ENGINEERING NEWS
AND
AMERICAN RAILWAY JOURNAL.

VOL. XL. No. 19.

TABLE OF CONTENTS.

TWO ELABORATE RAILWAY TRAINS for the Chicago and California service were on exhibition at Chicago last week. The "California Limited" of the Atchison, Topeka & Santa Fe Ry. consists of a baggage car (without front platform), buffet smoking car, dining car, sleeping cars, and observation car, the latter having a library, writing desks, etc. The specially interesting feature of the train is that it is lighted throughout by electricity, and has little electric reading lamps with frosted glass globes, set just above the backs of the seats. The current is generated for each car by a dynamo driven from one of the axles, a storage battery supplying the current when the car is at rest. This equipment is on the Moskowitz system (Eng. News, Oct. 29, 1896, and May 27, 1897). It was applied by the National Electric Car Lighting Co., of New York and Chicago, which has equipped a number of dining and sleeping cars of this road with the same system. On Nov. 4 the new "California Limited" of the Chicago & Alton, Iron Mountain and Southern Pacific railways made a trip to Joliet and back, with a number of invited guests representing the railways and the technical press. At Joliet a visit was made to the State Penitentiary. This train is very similar to that of the Santa Fe line, but is lighted by Pintsch gas and has compartment sleeping cars in addition to the ordinary sleeping cars.

THE EIGHT-TRACK DRAWBRIDGE over the Chicago Drainage Canal, which has already been the source of much friction and litigation, as noted in our issue of Oct. 20, is again to be made the subject for new bids. As the appeal to the higher courts from the recent adverse decision will consume a great deal of time, and as another adverse decision would cause serious delay, the trustees have decided to invite new bids, but only upon the Scherzer type of bridge, according to the plans and specifications now on file with the chief engineer. This will avoid the trouble arising from comparing bids on structures of different types.

A CIVIL SERVICE EXAMINATION will be held on Dec. 6, at 9 a. m., in New York and other cities where there is a local board of United States civil service examiners, to fill two vacancies in the grade of electrical engineer. One of these is at Fort Caswell, Wilmington, N. C., salary $75 per month, and the other is in the Engineer Department at Large at New York city, salary $150 per month. Those desiring to enter the competition should apply at once to the United States Civil Service Commission, Washington, D. C., for application blanks, Forms 304, 375 and 394.

THE NEW NAVAL DRY-DOCK, soon to be built by the government at Boston, Mass., will have the following dimensions, according to a published interview with officials of the Navy Department: Length, 750 ft.; width on floor, 80 ft.; width at top, 114 ft.; width at entrance, 95 ft.; depth to floor, 40 ft.; depth on sill, 30 ft. It will be built of granite, or concrete faced with granite. The steel caisson-gate will be about 95 ft. long, 36 ft. deep and 24 ft. beam. The pumping plant will include three 45-in. centrifugal pumps. If built entirely of granite, about 576,000 cu. ft. of cut stone and 1,390,000 cu. ft. of rubble masonry will be required; if concrete faced with granite, the quantities would be about 256,000 cu. ft. cut granite and 1,710,000 cu. ft. of concrete. Bids are to be called for in a few weeks.

FLOATING A BOW-LESS STEAMER is a feat lately performed by the Liverpool Salvage Co. The steamer "Milwaukee," a cattle carrier of large dimensions, went on the rocks off the Aberdeenshire coast of England last September. It was found that the forepart was held immovable on the rocks, and the salvage company then determined to cut the hull in two, forward of the boiler-room bulkhead, and save the more valuable part of the ship. This was done by the aid of dynamite; and after the bulkhead had been strengthened by planks and bracing the after two-thirds of the hull, with engines and boilers, was towed into the Tyne, where a new bow will be built to the "Milwaukee."

JAPANESE SHIPBUILDING is being rapidly developed. The Mitsu Bishi Co., of Nagasaki, has just launched the largest steamship built outside of American or European yards. This is the "Hitachi Maru," with 11,680 tons displacement, and a sister ship is being built. At the same port a new granite dock, 371 ft. long, has just been opened. The shipbuilding company mentioned employs 2,000 men, and the "Hitachi Maru" is rated at Lloyds at 100 A1.

THE MOST SERIOUS RAILWAY ACCIDENT of the week occurred on Nov. 5, at the transfer junction in Council Bluffs, Neb., in which a Union Pacific freight ran, head on, diagonally into the Omaha and St. Louis passenger train. The freight engine struck the tender and baggage car, in which were several men. One person was killed and two were seriously injured.

THE DEATH OF A LOCOMOTIVE ENGINEER while on duty occurred on the Chicago & Alton R. R. on Nov. 8 near Kansas City, Mo. The train, a fast freight, was running at full speed when the fireman, who had been busy in the tender, entered the cab and found the engineer dead.

THE FALL OF A MINE CAGE at the mines of the Lehigh Valley Coal Co., Wilkes-barre, Pa., on Nov. 5, resulted in the death of 7 miners and the fatal injury of 3 others. The accident is said to have resulted from "overwinding," which caused a loaded car to drop upon another car containing 10 miners.

THE COLLAPSE OF A THEATER ROOF in Detroit, Mich., on Nov. 5, killed, according to reports, 15 persons. The building was in course of construction when, without any warning, the heavy roof, supported by steel trusses, fell. The top gallery was carried down and all those in the building at the time were buried under the mass of brick and iron.

AN EXPLOSION OF GAS in the United States Capitol at Washington, D. C., on Nov. 6, wrecked the Supreme Court room and several adjacent rooms, doing in all about $20,000 worth of damage to that portion of the building. First reports stated that a portion of the foundation of the building was badly damaged, and that the valuable law library was largely destroyed. It now appears that the destruction was limited to the interior of the rooms, furniture, fittings and a number of valuable records. The accident is attributed to a leaky gas meter, which permitted a large volume of gas to escape into the rooms composing the damaged section. In some way this was ignited and the explosion followed.

THE "CROATAN," a Clyde Line steamer, was burned at sea, on Nov. 1 while about 18 miles north of Cape Charles and 5 out of the 27 persons on board were drowned. The "Croatan" sailed on Oct. 31, south bound, and when 24 hours from port was discovered to be on fire. The flames spread so rapidly that, notwithstanding a smooth sea, it was impossible to launch the life boats, and the passengers and crew had to jump into the sea. They were rescued by a passing schooner.

THE INVESTIGATION OF THE CORNWALL BRIDGE failure on Sept. 6, in which two spans of the new New York & Ottawa R. R. bridge across the St. Lawrence River, at Cornwall, Ont., were precipitated into the water by the failure of the masonry pier between them (Eng. News, Sept. 15, 1898), has disclosed the cause of the accident, according to press dispatches. The diamond drill borings which are being made into the foundation bed of the collapsed pier have shown that the pier was founded on a bed of hard pan barely 2 ft. thick, below which was a muddy deposit into which the drill sank 14 ft. without striking hard bottom. Further borings are being made to determine the conditions more exactly.

AN UMBRELLA LIFT, for the Paris Exposition, is proposed by Mr. R. E. Sherman, of Chicago. It is to be a rival to the Ferris wheel already erected, and the design has been worked out by Mr. H. R. Hinchcliff, an engineer of Chicago. The plan calls for a steel structure 350 ft. high and 250 ft. in diameter when the "umbrella" is spread. There would be a central cylindrical framed stem, serving as a guide for a lower platform supporting ten braced ribs. At the ends of each rib would be a car with a capacity of 50 passengers. Steel cables run from the ends of the ribs to the top of the stem, and the hydraulic lifting power is applied from the moving platform at the bottom of the ribs. There would also be a rotary motion electrically controlled. Application for a site on the Champ de Mars is said to be under favorable consideration. The cars are supposed to make three trips per hour, with an average of 350 passengers per trip.

A SEWAGE FARM OR FILTRATION AREA for the St. Denis Ward of Montreal is under consideration. It is said that plans and a bid for the construction of the work have been submitted to the city authorities by Mr. C. Janin, C. E., and referred to the City Surveyor, Mr. P. W. St. George.

THE FIVE-YEAR GARBAGE CONTRACT at Chicago has again been declared illegal, this time by the State Supreme Court, on appeal by the city. The contract was for the removal and disposal of garbage. The city has been doing the work, pending the decision. Future action will depend, it is supposed, on the conclusions of a garbage commission, composed of the mayor, commissioner of public works and others. The ground for the decision is that the city cannot make a contract payable from yearly appropriations for a period of more than one year.

A MUNICIPAL LIGHTING PLANT is under consideration by the city of Santa Barbara, Cal. The local private company, which has had a monopoly for 12 years, formerly received $156 per lamp per year for about a 5-hour service on a moonlight schedule. The present rate is $108 per lamp per year for 60 lamps for the same service. It is proposed in the design of a municipal plant to use the city water supply, which comes from the mountain under a heavy pressure, to operate turbines and the necessary electrical apparatus.

ANOTHER THAMES TUNNEL, for foot passengers only, is to be built and the London City Council is asking for proposals. The tunnel would have a vertical shaft and stairway at each end and cross between the Poplar and Greenwich sides of the river.

COMMERCIAL EDUCATION was recently discussed by the New York Chamber of Commerce, and it was generally admitted that present educational facilities for those contemplating a business career were inadequate. A special committee of five was appointed to prepare a plan for the establishment and development of a sounder system of education of this sort in the secondary and higher schools. It was pointed out that other nations, and especially Germany, are rapidly developing satisfactory systems of commercial training for young men and reaping marked benefits therefrom.

THE PACKING OF THE AMERICAN COTTON BALE is again causing trouble abroad, regardless of the repeated warning of American consuls on this head. Reports from Liverpool say that English companies are refusing to insure against loss from "wet and mud damage" due to loose and badly packed bales of American cotton. It is estimated that the claims arising from cotton thus damaged and delivered at Liverpool during the last season will aggregate $500,000. The English insurance companies sent an agent to the United States to investigate the cause, and the blame is placed partly upon the producer and partly upon the transportation companies. A closer and better woven covering is urged; but the chief requisite seems to be greater care in both packing and transport, and some decrease in the belief that foreign nations must take our cotton "any how." Indian and Egyptian cotton is an active competitor and the splendid condition in which cotton from these countries arrives in England is in very sharp contrast with our own.

ELECTRIC TRACTION ON NEW YORK STREET railways is rapidly growing. According to a late article in the "Street Railway Journal," nearly four-tenths of the entire Metropolitan system of lines was operated by electricity on Sept. 30, 1898. In the year ending June 30, 1898, about 34¼% of these lines employed cable traction, 20¼% underground electricity, and 45½% horse-power. Reducing the earnings and expenses to the mile basis the following comparison per car-mile is made:

	Gross earnings.	Total expenses.	Net earnings.
Cable lines, cts........	34.42	16.42	18.00
Electric lines, cts......	27.	10.25	16.75
Horse traction, cts......	27.35	17.87	9.50

While the electric lines thus show a less total expense for operation and maintenance than either cable or horse-car, the writer says that this statement may be somewhat misleading, owing to the fact that the electric lines are practically new, and cost for maintenance is only ⅛-ct. per car-mile, as compared with 3½ cts. on the cable lines and ¾-ct. on the horse-car lines. But the article also claims that the experience in New York demonstrates that the underground electric is better than cables in the large cities when traffic is dense and weather conditions favorable.

TWO RECENT MELAN ARCH BRIDGES.

The illustrations presented herewith show two Melan arch bridges erected for Mr. Frederick W. Vanderbilt on his private estate at Hyde-Park-on-the-Hudson, eight miles north of Poughkeepsie. They both cross Crum Elbow Creek, and while only 600 yds. apart, the scenery at the two locations required very different artistic treatment to harmonize the structures with their surroundings.

FIG. 1.—MELAN CONCRETE ARCH, WITH FIELD STONE FACING, ON GROUNDS OF FREDERICK W. VANDERBILT, HYDE-PARK-ON-HUDSON, N. Y.

Mr. Vanderbilt, after extended investigation, finally selected the Melan system of concrete-steel arch construction, not only on account of its lower cost with equal permanence as compared with voussoir stone arches, but also because of the ready adaptation of this style of construction to the varying architectural treatment required in different locations.

The structure shown in Fig. 1 with natural surroundings, was faced with unhewn field stone and boulders. It consists of two spans, 53 ft. and 26 ft. in the clear, respectively, and each 7.5 ft. rise, and is 17 ft. wide. The longer arch springs from the rock cliff to the pier and its concrete ring is 10 ins. thick at the crown, and 30 ins. near the springing line, and at right angles to the intrados, embedding five 7-in. steel I-beams bent to the curve of the arch. The shorter span springs from the pier to an abutment founded on a hard strata of gravel and clay. Its concrete ring is 8 ins. thick at the crown and 20 ins. near the springing lines, at right angles to the intrados, with five 5-in. steel I-beams, bent to the curve of the arch, embedded therein. The centers for this bridge were designed to suit the local circumstances.

The bridge shown in Fig. 2, being in a more improved part of the grounds, was given a more elaborate architectural treatment, all exposed surfaces being molded in Portland cement mortar. It has a clear span of 75 ft., with a rise of 14 ft. 8 ins., and a clear roadway of 16 ft., the total width of arch being 20 ft. The intrados is a curve of five centers. The wing walls on the four corners are curved outwards to give better approaches to the bridge and more easy and graceful connections with the driveways. The concrete arch ring is 15 ins. thick at the crown, increasing slowly towards the springing lines to a thickness of 21 ins. at a point 22.5 ft. from the center, and more rapidly from there to the abutments. Embedded in the arch ring are seven 9-in. steel I-beams characteristic of the Melan system, as shown in plan and sections.

One abutment is founded on solid rock, the other on reasonably hard strata of clay and gravel. The concrete in the abutments, spandrel and wing walls was proportioned 1 part Portland cement, 3 parts sand and 6 parts broken stone; near the springing lines of the arch the proportions were gradually changed to those used in the arch ring, which were 1 Portland cement, 2 sand and 4 broken stone. After the completion of the abutments the concreting of the arch was started simultaneously from both sides to the full width of the bridge, and work was continued day and night until the arch ring was completed and the spandrel walls carried up to the copings and expansion joints, in order to make the work monolithic and to avoid all signs of demarkation in connecting old with new concrete. Each of the four wing walls were then carried up as continuous work for the same reason, and expansion joints were provided between spandrel and wing walls to facilitate the free action of the arch under

FIG. 2.—MELAN CONCRETE ARCH, WITH MOLDED CONCRETE FINISH, ON F. W. VANDERBILT'S GROUNDS, HYDE-PARK-ON-HUDSON.

varying temperatures. The entire face finish is in concrete, as is also the balustrade. In all exposed faces, for a thickness of about 1¼-in., mortar was used without the broken stone, but in all cases deposited at the same time as the concrete backing. In order to get a very fine finish, the lagging of the centers and all molds for spandrel and wing walls were neatly covered on the inside with a thin coat of plaster, which was oiled before any concrete was deposited.

The centers for this bridge were constructed to rest on two old piers, which were afterwards removed. The base of the balustrades and the posts were molded in place, but the balusters and top rails were molded or cast in iron or wooden forms, and afterwards set in place exactly as would be done with cut stone. In all parts of the balustrades, concrete, 1 to 2½ to 5, was used, except near the faces where the mortar was without stone.

Mannheimer Portland cement was employed in the two-span bridge, and in the abutments of the single span bridge; and Germania Portland cement for all the remainder of the latter, including the railing. Both bridges were designed and superintended during erection by the Melan Arch Construction Co., 35 Nassau St., New York city, who are also the owners of the U. S. patents covering the Melan arch construction.

THE NEW HYDRAULICS: AN ESSAY FOR ADVANCED STUDENTS IN THE ART, AND FOR THOSE WHO LOOK BENEATH THE SURFACE.

By Clemens Herschel,* Hydraulic Engineer.

To the graduate student or practitioner in hydraulics of the present day, there has always been something disappointing in the art. Here is a science which pretends to give rules and formulae for the discharge of water through orifices and over weirs, when in truth it only indicates what these rules should be, and are not. Instead of being a science founded on fact, and deduced theory, as it set out to be, it has degenerated into a prolix schedule of coefficients to be applied in hydraulic cases as they are met with. So numerous have these coefficients become, that their great number has defeated their very purpose. It has been found impossible to match cases as they arise with their appurtenant coefficients, and engineers have been obliged to practically ignore the most of them, and, instead of using them, to confine themselves in their practice to a very few selected simple cases. Instead of practicing under the guidance of a science of hydraulics, the working hydraulician takes for his mentors only a few simple hydraulic experiments, and by repeating with slavish exactness the apparatus used in the experiments to be followed, he manages merely to allow nature to do for him what she did years before for another. Any step, therefore, that will do away with or merely will reduce the range of the multitude of coefficients now found recorded in hydraulic writings for the practice of hydraulics, will benefit that science very much.

Hydraulics, to look at the situation from another point of view, has not hitherto been able to free itself from the apron-strings of its older sis-

*2 Wall St., New York city, Oct. 5, 1898.

ter science of hydrostatics. Instead of noting the conditions obtaining strictly for the water in motion which is to be observed, and confining himself to them alone, the modern hydraulician still encumbers his work with measurements based on, or derived from, a water level which belongs in the domain of the hydrostatics of the case in hand, rather than in that of its hydraulics. Such cases are the measurement of the head on a weir, by measuring from the level of still water upstream

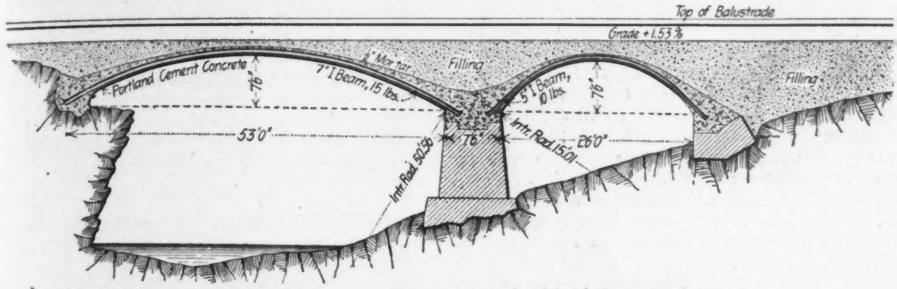


FIG. 3.—LONGITUDINAL SECTION OF TWO-SPAN MELAN ARCH.

from the weir; and determining the head on an orifice, from the position of the orifice and the level of still water upstream from it. Inasmuch as this mode of procedure totally eliminates the form and shape of the weir or orifice—takes no account of the same whatever—the measurements thus taken being precisely the same for any and all kinds of weirs and orifices; and inasmuch as these different kinds of orifices do have, nevertheless, very different unit discharges, it becomes necessary to introduce a host of coefficients to cause this method of procedure to produce the numerous called for practical results.

But how would it be, were we in these cases to take measurements and observations which would themselves be influenced by the shapes of the orifices and by the velocity of the water passing through them? May we not hope, that the coefficients to be applied to formulae containing data thus obtained, would have a much smaller range and would be much reduced in number, to the

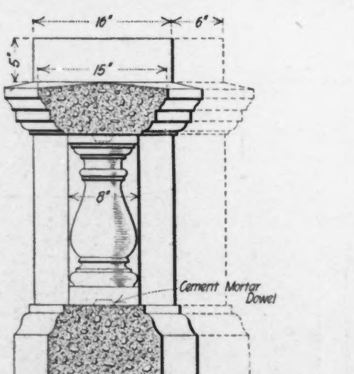


Fig. 5.—Detail Cross-Section of Balustrade for Single-Span Arch.

manifest benefit of the art and science now spoken of? This has indeed already been shown to be the result of such a method of obtaining data, as will presently appear.

A method of doing hydraulic work in the manner alluded to must be the next great step to take in the development of practical hydraulics, and there are many signs of the times, plain enough to those who will see them, that point in the stated direction.

Emboldened by what to-day's leading hydraulician, Inspector General H. Bazin, of the Corps des Ponts et Chaussees, says on this point, p. 240, Annales des Ponts et Chaussees, 1898, the writer may claim to have done pioneer work in that direction by the invention of the Venturi water meter in 1886. As many know, this is an instrument whose gaging of a stream of water is based on the observed difference of water level in two piezometers; in which, therefore, static water levels do not appear at all. And it is also known that the range of value of the appurtenant coefficients was found to be surprisingly small. The Venturi water meter has been so often described, that in place of a further description reference is here made to leading articles upon it.*

Another set of experiments made and founded upon the observation of hydraulic heads are those of Mr. John R. Freeman, on the discharge of nozzles,† unhappily named by the author to be experiments made for the purpose of converting the nozzle into a water meter. But a nozzle can never

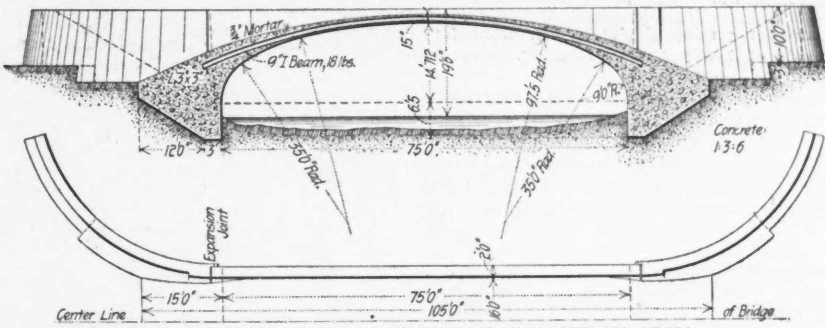


FIG. 4.—LONGITUDINAL SECTION OF SINGLE-SPAN MELAN ARCH.

become a water meter, properly speaking. The office of a nozzle is to discharge and waste or throw away water. The office of a water meter is to preserve the water measured, and to treat it as a thing of value. There must always be a large element of incongruity in any attempt to speak of a nozzle as though it were a meter, and much confusion of thought has no doubt followed Mr. Freeman's choice of title. But as an exhibit of the reduction of range, accompanied by an increase of accuracy, in hydraulic coefficients, when based on hydraulic, instead of on hydrostatic observations and measurements, and as a study of piezometer observations, Mr. Freeman's nozzle experiments are of great value.

A third series of such experiments have now been furnished by that Past Master in experimental hydraulics, Inspector General Bazin, in the last number of the Annales des Ponts et Chaussees, 2d trimestre, 1898, in the sixth article of the series describing his experiments on the discharge of weirs. By taking heights on the weir, as measured by means of a pressure tube laid in the body of the crest of the weir, and basing the formulae for the discharge of weirs on such hydraulic heights, instead of on heights derived from still water, which may be called hydrostatic heights, he gets again, as in the experiments above recited, a much smaller range of coefficients for his formulae. M. l'inspecteur general Bazin notes with pleasure that this method of observation and record gives more accurate results than the hydrostatic method, and is to be followed by preference.

Nothing is wanting, then, to enable engineers to use the method of hydraulic coefficients exclusively, except an advocacy and teaching of the practice, and a collection of the new coefficients, derived from experiment.

This article is intended to be an appeal, amongst other things, to engineers and others to begin the collection and publication of such new coefficients. Especially is this appeal addressed to the authorities having in charge the Cornell Hydraulic Laboratory. It has here an opportunity, in the writer's estimation, to practically found for all time a new science, and to make a most able beginning of the many benefits it may in good hands yet confer on mankind.

