is 46.70° F.

There have been various computations of the flow of Fall Creek, but very little actual observation. The report of Mr. Rudolph Hering, M. Am. Soc. C. E., on the sewerage of Ithaca (1894) gives 12 cu ft. per sec. as the minimum flow; 46.8, ordinary dry weather flow; 175, average flow throughout the year; 4,800 cu. ft. per sec. flood discharge; all based upon computations. High water mark at dams in the stream give 4,700 cu. ft. per sec. as the flood discharge, and computations from the performances of water wheels and low water marks on the driest days would indicate 13 to 17 cu. ft. per sec. as the minimum discharge.

The lower course of the stream where it descends from the elevated plateau above Lake Cayuga is through a narrow gorge between high rock cliffs. The fall is here about 400 ft. in a mile, over rapids and water falls. Two hundred feet above the Trip Hammer Falls the gorge widens suddenly into a flat basin of 20 acres in extent. There was built here in the narrow gorge about 70 years ago a 15-ft. stone dam, shown in Fig. 2,* impounding water for mills below. Immediately below this dam the new one was constructed. It abuts at the north end on a point of rock table land from which the rock was excavated to a level of 1 ft. below the proposed top of the new dam. This natural spillway curves through 90°, and discharges over the cliff into the gorge parallel to the axis of the stream, as shown by the view, Fig. 3. The earth slopes forming the sides of the spillway are protected by 18-in. paving, laid on 12 ins. of broken stone. The paving has a slope of 1½ horizontal to 1 vertical, and is toed into a trench cut in the ledge rock. Care was taken in determining the grades of the spillway and excavating to them to insure the waters discharging in a sheet when the quantity should be small. There was thus avoided the homely feature of the concentration of a small discharge into a single stream on one side of a broad spillway.

The dam proper is curved to a radius of 166½ ft., and is 153 ft. long where it crosses the stream. Its maximum height is 30 ft., with a gravity section and a face in steps so placed as to intercept the water passing over it, and thus reduce, except in extreme floods, the impact upon the ledge rock at the toe of the structure. At all ordinary stages of the stream the discharge is confined to the natural spillway. In times of flood the water discharges over the dam and spillway, a total width of 267½ ft., made up of 134½ ft. on the dam and 133 ft. on the natural spillway. A 5-ft. circular opening was left through the base of the dam until the structure was completed, which, together with an open well over it extending to the top of the dam, reduces the section at this point to 60% of the normal. Shortly after completion the structure cracked one-half its height from the top down through the well. During unusually cold weather, when the crack was widest, the opening through the dam and the well were filled with concrete.

On the south side of the stream, extending from the basin hereinbefore referred to, is a shelf of rock, which ends down stream at the edge of a vertical cliff 90 to 150 ft. high. Into the solid rock of this shelf, at a depth from 10 to 20 ft., a canal, Fig. 4, was excavated for 400 ft., intersecting the dam proper at its south end. The canal is lined with 18 ins. of concrete and has a finished width of 16 ft., and a depth of 10 ft. The level of the bottom of the canal is 17 ft. below the normal surface of the reservoir, and as the reservoir surface is higher than the natural rock surface along the north edge of the canal, that portion of the canal up stream from the dam has a heavy partition wall along the north side. This wall is in effect a wing dam, or an extension of the main dam.

*The views shown herewith are from photographs by Mr. G. B. Trumbull, of Ithaca, N. Y.

pensive. On the other hand, durability, strength, and resistance to frost pointed to the use of something better than Rosendale as highly desirable for the concrete generally. An "Improved" cement, being a mixture of Rosendale and Portland in the proportions by weight of 3 to 1, was adopted. It is not merely a mechanical mixture of the two cements, made in different places, but it is identically of the same rock

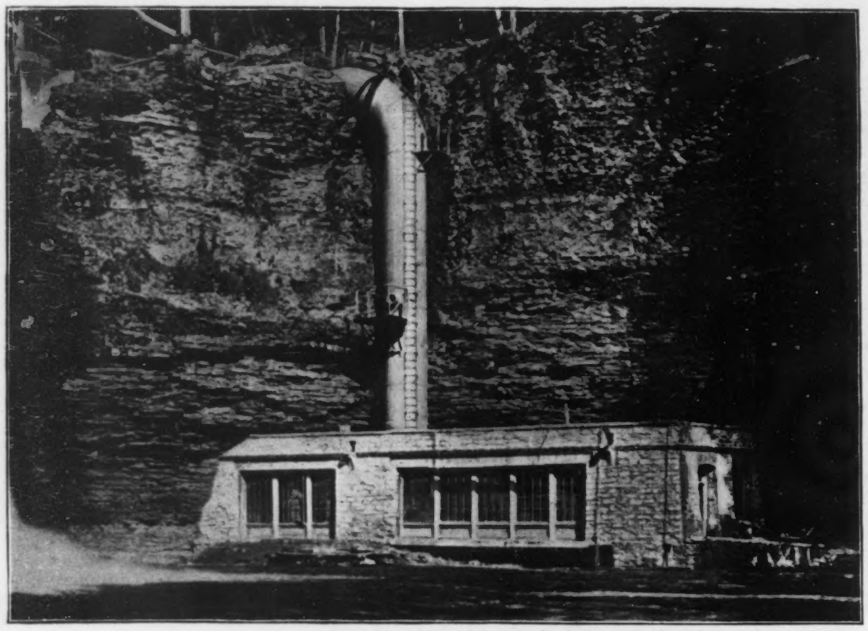

FIG. 5.—VIEW OF LABORATORY BUILDING UNDER THE CLIFF.

throughout, quarried in the same ledges and thoroughly crushed and ground together in the clinker state. The relative costs of Rosendale, Improved, and Portland cements, delivered at the work were as 1, 1¼, and 2½. As nearly as could be learned from tests of the Improved cement where it has been used for a number of years it attains nearly the strength of good Portland at the end of three to four years, and has an excellent curve of growth. The specifications required 100, 200 and 300 lbs. neat, and 120 and 200 lbs. 2 to 1, and these requirements were generally exceeded.

Of the whole amount of cement used 20 to 25% was Portland, employed for specially exposed places, in wet foundations, and on days when the temperature was so low as to make the use of other grades of cement questionable. All the cement was purchased by the engineer and delivered to the contractor free of cost. The generous use of cement was thus insured without any question of unfairness to the contractor. The exclusive use of concrete masonry in an exposed structure of importance, subject to widely varying temperatures, which, while practically monolithic, necessarily changes abruptly in size and shape of section, and in allnement, and in which integrity throughout is necessary to the purposes for which it is built, was looked upon as somewhat experimental. At the present writing the work has passed through one winter and the severe part of another with satisfactory results. There was slight exfoliation on the face of the dam the first winter, and there was practically complete destruction of the Portland cement "sidewalk" finish on top of the structures. The original specifications explicitly prohibited the use of Portland finish, but as the work neared completion the hope for a smooth, close textured coping was so seductive, that an expert and conscientious sidewalk layer was employed by the contractor at the request of the Engineer, and paid by the day for placing the best kind of sidewalk finish over the top of the dam and the berms of the canal. There happened what was originally anticipated, and what is entirely independent of the quality of the workmanship, namely, a separation between the two kinds of materials, resulting in the complete tearing off of the finishing layer.

It was replaced wherever possible, with a layer of fine crushed stone; elsewhere it was left rough. The concrete was in the proportions of 1, 2, and 4. The stone was crushed from hard, thoroughly clean, argillaceous shale, selected from the canal excavations. It came from the crusher in various forms and shapes and graduated sizes, not exceeding 2 ins., including a good proportion of very fine material. A screen removed the relatively small quantity of dust. The only sand to be had without bringing it by rail was of argillaceous origin, very fine and clean. The relative characters of the cement, sand and broken stone were thought to be highly favorable to watertightness and a good degree of strength. Tests made upon large blocks of concrete indicated that such would be the case.

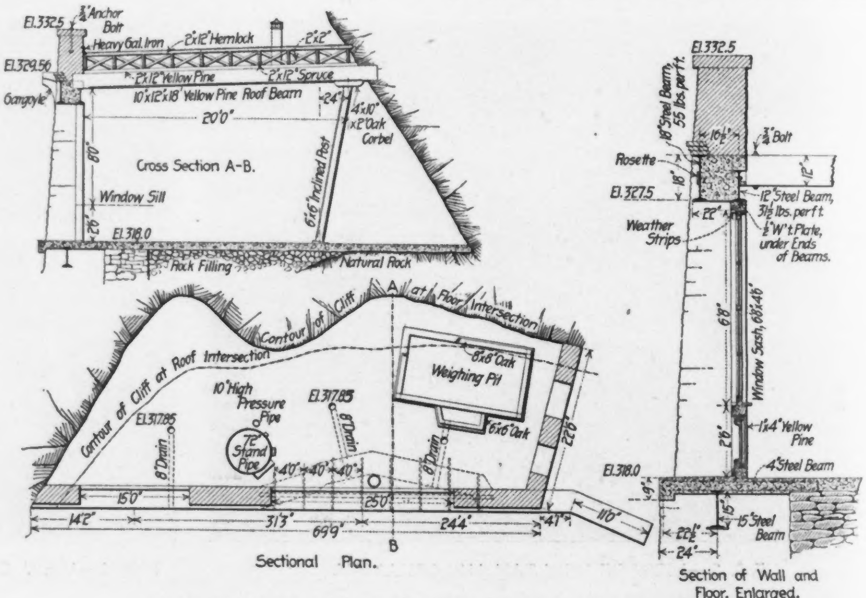

FIG. 6.—PLAN AND SECTION OF LABORATORY BUILDING.

The mixing and laying of the concrete was done with unusual care, and there seems to have been no exception to this, save on one occasion, where, so far as could be determined, the night shift placed a new layer over concrete laid a number of weeks previously without properly preparing the surface of the old work. This resulted in a series of small leaks in the partition wall; following the first winter the concrete at the leaks was removed and replaced with fresh. There has been no leakage since. The cutting out of old and substitution of fresh concrete was done on the face of the wall while it was still leaking. The area to be treated at any time was restricted to about 8 sq. ft. After the concrete about a leak was cut out, a ½-in. iron pipe was placed where the leakage could be best concentrated, and concrete inserted behind the forms and thoroughly rammed. The iron pipes were left to discharge for a number of weeks and were finally cut off close to the face of the wall and plugged with wood.

The concrete mixing was done by hand; the sand and cement received three turnings dry, and then were shoveled onto the dampened stone spread in a 9-in. layer. The whole mass was next turned once and then wet and turned three times and finally shoveled into a ½-yd. bucket. The concrete was raised to the wall by a derrick, spread in 4 to 6-in. layers and rammed. The loose stones were raked from each layer, after the tampers had passed over the area once, and were thrown away.

The concrete of the long, thin, high walls of the canal was thoroughly rammed into the rough face of the rock excavation, a layer of Portland mortar being first slushed and roughly spread on the rock. In this way it was hoped to attach the walls so strongly to the rock that temperature strains would not result in movement over any appreciable distance with consequent cracking. As yet there are no signs of cracks.

One of the principal purposes of the canal is that of a measuring basin, and consequently the principal quality demanded in it was watertightness. Various kinds of linings were considered, including asphalt, concrete, asphaltic layers and steel. A set of tests was made upon various materials proposed for the purpose, and it was finally decided that there were serious objections to everything except a good cement concrete, thoroughly bonded to the rock face of the excavation. That this alone would not be watertight was known, and it was believed that anything in the nature of a plaster upon the face of the concrete would disintegrate. As the concrete was laid there was inserted, back from the face of the form, 2 to 3 ins. of silica cement, mixed with the local sand in proportions of 1 to 2. A ¼-in. steel plate was blocked away from the face of the forms, the space filled with the silica-cement mixture, and the ordinary concrete layer filled in back of the steel plate. The mixture was well rammed with a special tool, the steel plate pulled out, and the concrete thoroughly rammed and forced into the facing layer. The very small amount of cement in the silica-cement mixture pointed to the necessity of keeping it much drier than ordinary concrete or mortars, consequently it was put in barely damp. In fact, it was so dry that unless a handful were tightly pressed by the fingers, it would lie in the hand like sand. After the forms were taken down this facing layer was granular, like soft sandstone, for two weeks; but it finally hardened to a close-textured, almost glazed, surface. The result of its use seems to be entirely satisfactory. In any event, it has not cracked or separated from the concrete in any place. Should there be, after these precautions, any leakage through the canal linings, a series of soap and alum washes will be given the whole interior of the canal. Provisions are made by channels exterior to the canal for measuring any leakage that may finally result.

FIG. 7.—EXPERIMENT STATION IN WINTER; LABORATORY BUILDING AT FOOT OF CLIFF PARTLY COVERED WITH ICE.

Every engineer at all interested in hydraulic work must have had presented him problems which in the present state of the art have no exact solution. Many such are basic in the art, while others are isolated and of less importance. Determinations of flow in all kinds of water channels have been confined too closely to expressing in one constant the value of all the various conditions and forces. Engineers in late years are called upon to deal with extreme volumes, pressures and velocities in works of such great magnitude that the available simple formulas are not adequate to determine the resultant of complex conditions within reasonable limits of economy. Hydraulic formulas must be built up in a larger degree of the elements in the problem, each being given a term of equation. Weir formulas which do not take into account at all, or express by too few terms, the character of the bottom, the height of the weir, the width and character of the lip, and pipe coefficients determined without knowing the number, character and effect of bends, the relative velocities at all points of the cross-section, the spiral movement of filaments, and other formulas, are not meeting the requirements of economy, or keeping pace with other branches of engineering. The specific proposed undertakings of the laboratory, as outlined by the Dean of the Engineering Faculty, are roughly as follows:

(1) Studies upon the dragging and the suspending power of water at various stages of its saturation with sediment.

(2) The effect of transverse, longitudinal, and submerged dams, under standard conditions which may be modified at will by disturbing influences covering any variety of complications.

(3) The determination of corrections to be made in the beds of streams to give them the most stable longitudinal profile.

(4) Study upon the conditions of such rivers as build their minor beds above the major bed.

(5) Study of littoral cordon formation, and of channels, bars and deltas, and of the deposition of sediment from rivers entering into quiescent water, and against tides.

(6) Study of the conditions affecting the length of tangents and the degree of curvature in natural and constrained water courses, looking to securing permanence of channels and depths of water.

(7) Studies upon the delivery and conditions of the Fall Creek drainage area, which feeds the canal, in reference to the amount and kinds of suspended matter by floods, the inter-relations of the deliveries of the tributary floods, and such studies as may prove useful for determining the coefficients of flood volume, length of dams and spillways, and height of floods over them, so as to perfect the formulas for the delivery of drainage areas, if this be possible. The drainage area of this canal covers about 117 sq. miles, which will be most carefully surveyed topographically and geologically.

(8) With this canal, experiments can also be made upon the rating of current meters, and general studies upon the motion of water in open channels, in pipes, and over weirs under variable conditions of velocity, materials of the bed, conditions of surface, contractions, and heads.

(9) The determination of the resistance to the motion of boats in canals in reference to their respective cross sections, effect of waves, etc.

(10) Experiments on water-jets, forms of water-wheel buckets, ratios of areas and forms of propellers, including water-jet propulsion; which subjects, by themselves, will give rise to a large number of investigations.

(11) Experiments on the construction and efficiency of water and other motors, including water meters.

(12) Effects of form and condition of the surface of vessels upon their speed and required motive power.

(13) The uses of this laboratory are not restricted simply to questions strictly classified as of hydraulic importance. For example, on the sanitary side, the relations that should exist between the grade of a sewer, its size, and the volume of flush water required to produce a given effect, are almost entirely unknown. The work heretofore published does not supply the requirements of sewer designers with needed generality. The equipment of this laboratory can settle the conditions required to determine how far down grade a definite volume of flush will be effective under the varied conditions of this problem.

Mr. Gardner S. Williams, Professor of Experimental Hydraulics, is in direct charge of the laboratory, the larger part of his time at present being given to the designing of the equipment. The problems involved in laying down the exact lines along which should proceed the development of a plant of this description are unique and many-sided. Experimentation is slow work at the best, and expensive, and it will be only with great care and forethought that faulty preparations may not exaggerate both these elements. Deciding upon the order of experiments and kind of equipment needed, and its design will, therefore, be slow.

RESULTS OBTAINED IN THE PAST FIFTEEN YEARS WITH STIFF AND HEAVY RAIL SECTIONS.*

By P. H. Dudley, M. Am. Inst. M. E.†

When we see the magnificent passenger trains of from 8 to 12 coaches, drawn by locomotives weighing from 100 to 110 tons, at speeds of from 50 to 60 miles per hour between terminals, to make a schedule of 45 miles per hour, and freight-trains of from 50 to 75 cars of 60,000 lbs. capacity, drawn by one locomotive, it is hard to realize that it lacks a few months of fifteen years since my pioneer 5-in. 80-lb. rail for the United States was laid by the New York Central & Hudson River Railroad Co., in July, 1884, on the Harlem line.

Shorter passenger-trains, of from 4 to 5 coaches, are run much faster, notably the Empire State Express, the schedule of which for the 440 miles between New York and Buffalo requires 53.3 miles per hour, calling for a running-speed, for much of the time, of from 65 to 75 miles per hour, while higher speeds are very common. On other railroads laid with my 5¼-in. 80-lb. rail, speeds of from 60 to 75 miles per hour obtain in daily practice. On many of the important railroads east of the Mississippi high speeds of from 60 to 70 miles per hour are part of the daily service. So many instances of speeds of 90, and even 100, miles per hour have been recorded that they must be considered as likely to occur on important lines, and provision must be made for them in the track. Solid mail trains of from 6 to 8 cars are run from New York to Chicago, 1,000 miles, in 24 hours; and, commencing with the present year, shorter trains are running from Chicago to San Francisco, 2,000 miles, in three and one-half days.

In the freight-service equally important progress has been made. Within the past fifteen years the 20,000-lb. capacity cars, with about same dead load for the structure, have been replaced with cars of 60,000 lbs. capacity, the weight of which is about 45% of the capacity-weight. Experience has been so satisfactory with the 60,000-lb. cars that cars of 80,000 lbs. capacity have been constructed, and many are in service. Many railroad companies, believing that the capacity of the cars should be farther increased, are constructing 100,000-lb. cars (dead load about 39% of the capacity), and many thousands of such cars are now running, to meet commercial competition and save something out of the prevailing low rates for freight.

There seems to be no prospect of a decrease in static wheel-loads and in the speed of trains. On the contrary, both are increasing, and the severer requirements of service must be met largely by applying principles now well known to prevent the generation of large destructive dynamic forces under the moving train, and by raising to a higher efficiency, in an economical way, everything which appertains to transportation. The loads under moving trains, which the rails and road-bed must sustain, are the combined effects of the static wheel-loads and the generated dynamic effects, the latter often excelling the former. One of the great advantages of the recent stiff rails, as factors in the higher standard of track obtained, has been not only to check the generation of so large destructive dynamic effects from the static loads, as was the case on the lighter roads, but, after that, to distribute the reduced load over larger areas of the road-bed. In other words, the heavier static loads with the lessening dynamic loads are not so destructive to the ties and road-bed on the stiff rails as was the case with lighter static but greater dynamic loads on the weak rails. This important fact is proved conclusively by the higher standards of track attained on the heavy rails, though under a greater volume of traffic.

