ENGINEERING NEWS AND AMERICAN RAILWAY JOURNAL.

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EDITORIAL:

BIDS FOR TRANSPORTING THE 25,000 SPANISH prisoners at Santiago de Cuba to Spain were opened in the office of Col. F. J. Hecker, U. S. Volunteers, in the Army Building, New York, July 20, at 11 a. m. The United States Government will deliver the prisoners at Santiago, and it asked proposals for a per capita price for transporting officers and men from Santiago and delivering them on shore at some Spanish port. Cabin accommodations must be provided for the 1,000 officers and the men are to receive the regular U. S. Army ration. Ships must report at Santiago between July 30 and Aug. 10, and payment will be made on satisfactory evidence of the landing of the prisoners in Spain. The following bids were received:

(1) New England Chemical & Supply Co., Boston, Mass., bid $890,000 for the transportation of 1,000 officers and 24,000 enlisted men. Officers to have cabin accommodation; enlisted men to be given steerage quarters. Transportation to be under any other flag than that of the United States.

(2) L. A. Thieme & Co., Philadelphia, Pa., offer to carry 25,000 Spanish soldiers to Spanish soil for $385,000.

(3) James W. Elwell & Co., New York, N. Y., offer the steamship "Meustria," with accommodations for 1,000, at $35 a head for enlisted men and $75 each for officers.

(4) William H. Thompson, New York, N. Y., offers a steamer to carry 150 officers at $90 each, and 1,400 enlisted men at $45 each.

(5) George Osgood Lord, New York, offers to carry 24,000 enlisted men at $37.50 each and 1,000 officers at $72.50 each. Another bid was also received from him which was not considered, owing to its not conforming to the terms of the advertisement, in which the United States was to provide blankets and rations for the prisoners.

(6) Thomas L. St. John bid $37.37 each for officers and $24.87 each for men, including subsistence.

(7) Joint bid from Anchor Line, represented by Henderson Brothers, New York; Cunard Line, represented by Vernon H. Brown & Co., New York; Leyland S. S. Co., represented by Sanderson & Son, New York; Hamburg-American Packet Co., New York; Wilson & Furness-Leyland Line, represented by Sanderson & Son, New York; North German Lloyd S. S. Co., represented by Oelrichs & Co., New York; Royal Mail Steam Packet Co., represented by Sanderson & Son, New York; Robert M. Sloman & Co., represented by Emil Boas, New York, bid as follows: $110 for officers, who are to be given cabin accommodations; $55 for enlisted men, to be carried in the steerage; payment to be made on the number embarked, without regard to whether the vessel reaches port safely or is lost.

(8) C. B. Richards & Co., New York, offer two ships: "Spartan Prince," to carry 40 officers at $55 each, and 800 enlisted men at $25 each.

"Tartar Prince," to carry 50 officers and 1,000 enlisted men at the same rates. A second offer from the same firm tendered its services as agents to arrange for the transportation; this proposition was not considered.

(9) Davis & Huger offered to furnish from one to fifty steamships of foreign build. The offer was not accepted as it did not conform to the terms of the advertisement.

(10) The Tweedie Trading Co. offered bids in triplicate for three ships, with a total carrying capacity of 3,000 men, at a charge of $29 each for enlisted men and $50 each for officers.

(11) R. A. C. Smith, New York, offered to carry enlisted men at $30 each and officers at $60 each on steamers of the Spanish Transatlantic S. S. Co., sailing under the Spanish flag, the United States to guarantee safe conduct.

The Washington authorities will award the contract later.

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THE LOG OF THE U. S. BATTLESHIP "OREGON," on her now famous run from Puget Sound to Florida, is thus filed in the U. S. Navy Department:

Port.		Record of run.		Average knots per h'r
Left.	Arrived.	knots.	hours.	
Puget Sound, March 6.	San Francisco, March 9	826	72	11.48
San Francisco, March 19.	Callao, April 4	4,112	375	10.96
Callao, April 7.	Tamar, April 16	2,550	214	11.9
Tamar, April 17.	Sandy Point, April 17	131	9	14.6
Sandy Point, April 21.	Rio Janiero, April 30	2,148	221¼	10.16
Rio Janiero, May 5.	Bahia, May 8	749.7	74¼	10.09
Bahia, May 10.	Barbadoes, May 17	2,228	191¼	11.54
Barbadoes, May 19.	Jupiter Inlet. May 24	1,666	141½	11.27

The total distance from Puget Sound, in the Pacific, to Jupiter Inlet, on the Atlantic Coast of Florida, was 14,511 knots, and the ship consumed on this trip 3,909 tons of coal. The total running time was 1,298.25 hours; and the average hourly rate of speed for the entire trip was almost 11.2 knots. According to the above record the coal consumption was almost exactly 3 tons per hour of actual running time, auxiliaries and consumption in port being included, however, in the total.

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PROGRESS ON NEW WARSHIPS is reported by Chief Naval Constructor Hichborn, to July 1, as follows: Battleships "Kearsarge," 61% completed; "Kentucky," 61%; "Illinois," 48%; "Alabama," 61%; "Wisconsin," 40%. These five battleships are all to have a maximum contract speed of 16 knots. Of the ten torpedo boats under construction, the "Rowan" and "Mackenzie" report 99% completed; the "Davis," 94%; the "Farragut" and "Fox," 88%; the "Dahlgren," 80%; the "T. A. M. Craven," 60%; the "Stringham," 35%; the "Bailey," 21%; and the "Goldsborough," 10%. The submarine torpedo boat "Plunger," at Baltimore, is within 73% of completion.

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THE COMPAGNIE TRANSATLANTIQUE or French Line of steamers, made, on July 3, a contract with the French government for ten years beginning in 1901. After 1901 the company is required to make 52 round trips per year to New York at an average speed of at least 20 knots per hour. The company is now building at St. Nazaire two new steamships which are to have a guaranteed speed of 22 knots per hour, and are to cost about $3,000,000 each. The "La Lorraine" will be ready in 1900, and "La Savoie," three months later. In 1903 and 1905, two more ships, faster still, are to be ready for service.

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AN OCEAN LINER LARGER THAN THE "KAISER Wilhelm der Grosse," of the North German Lloyd, is reported to have been ordered by the Hamburg-American Line of the Vulcan Shipbuilding Co., of Stettin, to be completed in 1900. The vessel will be 685 ft. long, 66½ ft. beam and 44 ft. deep. The "Kaiser Wilhelm" is 648 ft. over all, with 66 ft. beam and 43 ft. depth.

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THE MORGAN LINE has contracted with the Newport News Shipbuilding and Dry-Dock Co. for three freight steamships, to cost about $2,500,000 in all. These vessels will be built of steel, with single screws, and will generally resemble the "El Rio" and her sister ships now in the government service. They will each measure 5,000 tons gross, be 400 ft. long, 50 ft. beam and 35 ft. deep. They will have three decks, be provided with water-tight bulkheads, have steam heat, electric lights, etc., and triple expansion engines of 4,000 I-HP., with boilers carrying 165 lbs. of steam. The propellers will be 18 ft. diameter and the average speed is to be 17 knots. The Newport News Co. is also building two vessels for the Cromwell Line; and two are being built for the Old Dominion Line at Chester, Pa.; all intended to replace vessels secured by the government.

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BIDS FOR TWO FLOATING DOCKS are asked for by the U. S. Navy Department, the cost not to exceed $250,000 for both. Docks ready built are wanted, as there is need for them now in Cuban waters, and two such docks are located in New York and three are in and about New Orleans. The bids for the larger floating docks, provided for in the late naval appropriation bill, will be called for within a couple of weeks.

THE OUTER BREAKWATER LIGHTHOUSE, in New Haven harbor, Conn., will be put under contract on Aug. 1, 1898. This lighthouse will consist of a circular cast-iron caisson foundation 36 and 33 ft. diameter and 58 ft. high, sunk by the pneumatic process and filled with concrete. The depth of water is 28 ft. to M. H. W., and the caisson will be sunk into the sound for 8 ft., and then surrounded by rip-rap, 18 ft. deep. The upper 10½ ft. of the foundation pier will be lined with brick work and forms a cellar, covered by the main-gallery floor supported on brick arches. This will be surmounted by an iron dwelling house, 18 ft. diameter at the base and 45 ft. high to the focal plane. A covered gallery, with a diameter of 38½ ft., will surround the first story of the four in the dwelling portion. This gallery will be accessible from the water by ladders and a spiral iron stairway, inside, leads to the lantern. This light will be located some distance outside the entrance to the harbor, with the focal plane 61 ft. above Mean High Water. Lieut. Col. D. P. Heap, Engineer Corps, U. S. A., Lighthouse Engineer, Third District, Tompkinsville, N. Y., is the engineer in charge.

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THE EXTENSION OF THE WEATHER SERVICE to the Caribbean Sea is now before President McKinley in the form of a draft of an order, and an appropriation of $75,000 to be used at his discretion for this purpose. Negotiations are now in progress with other governments interested and whose consent will be necessary in locating stations and providing observers. The scheme contemplates stations on the islands of Trinidad, Curacoa, Martinique, Hayti, the Barbadoes and San Domingo. There are now operating stations at St. Thomas, at Kingston, Jamaica, and at Havana. The Mexican government is also establishing a line of stations along the Mexican Gulf coast to Yucatan, and these are being fitted with instruments adjusted to U. S. standards. With the proposed belt of stations daily weather reports would cover the entire coast line of the Gulf of Mexico and Caribbean Sea for the benefit of the commerce of all nations.