To illustrate still further the harvest waiting for future laborers in this field, attention may also be called to the conflict between the selected coefficients usually found, and the orifices, weirs, etc., met with in practice. The favorite coefficient is for an orifice or for a weir "in a thin plate"; and with reason; for no others can briefly be described. But the things to which such coefficients are to be applied persist in being almost anything else but holes or notches in "a thin plate."

The most of this contest would at once be done away with by the new hydraulics. It would be developed from experiments on orifices cut in the side walls of vessels of an appreciable thickness, and from choice, of a practical standard form, say a half circle in cross-section; but measuring heads from the indications of pressures at the crown of such a semi-circular edge and the hydraulic water level downstream; not from the static level upstream, to the static level downstream.

If these words shall induce future experimental hydraulicians to make a specialty of piezometric observations, and of their application to all forms of discharge measurements, their object will have been attained. That the results will be most useful and beneficial to succeeding generations is the writer's firm conviction.

*Trans. Am. Soc. C. E., 1887 and 1888; Engineering, March 9, 1894, and Aug. 14, 1896; Engineer, Jan. 4, 1895, and 1897, p. 210; Engineering News, June 15 and July 13, 1893; Annales des Ponts et Chaussees, 1898, p. 240; Journal fur Gasbeleuchtung (Schilling), vol. 40, 533; A Treatise on Hydraulics, by Mansfield Merriman, John Wiley & Sons, New York, 1895.

†Trans. Am. Soc. C. E., 1889, "The Hydraulics of Fire Streams;" and 1891, "The Nozzle as an Accurate Water Meter."

THE CAPTURED SPANISH CRUISER "MARIA Teresa," raised by the government at Santiago, was abandoned at sea, on Nov. 4, during a storm, while on her way to the United States. The "Maria Teresa" was a 7,000-ton armored cruiser, built at Bilboa, Spain, in 1890; her engines developed 13,758 I. HP., and this gave her a speed of 20.25 knots. After the battle of Santiago, she was raised by the Merritt-Chapman Wrecking Co., under the superintnedence of Naval Constructor Hobson. She was towed into Guantanamo harbor, and after being patched up, she started for Norfolk, Va., under her own steam, on Oct. 29. She was accompanied by the repair ship "Vulcan" and the wrecking tug "Merritt." On Nov. 1, when about 310 miles from the port from which she started, and in 24° N. Lat. and 74.30° W. Long., she encountered a heavy northeast gale and labored heavily; under the strain many new leaks appeared at the butts and seams of plates; the water gradually gained until it came into the firerooms, and the ship was finally abandoned in a sinking condition. The "Merritt" returned to hunt for her after the tow line parted, but could not find her. It is supposed that in addition to the damage to the hull by going on the rocks, the firece fire on board this vessel heated and warped the deck-beams, which later contracted again, and that this action imposed great strains upon the hull of the ship and possibly partly sheared some of the plate-rivets. If this were the case the subsequent leakage at these plates under the strain imposed by the storm would explain the disaster. Later accounts say that she may be still afloat, or stranded on Cat Island, as a vessel answering her description has been reported in that neighborhood.

STEEL HEAD FRAME FOR THE PHILADELPHIA & READING COAL & IRON CO.'S MINES AT GILBERTON, PA.

By W. L. Cowles, M. Am. Soc. C. E.*

Among the latest and most interesting examples of the rapid extension of the use of steel in construction is its employment in the erection of

Fig. 1. Perspective View of Steel Head Frame for the Philadelphia & Reading Coal and Iron Mines, at Gilberton, Pa.

head frames for mine shafts, which were formerly made of heavy timber framing. Several specimens of steel or iron head frames erected in earlier years are to be found in the coal regions of Eastern Pennsylvania, but within the past two years the development of this branch of structural engineering has been rapid, and a number of steel head frames have been erected in the vicinity of Wilkesbarre and Pottsville. The most recent practice in this line is exemplified in a steel head frame completed a short time since for the Philadelphia & Reading Coal & Iron Co. for their new water shaft at Gilberton, Pa., illustrations of which are presented here.

Plans had been prepared for erecting this structure in wood, but an investigation of its cost as compared with the cost of a steel structure, taking into consideration the relative life of wood and steel based upon experience in first-class railway bridge work, led the company to accept the proposed plan for a steel head frame. The superior rigidity of the steel frame, being riveted throughout, over the timber framing which, being bolted, is subject to continual readjustment and tightening up on account of shrinkage and racking, also had great weight in deciding the company to adopt the steel construction.

The Gilberton shaft is 1,100 ft. in depth and is divided into four compartments. It is located in a valley between two hills, in each of which are extensive collieries, and is intended to drain all the workings by means of tunnels connecting them with the bottom of the shaft, replacing a large number of independent pumps now operated continuously at great expense.

The two compartments nearest to the engines are used for hoisting water and are served by the engine nearest to the shaft, while the other two are ordinarily used for hoisting coal and rock, although in case of emergency they can also be used for water. The special arrangement of the shaft renders it necessary to place the sheaves serving the two front compartments, or those farthest from the engines, in front of and higher than the sheaves for the two rear compartments, and the engine operating the former must likewise be placed behind and higher than the engine operating the latter.

The center plane of the back brace produced passes through the centers of the two pairs of sheaves, which are so located that the line of resultant pressure produced by the load in the shaft and the pull from the engine falls slightly below this plane, thereby avoiding all overturning moment and throwing nearly all the pressure produced by hoisting directly upon the back brace. The main tower, therefore, carries practically no load except that resulting from its own weight and that of the sheaves and their frames, and its principal office is to provide a substantial and well-braced support for the sheave frames and sheaves and, by means of heavy cross struts, a secure and rigid connection for the tops of the shaft guides. The bracing is stiff throughout, consisting of four angles, laced, in I-section both for horizontal struts and diagonals, and all connections are riveted. The back brace is securely held and stiffened by struts running to the main tower and, together with the feet of the tower, is anchored to the heavy masonry foundation by 1½ in. steel bolts.

From the fact that in operating the shaft one car or bucket of a pair is filled, while the other is light, the back brace is nearly always unsymmetrically loaded, a condition which is provided for by a system of trussing at the top of the back brace, which efficiently distributes the stresses. The frequent reversal of load causes a constant racking of the structure which necessitates the use of heavy and rigid lateral bracing.

Provision is made for a working load of 20 tons in each compartment of the shaft and the engines have a capacity for raising these loads at a speed of 2,300 ft. per minute, the trip from bottom to top, therefore, lasting about half a minute. The rope is 2 ins. in diameter and is made of crucible steel wire. The sheaves are 14 ft. in diameter, with 10-in. journals, the bearings resting on horses inclined to the horizontal, so that the resultant of the live load is nearly normal to them. These horses are thoroughly braced and the frames of which they form a part are so placed that those supporting the lower sheaves are between and in contact with those supporting the upper sheaves and, being well bolted together,

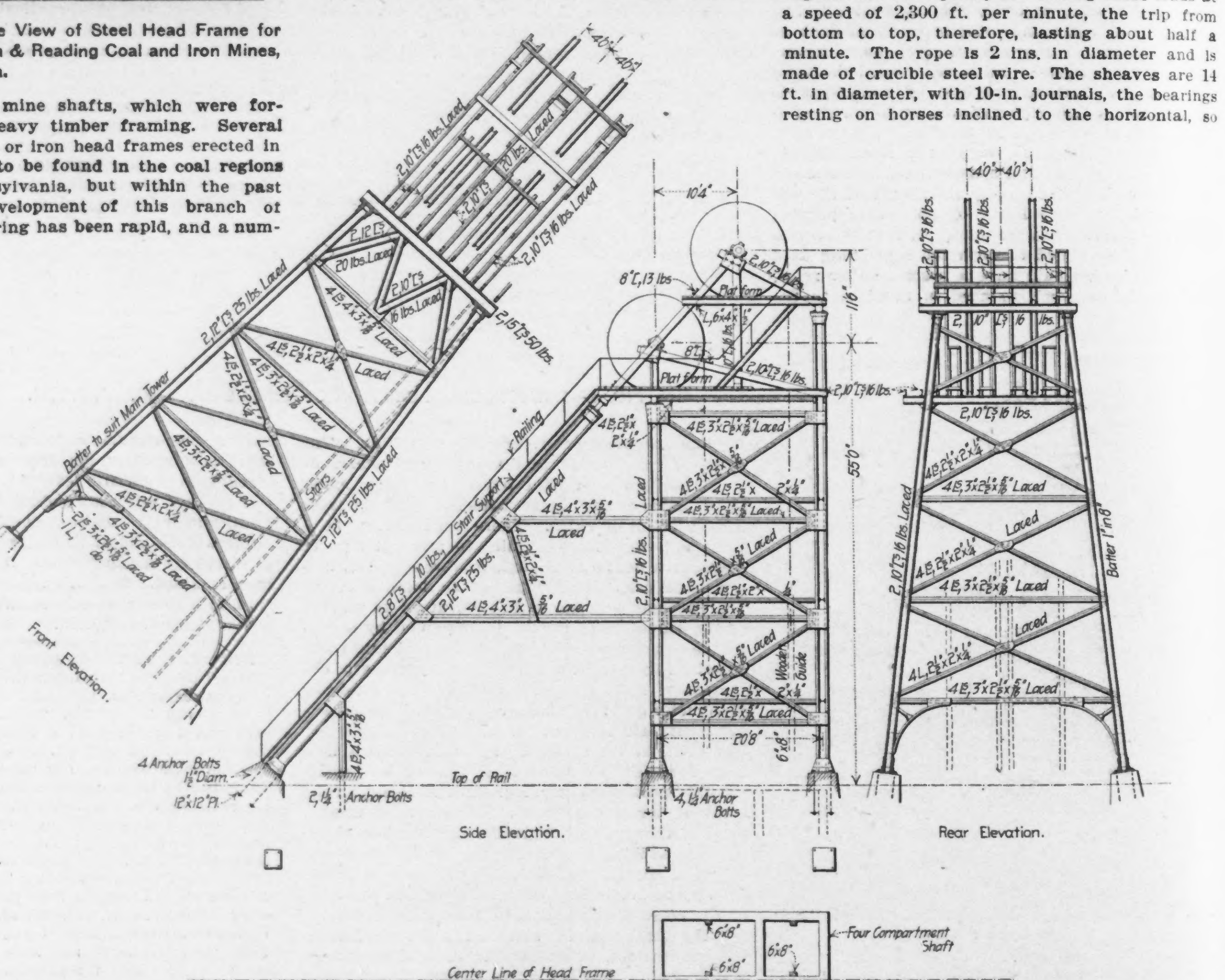


FIG. 2. ELEVATION OF STEEL HEAD FRAME FOR THE PHILADELPHIA & READING COAL AND IRON MINES, AT GILBERTON, PA.
Pottsville Iron & Steel Co., Builders.

*Keystone Bridge Co., Pittsburg, Pa., late Chief Engineer Pottsville Iron & Steel Co.

the construction becomes quite homogeneous, affording the maximum of rigidity. Access to the sheave platforms for purposes of oiling and inspection is provided by means of a stairway following the slope of the back brace, and consisting of channel iron strings with white pine treads and protected by a substantial gas-pipe railing.

The head frame was built by the Pottsville Iron & Steel Co. from drawings prepared by their head draftsman, J. S. Branne, C. E.,† after the designs of the writer, who was at the time chief engineer for the company.

AN ELECTRICAL SURVEY IN THE BOROUGH OF MANHATTAN.

It has heretofore been supposed that, inasmuch as New York city had been successful in preventing the building of electric railways operated by overhead trolleys on Manhattan Island, the water pipes, gas mains, etc., were free from the danger of rapid electrolytic corrosion.

In a paper just read before The American Institute of Electrical Engineers, however, the author shows that stray earth currents are to be found on the water and gas pipes in various parts of Manhattan Island, and in the part adjacent to the Harlem River and in the lower portion of the city these currents are sufficiently strong to furnish a possibility of serious injury to underground piping. The author of the paper, Mr. A. A. Knudson, began his investigations to determine whether any current from the conduit electric railway on Lenox Ave. was escaping from the conductors to the ground. It will be remembered that in this system the rails are not relied upon for a return conductor, but both positive and negative conductors are placed within the conduit and insulated. The tests showed that there was no ground current discernible from the conduit electric system; but that an overhead trolley railway in 135th St. was furnishing a very noticeable ground current, amounting in some cases to from 2 to 2¼ volts. In addition to this, a small but steady current flow was found with a potential of 1-30 to 7-30 volt, which was finally determined to proceed from an incandescent lighting system. This last current was found over a large area of the city.

As an illustration of the corrosive action of electric currents escaping from metal, the author gives the following:

Attention is now directed to the east side of this part of the city where another branch of the Union railway is located. Tests made here show even more pronounced results than at the branch running through 135th St. to the west side. It may be stated that the power-station of this road is located on the Bronx river in Westchester county.

Something more than a year ago when these tests were made, this branch had a terminus at Third Ave and 129th St., immediately in front of the Elevated Ry. station, the cars then passing over the Harlem river at the old wooden bridge, which is now being removed. The cars now pass over the public bridge recently opened, to the new terminal at Lexington Ave.

The maximum reading here was 10 volts, and the average 2 volts. The rails were positive to the elevated railroad pillars and to sewer and gas pipes. Tests on the Harlem bridge showed the same reading. A few days ago this locality was visited with a view of obtaining any further items which might be of interest for this paper, and workmen were found engaged in removing the rails of this very terminal.

Information was therefore obtained as to the results of electrolytic action on these rails (they having been positive). An impression was taken on paper of the exact size and shape of the end of one of the four rails which composed that terminal switch, the ends of the other rails all being in just about the same condition. Fig. 1 shows a comparison of the size and shape of the rail when new and its present condition; the position of the outlines as to each other being about as shown. From the condition of these rails now, it is quite plain that a large amount of metal has been removed from them by electrolysis. The rails were originally 70 lbs. per yd.; furthermore, the bottom sides of all these rails were cut by the current down to knife edges for several feet back from the ends. These edges were irregular in shape and somewhat jagged in appearance.

Another feature of interest is the condition of the cross-bars or tie-rods which keep the rails in position. These bars, which were originally 1½ ins. wide by ⅝-in. thick, were nearly all so eaten away that the middle portion was missing, the ends protruding from the rails from 6 ins. to 12 ins.

The concluding portion of Mr. Knudson's paper referred to the stray trolley current of which he

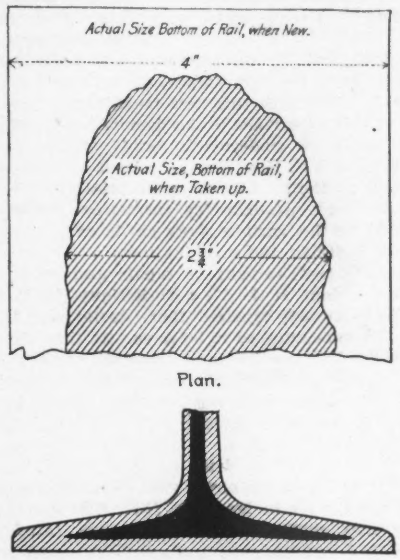


Fig. 1.—Plan and Section Showing Electrolytic Corrosion of Ends of Rails at Terminal of Union Ry. 3d Ave. and 129th St., New York city.

found evidences near the lower end of Manhattan Island, and his examinations to determine the effect which such a current might have on the Brooklyn Bridge. We print it, substantially in full as follows:

Just why there should be indications of a trolley current in this part of Manhattan Island was difficult to understand, but after making further tests coming up on the east side, this current was found to come from the Brooklyn bridge. Having pointed out how an overhead trolley, using the water pipes and incidentally the rails as a return, such as is operated on 135th St., can spread its influence, so to speak, for a distance of over 20 blocks in either direction north and south, through various pipes, railway structures, etc., the existence of this current from the bridge permeating underground metals through a large portion of the lower part of the city, is accounted for.

The tests were continued at the New York entrance of the bridge, and at the pillars which stand in the street just west of the Third Ave. cable railway, I found the readings as follows: At one pillar a maximum of 3 volts, average 1½ volts, pillar positive to Third Ave. cable rails. At another practically the same reading. Further up Park Row at the corner of Chambers St., pillar positive to cable rails, 1 volt maximum; water positive to cable rails ½-volt; pillar positive to water ¼-volt.

All of these tests were made nearly a year and a half ago. A few days ago, tests were made over this same ground, and at places where a difference of potential of 3 volts maximum existed at that time, it is now found to be 3 1-5 volts, pillars positive as before to rails of Third Ave. cable and also to water pipes, showing in all probability that this current has been during all this time actively and unceasingly passing down the pillars which support the "L" station at this place, as well as the bridge crossing the street, and out from their foundations to other metals as stated, with now a fifth of a volt more for good measure.

In the light of present knowledge on this subject the very serious question presents itself to any practical mind here present, in what condition would we expect to find the anchor bolts and iron foundations of these pillars, if excavations were made at their base?

In Mr. Farnham's excellent paper read before this Institute four years ago (Eng. News, May 3, 1894) he showed that but a small fraction of a volt was necessary to establish electrolytic action between metals. What then can be expected from an incessant action of from 1½ to 3 1-5 volts jumping out of these foundations during the past year and a half or perhaps two years?

Further tests at the New York entrance of the bridge at pillars nearest the four loop tracks, show that they are negative to rails of these tracks with maximum voltage of 3¼ and estimated average of 2¼. These tests were made on three different days at different times of the day, the highest maximum reading as above being taken at 4:45 p. m.

The other tests, one made during the so-called rush hour between 5:30 and 6 p. m., where a maximum reading of 2 1-5 volts noted at track 1, did not vary much from the tests made in the afternoon of another day at from 2 to 2:30 p. m. at track 4, where the voltage was found to be 2½ maximum. Previous to any use of electricity for operating cars on the bridge it had been known that current were escaping to that structure from trolley lines in Brooklyn, and passing over would find their way through the city by underground pipes, etc., and thence crossing the river arrive back to the power-station in Kent Ave.

The polarity of both of these railway systems now operated on the bridge, indicates that these currents escape from their lines, but it is also quite likely that currents are even now coming over the bridge as they were a year ago. Only an extended investigation would determine these points, even if it were desirable that they should be known.

Let us now take up the investigation made on the bridge to determine if possible the movements of straying trolley currents and their possible effect on the cable terminals. In view of the importance of this matter I regret not being able to make it more thorough than here stated, as it would involve not only a fortnight's work at least, but the shutting down of the bridge plant for a time, which could hardly be expected under the circumstances. Such facts are represented, however, as it was practicable to obtain.

In regard to the construction of the cable terminals; as most of us know, the main cables are made up of eighteen strands, or smaller cables, which are practically continuous, the wire running back and forth from New York to Brooklyn, passing through the holes at the ends of heavy steel bars or links at each place, and the ends of the single wire being finally fastened by a rigid screw coupling. These two rows of steel bars of nine each, which are attached to the cable strands, one row placed over the other, pass down with a graceful curve into solid stone masonry to the anchor-plates, and are secured to them by heavy steel bolts passing through the eyes at the ends. The anchor-plates are in shape somewhat longer one way than the other, each being a single piece of cast iron, weighing twenty-three tons.

Coming now to the tests, it will be noticed that there is no possibility of reaching the anchor-plates other than by connection through the cables themselves, and they being firmly attached to the structure, cables and all are practically one conductor; and a connection on the structure would mean connection with the cables, and consequently with the anchor-plates.

This point therefore being settled, the next thing was to obtain a suitable ground, and on the suggestion of Mr. C. B. Martin, the electrician of the bridge, one of the railway cables was used during that portion of the day when it was not in operation for hauling a bridge train. This was a convenient as well as a good ground, the cable surface being polished bright through friction in passing over the pulleys, it was possible to obtain a good contact, and as it passed over the large drums in the engine-room which were on foundations connecting with engines, water-pipes, etc., it was probably the best ground independent of the structure obtainable. The connection to the structure was made by the use of a 2-in. screw-clamp, the wire to the voltmeter being attached to it by the simple means of a screw and washer. Two of these clamps were generally used in nearly all of the previous tests, as they were found very convenient for attaching and detaching quickly to and from hydrants, pillars, etc. The first test under these conditions was made just over the Brooklyn anchorage, where the structure was found to be positive to the ground, with a difference of potential of 2¾ volts maximum, estimated average 1¾ volts.

At the Brooklyn tower another ground connection was made to a water-pipe, which ran down the side of the tower, and is intended for use in case of fire on the bridge. At this point the reading was 3¾ volts maximum, average 2¾, bridge structure was as before positive. At center of span, structure positive at first, with 2¼ volts maximum, but during the readings there were two reversals one of them only remaining long enough to obtain a reading, which was 1¼ volts maximum, structure negative. At the New York tower, structure positive to cable ground, with trolley variations ranging from ⅝ths to 3 volts, average 2 volts. At New York anchorage: maximum 2¾ volts, average 2 volts, structure positive to ground.

Other tests were made to determine the polarity of the rails of the bridge trains, and they were found positive to the structure, the same as the rails of the trolley road heretofore tested. Let us now consider the question of the electrolytical conditions of the cable anchorages, as this point appears to be of high importance in this matter, if not the key to the whole situation in determining whether or not electrolytic action is going on. First: These anchorages are composed of solid stone masonry and are put together with the highest quality of cement; there is no brickwork or mortar in their construction.

2. The 23 tons of iron composing the plates are set about 80 feet below the top of the anchorage. The distance from the bottom of the plates to mean high water is 3 ft. 8 ins. at the New York end, 5 ft. at the Brooklyn end; there is no earthly matter, salts or alkalies, such as is found prevalent in the streets which go to make up an electrolyte, so I am informed, in any part of this structure.

I was at first apprehensive that on account of the comparatively short distance between mean high water and the

†Now Chf. Eng. of Koken Iron Works, St. Louis, Mo.

plates at both anchorages there might be opportunity for salt water to reach the plates through seepage or capillary attraction and thereby produce such an electrolyte as to cause corrosion, but have been informed that it is not possible for salt water to reach these terminal plates on account of the distance from the river, the anchorages being over 900 ft. from the towers which stand at each side of the river. Even allowing 100 ft. for the salt water to work back, there is still ample margin as to distance before salt water can reach these plates.

In view of the tests therefore that have been made showing the structure and the cables to be positive at both ends, it is quite possible that a portion of the currents straying from the trolley lines, and possibly from the bridge service, find their way out of the anchor plates through the dampness of the stone-work of these anchorages. The construction of these anchorages, however, is such, as I have endeavored to set forth, that it seems reasonable from the general construction of these piers that the mass of stone and concrete surrounding these plates will not constitute an electrolyte such as would favor electrolysis, and thereby cause corrosive action on them.

The damages already done and threatened to public works in England by electrolysis has led to the establishment of regulations to prevent such action in the future, and similar legislation may be expected in this country should these conditions be allowed to continue. One of the provisions in the regulations prescribed by the British Board of Trade may be of interest just here. It is to the effect that if the pipe is negative to the rails the potential difference shall not exceed 4.5 volts, and if the pipe is positive to the rails the potential difference shall not exceed 1.5 volts. This appears to be very liberal for the railways, in view of the experience in cities on this side of the water; it is probable, however, they will be made more stringent as future experience in this direction dictates.