In 1883, after I had designed my pioneer 80-lb. section, and before any rails of that design had been rolled, I made some deductions, from the study of the many diagrams of track I had taken with my apparatus on 4 and 4½-in. rails, as to the possible results which could be expected from labor and from material, respectively, in reducing the undulations in the track, as summed up by the mechanism of my car. I used these results to calculate what could be expected on smooth 5-in. rails, making the calculation specially for the Boston & Albany Railroad, and put it on their condensed diagrams, indicating that by the use of stiff 5-in. smooth rails, good ballast

*A paper read at the New York meeting of the American Institute of Mining Engineers.
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and skilled labor, they could reduce the average undulation per mile for the entire road, so that it would fall between the 15th and 16th line on the condensed diagrams.

To the railroad officials, and especially to the Department of the Maintenance of Way, this seemed at that time an impossibility; for it meant a reduction of two-thirds of the amount of the undulations per mile in the track. The condition of the track, so difficult to maintain at a high standard on the mountain slopes, gave little promise to them that so great a reduction could be made. It was true that the condition of the track on the 4½-in. 72-lb. rail was somewhat better than on the 4-in. 63-lb. rail, but not sufficient to indicate to them that a 5-in. rail with a broad head would make a track 60% better than the 4½-in. 72-lb. rail.

In 1884 my pioneer 5-in. 80-lb. rail was rolled and straightened at the mill on the same presses, having narrow-spaced anvil-blocks, used for lighter rails. The required blows to straighten the rails were too severe, the gag producing indentations in the metal of the rail-heads, besides often producing short bends in the rails. The surface of the rails was wavy, and could not be improved by labor on the track; therefore the indulations were not reduced to as low figures per mile as I had calculated. Repeated inspection of the tracks with my car indicated that the principal cause was due to difficulties in straightening the rails, which could be largely overcome.

The mechanical element of stiffness in a steel rail-section for a given weight of metal is due more to the design and distribution of the metal than to its physical properties. To lessen the deflections in the tracks under the wheel-loads, stiffness was a primary consideration in my design of the 80-lb. section. The head was made broad for the increased wheel-pressures, for wear, and in order to increase largely the side-stability of the rails in the track, and prevent both lines of rails from rolling out and widening the gage, and increasing the wear of the rails on curves.

The undulations in the track were reduced practically one-half by the 5-in. rails, compared to the 4½-in. rails. The splice-bars could be made stiff enough so that the joints of the 5-in. rails could be maintained in surface without excessive labor. The stability of the track was largely increased, with much less cost of maintenance. The mechanical element of increased stiffness in the 5-in. and higher rail-sections was ever present to lessen the effects of every passing wheel-load on the ties and road-bed, by distributing them over a greater longitudinal area, thus benefiting particularly the road-bed. To this important fact much of the success of the stiff rails is due.

In 1890, the Boston & Albany Railroad Company proposed to change from their 4½-in. 72-lb. section, which they had adopted in 1880, to a 5-in. 95-lb. rail. From the large amount of work constantly required to "adze" the ties, and "roll in" the 4 and 4½-in. rails on the curves (the track rarely being in gage on the curves combined with heavy gradients), they were apprehensive that any section higher than 5 ins. would so largely increase the tendency to "roll" as not to be permissible. I distributed the metal in the head, making it broad, to secure greater vertical and lateral stability, and to reduce the uneven surface-wear incidental to narrow-topped rails on gradients and curves. The base of the rail was made 5½ ins. wide.

I wished to make the rail higher, and have the benefit of greater stiffness; and I also proposed that the rails should be rolled out of a high grade of tough steel of high elastic limit, so that the rails would wear well, and not take a set in the track, until the extreme fibers were stressed over 55,000 to 60,000 lbs. per sq. in. A long discussion followed this proposition. From my investigations of many years, I was firmly convinced that such rails could be made which would be tough, quite hard and yet not brittle. Mr. John Fritz confirmed this opinion. Mr. William Bliss, President of the Boston and Albany R. R. Co., was willing to meet the manufacturers in a fair spirit in contracting for such rails, and, in fact, paid the Bethlehem Iron Company $2 per ton over the market-price for ordinary rails. Of this type, 11,000 tons were rolled and laid in 1891, and 6,000 tons more in 1892.

I personally went to the mill, and had the anvils on the straightening-presses lengthened, and the anvil-blocks set 44 ins. apart, so that lighter blows would straighten the rails without indenting the heads by the gags. After a short experience, the men were able to straighten the rails so that they could be finished very smooth.

When put in the tracks, the 95-lb. rails of the Boston & Albany Railroad showed a marked reduction in undulations per mile, the figures in the first season being nearly down to my calculations of 1883. It requires two years, and something more, before heavy rails reach their highest behavior in the track.

In 1891 Dr. Seward Webb commenced to build the Mohawk and Malone Railway and used my 5-in. 75-lb. broad-top section, to the extent of some 30,000 tons of rails. These were laid, in most cases, before the road could be ballasted, but their stiffness protected them from injury from that cause.

In 1892, the New York Central & Hudson Railroad Company rolled my 6-in. 100-lb. section, the first 100-lb. section rolled in this country. Now there are many hundreds of miles of 100-lb. rails in the tracks of our eastern railroads.

In 1893, the Boston & Albany 95-lb. rails were rolled by the Lackawanna Iron & Steel Co. at the same price as ordinary rails. The low prices for steel hastened the relaying with 95-lb. rails of the entire line of this road, which was completed in 1897.

In 1897, the average undulations in the track per mile for the entire road, as summed up by my car, were equivalent to 15.42 lines on the condensed diagrams, confirming my calculations of 1883. It should be said that the railroad company did all that was possible to keep and maintain the condition of the track up to the full value of the rail-section. To secure such a result, the condition of the track over the mountains must be practically as good as on the level portions of the line. The smoothness and consequent wearing-properties of the 95-lb. rails have been so largely increased over those of the former 63 and 72-lb. rails on the heavy gradients as to render possible this important result, even after six years' service on many of the rails.

The inspection for 1898, the first year of maintenance of the whole line with the new rail-section, shows a still better result; the average undulation per mile for the entire road being reduced to 14.2 lines on the condensed diagrams, practically securing the full value of the 95-lb. section.

I copy a few paragraphs from the sheets of the condensed diagrams of the Boston & Albany Railroad:

The result is as remarkable as it is gratifying, and is unique in the development and maintenance of a high standard of track on a mountainous line; for the general experience has been that it has not been possible to maintain nearly as good a "condition of track" over the heavy gradients as on the more level portions of the line.

Before the use of broad-topped rails the universal fact in all countries of steel rails wearing more uneven and faster on the heavy gradients than on the other portions of the line under the same tonnage, has led to the general opinion that the "condition of track" must be expected to become much worse on the gradients and a limiting factor for the trains' loads.

Such an opinion was expressed by several Continental engineers at the International Railway Congress held in London in 1895.

The important results secured on the Boston & Albany R. R. show that by the form of section and grade of steel we have materially checked the rate of irregular wear on the combined gradients and curves of the line, so that not only is the condition of the track very uniform per mile for the entire road, but also the full value of the rail-section has been obtained and maintained on the heavy gradients. This evidence is confirmed by the results obtained in six years' service from broad-topped 75-lb. rails on the Mohawk & Malone Railroad, over the mountains. On the Adirondack and St. Lawrence line from Malone, my 75-lb. section is laid to the Canadian line, and is there joined by Sandberg's 5-in. round-top 72-lb. rail. The undulations on the latter are more than double those on the 75-lb. rail for the same traffic. On the Cincinnati Southern Railway, using the broad-topped 75-lb. rails, the condition of track over the mountains in Tennessee is quite as good as on the more level portions of the line.

On the stiff rails, made of the higher carbon-grades of steel, the joints can be and are easily maintained, the rails keeping in good surface without permanent set, and their receiving-ends remaining unworn, in striking contrast to the opposite conditions formerly exhibited on the lighter rails. Another important feature of the broad-topped stiff rails, as designed, is that the wheel-loads, acting through the treads of the passing wheels, are made to do duty in holding the rails in their normal position in the track, checking the tendency to "roll," widen the gage and spread on the curves. Moreover, the cutting out of the ties under the rails has been very much reduced by the use of such rails. The broad-topped rails do not require bracing on curves of 4° and larger radii, even for speeds exceeding 60 miles per hour. On the heavy gradients of the Boston & Albany R. R. the curves are not braced, yet remain in gage; and not a single curve has been "rolled in" on the 95-lb. rails since they were laid. Only actual experience has convinced the track-men that such results were possible. The ties on all curves of the Boston & Albany R. R. are provided with tie-plates; but even on other railroads, not using such plates, it has not been necessary, in using these rails, to "adze" the ties and "roll in" the rails in order to maintain the gage. This is a very important matter for the stability of the track, besides contributing to the longer life and better service of the ties. Again, the life of the wheel-tires has been very much increased by the use of such rails, there having been a gain amounting to 40% and 50% in the practicable mileage between successive turnings of steel tires.

Twenty-three years ago* I reported to the Institute that I found the resistance per ton of freight-trains of 25 to 30 cars (gross load 600 to 700 tons) to be 6 to 8 lbs. per ton on light steel rails, at speeds of 18 to 20 miles per hour. To-day, on my 5¼-in. 80-lb. rails, for a train of 81 cars of 60,000 lbs. capacity, making a total load of 3,428 gross tons, the resistance shown by indicator-cards, for a speed of 20 miles per hour, is only some 3 lbs. per ton for the level portions of the line.

*Trans., IV., 232, "Railway Resistances."

The energy required to be stored in such a train before it can attain the speed of 20 miles is equivalent to 92,000,000 ft.-lbs., which the locomotive must generate on a level line, besides overcoming the ordinary resistance to the train. In the case just cited, the locomotive was worked nearly at a constant effort, developing from 700 to 750 HP.; the train giving out energy on the ascending-gradients and storing up energy on the descending-gradients. On one light descending-gradient of some length, the train attained a speed of 30 miles per hour, the stored energy being equivalent to 205,000,000 ft.-lbs.

The problem, or rather series of problems, in regard to the stresses in rails, is so complex that no one has as yet been able to make a mathematical analysis of them which satisfies the conditions of practice. These stresses can only be determined experimentally in the track. That the stresses in rails has always been large is well known. The fact that they are of short duration permits stresses in them which would not be permissible in bridges. The set in rails, described in my former papers, shows that the light rails were frequently subjected to stresses beyond the elastic limit of the steel. The recent experimental work with my stremmatograph in determining the stresses in rails under moving trains establishes the important fact that the metal in rails is subjected to very large fiber-stresses, and shows how these stresses are distributed in heavy rails. Some of these results have been published.*

*See Engineering News, Oct. 6, 1898.

"REGENERATING" EXHAUST STEAM.

The United States Patent Office is, no doubt, the best Patent Office under the sun, but it is not infallible, and occasionally it makes a slip which lays it open to criticism. A recent instance is its issue of a patent, No. 607,582, July 19, 1898, to Mr. Hugh J. Barron for an apparatus for regenerating exhaust steam. A few weeks ago we received a circular from the Barron Steam Heating Co., 30 Cortlandt St., New York, calling our attention to the "Barron Steam Regenerator," which was said to be "a condenser that does not require condensing water; a feed water heater that heats the feed to 300°; a converter that converts all the heat in exhaust steam into live steam; and a device that makes the steam engine a perfect thermodynamic engine." We quote from the circular as follows:

Our specialty is to take the waste product known as exhaust steam, after it leaves the engine or feed water heater, and by a system of compression, re-evaporation, superheating and mixing with live steam, bringing its temperature and pressure up to that of the steam in the boiler, to return this exhaust now revitalized into the main steam pipe to engine—not to boiler. It will be seen that this makes a closed system of the engine and boiler, and while adding more machinery to the combination, practically returns all heat not used in work to the reservoir to be used over again; it will be also seen that this machine is also an auxiliary generator, doing part of the work of the boiler.

The fact is that the average engine does not account for more than 10% of the heat units in the steam given by the boiler; in other words, the average engine has about 10% efficiency. If by any system of working exhaust steam we can raise this to 20% efficiency, we have something that no steam user can afford to be without.

The circular stated that the "Regenerator" was patented July 18, 1898, and that patents were pending in this and foreign countries. We have obtained a copy of the U. S. patent, and make some extracts from it below. We have redrawn the principal drawing of the patent in order to simplify it by omitting the details of the mechanism for operating the valves of the apparatus, and some unnecessary lettering. The patent specification says:

My invention relates to improvements in steam engines, whereby it becomes possible to re-evaporate and reutilize the exhaust steam and the heat thereof, which is now wasted, and thus render the operation of the engine more perfect and economical than has heretofore been possible.

The apparatus is then described at length. It consists of two chambers, A and B, with connecting pipes and valves, so arranged that either the live steam, before entering the steam engine, or the exhaust steam leaving the engine, may be conveyed into either one of the chambers at will, for the purpose here described:

The operation is as follows: Steam will be admitted to the cylinder A through the main steam-pipe H, valve D', pipe D, and thence pass through said cylinder A into the pipe E, valve E', and into the main steam-pipe I to the engine, the exhaust steam being returned through the main exhaust pipe J, valve F', pipe F, and into the cylinder B. At about the same time the valve P' of the feed-water supply pipe P will be opened to admit water to the branch section Q' and cause a small quantity of water to enter the cylinder B and fall upon the disk S' and be sprayed in said cylinder, and thereby sufficiently reduce the temperature of any live steam remaining in said cylinder, and thus facilitate the entrance of exhaust steam therein. The steam condensing, if there be any, will thence be conducted from said cylinder by the pipe K and again partly fed to the boiler and the apparatus by means of a steam pump or other apparatus.

As soon as the operation above described has taken place, the valves D' and E' and the valves F', G' and P' will be reversed, the valve D' closing a trifle in advance of the valve E'. Hereupon steam will pass from the boiler through the main steam-pipe H, valve D', pipe D, into the cylinder B, and there unite with and thereby regenerate the exhaust steam therein and thence pass out of said cylinder B through the pipe E, valve E', and be conducted to the engine by the main steam-pipe I, the exhaust steam now being returned from the engine through the exhaust pipe J, valve F', pipe F, and into the cylinder A, the condensation, if any, being, as heretofore, conducted from the apparatus by the pipe K and recirculated. Immediately hereupon the valves will be again shifted by the operating levers, and the operation first described be repeated, and so on.

It will be observed that by the use of two cylinders or receptacles, each of which intermittently receives steam under high and low pressure, the same alternately become the high or plus pressure and the low or minus pressure receptacles, and by means of the valve mechanism I am enabled to normally maintain steam under high pressure intermediate the boiler and engine and steam under lower pressure (exhaust steam) intermediate the engine and the boiler or apparatus.

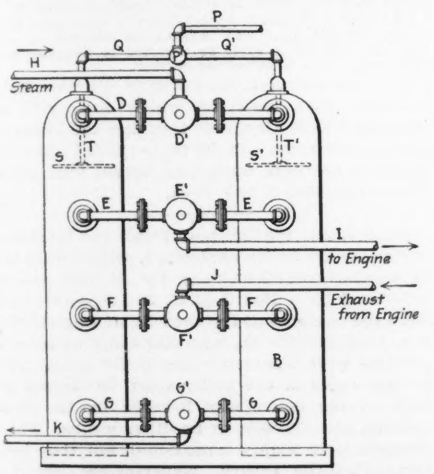
The valve mechanism may be operated directly by the engine or by any suitable or convenient independent mechanism.

There are no less than 17 claims in the patent, some of them long ones, but claim 2 seems to comprehend the gist of the invention:

2. The combination with a boiler and engine of an apparatus adapted to receive steam interposed between said boiler and engine and communicating therewith, and valve mechanism for intermittently supplying steam to a portion of said apparatus prior to its admission to the engine, and intermittently supplying steam to a portion of said apparatus after its admission to and discharge from the engine, substantially as specified.

The description of the mechanism is clear enough, but the explanation of what is accomplished by the mechanism is somewhat mystifying.

Suppose we have an engine whose piston has just about completed its stroke, and steam is to be exhausted after having done its work on the piston. Suppose the terminal pressure is 20 lbs. above the atmosphere, which it easily may be if the engine is heavily loaded. In order that the engine shall be at all economical it is necessary that the



Apparatus for Regenerating Exhaust Steam. Patented by H. J. Barron, New York.

pressure of this steam be instantly allowed to drop almost to the atmospheric pressure if the engine is non-condensing, or almost to the vacuum gage pressure if it is condensing. The first case requires an open exit to the atmosphere. The second requires a chamber in which there is maintained a vacuum by means of the condensation of the flow of a great quantity of condensing water, 20 times, or thereabouts, as great as the quantity of feed water, and an air pump. Mr. Barron's apparatus seems to provide neither the free exit to the atmosphere, by which the exhaust pressure in the cylinder may be reduced to that of the atmosphere, nor any provision for circulating a great quantity of condensing water, by which a vacuum may be maintained. For these reasons, therefore, we do not see how he can accomplish the most needful thing in steam engine economy, a low back pressure.

It is not clear, moreover, what becomes of the exhaust steam that remains uncondensed in the chamber. The patent says:

The steam condensing, if there be any, will thence be conducted from said cylinder by the pipe K and again partly fed to the boiler and the apparatus by means of a steam pump or other apparatus.

What the words "partly fed to the boiler and the apparatus" mean is not at all clear. The patent also says:

The condensation, if any, being, as heretofore, conducted from the apparatus by the pipe K and recirculated.

The drawing shows the end of the pipe K hanging in the air, and the patent leaves the description of its functions in the same condition. The patent does not explain where pipe K leads to, and in this as in many other respects the patent seems to violate one of the first principles of patent law, that the description should be so full, clear and accurate that any one skilled in the art to which the apparatus pertains could construct it.

But the words "the steam condensing, if there be any," indicate that nothing at all may pass out of the pipe K. The circular says the apparatus makes "a closed system" of the engine and boiler. It appears from the circular, moreover, that the exhaust steam is not condensed, but is "revitalized" and returned "to engine—not to boiler."

Let us try again to understand the operation of this apparatus. Steam is entering the chamber, A, and passing out of it to the engine. The engine, having received enough steam for one stroke, it is cut off. The valves of the chamber A are closed preparatory to their being reversed, the chamber being full of high pressure steam. A little later, at about the end of the stroke of the engine, the steam which has done work on the engine is ready to be exhausted into the same chamber A, the other chamber B being about to pass live steam through it for the next stroke of the engine. But the chamber, A, is full of live steam, so the cold water pipe must be opened

and cause a small quantity of water to be sprayed into said cylinder, and thereby sufficiently reduce the temperature of any live steam remaining in said cylinder and thus facilitate the entrance of exhaust steam.

So a quantity of live steam must be destroyed in chamber A, by having its temperature reduced, in order to facilitate the entrance of exhaust steam.

We will suppose now that the exhaust stroke is completed, and that a cylinder full of exhaust steam has been pushed into cylinder A, against a back pressure which will depend on how far the temperature of the live steam which was there a little earlier has been reduced by the cold water spray. This exhaust steam is now ready to be "revitalized" by the introduction of fresh live steam from the boiler. The exhaust steam in chamber A must be at a low temperature, corresponding to its pressure, and the inner surface of the chamber walls must also be of a relatively low temperature. The first of the live steam that enters will be condensed by heating up the exhaust steam and the cylinder walls, and when this is done another portion will proceed to the engine, there to do what work it can against whatever back pressure may exist, and a third portion will remain in chamber A, to have its temperature reduced by the next injection of cold water. Surely nothing more absurd has been proposed by any inventor of the steam engine since the days of Newcomen.