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THE EXPORT TRADE OF THE UNITED STATES, for the fiscal year ending June 30, 1898, amounted to $1,231,311,868, an increase of $180,300,000 over the preceding year. The imports for the same year were valued at $616,052,844, a decrease of over $148,600,000 as compared with 1896; the balance of trade in our favor was thus $615,259,024 for the fiscal year. For the month of June, 1898, the exports were valued at $94,808,263, or an increase of over $21,600,000 over the same month of the preceding year. The imports of gold coin and bullion, in the last fiscal year, amounted to $115,173,988, against an export of only $15,324,929.

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A PERMANENT EXHIBITION OF MANUFACTURES is proposed for New York city, under the direction of the Merchants' Association of New York, an organization having as its object the fostering of New York city's trade. The scheme contemplates the erection of a suitable building and the placing in it of a large and attractive collection of manufactured articles. It is further contemplated to establish similar exhibitions in a number of European commercial centers. A meeting will be held Oct. 1, details of which will be announced later, to organize a company for this purpose.

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THE SCARCITY OF TIN ORE IN THE WORLD is pointed out by Geologist B. G. Skertchley, of Australia, in a published monograph. He shows that while known gold fields cover 1,500,000 sq. miles of the earth's surface, the located tin fields have an area of only 12,500 sq. miles. The seven tin districts of Europe produce about 8,300 tons yearly, with 8,000 tons of this credited to the Cornwall mines. Asia has two tin districts; Hunan, in China, said by some to yield 10,000 to 20,000 tons annually, but proven to yield less than 2,500 tons per year; and the tin mines of the Straits Settlements and adjacent territory, the richest in the world, yielding 58,000 tons yearly. Africa has no known tin mines; North America has no paying mines; South America mines less than 4,000 tons per year, in Bolivia and Peru, and Australia contributes about 6,000 tons a year.

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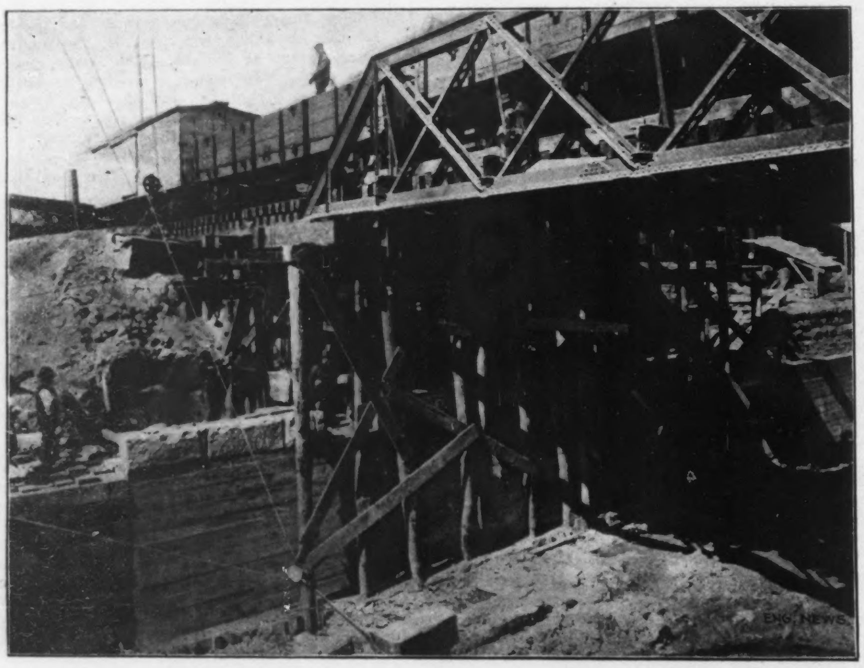
A HAWAIIAN CABLE CONTRACT was signed, on July 2, between the executive council of the Hawaiian government and the Pacific Cable Co., of New York, granting the exclusive right to lay a submarine cable between the United States, Hawaii, Japan and China. The grant also includes the Ladrones and the Philippine Islands, subject to authorization by Congress. The proposed cable would start from San Francisco, and then proceed to the Hawaiian Islands, a distance of 2,097 miles, and thence to Japan and such other islands as shall be later designated. The total distance from San Francisco to Japan would be about 6,500 miles, or, with 10% of slack, about 7,500 miles of cable would be required. The estimated cost of cable and repair ship is $7,500,000. The official messages of the United States are to be transmitted free of cost forever. The officers of the Pacific Cable Co. are: James A. Schrmyser, president; Edmund L. Baylis, vice-president; and these gentlemen, with Rear Admiral John Irwin, J. Pierpont Morgan and J. Kennedy Tod, are the directors of the company.

CONCRETE ABUTMENTS FOR A RAILROAD BRIDGE AT BUFFALO, N. Y.

The rebuilding of the abutments of the three-track bridge of the Buffalo & Niagara Falls branch of the New York Central & Hudson River R. R. across the branch of the Erie Canal in Buffalo, N. Y., known as "Niagara Slip," was made necessary by the recent deepening of the Erie Canal, and the consequent removal of the glacial drift between the original abutments, which were built of stone masonry some thirty years ago, and were founded upon this drift. The rebuilding was done during March and April, 1898, by the Donnelly Contracting Co., of Buffalo, N. Y., and the arrangement of the work and plant present several features of interest. The underlying limestone formation occurred at an average of 10 ft. greater depth; its surface being very irregular and varying 5 ft. or more in the area of the abutments. This was scraped clean to receive the concrete forming the new structures.

The branch of the canal spanned by this bridge connects the Erie Canal proper with Buffalo harbor, and two cofferdams were, therefore, needed to shut off the water. This construction presented difficulties in that the adjacent formation in which the cofferdams must abut was of the most irregular and uncertain character, consisting of drift, lake beach gravel with embedded logs and drift wood, and "made ground" of varied materials. A deposit of 8 ft. of quicksand was encountered and required careful handling to avoid undermining a closely-adjacent brick round-house.



VIEW OF NORTH ABUTMENT OF N. Y. C. & H. R. R. R. THREE-TRACK BRIDGE AT BUFFALO, N. Y., IN PROCESS OF RECONSTRUCTION.
Walter Katte, M. Am. Soc. C. E., Chief Engineer.
Donnelly Contracting Co., Buffalo, N. Y., Contractors.

The bridge is in daily use by 250 or more regular and yard trains of the New York Central, Grand Trunk, Michigan Central, Toronto, Hamilton & Buffalo, and Canadian Pacific railways (three trains having often been seen on the bridge at once), and this service must be maintained without interruption. To permit this, the bridge was supported upon pile bents at either end, and a platform was built beneath the bridge on which were placed the materials, conveyor and mixer for the concrete.

The cofferdams were formed of crib-work 18 ft. wide and 22 ft. high, filled with clay. The crib-work, of 12 × 12-in. square timber, was so designed that, without extra labor in building it, the timber from the dry side of each dam could be taken out intact, and in condition to be used elsewhere. This was effected by using interior vertical posts with horizontal screw bolts, engaging the cross-ties and the face timbers, and with the nuts of the screw bolts exposed. No drift bolts were used in this face of the crib, and no gains were cut in the timbers to receive tie-heads, which came through full size, with the face timbers butting against the tie ends. Wakefield triple-lap and other forms of sheet piling were used to secure the ends of the dams and extend them, and no breaks occurred, though rises of the lake level of 6 ft. or more, caused by the winds down the lake, overflowed the dams twice.

After the area had been pumped dry, the old abutments were taken out, and the excavations for the new ones were made to the bed rock. Upon the irregular surface of this, the abutments were built of concrete for an average height of 18 ft. above rock (to low water line), and of rock-face, massive, stone masonry for 13 ft. above the concrete.

To construct the latter, an overhead track was built lengthwise of each abutment, upon which traveled a truck, from which was suspended a 10-ton Harrington hoist for the blocks of stone, which were thus carried to place and laid in the superstructure. These blocks were first lowered from cars on the bridge overhead by steam derricks, standing on the nearest cofferdam, and thus placed within reach of the truck-hoists.

The total quantities were 835 cu. yds. of concrete and 466 cu. yds. of masonry. The prices were $6.50 per cu. yd. for American Portland cement concrete, and $7.93 per cu. yd. for second-class masonry of rock-face sandstone and backing. The aggregate was $21,000 for the whole work, including building and removing of cofferdams, etc.

The concrete was formed of one part Atlas Portland cement, one part beach sand, and six parts of crushed corniferous limestone and flint, using the total product of the crusher when set at 2-in. opening; the finely-crushed limestone included in this product being equivalent to one part of sand in addition to that already named. These materials were mixed by four or more revolutions of a Ransome rotary mixer, which is so arranged with interior paddles that one revolution is equivalent to four turnings by hand shovels. The mixer was run by a 10-HP. engine, supplied with steam from one of the boilers operating one of the cofferdam pumps.

The crushed limestone and flint were run directly into dump cars at the contractor's crusher, and the cars were then hauled on to the bridge, where their contents were dumped through the floor of the bridge on to the mixer-platform beneath. The plank molds into which the concrete was filled and which confined it to the defined form and dimensions, were composed of smoothly-dressed plank placed with care to have the butts and joints tight to prevent leakage of any surplus water from the concrete. That portion of the forms which came between the pile bents supporting the bridge was braced against these piles, while the molds for the wing-walls were tied together—front and back—by iron tie-rods which were removed as the concrete filling came up to them. As the concrete was to be wholly submerged and out of sight, it was not considered that the face should be specially finished, and therefore the lines of the mold-plank show in the accompanying photograph.