I have purposely avoided elaborating any particular scheme for preventing damage by stray railway currents in this paper, for the reason that methods are perfectly well known to railway companies for confining currents to their proper conductors, such as efficient bonding, and providing a return that will leave no inducement for the current to seek underground pipes, in preference to a legitimate conductor. It is simply a question of additional expense. Referring to the incandescent light current which was found prevailing everywhere in this part of the city from the Harlem river to the Battery, passing between all kinds of underground metals, and some on the surface, I do not consider these currents as particularly dangerous at the moment on account of their low voltage, but as before stated, it having been established that a fraction of a volt difference of potential will cause electrolytic action, it then comes down simply to a question of time, when those straying incandescent currents will have to be seriously considered.

In conclusion, I wish to say that these remarks regarding possible damage to public structures through the action of electrolysis, have been made with no desire on my part to appear as an alarmist, but to present simple facts as found in these investigations. I believe that too little attention has heretofore been paid to this matter by any of us; perhaps for the reason that electrolytic action being invisible, as well as noiseless, it has thus escaped attention, and its baneful effects not fully appreciated. It is my opinion, however, that ordinary caution would suggest that periodical tests should be made in every city by competent parties where a trolley road using a ground return is in operation, and the reports placed before those having authority to deal with the matter. In this way threatened damage by electrolysis to water and other pipes, as well as bridges, might be arrested and finally controlled.

ANNUAL REPORT OF THE BUREAU OF STEAM ENGINEERING, U. S. N.

The annual report of Commodore Melville, Chief of the Bureau of Steam Engineering, to the Secretary of the Navy, covers a period of most unusual activity, and the report shows that this bureau has well met the extraordinary emergency demands placed upon it.

Including the $430,613, alloted from the national defense fund, the appropriations for steam machinery in the last fiscal year aggregated $6,665,613; but of this amount only $1,922,054 had been actually expended up to Sept. 1, 1898. The work immediately necessary on the breaking out of the war was not so much extensive repairs to ships in commission as the fitting out of every available ship in ordinary, with the view of getting some service out of each in an emergency. In three of the old monitors at League Island worn-out boilers were replaced by new ones in 30 days, by the Babcock & Wilcox Co.; and this was done without cutting the decks, the boiler sections being passed through the smoke-pipe openings. The greatest amount of labor was expended in fitting out 110 vessels of the auxiliary navy, purchased, chartered or transferred to the government. Few of these vessels were provided with evaporators or distillers, and they all required outfits of stores and tools. After leaving the yards a number of these ships were partially disabled, as a result of the novelty of the machinery to the crews and the emergency of war which made it necessary to start them out before the men were familiar with this new machinery. One result of this experience is the demonstration of the importance of modernizing and stocking the naval station at Key West, the least accessible of all our stations. Liberal appropriations should also be made at once for correcting faults developed at the various navy-yards and stations, both in building and machine tools.

The greatest amount of repair and outfitting work was done at the New York Navy Yard; and of the 86 vessels repaired there during the fiscal year, 73 were handled in 90 days. At the Norfolk Navy Yard 72 vessels were repaired and fitted out in the year; of which 46 came within the 90-day limit. At Key West repairs were made to 64 vessels in the last year, and to 37 more in July of the present fiscal year.

The report deals in detail with the condition of the machinery of our naval vessels completed and authorized prior to March 2, 1883, and in nearly every case engines and boilers are rated as "good." A similar report of conditions and progress is given of vessels completed or building during the year ending Aug. 1, 1898.

Under the head of material it is noted that nickel-steel engine forgings have been brought to a high degree of perfection; and seamless drawn steel boiler tubes have been made of a degree of excellence undreamed of a few years ago. These seamless drawn steel tubes, with wrought steel flanges welded on, are now substituted for the copper and brass steam and feed pipes on destroyers and torpedo-boats. Owing to the temperature corresponding to the high pressures carried on these boats the copper and brass pipes formerly used lost a large percentage of their strength. The change in the machinery of the new battleships of the "Alabama" class, without hull changes, necessitates the reduction of the thickness of the shell plates for cylindrical boilers. In the "Alabama" class this thickness had reached 1 7-16 in. in material, having a tensile strength of over 65,000 lbs., an elastic limit of over 35,000 lbs. and an elongation of 24% in 8 ins. Experiments have been made on a higher carbon steel, oil-tempered and annealed, which has a tensile strength of over 74,000 lbs., an elastic limit of over 40,000 lbs., an elongation of over 21% and a very satisfactory cold-bending test. With the higher pressures called for in the new battleships this steel would allow a slight reduction in thickness. With this high-grade boiler plate, nickel-steel bracing and rivets will be used.

The use of water-tube boilers is increasing in all foreign navies, and the experience of the last year would warrant us in using boilers of this type in all our ships, says Commodore Melville. That contracts for the new battleships were awarded on the basis of cylindrical boilers is explained as follows: The Bureau designed and was anxious to use water tube boilers; but, as it was decided that these ships should be practically identical with the "Alabama" class, without change in hulls, the use of the water-tube boilers would have involved a readjustment of hull weights to maintain the trim. But in the Department circular of July 26, asking for designs for higher speeds and greater endurance, builders were encouraged to use the water-tube boilers, as the easiest way to secure the desired rsults. The bids received on Sept. 1 justify this idea and it is practically certain that the new type of boiler will be used, and all machinery will be of the most modern type. The present demand upon the naval engineer for great power on small weight, to secure the higher speed deemed necessary, practically rules out the cylindrical boiler, on account of its weight and its inability to carry the high pressure needed. The tactical importance of water-tube boilers was demonstrated by the conditions existing at Santiago previous to and upon July 3. It was necessary for a long period that all the ships should be ready to develop maximum power in a few minutes. With cylindrical boilers this involved keeping all the boilers under steam, with heavily banked fires and the attendant large consumption of coal. Proper water-tube boilers, admitting of the rapid raising of steam with safety, remove this difficulty and place the fighting machine under better control. Another great advantage is that water-tube boilers can be replaced, or practically rebuilt, without disturbing the decks.

The experiments with liquid fuel, on the torpedo-boat "Stiletto," were very satisfactory, though the economy over coal was not high, owing to the fact that the machinery was not specially adapted to oil fuel. The oil used had a specific gravity of 0.85 to 0.87, a flash point of about 315°F. and a burning point of about 350°F. As a bunch of burning waste was extinguished when plunged into this oil, there can be no doubt of its perfect safety for use on board ship.

Uniformity in machinery in naval vessels, as divided into classes, is an especially important feature; as it permits a reduction in the number of spare parts, facilitates repairs and enables a transfer of crew to another vessel of the same class, ready to at once get the best work out of familiar machinery.

The repair ship "Vulcan," fitted out during this war, did invaluable service. This ship arrived at Guantanamo on July 1, and by the end of August she had made repairs on 63 ships and had furnished supplies to 60 ships. The "Vulcan" was fitted with machine tools, cupola, forges, brass furnaces, etc., and carried a crew of 100 skilled mechanics. The usefulness of distilling ships was also proven in the war, though the two vessels thus equipped were not completed before active operations were over. It was shown that a multiple-effect evaporating machine could be made which would give 20 lbs. of fresh water for every pound of coal burned in the boilers; and such a vessel could supply 50,000 to 60,000 gallons of water per day and carry 3,000 tons of coal, supplying a large number of tank vessels and serving as a collier in case coal was more useful than water. The Bureau deems a distilling ship of vital necessity for a fleet of any size; and the cost of thus supplying fresh water is very much less than the purchase of water under any except the most favorable circumstances. Moreover, fresh water is absolutely necessary for the integrity of water-tube boilers.

The report deals briefly with the performance of the battleship "Oregon." Between March 6 and May 24 this ship steamed over 14,500 miles, stopping only for coal and not being delayed anywhere an hour through any derangement of the machinery. She stopped at Key West only for coal and at once joined the blockading fleet ready for service. While this is an unparalled record, the "Oregon" surpassed herself in the great battle of July 3. Always ready for service, she, on that day, speedily attained a power greater than that developed on her trial, and notwithstanding her greater displacement and foul bottom she reached a speed only slightly less than was then recorded. Had it not been for this wonderful speed, one, and possibly two of the Spanish ships might have escaped. Commodore Melville ascribes the credit for the performance partly to her builders, the Union Iron Works, for excellence of material and workmanship, but chiefly to the engineer department of the "Oregon" as organized and led by Chief Engineer Robert W. Milligan.

The performance of the two 1,000-ton gunboats, "Annapolis" and "Marietta," is also most favorably commented upon. Both of these ships have water-tube boilers, made by the Babcock & Wilcox Co., and both were commissioned in 1897 and have been over one year in service. The "Marietta" covered 13,000 miles at an average speed of 9.2 knots, and for several periods of about a week each the average was 10 knots. Yet, in both of these vessels the boilers are now in excellent condition and ready for any service; and at the end of her long voyage from the Pacific the "Marietta" only needed a few fire-brick, and the "Annapolis," after steaming thousands of miles, needed nothing.

The lessons of the war, for the steam engineering department are summed up as follows: The necessity of frequent tests under working conditions of the machinery of all vessels in reserve. All naval stations should be in positions of strategic value, and be properly fitted for repairs and provided with adequate quantities of non-perishable stores. Key West is such a station. Fresh water is almost as important as coal and distilling ships are a necessity. Every fleet should have a repair-ship. With more than two main engines, there should be three engines driving three screws, and not two main engines on each shaft. At Santiago the "New York" and "Brooklyn" had their forward engines disconnected on July 3 and could not stop to couple them. An accident to any part of either of the two engines on a shaft disables half the power; in the three-screw ship this fraction would be only one-third. There should be frequent trials under forced draft to keep the blowers in good condition and make the men familiar with working under maximum conditions. Until the day of the Santiago fight some of the ships had never been under forced draft since ther trial trips. The position of these blowers is important, and they should not be put in pockets or corners in the fire-rooms to make space for other equipment. In the "Cincinnati," temperatures as high as 205°F. were noted in the fire-rooms. The personnel must be regulated by the class of the ship, and there must be a reserve of trained men and officers; a war of long duration would have greatly embarrased the government owing to the difficulty of supplying the places of disabled or invalided men. Volunteers, however, well trained in other ways, can not replace the regular officers. Finally our fighting ships must have the highest practicable speed, and 18 knots is now recognized as a standard in battleship construction.

NOTES ON THE SEWERS AND PAVEMENTS OF DENVER, COLO.

By W. P. Hardesty.*

Both the sewers and pavements of Denver, Colo., are of comparatively recent construction. Nearly all of them have been put down under supervision of the Board of Public Works since the latter was organized in 1889.

The sewers are divided into three distinct classes, as follows:

I. Public Sewers.—Up to May, 1898, 61,129 lineal ft. have been laid, at a total cost of $520,020. Of this there are 17,766 ft. of vitrified sewer pipe 8 to 24 ins. diameter; 15,211 ft. of oval brick, 1 ft. 11 ins. x 2 ft. 10½ ins. to 3 ft. 6 ins. x 5 ft. 3 ins.; 13,805 ft. of circular brick, 24 to 58 ins., and 13,298 ft., 70 to 94 ins.; also 1,049 ft. of 24-in. cast-iron pipe.

II. District Sanitary Sewers.—Work has been done in 20 districts from 1880 to 1897. The total cost has been $1,687,709, and the cost per lot of 25 x 125 ft. varied from $14.80 to $73.61. There is a total length of 1,066,829 ft., or 202.04 miles, divided as follows:

Vitrified pipe.			
Size.	Length, ft.	Size.	Length, ft.
8-in.	775,956	18-in.	17,701
9-in.	102,164	20-in.	5,269
10-in.	25,237	21-in.	9,076
12-in.	72,723	22-in.	1,759
15-in.	43,301	24-in.	7,039
Total pipe			1,060,225
Brick.			
Oval.		Circular.	
23 x 34½ ins.	1,740	21 ins.	6
18 x 30 ins.	1,320	24 ins.	2,639
		30 ins.	1,169
Total	3,060		
		Total	3,544

There are 67,816 Y's and 3,821 manholes.

III. Storm Sewers.—There are 13 storm sewer districts in which work has been done from 1890 to 1896. There are 19,788 ft. of vitrified pipe 8 to 24 ins.; 2,521 ft. of oval brick sewer, 2 ft. 10 ins. x 4 ft. 3 ins. to 3 ft. x 4 ft. 6 ins.; 10,003 ft. of circular brick 26 to 54 ins. diameter, or 32,312 ft. in all. There are 53 "Y's," 140 manholes and 233 basins. The total cost has been $157,268.

The total length of the three classes of sewers is 223.97 miles. Some sewer construction was done in 1880, but nearly all of it has been done since the beginning of 1890.

The most interesting and most expensive piece of work per foot is the extension of the Delganey St. public sanitary sewer, 8,290 ft. long. It is 94 ins. in diameter for 2,380 ft. when it is bifurcated, a branch or spillway discharging into the Platte River near by. Here the diameter is reduced to 70 and 77 ins. to the end. The grade to the spillway is 0.10, then it is 0.05. The spillway or storm overflow is designed to take care of all the excess of storm waters that enter before it is reached. The storm area drained is 300 acres, from which the estimated maximum flow is 188.4 cu. ft. per sec.; the sanitary area is 10,585 acres and the expected flow is 128.9 cu. ft. per sec. The standard construction of this sewer is of three rings of brick. The storm overflow is 10 ft. wide and is semi-circular. The actual cost of construction of both was $148,628.18, including $9,687.90 for river protection.

*Progress Building, Salt Lake City, Utah.

Paving.—The first street paving was done in 1890. There was a bitter fight made against the use of asphalt, both by newspapers and parties directly interested, but it was adopted and has proven so satisfactory that nothing else has been used except for the wholesale and manufacturing districts; 2.298 miles of sandstone and 11.761 miles of asphalt had been laid up to May, 1898. The price for the former ranged from $3.47 to $2.39 per sq. yd., and for the latter from $3.23 to $2.595. Asphalt is laid 2½ ins. thick on a 6-in. concrete base, and sandstone in blocks 6 ins. deep on 1½ ins. of sand on 6 ins. of concrete. The streets are 80 ft. wide, leaving 48 ft. for the paving and the gutters. Of this the street car companies have to pave between their rails (3½-ft. gage) and for 2 ft. each side, making 15.8 ft. The average arching of the pavements from the gutters to the center is 6 ins. To obtain sufficient fall for the gutters in many parts of the city, they are raised or lowered so as to make the height of the curb vary all the way from 4 to 10 ins., at the same time reducing or increasing the crown of the pavement. Prices have gradually come down, and last spring 1⅓ miles of asphalt paving was let to the Colorado Paving Co. at $1.80, including grading. The Denver Paving Co. also took work of the same class at $1.93. On the new 14th St. viaduct 2 ins. of Alcatraz asphalt on 6 ins. of concrete is being laid at $1.45.

AMERICAN NAVAL ORDNANCE AND ARMOR IN THE LATE WAR.

Naval ordnance in the American-Spanish war is reported upon by Capt. Chas. O'Neill, U. S. N., Chief of the Naval Bureau of Ordnance. Contrary to current opinions but little war material for the navy was purchased abroad; a number of minor caliber guns and some ammunition for them and a few torpedoes covered the foreign supply; all else came from the United States. Nevertheless, batteries and ammunition were placed on 107 auxiliary vessels purchased or otherwise acquired, and these vessels mounted an aggregate of 576 guns. Besides these, two new gunboats and twelve new torpedo boats have been armed since January last, bringing the total up to 121 vessels supplied with munitions of war in the emergency.

The main batteries of the U. S. regular naval vessels now number 564 breech-loading rifles, and the secondary batteries of these ships carry 1,023 guns of less than 4-in. caliber. Since the date of the last annual report, 112 guns, of from 4 to 13-in. calibers have been completed at the naval gun factory; or, 16 4-in., 54 5-in., 29 6-in., one 12-in., and 12 13-in.; besides this two 8-in. and 33 6-in. guns were converted into quick-firing rifles. Under contract with private establishments 37 4-in. guns and mounts have been partly completed, and forgings have been ordered for five 8-in., 20 5-in. 26 4-in., and one 3-in. guns. New designs adopted for future guns of all calibers are calculated to insure a much greater muzzle-energy than is now obtained from guns of like caliber.

Guns, mounts and their appurtenances have been severely tested during the war, and their performance has been in general thoroughly satisfactory. Some minor defects in the mounts of guns of small caliber have been, or are being remedied.

As soon as the war became imminent orders were at once given for large quantities of powder, projectiles, fixed ammunition, small arms and small guns for secondary batteries, and these orders were promptly filled. It was proposed by Engineer-in-Chief Melville to utilize bicycle and other machine shops in rapidly building 75 torpedo boats; but this plan was abandoned when Admiral Dewey, in Manila Bay, proved that the Spanish fleets could be defeated without them.

The lessons of the war, as to guns and armor, are covered in the following statement of Capt. O'Neill: While heavy guns in turrets must be regarded as one of the chief characteristics of a battleship, the greatest execution, except against the heaviest armor, may be expected from a number of quick-firing guns of small caliber. The larger guns demand a greater sacrifice of space and weight, to accommodate them and their protection, and are slower and less accurate in fire. Turrets do not protect the hull; the space within them is limited, and so is the field of view from the sighting-hood; the heat in them is intense in warm climates; ventilation is imperfect and elaborate machinery is necessary to operate them. Notwithstanding these drawbacks, heavy guns in turrets are recognized as a necessity; but the question of the maximum caliber to be used in them is now demanding the serious consideration of the Bureau.

The 13-in. gun, of 60½ tons weight and 35 calibers long, has a muzzle velocity of 2,400-ft. seconds with smokeless powder, and a capacity to penetrate, with a capped-projectile, 19 ins of face-hardened armor at a distance of 2,500 yds. This gun has been heretofore considered as the best type of heavy turret gun for our first-class battleships, and all, excepting the "Iowa," with her 12-in. guns, were so equipped. The development of the 12-in., however, has been so great and its power has been so much increased that the Bureau now recommends it as the maximum caliber to be installed on future battleships; and it proposes to supplement these 12-in. guns by a battery of 6-in. quick-firing guns in casements, and with a secondary battery of 6-pdr. and 12-pdr. guns. The present 12-in. gun weighs only 7½ tons less than the present 13-in. gun; but the reduction in size and weight of the turrets, barbettes and ammunition is very great. As to armor, the Bureau believes that 12 ins. is sufficient in view of the recent improvements in manufacture, and the necessity of distributing protection over a greater area than was formerly the practice.

Smokeless powder, made by the Bureau's formula from soluble nitro-cellulose, dissolved in ether alcohol, is successfully made and proven to be uniform in character and to possess good keeping qualities. This powder could have been furnished in considerable quantities during the war; but, owing to lack of time, it was impracticable to furnish complete outfits of this ammunition, and a few guns using brown powder would have nullified the advantages gained by using smokeless powder in other guns. Considerable quantities of smokeless powder are now provided, and hereafter all naval vessels will be supplied exclusively with this powder, excepting only a certain number of brown powder charges for practice work. This will use up the cheaper brown powder on hand. The government is now building a smokeless powder factory at Indian Head.

As showing the amount of work speedily accomplished by the Ordnance Bureau, we find that at the New York Navy Yard alone, 48 vessels were surveyed, transformed for war service, fitted with batteries, ammunition and ordnance outfits; and the guns, ammunition and outfits for 41 of these vessels were prepared and shipped in the ten weeks between April 15 and July 1, 1898. Freight trains loaded with ammunition were rushed to San Francisco and to Tampa on passenger train schedules.

TORPEDO BOAT DESTROYERS OF 35 KNOTS SPEED are being built by the Parsons Steam Turbine Co., of Wallsend-on-Tyne, England. One of these is for England and the other for a foreign country. These destroyers will be twice the length and six times the weight of the original "Turbinia," and there are reasonable expectations of attaining a speed of 40 knots. The advantages claimed for the turbine-type of destroyer, aside from great speed, are economy in coal consumption, which was 15% in the "Turbinia," traveling at ordinary rates; a great saving in engine space and weight; the absence of vibration; and the absolute command over the engine, as the "Turbinia" could be brought to a standstill in 40 seconds, and she could be quickly turned and handled while going at full speed.

ENGINEERING NEWS
AND
AMERICAN RAILWAY JOURNAL.

Entered at the New York Post-Office as Second-Class Matter.
Published every Thursday
at St. Paul Building, 220 Broadway, New York, by
THE ENGINEERING NEWS PUBLISHING COMPANY

GEO. H. FROST, ... PRESIDENT
D. McN. STAUFFER, ... VICE-PRESIDENT
CHARLES WHITING BAKER, SECRETARY AND MANAGING EDITOR.
F. P. BURT, . . . TREASURER AND BUSINESS MANAGER

WM. KENT, E. E. R. TRATMAN, M. N. BAKER, CHAS. S. HILL, J. J. SWANN, } ASSOCIATE EDITORS.

A. B. GILBERT. . . . . . ASSISTANT MANAGER

CHAS. W. REINHARDT, ... CHIEF DRAFTSMAN.

ALFRED E. KORNFELD, New York, F. A. PECKHAM, Chicago, S. B. READ, Boston, } ADVERTISING REPRESENTATIVES

PUBLICATION OFFICE, 220 BROADWAY, NEW YORK.
CHICAGO OFFICE, 1636 MONADNOCK BLOCK.
BOSTON OFFICE, 299 DEVONSHIRE ST.

SUBSCRIPTION RATES: United States, Canada and Mexico, One Year, $5.00; 6 *months,* $2 50; 2 *months,* $1.00. *To all other countries in the Postal Union: Regular Edition, One Year,* $7.60 (31 *shillings*); *Thin Paper Edition, One Year,* $6.31 (26 *shillings*). *SINGLE COPIES of any number in current year,* 15 *cents.*

In ordering changes of mailing addresses, state BOTH old and new addresses; notice of change should reach us by Tuesday to be effective for the issue of the current week. The number on the address label of each paper indicates when subscription expires, the last figure indicating the year and the one or two preceding figures the week of that year; for instance, the number 328 *means that subscription is paid to the* 32d *week (that is the issue of Aug.* 11) *of the year* 1898; *the change of these figures is the only receipt sent, unless by special request.*

ADVERTISING RATES: 20 *cents per line. Want noticees, 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.*

A new evidence of the passing of the old barge canal as a factor in freight transportation under modern conditions is furnished by the announcement that the Delaware & Hudson Canal Co. is considering the abandonment of the famous old waterway, for the construction of which the corporation was originally organized. The Gravity R. R., completed by the company in 1829, is to be closed to traffic on Jan. 1 next, and it is not likely that the company will continue to maintain and operate the canal. For a number of years the traffic on the canal has been falling off, and it is said that only 250 boats were run last summer, where 1,400 boats once ran during the canal's prosperous days. A large proportion of the coal mined by the Delaware & Hudson Co. has been sent to the New York market over the Erie R. R. for several years; and it is now said that such traffic arrangements have been obtained that all the coal for the New York market from the company's mines will take this route.

It is plainly evident that a few years more will see the entire disappearance of the old-time canal barge as a vehicle for freight transportation. The 60,000-lb. freight car is a competitor which it cannot meet. The only ones of the old-time canals on which even a semblance of their old-time traffic is to be found are such canals as the Erie, where the taxpayers foot the bills for maintaining and operating the canal. Even here, however, the question of who is to carry on the traffic in the near future is a serious one. The profits to the canal boatmen for several years have been so meager that hardly any new boats have been built for some time; the old boats are fast becoming rotten and useless; and with the present uncertainty as to the future policy of the state respecting the canal, no new investments in boats to ply upon it are likely to be made.