Watt's great discovery, which led to his invention of the separate condenser, was that the poor economy of the Newcomen engine was due to cylinder condensation, caused by the cool walls of the cylinder, which had been cooled by the injection into them of cold water, the cylinder thus being alternately a condenser and a working cylinder. Mr. Barron's invention is a retrograde step of over 140 years. Newcomen condensed a great portion of his live steam by causing it to enter a cold cylinder, but he at least obtained a vacuum in his cylinder and reduced the back pressure below the atmosphere. Barron also condenses a portion of his live steam, but he does it in a chamber between the engine and boiler, and he does not secure the low back pressure that Newcomen did.

The Patent Office has done a great wrong to Mr. Barron. It has issued him a worthless patent for a worse than worthless device. It has taken his money for final patent fees, has led him to believe he has a good patent, and caused him to go to the expense of printing and mailing his circulars, in which he publishes to the world his ignorance of the first principles of steam engineering. It should have rejected his application, saved him this expense and humiliation, and sustained its own reputation for careful work and intelligence.

Since writing the above we have obtained an abstract of the papers filed in connection with Mr. Barron's patent, which shows that the examination by the Patent Office of his specifications and claims was of the most superficial character, and had reference only to the verbal form of the claims and to the possible anticipation of Mr. Barron's invention by an English patent of 1852. It does not seem to have ever entered into the mind of the examiner that Mr. Barron's device might be inoperative, and therefore unpatentable, on account of lacking the essential element of a "useful" invention.

The examiner in his first rejection of the patent says:

"Claims 1, 2, 3 are so indefinite in their terms that they are met in any of these constructions in which the exhaust steam is superheated and then conducted to the engine, e. g., patents to Sauer, 396,713; Gerner, 104,573; De Beauregard, 237,828. See also English patent to Spence, 3, 1852, which shows several features of applicant's device and a similar method.

The attorney for the inventor meets these objections by modifying the forms of the claims and by an argument, of which the following is an abstract:

Beauregard, Gerner and Sauer do not show an apparatus comprising a plurality of receivers adapted to receive, first, steam under low pressure, and then steam under high pressure, and thence discharge the mixture into the engine.

The devices shown in the above patents are continuous in operation, and seek to create with live steam, a suction, and thereby carry away with it the exhaust steam.

I cannot determine the construction and operation of the English patent. This much appears to be clear: If Spence's apparatus is operative, it does not regenerate the exhaust steam by combining the same with live steam. Spence does precisely what the applicant desires to obviate, viz., the discharge of exhaust steam to the atmosphere.

This argument seems to have been sufficient to convince the examiner that Barron's invention was not anticipated by Spence or by any of the others whose names are cited, and a few verbal changes having been made in some of the 17 claims, he allowed the patent.

SPLIT FLY-WHEELS for small steam engines are generally cast in halves with the joint midway between the arms. Mr. F. W. Salmon, of Burlington, Ia., calls attention to the fact that this construction is defective, on account of the bending strains set up in the rim by centrifugal force at high speeds. He would place the joint at or near the end of the arms.

CEMENT PRODUCTION IN 1897 is reported upon in the 19th annual report of the U. S. Geological Survey. Mr. Spencer B. Newberry says that, in 1897, 2,677,775 barrels of Portland cement were made in the United States, an increase of nearly 74% over the product of 1896. This growth is most marked in the Lehigh Valley region of Pennsylvania, where seven establishments produced 1,579,724 barrels in 1897, valued at $2,369,586, as compared with 825,054 barrels, worth $1,224,294, in 1896. The value of the total product for 1897, not including packages, was $4,315,891. The imports of Portland cement amounted, in 1897, to 2,090,924 barrels of 400 lbs. each, or 898,673 barrels less than in the preceding year. Germany supplied 1,109,280 barrels of that imported, with Belgium and England coming next. As showing the importance of the Portland cement industry in Germany, the Association of German Portland Cement Manufacturers, in February, 1898, represented 66 German factories, with a total production of 15,000,000 barrels per year. The total consumption of Portland cement in the United States increased in the five years ending with 1896 by about 1,000,000 barrels; and all former prejudice against the American product has entirely disappeared; in fact, the product of leading American factories show decidedly higher tests than imported brands long considered as a standard. This is shown in the reports of Mr. R. L. Humphrey, inspector of cements for Philadelphia, in 1896-97. Mr. Uriah Cummings reports that the production of American rock cement in 1897 was 8,311,688 barrels, the largest output in the history of this industry, and an increase of 341,238 barrels over 1896. New York State produced 2,123,771 barrels of this output, and the total value of the 1897 production was $3,862,392, at the mills in bulk. There are now 72 manufactories of this cement scattered over 14 states, with 29 in New York alone and 15 in Indiana and Kentucky. It should have been noted that in the manufacture of American Portland cement the use of the rotary kiln is increasing; as is shown by the fact that, in 1897, 1,311,319 barrels were made by the rotary kilns, as compared with 1,366,456 barrels made in vertical continuous or intermittent kilns. The percentage of product by rotary kilns has increased from 25.2% in 1893 to 49% in 1897.

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

The bid of nearly 5 cts. per lb., or, to be exact, 4.9905 cts., for the steel work of the towers and end spans for the New East River Bridge, which is noted more fully in another column this week, establishes the high-water mark in prices for structural steel work for a number of years past. For ordinary bridge and structural work this would be regarded generally as an exorbitant price, and even for the excellent quality of material and workmanship specified for this particular structure, it will, we believe, strike most engineers as surprisingly high. It is important to note, however, that the prices set by the six firms which bid for the work ran from 4.945 cts. to 5.79 cts. per pound. This, of course, may indicate either that legitimate reasons exist for the high cost of the work, or else that the different bidders have been able to agree upon a pooling arrangement, and the latter explanation is probably the one that will be hit upon at first thought by the majority of people. It should not be overlooked, however, that a more legitimate explanation is possible. The requirements of the engineer for acid steel of a particular quality limits the production of the material to one, or, at the most, to two companies, and there is good reason to think that only one of these companies is in shape to-day to turn out the quality and quantity of material required without more or less extensive alterations in its plant. Indeed, we have been informed upon very good authority that all six bidders for the contract submitted their figures upon the basis of purchasing the steel from this one particular firm in position to supply it, and that the price charged by this firm was practically 1 ct. per lb. higher than the prevailing market price for structural steel. That the various steel manufacturers should not have been found more willing to make the changes in their plants necessary to furnish the steel required, is explained by the extensive orders at good prices already booked for material which their plants are capable of supplying without such changes. To this high price for material there have to be added the unusually rigid requirements specified for workmanship and inspection, the cleaning of the metal by sand blast before painting, the very considerable risks in erection, and the heavy bonds required, delays in collecting payments from the city, and the possibilities of the work being held up in one way or another, among which the devious methods of New York city politicians are probably not least dreaded. Whether the quality of material and workmanship which is required is worth the price or not, we shall not discuss here. It does afford an explanation, however, of the very high prices to which experienced bridge builders have so closely adhered in bidding for the work, and we are inclined to think that it is the correct explanation.

The close of the present week will see the end of the 55th Congress, and will determine the fate at its hands of the River and Harbor Bill and of the Nicaragua Canal enterprise, the two measures in which engineers are most interested. At the time we write it would be extremely hazardous to prophesy the failure or success of either of these measures. We recorded in our issue of Feb. 16 the attempt to attach the Hepburn bill for the construction of the canal as a "rider" to the Sundry Civil Appropriation bill in the House. This attempt failed, however, and the next move was made by the Senate, which on Feb. 24 attached to the River and Harbor Appropriation bill a "rider" modeled closely upon the lines of the Hepburn Nicaragua Canal bill. In this form the River and Harbor bill was reported back to the House, where it was referred to the River and Harbors Committee, in whose hands it still remains.

It is especially notable that the Senate chose the Hepburn bill for the form of its amendment, instead of the highly objectionable Morgan bill which it passed some time ago. We take it that this marks the final abandonment of the attempt to perpetuate the old Maritime Canal Co. of Nicaragua, as a cloak under which the United States Government may perform this work, and also of the attempt to secure a Treasury appropriation for the benefit of the stockholders of that corporation.

The language of the Senate "rider," as stated above, follows closely that of the Hepburn bill (Eng. News, Feb. 9, p. 89), for the first two sections, but Section 3 is altered to read as follows:

> That in making surveys for, and in the construction of, said canals and harbors, the President may detail such number of engineer officers of the Army and Navy, or employ such civil engineers as may be necessary, and may require of them the performance of such professional duties as he may desire. The Secretary of War shall have power to enter into contracts for the performance of all or such portions of the work as may be necessary to most speedily and advantageously complete the construction of said canal and harbors.

It will be seen that this clause permits both civil and military engineers to take part in the work in the discretion of the President, and also permits the contracts to be let in sections, whereas in the Morgan bill it was at least implied that the whole canal was to be let as a single contract, a plan whose objections will be readily understood by our readers.

The final section of the rider is taken, not from the Hepburn bill, but from Senator Spooner's amendment to the Morgan bill, and reads as follows:

> That if the President shall be unable to secure from the Governments of Nicaragua and Costa Rica such concessions as will enable the United States to build and perpetually own and control said canal, the President is authorized to negotiate for a control of or a right to construct, maintain and perpetually control some other canal connecting the Atlantic and Pacific oceans, and the President is requested to negotiate for the abrogation or modification of any and all treaty obligations, if any such exist, as shall in any wise interfere with the construction, ownership and perpetual control of any such canal.

It will be seen that this clause gives the Executive a free hand in its negotiations, and permits the consideration of offers from the Panama company in case Nicaragua and Costa Rica will not accept reasonable terms. Moreover, it provides for the abrogation of the Clayton-Bulwer treaty or any other which is deemed to conflict with the proposed enterprise.

On the whole, the Senate "rider" is a vastly better measure than the Morgan bill, and is a considerable improvement upon Congressman Hepburn's measure; yet it falls far short of being a thorough and well-considered measure for the authorization of a work of such magnitude. To place the administration of so vast a piece of work in the hands of bureau clerks in the War Department—for that is what the proposition to place it in the hands of the President, of necessity, amounts to—appears to us a huge mistake. Present indications are, moreover, that the "rider" will not be accepted by the House, at least without radical amendment. The House Committee on Rivers and Harbors, which has it in charge, is strongly opposed to it, and Chairman Burton, of the Committee, on Feb. 27, introduced a measure which he will propose as a substitute, in terms as follows:

> The government of the United States declares its purpose to secure at the earliest practicable date the construction of a canal connecting the Atlantic and the Pacific oceans. A board of seven engineers shall be appointed by the President to make the surveys and examinations necessary to ascertain the most desirable and practicable route for such canal, and for the performance of such other duties as the President may direct; three from the Corps of Engineers of the Army, two from the engineers of the Navy, and two from civil life.
>
> The Board shall investigate the proposed routes for a canal between the said oceans, giving special and personal attention to the so-called Nicaragua and Panama routes, and shall complete estimates of the probable cost of constructing such canal or canals. It shall also report upon the commercial and military value to the people of the United States of such canal route or routes.
>
> The President may enter into negotiations with the respective nations owning the territory through which such canal or canals may be constructed in order to obtain the necessary land for the construction of a suitable canal and to acquire such rights in natural waterways as may be necessary. He is also required to enter into such negotiations as he may deem necessary with any other nations having rights in any way connected with the construction or operation of such canal or canals. The President shall acquire, if possible, the absolute title to necessary territory; but if such absolute title cannot be obtained, he may acquire such rights or easements therein as may be required, and may cause investigation to be made to ascertain the route upon which terms most favorable to exclusive control by the United States can be obtained, but in no case shall obligation be incurred or money paid to any company or individual for rights, easements or privileges heretofore or hereafter acquired with a view to the construction of any such canal, except under authority given by further action of Congress.
>
> One million dollars is appropriated to carry out the provisions of the act. The information obtained or action that may be taken shall be reported to Congress at the beginning of the next regular session.

This measure appears far more businesslike and practical than anything which has yet been brought before Congress touching the Nicaragua Canal enterprise. It is to be hoped that some measure on these lines may secure final passage before the close of the week.

Some of our readers may recall the Lawson experiments on boiler explosions, which were made at Munhall, near Pittsburg, Pa., in 1882, and were witnessed by a Board of U. S. Inspectors. They were the outcome of the theories of Daniel T. Lawson, of Wellsville, O., who claimed that boiler explosions were frequently due to the sudden lifting of the water in the boiler when the steam pressure in the boiler was lowered by the sudden opening of a throttle, or by other means. The explosions were highly sensational, but they hardly established the theory. Nevertheless, Mr. Lawson applied for and obtained a patent (No. 227,024) upon a "Means for Preventing the Explosion of Boilers," consisting in the insertion of a sheet metal diaphragm in the steam space. All this ancient history is called to mind by the news that a bill is pending before Congress for the extension of Lawson's patent, on the usual grounds that the inventor has not received sufficient recompense for his labors and expenditures during the seventeen year term, which expired April 27, 1897.

We believe that very few engineers took Mr. Lawson's experiments seriously, even at the time they were made; and the years that have elapsed since then have served to strengthen the belief that boilers explode not through occult or obscure causes, but because they are too weak to sustain the pressure to which they are subjected. The users of steam boilers have betrayed no great anxiety to make use of Mr. Lawson's diaphragm during the past 19 years, and they are no more likely to do so during the next half dozen years. If, therefore, Congress wishes to amuse its idle hours and gratify Mr. Lawson by extending this patent, nobody will offer any objection.

The Central Pacific Railroad Company has reached a final settlement of its indebtedness to

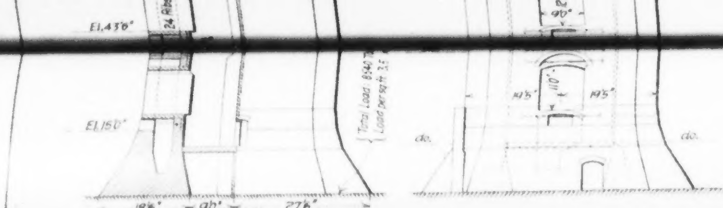

FIG. 6. DETAILS OF CHIMNEY.

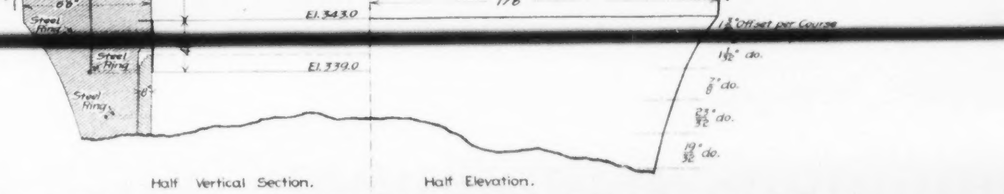

FIG. 7. DETAILS OF CHIMNEY CAP SHOWING METHOD OF PROTECTION FROM LIGHTNING.

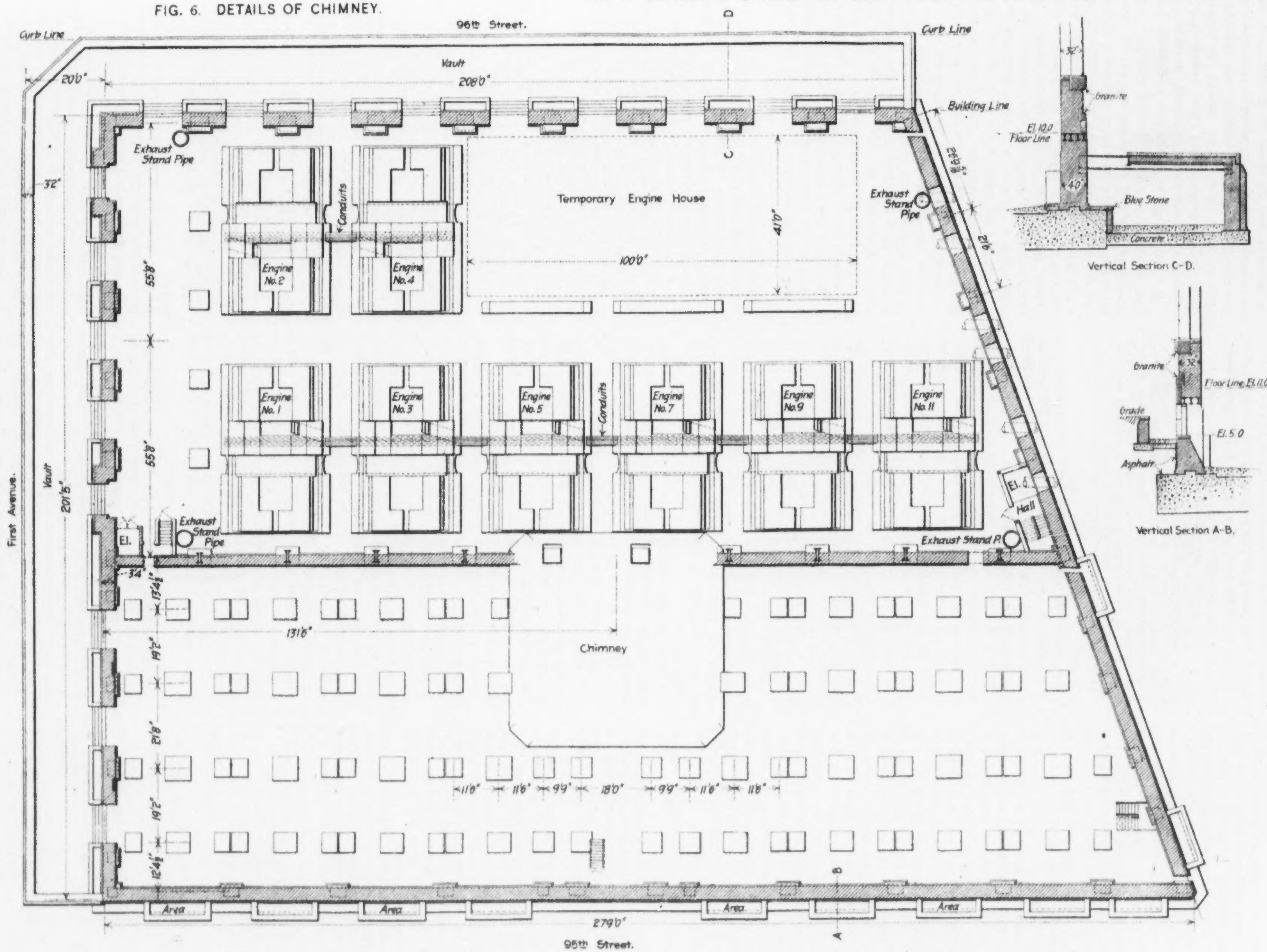

FIG. 2. GENERAL PLAN OF FOUNDATIONS FOR ENGINES AND COLUMNS SUPPORTING BOILERS AND COAL STORAGE BIN.

FOUNDATIONS AND CHIMNEY FOR THE 45,000 HP. ELECTRIC POWER STATION, METROPOLITAN TRACTION CO., NEW YORK CITY.