The proportions of materials were here accurately measured in cubical barrows of 2 cu. ft. capacity each, and the concrete was made in batches of 16 cu. ft. every two hours, producing about 90 cu. yds. per day of ten hours. This was conveyed to place and thoroughly rammed in 10-in. layers with 6 x 8-in. wooden rammers. No concrete was made or placed at night, and each morning when work was resumed, a thin grout of clear Portland cement was spread over the top of the last-made concrete, just before placing the fresh concrete upon it. The actual weight of the resulting mass was found to be 159 lbs. per cu. ft. after the test-block of about 1 cu. ft. had been dried for two weeks in a warm room; this being 95% of the weight of the solid rock before crushing.

The work was under the direction of Mr. Walter Katte, M. Am. Soc. C. E., Chief Engineer of the N. Y. C. & H. R. R. R., with Mr. E. F. Van Hoesen, M. Am. Soc. C. E., Division Engineer; Mr. Wm. Pierson Judson, M. Am. Soc. C. E., was the engineer for the contractors.

The accompanying illustration shows the north abutment on April 14th, when the concrete base was completed, and the first course of sandstone superstructure was in progress. When completed and the cofferdams removed, the mean low water level stands about 1 ft. above the top of the concrete.

MARINE WOOD BORERS.

(With full-page plate.)

The destruction wrought by the teredo navalis upon marine constructions in wood is doubtless familiar in a general way to every engineer, but comparatively few are acquainted with the habits of this pest and with the methods by which he accomplishes his destructive work. It is also a fact not generally well known, perhaps, that the navalis is only one species of the teredo, and that the teredo is only one of several forms of wood borers known to naturalists and abounding in sufficient numbers to be a serious menace to marine works constructed of wood. In an interesting paper, by Prof. Charles H. Snow, of New York University, to be presented at the Detroit Convention of the American Society of Civil Engineers next week, the more destructive forms of these marine wood borers are described, with numerous illustrations of the animals themselves and their work. From these illustrations we have selected the engravings published on a full-page plate with this issue, and from the paper itself we abstract the following items of most interest in connection with them. We are indebted to the courtesy of the American Society of Civil Engineers for the use of the cuts.

The four forms of marine wood borers, which are the most numerous, and, consequently, about which the most is known, are: the teredo, the limnoria, the sphaeroma and the chelura. Of these the teredo is the most destructive, and therefore merits the most extended description:

The Teredo.

The teredo is a very ancient form of life, fossil remains having been found in both England and America. Among the ancients it has been mentioned in the writings of Pliny (23-79 A. D.). In modern times it was first observed and studied by the Dutch in 1730, when it threatened the woodwork of the Holland dykes. It has been since this latter date that most of our present knowledge of the teredo has been developed. Up to the present time seven species of teredo have been identified as existing in the United States, one of which is the navalis. This multiplicity of species needs to be remembered, since, owing to the comparatively greater familiarity of engineers with the navalis, the term "teredo navalis" is used indiscriminately by many engineers in speaking not only of the teredo but of all forms of marine wood-borers. The generic name is of course "teredo," which should be used always unless the specific form of teredo is known. These various species of teredo, however, are similar in their principal characteristics, which are shown by Fig. 1.

Fig. 1.—Sketch Diagram Showing Distinctive Features of the Teredo.

a, body; C, collar; p, pallets; s, syphons; B, boring shells; f, foot or sucker.

Notwithstanding its worm-like appearance, the animal is a true mollusk. Its principal parts are the body a, the collar C, the pallets p, the siphons s, the boring shells B, the foot or sucker f, and the lining shell. The last is a calcarious substance invariably deposited by the animal upon the newly cut surface of the tunnel which he excavates; and it forms an enameled lining through which he can glide backward and forward as he expands and contracts. The several members and their processes can be considered best separately.

The Body.—The body of the teredo in the young animal is so transparent that some of the interior organs, such as the heart and the ovary, may be observed through it. The heart consists of two auricles and a ventricle. The pulsations, which may be readily counted, are irregular, the rate being about four or five per minute. The blood is a transparent, colorless fluid. Many of the important organs, as the mouth, the palpi, the liver and the foot are inclosed in the boring shell at the further extremity of the animal. The gills are located for the most part at the outside of the shell, and are long and narrow, usually reddish brown in color, and perform the important office of sheltering the eggs and embryo. The nervous system is well developed, and consists of filaments and ganglions connecting the mouth, the branchiae, the foot, the collar and the syphons. The stomach is not distinguished by any peculiarity, but there is a well-developed intestine. The great length of the body is due to the elongation of the syphons or breathing tubes.

The Collar.—The collar extends entirely around the posterior portion of the animal, and fills the place between the body and the circumference of the tunnel. Water cannot pass through the orifice of the tunnel, save as it is controlled by the syphons. The collar contains several well-defined muscles, and these act upon the pallets, which are pulled down over the syphons in such a manner as to close the entrance to the tube when the extremities of the syphons are drawn into the burrow.

The Syphons.—The syphons are the two principal organs, and extend throughout the greater length of the body. One of these tubes conveys the oxygen, water and infusorial food to the vital processes of the animal; the other conveys the exhausted water, the excretions, the debris from the excavation and the eggs to the free water without. The outer structures of the syphons are united while they remain in the body, but signs of divergence are seen as they emerge from between the pallets. They continue united for a little and are then separated into two distinct tubes. These divergent extremities constitute the only part of the animal which can be seen from the outside, and are sometimes mistaken for the entire animal. The longer or incurrent extremity can be pushed out to a distance of 2 ins. or more, while the outcurrent throat remains at about half the distance. The teredo is able to expand or contract these extremities at will and when the conditions are favorable they are extended through the orifice to their full length, and remain stationary or wave slowly backward and forward. When the animal is alarmed the syphons are withdrawn into the tunnel. The siphons are erected by means of a current of blood sent into them from the vessels within. When the water is warm the animal is active and the siphons are extended out full length. They are withdrawn when the water becomes cold, and the teredo is entirely hidden. The extremities of the syphons must always be kept at the orifice of the wood. As the animal grows, the muscular collar and the pallets recede from the entrance, so as to permit the extremities of the syphon to remain there.

The Pallets.—The two shelly plates near the orifice are called pallets, and are connected with the muscles of the collar so that they relax when the syphon extremities pass out between the crescents or horns, which will be seen at the top of the shells, and contract when the syphons are withdrawn. The pallets are then folded over so as to serve as an operculum to protect the soft tubes from enemies.

The Boring Shell.—The boring shell, which is nearly as long as it is broad, presents an irregularly triangular appearance when observed from the side. It may be best seen in Fig. 2. The two halves close tightly at the hinge and at the side opposite the hinge; the open space at the top being toward the main bulk of the animal, and the opening toward the extremity of the tunnel permitting the emergence of the foot or sucker. The shells of young animals are larger in proportion than those of old animals, and when the animal is very young it is for a short time entirely enclosed in the shell.

The Foot.—The foot, which in form resembles a pestle, is a short, stout, muscular organ, broadly truncated or rounded at the end, and so arranged that it can exert a powerful suction upon anything to which it is attached. This cupping action assists the shell in excavating.

The Lining Shell.—This shell follows the tunnel until it finally terminates in a spherical cap. The adult animal occasionally shrinks, and a second cap or partition may be formed as he retreats, the space between the caps remaining unoccupied. The early portion of the tunnel, which was cut by the young animal and is later occupied by the syphon extremities, is below the normal diameter. The lining shell at this point sometimes divides itself into two tubes, each containing one of the syphons. It has been stated that the extremities of the syphons must be kept at the orifice of the wood. The collar and pallets recede as the animal grows larger, thus forming a considerable space between the pallets and the orifice of the tunnel, which is filled with little rings of shell, whose sharp edges serve to protect the entrance. The slender syphons emerging from the pallets pass readily through the spaces at the centers of the rings.

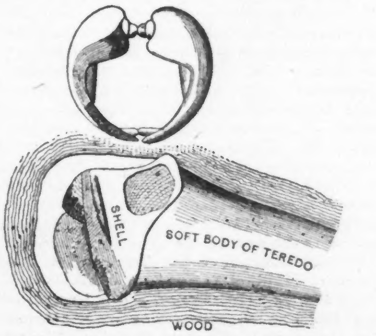


Fig. 2.—Enlarged Sketch of Head of Teredo, Showing Boring Shell.

The teredo can rarely advance for any time in a straight line, being forced to deviate therefrom so as to pass around obstacles, such as cracks, knots or the pre-existing tunnels of its companions. The tunnels may wind in and out and pass so close to one another as to occupy almost the entire content. This fact is well illustrated by Fig. 3.

Fig. 3.—View Showing Proximity and Tortuous Nature of Tunnels Made by Teredo.

The thickness of the lining varies with the species. It is sometimes so thin and fragile that it becomes detached by the slightest shock, and is sometimes very thick. The lining presents a surface against which the soft body of the mollusk may press without injury, and also seals the interior of the cell so that the water supply may be better controlled by the syphons.