The proposition to erect a memorial of some kind to the late Col. George E. Waring, in testimony of the value of his services to the city of New York, and in a broader sense, to the cause of better municipal sanitation, is a project eminently worthy of consideration. By his masterly executive ability and strong personality, Col Waring introduced new methods, and organized on a new system the work of street cleaning and refuse disposal in New York city, and so greatly improved the sanitary conditions that the system which he established is likely to be perpetuated. His services to the city were, indeed, valuable, far beyond the salary which he received, as is indeed often true of the engineer's work. It is well that the value of his services should now be substantially recognized, if for no other purpose than to preserve the memory of an energetic and faithful public servant who intelligently and honestly performed his duty.

That Col. Waring died a poor man speaks much for his honesty in positions of large responsibility; but he leaves a widow practically unprovided for, and, if a memorial fund is to be raised, we heartily commend the method for disposing of this fund suggested by Ex-Mayor William L. Strong. Briefly stated, the project, as thus far outlined, is to raise a fund from among the friends of Col. Waring, and those who appreciate his services to New York, and his later services to the government, to put this fund in trust and to pay the income to Col. Waring's widow during her lifetime. After her death the principal can then be disposed of as may be deemed best; enther in erecting a monument, or, better, in endowing a department of sanitary engineering in some reputable technical institution. Whatever the final disposition of such a fund might be, however, if it is to be raised at all, its first object should evidently be to secure Mrs. Waring from want. Posthumous recognition of valuable public service is better than none at all; but it should at least take the form that will best carry out the wishes of the deceased had he survived.

In our issue of Oct. 27, we noted the displeasure of the City Councils of Philadelphia because the Chief of the Water Department, Mr. John C. Trautwine, M. Am. Soc. C. E., did not complete the plans and specifications for the new George's Hill Reservoir as soon as they desired. Mr. Trautwine has now completed these plans, and in submitting them to the Director of Public Works, he has taken occasion to fully answer the charges of "contumacious conduct," etc., which were made in the Council sessions. He shows that the force of assistants which is allowed him comprises, all told, four draftsmen, at an average yearly salary of less than $1,200, and three rodmen at $2.50 each per day. With this force Mr. Trautwine, during the past summer has had to perform all the routine work of his department, and, in addition, prepare the following plans, estimates and reports: On Aug. 1 he was instructed by his superior officer to carry out a resolution of the city council calling for "plans and drawings and estimated cost of the filtration of all the water used by the city," and he was given just one month in which to do it. On Sept. 12, the site for the new reservoir, mentioned above, was approved, and on Sept. 15, Councils called for detailed plans for the reservoir, to be submitted at its next regular meeting, Oct. 6. About Oct. 20, Mr. Trautwine received a letter from the director of public works transmitting a resolution of the Select Council, calling for a report

> at the earliest possible time as to whether there is, within a radius of one hundred miles from the city, a supply of good water capable of furnishing this city with a sufficient storage quantity for 150 days, and whether the same can be stored and brought down by gravity and deposited in the city reservoirs for distribution. Also, report on the estimated cost of procuring such supply, together with any other information bearing upon the subject.

Mr. Trautwine is by no means the first engineer who has been overwhelmed with work, and then found fault with because he could not perform miracles. In fact, it is one of the greatest difficulties in carrying on work under state or municipal or national control that duties are assigned to public officials without the slightest question as to whether other demands on their time make it possible for them to perform them. In work under direction of a private firm or corporation, when an officer is given additional duties or special work, he is empowered to employ assistants enough to do it. But red tape prevents this, as a rule, in work under municipal or state control, and the man on whom the responsibility is laid has to struggle along as best he can.

LESSONS FROM THE LOUISVILLE EXPERIMENTS ON WATER PURIFICATION.

The value of experimental work, especially when conducted on a sufficiently large scale to make the conditions comparable with those prevailing in practice, is seldom better illustrated than by the results of the Louisville experiments on water purification. From the advance pages of Mr. Fuller's report on this subject, reviewed in Engineering News of Oct. 27, it appears that had the Louisville Water Co. awarded a contract for filters of the current mechanical type at the outset, instead of making, as it did, an exhaustive investigation of their efficiency, the results obtained would have been unsatisfactory, at times, and the expense unnecessarily great. The reason for this is that the companies, whose apparatus was tested, did not, prior to these experiments, fully appreciate the magnitude of the task of purifying a water so variable in character, and so heavily charged with minute particles of suspended matter, as is the Ohio River, at Louisville. In other words, too much reliance was placed, at the start, on coagulation and mechanical filtration and too little upon sedimentation. A number of other points brought out by the investigation were, when taken together, of much practical importancee as regards both the cost of purification and the quality of the water, especially the uniformity of the results obtained.

It may seem surprising that after 10 or 15 years of experience with mechanical filtration, and the installation of a hundred plants, by various companies, it was deemed necessary to undertake an exhaustive series of experiments at Louisville before the water company felt warranted in adopting the system. But the facts are, as we have repeatedly pointed out, that the data were lacking which would enable an engineer to decide upon the capabilities of mechanical filtration. The filter companies themselves did not possess such data, for two reasons: (1) Because they, like most proprietors of patented systems, had such confidence in their filters that they thought much experimental work, outside the laboratory, unnecessary; and (2) because their energies have been concentrated more upon fighting each other in the courts, and in competition for business, than upon learning the limitations of their filters. Public officials and private water companies have done very little in the way of studying mechanical filtration, (1) because the various filters were regarded as proprietary devices, and (2) because of the general apathy that has prevailed, until recently, regarding water purification. This apathy has been remarkable, even on the part of officials having mechanical filters under their care, some of these never having taken the trouble to learn how much wash water they were using, while it is a rare thing to find a filter plant for which periodical water analyses are made.

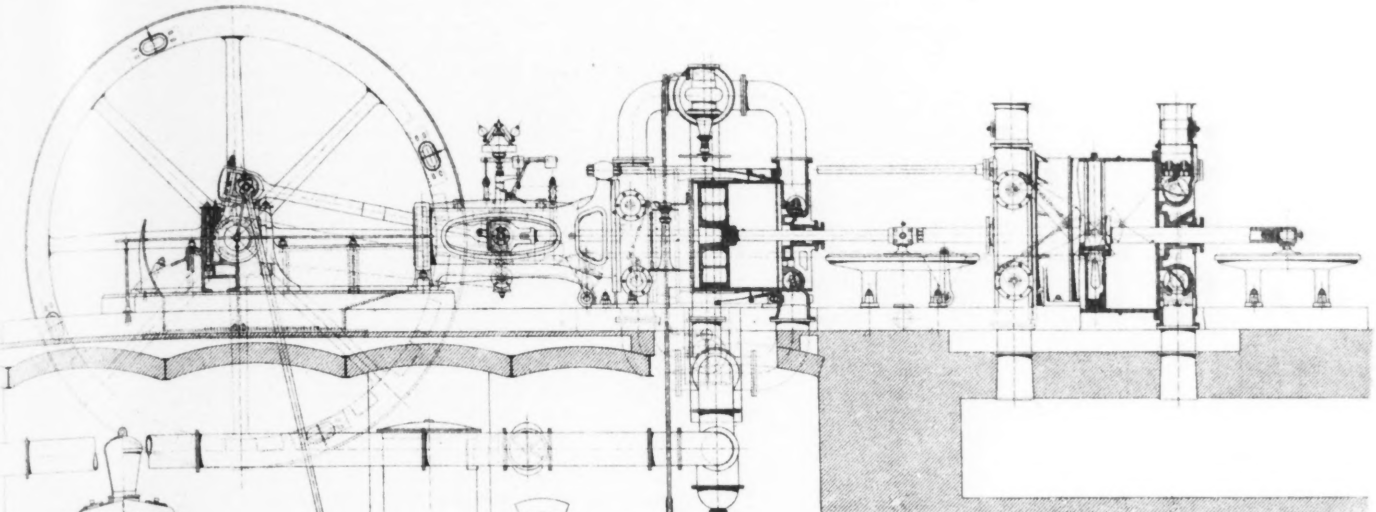
When the Louisville investigations were begun, the only notable experimental test of mechanical filtration on record was the one conducted at Providence, R. I., in 1893-4, by Mr. Edmund B. Weston, M. Am. Soc. C. E., reviewed at length in Engineering News of April 16, 1896. This test was made on a small scale, and had other limitations besides. In addition, the water treated contained such small amounts of suspended matter, in comparison with the water of the Ohio River, as to throw little light upon this phase of the Louisville problem, where the removal of mud must accompany bacterial purification. Besides this lack of experimental data, there confronted the Louisville officials the fact that a large mechanical filtration plant at New Orleans had been rejected by the water company there, after installation and a long contract trial, on the ground that it did not remove the suspended matter in the Mississippi River water without the use of an excessive amount of coagulant. The courts sustained the contention and the filter company suffered a heavy loss.

In view of the meager data available, and the

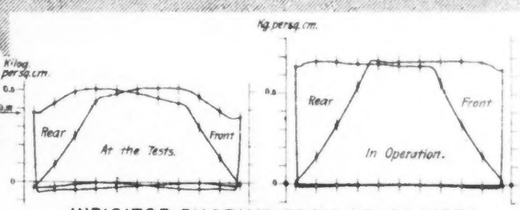
Fig. 1. State Ry. Saxony.
Fig. 2. Wurttemberg State Ry.
Fig. 3. Austrian State Ry.
Fig. 4. Pfalz Ry., Germany.
Fig. 5. Belgian State Ry.
Fig. 6. Austrian State Ry.
Fig 7. Holland Ry.
Fig. 8. Manchester, Sheffield & Lincolnshire Ry.
Fig. 9. London & N. W. Ry.
Fig. 10. Northern Ry., France.
Fig. 11. Paris, Lyons & Mediterranean Ry.
Fig. 12. Eastern Ry. of France.
13. Trans-Rhine Ry., Germany.
Fig. 14. Southwestern Ry., Russia.
Fig. 15. Chicago, Burlington & Quincy Ry.
Fig. 16. New York Central Ry.
Fig. 17. Vauclain's Columbia Type.
Fig. 18. Phila. & Reading R. R.
Fig. 19. Prussian State Ry.
Fig. 20. Gr. Eastern Ry. England.
Fig. 21. Gr. Northern Ry.
Fig. 22. Lancashire & Yorkshire Ry.
Fig. 23. Prussian State Ry.
Fig. 24. Oldenburg State Ry., Germany.
Fig. 25. Wurttemberg State Ry.
Fig. 26. Jura-Simplon Ry.
Fig. 27. Belgian State Ry.
Fig. 28. Baden State Ry., Germany.
Fig. 29. Canadian Pacific Ry.
Fig. 30. C., M. & St. P. Ry.
Fig. 31. Austrian State Ry.
Fig. 32. Mediterranean Ry., Italy.
Fig. 33. Schenectady Locomotive Works
Fig. 34. Hungarian State Ry.
Fig. 35. Prussian State Ry.
Fig. 36. Great Northern Ry., U.S.
Fig. 37. Duluth & Iron Range Ry.
Fig. 38. Prussian State Ry
Fig. 39. Austrian State Ry.
Fig. 40. Paris, Lyons & Mediterranean Ry.
Fig. 41. Mohawk & Malone Ry.
Fig. 42. Prussian State Ry.
Fig. 43. Wurttemberg State Ry.
Fig 44. Erie R. R.
Fig. 45. Prussian State Ry.
Fig. 46. Prussian State Ry.
Fig. 47. Hanover Ry. Germany.
Fig. 48. Narrow Gage, Hanover Ry.
Fig. 49. Central Ry., Switzerland.
Fig. 50. South Eastern Ry., England.
Fig. 51. London City Ry.
Fig. 52. London, Tilbury & South End Ry.
Fig. 53. Western Ry., France.
Fig. 54. Chicago & N. Pac. Ry.
Fig. 55. Prussian State Ry.
Fig. 56. Central Ry., Switzerland.
Fig. 57. St. Gothard Ry, Switzerland.
Fig. 58. System Hagans.
Fig. 59. Emmenthal Ry., Switzerland
Fig. 60. Prussian State Ry.
Fig. 61. Northern Ry., Austria.
Fig. 62. Prussian State Ry.
Fig. 63. Saxony State Ry.

(FIGS. 48, AND 58 TO 63, NARROW-GAGE LOCOMOTIVES)

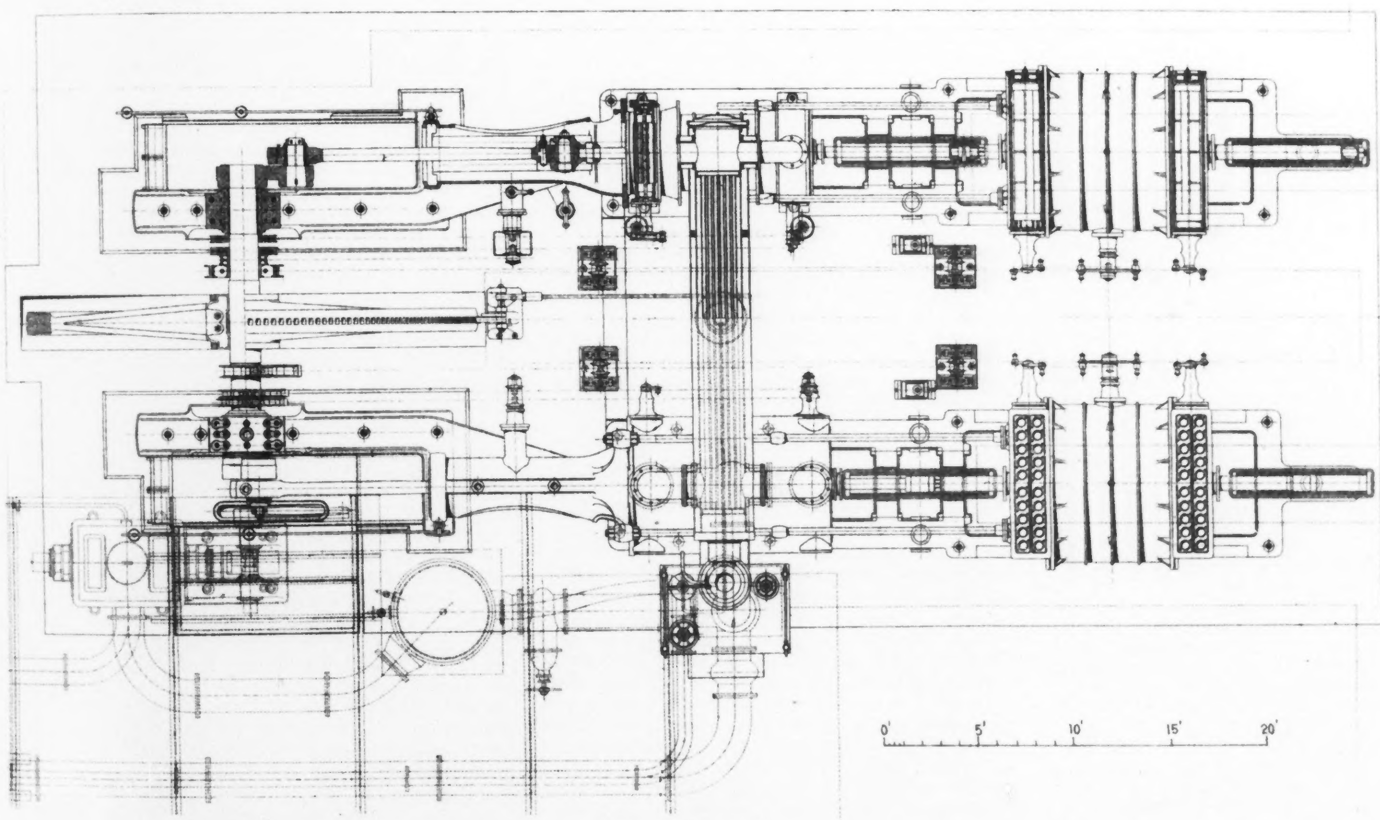
RECENT TYPES OF EUROPEAN AND AMERICAN LOCOMOTIVES.



LONGITUDINAL SECTION.



INDICATOR DIAGRAMS FROM AIR CYLINDER.



SECTIONAL PLAN.

CROSS-COMPOUND DUPLEX HORIZONTAL BLOWING ENGINE.

Built by Bolzano, Tedesco & Co., Schlan, Bohemia,
for the
Hungarian Iron Works, Krompach.

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

sad
tha
Eng
wer
con
the
rect
the
tha
mov
tion
the
amo
beer
som
A
of
beer
day
furt
rais
Fina
ficie
wate
and
not
indi
ter
bein
of t
Con
writ
not
Th
ficie
to e
of d
or a
sugg
puri
basi
neer
think
proa
Pitts
to th
ble
Expe
there
comp
puri
form
tion
origi
the c
slow
on th
tities
other
burg
ward
tuted
reali
to su
exper
some
slow
as to
ever,
when
Mr.
engin
Cinci
ing c
ist a
L. F.
neer
proba
Wi
we sl
obtai
ready
alyse
and
obtai
city
analy
Exan
filter
frequ
port
Wis.,

sad experience at New Orleans, it is not strange that the Louisville Water Co., and its able Chief Engineer, Mr. Chas. Hermany, M. Am. Soc. C. E., were unwilling to contract with any of the filter companies for a purification plant. Nevertheless, the indications were strongly in the direction of mechanical filtration, as best suited to the conditions at Louisville, because it was felt that a coagulant would be necessary for the removal of the suspended matter. Slow sand filtration alone was out of the question, on account of the rapid clogging of the beds and the vast amount of labor required to clean them, as had been determined experimentally by Mr. Hermany some ten years before the recent tests.

After ten months of experience with the filters of three different companies, each plant having been designed for a capacity of 250,000 gallons a day, the Louisville Water Co. felt the need of still further investigations to settle some questions raised but not answered by the filters tested. Finally, we understand, the company secured sufficient data to enable it to design a system of water purification which it believes will be efficient and economical. The details of this system are not given in the report, but its final conclusion indicates that a modified form of mechanical filter will be adopted, the facilities for sedimentation being greatly increased over those provided in any of the plants installed by the filter companies. Contracts have been let, since the report was written, for portions of the purification plant, but not for the filters proper.

The question naturally arises, have we now sufficient information regarding mechanical filtration to enable an engineer to say whether it is capable of doing the work required in any specific case, or are further investigations necessary? This suggests the broader question, whether water purification as a whole is now on as definite a basis as other branches of water supply engineering, say pumping machinery? We do not think it is, although it seems to be rapidly approaching that state. When the reports on the Pittsburg and Cincinnati experiments are added to the Louisville report and to the mass of valuable information emanating from the Lawrence Experiment Station and from foreign sources, there will certainly be no longer any ground for complaint of a scarcity of data regarding water purification. We have had a fair amount of information regarding some phases of sand filtration for a number of years, most of which has originated at Lawrence or abroad. At present the chief deficiency in American records relating to slow sand filtration is that they throw little light on the treatment of water carrying large quantities of mud, like the Ohio and Mississippi, and other Southern and Western streams. The Pittsburg and Cincinnati experiments will do much towards supplying these wants, as both were instituted largely for this very purpose, but with a realization that sedimentation would be necessary to supplement slow sand filtration. These later experiments, it is to be hoped, will also afford some comparative data regarding mechanical and slow sand filtration, although official statements as to this have not been made. It is known, however, that both systems were tested at Pittsburg, where the experiments were recently completed, Mr. Allen Hazen, Assoc. Am. Soc. C. E., being engineer to the commission on filtration. The Cincinnati tests, like those at Louisville, are being conducted by Mr. Geo. W. Fuller, Chief Chemist and Bacteriologist, under the direction of Mr. L. F. G. Bouscaren, M. Am. Soc. C. E., Chief Engineer of the new water supply. Both reports will probably be published promptly.

With the information outlined available, what we shall mostly need will be the detailed results obtained by full-sized working plants. As already stated, scarcely any regular periodical analyses of filtrates have been made in this country, and fewer yet have been published. The results obtained by the slow sand filtration plant of the city of Lawrence, Mass., are available, but the analyses are not made at very frequent intervals. Examinations of the water from the mechanical filter plant at Davenport, Ia., ware made at fairly frequent intervals, some time ago, for the Davenport Water Co. by Prof. E. G. Smith, of Beloit, Wis., but only portions of the results have ever been published, so far as we know. Prof. Smith also made some analytical studies of the effect of sedimentation of Missouri River water at Omaha and Council Bluffs, a few years back, but these figures, also, have not been made generally available. Valuable studies, extending over several weeks, of the work done and coagulant used by the mechanical filter plant at Lorain, O., were made not long ago, under the direction of Mr. Hazen, as will be seen by referring to Engineering News for Oct. 28, 1897. In our issue of June 4, 1896, there appeared a report by Dr. Thos. M. Drown, President of Lehigh University, on the removal of iron from ground water at Asbury Park, N. J., by means of aeration and mechanical filtration, the tests here also extending over a number of weeks.

When the sedimentation and slow sand filtration plant at Albany, N. Y., described in our issues of Feb. 10 and Oct. 20, 1898, is put in use we may expect to have some valuable figures regarding it, for a chemical and bacteriological laboratory are very wisely being provided as a part of the works. Soon other of the larger cities will have water purification plants in use, and doubtless they also will see the advisability of providing and operating analytical laboratories. The importance of frequent chemical and bacterial analyses in connection with purification plants can hardly be urged too strongly, both as a guarantee of good results and of economical design and operation.

While we are learning and expecting to learn so much about water purification from the various sources already open to us and likely to be open soon, five or ten years, at least, will probably pass before most of our largest and many of our smallest cities can safely install complete systems of water purification without making more or less preliminary experiments. Where large plants are to be constructed, the total expense of such tests need be only a small fraction of the capital charges and operating expenses for one year, and the tests may often more than pay for themselves in a single suggested modification in design. In many cases the only doubtful points may pertain to operation, rather than design, when the tests may be delayed until the plant is in use. In fact, the supreme test is daily use, and that is why any filter plant should be constantly under good engineering, chemical and bacterial supervision.

Reverting now to the specific lessons of the Louisville tests, we have as the most important the great value and necessity of sedimentation in the treatment of all waters high in suspended matter, the process also removing a large percentage of bacteria. But where the sediment is finely divided, or where a high degree of bacterial purification is necessary, sedimentation must be supplemented by filtration. Coagulation would also be necessary at Louisville and is now almost universally recognized as an essential part of mechanical filtration, at the high rates usually employed.

The proper amount of coagulant, or the optimum quantity, as Mr. Fuller terms it, is a subject demanding careful investigation for each water to be treated. At Louisville it was found that the clayey particles in suspension absorbed a large amount of sulphate of alumina, without any effect upon the water. This was at times as high as ¾-grain per gallon. On the other hand, this coagulant in excess of certain quantities may be worse than useless, as has been known for some time, since all in excess of that which the carbonates in the water are able to take up passes into the filtrate. There might be cases where the use of sulphate of alumina, or alum, in sufficient quantities for efficient work, would be objectionable on account of adding to the corroding and incrusting qualities of the water and increasing its hardness. At Louisville this would not be the case, with proper design and operation of the purification works. These possibilities are one of the many reasons for careful analytical studies in connection with each filter plant. Another point about coagulants is that they must be given a proper amount of time to act, depending upon the character of the water and, presumably, the nature of the agent. Uniformity in the rate of admission of coagulants is essential to good results and to economy. Mr. Fuller thinks each of the devices used for this purpose at Louisville in the experimental plants could be improved upon, either by modifications in design or by the substitution of a direct gravity feed, instead of some form of pump. Reliance upon passing a stream of water through a receptacle containing the coagulant is wrong.