M. G. Starrett, Chief Engineer. W. A. Low, Engineer in Charge of Construction.

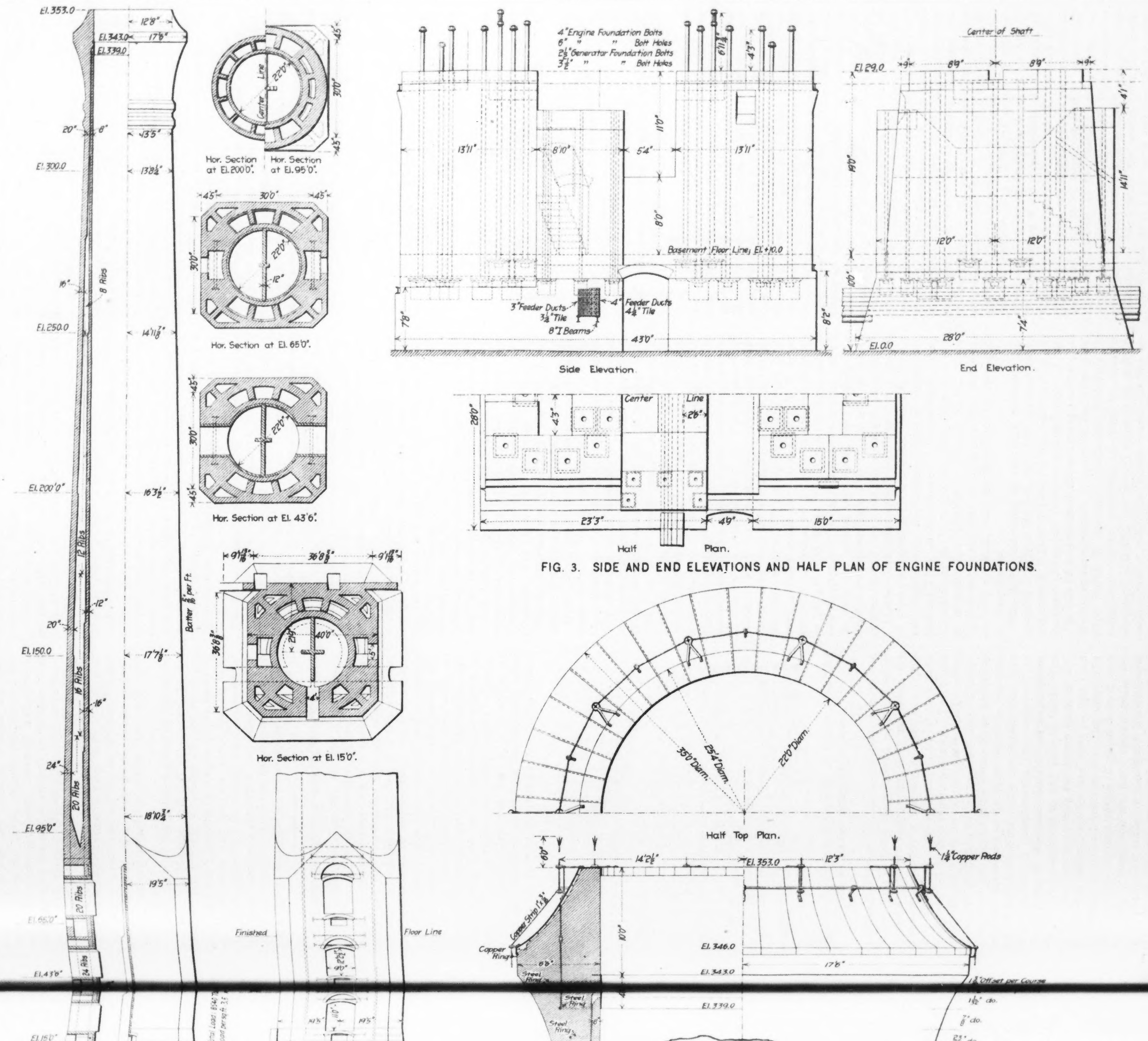

FIG. 3. SIDE AND END ELEVATIONS AND HALF PLAN OF ENGINE FOUNDATIONS.

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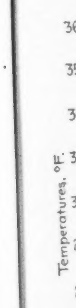

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the government, under which it agrees to pay the entire amount now due, amounting to $58,812,715, in 20 semi-annual instalments, under conditions which ensure that the company will fulfil its agreement. Thus the United States at last emerges from its great experiment in loaning money to transcontinental railway enterprises, receiving back the entire amount of its loan with the interest thereon. It would hardly have been prophesied a few years ago that so fortunate an outcome of the Government loans to the Pacific railroads would be possible at so early a date; and the fact is most instructive as showing what improvement has been made in the financial position of railway securities within the last half dozen years.

Not the least of the indirect gains to the country from the Pacific railroad experiment is the salutary lesson which has been learned as to the evils attending partnership arrangements between the Government and private corporations; and notwithstanding the fortunate final outcome of the Pacific Railroad subsidies, the Government is not likely soon to repeat the experiment of loaning its credit to a private corporation.

CYLINDER RATIOS FOR COMPOUND ENGINES.

About eight years ago Mr. George I. Rockwood, M. Am. Soc. M. E., of Worcester, Mass., first published his views concerning the theory of compound and triple expansion engines, and claimed that the intermediate cylinder of a triple expansion engine was of no practical value in economizing steam. As at that time he had no results of experiments with which to substantiate his views, his theoretical conclusions met with no acceptance among authorities on the steam engine. A year later he published the results of some tests of a triple expansion engine (Trans. Am. Soc. M. E., 1892, vol. xiii., p. 647), which on their face appeared to sustain his position, since the engine showed practically the same steam

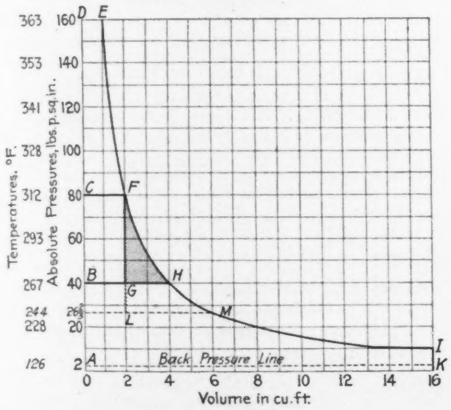


Fig. 1.—Theoretical Expansion of Steam from 160 lbs. to 10 lbs. Absolute Pressure.

consumption when run as a compound, with the intermediate cylinder disconnected, as it did when all three cylinders were in use, and, moreover, the steam consumption of the engine with two cylinders was lower than any that had at that time been recorded for a compound engine. The paper then published led to considerable controversy, which has continued to the present time. The opponents of Mr. Rockwood's views have generally held that the results of the tests which he has presented were inconclusive, for the reason that they were not strictly comparative, the conditions of steam pressure, vacuum, number of expansions, etc., not being uniform in any pair of tests. The bulk of the argument thus far seems to be in Mr. Rockwood's favor, since he has built no less than eight large compound engines with " unusually large cylinder volume ratios of abo t 7 to 1, and the tests of these engines have shown quite remarkable results, while no conclusive experiments have yet been placed on record to sustain the arguments of the opposition.

Mr. Rockwood has recently restated his position in a paper read before the Providence Association of Mechanical Engineers, which we reprint, considerably condensed, elsewhere in this issue. We commend his paper to the careful attention of those who are interested in steam engine design. If Mr. Rockwood's views are finally sustained by conclusive experiments, the result will be of great importance to steam users. If the intermediate cylinder of a triple expansion engine can be dispensed with, and just as good steam economy secured with two cylinders as with three, there will be a great saving in first cost of engine, in ground space occupied, and in the number of parts liable to wear or other damage.

In order that those of our readers who are not already familiar with Mr. Rockwood's attempts to modify the design of compound engines, giving them cylinder ratios far larger than is customary, and entailing "drop" between the two cylinders, we present the following elementary discussion of the problem, which may make the reasoning given in Mr. Rockwood's paper somewhat more clear.

In the accompanying cut, Fig. 1, the complete diagram A D E K represents an ideal indicator diagram of the expansion of 1 cu. ft. of steam from 160 lbs. steam down to 10 lbs. absolute pressure, in a cylinder without clearance, leakage or cylinder condensation, the expansion being assumed to follow the Marriotte or hyperbolic law. In an ordinary compound engine the 16 expansions would be divided into two stages, say 4 expansions in each cylinder, and the cylinder ratio would be 4 to 1. That is, the 1 cu. ft. of steam would fill the high pressure cylinder for one-fourth of its stroke, and would then expand, filling the whole cylinder, to 4 cu. ft., and to 40 lbs. absolute pressure. This 4 cu. ft. would then be discharged into the receiver, assumed to have a constant pressure of 40 lbs. absolute, and thence into the second cylinder, of 16 cu. ft. capacity, in which it would be cut off at ¼-stroke and then be expanded to 10 lbs. absolute, and finally discharged into the condenser against 2 lbs. back pressure. The indicator diagram of the high pressure cylinder would be the line B D E H, and that of the low pressure cylinder A B H K.

In Mr. Rockwood's design of an engine, with cylinder ratio of 8 to 1, practically the only difference would be that the area of the piston of the high pressure cylinder would be reduced one-half, the stroke remaining the same, so that the volume of the cylinder would be 2 cu. ft. instead of 4. The 1 cu. ft. of steam would then be cut off at half stroke in the high pressure cylinder and would expand to 2 cu. ft. and 80 lbs. absolute pressure. Communication with the receiver, still maintained at 40 lbs. absolute, would then be opened, and the pressure would suddenly drop to 40 lbs. as the steam flowed by "free expansion," doing no work, into the receiver. The back stroke would then push the remaining 2 cu. ft. at 40 lbs. into the receiver. The diagram of the high pressure cylinder would then be B D E F G. The low pressure cylinder would give the same diagram as before, A B H K. The difference between the two diagrams of the high pressure cylinder would be that the second one would not include the shaded triangular area F G H, the area of which represents the lost work due to free expansion.

In the particular case considered the 1 cu. ft. of steam expanding from 160 lbs. down to 10 lbs. and then being discharged into a condenser, against 2 lbs. back pressure, is theoretically capable of doing 571.6 ft. lbs. of work. The area F G H is equivalent to 30.9 ft. lbs. or 5.41%. These figures are calculated by means of the usual hyperbolic formula, with no allowance for clearance or other losses.

The work indicated in the high pressure diagram B D E H is 221.8 ft. lbs., that in the smaller diagram B D E F G 190.9 ft. lbs., and that in the diagram of the low pressure cylinder 349.8 ft. lbs.

It will be noticed that these figures are far from giving equal amounts of work in the two cylinders, which is usually considered desirable in compound engine practice. In order to equalize the work, 285.8 ft. lbs. would have to be done in each cylinder, and this would require in the ordinary design of engines that the steam should be expanded about 6 times instead of 4 in the high pressure cylinder, giving a terminal and back pressure of 26⅔ instead of 40 lbs. This is represented in the cut by the dotted line L M. If it were attempted to approximately equalize the work done in the two cylinders of a Rockwood engine with cylinder ratios of 8 to 1, the free expansion would extend down to L M, and the theoretical loss of work by free expansion, according to the diagram, would be 69.1 ft. lbs., or 12.1% of the total work. This amount of "drop" however, is probably far beyond any that Mr. Rockwood would approve.

Assuming that no attempt is made to equalize the work in the two cylinders, and that the free expansion is from 80 to 40 lbs., as shown in the cut, the apparent loss work being represented by the shaded area F G H or 5.41% of the total work indicated by the diagram A D E K, let us consider whether there are any counterbalancing advantages due to the drop which may more than offset the apparent loss of 5.41%.

The first and most important advantage is, probably, a considerable decrease of cylinder condensation in the high pressure cylinder. Cylinder condensation is well known to depend on the extent of the interior surface of the cylinder and upon the point of cut-off. The larger the cylinder and the earlier the cut-off, other conditions being equal, the greater the condensation. Mr. Rockwood greatly diminishes the surface of the high pressure cylinder, and greatly lengthens the point of cut-off, as compared with ordinary prac-

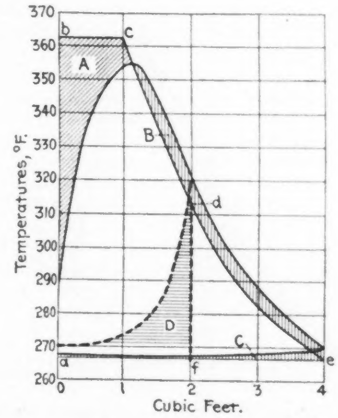


Fig. 2.—Diagram Showing Transfers of Heat in a High-Pressure Steam Cylinder.

tice, and therefore the cylinder condensation in his high pressure cylinder must be lessened. The next apparent advantage is the reduction of radiation loss from the high presure cylinder, by the reduction of its surface. A third offset to the apparent loss of 5.41% is the fact that some of the loss is only apparent and not real. The steam doing no work in expanding freely from 80 to 40 lbs. loses no heat, and therefore the 4 cu. ft. at 40 lbs. discharged into the receiver after free expansion from 2 cu. ft. at 80 lbs. contains more heat, either in the form of superheat or in containing less moisture, than if it had done work in expanding from 80 to 40 lbs. in the first cylinder.

The nature of the temperature changes and of the transfers of heat between the steam and the walls of the high pressure cylinder differs considerably in the Rockwood and the ordinary type of engine. This is shown in the accompanying cut, Fig. 2, in which the ordinates represent the temperatures of the steam and the abscissas the corresponding volumes to which 1 cu. ft. is expanded. The diagram a b c e is a temperature-volume diagram of 1 cu. ft. of steam of 160 lbs. absolute pressure expanded to 4 cu. ft. at 40 lbs. The diagram a b c d f represents the 1 cu. ft. of steam expanded to 2 cu. ft. at 80 lbs. and then dropped, by free expansion into a receiver, to 40 lbs. The 1 cu. ft. of steam at 363° F. enters the cylinder, finding, at the instant of entering, the walls cooled approximately to 267° F., the temperature of steam at 40 lbs. absolute pressure. The transfer of heat from the steam into the walls takes place at a very rapid but decreasing rate, depending upon the difference in temperature between the steam and the metal of the cylinder. The amount of this transfer of heat, which represents the cylinder condensation, may be indicated by the shaded area A. When the steam is cut off, its temperature rapidly falls until it is lower than that of the cylinder walls, and then the transfer of heat takes place in the opposite direction, as shown by the shaded area B, representing re-evaporation of a portion of the steam condensed in the early part of the stroke. During the return or back stroke the temperature of the walls gradually cools down to near the temperature of the exhaust steam, as shown by the shaded area C. In the Rockwood engine the expansion of the steam while doing work in the cylinder is stopped at the point d in the diagram, and the area B representing re-evaporation, or transfer of heat from the cylinder walls during the forward stroke, is only about half of that for the ordinary engine, while instead of the temperature of the walls decreasing slowly during the exhaust, reaching finally a temperature near to that of the exhaust, it decreases rapidly, as shown by the shaded area D, on account of the sudden fall of the temperature of the steam at d; but it is not certain that the wall temperature falls to nearly as low a point as when the steam is expanded four times in the cylinder. It is not at all improbable that in high speed engines on the Rockwood system the range in temperatures of the metal in the cylinder walls is less than in the ordinary engine, and this would tend to lessen the cylinder condensation.

The sum of all the advantages and economies due to drop may, therefore, be greater than the loss of work due to drop, as shown by the diagram, and thus the Rockwood engine may be superior in economy to the ordinary compound, and may closely approach the economy of the triple expansion engine. If this is true, however, there must be a point at which any increase in drop will cause a loss of economy, since, as shown by the diagram, Fig. 1, the apparent loss of work is quite small, only a trifle over 1%, for a drop from 80 to 60 lbs. is over four times as much for a further drop to 40 lbs., and thereafter it increases still more rapidly. Just what will be the amount of drop corresponding to most economical performance it would require extensive experiments to determine.

LETTERS TO THE EDITOR.

Tests to Determine Rates of Combustion Corresponding to Various Drafts in Anthracite Chestnut Coal.

Sir: We have recently conducted four trials of chestnut white ash coal (Parish) from the Scranton district, made on a common grate with 40% air openings, which was placed under a two-pass horizontal tubular boiler. Extreme care was exercised to secure exact results. The drafts were measured every 10 minutes by a micrometer gage reading to 0.001-in. The results include cleanings of fires and the building up of new fires thereafter, and accordingly represent working conditions. The coal averaged 13.17% of ash and refuse on the trials.

The following results were obtained:

Draft, ins.	Dry coal burned per hour per sq. ft. grate, lbs.
0.300	11.87
0.404	16.14
0.468	18.62
0.499	21.75

The first three tests may be practically represented by the following equation to a straight line passing through the origin:

Lbs. dry coal per sq. ft. grate per hour = 40 × draft in inches.

The weight of undisturbed ash and clinker on the grate was 38.9 lbs. per cu. ft. Very truly yours,

Whitman & Johnson.

131 South Third St., Philadelphia, Pa., Feb. 12, 1899.

How to Gain Experience in Structural Iron Work.

Sir: I notice that in the column of "Situations Open" in Engineering News' advertising pages, engineers experienced in iron and steel construction are more in demand than others. This, of course, is to be expected; but invariably the advertisement calls for experienced men. Engineers, however, have to acquire such experience before they can fulfil this condition, and if you can inform me how a young engineer can obtain experience in this branch of work to enable him to fill such positions as are advertised, the advice will be much appreciated. Respectfully,

"Structural Engineer."

Feb. 20, 1899.

(Our correspondent had better apply directly by letter to the firms engaged in the class of work in which he desires to gain experience, stating his professional training and past record, and his desire for a position. He may thus bring himself to the attention of some concern in need of additional help and willing to take a man without experience, under conditions that will make it to their advantage. We may say for our correspondent's encouragement, that many firms prefer to take men without experience and train them rather than take men who have become accustomed to the different standards and system in some other establishment.—Ed.)

A Wire Fence as a Telephone Line.

Sir: You may be interested in the following particulars respecting the fence-wire telephone which has been mentioned recently in the daily papers.

In the first place, it might be well to mention we live about 2½ miles from Glidden, Ia., and are connected with a system of telephones in town by a line put up on poles and properly insulated. Then, starting at our place, the line extends on the wire fence a distance of 1¾ miles. We used the top wire of an ordinary three-wire fence. In making connections, wherever the wire had been spliced we used a short piece of No. 12 wire soldered on each side of the splice, so as to make a good metallic contact.

The posts in the fence are cedar, with the exception of a few live willows. Around these we insulated the wire by spiking small porcelain knobs on the trees and using a No. 12 wire on these insulators. We also cut the wire on each side of the live trees so as to prevent any contact with them or with any other wire on the fence. We also cut it wherever we left the fence for the houses, in order to prevent any branches from the line which might possibly be grounded. We soldered our ground wire to a hydrant, thus making a good connection with moist earth.

Part of the wire was badly rusted, having been on the fence for about 16 years, but by filing the joints to insure good contact it works just as well.

The results obtained are entirely satisfactory. By closing a switch we can connect the fence line with the town line, and people in town say that they can hear just as plainly over the four miles of wire as they can in town where the instruments are not over a block apart.

The instrument on the end of the line is not a long distance telephone, but it will ring the bells of 13 instruments in Glidden.

As to how it will work in wet weather, I cannot say, as it has been in operation only a short time.

We are working, however, on a plan which we think will overcome all difficulties caused by wet weather, and if it is successful we will be glad to inform you of the result, as we are much interested in rural telephones, and are working with the intention of cheapening the cost of them as much as possible.

The newspaper reports about our experiment have been somewhat exaggerated, but we cannot be responsible for that. Very respectfully, Frank Evarts.

Glidden, Ia., Feb. 8, 1899.

Finding the Center of a Group of Shots.

Sir: Mr. R. E. Moritz, who is connected with the mathematical department of this institution, suggests the following mechanical solution of the "Curious Mathematical Problem" noted in Engineering News of Feb. 2:

At each of the shots, except one, is fixed a pulley or smooth peg, with its axis perpendicular to the plane of the target. One end of a thread is attached to a pin at the shot where there is no pulley. The thread is then passed alternately around a pulley which is free to move in the plane of the target, and around each one in turn of the fixed pulleys. Then it is obvious that a pull applied at the free end of the thread will pull the movable pulley into the position of the desired point.