The teredo rarely crosses a seam or joint in the wood, probably because it fears for the integrity of the lining. Specimens exhibiting the attempt of the teredo to cross a seam show that the shell has been much strengthened at the junction point. When the teredo arrives at maturity, or whenever an insurmountable obstacle is encountered, it seals over the inner extremity of the lining. The growth of the animal, in length, is stopped in either case, and it is entirely surrounded by shell. There is a communication with the outer sea at the two syphon points only, and as the animal continues to live for some time under these conditions it is evident that its sustenance is derived from other sources than the wood.

Vital Processes.—The teredo resembles other bivalve mollusks in that it exists upon infusorial life. This food, together with the necessary amount of oxygen, is drawn in through the longer or incurrent syphon, and flows throughout the length of the animal until it reaches the mouth at the other extremity. The mouth, stomach and intestine are well developed and perform their usual offices. The oxygen is retained by the gills. The return current, beginning at the gills, removes the exhausted water, the excretions and the woody particles. These flow out through the animal and are ejected by the shorter or outcurrent syphon. The teredo does not devour wood; its form is such that dust and other debris have to pass through its body to the point of ejection. Where a teredo is watched for some time, small clouds of very fine dust may at length be observed puffed out from the orifice. The circulation through the syphons is continuous. The teredo may live for a short time out of water. This fact explains its ability to attack wood between high and low water. The specimens which enter wood where it is exposed between the tides do not seem to be greatly hindered in their work.

The Boring Apparatus.—While the animal is still very small, it settles upon the surface of the wood and almost immediately begins to clear away a place in which to burrow. A small pit is made by the edges of the valves of the shell, which come together on pivots shown in Fig. 2. The shells are controlled by powerful muscles acting so as to swing them backward and forward upon the pivots. Only a few of the teeth upon the shell are shown in Fig. 2, and these are exaggerated in size. When the posterior muscle contracts, the shell, with the teeth, is thrown outward and backward and rasps upon the surfaces of the wood. The process is assisted by the foot which emerges through the large blank space between the shells and performs a cupping action.

The Character of the Excavation.—The teredo is very small when it begins to attack the wood, and the hole by which entrance is made, which is the only perforation that appears upon the exterior, is very minute, as shown by Fig. 4. Fig. 5 shows the real interior condition of the same piece of wood. The animal develops very rapidly. The adult diameter is usually attained within 1 or 2 ins. of the surface, and the burrow increases in diameter regularly from the point of entrance to the maximum diameter. The animal grows principally in the direction of length, and therefore it atacks the wood so as to accommodate its quarters to this increase in length. The boring is first carried on across the grain, but ordinarily turns within a short distance and passes in the direction of the grain. This general direction is usually followed, but obstacles are so frequently encountered that the tunnels become exceedingly tortuous, and pass in every conceivable direction.

The teredo usually passes around knots, although quite competent to penetrate knots of oak and other hard woods. Adjoining tunnels are not encroached upon, because these tunnels are completely occupied by live teredos, and more ingenuity would be required to pass through one of them than to avoid it. When cracks exist in the centers of large timbers, they are approached from all sides, but the film is never willingly broken through. It prefers wood that is not surrounded by bark, because of the line of contact between the wood and the bark. When a piece of wood is thoroughly infested, the animals have to pass very close to one another, and the thin film of wood left between the adjacent tunnels is reinforced by the calcareous lining. More than 50% of the weight of the wood may be removed by the teredo, without being greatly evidenced upon the surface. Wood may appear to be quite sound and yet be so weakened that much of it can be crushed by the hand. Failure, therefore, frequently comes suddenly.

Fig. 6 is from a photograph of a log of Panama mahogany, which was cut in the uplands of the isthmus and floated through fresh water to the harbor of Colon, where it remained floating in salt water awaiting shipment. The log was overlooked for one season, and the work of the teredo is thought to have been accomplished in about nine months. The heavy, wet specimen was shipped with others, under the impression that it was sound, but it broke by its own weight after its arrival in New York.

The Size of the Teredo.—The size of the teredo depends upon the species, locality and age, and the absence of obstacles to excavation. Locality has much to do with development. Specimens grow more rapidly and attain larger size where the climate is warm. The teredo continues to grow until it reaches its maximum size, unless an obstacle is encountered. The species navalis may be assumed to average from about ¼ to ⅝-in. in diameter and from about 10 to 15 ins. in length, but specimens of the teredo frequently attain a much greater size. Prof. C. O. Siegerfoos, of Johns Hopkins University, writes that he has measured them up to 4 ft. in length and that the specimens thus measured had not arrived at their full limits. The minimum diameter and length of a boring may be taken as ¼-in. and 5 ins., respectively. The maximum length may be taken at 4 ft. After the teredo has penetrated the wood for a little distance, the diameter remains about constant. Diameters are measured in this portion of the burrow and not at the entrance.

The Range or Field of Work.—The teredo operates throughout a vertical field of considerable depth. This field begins at a point a little above low-water mark, and extends downward until the pressure becomes too great, or the soil at the bottom is encountered. The teredo seems to be able to exist for a little time without submergence, and is therefore able to live above the low-water mark, although exposed daily between the tides. The interior extremity of the tunnel may be higher up than the entrance. The upper limit of the excavated wood cannot be determined by an examination of the orifices at the surface. The lower limit is uncertain and is probably different for different species. It has been assumed by many that the lower limit could be set at about 14 ft. below low water, but recent information, thought to be reliable, indicates that piles have been affected at a depth of from 20 to 25 ft. below that level. The fact that the interior extremity of the burrow is often found below the mud line has given the impression that the field of the animal may extend below this limit, but the outside opening or entrance made by the teredo is never below the soil, although the boring may turn downward for the whole length of the animal. If sediment accumulates around the bottom of the wood so as to cover the syphons, the death of the teredo results.

It is reported that in some harbors the teredos attack at the surface, and in others at the mud line These differences are partially due to differences in the constituents of the upper and lower layers of water. Where the fresh water of a river meets the heavy water of a sea, the teredo may be almost entirely confined to the lower stratum. The range or field of the teredo is important, because protective processes which could be confined to this field would be more economical than those in common use which are applied to the entire structure.

The Rapidity of the Work.—The rapidity of the work of the toredo depends upon conditions similar to those which govern its size. The evidence upon this subject is not always accompanied by a statement of the conditions under which the results were accomplished, such as the species of toredo, the character of the wood, the season, the climate and the depth of submergence, all of which are points as important as the geographical location of the work. The period in which the teredo accomplishes its work is variable. It may be six weeks or as many years, but rapid work is usually accomplished under the conditions which exist in warm climates. Impure water and cold weather retard its activity, while pure or warm water expedites the work. Maximum probabilities being more important than minimum possibilities, it is safe to assume that a 6-in. boring may be driven in six weeks, and hence, as the animal attacks all sides, a pile 1 ft. thick may be destroyed in that period.

Reproduction and Development.—Mollusks produce their young by means of eggs. Those of the teredo are spherical in shape and greenish yellow in color. The animal is exceedingly prolific; the eggs of a single specimen being probably numbered by the million. The eggs are first deposited in the gill cavity, and are almost at once fertilized. They are free-swimming at the end of three hours, have a well-developed shell before the end of the day, are very hardy, and all seem to be fertilized and to develop.

The embryo passes through several interesting stages before it assumes the character and form of the adult. It is first covered by fine hairs or cilia, which enable it to swim. These are soon lost, and the rudiments of a small bivalve shell appear, which is at first heart-shaped and very small, yet large enough to enclose the entire animal. The portion of the body which protrudes from the shell is fringed with cilia. These, again, constitute swimming organs, and the teredo swims actively until a piece of wood is encountered. The shell has now become rounder, and organs of sight and hearing have been developed. The appearance of these organs marks a climax in the life of the young animal, and it begins to elongate. The locomotive cilia disappear, the eyes are lost, and the mature form is gradually assumed. The life of the larvae is about four weeks, during all of which time they are free swimmers. If the animal has become attached to wood, however, its energies may be expended thereon. The life of a specimen which has not found any wood to attack has not been determined, but is probably quite short.

The extreme life limit of the teredo is unknown, but it is thought that under favorable conditions the animal may live for several years. In the vicinity of New York the processes of reproduction take place for the most part in May. They are not entirely confined to that month, however, but may extend throughout a greater part of the summer. Reproduction in tropical countries is probably extended throughout the entire year. The animal may develop to a very large size, and may possibly attain maturity in a single season.

The Effect of Climate, Temperature or Water.—The teredo navalis thrives best under the influence of heat, but, notwithstanding this fact, it can resist cold to a considerable degree. It is not active when subjected to low temperatures, yet it can endure them. Some species of the teredo have been reported as far north as Eastport, Me., and they exist abundantly under such conditions as obtain at Cape Cod. Destruction is not carried on as continuously or as rapidly in cold climates as in warmer ones, and for this reason maximum results are seen along the South Atlantic and Gulf States and on the Pacific Coast, where the conditions are more favorable, and where reproduction is continued during a longer period.

The purity of the water should be considered in connection with the work of the teredo. Some species inhabit pure sea water; some prefer brackish water, others abound in waters that are muddy, while others again live only in waters that are clear and pure.[*] The teredo is often present in certain waters, yet absent in the others nearly adjacent. This is usually due to some difference in the water. The xylotrya fimbriata seems to be able to survive the brackish, impure water of the inner New York Harbor, while other species could not live there, though they are present in the nearby outer ocean. The teredo is very active on the North Pacific Coast, yet is absent near the mouth of the Columbia, where the ocean is influenced by the outflow from the river.