For the Ohio River water, sulphate of alumina was found to be the best and cheapest coagulant available, after an exhaustive study of the whole range of possible agents. This coincides pretty generally with experience elsewhere, although there might be waters for which some other agent was better suited.

Another confirmation of the opinions commonly held by disinterested scientists who have given the matter sufficient attention to warrant sound conclusions is that the direct treatment of water by electrical currents is of little value. There were, however, such apparently good grounds for hoping that a coagulant might be produced by electrolytical, in preference to chemical, methods, that extended studies of the subject were made. Nearly all of the so-called electrical systems of water and sewage purification, it may be stated here, are such only in the electrolytical production of a coagulant at the purification works, and for immediate use, instead of buying it from a manufacturing chemist. The Louisville experiments showed that the cost of the electrolytical production of aluminum hydrate was not only excessive, but that this method was unreliable "on account of the very low and irregular formation of the hydrate." An iron hydrate could be produced much more advantageously than an aluminum, and would be somewhat cheaper, apparently, than commercial sulphate of alumina, but it could not be safely employed at Louisville because the water there at times is too low in dissolved oxygen to oxidize more iron than an equivalent of three grains of sulphate of alumina per gallon, which would be insufficient. If more iron were used, it would appear in the effluent. Iron and aluminum, the report states, are the only metals available for the electrolytical production of coagulants. Neither of these hydrates, when thus produced, increases the hardness, corroding or incrusting qualities of the water, as does the commercial sulphate of alumina.

LETTERS TO THE EDITOR.

Formulas for the Volume Enclosed by the Intersection of Two Cylinders.

Sir: From a careful examination of the various formulas for the volume enclosed by two intersecting cylinders, published in your issue of Oct. 6, it is apparent that five of the ten mathematical formulas given are identical. For, if in those submitted by Messrs. Baldwin, Comstock, Talbot, and Dean, we retain only the first three terms of the series, represent $\frac{a}{r}$ by P, give to π its numerical value and reduce, we shall obtain in each case the expression

$$0.3927\ a^3\ P \left\{1 + \frac{P^2}{8} + \frac{5\ P^4}{128}\right\},$$

Volume Enclosed by Two Right Cylinders Whose Axes sect at Right Angles.

r = larger radius;

a = smaller radius;

$$P = \frac{a}{r}.$$

Values of the volume in terms of r obtained by retaining only the first three terms of each series and substituting different values for $P = \frac{a}{r}$ in the formulas submitted by

Value of P substituted.	True value.	Mr. Sherman.	Mr. Peterson.	Mr. Serviss.	Mr. Frescoln.	Mr. Thomas.	Messrs. Baldwin, Comstock, Talbot & Dean.
P = 1.0........	$0.475\ r^3$	$0.8\ r^3$	$2.6804\ r^3$	$0.4748\ r^3$	$0.4749\ r^3$	$0.466\ r^3$	$0.457\ r^3$
P = 0.8........	...	$0.2048\ r^3$	$1.833\ r^3$	$0.1504\ r^3$	$0.1586\ r^3$	$0.350\ r^3$	$0.344\ r^3$
P = 0.5........	...	$0.0268\ r^3$	$0.76\ r^3$	$-0.00625\ r^3$	$+0.0078\ r^3$	$0.2067\ r^3$	$0.203\ r^3$
P = 0.3........	...	$0.0033\ r^3$	$0.2795\ r^3$	$-0.01185\ r^3$	$-0.0044\ r^3$	$0.1214\ r^3$	$0.11916\ r^3$
P = 0.2........	...	$0.000646\ r^3$	$0.125\ r^3$	$-0.0066\ r^3$	$-0.0029\ r^3$	$0.0804\ r^3$	$0.0789\ r^3$
P = 0.1........	...	$0.0004\ r^3$	$0.031\ r^3$	$-0.00185\ r^3$	$-0.00087\ r^3$	$0.04\ r^3$	$0.0393\ r^3$

which is exactly the value from which my approximate formula was obtained by using 0.4 in place of the coefficient 0.3927.

Since five of the formulas agree so exactly, while the others are all dissimilar, it seems fair to assume that these five are correct solutions of the problem.

I desire to take exception to your published statement that formulas 4, 5 and 6 agree quite closely.

Having tested them carefully, I submit herewith a table showing results obtained by substituting various values for the ration $\frac{a}{r}$ in the nine principal formulas given:

From an inspection of the above table it will be seen that the last five formulas give practically identical results. Those of Messrs. Serviss and Frescoln give correct values only when P = 1 or a = r, and they agree with each other pretty closely when P = 0.8; but they both give negative values for the smaller values of P. Mr. Peterson's formula seems to come nowhere near the mark except when P = 0.1, and Mr. Sherman's is not "in it" at all.

Yours truly, Frederick M. Thomas.

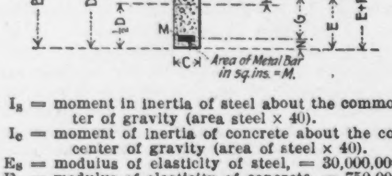
Skaneateles, N. Y., Oct. 17, 1898.

A New Formula for Determining the Fiber Stresses in Concrete and Steel Beams.

Sir: The analysis of concrete beams reinforced by iron or steel, arranged in several ways, has been the subject of considerable discussion, and, although several formulas have been given in the columns of Engineering News (Eng. News, Jan. 3, 1895, and Oct. 21, 1897), some of them undoubtedly correct, the following, which, I believe, has not appeared in print, may be found to have some advantages. No originality is claimed for the analysis, but the formulas are arranged with a view to simplifying their practical application.

One method of analysis has aimed at determining the stresses after the concrete has cracked (failed in tension), because this occurs with "one-third the load required to develop the compressive strength of the concrete or elastic limit of the steel." To accomplish this the depth of the cracks is "assumed," the result therefore being true only for that depth. In a material like concrete it would be hardly safe to assume that repetitions of the load that first caused the crack would not extend it indefinitely, possibly up to the constantly changing neutral axis. This point can be determined and should be used for the depth of the crack. But the author of this method himself says "the factor of safety used in practice would always keep the working load well inside of this limit." To this, I think, all will agree. Therefore, the rational formula to use in proportioning concrete-steel beams, is one giving the working stresses. With these formulas the proper working unit stresses may be selected by the designer to suit each case. Ordinarily the unit tensile stress allowed for the concrete may safely be 75% of the ultimate tensile strength of the concrete when seven days old, or about 50% when 28 days old, and a decreasing percentage of the ultimate strength as the concrete ages.

In the examples given below I believe the ultimate breaking load would be from ten to twelve times the safe loads used. The only assumption made is of the value of the modulus of elasticity of concrete. This I have taken at 750,000, the result obtained by Professor Boek, in the Vienna experiments. This, however, can be determined for any given concrete when required.



Let I_s = moment in inertia of steel about the common center of gravity (area steel × 40).

" I_c = moment of inertia of concrete about the common center of gravity (area of steel × 40).

" E_s = modulus of elasticity of steel, = 30,000,000.

" E_c = modulus of elasticity of concrete, = 750,000.

" L_c = load on concrete.

" L_s = load on steel.

" c = proportion of total load sustained by concrete.

" s = proportion of total load sustained by steel.

Test, No.	Width, ins.	Thickness, ins.	Area, sq.in. Concrete.	Steel.	Common c. of g., above under side, ins.	I_c = for concrete, ins.	I_s = for steel, ins.	P. c. of load carried by Concrete, c.	Steel, s.	Bending moment, in.-lbs.	Stress per sq. in. on Concrete, tension.	Steel, tension.	Remarks.
5.	42	3.5	147	0.52	1.60	153.25	1.245	75	25	43,500	341	13,550	
6.	42	3.5	147	0.52	1.56	155.20	0.960	80	20	43,500	350	12,300	
7.	41.5	3.75	155.5	0.52	1.68	187.90	1,060	81.5	18.5	52,500	382	13,150	
8.	42.5	3.75	159.2	0.52	1.69	191.50	1.080	81.6	18.4	45,000	324	11,050	
9.	41	3.62	148.3	0.52	1.60	168.50	1.140	78.7	21.3	52,500	392	14,500	Metal broke.
10.	42	3.75	157.5	0.52	1.72	188.30	0.770	86.0	14.0	69,000	541	15,300	
11.	42	3.81	160	0.52	1.69	200.90	1.380	79.0	21.0	60,000	399	14,900	Metal broke.
12.	42	4.50	189	0.52	2.09	322.80	2.140	79.0	21.0	63,000	324	12,600	
15.	42	4.75	199.5	1.04	1.96	410.00	3.980	72.0	28.0	139,500	480	19,100	
17.	42	3.87	163	0.52	1.72	210.50	1.410	79.0	21.0	67,500	435	16,600	
18.	42	4.00	168	0.52	1.84	227.30	0.930	86.0	14.0	87,000	604	17,600	Metal broke.
33.	42	4.50	189	1.74	1.74	367.20	3.270	74.0	26.0	127,500	445	13,800	
34.	42.5	3.82	162.2	0.52	1.71	203.5	1.31	79.5	20.5	51,000	340	12,700	
38.	42.5	3.75	159.2	0.52	1.66	193.4	1.35	78.0	22.0	75,000	502	19,700	
39.	43.	3.50	150.5	0.52	1.60	156.4	0.95	80.0	20.0	60,000	490	17,600	
40.	42	3.81	160	0.52	1.79	195.2	0.44	92.0	8.0	67,500	570	11,300	
41.	42	4.06	174	0.52	1.90	241.0	0.69	90.0	10.0	90,000	639	15,000	
42.	42	4.06	174	0.52	1.84	244.3	1.31	82.0	18.0	75,000	465	16,400	Metal broke.
43.	42	3.38	142	0.52	1.54	138.0	0.56	86.0	14.0	60,000	...	15,600	Metal broke.
44.	42	3.81	160	0.52	1.79	195.2	0.44	92.0	8.0	58,500	493	9,800	
45.	43	3.94	169.2	0.52	1.78	224.1	1.22	82.0	18.0	81,000	528	18,300	
56.	42	3.93	165.2	1.04	1.59	236.0	2.44	71.0	29.0	135,000	642	24,600	

Then

$$\frac{L_c}{L_s} = \frac{E_c\ I_c}{E_s\ I_s} = Y = \frac{I_c}{40\ I_s}.$$

and

$$c = \frac{Y}{1+Y},\ \text{and}\ s = \frac{1}{1+Y}.$$

If M = bending moment in inch-pounds, tension in concrete will be $= \left[\frac{M\,E}{I_c}\right] \times c.$

Compression in concrete will be $= \left[\frac{M\,F}{I_c}\right]$ c.

Tension in steel will be $= \left[\frac{M\,G}{I_s}\right]$ s.

The letters E, F and G refer to the figure, although the formulas are perfectly general. This figure represents one element of a floor, the beam and floor being built at the same time and monolithic. A is equal to the distance from center to center of beams. The values for seven different sections are tabulated below.

There have now been made a number of tests of concrete-steel beams, and it is quite likely that a careful and rational analysis of the results would suggest the use of other unit stresses than I have used in these examples. But as the formulas are general it is very easy to substitute other unit stresses whenever, in the opinion of the designing engineer, the state of knowledge on the subject indicates it. Mr. George Hill has presented in tabulated form 56 tests of concrete-steel slabs, in which the steel was in the form of "expanded metal." The concrete was of several different kinds, both as to ingredients and proportions. The "load producing first crack," as well as the "load at which metal broke," are given, and in the calculations given below I have used the smaller of the two, which is generally, but not always, the first mentioned.

The slabs made of cinder concrete are neglected because the modulus of elasticity for that is not at hand.

The modulus of elasticity of the stone and gravel concrete has been taken at one-fortieth that of steel.

The slabs for which the distance of the metal from the surface of the concrete at the center of the span was not clearly given, have of necessity been omitted.

This table shows the stresses developed in concrete and steel, for the load-producing rupture, on the tension side of the beam or slab, by the formulas

$$T_s = \frac{M\,G\,s}{I_s},\ \text{and}\ T_c = \frac{M\,E\,c}{I_c}.$$

Many tests of concrete beams have shown that they develop a tensile stress in the extreme fiber, by formula, about twice that of the tension tests. The above seem to correspond with those results very closely, but as no tension tests were given for the concrete in the slabs, they cannot be directly compared. The compression tests given are not applicable, since the ratio of tensile to compressive tests of concrete are very variable. (Tensile strength of concrete indicated, average = 230 lbs. per sq. in.) The low stress at which the metal broke may be attributed to tearing, due to its form, and to punishment by shearing and bending in its manufacture.

Albert W. Buel.

150 Broadway, New York city, Sept. 27, 1898.

Table Giving Dimensions, Moments of Inertia, Loads, Capacity in Bending Moments, Safe Span, and Quantities of Material Required for Concrete-Steel Beams.

Dimensions of beams in Inches. A.	B.	C.	D.	E.	F.	G.	H.	M.	N.	I_c for concrete.	I_s for met'l	Load on concrete, c.	Load on met'l s.	Capacity in bending moments, ft.-lbs.	Safe span in feet.	Concrete Cu.ft. per sq.ft.	Concrete Cu.yd. per sq.ft.	Lbs. of metal per sq. ft.
18	4	4	14	8.00	10.00	6.50	1.00	2.0	1.50	5,735	85	0.63	0.37	9,500	12.0	0.590	0.022	5.0
18	4	4	16	8.30	11.70	6.80	0.30	2.5	1.50	8,237	116	.64	.36	12,900	14.0	0.628	0.023	6.0
24	6	6	14	8.23	11.77	7.00	1.23	4.0	1.23	13,004	196	.62	.38	21,250	15.6	0.793	0.030	7.0
24	6	6	18	10.00	14.00	9.00	1.00	4.0	1.00	20,860	324	.617	.383	28,100	18.0	0.875	0.033	7.0
24	6	6	18	9.10	14.90	7.10	0.10	6.0	2.00	23,753	303	.662	.338	32,800	19.36	0.875	0.033	10.5
18	4	6	20	8.60	15.40	7.10	1.40	4.0	1.50	17,330	202	.68	.32	24,650	19.36	0.890	0.033	9.3
18	4	6	20	7.55	16.45	5.55	2.45	6.0	2.00	19,856	185	.728	.272	30,100	21.4	0.890	0.033	14.0

Note.—Allowed tension on concrete, = 100 lbs. per sq. in.; allowed compression on concrete = 500 lbs. per sq. in.; allowed tension on steel, equals 16,000 lbs. per sq. in. Safe spans given are for dead load of 150 lbs. and live load of 200 lbs. per sq. ft.

RECENT TYPES OF EUROPEAN AND AMERICAN LOCOMOTIVES.

(With full-page plate.)

The fact has been frequently noted that locomotive design in this country for the past quarter century has been tending more and more towards uniformity, and the half dozen or more standard types of locomotives which are in use in this country vary little in their design on different roads except in minor details. In Europe, however, notwithstanding the smaller mileage of railways and the fact that they are spread over a much smaller territory, the greatest diversity in design continues to exist. This fact is very well shown in a plate published in a recent issue of our German contemporary, "Der Praktische Maschinen-Constructeur," showing 63 locomotives in use on various European and American railways, all drawn to a uniform scale. We have reproduced this plate and the article accompanying it has been translated for us by Mr. Geo. L. Fowler, M. Am. Soc. M. E., and is printed below.

In considering the causes for the greater uniformity in locomotive design in this country, we are inclined to assign a first place to the work of such organizations as the Master Mechanics' Association, the various railway clubs and the various railway technical journals. Of course the political and social barriers between different countries in Europe has operated to hinder any such full and free interchange of experience between the mechanical officers of different railways as prevails in this country. It is also true, we think, without doubt, that variations from standard practice are easier to introduce on the other side, and especially on the continent, than in this country. The inventors who want to improve the locomotive are classed in the same category with beggars, peddlers and book agents, by the average American Master Mechanic. Anything in the way of complication is his especial abhorrence; while on the Continent, if we may judge from the looks of the locomotives, each new designer of complicated valve motions and similar mechanical curiosities is greeted with open arms.

It is a little curious, however, how steadfastly every railway on the other side refuses to accept two distinctive American features of locomotive design, the pilot and the headlight, and how every American railway as steadfastly persists in their use. Our English friends, who still persist in calling the pilot the "cowcatcher" used to gravely explain that it was necessary in America because the railways there were not fenced and the cattle and other wild animals roamed at large on the tracks; but though we have now a considerable mileage of track protected from trespass of this sort, nobody proposes to take the pilot off road locomotives and is not likely to. About the same thing is true of the headlight. Its value as a safety appliance is so well established that nobody in this country would think of discarding it. On the other side, however, they argue that they have always got along very well without pilots and headlights and have fewer accidents in proportion to the traffic than American roads. Hence they see no reason for using them.

Taking up now the article in our contemporary, we may remark that it gives credit for the greater portion of the drawings and data to a treatise

on "Railway Technics of the Present Time," by Messrs. Blum, Von Borries and Barkhausen, which has just been published by C. W. Kreidel, of Wiesbaden. In denoting the type of a locomotive a fraction is used in each case, the numerator denoting the number of driving axles coupled and the denominator the total number of axles. Mr. Fowler's translation follows:

I.—Passenger and Express Locomotives.

Up to the year 1880, the majority of the locomotives on European railways were of the 2/3 coupled type. In the decade between 1880 and 1890, the 2/4 coupled locomotive was introduced, which ran more smoothly at high speed and put less strain on the tracks. In these new locomotives a four-wheeled bogie truck was placed beneath the smokebox; the driving axle was in front of the firebox and the coupled axle beneath or back of the same. Engines with three and four axles with only a single pair of driving wheels are still used principally in England; while in America, locomotives with three axles coupled are in common use.

Fig. 1 is a 2/4 coupled express locomotive of the State Ry. of Saxony. In common with many German engines, these locomotives have two outside cylinders, Heusinger valve motion, inside frames and fireboxes held by radial stays. The springs of the two driving axles are connected by equalizing levers; the bogie truck is fitted with four springs that are independent of each other and a ball-and-socket center bearing on a spring bolster so that the locomotive is carried on three points. By means of his system of intercepting valves von Borries can admit live steam into his large cylinder and thus increase the tractive power of the locomotive.

Fig. 2 is a 2/4 coupled express locomotive of the Wurtemberg State Ry. In order to secure a deeper firebox, there is no driving axle placed beneath it; the locomotive is carried by trailing wheels at the front and back with the two pairs of driving wheels set between them. The engine has three cylinders of the same diameter, whose cranks are placed at an angle of 120° with each other. The inside cylinder is the high-pressure cylinder, but live steam may be admitted to all three, so that a wide variation in the tractive force may be exerted. The trailing axles are connected with the tender from their center, so that curves of 500 ft. radius can be readily traversed by these locomotives. The steam pressure is 180 lbs. per sq. in.; the heating surface, 1,581 sq. ft. and the grate area, 21.3 sq. ft.

Fig. 3 is a 2/4 coupled Austrian passenger locomotive. The firebox is of the Belpaire type. The boiler is fitted with two domes, which are connected by an outside steam pipe. An outside pipe also runs from the forward dome to the steam chest. The tubes are of steel.

Fig. 4 is a 2/4 coupled express locomotive of the Pfälz Ry. The arrangement of the wheels is the same as in Fig. 2, but a Krauss truck is used, by means of which the forward axle will be set radially to a curve by the side movement of the front driving axle. Owing to the better arrangement of the cylinders, the running is smoother than in the preceding design. The steam pressure is 180 lbs. per sq. in.; the heating surface, 1,215 sq. ft., and the grate area, 19.4 sq. ft.

Fig. 5 is a 2/4 coupled locomotive of the Belgian St. Ry. In this locomotive all of the peculiarities which characterize the Belpaire system are to be found, namely: outside frames, cylinders with the Heusinger valve motion inside the frames, a large firebox spreading out to the back of the rear wheel and an inclined grate. The front truck axle is movable, and the cylinders are set at the extreme front end, an arrangement that is very detrimental to the stability of the engine. In order that fine coal may be burned the grate has a large area, namely, 51.6 sq. ft., but the heating surface is small, being but 1,204 sq. ft. The steam pressure is 150 lbs. per sq. in.

Fig. 6 is a 2/4 coupled express locomotive of the Austrian State Ry. It is a two-cylinder compound engine and is used in heavy express traffic on the main line. It is built upon the Gölsdorf plan, which provides for the admission of live steam to either end of the low-pressure cylinder. This is accomplished by means of two holes drilled in the valve seat, which are kept closed under ordinary conditions of valve travel, but which are opened when the point of cut-off is later than from 50 to 60% of the stroke. The wheelbase of the truck is very great, being 8 ft. 10¼ ins., and it is also set so far to the rear that it carries a large portion of the weight of the boiler, since an axle loading of 14½ tons must not be exceeded. The grate area is comparatively large (31.2 sq. ft.) because fine coal of a medium quality must be burned. This engine also has two domes connected by an outside pipe. The steam pressure is 195 lbs. per sq. in., and the heating surface 1,489 sq. ft., and the grate area 31.2 sq. ft.

Fig. 7 is a 2/4 coupled express locomotive of the Holland Ry. Co. This new Dutch locomotive resembles the English patterns and differs from them only in the use of inclined grates and Belpaire firebox.

Fig. 8 is a 2/4 coupled express and passenger locomotive of the Manchester, Sheffield & Lincolnshire Ry. The principal English lines have, in recent years, built a large number of locomotives with four wheels coupled and a bogie truck in front, and this is becoming typical of English practice. Owing to the good fuel which is available on most of the English roads, the boiler may be made comparatively small. The cylinders are inside and have one steam chest in common; the frames are also inside, and the springs are independent. The firebox is fitted with a long fire-arch and the crown is held by crown-bars.

Fig. 9 is a 2/4 coupled express locomotive of the London & Northwestern Ry. This locomotive is of the well-known Webb three-cylinder compound type. The two high-pressure cylinders are on the outside and are back of the forward wheels. The pistons of the outside cylinders turn the back driving axles and that of the low-pressure cylinder, which is beneath the smokebox, drives the forward axle. The driving axles are not coupled together. The steam distribution in the high-pressure cylinder is accomplished by means of a piston valve driven by the Stephenson link-motion; that of the low-pressure by a slipping eccentric. The tubes start from a combustion chamber in front of the firebox. The steam pressure is 180 lbs.; the heating surface is 1,413 sq.ft., and the grate area, 20.4 sq.ft.

Fig. 10 is a 2/4 coupled four-cylinder, compound express locomotive of the Northern Ry. of France. The same type is also used by some of the other great French companies. The two outside high-pressure cylinders are located back of the truck, and their connecting rods take hold of the crank-pins of the back driving wheels, while the low-pressure cylinders are set beneath the smokebox and their connecting rods take hold of the cranks of the forward driving axle. The cranks stand at an angle of 120° with each other in order to relieve the working parts to as great an extent as possible. The two pairs of cylinders can be worked perfectly independently of each other, which is a valuable quality in case of accident. The steam distribution is effected by means of the Heusinger valve motion. Live steam can be admitted to all of the cylinders in starting.