While this suggestion is original on the part of Mr. Moritz, it seems quite probable that the same idea is at the basis of the graphical method ascribed to Mr. Roebling, as the equal tensions in the strings suggest the equivalent polygon which is used in the graphical method.

Very truly yours,

O. V. P. Stout.

Dept. of Civil Engineering, University of Nebraska, Lincoln, Neb., Feb. 14, 1899.

Sir: Referring to the article headed "A Curious Mathematical Problem" (page 70, issue of Feb. 2), it would seem that the definition there given for the center of a group of shots is open to question. This definition is "that point in a group of shots from which the sum of the distances to each individual shot would be a minimum." Though the point thus defined may be of some purely mathematical interest, it is of no practical use. The object of getting the "center of a group of shots" is to find that point which will most probably be the point of impact of the next shot, the probability being deduced from the points of impact of all preceding shots. The problem is therefore merely one of probability and in such cases the theory of probabilities demands that we take, not the sum of the distances to the individual shots and make this a minimum, but the "sum of the squares" of these distances. To do this:

Let $(a_1\ b_1)$, (a_2, b_2), (a_3, b_3), etc., be co-ordinates of individual shots referred to any set of rectangular axes, (x, y) be center of shots as just defined, n number of shots, Σ = sum of square of distances to individual shots, which must be a minimum. We have then:

$$\Sigma = [(x - a_1)^2 + (y - b_1)^2] + [(x - a_2) + (y - b_2)] + [(x - a_3) + (y - b_3)], \text{ etc.}, = X + Y, \text{ if } X = (x - a_1)^2 + (x - a_2)^2 + (x - a_3)^2 +, \text{ etc., and } Y = (y - b_1)^2 + (y - b_2)^2 + (y - b_3)^2 + \text{ etc.}$$

Now all the terms of Σ, X and Y are squares and therefore positive and X and Y are independent (since x and y are). It is necessary, therefore, in order that Σ should be a minimum, that both X and Y should be. For

$$X = \text{a minimum we have } \frac{dX}{dx} = 0 = 2\ [(x - a_1) + (x - a_2) + (x - a_3) +, \text{ etc.}]$$

$$n\,x - (a_1 + a_2 + a_3 +, \text{ etc.}) = 0,\ x = \frac{a_1 + a_2 + a_3 +, \text{ etc.}}{n}$$

$$\text{and in same way for } Y = \text{min.},\ y = \frac{b_1 + b_2 + b_3 +, \text{ etc.}}{n}$$

but the point (x —, y) defined by these equations is merely the center of gravity of the individual points considered as of equal weight, the determination of which in any case is extremely simple. E. E. W.

Memphis, Tenn., Feb. 12, 1899.

(Our understanding of the purpose for which "the center of a group of shots" is desired differs somewhat from that of our correspondent. We supposed it was wanted for use in target shooting, to closely determine the respective accuracy attained by different competitors. In ordinary target practice, a shot striking the outer edge of a ring scores as much as one which strikes the same ring nearer the center. If, however, the "center of a group of shots" is found, the distance of this center from the center of the target tells at once what accuracy the marksman has attained. Another and much simpler method for accurate scoring, however, would be to measure the distance of each individual shot from the target center, and divide the sum of these distances by the number of shots. The quotient would then fairly express the average accuracy attained by the marksman in the several shots.—Ed.)

Notes and Queries.

"Surveyor," Washington, D. C., submits the following proposition: Given the area of any irregular polygon as 36 acres. This was measured by a chain .015 too long. What will be the exact area? In any closed survey the true area is to the computed area as the (chain used)^2 is to (true chain)^2. But our correspondent asks, is there not a polygon conceivable in which the rule for exact area will not hold good, or will not, in some cases, the angles be changed, as in the case of some reentrant angles? As long as the sides only differ, proportionately, we cannot see that the angles are in any way effected. A case in point is the photo-reduction of any irregular polygon; for while the lengths of sides and the area are polygon; for while the lengths of sides and the relative area are changed, all the angles remain the same.—Ed.]

OVERHUNG SANDBOXES FOR LOCOMOTIVES.

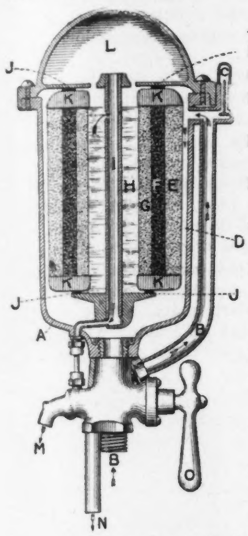
The almost universal practice in American locomotive design is to put the sandbox on the top of the boiler, although in a few cases European practice has been followed in placing two sandboxes in front of the wheels (below the running-board). A singular arrangement, however, is employed on some of the eight-wheel express engines of the Illinois Central R. R., in which the sandbox is attached to the underside of the boiler barrel, between the frames and just in front of the driving axle. These engines were built some time ago, but it was only recently that this peculiar feature of design came to the attention of this journal.

Enquiries as to the reason for the adoption of this feature of design, addressed to the Brooks Locomotive Works, of Dunkirk, N. Y., the builders, brought the following reply from R. J. Gross, Vice-President:

We built in 1896 eight eight-wheel passenger engines for the Illinois Central R. R., and at the request of one of the executive officers built them (to use his words) "to look like racing machines." In conversation with the writer, he contrasted the trim appearance of English locomotives with the American locomotive, all covered with piping and excrescences (as he termed it), and his criticism was not much to the advantage of the American locomotive. We told him that we could build such an engine as he wanted, and the engines you saw were the result. We placed the sandbox underneath the boiler in order to do away with one "excrescence," and located it underneath, as there was ample room there, and the location was quite as suitable as on top of boiler, it being filled from the sides by permanent tubes for that purpose, while the heat from the boiler kept the sand sufficiently dry to feed well. We have built some few engines in this way for other roads, mostly foreign, and, so far as we are aware, the idea was original with us.

A SELF-CLEANSING DOMESTIC FILTER.

The accompanying illustration shows a domestic filter which is provided with automatic means for washing the filter surface clean every time water is drawn from it. The design and mode of operation of the filter will be readily understood by examining the sectional view herewith and its accompanying legends. Air is admitted to the space between the outer filter cylinder and the external case through an automatic valve. When the faucet is turned to draw filtered water the air between the case and the cylinder is forced, with the water, through the filtering material to the central chamber and rises to the dome, where it is compressed to a greater or less extent. The filtered water discharges through a small hole in the



A—Enameled outside case.
B—Supply pipe.
C—Air valve.
D—Space between case and filter material.
E—Exterior earthenware cylinder.
F—Compressed bone charcoal.
G—Interior earthenware tube.
H—Space for filtered water.
I—Delivery tube.
J—White rubber gaskets.
K—Non-porous caps.
L—Dome for compressed air.
M—Outlet for filtered water.
N—Outlet for ordinary and refuse water.
O—Faucet.

Section of Self-Cleansing Filter.

center tube and down into the pitcher or other receptacle for filtered water. When the faucet controlling filtered water is closed the waste pipe, N, is automatically opened and the compressed air stored in the dome displaces some of the water in the central chambers, which flows in a reverse direction through the filtering material, washing away, it is claimed, all the impurities. Simultaneously the automatic air valve, C, drops, displacing the wash water and admitting a new air supply. It is also claimed that the action described aerates the water. These filters are rented or sold, as desired by patrons, by the Weir Filter Co., 63 Fifth Ave., New York city. We are indebted to Mr. Francis C. Green, Manager of the company, for the above information.

CYLINDER RATIOS FOR COMPOUND ENGINES.*

By Geo. I. Rockwood, M. Am. Soc. M. E.

Although great numbers of compound Corliss and marine engines have been built within the last 25 years, it is nevertheless a fact that next to nothing was known experimentally previous to eight or ten years ago in regard to the most economical ratio of cylinder volumes. The ratio was, and still is, fixed within narrow limits in all compound engines. Continental manufacturers have favored a proportion varying from the ratio 1:2.75 to the ratio 1:3.25. English and American builders have generally adopted a slightly larger ratio, namely, from 1:3 to 1:4. A common rule is to make the diameter of the low-pressure cylinder 2 ins. less than twice the diameter of the smaller cylinder. The explanation of this rule is found in the fact that an engine so proportioned avoids more than a very slight drop in pressure from that at the end of expansion in the smaller cylinder to the pressure at cut-off in the large cylinder, with reasonable ratios of expansion in each. When "drop" occurs, it is because (at least the great engineering authorities have agreed that it is solely because) free expansion takes place —that is, a sudden enlargement of the volume of gas without doing work against a piston, as in suddenly opening a cock in the pipe joining two cylinders, one full and the other empty of gas. Since free expansion of a working gas undeniably lowers the working pressure of that gas, any loss which such a lowering of pressure would entail may be obviated by preventing the free expansion. Hence, it is said, in a compound steam engine it is best to avoid "drop."

*Condensed from a paper read before the Providence Association of Mechanical Engineers.

For 30 years this reasoning has controlled the design of the compound engine.

In the article on the steam engine in the Encyclopædia Britannica, by Professor Ewing, may be seen the following statement:

> Whenever a receiver is used, care should be taken that there is no unresisted expansion in it; in other words, the pressure in the receiver should be equal to that in the high-pressure cylinder at the moment of release. If the receiver pressure is less than this, there will be what is termed "drop" in the steam pressure between the high-pressure cylinder and the receiver, which will show itself in an indicator diagram by a sudden fall at the end of the high-pressure expansion. This "drop" is, from the thermo-dynamic point of view, irreversible, and therefore wasteful.

At the time when this statement was written (1886), no one had ever made any experiments on actual compound steam engines to determine the effect of permitting "drop"; still less had it ever occurred to anybody, so far as I know, to determine experimentally whether a gain or a loss would follow the adoption of larger cylinder ratios that that ratio which is small enough to prevent "drop" almost entirely.

The sentence: "This 'drop' is, from the thermo-dynamic point of view, irreversible and therefore wasteful," is true enough; but the caution based on it is not logically connected with it, because it is often the case that things, slightly objectionable per se, are inseparable companions of other things which are necessary or indispensable.

The loss in pressure of the receiver steam, due to the practice of taking more steam by volume from the receiver than it gets from the high-pressure cylinder, is accompanied by an increase of work in the high-pressure cylinder. That is, the back pressure in that cylinder is reduced at the same time with the reduction of the initial pressure in the low-pressure cylinder. Hence the loss of power occasioned by receiver expansion, though it exists, is, with high boiler pressures and moderate amounts of "drop," even from a thermo-dynamic point of view, quite insignificant. While the waste attributed to "drop" is a reality and its amount may be computed if the amount of "drop" is known, such waste is not necessarily a controlling factor in determining the ratio of the cylinder volumes.

Let us consider what are the causes of "drop," and what are the advantages which accompany its moderate use.

The causes of "drop" are of two kinds. First, "intermediate expansion," and second, cylinder condensation and clearance in the low-pressure cylinder. Suppose a receiver compound engine had neither clearance or condensation in the low-pressure cylinder. There might still be any amount of "drop" if the cut-off on that cylinder were lengthened enough. On the other hand, if the cut-off were adjusted just right to prevent any "drop" in such an engine, and then that cylinder were endued with both the usual amount of clearance and of condensation, probably at least 15 lbs. of "drop" would be the immediate result. Again, this even then could all be prevented by making the cut-off earlier in the stroke. It is thus obvious that the point of cut-off may be a cause, or it may be a corrective of "drop." But the point of cut-off is dependent on other considerations than its influence on the amount of "drop." As a matter of fact, it would be desirable to have the cut-off take place late in the stroke, were it not for the loss from excessive free expansion thereby involved, because this would reduce the range in temperature of the low-pressure cylinder walls, and hence would reduce the loss from initial condensation in this cylinder.

It is evident from the foregoing that unless the best point of cut-off, estimated solely with reference to the waste by initial condensation, happens to coincide with that particular point at which "drop" would be entirely prevented, a compromise must be made between the gains made by lengthening cut-off and thereby reducing condensation, and the loss thereby incurred from free expansion. It happens that with cylinder ratios in the neighborhood of 3:1 no such compromise need be made because both considerations suggest the same point of cut-off; but with larger cylinder ratios, such as 5, 6, or even 7 to 1, some "drop" is inevitable, and it becomes a question of just where to locate the points of cut-off in both cylinders so as to secure a minimum net loss from clearance, intermediate expansion, and initial cylinder condensation. If "drop" is accompanied by a reduction of initial condensation in the second cylinder in amount sufficient to overbalance the waste of power by intermediate expansion, it is, at least, no detriment to the coal consumption to allow that much "drop." Moreover, nearly all light, heat and factory loads are decidedly variable, and engines most suitable for driving such loads are compound condensing engines working with considerable "drop," because this permits a widely variable cut-off in the second cylinder without either looping at the end of expansion in the first cylinder or materially changing the receiver pressure. It is seen, therefore, that the advantages of "drop" are of both a thermal and a practical nature.

In the year 1891 "The Railroad and Engineering Journal" published an article, written by myself, with this title: "How Many Cylinders Will It Pay to Introduce in the Multi-Cylinder Engine?" This was a brief discussion of the theoretical and practical utility or uselessness of the intermediate cylinders of a multi-cylinder engine, and was written before any experimental data were available to reinforce the position taken, which was that these cylinders were of no theoretical or practical advantage as aids to the economical operation of the engine. At that time a triple-expansion engine was being constructed, and the opportunity thus presented of arranging the intermediate cylinder so that the engine could be run without it was embraced, and the following year, numerous tests of this engine, with and without its intermediate cylinder, appeared to show that on that engine the second of the three cylinders was of no advantage. This was with reference to the economy of producing an indicated horse-power. The friction of its piston and valve gear, not to mention the interest and fixed charges on the investment, made it a considerable loss per delivered horse-power.

Since the tests of this triple expansion engine were made, eight other large engines, built by the Wheelock Engine Co., on lines which these tests indicated to be correct, have been tested. In all, the same builders have built about 25,000 HP. of these compound condensing engines, and each engine was sold under agreement to use not over 12½ lbs. of dry steam per I. HP. per hour. In some cases the engines were not at first complete mechanical successes, and in one case this extended to the tightness of the valves and pistons, etc., causing a greater steam consumption than that guaranteed. In all of the other cases, however, so far as I am informed, the guarantee was surpassed. The very best performance of any mill engine which has been tested by recognized and competent experts is one of this type running at the mills of the Grosveuor Dale Company, and tested by Mr. Barrus, who published his report in "The Engineering Record," Nov. 20, 1897. The steam consumption was 11.89 lbs. total per I. HP. per hour, and the coal consumption was 1.18 lbs.! The average I. HP. developed by the engine during the test was 660.

If some one having the opportunity would test the most economical triple expansion engine anywhere to be found, working with a boiler pressure of 160 lbs., and a vacuum realized in the low-pressure cylinder of 13½ lbs., both with and without its intermediate cylinder, and have as his object to determine the heat required per brake HP. per hour, by this engine in each case, I think (but I do not, nor does anyone else, know) that the result would show the advantage to lie with the simpler form of engine. Such a comparative test would be a truly scientific one, and the knowledge thus obtained would be definite and compel our assent to its authority.

In the absence of such a perfect series of tests as I have outlined, we may, at least, be interested in, and allow our judgments to be influenced by, the tests made on the comparatively uneconomical and, because of its small size, low boiler pressure and poor vacuum, unrepresentative triple expansion experimental engine in the laboratories of Sibley College, Cornell University. These tests are reported and very fully discussed in a paper in Vol. XIX. of the "Transactions of the American Society of Mechanical Engineer." The water rate of this engine, run both as a triple and as a compound, was as follows:

Jacketed Engine.

	I. HP.	Water rate.
Triple	141.4	15.37
Two cylinders	152.0	15.58
Triple	45.6	17.70
Two cylinders	47.7	16.80

The compound does as well as the triple on heavy loads, and better on light loads. This paper, together with one by Mr. F. W. Dean, entitled "Trials of a Recent Compound Engine with a Cylinder Ratio of 7 : 1" (Trans. A. S. M. E., Vol. XVI., p. 179), cover about all the philosophy and data that are at present known on this subject.

The answer to the question, What is the best cylinder ratio for a compound engine? depends upon the facts with regard to the loss by cylinder condensation and the loss by intermediate expansion. Little is known specifically about these facts so far as they appertain to these recent compound engines which work with high steam pressures and have very small high-pressure cylinders. As I have shown, all that we know is that high ratios and high pressures beat low ratios and low pressures; and with the exception of the analysis by Dr. Thurston of the Sibley engine tests, we have no experimentally delivered knowledge of the details of the saving process. This analysis, so far as it goes, bears out the view which I originally entertained of the essential incorrectness of the received theory of the action of steam in a compound and in a triple expansion engine. The deduction from that theory has been that the thing to aim at in the design of either type of engine was, besides eliminating "drop," to so proportion the cylinders as to have each cylinder do an equal proportion of work, and have the steam work through an equal range in temperature in each cylinder. Almost the first thing that was said when the proposition to do away with the intermediate cylinder in triple expansion stationary engines was made was that the great increase in the range in temperature in the first cylinder caused thereby would greatly increase the loss by cylinder condensation in that cylinder. My answer to that was that even if there were more condensation thus effected in the first cylinder, this would not matter unless there was such a great increase in condensation as to exceed in quantity that in the low-pressure cylinder. The singular fact is developed by Dr. Thurston's analysis, however, that the quality of the steam at cut-off in the first cylinder of the Cornell engine when operated without its intermediate cylinder was actually better than when the range in temperature was lessened by using that cylinder, and his explanation was that this was the direct result of the sudden drop in pressure at release in the first cylinder of the compound, which did not take place in the triple. Furthermore, the improvement in the quality of the steam caused by "drop" was about equal in both the high and the low-pressure cylinders, and was most noticeable with the most "drop"!

These experiments, at all events, make it perfectly plain that cylinder condensation does not depend directly and solely on the range in the temperature of the steam. The extent of the surface exposed, and the amount of "drop" allowed, have at least as much to do with it.

I will bring my remarks to a close by saying, finally, that I do not desire to see the triple expansion engine discarded absolutely and for every purpose. I believe it is indispensable at sea for mechanical reasons; also for certain kinds of direct-acting steam pumps, working without cut-off in individual cylinders. But for stationary power plant engines the most economical engine at present practically possible, all things considered, is, in my judgment, a cross compound engine, working with a boiler pressure of 180 lbs., a vacuum of 13½ lbs., a receiver pressure of 8 lbs., and a cylinder ratio of 8 to 1.

FOUNDATIONS AND CHIMNEY FOR 45,000-HP. ELECTRIC POWER STATION, METROPOLITAN STREET RAILWAY CO., NEW YORK CITY.

(With two-page plate.)

The two largest electric power stations in the world are now being erected in the upper part of New York city, and are designed to furnish current for the two great street railway systems of the city, one controlled by the Metropolitan Street

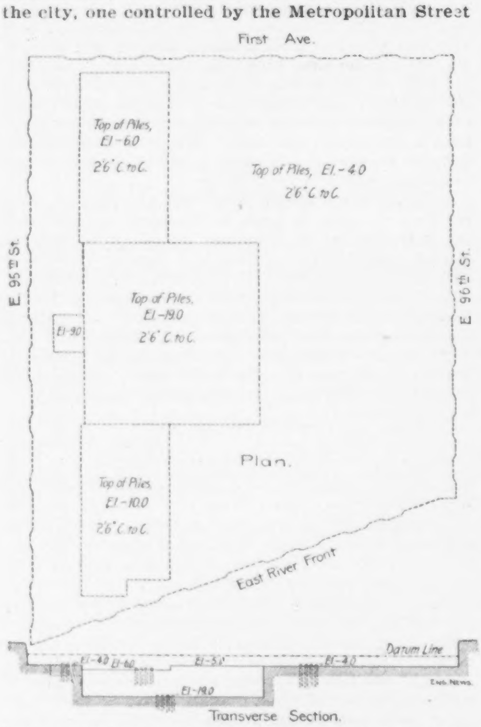


Fig. 1.—Diagram Showing Spacing of Piles Over Power House Site.