The effect of the condition of the water upon the teredo is interesting. The opinion that the periods of unusual prevalence in Holland were in some way connected with a change in the quality of the water was expressed as early as 1733, and since that time has frequently been endorsed by Dutch engineers. Dr. von Banmhauer, Holland Commissioner to the Centennial Exposition, has called attention to the fact that but little rain fell in the years when the teredo was so unusually prevalent, hence the smaller volumes of river water were thought to have permitted larger proportions of salt to reach the coast. This theory is strengthened by the fact that analyses showed a variation in the proportion of salt during dry and rainy seasons.

The Distribution of the Teredo.—The teredo navalis has been identified as existing in the United States between Florida and Cape Cod, and in Europe, from Sweden to Sicily. The teredo norvegica has been found from Cape Cod northward to the coast of Maine. The teredo megotara has been found in floating pine wood at Newport, R. I., and in cedar buoys, etc., at New Bedford, Mass. It has been found south as far as the coast of South Carolina. The teredo dilatata occurs from Massachusetts Bay to South Carolina. The teredo thompsoni has been found at Cape Cod, Mass. The xylophaga dorsalis inhabits the waters of the North Atlantic. The xylotrya fimbriata is found along the Atlantic Coast from Long Island Sound to Florida. It also abounds in the waters of the North Pacific, and is one of the European forms. Different species of the teredo are notably present in such localities as the Bermudas, Jamaica, New Zealand and Australia. The teredo, as a rule, may be generally found in the tropics, and is hardly less numerous in many of the northern waters.

Woods Affected by the Teredo.—All varieties of wood commonly used in construction are subject to attack when exposed to the teredo. Immunity is occasionally claimed for some particular wood, but it will generally be found that the claims have been based upon local conditions and are not fully substantiated.

The following list of partially exempt woods has been compiled by Mr. T. A. Britton from authorities which are said to be reliable:[†] (Western Australia) jarrah, beefwood and tooart; (Bahama) stopperwood; (Brazil) sicupira, greenheart; (India) malabar teak, sisso, may-tobek; (South America) Santa Maria wood; (Tasmania) blue gum; and (West Indies) lignum vitae. It is not urged that these are entirely exempt, but that they have been exempt for long periods. Very few of them are widely known in construction. It is understood that at Southampton some greenheart piles have failed recently. It may be assumed that the conditions of impregnation or structure necessary to repel the teredo do not exist naturally in such woods as are commonly used in engineering works. It may also be assumed, so far as known at present, that partial or complete immunity, as applied to such woods as are in common use, is a question of locality rather than of variety of wood.

The Limnoria Lignorum.

This small crustacean has several names, as the limnoria terebrans, the gribble and the boring gribble. The limnoria has not been studied for so long a period as the teredo. It was first noticed by Robert Stevenson in 1810, and was examined by Dr. Leach, who one year later pronounced it a new species. It has been investigated since that time by numerous European writers, and, in the United States, it has been studied by Dr. Verrill, of Yale University, and Dr. Sidney I. Smith, of the United States Fish Commission.

The limnoria is gregarious and is found, if at all, in large quantities. It is much smaller than the teredo, but it exists in greater numbers. It has been traced from New York northward to the Bay of Fundy, and large numbers exist in the North Pacific Ocean. It is a very familiar and destructive form of life in Europe. If the destruction accomplished by the limnoria could be estimated it would be found to be surprisingly great.

Descriptive.—The limnoria, Fig. 7, is about as large as a grain of rice. The body is flat, round at each end, and consists of fourteen segments. The sides are nearly straight and are parallel to one another. To each of the seven segments which follow the head is attached a pair of short, stout legs, terminating in claws, the shape of which suggests the small claw of the lobster. The upper surface of the body is covered with small hairs to which more or less dirt usually adheres. The body is grayish in color, and sometimes resembles the color of the wet wood so much that it is difficult to distinguish it. The limnoria can swim, creep backward and forward, as well as jump backward by means of its tail. When touched, it rolls itself into a ball, and in this particular, as well as in general appearance, it resembles the common sow bug.

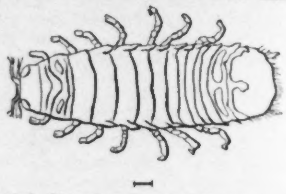


Fig. 7.—Sketch Showing General Appearance of Limnoria or Boring Gribble.

Vital Processes.—The limnoria differs from the teredo in that it is a vegetarian. The teredo is sustained by infusorial life, but the limnoria devours wood. Its tunnel affords both food and shelter.

Boring Apparatus.—The limnoria attacks the wood by means of its mandibles or claws. It prefers wet wood, and succeeds in making a very clean-cut excavation.

Character of the Excavation.—The work of the limnoria differs from that of the teredo in that it works upon the surface of the wood in such a manner as to be clearly seen. The limnoria is similar to the teredo in that its tunnel must communicate directly with the salt water; hence neither of these animals can live in the interior of thick woodwork, such as that of a caisson. The limnoria makes a small, round, parallel-sided tunnel through which it can pass freely back and forth from the sea. The diameter of the entrance of the tunnel is similar to the average diameter. The tunnels are quite short, and are placed very close together, as shown by Fig. 8. They are so numerous that the wood is rapidly reduced to a series of very thin partitions, which soon decay or are washed away by the waves, thus exposing a fresh surface which is at once attacked. Layer after layer is thus rapidly removed, so that the timber is destroyed in a very few years. The limnoria frequently works in conjunction with the teredo, attacking the exterior, while the teredo destroys the interior of the wood, and this combination effects a rapid destruction.

The limnoria attacks both the hard and soft parts of the wood. The hard annual layers have not been avoided in the specimens examined. The limnoria can penetrate knots, but frequently avoids them, so that these hard portions stand out in relief as the timbers waste away. Iron rust is said to cause a somewhat similar effect.

The Range or Field of Work.—The wide range observed between the several species of the teredo does not apply to the limnoria. Its work, as observed in the United States, is generally confined to a limited distance above and below the low-water mark. Where the variations of the tides are extensive, as in the vicinity of the Bay of Fundy, the range of the limnoria is correspondingly great. The United States Fish Commission states that it has been found, although rarely, as deep as 40 to 60 ft.

The Rapidity of the Work.—The limnoria does not work as rapidly as the teredo. The number of individual workers may be taken as a measure of the work they accomplish. The number of tunnels is more important than their depth. Limnoria are almost invariably found in large numbers and destroy a layer from ¼-in. to 1 in. in thickness in a year, the average yearly destruction being probably ½-in. Almost all wood used in marine locations is in the form of piles, which are necessarily exposed upon all sides. Their effective diameter may be reduced at the rate of 1 in. for each season, which result, while not equal to that accomplished by the teredo, is sufficient to cause a great loss.

The Effect of Climate, Temperature and Water.—The limnoria is found where the coldness of the climate prohibits the existence of the teredo. It requires pure sea water, and cannot exist in fresh or impure water, consequently it is not found at the mouths of rivers.

Distribution.—The animals are distributed along the American coast from Florida to Nova Scotia. They exist sparingly in Long Island Sound, but are quite numerous upon the coast of Massachusetts, and are very destructive in the Bay of Fundy. They are very active along the North Pacific coast, and are as much feared in the vicinity of Puget Sound and the Straits of Fuca. They exist also in abundance upon the coast of Great Britain and in other parts of Europe.

Woods Affected.—The limnoria seems willing to attack all varieties of wood commonly used by American constructors, but is said to prefer soft woods. It has been known to attack the gutta percha of submarine telegraph cables. It is said that teak wood is free from attack. Fig. 8 is a life-size photograph of part of a piece of wood from Port Townsend, Wash., showing the work of the limnoria.

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[*] Percival Wright describes a kind of "ship worm" called Nausitora Dunlopei found in India, 70 miles from the sea, in perfectly fresh water.

[†] Treatise, "Dry Rot in Timber," p. 223.

Sphaeroma Destructor.

Attention has recently been called to this hitherto undescribed form of life. This animal is interesting in that it is active in comparatively fresh water. It resembles the limnoria, in that it attacks the wood from without, the interior of the wood being unaffected while the exterior is being destroyed. The work of these animals was first noticed upon some of the trestles of the Florida East Coast Railway in the vicinity of St. Johns River in Putnam County, Florida. Specimens of the wood were submitted to the Carbolineum Wood Preserving Co., of New York city, and were referred by them to the Smithsonian Institution at Washington, where they were studied by Miss Harriet Richardson. The animal somewhat resembles the limnoria in appearance, and is dark brown in color. It works between high and low-water marks. These are not tidal levels, but changes due to the wind assisted by the tides. The water appears to be quite fresh and the water hyacinth, which is not commonly found in salt water, flourishes in the vicinity. The distance to the ocean is about 100 miles.

The Chelura Terebrans.

This animal was first noticed at Trieste in 1839, and was next found in some piles in the harbor of Kingston. The chelura was not identified in America until 1875, when two small specimens were discovered by Prof. Sidney I. Smith at Wood's Holl, Mass. No others were observed until August, 1879, when Professor Verrill discovered a number of them in some piles at Provincetown, Mass. The chelura unquestionably belongs to the amphipods, and there is apparently but one species of the genus.

Fig. 9.—Sketch Showing General Appearance of Chelura Terebrans.