Fig. 11 is a 2/4 coupled compound locomotive of the Paris, Lyons & Mediterranean Ry. In size and general arrangement it is very similar to Fig. 10, as just described, but in the details of its construction it is very different. The boiler, for instance, is much shorter, the Serve ribbed tubes are only 9.8 ft., instead of 12.8 ft. long. The smokebox is 5 ft. 9 ins. long. In the firebox there is an arch of firebrick. The truck has a side play. The frames are carried on a wedge-shaped surface by means of which they can be brought back to their original position. All parts of the machine which present a resisting surface to the wind, are protected by wedge-shaped shields. By this means the resistance of the air is said to be decreased about 22* tons at a speed of 62 miles (100 km.) per hour.

Fig. 12 is a 2/4 coupled locomotive of the Eastern Ry. of France. For express service these locomotives are fitted with the double boiler of the Flaman type. The lower boiler, which is entirely filled with tubes, is really the water space, while the upper one forms the steam chamber. This boiler has 304 tubes, each 14.1 ft. long, giving it a heating surface of 1,809 sq. ft. As the firebox is formed of corrugated steel plates, it needs no further staying. The cylinders are outside and their pistons turn the back driving axles. The engine weighs 57 tons. In order to relieve the driving axles of a portion of the load that they would otherwise carry, the truck is set somewhat back, in spite of which the loading amounts to 33.4 tons, or practically 17 tons per axle.

Fig. 13 is a 2/4 coupled passenger locomotive of the Left Bank of the Rhine Ry. The characteristic feature of this locomotive is the boiler, which is of the Lentz type with a corrugated flue firebox. The boiler consists of three divisions, namely, two conical end pieces at the ends and a cylindrical connection between the two in the center. The sheets are welded together without any riveted joints. At the front end the boiler rests with the smokebox on the frames, at the back it is carried by two side stays. In front of the horizontal grate there is a space that serves as a combustion chamber.

Fig. 14 is a 2/4 coupled compound locomotive of the Southwestern Ry. of Russia. The engine has four cylinders, which are placed above the truck. On account of their lesser weight, the high-pressure cylinders are placed at the front. The steam first enters the small cylinder and then passes out through a large tube, which serves as a receiver, into the large cylinder upon the other side of the engine. This pipe passes through the smokebox. The steam distribution is effected by the Stephenson link-motion. Live steam can be admitted to the low-pressure cylinder through a small pipe on starting. The driving axles are loaded with but 13 tons.

Fig. 15 is a 2/4 coupled passenger locomotive of the Chicago, Burlington & Quincy R. R. The principal characteristics of the American machine are as follows: The main frames are formed of bars of iron or cast steel. The firebox is always made of steel, and, in case of the example given, the crownsheet is flat and is stayed on the Belpaire system. The cylinders are outside and above the truck. The valve seats are on top of the cylinders and the steam distribution is effected by means of the Stephenson link-motion with open links. The wheels are made of cast iron with steel tires. In order to prevent the throwing of sparks, the cylindrical smokebox is made very large and is fitted with spark arresters. A bell is used instead of a whistle. (So in the original.—Ed.) The steam pressure is 165 lbs. per sq. in.; the heating surface, 1,280 sq. ft., and the grate area, 24.7 sq. ft.

Fig. 16 is a 2/4 coupled express locomotive of the New York Central & Hudson River R. R. The large dimensions of the boiler make this engine still stronger than the preceding. The weight on the driving axles rises to what in European practice would be the unprecedented amount of 19 tons. These locomotives are used to haul the fastest train in the world between New York and Buffalo. The steam pressure is 200 lbs. per sq. in., the heating surface is 1,742 sq. ft. and the grate area is 30.1 sq. ft.

Fig. 17 is a 2/4 coupled express locomotive built by the Baldwin Locomotive Works, of Philadelphia, on the Vauclain system. The engine has four cylinders. Upon each side there is a small cylinder above a large one, the two are cast in one piece, and the steam is distributed in both by a single piston valve. The two piston-rods of each group take hold of a single crosshead, so that the steam works after the manner of a Woolf compound engine. In contradistinction to other American locomotives, these engines are not fitted with a bogie truck. The steam pressure is 190 lbs. per sq. in., the heating surface is 1,333 sq. ft., and the grate area is 24.7 sq. ft. (This is the "Columbia" locomotive, as most of our readers will recognize.—Ed.)

Fig. 18 is a 1/4 coupled compound locomotive of the Philadelphia & Reading R. R. This engine is also built on the Vauclain system. The driving axle is placed in front of the firebox, and carries the enormous weight of 21.6 tons. The firebox is placed above the back pair of wheels and occupies about one-half of the whole length of the locomotive. The grate is separated from the tubesheet by a firebrick bridge, so that a combustion chamber is formed in which the gases from the fire are mingled with the air, and these, with the particles of coal carried with them, are thus perfectly burned. The grates are slightly inclined and are formed of water-tubes, between each alternate one of which there is a bar of hard cast iron. The closed ashpan is opened from the rear. The position of the engineer is separated from that of the fireman.

Fig. 19 is a 2/3 coupled compound locomotive of the Prussian State Ry. The cylinders are back of the leading axle, and it is the rear wheel that serves as the main driver. The valve motion is of the Heusinger type; the receiver pipe is laid around the shell of the boiler. The steam pressure is 180 lbs. per sq. in., the heating surface is 1,110 sq. ft., and the grate area 20.1 sq. ft.

Fig. 20 is a 2/3 coupled express locomotive of the Great Eastern Ry. For a long time this type of locomotive was the principal one used for express service in England. The cylinders are inside. The frames are outside. The springs are perfectly independent of each other. The steam pressure is 180 lbs. per sq. in., the heating surface is 1,290 sq. ft., and the grate area 18.3 sq. ft.

Fig. 21 is a 1/4 coupled express locomotive of the Great Northern Ry. of England. The driving axle of this engine carries 18 tons, so as to obtain the necessary adhesive weight for starting. Such an exceptional loading as this is only allowable upon an exceedingly well built permanent way. In spite of the small dimensions of the boiler, the engine is comparatively heavy, 74,400 lbs. The cylinders are outside, and the driving wheels, with a diameter of 8 ft. 2 ins., are the largest in the world. The steam pressure is 170 lbs., the heating surface is 1,025 sq. ft., and the grate area 17.7 sq. ft.

Fig. 23 is a 2/3 coupled passenger locomotive of the Prussian State Ry. This type of engine is still extensively used upon the railroads of Continental Europe. The cylinders are upon the outside and the frames and steam chests on the inside. This very simple construction labors under the disadvantage that, on account of the location of the heavy cylinders at the front end, the running of the machine is unsafe and the track must necessarily be very rigid. The valve-motion is of the Allen type. The crown of the firebox is held by radial stays. The steam pressure is 180 lbs. per sq. in., the heating surface is 1,107 sq. ft., and the grate area is 19.4 sq. ft.

Fig. 24 is a 2/2 coupled locomotive for mixed service on the Oldenburg State Ry. Owing to their lack of stability and their small tractive power, these engines are but little used. The steam pressure is 180 lbs. per sq. in., the heating surface is 1,007 sq. ft., and the grate area is 10.1 sq. ft.

Fig. 26 is a 3/4 coupled compound passenger locomotive of the Jura-Simpton Ry. The several Swiss railway companies make a very frequent adaption of that American type of locomotive known as the mogul, since it is very well fitted to work on lines with heavy gradients. It has three axles coupled, and one located in front ahead of the cylinders. The steam works in two cylinders only; and, by means of an automatic starting valve of the von Borries type, live steam may be admitted direct to the low-pressure cylinder. The cylinders and their steam chests are upon the outside. The springs of the first and second wheels are connected by a longitudinal and a cross equalizing lever; while those of the third and fourth axles are connected by equalizers at the sides. The steam pressure is 180 lbs. per sq. in., the heating surface is 1,209 sq. ft., and the grate area is 16.1 sq. ft.

Fig. 27 is a 3/4 coupled passenger locomotive of the Belgian State Ry. The engine is remarkable for its weight, and is used for hauling heavy express trains upon

*This was probably intended for 2.2 tons.—Ed.

difficult stretches of track. The very wide and very shallow firebox lies above the back axle, and has a firebrick bridge in front of the tubesheet, which is rendered necessary by the high grate. The Heusinger valve-motion is used. The cylinders are inside the frames and inclined. The support is from four points. These engines are capable of hauling 100 tons up a grade of 1 in 60 at a speed of 40 miles an hour.

Fig. 28 is a 3/5 coupled four-cylinder, compound, express locomotive of the Baden State Ry. It is used for work on the long grades in the Black Forest. Here a locomotive of the "ten-wheeled type" was chosen, which is distinguished from the mogul by having a four-wheeled truck in front. The steam works in two high and two low pressure cylinders, as in the French compound locomotives. These locomotives were built by the Société Alsacienne, with the French engine as a pattern. The steam pressure is 180 lbs. per sq. in., the heating surface is 1,204 sq. ft., and the grate area is 22.6 sq. ft.

Fig. 29 is a 3/5 coupled express locomotive of the Canadian Pacific Ry. This engine is a sample of the "ten-wheeled" type. All of the details are the same as those given for Fig. 15, with the exception that the crownsheet of the firebox is carried by crown bars. The steam pressure is 190 lbs. per sq. in., the heating surface is 1,344 sq. ft., and the grate area is 25.8 sq. ft.

Fig. 30 is a 4/6 coupled express locomotive of the Chicago, Milwaukee & St. Paul Ry. In order that the weight on the driving wheels might not be excessive, a third trailing axle is placed at the rear. This engine, which is the most powerful express locomotive that has up to this time been put into service, carries a steam pressure of 210 lbs. per sq. in., has a heating surface of 1,774 sq. ft., and a grate area of 33.3 sq. ft.

Fig. 32 is a 3/5 coupled locomotive of the Mediterranean Ry., of Italy. This engine was built as a ten-wheeler in order to climb the steep grades of the Apennines. The frames are inside and the cylinders and the steam chests outside.

Fig. 34 is a 3/5 coupled express locomotive of the Hungarian State Ry. This engine was built for the same service as the preceding, but with a compound action. The frames are outside and the boxes of the cranks play in them. The steam pressure is 195 lbs. per sq. in., the heating surface 1,530 sq. in., and the grate area 32.3 sq. ft.

II.—Freight Locomotives.

In order to utilize the whole weight of the locomotive for tractive purposes it is customary in Europe to couple together all of the wheels of their freight locomotives; in America, on the other hand, it is the practice to place a pair of leading wheels or a bogie truck in front, whereby the running of the engine is made much smoother and the motion on sharp curves easier. The number of coupled axles varies from three to five. Upon European roads with heavy grades, 3/3 or 4/4 coupled engines prevail, the latter being the ruling type for steep gradients in Austria, France and Russia. In England the Northwestern is the only road having 4/4 coupled locomotives, the other companies using the 3/3 coupled. In Germany and France they have now made some headway in the introduction of the 3/5 coupled locomotives, with a bogie truck at the front, in imitation of the practice of the United States. In America there are two types in use: the 4/5 coupled locomotives, known as the "consolidation" type, and the "mastodon" type, having five axles coupled. By the use of two sets of working parts with three axles coupled, as in the Meyer, Fairlie and Mallet systems, a still higher tractive power is obtained. The Hagan system has a strong and flexible mechanism.

Fig. 22 is a 3/3 coupled freight locomotive of the Lancashire & Yorkshire Ry. The noteworthy peculiarities of this locomotive are the shortness of the boiler, the long wheel-base, and the position of the cylinders inside the frames. The valves are placed on top of the cylinders and are driven by the Joy valve motion. There are no overhanging weights and, in spite of the long wheel-base, the engine rides very easily. The steam pressure is 170 lbs. per sq. in., the heating surface is 1,099 sq. ft., and the grate area 18.3 sq. ft.

Fig. 31 is a 3/3 coupled compound freight locomotive of the Austrian State Ry. For a number of years the 3/3 coupled freight locomotive was the only one used on the moderately heavy grades. Now they are only used on branch lines, since their short wheel-base and overhanging weights unfit them for speeds of more than from 28 to 30 miles an hour. The locomotive shown has a high tractive power; the starting apparatus is of the Golsdorf type, with valves driven by an outside Heusinger motion. The steam pressure is 180 lbs. per sq. in., the heating surface 1,290 sq. ft., and the grate area 12.9 sq. ft.

Fig. 33 is a 3/3 coupled locomotive built by the Schenectady Locomotive Works. This locomotive is used in America for switching purposes in railway yards, and is provided with a tender having a sloping tank at the back.

Fig. 35 is a 3/4 coupled compound freight locomotive of the Prussian State Ry. Like the mogul type of engines on the American roads, these engines have a single pair of wheels in front of the cylinder, and, on account of their weight, they are especially fitted for the hauling of fast freight as well as passenger trains on steep grades. The boiler, with its heating surface of 1,481 sq. ft., is very large, and the firebox is placed above the back axle. Both cylinders are on the outside; the steam pressure is 180 lbs. per sq. in., and the grate area is 24.7 sq. ft.

Fig. 36 is a 3/4 coupled freight locomotive of the Great Northern Ry. These locomotives resemble other American passenger locomotives in their construction, so that what has already been said of them need not here be repeated. Their steam pressure is 190 lbs. per sq. in., the heating surface is 1,236 sq. ft., and the grate area 21.3 sq. ft.

Fig. 37 is a 4/6 coupled freight locomotive of the Duluth & Iron Range R. R. The tractive power of this locomotive is very great, and the use of a four-wheeled truck causes it to take curves very easily. It is used for hauling iron ore in the Lake Superior region. The steam pressure is 190 lbs. per sq. in., the heating surface is 2,171 sq. ft., and the grate area 34.4 sq. ft.

Fig. 38 is a 4/5 coupled freight locomotive of the Prussian State Rys. In the 4/4 coupled Prussian locomotives the distribution of the weight is not particularly favorable, a fifth axle running in a truck has, therefore, been added. The cylinders are outside and slightly inclined. The valves are driven by an Allan motion placed inside the frames. The springs of the driving wheels are connected in pairs by equalizers. The steam pressure is 180 lbs. per sq. in., the heating surface is 1,484 sq. ft., and the grate area is 24.6 sq. ft.

Fig. 39 is a 4/4 coupled freight locomotive of the Austrian State Rys. Although belonging to an old system, this engine is still extensively used in Austria. The steam pressure is 165 lbs. per sq. in., the heating surface is 1,769 sq. ft., and the grate area is 24.6 sq. ft.

Fig. 40 is a 4/4 coupled, compound, freight locomotive of the Paris, Lyons & Mediterranean Ry. The engine has four cylinders, arranged with the low pressure cylinders (diameter 23.2 ins.) outside and the high pressure (diameter 14.2 ins.) inside. The Serve tubes have inner ribs, an outside diameter of 2.46 ins., and a length of but 9 ft. 10 ins. The driving wheels have a diameter of 59 ins., which is larger than that usually employed on freight locomotives. As a consequence of the use of the Serve tubes, the heating surface is comparatively large, 1,656 sq. ft., the grate area is 27.8 sq. ft., and, in all of the new locomotives of this company, the steam pressure is 225 lbs. per sq. in.

Fig. 41 is a 4/5 coupled compound locomotive of the Mohawk & Malone R. R. The arrangement of the axles is similar to that of the Prussian locomotive, Fig. 38. The locomotive is a characteristic example of the consolidation type. The steam pressure is 190 lbs. per sq. in., the heating surface is 1,838 sq. ft., and the grate area 32.3 sq. ft.

Fig. 42 is a 4/4 coupled compound locomotive of the Prussian State Rys. The first locomotive in Prussia with four axles coupled and intended for heavy freight service on steep grades was built in 1894. The frames are inside and the firebox is placed over the rear axle. The engine is fitted with the Allen valve motion, and, for starting or the exertion of the maximum tractive force, it is fitted with a von Borries intercepting valve. The cylinders have a diameter of 20.87 ins., and 29.53 ins., with a stroke of 24.8 ins. The other measurements are the same as in Fig. 38.

Fig. 43 is a 5/5 coupled compound freight locomotive for the Wurtemberg State Ry. The peculiarity of this locomotive consists in the fact that the two end axles can move into a radial position with reference to a curve, and, yet, are coupled together. This result was obtained by the use of the Klose system. The steam works in the three cylinders either with single expansion or on the compound principle. The steam pressure is 180 lbs. per sq. in., the heating surface is 2,129 sq. ft., and the grate area is 23.7 sq. ft.

Fig. 44 is a 5/6 coupled, compound, freight locomotive of the Erie R. R. This enormous engine was built by the Baldwin Locomotive Works, and it is intended for the Pennsylvania coal traffic. It is built on the Vauclain system, with one cylinder over the other. The diameter of the high pressure cylinders are 16 ins., diameter of the low-pressure cylinders 28 ins., and stroke of the piston 27 ins. The number of coupled axles and the weight put upon them (16 tons per axle) do not indicate good design. The firebox is very large and very long, is of the Wootten type, and is adapted to the burning of anthracite culm. As a result of their great length the engineer is stationed alongside the boiler, and there is another cab for the firemen at the back. The separation of the two men is a great disadvantage.

Fig. 45 is a 2/2 coupled compound freight locomotive of the Prussian State Ry. The frames are carried on two swivel trucks. The forward truck carries the low-pressure and the back the high-pressure cylinders. The parts of the engine proper are entirely separated from each other. The springs of each truck are connected by equalizing levers, so that the weight on the individual axles remains unchanged and the locomotive is carried on four points. This engine possesses great tractive power and flexibility. The steam pressure is 180 lbs. per sq. in.; the heating surface is 1,559 sq. ft., and the grate area is 20.4 sq. ft.

III.—Tank Locomotives.

The arrangement and proportions of tank locomotives vary according to the service for which they are intended. Tank locomotives are built either with ordinary frames or on the Krauss system whereby the frames are so arranged as to form the water tank. This portion of the review will be divided into two heads, in the first of which those tank locomotives intended for main line traffic will be described, and in the second those designed for branch lines.

(a).—Main Line Locomotives.

Fig. 46 is a 2/3 coupled passenger, tank locomotive of the Prussian State Ry. These engines, with ordinary plate frames and side water tanks, are used in passenger traffic on lines where the grades are light. The ease of running is injured by the weight of the overhang. The steam pressure is 180 lbs. per sq. in.; the heating surface is 968 sq. ft., and the grate area is 17.2 sq. ft.

Fig. 47 is a 2/3 coupled passenger tank locomotive of the Hanoverian Rys. The arrangement of the cylinders back of the leading axles in connection with the long wheelbase insures a very easy motion for the engine. The water tanks form a portion of the frames. The steam pressure is 180 lbs. per sq. in.; the heating surface is 807 sq. ft., and the grate area is 15 sq. ft.

Fig. 49 is a 2/4 coupled, compound passenger tank locomotive of the Central Ry. of Switzerland. The application of the bogie truck to tank locomotives has also been made in England, and the north of France, as well as in Switzerland. The engine shown here has ordinary frames with side water tanks. The steam pressure is 180 lbs. per sq. in.; the heating surface is 1,043 sq. ft., and the grate area, 17.2 sq. ft.

Fig. 50 is a 2/4 coupled passenger locomotive of the South Eastern Ry. The passenger traffic within the city limits of London requires a rapid acceleration, and the locomotive here shown is intended to do this. The tractive power is 10,230 lbs.; the steam pressure, 170 lbs. per sq. in.; the heating surface, 714 sq. ft. and the grate area, 15 sq. ft.

Fig. 51 is a 2/4 coupled freight locomotive of the London City Ry. A long wheelbase is obtained by placing the axles at either end of the firebox, which is 6½ ft. long. The cylinders are outside and inclined. When running through the tunnel the steam is exhausted into the feed-water, whence it naturally follows that the boiler must be fed by pumps. Since the running is done for the most part in tunnel, no shelter is provided for the engineer.

Fig. 52 is a 2/5 coupled freight locomotive of the London, Tilbury & South End Ry. It is designed for special freight traffic on lines with light rails. It runs in either direction with equal facility and readily passes around curves of short radius. The front end of the engine is carried by a bogie truck, and the back end by a single axle, which is held in position by springs. The steam pressure is 170 lbs. per sq. in.; the heating surface, 919 sq. ft., and the grate area, 15 sq. ft.

Fig. 53 is a 3/3 coupled passenger tank locomotive of the Western Ry. of France. The constructive proportions of the engine are good; it resembles the English types in size and appearance. Its three coupled axles enables it to work successfully upon steep grades. The steam pressure is 150 lbs. per sq. in.; the heating surface is 968 sq. ft., and the grate area is 14 sq. ft.

Fig. 54 is a 3/7 coupled passenger tank locomotive of the Chicago & Northern Pacific R. R. The engine is of the Forney type, and is used for suburban traffic out of Chicago. The weight in working order is 71 tons. Similar engines are now extensively used in the suburban traffic about other large American cities. The steam pressure is 190 lbs. per sq. in.; the heating surface is 1,462 sq. ft., and the grate area is 22.6 sq. ft.

Fig. 55 is a 3/4 coupled compound freight locomotive of the Prussian State Ry. The engine was designed to meet the requirements of a fast freight service and heavy passenger traffic upon steep grades. The boiler has a heating surface of 1,481 sq. ft.; a grate area of 24.7 sq. ft., and carries a pressure of 180 lbs. per sq. in. The forward axle is carried in a curved box in such a way that it has some side play.

Fig. 56 is a double 2/2 coupled freight locomotive of the Central Ry. of Switzerland. It is built on the Mallet system. The engine has a tractive power of 20,550 lbs. It is used on the line between Basle and Olten.

Fig. 57 is a double 3/3 coupled freight locomotive of the St. Gothard Ry. On the St. Gothard Ry. there are long grades of 1.4% and over, with curves of 1,000 ft. radius. Until recently two 3/3 coupled locomotives were always used for working trains over these grades, but they have now been supplanted by the locomotive here shown, which is a Mallet compound engine. The total wheelbase is 26 ft. 8 ins. The tractive power reaches the remarkable figure of 22,000 lbs. As the result of its great adhesive weight, it can haul a train of 220 gross tons up a 1.37% grade.

(b).—Tank Locomotives for Narrow Gage Lines.

Fig. 48 is a 1/2 coupled compound locomotive of the Hanoverian Ry. The engine has box frames, Heusinger valve motion, and the von Borries automatic intercepting valve. The steam pressure is 180 lbs. per sq. in.; the heating surface, 371 sq. ft., and the grate area, 8.6 sq. ft.

Fig. 58 is a 4/4 coupled tank locomotive of the Hagans type. It is designed for a gage of 2 ft. 11.4 ins., and to work on grades of 1.4%, and around curves of 130 ft. radius where it can haul 114 tons. The two forward axles are set in the main frames, while the two back ones are in a swivel truck. The Heusinger valve motion is used; the water tanks and coal bunkers are on the side next to the boiler, which carries a steam pressure of 180 lbs. per sq. in.; has a heating surface of 548 sq. ft., and a grate area of 9.1 sq. ft.

Fig. 59 is 2/2 coupled tank locomotive of the Emmenthal Ry. This system has been extensively introduced into Switzerland on account of its great simplicity. The engine works with a steam pressure of 150 lbs. per sq. in.; has a heating surface of 408 sq. ft., and a grate area of 7.5 sq.ft.

Fig. 60 is a 2/3 coupled locomotive of the Prussian State Ry. It is designed for work on branch lines at speeds of 18 miles an hour and over. The engine has a boiler that carries a pressure of 180 lbs. per sq. in.; has a heating surface of 817 sq. ft., and a grate area of 15 sq. ft.

Fig. 61 is a 3/3 coupled locomotive of the Northern Ry. of Austria. In spite of its light weight (28 gross tons) it has a tractive power of 8,800 lbs. The steam pressure is 165 lbs. per sq. in.; the heating surface, 580 sq. ft., and the grate area, 10.75 sq. ft.