Ry., and the other by the Third Ave. Ry. Co. As our readers will recall, New York city has been, with the exception of Washington, D. C., the last city in the United States to adopt electric traction for its street railway lines. By reason of the refusal of the city authorities to permit the use of the overhead trolley system, the horse-car and the cable car have survived in New York until the recent development of the conduit electric system has made it possible to adopt that system for the street railway lines of the city. Again, had the electric railway been introduced in New York a half dozen years ago, it is altogether probable that many power stations would have been erected in different parts of the city to supply current to the various lines, from direct current generators working at the ordinary street railway potential of 500 volts. The delay in the introduction of electric traction, however, has made it possible to utilize the latest advancements in electrical engineering practice in the generation and transmission of high potential currents, and to concentrate all the current generating machinery in a single enormous station located on the water front, where coal can be obtained and ashes discharged at the lowest cost, and where water for condensing can be obtained in ample supply.

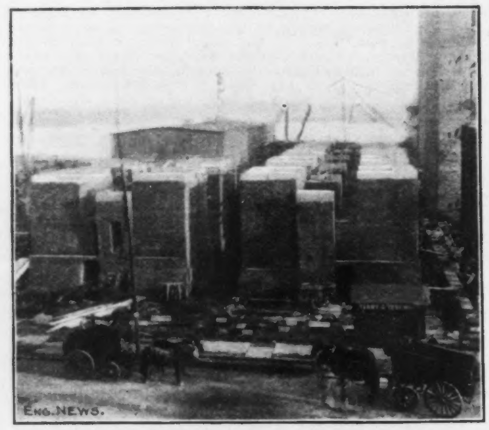


Fig. 4.—View of the Engine Room Side of the 45,000-HP. Power Station, Showing Completed Foundations for Eight Engines.
(Reproduced from a photograph taken Dec. 8, 1898, before erection of power-house frame began.)

From this station alternating current at high potential will be carried to small substations scattered all over the railway system to be supplied with current. At these substations the high-potential alternating current will be transformed to direct current at low voltage and fed directly into the mains along the line of the road. Besides this, it is currently reported that this great station and the underground feeders along the lines of the conduit electric roads will be made use of to supply electric current for lighting and power purposes, as well as for street car traction.

The Metropolitan Street Ry. system in New York city now comprises over 200 miles of street railway tracks. While only a small part of this is as yet operated by electricity it is expected that nearly all of it will be at an early day; and to provide for this and for the rapid growth of traffic the company is designing its new power-house for a normal output of 45,000 HP. Allowing for reasonable short-travel overloads on engines, generators, etc., it is believed that the new power-plant, when equipped to its full capacity, can carry a load for a short time as great as 75,000 HP.

Upon our inset sheet this week we illustrate the foundations for this great structure, with details of the lofty chimney, which has already been erected, and which will furnish draft for the entire boiler plant. Views of the chimney and of the completed engine foundations are shown in the accompanying half-tone cuts.

The great power-house is divided into two parts, one of which will contain the boilers and coal bins and the other the engines and generators. The boiler-room will contain 87 Babcock & Wilcox water-tube boilers of a maximum capacity of 800-HP. each, or a total of 69,400 H.P., arranged in three tiers. Supported upon the columns holding up the three boiler floors and over the boilers will be a coal storage bin with a capacity for about 10,000 tons. The engine-room, separated from the boiler-room by a heavy brick wall, will contain 11 engines, built by E. P. Allis Co., Milwaukee, Wis., each of about 4,000 HP. at its point of economical load, or about 6,000 HP. at maximum load, arranged in two lines. Each engine will be directly connected to a three-phase generator furnishing current at 6,000 volts.

At the present time the building and engine foundations are completed, the great chimney is finished, and the heavy columns to support the boilers and coal bins are being placed. The power-house occupies the block between First Ave. and the East River, and 95th and 96th Streets. It is centrally located, when the future growth of Harlem and the Borough of Bronx are considered, although just at present it is somewhat north of the center of traffic. Before constructing the foundations, test borings were made over the power-house site. These borings passed through earth filling, ashes, river mud and beach sand, and at a depth varying from 53 to 65 ft. reached a layer of red clay. Rock was found below this at an average depth of 80 ft. It was considered safe to found the structure on piles driven into this clay. The entire block was excavated to an average depth of 11 ft. except where the chimney was to stand, where the excavation was carried down to about 26 ft. below the street surface. Piles were then driven over the entire area and cut off, as shown in Fig. 1, and concrete was rammed about and over the ends to a depth of 5 ft., thus bringing the whole surface on one level. The pit dug for the chimney foundation was also filled in to the same level. Upon the foundation thus formed the side walls of the building, the bases of the great chimney, columns for the boiler-room, and the brick engine foundations were built up.

The outside dimensions of the building are: 201 ft. 5 ins. on First Ave., the front of the building, and 279 ft. at right angles to this along 95th St. The chimney, Figs. 5, 6 and 7, is one of the largest brick chimneys ever erected. It rests upon a solid block of concrete 88 × 85⅓ ft. by 20 ft. deep. It starts from this concrete foundation with a square pyramid base 55 ft. on a side, with the corners cut off, and decreases to 40 ft. at a height of 15 ft. from the base, from which point it is continued on up, square in section, with the corners cut, to the 80-ft. mark, where it has a dimension of 38 ft. 10 ins. on a side. At this point begins the change to a circular section, which is

Fig. 5.—The 353-ft. Brick Chimney of the New Power Station of the Metropolitan Traction Co., New York City.
(Reproduced from a photograph taken Feb. 24, 1899.)

completed at a height of 95 ft., and above this point the chimney is circular, with a taper of 5-16-in. to the foot. It reaches a diameter of 26 ft. 10 ins. at a height of 317 ft., where the ornamental top begins, and continues on to a height of 353 ft. Into two opposite sides of the lower square portion open three 9 × 11-ft. flues, one above the other, to accommodate the three tiers of boilers. Built into the sides of the square portion of the chimney, where the flues enter, and just over the arched tops of the flue openings, Fig. 6, are tie bars to prevent spreading and to stiffen the sides and offset the weakening due to the openings.

In the center of the chimney, Fig. 6, and dividing it into two semicircular compartments, is a 12-in. fire-brick wall extending up 85 ft., or about 5 ft. above the top of the upper flue. The object of this being to prevent the current of hot gases from one set of boilers having any influence upon the gases rushing out of the other flues on the opposite side. This dividing wall is braced by two 12-in. central buttress walls, one on each side. The fire-brick lining of the chimney begins about 4 ft. below the floor of the lowest flue and extends up, 8 ins. in thickness, to 5 ft. above the upper flue, from which point on up to the 115-ft. mark it is 4 ins. thick, as will be seen in Fig. 6.

The other illustrations show sections at various elevations, and show quite clearly the inner and the outer shells, and the stiffening ribs as they gradually decrease in size towards the top. At the foot of the cap, just under the two ornamental projecting bands, the outer wall is 20 ins. thick, and here the inner wall is 8 ins. thick. From this point the inner and outer walls continue on up only an inch apart for about 26½ ft., where an expansion space of 15 ins. is left, Fig. 7. To seal this a steel slip sleeve, 4 ft. deep, is built into the outer casing, thus allowing the inner lining to telescope, to allow for expansion due to differences in temperature between the inner and outer walls. To counteract the weight of the overhanging enlarged portion of the top, three steel rings were built into the brickwork, as seen in Fig. 7, the first being at a height of 335½ ft., the second, made of 4 × 1 11-16-in. steel, 3 ft. above, and the third ring 3 ft. above this. The brickwork in the thickest portion of the cap is 6½ ft. thick, from which it slopes off to 20 ins. at the very top. This final slope is covered by 40 cast-iron segmental plates, bolted together and held down by long turnbuckle bolts hooked under the middle ring and built into the brickwork. These plates run up and over the top and hook down into the chimney a short distance. The diameter of the cap at its widest portion is 35 ft., and the inside diameter, or flue diameter, is 22 ft., or the same as the interior of the chimney all the way up.

To give a better idea of the size of this great chimney it may be roughly stated that the 4,000,000 bricks used in its construction would be sufficient to build 40 of the old-fashioned 4-story, brownstone-front houses, or between 18 and 20 ordinary 25 ft. front flats so common in New York city.

The method of protecting the chimney from lightning, is well shown in Fig. 7. Briefly, a series of 10 1¼-in. copper rods, supported upon substantial bracket insulators, project 6 ft. above the top of the cap, and each terminates in a four-pronged point, tipped with platinum for 2 ins. At the base of these rods is a heavy copper band encircling the cap and attached to each rod, and at diametrically opposite points two heavy copper strips 1 × 3-16-in., lead down the sides of the chimney to suitable ground plates. The total length of the lightning conductors used was 1,030 ft. Running around the lower and inner edge of the cast-iron segmental cap, and attached thereto, is a second copper strip also connected with the ground conductors. In this way double, and, it is believed, ample protection is afforded.

Turning now to the engine-room, as seen by the drawings, this will have an average length of 224 ft., and a width of 111 ft. In it have been built eight large brick engine and generator foundations, upon which will stand the huge vertical engines and electric generators. Eventually three more foundations will be built, and other engines installed, but at present that portion of the engine-room is occupied by a shed 100 × 41 ft., in which are two horizontal Corliss engines of 1,200 I. HP., with cylinders 30½ and 48 ins. by 48 ins. stroke, running at 80 revolutions, using steam at 160 lbs. Each of these is directly connected to an 850-K-W. General Electric railway generator with a rated current output of 1,478 amperes. This temporary station supplies power to the Metropolitan electric railway lines in the immediate neighborhood.

These engine foundations are very massive, and the view given in Fig. 4, besides showing them, affords some idea of the scale upon which the entire plant is being constructed. It will be noticed that a narrow passage leads up inside the foundations, so that the portion of the generator beneath the floor can be inspected. These brick pedestals are 43 ft. long, 24 ft. wide, and 29 ft. high from the concrete floor to the top of the granite capstones. For the information and material from which this description has been prepared, we are indebted to Mr. M. G. Starrett, Chief Engineer of the Metropolitan Street Railway Co.

EARLY DEVELOPMENT OF WATER POWER IN THE UNITED STATES.*

By J. T. Fanning,† M. Am. Soc. C. E.

About five years after the landing of the Pilgrim Fathers the Plymouth colony granted to John Endicott and 25 others a tract of land extending from three miles south of Massachusetts Bay to three miles north of the farthermost point of the Merrimac River, and from the Atlantic to the Pacific Ocean.

The successive periods of our water power history and development, which began in the days of Endicott's colonies, have been momentous. The early water mills almost antedated colonial newspapers, and records of them are now traced only with difficulty in old reports of town histories, often lacking in explicitness and in precision.

It is important that the story of their construction be now preserved with chronological arrangement, indicating where and what the mills were, and their relations to colonial and national establishment. It is furthermore proper that this chronology, imperfect though it be, shall be preserved in the annals of this association of pulp and paper makers, which, more than all others, represents an industry that adopted water power as its ally, thrived with the water powers, and has shared with them a marvelous growth.

There were but a few years of colonial struggles before the substitutions of revolving millstones for mortar pestles in preparations of foods, and substitutions of muley saws for whip saws in construction of shelters, became necessities.

The colonists from Holland were familiar with windmills, and colonists from England were familiar with horse-powers, and but few of the colonists had knowledge of water mills, so that to them, early water mills were innovations.

Endicott's first colony erected a water grist mill at Dorchester, Mass., as early as 1628. In 1631 there was a tide mill for grinding corn in Boston, on Mill Creek, and in the same year a sawmill was erected at Neponset, in Massachusetts.

So early as 1634 a more ambitious effort was made at the lowest fall of the Charles River, where a low stone weir was built across the river and a mill race or canal was excavated to lead water on to the flutter wheel. In those days a journey of 30 miles to mill with a grist on the back of a bull was not an unusual experience. Soon after 1634 corn mills began to multiply in various parts of the colonies, and their equitable management became a matter of so much moment that the General Court of Massachusetts, in 1638, issued regulations respecting them.

A Massachusetts colony, following New Hampshire, erected a sawmill in 1638. The colony of Maryland is reported to have raised funds by subscription, in 1639, to aid in building its first water-power mill for corn. Pennsylvania followed with a water grist mill on Cobbs Creek near the site of Philadelphia, in 1643.

The court, in 1661, granted Winthrop (afterward Governor of Connecticut) the right to set up a sawmill near New London, and encouraged the work by special privileges. The town of Norwich, Conn., in 1680, gave Captain Fitch a grant of land for his encouragement to set up a sawmill.

In the latter year there were reported water grist mills on Rancocas Creek and in Trenton, in New Jersey, and two years later, William Penn's colony arriving on the Delaware River, brought as part of their cargo the frame of a mill which they set up, and in this mill ground their corn. In 1682 there were reported six sawmills at Pissataqua, N. H., and six others at Kittery, Me., and 18 other sawmills in other water power localities in Maine.

In these colonial days we recognize the germ of American genius that has since asserted itself, for we read that in 1698 an Englishman, writing home from the Pennsylvania colony, said: "The water mills far exceed those in England, both for quickness and for grinding good meal," and we also read that an American gang sawmill was purchased for use in an English dockyard because of its superior capacity and product.

In 1693 we learn of the manufacture of paper by hand processes at Roxborough, followed by other mills in Pennsylvania, in New Jersey and Delaware, but the paper makers were not yet conspicuous among the developers of water powers. The housewives were as yet spinning their yarns of flax and wool at their own firesides, and the muslins and broadcloths were imported luxuries for the fortunate few.

Nevertheless, there were, by the year 1700, beginnings of exportations of flour, boards and yarns to other colonies of the mother country that attracted the attention and alarm of her statesmen. The English Parliament was therefore constrained to pass an act imposing a fine for the colonial exportation of manufactured goods, and forbade the exportation from Great Britain of textile machinery, in order to prevent the American colonists from procuring such machinery, to be operated by the American water powers.

In 1790 Congress passed an act for maintaining the public credit, and for adjusting the revolutionary war debt, and in the same year passed the first American patent law, encouraging inventions and protecting inventors. A new industrial era was thus auspiciously inaugurated, and then the beginning of the textile industry introduced a new factor in the development of American water powers.

A modest attempt had been made at Beverly, Mass., in 1787, to spin cotton and woolen yarn by machinery driven by horse-power, and later similar trials were made at Philadelphia. Then, in 1793, Eli Whitney perfected his cotton gin, and in 1797 Amos Whittemore invented his card-setting machine. About the time the pioneer mill at Beverly was started, a mill was erected at "the Falls" in Norwich, Conn., then prominent in shipbuilding, for the spinning of hemp and weaving of duck, and two rope-walks were there in operation. During the maritime war between France and England, in 1801-1802, Norwich became, in consequence of its manufactures, the base, on this continent, of ship supplies, for the fleets of both contending nations.

The possibilities of home manufacture of textile goods, finer than domestic homespuns, were at that time being earnestly discussed by American merchants. The stories of this discussion reached in England young Samuel Slater, an experienced manufacturer of marked mechanical genius, who soon came and met merchants of Providence, R. I. As a result, he built, with their encouragement, some cards, weaving frames and spinning frames, to demonstrate his ability and set them in operation at the falls at Pawtucket, R. I. This, in 1790, is reported to be the first spinning of cotton in America by the aid of hydraulic power and by means leading to both mechanical and financial success.

In the following year William Pollard's newly invented water spinning frame was erected near Philadelphia. In 1793 the "Old Slater Mill" was built at Pawtucket and was the first successful cotton mill construction and operation in America.

Before the completion of the first Slater machines several machanics were striving to invent machines for spinning, such as England then had and withheld, under a penalty for their exportation in fact or by drawing or by description.

We see the evidence of the early farsightedness, progressiveness and enterprise of the citizens of Massachusetts in the acts of her legislators, who, in the year 1786, granted £200 to John Cabot and Joshua Fisher to assist in equipping the Beverly mill above mentioned. Just previous to the year 1790 mechanics were devoting their studies and labors to producing woolen yarns and to fulling woolen cloths by aid of power, and small stocking mills and woolen mills began then to be operated. President Washington journeying in New England, visited a mill where broadcloth was finished near Hartford, Conn., and was so much interested that he ordered cloth for suits for his servants at home and for himself, and in 1789 Washington read his message to Congress while dressed in this suit of domestic wool.

Peace and stability of government after the Revolution encouraged a great flow of immigration and encouraged enterprise, manufactures, agriculture and commerce. The acreage of wheat multiplied, new flouring mills were built and flour began to be exported in considerable quantities. New colonies were planted farther inland and the farmers began to take up lands west of the Hudson River, even so far as about the eastern end of Lake Erie. Flouring and saw mills were established at Genesee Falls in New York, as early as 1789, at Rotterdam as early as 1794, and at Seneca Falls as early as 1798, while nearly a thousand small mill sites were occupied in the 13 original states before the opening of the year 1800. The lumbermen were also pushing their camps higher up the streams of Maine, and occupying the rapids for power, and shipyards were building schooners to distribute the manufactured lumber to the Atlantic coast towns.

In the early colonial era a sawyer pointed with pride to his new mill, in which he said two men could cut 4,000 ft. of boards in 24 hours. In the new era the water powers brought into use for sawing were larger and the daily cut per mill multiplied more than twentyfold.

The successful development and profitable use of many small water powers led to investigations of more ambitious hydraulic enterprises. The falls of the Passaic in New Jersey was one of the first to attract attention as a source of large power and a nucleus about which various manufactures might be grouped. The legislature chartered a company in 1791 with ample privileges to build the power and conduct various manufactures, and the construction of the water power was started on a plan of comprehensive proportions. The scale proved, however, in advance of the times and its expense called for more cash than could then be found available. A little later a portion of this power was brought into use for cotton spinning and became later the nucleus around which have grown the important silk and other industries of the city of Paterson.

Notwithstanding so much advance had been made in invention at the opening of the present century, the hydraulic powers were not yet making the finished cloth products. Until about the time of the War of 1812 the mills were spinning the wool and cotton yarns and nearly every

*Extract from a paper read at the annual meeting of the American Pulp and Paper Association.

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farm house in Eastern New England was furnished with a loom and nearly every housewife was a weaver. As above, we observed the farmers bringing home their grists from the mills, so now we observe the women bringing home from the spinning mills, sometimes six, eight or ten miles, their bundles of wool or cotton yarn to weave cloth for their households or for the market at prices of 3 to 7 cts. per yard, according to the nature of the cloth.

The War of 1812 shut out foreign competition and gave an increased demand for domestic goods and a stimulus to manufacturing. The operations of the year 1813 were eventful, especially in their influence upon the water power developments and the expansion of the industries that have clustered about them.

In this year Messrs. Francis C. Lowell and Patrick T. Jackson, merchants, of Boston, bought the "Bemis" power in Waltham, Mass., on the Charles River, and equipped it with 1,700 spindles, with cards and power looms. This was the first American mill producing under one roof from raw cotton the finished cotton cloth, which it did successfully.