Descriptive.—The general appearance of the chelura, Fig. 9, resembles that of the ordinary shrimp, and for this reason is sometimes referred to as the wood shrimp. Its shape differs from that of the limnoria in a very striking degree. The two animals resemble one another only in size. The chelura is a very active little animal, and swims upon its back. It is a jumper, and can project itself to a considerable height when placed upon dry land, and in this respect resembles the sand hopper. The body is semi-translucent, and is thickly spotted or mottled with pink. The animal is distinguished by three pairs of caudal stylets, the last of which are nearly as long as the body. Those of the females or the young animals are not so long.

Vital Processes.—The chelura resembles the limnoria in that it is a vegetarian, and its burrow affords both residence and food. The fact that the chelura devours wood for sustenance is proved by the minutely divided ligneous matter found in the alimentary organs of dissected animals.

Boring Apparatus.—Professor Allman's original study of the chelura is in part yet regarded as authoritative. He states that the chelura attacks the wood and reduces it to minute fragments by means of a kind of file.

The Character of the Excavation.—Great difficulty has been experienced in obtaining specimens of the work of the chelura, and those obtained are not sufficient to warrant many generalizations. In many particulars the work of the limnoria and of the chelura bear such a close resemblance, Fig. 10, as to lead to the suspicion that these animals are sometimes confused with one another. The excavations of the chelura are slightly larger than those of the limnoria, but are conducted in much the same manner, as the wood is attacked entirely from without. Numerous punctures are made, and then the weakened layers succumb to the action of the waves, the surface thus exposed being in turn attacked and the wood destroyed in the same manner. It is stated that the excavations of the chelura are more oblique in their direction than those of the limnoria, and this is certainly true of the specimens observed.

FIG. 10.—APPEARANCE OF TIMBER INFESTED BY CHELURA TEREBRANS.

The chelura appears to prefer soft wood, and its attack is made as much as possible in the softer annual rings. The work of the chelura differs from that of the limnoria in that the latter attacks the wood at any available point, while the chelura, on the contrary, prefers the softer portions, and avoids the hard wood around knots. Perforations found in such localities may be assumed to be the work of the limnoria.

The Range of Field Work.—The question of range is unsettled. The specimens found at Provincetown were all taken from wood submerged from 8 to 12 ft. below low-water level.

The Distribution of the Chelura.—The chelura was sought many times along the American coast between New Jersey and Nova Scotia, but was not discovered until 1875. It is yet confined, so far as known, to the two original localities, Wood's Holl and Provincetown, both in Massachusetts, but it is more than possible that the animal has escaped observation, and that it is common on the North Atlantic coast. The unskilful eye would readily confound the chelura with the limnoria, although the two animals belong to distinct divisions of the crustaceans. It is quite possible that some of the damage hitherto ascribed to other animals has been accomplished by the chelura.

The chelura has been reported at many places on the coast of Europe, and is mentioned as existing from South Norway to the Adriatic. Attention has been called to the extent of its range. It is said to be an inhabitant of Australia. In Europe a very great amount of destruction is attributed to this species, and efforts have been made to substantiate these points, but have thus far been unsuccessful. It may be that some European results, attributed to this animal, are deserved by the limnoria, as it is probable that some of the work of the limnoria in America should be attributed to the chelura, and it is more than probable that the animals are frequently associated. Efforts to discover particular works affected exclusively by this form of life in Europe have not thus far met with success. The chelura has earned a most unenviable reputation in Europe, but it is not known in which places it exists as a specimen and in which as a pest.

A COMPLETE THEORY OF IMPULSE WATER WHEELS AND ITS APPLICATION TO THEIR DESIGN.

By R. T. Kingsford.*

The common theory of the impulse water wheel has been given so many times by different authors that the fact that it is only an approximation has been almost entirely lost sight of. It is well known that the speed of the bucket for maximum efficiency is not one-half of the velocity of the jet as the ordinary theory indicates, but from 85 to 95% of the half velocity.

The common theory is correct for the conditions assumed, i. e., a wheel of infinite radius and without friction; conditions that are impossible, and far enough from the facts to make the theory based on them of very little use to the designer and engineer. In a wheel of finite dimensions the bucket does not travel straight before the jet, but cuts through it at an angle of say 20° or 30°, and changes its direction relative to the jet by 70° or 80° before leaving it. It is usually stated also that for maximum hydraulic efficiency the direction of discharge relative to the bucket should be parallel and opposite to that of the jet, while in reality it should be tangential at all times, irrespective of the direction of the jet, for in no other way can the velocity of the bucket neutralize that of the discharging water on the bucket, and the resulting absolute discharge velocity become zero.

For the velocity of discharge to become zero, it is then necessary for the velocity of the water relative to the bucket at the point of discharge to be equal and opposite to the velocity of the discharge portion of the bucket. In practice the discharge velocity can never be quite zero, as the relative direction of discharge must depart from a tangent to the bucket's path, by a small angle of from 5° to 15° in order that the water may leave the wheel without being struck by and exerting back pressure on the succeeding bucket. Referring to Fig. 1, it is clear that the minimum value of this discharge angle, b, may be found from the equation

$$\tan b = \frac{n\ t}{2\ \pi\ R}. \qquad (1)$$

Where t = the combined thickness in feet, of water and bucket, at the point of discharge, as shown in the figure.

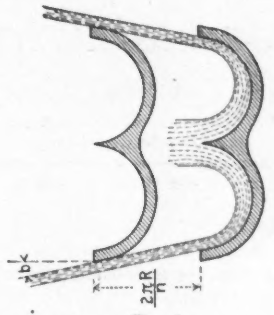

Fig. 1.

n = the number of buckets on the wheel.

R = radius in feet, to the average point of discharge from bucket.

To Find the Speed for Maximum Hydraulic Efficiency.

In Fig. 2, the nozzle T is shown, and four of the buckets or vanes, A F, N P, etc. The centre of the shaft is at M.

Let

H = Head of water available, before nozzle.
P = Pressure per sq. in. equivalent to head H.
V = Spouting velocity of jet in ft. per second = A C in figure.
v = Velocity of bucket for maximum hydraulic efficiency at average point of discharge, in ft. per second = F G in figure.
a = Angle of jet to the path of the average point of water entrance = $\cos^{-1}(p/r)$ = angle D A C in figure.
b = Angle between the direction of discharge relative to the bucket, and the path of bucket at average point of discharge = angle K F J in figure.
c = Average angle of water entrance on bucket = angle D A B in figure.
R = Radius of bucket at average point of discharge, in ft. = F M in figure.
r = Radius of bucket at average point of water entrance in ft. = A M in figure.
p = Perpendicular distance from center of wheel to center of jet in ft.
N_h = Revolutions per minute for maximum hydraulic efficiency.
S_h = Speed ratio for maximum hydraulic efficiency, i. e., ratio of circumferential velocity v of wheel to one-half the spouting velocity of the jet = 2 v/V.
C_f = Retardation or friction factor of water on buckets.
C_v = Retardation or friction factor of water in nozzle.

Referring to the figure, the absolute velocity of discharge F H will be a minimum, and, therefore, the hydraulic efficiency a maximum, when the tangential component F K of the relative discharge velocity F J is exactly neutralized by the velocity F G of the discharge portion of the bucket. The velocity of discharge F J relative to the bucket, is less than the velocity A B of entrance, because of friction between water and buckets, i. e., F J = $C_f \cdot$ A B; also from the right angle triangle J K F, F J = $\frac{v}{\cos b}$, therefore,

$$D\ C = A\ B = \frac{v}{C_f \cos b}.$$

Since velocities of rotation vary as the radii, the velocity A D of the entrance portion of the bucket

$$= \frac{v\ r}{R}.$$

Now, from the figure A E = A D + D E, or,

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*120 Liberty St., N. Y. City.

$$V \cos a = \frac{v\,r}{R} + \frac{v}{C_f \cos b} \cos c;$$

which is

$$\frac{\cos c}{\cos b} = \frac{V}{v} C_f \cos a - \frac{r}{R} C_f. \qquad (2)$$

From the figure, A C . sin a = D C . sin c, or $(A\,C)^2 \sin^2 a = (D\,C)^2 \sin^2 c$. Substituting A C = V, $D\,C = \frac{v}{C_f \cos b}$, $\sin^2 a = 1 - \cos^2 a$, and $\sin^2 c = 1 - \cos^2 c$, this becomes

$$\frac{\cos^2 c}{\cos^2 b} = \frac{1}{\cos^2 b} - \frac{V^2}{v^2} C_f^2 + \frac{V^2}{v^2} C_f^2 \cos^2 a. \qquad (3)$$

Squaring (2) and equating its second member to the second member of (3),

$$\frac{r^2}{R^2} C_f^2 - 2\frac{V r}{v R} C_f^2 \cos a = \frac{1}{\cos^2 b} - \frac{V^2}{v^2} C_f^2. \quad (4)$$

To simplify this equation let

$$A = \frac{r}{R},\ B = A \cos a = \frac{p}{R},\ \text{and } C = \frac{1}{C_f \cos b},$$

then (4) becomes

$$\left(\frac{V}{v}\right)^2 - 2\,B\left(\frac{V}{v}\right) = C^2 - A^2,$$ and, solving for V/v, thus gives

$$\frac{V}{v} = B + \sqrt{B^2 + C^2 - A^2}. \qquad (5)$$

and, therefore,

$$S_h = \frac{2}{B + \sqrt{B^2 + C^2 - A^2}}. \qquad (6)$$

Knowing the speed ratio S_h, the speed of the wheel for maximum hydraulic efficiency N_h may be found from either of the equations,

$$N = \frac{15\ V\ S}{\pi R} = \frac{15\ S\ C_v \sqrt{2gh}}{\pi R} = \frac{183\ S\ C_v \sqrt{P}}{\pi R}$$

Where N = revolutions per minute, corresponding to any speed ratio, S.