Fig. 62 is a 3/4 coupled locomotive of the Prussian State Ry. On the line between Wiesbaden and Langenschwalbach there are grades of 1 in 30. These strong engines were built for such steep grades. The back axle runs in curved boxes and has some side-play. The engine is usually built with plated frames, side water tank, an outside Allan valve motion, and the air brake. The steam pressure is 180 lbs. per sq. in.; the heating surface is very large, being 1,450 sq. ft., and the grate area is 18.3 sq. ft.

Fig. 63 is a double 2/2 coupled compound locomotive of the State Ry. of Saxony. The Meyer system, upon which this engine is built, differs from the Mallet system in that each steam truck is free to turn over a center plate having a smooth upper surface. The engine, therefore, runs more easily over sharp curves, but it requires more joints in the steam pipes. The steam pressure is 180 lbs. per sq. in.; the heating surface is 925 sq. ft., and the grate area, 15, sq. ft.

THE ADOPTION OF A STANDARD KNUCKLE FOR M. C. B. COUPLERS.*

By P. H. Peck.†

I will give the Club facts and figures, gathered by close observation during the past seven years in heavy interchange of cars, to show why a standard knuckle should be adopted by the M. C. B. Association. If it were not for the interchange of cars by railways, the Interstate Commerce Commission and M. C. B. rules or standards would not be necessary. The more cars interchanged, the more standards are required in order that the cost of repairs may be kept at a minimum, and switching and delay to traffic avoided. As the volume of interchange has increased, new difficulties and dangers have arisen, and the M. C. B. Association was organized to devise means for overcoming these difficulties and dangers and the annoyances occasioned thereby. Rules governing the interchange were framed and standards adopted, and the adoption by the Association was followed by legislation on the part of both the state and national governments to compel the use of the standards.

We have standards for many parts of trucks, and standard drawbars, but the latter ends at the contour lines, leaving the most essential feature, the knuckle, not standard. The knuckle receives the shock first and is, therefore, most likely to be injured, and for this reason, if for no other, it should be interchangeable. Delays of several hours are frequently caused by having to set a car on the repair track to change the bar, because there may be no knuckle at hand which will fit the coupler head. With the link and pin bar such delays would not occur.

During the last few months I have endeavored to secure the names of the different knuckles in use at the present time and the numbers of different designs furnished by each coupler company. The result was a surprise to me. The following statement represents the result of my efforts in the direction referred to:*

M. C. B. Couplers and Knuckles in Use.

Weight of knckls, lbs.	Name of coupler.	Number of knuckles.	Weight of knckls, lbs.	Name of coupler.	Number of knuckles.
46	American	2	51	Erie	1
	Ajax	1	41	Elliott	1
49	Barfield	1		Foster	1
	Barnes	1	49	Forsyth	1
	Brown	1		Fox	1
54	Burns	1	38	Gould	1
46	Buckeye	3	38	Gallager	1
	Cowell	1		Gifford	1
48	Columbia	1		Gelston	1
51	Chicago	2	51	Hinson	2
35	California	1	41	Hinson	0
40	Champion	1	38	Hien	2
	Deetz	1		Imperial	1
64	Dowling	2	40	Interstate	1
57	Dowling	0	37	Janney	1
60	Drexel	2	37	Johnson	1
45	Detroit	1		Kling	1
43	Diamond	1		Laburt	1
52	Excelsior	1	61	Ludlow	1
	Edwards	1	50	Lone Star ...	1
36	Empire	1	50	Little Delaw're	1
42	Eureka	1	49	Mo. Pacific ...	2
37	Mather	1	54	St. Louis	2
48	Murphy	1	47	Smith	1
	Marks	1	66	Stand. improvd	1
53	New York	1	53	Smillie	2
43	National	1	51	S. H. & H.....	1
	Price	1	51	Safety	1
38	Pooley	1	50	Talbot	1
49	Perfected	1	50	Trojan	1
	Paragon	1	53	Tower	2
39	Peerless	1	50	Thurmond	2
	Pacific	1	46	Taylor	1
	Rickison	1		Timms	1
55	Standard	1		Union	1
49½	Solid	1	50	Vandorston ...	1
	Shomaker	1	34	Williams	3
	Saams	1	40	Williams	0
	Springer	1	45	Williams	0
	Simplex	1		Walker	1
			50	Washhurn	1

*Abstract of a paper read at the October meeting of the Western Railway Club.

†Master Mechanic, Chicago & Western Indiana R. R., Chicago, Ill.

*We believe that some of the couplers included in this table are not of the M. C. B. type.—Ed. Eng. News.

This is a total of 77 bars and 83 knuckles; 9 bars having 2, and 2 bars having 3 knuckles each, and in only one instance will the knuckles interchange with each other. The average weight of the 56 knuckles, the weight of which is known, is 48 lbs.; the heaviest being the Standard, 66 lbs.; the lightest, the Williams, 34 lbs.

In order to have, in way cars or at interchange points, knuckles (one of each kind) averaging 48 lbs., it would require 4,464 lbs., which, at 3½ cts. per lb., would cost $156.24. To furnish one knuckle of each of the above kinds, at 16 different points and for 20 way cars, it would require 160,704 lbs., representing a value of $5,624.64.

I find, from the records kept in my office for the past 6½ years, that as the number of M. C. B. bars handled increased, the percentage of broken bars and of broken knuckles decreased, as shown by the following table:

Year.	M.C.B. bars.	No. cars to 1 bar broken.	No. cars to Knuckles broken.	Year.	M.C.B. bars.	No. cars to 1 bar broken.	No. cars to Knuckles broken.
1892...	8%	377	2,476	1896...	42%	996	2,345
1893...	15%	385	1,684	1897...	48%	1,240	2,573
1894...	20%	424	1,609	1898...	59%	1,872	3,047
1895...	28%	620	1,663				

A large proportion of the breakage of knuckles occurs when an M. C. B. coupler is coupled with a link and pin bar, such breakages being most likely to occur in heavy trains. In some cases the coupling is made by the pin being placed through only the top hole of the knuckle and into the link; this either breaks the top lug off or breaks out the pin hole; in other cases the knuckles may be broken when two cars strike together and both knuckles are closed. Very few M. C. B. bars are broken when two of these bars are coupled together. Included in our own equipment we have 88 cars and 22 locomotives equipped with M. C. B. couplers; 32 cars equipped last year and the locomotives equipped within the last eight months. As yet we have had but one knuckle broken (that on a car) and that was caused by an accident. One of the engines equipped in this manner is double-crewed most of the time for service both night and day. This serves to illustrate that fact that the proportion of breakage to M. C. B. couplers on switching roads is much less than many believe to be the case.

I do not find, in actual practice, the trouble anticipated by Mr. P. Leeds, in his paper before the Central Association of Railroad Officers, as published in the "Railroad Gazette," of Aug. 12, 1898, viz.: Flange wear or crowding the flanges against the rail, or that the bar is not strong enough for our modern 80,000 and 90,000-lb. capacity cars. We handle hundreds of these cars and the number of breakages of couplers is no greater than with other cars. We do find, however, that when these heavy cars strike very hard, the load shifts, in some instances forcing the end out of the car, but not breaking the bar. I have seen cases of rear-end collisions and trains breaking in two, and have found that in such accidents the damage to M. C. B. bars was not one-fourth as great as that to link and pin bars. Cars are not as liable to telescope when equipped with M. C. B. couplers as when equipped with link and pin drawbars.

In regard to the handling of passenger equipment, we have five roads for whom we do the switching at Dearborn St. station, four of which use the M. C. B. bars, the fifth the Miller hook bar. It is possible to couple the M. C. B. couplers on short curves where the same is impossible with the Miller hooks. We have two engines equipped with the M. C. B. couplers in this service and we are able to couple the engine to M. C. B. bars at points where it is impossible to couple the Miller, with link and pin.

Finally, the trucks, draft rigging, drawbar stops, uncoupling levers and knuckle should be standard and interchangeable. The knuckle, most important of all, should receive immediate attention by the M. C. B. Association, and either the patent rights of a knuckle should be purchased by the Association, or six or seven of the best knuckles at present on the market should be adopted as standard; there are, at least, six or seven which are first-class. If something like this is not done before the law goes into effect, we will soon be in worse trouble in interchanging cars than we were in with the link and pin. A cored or hollow knuckle should not be considered; such knuckles are of no value whatever. It is only 14 months to the time the law takes effect, and something along the lines indicated in the foregoing should be done without delay.

Discussion.

Mr. Ira C. Hubbell (K. C., P. & Gulf Ry.).—I hope that the Western Railway Club will voice itself unanimously in favor of a standard knuckle, and also demand a reasonable, uniform price to all lines on all M. C. B. couplers.

Mr. Gustav Giroux (C., B. & Q. R. R.).—A point that ought to receive some attention soon, is the amount of play that can be allowed around the contour line before the coupler becomes unsafe. There is an M. C. B. gage that gives a minimum and maximum limit to this play, and its use is required by a few roads when buying new couplers; but is there no limit to this play after the coupler is put in service? There are hundreds of couplers in service which do not pass or meet the requirements of the M. C. B. gage.

It will pay to get couplers fitted together in a better manner and with as little lost motion as possible, because we all know a coupler wears loose too soon. Require that the contact parts of the coupler be smooth and clean, free from sand, grit or scale, and the coupler will work easier. I think that it would be much better for all roads to request the manufactureres not to paint couplers, but to put the cost of painting into producing smoother and cleaner castings and fitting the same together with more care; this would enable us to see who are turning out the best castings.

I hope that a standard diameter and length of pivot pin will be adopted; we now have pins 1¼, 1⅜, 1½ ins. diameter and find couplers made for 1½-in. pivot pin repaired with pins 1⅜ or 1¼ ins. in diameter. Again, if a cotter or split key is put through the lower end of the pivot pin, I think we would not hear of so many pivot pins working out of place. I have seen a round coupling pin used for a pivot pin; also a knuckle of a certain coupler put in a bar of a different make; I have known repairs similar to the latter to cause breaks in the train three times in a distance of 38 miles.

I hope that the M. C. B. Association will get out very soon a standard specification, specifying not only what kind of a test couplers shall stand, but also specifying the length of guard arm, amount of play around contour lines (not only for new couplers but also for couplers in service), diameter and length of pivot pin and diameter of hole, thickness of knuckle through pivot-pin hole. and distance between lugs of bar, and that all parts shall be plainly marked at a specified place in such a manner as to enable ordering parts for repair.

Mr. A. M. Waitt (L. S. & M. S. Ry.).—I think no one will question the desirability of having a standard knuckle for couplers, but I think many will question the probability that we shall ever enjoy such good fortune. Mr. Peck has shown, in the table given in his paper, the great variety of knuckles, and, excepting two, none are interchangeable with those of other makes. On this account it seems to me that we are a long distance from anything like uniformity. I think that it would not be practicable to attempt voting into existence anything in the way of a standard coupler or a standard knuckle. It seems to me that uniformity in the M. C. B. couplers, or in the knuckles, can be accomplished only gradually and by educating people to appreciate what is the best. I believe we can, however, go a great way toward eliminating the poorer class of couplers and knuckles, either by bringing about the survival of the fittest, or in some other way reduce to a few the number of couplers in the market. That can only be done, I believe, by adopting a specification of some kind.

Mr. Peter H. Peck (C. & W. I. R. R.).—The solution that Mr. Waitt offers is one I have had in view, namely, accepting five or six couplers as standard. In the present state of affairs, roads that are using good couplers pay for the bad couplers. Mr. Waitt might, as he thinks, be using the best coupler, and Mr. Mackenzie might be using another best coupler; but if their cars get on a road which has a cheap coupler that was removed on account of a broken knuckle, the inspector will get rid of the bad coupler by replacing it with a good one, and the road using the good coupler has to pay for the bad one.

Mr. John Mackenzie (N. Y., C. & St. L. Ry.).—I think the larger roads are adopting what we may call a fairly good coupler. When an undesirable coupler is broken, a second-hand good coupler may be used in replacement and the undesirable ones will be driven out gradually, and it will be possible to carry less stock for repair.

Mr. Clement F. Street ("Railway and Engineering Review").—A few years ago a number of public tests were made by committees from this club and from the Master Car Builders' Association, which brought out weak points in some of the couplers submitted. Immediately after the tests several manufacturers started their pattern makers and engineers to work making changes which were beneficial not only to themselves, but also to the railway companies. These tests have undoubtedly aided in driving from the market a number of undesirable couplers, and it would seem to me that the revival of this practice would eliminate some of the poor couplers which are being used.

Mr. F. A. Delano (C., B. & Q. Ry.).—I agree with what has been said in regard to the impracticability of adopting even five or six standard knuckles. The Interstate Commerce Commission is flattering itself that it is compelling the use of an automatic coupler; and yet, if you talk to trainmen and switchmen, you will find that they do not regard the M. C. B. coupler as an automatic coupler. They will tell you that they have to ride the cars, both to couple and uncouple them, and to hang on by their eye-teeth to hold up the pin and to insure that the cars will uncouple while in motion. Surely, that is not the kind of coupler that the Interstate Commerce Commission thinks it is compelling the roads to put on. I would suggest the appointment of a committee to look into the whole question of better standards for couplers.

Mr. H. R. Curtis (Latrobe Steel & Coupler Co.).—I think a great deal of the fault found with automatic coupler equipment is not due to the non-education of the Interstate Commerce Commission, but to the fact that a great many railways have followed the practice of buying and applying the cheapest coupler on the market. If the railways of the country had adopted and adhered to a standard test, they would not have had one-third of the many makes of automatic couplers that are now in service.

After further discussion the President was instructed to appoint a committee to investigate the general subject of standards for M. C. B. couplers. The committee appointed was composed of Messrs. Delano, Peck, Barr, Mackenzie and Fildes.

CONCRETE AND STEEL FLOORS FOR THE PETIT PALAIS DES BEAUX ARTS, PARIS EXPOSITION OF 1900.

This smaller palace of the fine arts occupies part of the site of the old Palais l'Industrie on the right bank of the Seine, in Paris. The basement and lower floors of this structure are interesting as examples of the Hennebicque system of floor construction in "armed-beton," or concrete and steel. The advantages claimed are that—with equal weights imposed, it has superior resisting qualities over floors made of iron and brick; and it is also expected to last longer than these because the iron employed is protected against rust by being completely embedded in beton. As described in "Le Genie Civil" these floors are of several types differing with their span.

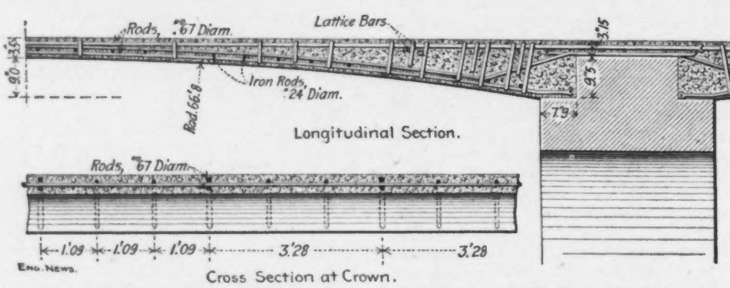


FIG. 1.—HENNEBICQUE ARCH SYSTEM OF STEEL AND CONCRETE FLOOR CONSTRUCTION FOR THE PETIT PALAIS DES BEAUX-ARTS FOR THE PARIS EXPOSITION OF 1900.

For the smaller arches of 20-ft. span (Fig. 1) the beton mass presents a flat extrados, and an intrados that, with a rise of 9 ins., has a thickness of 3½ ins. at the crown and 12½ ins. at the springing point. For the larger spans of 24.11 ft. (Figs. 3 and 4) a series of armed-beton beams are used, 1.08 ft. wide by 1.41 ft. high, placed 7.6 ft. apart on centers; these beams support a floor of armed-beton of a constant thickness of 4 ins. The beams and floor are built separately, but form one mass.

The loads which these floors should carry are estimated as follows:

For the arched floor:	
Free load	1,540 lbs.
Flagging	220 "
Total per sq. meter	1,760 lbs.
Total per sq. ft.	163.6"
For the floors with beams:	
Free load	2,200 lbs.
Flagging	220 "
Total per sq. meter	2,420 lbs.
Total per sq. ft.	225 "

These floors are to be tested by proof loads equaling one and one-half times these values; the rise must not exceed 1-800th of the span. A test of one of the floors with beams was made by loading it with 90,200 lbs. per beam, the equivalent of about 494 lbs. per sq. ft., and the maximum deflection at the crown was .9 mm.

As shown in Fig. 1 the armor in the arched type of floor is made of a series of beams placed at right angles to the axis of the arch and spaced one meter, or 3.28 ft. apart. Each of these beams is formed of two round iron rods, 17 mm. or .67-in. diameter; one of these rods is horizontal and only a few millimeters below the surface of the floor, and is built into the supporting walls. The other rod takes the curve of the arch, it is buried very near the surface of the intrados of the arch, and its ends are also built into the wall. The beam is then completed by adding a series of flat iron lattices, 30 × 2 mm., uniting the two round rods and tying them into the mass of beton, as shown. Upon the curved member of the beam, or arch truss, at intervals of about 8 ins., are placed a series of iron rods, 6 mm. or 0.24-in. diameter, running parallel with the axis of the arch. These latter rods are 25.6 ft. long, and at their extremities they pass the adjoining rods for a distance of about 2.3 ft., so as to avoid all danger from any lack of continuity perpendicular to the axis of the arch. Upon these longitudinal rods other rods of the same diameter, and spaced 13 ins. apart, are laid perpendicular to the first, so as to form a kind of network.

In the beam type of floor (Fig. 2) there are two systems of arming; one applied to the beams and the other to the floor. In the beams the armor takes the form of three longitudinal beams, or trusses, arranged somewhat like those in a suspension truss. In each there are two round iron rods, about 1 in. diameter; with one located horizontally and near the lower surface of the beam, and the other lying almost upon the first at the middle of the span and then rising at each end to the upper surface of the floor. These two rods are anchored in the supporting walls and are united to each other and to the beton mass by a series of flat bars, as shown.

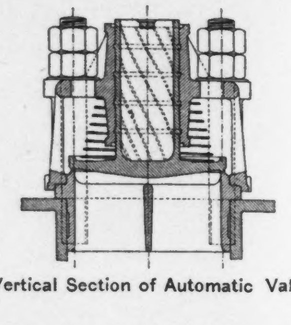
The armor in the floor portion is made up of a series of round rods, 0.47-in. diameter, placed perpendicular to the direction of the beam and spaced about 8 ins. apart. These rods, alternately, are straight and running near the bottom of the floor, and bent so as to pass from the bottom of the floor span to the top surface of this span.

The beton employed in this work was made of 550 lbs. Portland cement to 400 litres, or 422.4 quarts of sand and 898 quarts of gravel. This beton was made on the spot, and was then spread upon a wooden falsework, which forms the mold for the intrados of the arch, and was rammed against the iron armor placed in position in advance. When the arch was completed the beton was allowed to set for eight days, when its resistance was sufficient to allow the centers to be removed. At the end of 30 days the set was complete, and the floor was then ready to be subjected to the prescribed test load.

COMPOUND BLOWING ENGINE BUILT FOR THE HERNADTHALER IRON WORKS, KROMPACH, HUNGARY.

(With full-page plate.)

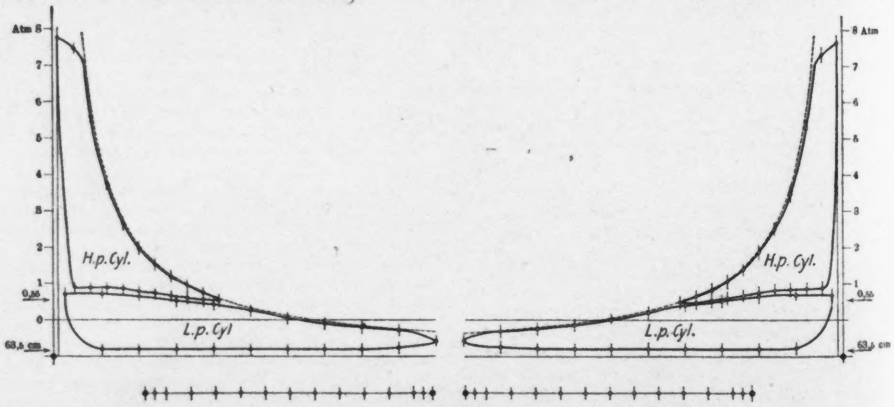
We show on our inset sheet this week an interesting horizontal blast furnace blowing engine built by the firm of Bolzano, Tedesco & Co., of Schlan, Bohemia, for the Hernadthaler Iron Works, at Krompach, Hungary. We have reproduced the engravings on our inset sheet, and those shown herewith from the "Zeitschrift des Vereines Deutscher Ingenieure," and the following description has been translated from the same journal by Mr. Geo. L. Fowler, M. Am. Soc. M. E.:



Vertical Section of Automatic Valve.

The specifications prepared by the purchasers of this engine required the valve-motion of the high-pressure cylinder to be controlled by a governor so that steam could be cut off up to half the stroke, or could follow the piston full stroke in starting the machine. Positive-moved valves were required on the air cylinders and they were to have a capacity of 28,250 cu. ft. of air per minute with the engine making 52½ revolutions, and a capacity of 26,840 cu. ft. per minute at 50 revolutions, and a maximum air pressure of about 10 lbs. per sq. in., the initial steam pressure being 112 lbs. and the steam expanding 8 to 1. The fly-wheel was to be so proportioned that the engine should run evenly and smoothly at 26 revolutions per minute, with steam of 82½ lbs. per sq. in., expanding 7 to 1, and the air pressure about 6.4 lbs. per sq. in.

As shown on the inset sheet, the engine is of the horizontal, cross-compound duplex type, and is fitted with Corliss valve-gear throughout. The cylinders are 35.43, 54.33 and 76.77 ins. diameter, with a common stroke of 55.12 ins. The piston rod of the air cylinder extends through the back head, and its weight and the weight of the piston is carried on slides in the front and rear of the air cylinder. The steam cylinders are jacketed, and the jacket is a riveted steel shell made in halves and secured to the cylinder, a special design of the builders. A reheating receiver is placed between the high and low pressure cylinders.



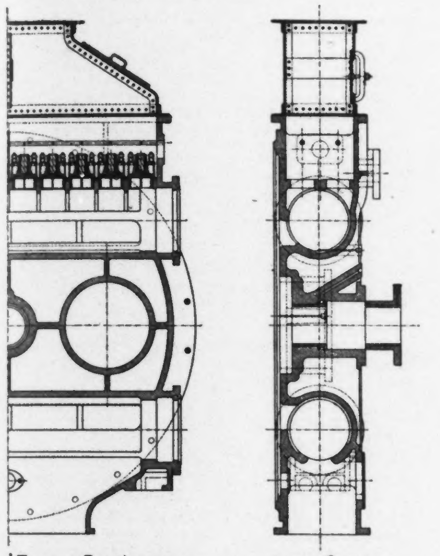
INDICATOR DIAGRAMS FROM STEAM CYLINDERS.

The valve gear is operated by three eccentrics, one driving the steam exhaust valves, one the steam admission valves, and the third the air valves. The valve motion is controlled by means of the Proell weight governor, which has two sliding weights. By changing position of these weights the speed of the engine may be varied about 10 revolutions per minute while the engine is in motion. By changing the driving wheel of the regulator while the engine is at rest a still further change in the speed is possible, and a total range of speeds of 33 to 53 revolutions per minute thus provided for. The low-pressure admission valves have a fixed point of cut-off.