The success of this small experiment led shortly to the erection of a second water power mill at Waltham, equipped with 3,584 spindles, with full machinery to produce finished cloth, which was a second mechanical and financial success. Competition with foreign mills had long been trying and often discouraging, but its success was now assured and attention turned rapidly to the waterfalls of the principal rivers of New England.

About 1820 stimulated enterprise called from France the Fourdrinier paper machines, and in 1830 the Phelps and Spoffard cylinder machines were perfected at Windham, Conn., and then the paper makers became well established mechanically and as power users and were competitors with the millers, the lumbermen and the textile manufacturers for the available water powers.

Soon after the opening of the present century a remarkable era of canal building was inaugurated, beginning with the Santee Canal in South Carolina in 1800, and including the Schuylkill in 1816, the Erie in 1817, the Lehigh in 1819, the Morris & Essex in 1825, the Miami in 1825, the Delaware & Hudson in 1826, the Chesapeake & Ohio in 1828 and others. In connection with these canals and their dams numerous small water powers were developed. The doors of other proposed navigation canals were, however, sealed when the Boston & Lowell Railroad was opened in 1830, a pioneer in both passenger and merchandise transportation by rail.

The commercial depression from 1815 to 1820 was a trying time for many of the small manufacturers. In 1821 prospects were brightening, and Mr. Lowell, above mentioned, desired, with his associates, to erect a new mill larger than their Waltham mill. After an examination of several water powers they decided in 1821 to purchase the Pawtucket Locks and Canal, and thus secure the great water power of Pawtucket Falls in the Merrimack River in Massachusetts. In 1822 the Merrimack Mfg. Co. was incorporated on Feb. 5 with $600,000 capital stock. Then was inaugurated the beginning of the great industrial enterprise of the city of Lowell, Mass.

Thereafter important water privileges were secured and important manufacturing companies were incorporated in such numbers previous to the Civil War, and then since the Civil War, that our space permits cataloguing as follows, in tables Nos. 1 and 2, only those that have notably enhanced the industrial advance of America.

Among the small water powers not enumerated that operate important textile mills are two on the Shetucket River, in the suburbs of Norwich, Conn., where the Tatville and Baltic mills are among the largest and finest mills anywhere to be found. In another suburb of Norwich, on the Yantic River, is a large and fine woolen mill, and on the Androscoggin and Fox rivers, are important pulp and paper mills.

TABLE NO. I.—Water Powers, as Reported, 1822 to 1861.

	Year.	Fall, ft.	Min., HP.	Water shed, sq. miles.
Lowell, Mass.	1822	35	11,845	4,083
Nashua, N. H.	1823	36	1,200	516
Cohoes, N. Y.	1826	104	9,450	3,490
Norwich, Conn.	1828	16	700	1,240
Augusta, Me.	1834	17	3,500	5,907
Manchester, N. H.	1835	52	12,000	2,839
Hooksett, N. H.	1841	14	1,800	2,791
Lawrence, Mass.	1845	30	11,000	4,625
Augusta, Ga.	1847	50	8,500	8,830
Holyoke, Mass...........	1848	50	14,000	8,000
Lewiston, Me.	1849	50	11,900	3,200
Columbus, Ga.	1850	25	10,000	14,900
Rochester, N. Y.	1856	236	8,000	2,474
St. Anthony Falls, Minn.	1857	50	15,500	19,7[illegible]
Niagara, N.Y.(Hy. canal)	1861	90	15,000	271,000

TABLE NO. 2.—Water Powers, as Reported, 1861 to 1898.

	Year.	Fall, ft.	Min., HP.	Water shed, sq. miles.
Turner's Falls, Conn. ..	1866	35	10,000	6,000
Fox River, Wis.	1866	185	.....	6,449
Birmingham, Conn.	1870	22	1,000	2,000
Bangor, Me.	1876	9	1,767	7,200
Augusta, Ga.	1876	50	8,500	6,830
Palmer's Falls, N.Y.....	1882	30	1,125	2,650
Mechanicsville, N, Y....	1882	20	3,636	4,476
St. Cloud, Minn.	1885	14	4,500	13,250
Little Falls, Minn.	1887	14	4,000	11,084
Spokane, Wash.	1888	70	18,000	4,180
Howland, Me.	1888	22	6,000	.....
Great Falls, Mont.	1890	42	16,000	22,000
Austin, Tex.	1891	60	10,000	40,000
Sault Ste. Marie, Ont....	1891	18	10,000	51,600
Folsom, Cal.	1891	55	6,200	.....
Concord, N. H.	1894	13	5,000	2,350
Niagara, N. Y. (tunnel).	1894	170	50,000	271,000
Ogden, Utah.	1896	446	2,940	360
Helena, Mont.	1897	32	10,000	14,900
Minneapolis, Minn.	1897	18	6,000	19,737
Mechanicsville, N. Y....	1898	18	3,270	4,478

THE MOTOR VEHICLE IN COMMERCIAL OPERATION.*

By G. Herbert Condict.†

The motor vehicle is in far more extensive use abroad than in this country, but oil and steam furnish the power almost exclusively and the electrics are in a small minority. With oil, gas and steam motors counted by the thousands, the electric foots up only by tens. Far different is the case on this side of the ocean. Oil, gas and steam vehicles are few in number, and there are not 150 electrics in actual service. Yet the Yankee vehicle, especially of the electric type, has already made an enviable reputation for itself, and promises to distance all.

I am not referring here to the light pleasure vehicle, run by its owner, who, as a general proposition, cares comparatively little what the cost of operation may be, but to that business affair that is to carry you and your goods to and fro in all conditions of weather—rain, shine, snow and sleet—within the narrow confines of the city streets. It was the raging blizzards of the present season that served more than anything else to bring into prominence the motor vehicle, which ventured in where horses feared to tread and, in spite of all prophecies to the contrary, got out again with ease. It is in such service that the future of the motor vehicle lies.

The great advantage of the electric motor vehicle over its rivals lies in the absence of objectionable features, such as odor, noise, vapor from exhaust, vibration and liability to accident. City transportation must be carried on with as little interference as possible with the rights and comforts of others. No motor using any of the products of petroleum is free from disagreeable odor. The principal streets of Paris, where the oil motor holds sway, are filled with the offensive odor so inseparable from the oil well districts of Pennsylvania. A trail of unsightly vapor accompanies the onward march of the steam motor, particularly in cold weather. Vibration produced by the reciprocating parts of many motors is very disagreeable, especially when they are operated slowly and stopped and started frequently, as in city service. But the electric vehicle is noiseless, odorless, vaporless and operates without jar or vibration. In the crowded, narrow streets of the city it excels in all that goes to make up a mode of transportation void of offence. But some one says that the electric vehicle is heavy and cumbersome; no one buys a motor vehicle by the pound, however, and it does not make any particular difference what the weight is if the machine performs successfully and economically the work for which it was fashioned. In this connection it is often necessary to remind the critic that in comparing the horse vehicle and the motor vehicle the weight of the horse or horses must be included in the weight of the former. Of course, we all know that the moving of weight calls for the expenditure of energy, and unless this expenditure is offset in some other direction, the system having the burden must fail. If the heavy vehicle can transport a passenger or a ton of paying load from one point to another in a more acceptable manner than the light vehicle, the former does the business. At this time it is impossible to obtain reliable data for the comparison of cost of operation of the various systems now on the market. Figures made up from absurdly inadequate data have been published from time to time, but so far nothing of much value is known on this point. By "cost of operation" I mean the total expenditure in cash for fuel, oil, attendance, repairs and replacements of parts for a period of sufficient length to secure a fair average. Such observations should extend over, at the very least, a year, and there has been no commercial operation of any magnitude in this country, or any other, for that length of time. In Europe, in spite of the fact that thousands of motor vehicles are used for pleasure riding, there is to-day only one cab station in actual operation and a few light delivery wagons, with here and there a lumbering steam truck or a fear-inspiring omnibus. In this country there are a few cabs operated from one little station and perhaps a dozen delivery wagons. In spite of the almost unqualified success of these few vehicles we know them to be far from perfect, and more than that, we know how to make many most important improvements. The most unexpected demand during the last few weeks for the electric cab in New York city has given it a test which years of ordinary intermittent operation could not furnish. Its faults have glared out prominently, but its virtues have been shown in a brilliant manner. Having covered over 250,000 miles of actual and commercial service, the vehicle has proved itself no longer a toy to be played with by the wealthy, but a practical machine for general use. It has been impossible to make accurate tests of the efficiencies of motors, batteries, gearing, bearings, etc., although such data is now being obtained. There is still much to be desired and in future equipments most material improvements will be made.

Outside of the consideration of large weight in proportion to power delivered, the battery has been giving excellent service. Up to the present time there has been practically no expense for maintenance, and the old-time troubles of buckling, short-circuiting, sulphating, disintegrating, are as yet entirely absent.

The tire situation is at present the absorbing subject. Were the streets in New York paved in an up-to-date manner, there would be comparatively little cause for anxiety on this score, but with the antiquated and despicable cobble, the case is far different. Over 20 separate and distinct types of tires have been tried, or are to be tried in the near future, and others will probably follow. Solid, single and double-tube pneumatic, cushion, clincher, sectional, protected and unprotected have all had, or are to have, a trial. Their faults are many, their virtues few, and we are still on the search. We have heard of some eminent authorities in the motor vehicle field who say that the solid is the only tire. They are rendering judgment without full knowledge of the facts and from a purely local standpoint. They are evidently not acquainted with the streets of Manhattan. A very satisfactory combination for a brougham is that of rear pneumatics and front solids.

The wheels also require most serious consideration. The severe strains unavoidable in crossing railway tracks and other inequalities and running up against curbstones speedily put out of service even the most substantial constructions. Everything from the light and airy bicycle-wheel construction to the dishpan wheels, now so familiar in our streets, have been tried, and still there are more to follow.

In describing the operation of the vehicles of the Electric Vehicle Co., of New York city, to some 200 members of the New York Electrical Society, on the occasion of its visit to the charging station of the company, on Feb. 14, Mr. W. F. D. Crane made the following remarks:

The carriage body, as it appears upon the wheels to-day, is a work of the past, while the running gear below is a little more up-to-date. The body is not connected with the running gear, and so far the running gear is inadequate for the service required of it. But if some radical change were made in the appearance and shape of that body; if a vehicle very different in appearance from what you are accustomed to see should be put upon the streets, people generally would criticise them for being queer.

One of the difficulties that must be faced in designing the mechanism to run the cab or carriage, is the spring-body. You must have a running gear fairly rigid and stationary to receive your machinery and at the same time make all allowances for the spring motion, which contributes to the comfort of the rider. The present carriages do not seem to follow any known laws of ordinary machines, where things are made rigid and fast. The electric vehicle is going through the same stage that the street cars did in times past.

The motors are placed upon the axle, two of them in the vehicles in use in New York, with the gear rigidly fixed upon the wheels. These wheels are not rigid with the axles, but are independent. The pinion upon the motor meshes with the gear which is attached to the wheel. The steering arrangement is applied to the rear wheels. The axle does not turn with the wheels, but the wheels are arranged upon separate spindles, which are hinged to the axle, which is rigid with the body attached to the springs. The wheels are moved by the steering mechanism, which swings both wheels like the rudder of a boat.

The batteries are placed within the cab, either from the front or rear, dependent upon the character of the vehicle, whether a brougham or hansom. These batteries when shoved into the vehicle make automatic contact, so that the operator has nothing to do except to put the door over the compartment. The motorman, or driver, as he is still called, has everything within hand's reach or foot reach. With his hands he operates the controlling lever for operating the switch beneath his seat; he also steers with his right hand. The braking is done with the foot. There is an emergency switch placed near his heel, by which the current can be cut off from the motors.

The batteries weigh between 1,300 and 1,500 lbs., but owing to the ingenious handling apparatus the batteries are picked up and carried around sideways, backward and forward, as if they had no weight at all. In street cars run by storage batteries, one of the early difficulties was to get the car to a position where you could put in the battery. The same thing occurred with the electric cab; but the difficulty has been overcome by a table which is split in two parts, and balanced below, so that the parts are free to move in either direction sideways. The cab enters and takes its position on any part of the table. Then levers forced by hydraulic cylinders on the sides come up and engage the hubs, and make the movement which forces the cab into position for removing or placing the battery-box. While this is going on, hydraulic

*Abstract of a paper prepared for the meeting of the New York Electrical Society, held on Feb. 14, at the station of the Electric Vehicle Co., New York City.

†Electrical Engineer, Electric Vehicle Co., 1684 Broadway, New York city.

jacks come up under the floor of the table to raise the carriage to the level of the table. Meanwhile, the batteries which have been charging on the tables in the charging room have been brought forward by a travelling crane. They are deposited on a chain conveyor which moves them over in front of the battery space of the cab. The exhausted battery is then removed and the fresh one shoved into place.

WEIGHT OF STEELWORK IN THE TOWERS AND END SPANS OF THE NEW EAST RIVER BRIDGE.

The steel towers and end spans of the New East River Bridge, the contract for which has been let to the New Jersey Steel & Iron Co., of Trenton, N. J., for $1,220,230, will require 24,450,800 lbs. of steel, according to the estimates of the engineers. The items going to make up this weight, for one side of the river, are as given in the accompanying table, which has been furnished us by the engineers:

was 7.12 per 1,000. In the Philippines typhold fever caused deaths equal to an annual rate of 5.16 per 1,000, or half those reported; this is not a climatic disease, and if excluded from the record, the remaining mortality is less than the corresponding mortality in the United States. Noting admissions to the hospitals, we find that malarial diseases in the Philippines exceed their prevalence in the United States, at military stations, as 370 to 96; and diarrhœal diseases, as 445 to 116, or about 4 to 1 in both instances. Diseases of the respiratory organs are less prevalent in Manila than in the United States. But in March, April and May, fevers are said to be more frequent than at other periods, and this cause may increase the above record.

A PAN-AMERICAN EXPOSITION FOR 1901, on the Niagara frontier, is the subject of a bill introduced into the United States Senate. The purpose is to illustrate the development of the Western Hemisphere by a display of the arts, industries, manufactures, and products of the soil, mines and sea. The bill calls for import free of duty of foreign exhibits; the creation of a government board of managers for national exhibits; and the erection of a building for these exhibits by the Treasury Department, to cost not more than $200,000; that medals be prepared at the U. S. Mint on payment of cost; and that the total expenditure of the Government, for building and expenses of exhibitions, shall not exceed $500,000. The exposition would be open from May to November, 1901, and it is claimed that satisfactory assurances have been already given for exhibits from Canada, Mexico, the Central and South American Republics, and most of the states of the United States. As stated in our issue of Feb. 16, a similar bill to appropriate $500,000 is now before the New York Legislature.

Table Showing Items and Amounts Going to Make Up Total Weight of Steel in Towers and End Spans of New East River Bridge, for One Side of the River.

	Plates, lbs.	Angles, lbs.	Beams, channels, pins & bolts, lbs.	Castings, lbs.	Total, lbs.
End Span: Cantilever span (one)	822,080	481,260	3,560	24,000	1,330,900
Connecting span (one)	369,340	259,750	.....	.....	629,090
Top lateral system	35,250	61,650	.....	.....	96,900
Bottom lateral system	39,820	126,600	.....	.....	166,420
Overhead trusses, etc.	350,370	246,030	.....	.....	569,400
Floor beam hangers	13,470	93,150	.....	.....	106,620
Floor system	938,400	1,033,800	363,200	.....	2,335,400
Total	2,568,730	2,302,240	366,760	24,000	5,261,730
Rivet heads					201,270
Total for End Span					5,463,000
Intermediate Tower: Columns	120,910	45,950	200	.....	167,060
Longitudinal bracing	36,680	41,900	.....	.....	78,580
Transverse bracing	46,260	54,240	.....	.....	100,500
Transverse bracing (center)	17,630	22,470	610	.....	40,710
9-in. girders	15,940	8,360	.....	.....	24,300
18-in. girders	78,150	20,070	.....	.....	98,220
Cover plates	4,770	.....	.....	.....	4,770
Diaphragms	5,080	5,680	.....	.....	10,760
Bearings	10,010	.....	18,820	.....	28,830
Pins	.....	.....	1,290	.....	1,290
Column bases, etc.	.....	.....	.....	79,900	79,900
Foundation	.....	.....	9,800	600	10,400
Total	335,430	198,670	30,720	80,500	645,320
Rivet heads					20,980
Total for Intermediate Tower					666,300
Main Tower: Saddles, etc.	95,560	.....	209,980	582,260	887,800
Girders at top	340,230	179,650	.....	.....	519,880
Trusses and girders	172,600	83,430	70	1,380	257,480
Main columns	2,246,890	425,550	.....	.....	2,672,440
Bracing	761,500	756,000	.....	.....	1,517,500
Total	3,616,780	1,444,640	210,050	583,640	5,855,100
Rivet heads					241,000
Total for Main Tower					6,096,100
Totals (one side of river)	6,520,940	3,945,540	607,530	688,140	11,762,150
Rivet heads					463,250
Grand total for whole of one side of river					12,225,400

These figures make the pound price of the metal work, including erection, about 4.99 cts. The details of this portion of the steel work of the bridge were published in Engineering News of Feb. 17, 1898.

THE COMMISSIONERS ON THE TOPOGRAPHICAL survey and map of Massachusetts, report as follows to date of Dec. 31, 1898: The Rhode Island boundary line has been fixed and permanently marked by stone monuments 12 ins. square and 9½ ft. long, carrying on their respective faces the inscriptions, "Mass.," "R. I.," and the date "1898." They cost $14.45 each. The New York boundary line has also been agreed upon and the northerly half is permanently marked in a similar manner. The Connecticut boundary is in bad condition, and is being examined with a view to monumenting; this latter work will cost $14,000, half the cost to be borne by each state. In connection with the town boundary surveys ordered, the Commission has been engaged in extending and completing the primary triangulation of the state; for this the field work is now complete. An appendix to the report contains the detailed report of the Chief Engineer, Mr. Henry B. Wood. The Commissioners are Messrs. Desmond FitzGerald, Alfred E. Burton and Frank W. Hodgdon.

HEALTH AND MORTALITY STATISTICS among our soldiers in the Philippine Islands, having been demanded from the Secretary of War by the U. S. Senate, Surgeon-General Geo. M. Sternberg reports as follows: Gen. Otis, on Feb. 2, 1899, reports that "9% of the command is reported sick, the great majority of the cases being slight ailments." The total death rate from July to October was 9.36 per 1,000, or slightly in excess of that in United States garrisons in time of peace; no deaths are reported from malarial diseases. The average annual death rate in the U. S. Army, in the decade 1886-1895,

THE LIST OF INDUSTRIAL EXPOSITIONS which are to be held during the next few years is a large one. During the present season Omaha is to repeat, and, if possible, eclipse her success of last year by holding a "Greater America" exposition. It is stated that the expenditures on its buildings and grounds already aggregate $2,000,000. Philadelphia's exposition is to be chiefly devoted to the display of manufactured products suited to the export trade, and is under the direction of the Philadelphia Commercial Museum. In 1900, nobody ventures to compete with the attractions which Paris will offer. For 1901, however, Buffalo and San Francisco have exposition enterprises under way. The first-named city has already raised a large amount of money, and is appealing to state and national treausuries for a million more. San Francisco has fixed on a name for its display, "The Pacific Ocean and International Exposition," but whether it has done more than this we cannot say. In 1902 Toledo proposes to celebrate the centennial of Ohio's admission to the Union, and is already raising funds in an enthusiastic fashion. St. Louis and New Orleans propose exhibitions for 1903, but have made no definite arrangements as yet. On the other side of the water, Glasgow is preparing for an exhibition in 1901, which will doubtless secure many of the exhibits that have been shown at Paris.