To Find the Speed for Maximum Commercial Efficiency.

The effect of bearing friction is to drop the speed for maximum efficiency below that for maximum hydraulic efficiency. This is shown in Fig. 3. O A N C is a curve of HP. and speed of a wheel with frictionless bearings, and is therefore the hydraulic efficiency curve of the wheel. Bearing friction varies directly with the speed, and may therefore be represented by the straight line O J B. By subtracting the ordinates of O J B from those of the curve O A N C, the actual or commercial efficiency curve, O D K, is obtained, having its maximum, D, at a lower speed ratio.

The efficiency curve of a perfect wheel would be a parabola, and if a wheel has enough buckets, the actual curve does not depart from the parabolic form until the speed is beyond the point of maximum efficiency. In the figure, O A B C is a parabola corresponding to the curve O A N C, and this when combined with the line O J B, gives the parabola O D E.

It may be proven from the properties of the parabola, that the ratio of G F to O F is half the ratio of F J to F A, therefore,

$$C_b = \frac{2 - D}{2}. \qquad (8)$$

Where, C_b = Ratio of speed for maximum commercial efficiency, to speed for maximum hydraulic efficiency = O G / O F in figure.

D = Ratio of power absorbed by friction at the speed for maximum hydraulic efficiency, to the maximum power that would be developed with frictionless bearings = F J / F A in figure.

Putting S_c = Speed ratio for maximum commercial efficiency = C_b, S_h, equation (6) gives

$$S_c = \frac{2 - D}{B + \sqrt{B^2 + C^2 - A^2}}. \qquad (9)$$

Knowing S_c, the revolutions per minute may be found from equation (7).

To Find the Maximum Commercial Efficiency.

The losses in a mounted impulse wheel may be divided into nozzle, bucket, and bearing losses. Referring to Fig. 3, it may be proven from properties of the parabola that the miximum commercial efficiency G D, equals C_b^2 times the maximum hydraulic efficiency F A. Therefore,

$$E_c = C_b^2\ E_h \qquad (10)$$

In which E_c = Maximum commercial efficiency.

$E_h = C_v^2\ E$ = Maximum hydraulic efficiency.

E = Maximum efficiency of buckets.

The bucket losses may be further divided into losses due to clearance angle at discharge, friction of water or buckets, and irregular actions such as breaking up of the jet by impact, back pressure on buckets, etc. The irregular losses cannot be calculated, but are negligible when the entrance and discharge angles are correct, dividing edges sharp, and curvatures not abrupt. The proportion of power lost in the discharge (see Fig. 2)

$$= \frac{(F\ H)^2}{(A\ C)^2} = \frac{v^2 \tan^2 b}{V^2} \text{ or}$$

$$= \frac{S_h^2 \tan^2 b}{4} \qquad (11)$$

The effect of friction between water and bucket is to reduce the velocity of the water, and produce a polygon of forces on the surface of the bucket, the resultant of which is practically perpendicular to the plane of rotation, and, therefore, lost.

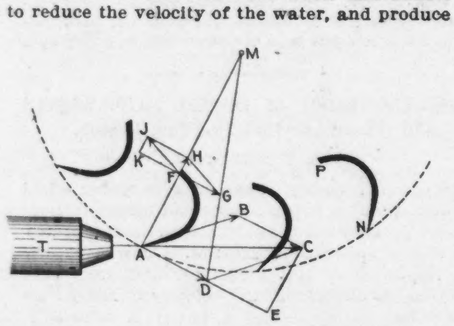

Fig. 2.

The proportion of bucket friction loss

$$= \frac{(A\,B)^2 - (F\,J)^2}{V^2} \text{ (Fig. 2.)}$$

Substituting $A\,B = \frac{F\ J}{C_f}$, and $F\ J = \frac{V\,S_h}{2 \cos b}$, this becomes

$$\frac{S_h^2\ (1 - C_f^2)}{4\,C_f^2 \cos^2 b} \qquad (12)$$

therefore from (11) and (12) the maximum efficiency of the bucket is

$$E = 1 - \frac{S_h^2 \tan^2 b}{4} - \frac{S_h^2\ (1 - C_f^2)}{4\,C_f^2 \cos^2 b} \qquad (13)$$

the second term being the loss at discharge and the third that due to bucket friction. The maximum commercial efficiency may now be found from (10) and (13), thus:

$$E_c = C_b^2\ C_v^2\ E \qquad (14)$$

To Find the Proper Number of Buckets.

The number of buckets has much to do with the efficiency and regulation of the wheel. If too many, the losses due to the breaking up of the jet, clearance angle, and bucket water friction, will be much increased; and if too few, part of the water will pass through between the buckets without imparting its energy to the wheel. The effect of the latter on the efficiency is shown in Fig. 3 by the falling away of the efficiency curves O A N C and O D K at high speeds.

In Fig. 4, A B is the bottom of the jet, and A and C two adjacent bucket tips. A particle of water having just passed under bucket A, must overtake bucket C, before it reaches B; i. e., for the minimum number of buckets, the time of the jet from A to B equals the time of the bucket from C to B.

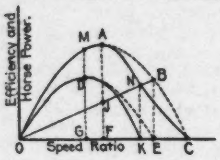

Fig. 3.

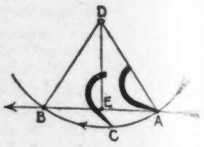

Fig. 4.

Let n_o = Minimum number of buckets allowable.

d = Diameter of jet, in feet.

e = Half the angle subtended by the bottom of the jet = angle E D A in the figure $= \cos^{-1} \frac{2\,p + d}{2\,r_1}$

p = Perpendicular distance in feet from centre of wheel to centre of jet.

r_1 = Radius of bucket in feet at tip, or initial point of water entrance on bucket = D A in figure.

S_b = Speed ratio at which water commences to pass through between buckets. It must not be taken less than S_c.

The time of jet from A to B is

$$\frac{2\ r_1 \sin e}{V} \qquad (15)$$

The time of bucket from C to B is

$$\frac{2\ R}{V\ r_1 S_b} \cdot C\ B \qquad (16)$$

and, from the figure, C B = A C B − A C

$$= 2\ \pi\ r_1\left(\frac{e}{180} - \frac{1}{n_o}\right)$$

Substituting value of C B, equating (15) and (16) and solving for n_o,

$$n_o = \frac{180\ \pi\ R}{\pi\ R\ e - 90\ S_b\ r_1 \sin e} \qquad (17)$$

If a wheel is to be used without a governor, S_b should be taken as small as possible, so that the rapid falling off of efficiency at speeds higher than that for maximum efficiency, will tend to prevent racing at light loads.

To Find the Entrance Angle of the Bucket.

In order to prevent loss by the generation of heat, formation of eddies, backwater, etc., the bucket surface at entrance should be parallel to the course of the jet relative to the wheel.

Let c_1 = Angle between entering or initial edge of bucket, and an arc of radius r_1, = angle D A B in Fig. 2.

$a_1 = \cos^{-1} p/r_1$ = angle between center line of jet, and an arc of radius r_1, = angle D A C in Fig. 2.

From the figure, $D\,E \cdot \tan c_1 = A\,C \cdot \sin a_1$, or,

$$\tan c_1 = \frac{A\,C \cdot \sin a_1}{A\,E - A\,D},$$

and substituting $A\,E = V \cos a_1$, and $A\,D = \frac{V\,S_c\,r_1}{2\ R}$, this gives

$$\cot c_1 = \cot a_1 - \frac{S_c\ r_1}{2\,R \sin a_1} \qquad (18)$$

Calculations of a Wheel of 32-in. Nominal Diameter.