A most interesting feature of the engine is the arrangement of the air valves. As already stated, these are driven by a valve-gear of the Corliss type. The air enters through ducts in the masonry foundation, passes up through the inlet valves at the bottom of the cylinders, and is expelled through exit valves at the top. Besides the positive moved valves, automatic spring-actuated valves are placed on top of the cylinder. There are 20 of these at each end of the cylinder. These valves are rotated as they rise and fall by helical guides in the casings in which they work. The sectional area of the air passages at different points are as follows:

	Passages— Inlet.	Outlet.	Check valves.
Total area, sq. ins.	325.6	279.0	379.8
Ratio to net cross-section air-cyl.	1 to 14	1 to 16.4	1 to 12
Vel. air at 33 revs., ft. per min.	70.8	83.0	60.7
Do. at 53 revs., ft. per min.	113.5	132.8	97.1

It may be noted that the above engine speeds correspond to piston speeds of 300 to 486 ft. per minute.



½ Transv. Section. Long. Section.

Sections Through Air Cylinder.

Tests of the engine were made before its acceptance by the purchasers, and the results are summarized as follows:

Date of test, Aug. 20, 1897. Duration, 9 h. 55 mins.

M. E. P., high-pressure cylinder, lbs. per sq. in.	29.1
M. E. P., low-pressure cylinder, lbs. per sq. in.	7.7
M. E. P., air cylinder, lbs. per sq. in.	5.6
Revolutions, per minute.	37.5
Power developed, high-pressure cylinder, HP.	304.9
" " low-pressure cylinder, HP.	333.0
" " total HP.	637.9
Work done in air cylinder, HP.	547.1
Efficiency, %.	85.75
Steam consumption, lbs. HP. hr., inc. jacket & recvr	15.25
Excluding jacket and receiver	13.93

The steam diagrams are herewith reproduced. The vacuum in the condensers amounted to only 25 ins. on account of the temperature of the injection water, which ranged from 64° to 68° F.* The temperature of the air above the pressure valves was 132.8° F.

The suction lines of the left-hand diagram from the air cylinder on the inset sheet show some irregularity, which investigation proved to be due to a temporary change in the inlet passage, which caused eddies in the air current. The reservoir into which the air cylinder discharged was also so small that the pressure in the air cylinder rose considerably during the period of delivery. When the machine was put into actual use, however, both these defects no longer existed, and the card taken from the air cylinder as run in actual service (the right-hand diagram in the inset) shows excellent work in both the intake and discharge of the air.

*This would not account for the low vacuum. A temperature of 70° corresponds to a vacuum of 29.2 ins. A temperature of 126° corresponds to a vacuum of 25.85 ins.—Ed. Eng. News.

RAILROAD SURVEYING IN TROPICAL FORESTS.

In a recent paper read before the Institution of Civil Engineers Mr. Frederic Shelford, Assoc. M. Inst. C. E., describes "Railway Surveying in Tropical Forests." This paper refers to rapid work performed in the location of railways in Africa, British Honduras and British Guiana. He divides the work to be done as follows: (1) The ride or march over several routes to determine the general route. (2) A reconnoissance survey, for approximate location on the route selected. (3) The location of the center line; with cross-sections of adjoining grounds. (4) The final staking-out.

The first rough survey is to gain general information concerning villages and towns, rivers and small water courses, notes on the geology of the country, a general idea of population, healthfulness of the country and general topography. A prismatic compass and aneroid are used, with distances estimated by noting the time of walking or riding. Rapid work is the essential point aimed at; but a trained observer can secure much valuable information in this way.

With the general route decided upon, a base is required to start the line. This is usually an existing path, road, timber pass or trade route; and the trade route or traveled path established by the natives, after long years of trial and the cutting of corners, is usually found to be the best for permanent location. As timber cutting is costly and occupies much time, it is to be avoided as much as possible. The instruments used were the miners' dial or compass, mounted on a stout tripod, with a plumb-bob and a ball-and-socket joint. This instrument costs only $30, so several may be taken along; it is light, and will stand rough treatment that would use up a more delicate instrument. The author says he never found a prismatic compass satisfactory; in hot, damp countries it becomes foul and slow in action and is apt to give false readings by the dial touching the top glass, when read several hundred times a day.

The chain used is a steel band tape, ⅝-in. wide, with the 1-10 meters marked by brass studs. This chain has no projections and will drag easily, but it must be constantly oiled to prevent rust. It is not very durable, but the author has used one tape in measuring 70 miles of railway.

The method of procedure is for one engineer to run the compass, and a reliable native is sent ahead as far as possible with a pole, other natives cut a pathway towards this pole until it can be seen from the compass. Trees are blazed and marked with a chalk at each turning. In bush country, 3 miles, 60 chains is a good day's work, as there is a long walk to camp and the work must be plotted in the evening. Distances are sometimes measured by a measuring wheel, though owing to rough and crooked paths this is not very accurate. Leveling is done by a dumpy level and two rodmen, with levels taken at every station and bench marks established. This leveling is done at about two-thirds the speed of running the line, and this gives the compassman one day in three for plotting work, etc. Cross-section lines are often surveyed by a pocket compass, fixed on top of a sharpened stick; and here an aneroid barometer is at its best for obtaining levels, as the whole line is measured in 20 or 30 minutes, and the atmospheric pressure has little time to vary.

Plotting the surveys, final location and staking-out for work, differ little from ordinary methods. The author reckons the cost of such surveys per mile, as follows, including instruments and equipment, but without traveling expenses to point of commencing work:

	Per mile.
Rapid reconnoissance survey of 200 to 400 miles; with a rough location of the railway, approximate estimate, statistics, etc.	$40.00
Cutting path through unknown forest, without roads or paths of any kind; with rough railway location.	70.00
Reconnoissance survey along trade routes; with numerous cross sections; careful location and leveling of line; close approximate estimate, etc.	80.00
Accurate reconnoissance survey; exact location of line; clearing the same, staking out, leveling, cross sections and complete working survey	$600.00 to 650.00.

These results are deduced from actual surveys made in very hilly countries, where railway location is troublesome.

An ingenious method of permanently marking stations was used in British Honduras, the chief object being to reduce the material transported to the smallest bulk. It should be understood that pencil or paint marks cannot be put upon a freshly cut and bleeding blaze on a young tree, so as to last any time. The plan adopted enabled the station marks to be found after the lapse of two or three years.

The marking was done with copper nails about 1½ in. long. These nails were driven in about halfway and then bent over in various directions, to indicate the numerals from 1 to 9 inclusive, according to an arbitary code. A blaze was first cut on the tree in the form of a cross. A nail in the center of the cross indicated units; one in the right hand upper arm, tens; left hand upper arm, hundreds; bottom left hand arm, thousands, and bottom right hand arm, tens of thousands. The bending of the nails to indicate numerals may be on any convenient system. In that used by the author, a nail bent up and to the right at an angle of 45° with the vertical represented 1; horizontally to the right, 2; bent down and to the right at 45°, 3; bent down on the vertical, 4; down to the left of the vertical and at an angle of 45°, 5; to the left, horizontal, 6; to the left and up at 45°, 7; up on vertical, 8; driven in straight, 9. For zero the nail was omitted. For example, the number 1,385 only required four nails; and as the full number was only marked at every tenth station, about 10 lbs. of copper nails were sufficient to mark 70 miles of line. For a reconnoissance survey by a party of two engineers not less than 30 men and 9 mules were required; or, if no mules were available, 57 men; 3 men being taken as the equivalent of one mule. For a staking-out survey, with numerous side lines to be cut and heavy clearing to be done, 80 men can be easily employed. In a rapid survey where the camp is moved about every third day, carriers are wanted in addition to the above. About 12 natives will be sufficient for shifting camp every third day. The march down country to Lagos, after finishing the survey, required 250 natives to carry five Europeans, three sick men and all stores, tools and camp equipment.

For a party of two engineers the following instruments were found suitable and sufficient for these surveys. Two miners' compasses on solid legs and of the plainest pattern; two 12-in. levels; two 16-ft. leveling rods; three steel tapes, ⅝-in. wide, on reels; three sets of steel pins; two pocket compasses; two paceometers; one measuring wheel; 36 ranging poles, 10 ft. long, and two 3-in. aneroids. For plotting work, they carried: Scales, set-squares, one protractor, one parallel ruler, two drawing-boards, sets of drawing instruments, etc. The cost of the equipment, for instruments only, was about $450.

Great care must be taken in selecting the equipment, as no useless articles should be carried; but to fail to bring some essential article may mean the failure of the whole expedition and the waste of much money. The equipment must be packed into loads according to means of transport. For a mule, this load must not exceed 30 × 15 × 12 ins., in dimensions, and weigh from 200 lbs. to 300 lbs. in a rough country. With native carriers the weight is more important than the bulk; and this weight should not exceed 50 lbs. for a long march, and 80 to 100 lbs. for a march of a few hours. Engineers for such expeditions need some medical and surgical knowledge, as accidents are frequent when timber is being felled.

BOOK REVIEWS.

ENGINEERING CONTRACTS AND SPECIFICATIONS.—A Brief Synopsis of the Law of Contracts and Illustrative Examples of the General and Technical Clauses of Various Kinds of Engineering Specifications. By Prof. J. B. Johnson, M. Inst. C. E., M. Am. Soc. C. E., M. Am. Soc. M. E., etc. Second edition. New York, N. Y.: Engineering News Publishing Co. Cloth; 6 × 9 ins.; pp. 452; $3.50.

The first edition of this now well-known work was reviewed at length in Engineering News of Aug. 15, 1895, and about all that is called for here is a brief mention of the additions and revisions which have been made in the present edition. These comprise for the most part a very complete set of specifications for the machinery, track and overhead construction of electric railways for both cities and country towns, these having been drawn by two of the leading engineers of the country in this class of work. The book has been improved in size and appearance, and taken altogether, as we said of the first edition, it should find a large field of usefulness among engineers and contractors.

THE UNIVERSAL DIRECTORY OF RAILWAY OFFICIALS. Compiled from official sources by S. Richardson Blundstone, Editor of "The Railway Engineer." London: The Directory Pub. Co., 8 Catherine St., Strand, W. C. 8vo.; cloth; pp. 475; 10 shillings.

This is the fourth annual issue of this directory and it contains about 25 pages more in the directory than last year. It is stated that with the exception of the African-German colonies, it is believed that information respecting every railway in Africa is now included in the Directory. We are compelled to judge the book, however, by its treatment of United States railways, and on these the editor appears to have drawn the line at about 250 miles. Companies controlling less mileage than this are generally not included. This omission must, of course, be intentional, as the publishers undoubtedly have access to the many excellent and complete directories of American railways which are published, and we suspect no better reason exists for it than disinclination to increase the size and cost of the book. To be really honest, the publishers should frankly state that railways of less than a certain size are not included, or else refrain from calling their work "The Universal Directory."

WATER SUPPLY AND IRRIGATION PAPERS OF THE U. S. GEOLOGICAL SURVEY.—No. 12, Underground Waters of a Portion of Southeastern Nebraska, by Nelson Horatio Darton; No. 13, Irrigation Systems in Texas, by William Ferguson Hutson. Department of the Interior, Washington, D. C. Paper; 9 × 6 ins.; pp. 56 and 68, respectively.

These two separate pamphlets are issued by Mr. F. H. Newell, Hydrographer in Chicago, in advance of the regular report, and for the convenience of those desiring to use their contents. No. 12 relates to a tier of counties, covering about 6,700 sq. miles of Southeastern Nebraska, and largely situated along the Platte River. In this region the annual rainfall is not large enough to always insure full crops, and the report treats of the geological formation and the water-bearing deposits which underlie nearly all of this area, at depths varying from 10 to 300 ft. No. 13 discusses, for the State of Texas, legislative enactments and the history of irrigation, the distribution of rainfall, and finally describes the irrigation, works and projects in that state. Both of these pamphlets are well illustrated by colored maps, half-tone photographs, plans and diagrams.

CALCULATIONS IN HYDRAULIC ENGINEERING.—A Practical Text-Book for the Use of Students, Draftsmen and Engineers. With numerous Illustrations and Examples. By T. Claxton Fidler, M. Inst. C. E., Professor of Engineering, University College, Dublin, Ireland. Part I. Fluid Pressure, and the Calculation of its Effects in Engineering Structures. Longmans, Green & Co., London, New York and Bombay. Cloth; 8vo.; pp. 153. $2.50.

The purpose and scope of this book are shown in the following quotations from the preface:

> This little book does not profess to be a treatise on hydraulics, but relates to those calculations which have to be made—many of them very frequently, and others perhaps more rarely, in connection with works of hydraulic engineering. . . . It has been written in the language of practical men rather than in that of the schools or of the mathematician. In all cases, it has been the author's desire to discuss the rational groundwork of these problems in the simplest and plainest terms; and the student who happens to be accustomed to a more rapid mathematical treatment may perhaps find these preliminary discussions unnecessary; but they may nevertheless be acceptable to other students, whose training has been of a more practical kind, and whose ideas have been cast in a somewhat different mould.
>
> In dealing with the effects of fluid pressure, a good many of the calculations which have to be made are too simple to need any extended illustration in this book; and for that reason a great part of its contents is devoted to those problems which are not so simple, or to those which seem to have received but little consideration at the hands of other writers. Among these matters may be mentioned the forces which result from the axial fluid stress in a curved or in a straight pipe.
>
> The stability of floating bodies is treated with especial reference to engineering structures, such as floating docks, pontoons, and the caissons which are sometimes used for bridge foundations. . . . Some experimental measurements of the displacing forces, in the fluid arch and in the fluid column, are described in detail in the appendix, which also contains a short series of experiments upon the direct tensile strength of various forms of socket joints.

The author has made a valuable contribution to the literature of one branch of hydraulic engineering. The field he covers is a limited one, relating to hydrostatics only, and he by no means covers the whole of this subject, but the work as far as it goes is well done. Many of the problems in the book are rare and difficult, and the author's method of treating them is as clear and simple as the subject permits. The chapter headings are as follows: Practical Conception of Elementary Principles. The Action of Fluid Pressure of Uniform Intensity. Cylinders, Pipes and Bends under Uniform Pressure. The Buckling Tendency in Straight Pipes under Pressure. Fluid Arches. The Stability of a Line of Pipe. Hydrostatic Pressure of Varying Intensity. Floating Vessels. Bending Stresses in Floating Pontoons. The typography, illustrations and press work are excellent. We would suggest to the publishers that the leaves of the book should be trimmed. The use of uncut edges is carried too far when they are applied to engineering text-books.

U. S. GEOLOGICAL SURVEY.—18th Annual Report to the Secretary of the Interior, 1896-97. Charles D. Walcott, Director. In five parts. Part IV.—Hydrography. Washington, D. C.: Government Printing Office. Cloth, 11¼ × 7½ ins.; 756 pp.; maps, photographs and plans.

This is a full and very interesting report upon the following hydrographical heads: Progress report on stream measurements, by Mr. Arthur P. Davis; water supply of Indiana and the greater part of Ohio, by Mr. Frank Leverett; continuation of report on artesian waters of a portion of the Dakotas, by Mr. N. H. Darton, and storage reservoirs in the West, by Mr. James D. Schuyler. The book itself is the ninth annual report upon what has been known as the Irrigation Survey, authorized by Congress for the purpose of ascertaining the best means of utilizing the water resources of the arid and semi-arid sections of the United States. This Irrigation Survey was organized under the provisions of the Act of Congress of Oct. 2, 1888, and, under the title of "Water Supply and Irrigation Papers," a series of distinct bulletins has already been issued. Those published cover the following heads: Report of 1888-89, detail of organization and plans adopted; Report of 1889-90, a discussion of the hydrography and of the engineering surveys for canals and reservoirs, and a report upon the topography; Report of 1890-91, location and survey of reservoir sites, hydrography of the arid region, and discussion of irrigation in India; Report of 1891-92, water supply for irrigation, American irrigation engineering, engineering results of irrigation survey, and location of reservoir sites during year; Report of 1892-93, results of stream measurements, potable waters of Eastern United States, and natural mineral waters of the United States; Report of 1893-94, field work; Report of 1894-95, public lands and their water supply, and water resources of a portion of the great plains; Report of 1895-96, report of progress in the Division of Hydrography, underground waters of the Arkansas Valley in Eastern Colorado, water resources of Illinois, and artesian waters of a portion of the Dakotas. This list of subjects sufficiently outlines the scope of the survey and the general progress made.

The report of Mr. A. P. Davis, in the present volume, gives the discharge measurement of streams in nearly 20 states, as obtained by special, resident skilled hydrographers. In these detailed reports we find the area of section, mean velocity discharge per second, drainage areas, run-off, etc., for rivers and their tributaries. While the list is by no means complete, a good beginning has been made in what will be of the greatest value to the hydraulic engineer. The territory covered is mainly west of the Mississippi River; though Georgia, Alabama, North and South Carolina, Virginia and West Virginia are included. In the report upon the Water Resources of Indiana and Ohio, by Mr. Leverett, we have a general statement of the physical conditions, with a contour map; a geological map and sections; a discussion of glacial ridges, and a map showing the Pleistocene Deposits on this territory, and the main drainage systems, separately treated. Underground waters and wells are studied in relation to the drift deposits; analyses of water are given, and the report continues with detailed observations on the water supply of cities and towns in Indiana and Ohio, as obtained from the latest authorities. Considerable space is given to rainfall data.

Irrigation by artesian well water in Eastern South Dakota is the substance of the report of Mr. Darton. He tells of the progress made, by counties; both in well-sinking and in irrigation. These South Dakota artesian wells are remarkable for their pressure; many of them showing pressures of 150 lbs. or more per sq. in.; or, the equivalent of a head of 350 to 400 ft. In a well sunk in 1896, at the Cheyenne Agency, the pressure is said to equal 205 lbs. per sq. in. The temperature of the waters of these wells reaches 94.9° F., as a maximum, with 70° to 80° as a common temperature. Though carefully studied, no satisfactory explanation has yet been found of the thermal conditions in the Dakota artesian basins. Chemical analysis shows that in the majority of the basins the waters have the character of surface water, and this would seem to prove that they are derived from local beds of sand and gravel in the drift formations, as some suppose. The volume of flow of the deep wells varies, with different diameters of tubing and local conditions causing partial clogging at the bottom. As shown on a map, the flow in gallons per minute for a 4½-in. outlet ranges from 10 to 2,000 gallons and more.

The paper of Mr. James D. Schuyler, M. Am. Soc. C. E., on "Reservoirs for Irrigation," is treated as we would expect it to be by an engineer of his ability and wide experience. He handles his subject under the main heads of rock-fill dams, hydraulic dam construction, masonry dams, earthen dams and projected reservoirs; and illustrates his paper with a large number of photographic views of completed work and work in progress, accompanied by plans and sections. In the case of many of the completed dams, Mr. Schuyler goes into the details of construction and cost, and the paper, in itself, forms an exceedingly valuable treatise on dam building and flume construction, under varied and difficult conditions. Many of these dams, however, have already been illustrated in this journal, and we shall later give more space than can be spared here to the illustration of several others that are worthy of especial mention.

ANNUAL MEETING OF THE AMERICAN INSTITUTE OF ARCHITECTS.

The 32d annual convention of this association was held at the Arlington Hotel, Washington, D. C., on Nov. 1-3.

The morning of the first day was devoted to the customary routine business attending the opening of a convention, which included a welcoming address by District Commissioner John B. Wight and the annual address by President George B. Post. Mr. Post expanded upon the advantages of selecting designs for government buildings by competition. In speaking of the work done in the past by the supervising architect's office, he said:

> Unfortunately these buildings are built with extravagant excellence and will stand for ages a travesty upon the art of the country, a reproach to the intelligence of those in power who have refused to listen to the urgent and repeated opinions of those qualified by education and experience to give advice, and have persistently neglected to use the means always at their hands to procure designs which should at least represent the average skill and economy daily shown by the architects of the country in private practice.

The report of the Board of Directors, among other things, called attention to the fact that the Institute in establishing its permanent headquarters in Washington was breaking away from all precedent and conducting what really might be called an experiment. This referred to the leasing of the historic "Octagon House" for a term of five years at an annual rental of $360. The object of this move is best expressed in the report of the committee having the matter in charge.

> That it afforded the broadest field for the Institute to obtain national legislation in relation to art and construction; that it could here more efficiently advocate the establishment of a government testing station and a national architectural museum, and would be in a position to make its influence felt in the methods adopted by the government for procuring designs for national buildings.

The second day, Prof. W. C. Sabine, of Harvard University. read a paper entitled "Acoustics," in which he stated that the problem of securing an acoustically satisfactory auditorium depended upon three points. The first of these was the proper arrangement of reflecting surfaces, i. e., the walls and ceilings; the second, the avoidance of "interference;" the third, the prevention of the prolongation of the sound, which is due to improperly inclined walls, and an inadequate use of absorbent materials in the construction and furnishing of the halls. Relative to this latter point a chart was exhibited, which indicated the absorption power of different materials as follows:

Hair cushions on seats, per square yard, 2.03; heavy oriental rugs on floor, per square yard, .56; chenille draped as curtains, per square yard, 1.32; cretonne, hanging flat, per square yard, .33; canvas, hanging flat, per square yard, .71; hair felt against wall—half inch thick, per square yard, 1.00; one inch thick, per square yard, 1.8; two inches thick, per square yard, 2.4. Audience, per person, 1.3; individual man, sitting clear, 1.8; individual woman, sitting clear, 2.2.

The secretary read a paper by Adolph Cluss which emphasized the points brought out by Prof. Sabine.

The next paper, by Prof. G. P. Merrill, of the National Museum, "Remarks on Some Little-known American Ornamental Stones." was a review of the history of stone as a construction material and a description of a number of kinds of American stone suitable for building and ornamentation. The last paper of this session, "Peculiarities of Wood," by Prof. B. E. Fernow, Cornell University, was read by Mr. J. C. Hornblower.

The afternoon was devoted to an excursion to Cabin Johns bridge and vicinity, and in the evening papers were read on "The Place to Be Assigned to Jewish People in Architectural History," by Dr. Cyrus Adler, and "General Practice in Regard to the Employment of Electric, Heating and Ventilating Engineers," by H. G. Bradlee.

The latter paper advocated the employment of the engineer by the architect and not by the owner, and that the minimum commission should be 5% on all work costing over $10,000. The work of the architect is no longer confined to the design of a building which is architecturally beautiful, carefully planned and substantially constructed, but to-day be must equip the building with a complicated system of mechanical and electrical apparatus and must design and provide for a network of pipes, flues and wires running through all parts of the building. The architect of the modern building must be an engineer and must be familiar with mechanical, electrical and sanitary engineering in all its branches.

Pittsburg, Pa., was selected as the place of meeting for 1899, and the following officers were elected for the ensuing year: Pres., Henry Van Brunt; First Vice-Pres., W. L. B. Jenney; Second Vice-Pres., J. W. McLaughlin; Secy. and Treas., Glenn Brown; Directors, Frank Miles Day, Joseph C. Hornblower, T. D. Evans; for two years, Robert W. Gibson, Levi T. Scofield, W. M. Poindexter; for three years, Arthur G. Everett, of Boston; W. C. Smith, of Nashville; George B. Post.

The session of the last day was given over to a discussion of the By-Laws of the Institute and the consideration of reports.