THE NEW YORK MEETING OF THE AMERICAN INSTITUTE OF MINING ENGINEERS.

The twenty-ninth annual meeting of the American Institute of Mining Engineers, held in New York city, Feb. 21 to 25, inclusive, was one of the most largely attended, and on the whole, one of the most interesting and successful meetings the Institute has held for some years. New York city is the best place for a meeting of any engineering society, if a large attendance is desired. The city and its suburbs, within a radius of 20 miles, contain the homes of a larger number of engineers than can be found in any whole state in the Union, with two or three exceptions; and the city is also a most attractive place to visit.

The usual object of the meeting of an engineering society is for the presentation and discussion of professional papers. The Institute is an exception to the rule. It receives more papers, probably, than any other engineering society, but most of them are of a class which are better adapted for printing in the "Transactions" as a permanent record of work accomplished, than for discussion in a meeting. The objects of the meeting, therefore, are for the members to get together socially, to attend receptions and to go on excursions of professional interest, and these objects were fulfilled in the recent meeting to the fullest degree.

The professional papers of the New York meeting were divided according to a circular issued to the members a few days before, into three classes, viz.: Papers Nos. 1 to 12, inclusive, which in pamphlet form were forwarded to the members a day or two before the meeting and which were to be "open to discussion;" Nos. 13 to 20, of which printed proofs were to be on hand at the meeting, but which actually were to the extent of 25 copies of each in the Secretary's room at the Murray Hill Hotel, and could be had on application; Nos. 21 to 41, of which it was said that it was probable that proof copies of some of them would be on hand, but in fact none of them were. The complete list of papers is as follows:

1. "Rich Patch Iron Tract—Virginia," by H. M. Chance.
2. "The Discovery of New Gold Districts," by H. M. Chance.
3. "A Description of the Semet-Solvay Plant By-Product Coke Oven at Ensley, Ala.," by W. H. Blauvelt.
4. "Corundum in Ontario," by A. Blue.
5. "Note on the Tuyeres in the Iron Blast Furnace," by J. M. Hartman.
6. "Tuyeres in the Iron Blast Furnace," by B. F. Fackenthal, Jr.
7. "The Possible Origin of the Pneumatic Process of Making Steel," by W. B. Phillips.
8. "Notes on the Operation of a Light Mineral Railroad," by James Douglas.
9. "The Platinum Deposits of the Tura River System, Ural Mountains, Russia," by C. W. Purington.
10. "Note on the Disintegration of an Alloy of Nickel and Aluminum," by Erwin S. Sperry.
11. The Analysis of Blast Furnace Gas while Blowing-In," by R. H. Sweetser.
12. Kytchtym Medal discussion.
13. "Results Obtained in the Past 15 Years with Stiff and Heavy Rail Sections," by P. H. Dudley.
14. Continued discussion of Kellar's paper on the "Elimination of Impurities from Copper Matte," etc.
15. "A Prospector's Density Rule," by Jas. Holms Pollok.
16. "A Geologic and Economic Survey of the Clay Deposits of the Lower Hudson River Valley," by Clemens C. Jones.
17. "The Occurrence, Origin and Chemical Composition of Chromite, with Special Reference to the North Carolina Deposits," by Joseph H. Pratt.
18. "The Abrasive Efficiency of Corundum," by Prof. W. H. Emerson.
19. "The Coking in Bee-Hive Ovens of the Coals of the New River District, West Virginia," by Charles Catlett.
20. "The Gold-Bearing Veins of Bag Bay, near Lake of the Woods," by Peter McKellar.
21. Presidential address by Charles Kirchoff.
22. "Improvements of the Spring Valley Coal Mines, Illinois," by J. A. Ede.
23. "Coal Cutting Machinery," by E. W. Parker.
24. "The Copper Queen Mine," by James Douglas.
25. "Modern Gold Mining in the Darien; Notes on the Reopening of the Espiritu Santo Mine at Cana," by Ernest R. Woakes.
26. "Order of the Formation of the Minerals in the Copper Veins at Ducktown," by J. F. Kemp.
27. Discussion of Scott's paper on the "Evolution of Mine-Surveying Instruments."
28. "The Patio Process at Guanapuato, Mexico," by Roberto Fernandez.
29. "The Liberty Bell Mine, Tulluride, Colo.," by Arthur Winslow.
30. "The Lay System of Hydraulic Placer Mining," by Otto A. Moses.
31. "The Longest Mine-Haulage," by F. Z. Schellenberg.
32. "Correspondence Schools," by R. P. Rothwell.
33. "The New Laboratories of the Department of Mining and Metallurgy," by John Bonsall Porter.
34. "Iron Ores of the Potsdam Formation in the Valley of Virginia," by Charles Catlett.
35. "Peculiar Crystal Forms of Gold," by George F. Kunz.
36. "The Elkhart Dressing Works at Chloride, Ariz.," by Geo. W. Maynard.
37. "The Geological Structure of the Rocky Mountains, within the Lewis and Clarke Timber Reserve, in Montana," by Robert Hollister Chapman.
38. Discussion of Scott's paper on the "Evolution of Mine-Surveying Instruments."
39. Biographical Notice of Oberberg-hauptmann, Dr. Albert L. Serlo, by Prof. Dr. Hermann Wedding.
40. "Mining Laboratory of Columbia University," by Henry S. Munroe.
41. "Metallurgical Laboratory," by Henry M. Howe.

Papers Nos. 5, 6, 7, 8, 11, and 12, were papers of the Buffalo meeting, which were delayed in printing.

At the first session, held on Tuesday evening in the hall of the American Society of Mechanical Engineers (by the way, why hasn't the Institute a hall of its own?), the Secretary, Dr. Raymond, said that all the papers would be "read by title," an easy way to get rid of them, but that a few of them would be read by their authors, chiefly those that required lantern slides for their proper presentation, and that if any member wished to debate any other one of the papers on the list, by giving notice to the Secretary it could be called up for discussion. No one, however, seemed to care to have any one of the printed papers taken out of its resting place in the Secretary's room to have a debate on it.

It was announced that the next meeting of the Institute would be held in San Francisco, probably early in October, on the invitation of the California State Miners' Association. The Canadian Institute of Mining Engineers will hold a meeting in British Columbia in September, so it may be convenient for some members of the Institute to attend both meetings.

The Secretary then read paper No. 39, which was a biological notice of the late Dr. Albert L. Serio, translated from the German.

Mr. James Douglas, the newly-elected President of the Institute, then presented his paper on "The Copper Queen Mine, Arizona." It was illustrated with a great number of excellent lantern slides, which gave the impression that Arizona may be a great place for copper mining, but very undesirable as a place of residence. The members of the Institute were invited to visit this mine and its surroundings while going to or returning from California next October.

Mr. E. E. Olcott then entertained the meeting with a number of lantern views of scenery, travel and mining operations in Peru, from Mollendo to the gold mines.

On Wednesday, sessions were held in the morning and afternoon in the large hall of the Havemeyer Building of Columbia University. Prof. H. S. Munroe, of the Department of Mining Engineering, made an address, in which he described the buildings of the University and their work. The engineering building is erected in harmony with the Fayerweather, Schermerhorn and Havemeyer buildings, but it still awaits "a donor and a name." Of the six new buildings on the University grounds, four are devoted to science.

The retiring President, Mr. Chas. W. Kirchoff, then gave his annual address, which was on the subject of reduction of costs in metallurgical processes during the last decade. In iron and steel manufacture these reductions have been most remarkable. The address, when printed, will be of great interest to students of economic statistics.

Mr. Otto A. Moses then read his paper on the "Lay System of Hydraulic Mining." It was illustrated by lantern views. The system has been worked in a small way in British Guiana, and consists in a method of using the same water over and over. Some discussion followed the reading of the paper. Dr. Henry M. Howe then read a paper on the "Work of a Metallurgical Laboratory." Lunch was served in the comfortable students' dining-room, and then parties were made up for exploration of the various buildings, laboratories, etc. At the afternoon session, Prof. J. F. Kemp, of Columbia University, gave an illustrated description of the zinc ore deposits at Stirling Hill and Franklin Furnace, N. J., which were to be visited by the members on Friday. It was illustrated by lantern slides, by a large plaster model, and by specimens of the ores. Professor Munroe then described the mining laboratory at the University, and he was followed by Mr. R. H. Chapman's paper on "The Geological Structure of the Rocky Mountains within the Lewis and Clarke Timber Reserve in Mointana." In the evening a reception and dance were held at Sherry's which was largely attended, and was one of the finest social affairs in the Institute's history.

On Thursday morning a session was held at the hall of the Mechanical Engineers' Society, for the reading and discussion of papers. The first paper presented was the printed discussion on the Kytchtym Medal, which medal had been exhibited at the Atlantic City meeting, a year ago, as a wonderful specimen of Russian cast-iron work. At the Buffalo meeting one of the finely engraved badges presented to the members at that meeting was used as a pattern by Mr. O. S. Garretson, a Buffalo iron founder, and castings were made from it, using "American-Scotch" iron, which were fully as fine in detail as the Russian casting. The secret of making such fine castings is in using very fine sifted sand. The paper contained a letter from Mr. N. Poulsen, of the Hecla Iron Works, Brooklyn, N. Y., which gave an account of the experiments leading to the making of fine castings by the firm of Poulsen & Eger about 20 years ago, which were quite as fine as those made at Ilsenburg, in Germany, which were considered finer in detail than the Russian castings. The remarkable castings made some years ago by Mr. A. E. Outerbridge, of Philadelphia, by pouring iron over carbonized lace, were also referred to and illustrated in the paper.

The next paper, which was read in abstract by the Secretary, was "The Coking in Bee-Hive Ovens of the Coals of the New River District, W. Va.," by Charles Castlett. The paper discussed the very poor coking practice of the district. Coals which by analysis should give 75% of coke giving actually from 55% to 60%. Experiments on the suppression of leakage and the diminution of the air supply led to an increased production of 4%, and this can probably be improved upon when ovens are built with reference to this particular coal.

The last paper of the session was Mr. P. H. Dudley's paper on "Important Results Obtained in the Past Fifteen Years with the Stiff and Heavy Rail Sections." We print this paper elsewhere in this issue. A long and interesting discussion followed the reading of the paper, and the great benefit to the railways of Mr. Dudley's researches with his dynagraph car and other instruments, which have led to his designing of heavy rail sections, was referred to by more than one speaker.

The afternoon of Thursday was left free for excursions to various manufacturing establishments and other points of interest. On a special invitation about 40 of the members visited the copper refining works of the Nichols Chemical Co., at Laurel Hill, Long Island, near Brooklyn. After a trip through the chemical laboratory, the visitors were conducted to a dining room, where a most elaborate lunch with champagne accompaniment was served. During the speeches which followed the lunch it was stated that the works had grown so fast during the past few years that it now had the largest electrolytic copper refining plant in the world. This raised the hopes of the visitors to a high pitch. Said they: "We are going to see one of the big things of the world, and best of all an electrolytic copper refinery, a thing that we have read about but have never seen," but they were doomed to disappointment. They were shown the Bessemer converters for refining matte, a vertical circular roasting furnace, patented by Mr. J. B. Herreshoff, manager of the works, blue-prints of the furnace being freely distributed, and several other interesting furnaces, but when the question was asked, "Are we going to see the electrolytic refinery?" the mild but firm answer was given, "No, that is never shown to visitors." Their disappointment was lessened and their curiosity was satisfied, however, two days later, at the works of the Guggenheim Smelting Co., where a large elctrolytic copper refinery was shown to the visitors. The mystery still remaining in the minds of the engineers, after seeing the Guggenheim works, is what can there be in an electrolytic refinery that is worth keeping secret? It is nothing but a series of large electroplating baths, with cast slabs of impure copper for anodes and refined copper for cathodes. The process is very clearly described, with illustrations, in Schnabel's Metallurgy, Vol. I., pp. 260-274. The condition of success of such a refinery does not consist in keeping secret any part of the process, but only in getting a good location for the works, abundance of capital, and good management. Late in the afternoon a reception was given to the members at the residence of Mr. and Mrs. Abram S. Hewitt. In the evening a session was held at the hall of the Mechanical Engineers. Mr. E. W. Parker, of the U. S. Geological Survey, Washington, D. C., read a paper on "Coal Cutting Machinery." It was fully illustrated by lantern slides, and traced the development of the several kinds of coal cutters since the first practical cutter-bar machine was made, in 1876, down to the present time. A brief discussion followed. The election of officers for the coming year by letter-ballot was then announced as follows: President, James Douglas, New York; Vice-Presidents, E. C. Potter, Chicago; G. F. Kunz, New York; W. N. Page, Ansted, W. Va. Managers, Arthur Winslow, St. Louis; W. Glenn, Baltimore; W. J. Taylor, Bound Brook, N. J. Theodore D. Rand was re-elected treasurer and Dr. R. W. Raymond, secretary.

Mr. Douglas in a few words thanked the members of the Institute for the honor conferred on him. After the usual resolution of thanks to the local committee and others, the meeting adjourned till the October meeting, to be held in San Francisco. Two days of excursions, however, followed the adjournment on Thursday evening. The whole of Friday was taken up in an excursion to Franklin Furnace, N. J., to visit the mines and concentrating works of the New Jersey Zinc Co. Four cars were filled with the party. The weather was fine, the lunch was excellent, and the trips through the concentrator and down into the mine were full of interest. The following description of what was seen is taken from the programme:

The mines, located in Sussex County, N. J., have no parallel in other parts of the world. The ore deposits consist of folded beds in crystalline white limestone. The ore is an intimate mixture of Franklinite and Willemite, with small amounts of Zincite, Garnet, Fowlerite, Tephroite, etc. The deposit has long been renowned as a field for the mineral collector, a large variety of minerals being found here, some of them unique to the section. There are two deposits about two miles apart, one located at Franklin Furnace, and the other at Ogdensburg, N. J. At present, work is being carried on only at Franklin Furnace. The southern end of this deposit is being mined by stripping and open cut work. The limestone is being removed to a depth of 100 ft. An exceptional opportunity is given here to view the nature and extent of the ore body.

In all, the deposit has been explored for a length of about 3,500 ft., the ore body varying in thickness from 25 to 200 ft. The eastern end of the ore bed cropping to the surface has been mined in places to a depth of some 600 ft. on the incline, but work is not being carried on here at present. The northern end is developed by a vertical three-compartment shaft sunk to a depth of 1,000 ft. The mine is drained by two duplex triple expansion Worthington pumps, one located at the 600, and one at the 1,000 ft. level, each having a capacity of 1,000 gallons per minute.

The concentrating plant, which is located at this shaft, presents many features of interest. The ore is raised from the mine, crushed to ½-in. and dried by means of an Edison Tower Dryer. It is then crushed to 10 mesh and sized into five sizes by means of Edison Tower Screens. Each size is run separately over a magnetic concentrator of the Wetherill type. These machines utilize the Wetherill process of separating ores of very slight magnetic attractability, in fact, such ores which previous to the invention of this process were considered incapable of magnetic concentration. Over each feed belt on these machines there are six magnets, which divide the product into different classes, depending on the magnetic attractability of the material removed. Three products are obtained: 1. Franklinite, from which Oxide of Zinc and Spiegel-eisen are produced. 2. Middlings, which consist of a mixture of Manganese and Iron Silicates, as well as some proportions of the Willemite which has particles of the Franklinite or other magnetic material attached to it. This material is used for production of Oxide of Zinc only. 3. A mixture of Willemite, Red Oxide of Zinc and Calcite, practically free from Iron and Manganese. This product, constituting the tails from the magnetic separator, is passed over jigs which remove the Calcite, leaving practically clean Willemite and Red Oxide of Zinc. This product is used in the Spelter furnace. Almost chemically pure metal is obtained from it, as it contains no lead, cadmium or other materials, which commonly contaminate Spelter.

The concentrating plant has a capacity of about 350 to 400 tons per day of 24 hours. A new concentrating plant is now in process of erection, which will handle 1,000 tons of ore in 10 hours. The foundations for this building have been completed, and some of the crushing machinery, which will be on the Edison principle, is in course of erection. The Edison scheme of crushing does away entirely with the jaw-breaker, handling the material from the beginning with rolls.

On Saturday, visits were made to the smelting works and refinery of the New Jersey Zinc Co. and to the Wetherill Separating Works, both at Newark, N. J., and to the Guggenheim Smelting Works at Perth Amboy, N. J. At all of these works every department was thrown open, and full explanations were given of the processes employed. At the Wetherill Separating Works the process of separating Monazite from its ore was shown. In the first pass a current of 7 amperes removes monaconite and rutile from the ore, the second and third pass, the latter with 25 amperes, removes monaconite and garnet, and the fourth, with 35 amperes, removes the monazite, containing 3 or 4% of thorium, which is used in making the mantles for Welsbach lamps. The tailings from the last pass contain a great variety of impurities.

At the Guggenheim works, one of the most interesting things seen, in addition to the electrolytic copper refinery, was the electrolytic separation of gold from silver by the Moebius process. The ingot of bullion is enclosed in a canvas bag and placed as an anode in a bath of nitrate of silver. The cathode is a silver plate, upon which the silver is deposited in the form of tree-like crystals, which are continually brushed off by wooden rods, moved by machinery, so as to prevent their accumulation on the plate which would cause short circuiting. The gold remains in the anode in the bag in the form of a black powder.

We give below brief abstracts of two of the papers presented at the meeting:

The Rich Patch Iron Tract, Virginia.

By H. M. Chance, of Philadelphia, Pa.

This paper describes the results of an examination of a tract of about 9,000 acres located about three miles west of Lowmoor, Allegheny county, Va., on the Chesapeake & Ohio Ry. It contains two distinct beds of Oriskany brown hematite ore, but mining has been confined to the lower bed. The ore contains practically no sulphur and ordinarily below 0.03% of phosphorus. The iron ranges from 42 to 55%, averaging, 47 to 49%. With careful preparation it may be raised to 50%, and the silica kept down to possibly 11 to 14%, although under the present methods of preparation it has ranged from 15 to 19%. The Buena Vista furnace when run exclusively on this ore produced a ton of pig iron with an average consumption of 2.19 tons of ore. The ore of the lower bed is found in a regular synclinal trough, the bed having an average thickness of 35 to 40 ft. The quantity of ore in the two beds is enormous. One range, estimated conservatively at 20 ft. thick, extends east and west about 6½ miles, or 32,000 ft., with not less than 500 ft. on the slope above water level. Another range is 30,000 ft. long, 300 ft. deep, and 30 ft. in average thickness, and a third range is estimated at 20,000 ft. long, 500 ft. deep and 300 ft. thick.

The Discovery of New Gold Districts.

By H. M. Chance.

The opening paragraph of this paper is as follows:

The recent discoveries of important new gold-districts in limestone, granite, sandstone and porphyry have awakened the more intelligent class of prospectors to a realization of the fact that any rock may be gold-bearing; that from the appearance of a rock it is impossible to judge whether it carries gold or not; and that gold-ores may occur in any geological formation.

The author discusses the frequent accidental discoveries of gold in unexpected locations by others than professional prospectors. The old methods of judging whether any formation may contain gold are now considered insufficient and it is becoming the rule to "assay everything." Gold has even been found in coal to the extent of from $1 to $5 per ton, and in coke made from the same coal to an average of $2 per ton, an amount, however, which is not sufficient to justify a separate treatment for gold extraction.

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