The following calculations will serve to show the application of the preceding formulae:

The wheel in question is of the tangential type, discharging on the sides; the principal dimensions being, diameter outside of buckets, 35 ins.; radial length of buckets, 4 ins.; diameter of jet, 2 ins., radius to center line of jet, 15¼ ins. These dimensions, in the notation used, give:

$$r_1 = \frac{35}{2 \times 12} = 1.46;$$

$$d = \frac{2}{12} = 0.167;$$

$$p = \frac{15.25}{12} = 1.27.$$

The average radius of entrance will necessarily be between p and r_1, and may be taken as equal to $\frac{3}{4}p + \frac{1}{4}r_1$; i. e.,

$$r = 0.95 + 0.36 = 1.31.$$

The average radius of discharge will be slightly less than p. With type of wheel it may be taken equal to 1.5 p — 0.5 r, or

$$R = 1.9 - 0.65 = 1.25.$$

The value of S_b should be taken to suit the conditions under which the wheel is to run, as previously explained. Ordinarily take

$$S_b = 1.1.$$

Half the angle subtended by the bottom of the jet equals

$$e = \cos^{-1} \frac{2p + d}{2r_1}, \text{ or,}$$

$$e = \cos^{-1} (0.93) = 21° 30'.$$

To find the proper number of buckets use equation (17),

$$n_0 = \frac{180 \times 3.1416 \times 1.25}{3.1416 \times 1.25 \times 21.5 - 90 \times 1.1 \times 1.46 \times 0.366} = 24.$$

The combined thickness, t, of water and bucket at discharge equals $\frac{\text{Area of jet}}{2 \times \text{Radial length of bucket}}$ + thickness of bucket and an allowance for irregularity. In this case, make

$$t = \tfrac{3}{4}\text{-in.} = 0.0625.$$

To find the minimum clearance angle, b. use equation (1).

$$b = \tan^{-1} \frac{24 \times .0625}{2 \times 3.1416 \times 1.25} = 11°.$$

The actual angle of discharge will probably be about 16°. The friction factor of the water on the bucket C_f must be found experimentally. It increases with the extent and roughness of the surface. Assume,

$$C_f = 0.94.$$

To find the speed ratio S_h, for maximum hydraulic efficiency, use equation (6). In this equation,

$$A = \frac{r}{R} = 1.05,\ B = \frac{p}{R} = 1.02,\ C = \frac{1}{C_f \cos b} = 1.11$$

$$S_h = \frac{2}{1.02 + \sqrt{1.04 + 1.23 - 1.1}} = 0.954$$

The proportion of bearing friction, air resistance, etc., must be estimated. Assume D = 0.03. The coefficient C_b may now be found from equxation (8),

$$C_b = \frac{2 - 0.03}{2} = 0.985.$$

The speed ratio, S_c, for maximum commercial efficiency, may be found from equation (9),

$$S_c = C_b\ S_h = 0.94.$$

The friction factor C_v, of the water in the nozzle, increases with the taper angle, being almost unity for a thin flat plate, and for a reamed taper of not less than 25°, it is seldom less than 0.96 or 0.97. Assume

$$C_v = 0.97.$$

The correct speed in revolutions per minute may now be found for any head or pressure from equation (7),

$$N = \frac{183 \times 0.94 \times 0.97}{3.1416 \times 1.25} \sqrt{P} = 42.5 \sqrt{P},$$

The efficiency, E, of the bucket may now be found from equation (13),

$$E = 1 - 0.019 - 0.034 = 0.947.$$

Knowing E, C_b, and C_v, the maximum commercial efficiency may be found from (14),

$$E_c = 0.97 \times 0.94 \times 0.947 = 86\%.$$

To obtain this efficiency, the wheel must be run at the correct speed: i. e., $N = 42.5 \sqrt{P}$, as found above, and the entrance angle of the bucket must be correct.

To get this angle, use equation (18), in which

$$a_1 = \cos^{-1} p/r_1 = 29° 30'.$$

Then the correct angle for the entering edge of the bucket is, from (18),

$$c_1 = \cos^{-1} (1.78 - 1.12) = 56° 30'.$$

With some wheels the bucket is of such a form that the loss at discharge would be much increased if the angle were made as large as formula (18) indicates, and a compromise has to be made. This is, however, a source of considerable loss and should be avoided by proper designing.

ATMOSPHERIC RESISTANCE TO THE MOTION OF RAILWAY TRAINS.

In a paper with the above title by Prof. W. F. M. Goss, published in the "Proceedings of the Western Railway Club" for April, 1898, there is described a series of experiments on wind resistance of small models of railway cars, from which the author deduces a set of formulas for the air resistance of actual trains of different number of cars at various speeds. The models used were 1-32 the size of an assumed standard box car, or 12 1-16 ins. long, 3⅛ ins. wide and 4½ ins. high. They were placed inside of a smooth air-tight wooden conduit with glass sides, 20 ins. square, 60 ft. long, through which air was blown by means of a fan blower, the velocity of the air current being ascertained by Pitot tube gages. The pressure exerted by the wind in the direction of the axis of the conduit was measured by a very sensitive dynamometer attached to each car. The condition of the cars being at rest and the air in motion was taken as equivalent, so far as the pressure tending to move the cars was concerned, to the natural condition of cars in motion through still air. Numerous observations were made with the number of cars varying from 1 to 25 and with velocities of air from 25 to 105 miles per hour. The actual pressures on the model cars, as registered by the dynamometers, were compared with the theoretical pressures due to the velocity calculated from the formula $P = .0025\ V^2$, in which P = pressure per square foot and V = velocity in miles per hour.*

It was found that when one model only was used the ratio of the force tending to displace the model to the pressure due the velocity was respectively 0.61, 0.54, 0.48, 0.47 and 0.49 for velocities of 25, 41, 73, 88 and 102 miles per hour. For the speeds higher than 25 miles per hour the average ratio approximates 50%. When two models, placed end to end, were used the pressure on the first was about 40% and that on the second about 13%, a total on both of about 53% of the theoretical pressure acting on an area equal to the cross section of a model. For three models the pressures were respectively about 0.40, 0.05 and 0.13 of the theoretical, a total of 58%. For five models the pressures were about 0.39, 0.03, 0.04, 0.04, 0.11, a total of 61%. For ten models the pressure on the first was about 0.39, on the second to the ninth inclusive about 0.039 each, or one-tenth that on the first, and on the tenth about 0.1, making a total of 80% of the theoretical pressure on the cross section of one model. With 25 models the pressures were about the same on the first, last and intermediate models respectively as with ten models, the sum of the pressures for the 25 models being about 1.4 times the theoretical end pressure on a single model. In all cases of trains of more than ten models, however, the pressure on the second model of the train is somewhat less than that upon the third or any other succeeding model except the last.

The relation between the force and the velocity upon the several models of a train may be expressed by the following equations:

For a single model, $A = 0{,}000116\ V^2$.
For the first model of a train, $A = 0.000097\ V^2$.
For the last model of a train, $A = 0.000025\ V^2$.
For the second model of a train, $A = 0.000008\ V^2$.
For any intermediate model, $A = 0.000010\ V^2$.

In which A = the force in pounds acting on the model in the direction of its length, and V = the velocity of the air current in miles per hour. These equations apply only to models of the particular dimensions used. Equations of a more general character are obtained by reducing the forces acting upon each model to equivalent forces per square foot of area of cross section, as follows:

For the Pitot gage, $P = 0.0025\ V^2$.
For the model alone, $P = 0.0012\ V^2$.
For the first model of a train, $P = 0.001\ V^2$.
For the last model of a train, $P = 0.00026\ V^2$.
For the second model of a train, $P = 0.00008\ V^2$.
For any intermediate model between the second and the last, $P = 0.0001\ V^2$.

The models being 1-32 the size of a 33-ft. box car, the area of surface of an actual car is 32^2 = 1,024 times the surface of a model. The coefficients of V^2 in the above formulae being multiplied by 1,024 the resulting values of P will then represent the atmospheric resistance to the passage of an actual car at the speed of V. The atmospheric resistance of trains of such cars is the sum of the resistances of the several cars, and it may be expressed by the following formula, which is developed from those already given:

$$A = (0.105 + 0.010\ N)\ V^2,$$

in which A = the resistance in pounds, N the number of cars in the train, and V the speed in miles per hour. In a train of cars headed by a locomotive and tender, the locomotive should be regarded as the first car and the tender the second. A passenger car may be considered as equivalent to two freight cars. Taking the freight car as 33 ft. in length, a formula may be constructed in which the length of the train in feet, instead of the number of cars, is a factor.

Prof. Goss concludes his paper by summarizing his several formulae in the convenient forms given below. He says they apply to trains and parts of trains having an area of cross-section equal to that which is common in American practice, with possible errors of from 15 to 20% in individual cases. In the following equations A is the tractive force in pounds necessary to overcome the resistance of the atmosphere, and V the velocity in miles per hour:

a. For a locomotive and tender running alone: $A = 0.13\ V^2$.
b. For a locomotive and tender running at the head of a train: $A = 0.11\ V^2$.
c. For the last car of a train of freight cars: $A = 0.026\ V^2$.
d. For the last car of a train of passenger cars: $A = 0.036\ V^2$.
e. For each intermediate freight car in a train of 33-ft. cars: $A = 0.01\ V^2$.
f. For each intermediate passenger car in a train of 66-ft. cars: $A = 0.02\ V^2$.
g. For a train consisting of locomotive, tender and freight cars: $A = (0.13 + 0.01\ C)\ V^2$, where C is the number of cars in the train.
h. For a train consisting of locomotive, tender and passenger cars: $A = (0.13 + 0.02\ C)\ V^2$.
i. For a train of freight cars following a locomotive, but not including either locomotive or tender, $A = (0.016 + 0.01\ C)\ V^2$.
j. For a train of passenger cars following a locomotive, but not including either locomotive or tender, $A = (0.016 + 0.02\ C)\ V^2$.
k. For a locomotive and any train, either freight or passenger: $A = 0.0003\ (L + 347)\ V^2$, where L is the length of the train in feet.
l. For a train of cars, either passenger or freight, following a locomotive, but not including either locomotive or tender: $A = 0.0003\ (L + 53)\ V^2$, where L is the combined length of the cars composing the train.

◆

THE BLUNT DIVIDING ENGINE, built by E. & G. W. Blunt, of New York, in 1851-58, has been secured, along with the business of Mr. F. Eskel, by Koiesch & Co., manufacturers of drawing instruments, of 155 Fulton St., New York. This engine, which was one of the first built in this country, and is still one of the best in use, has a circle 35 ins. diameter, with the circumference divided into 2,160 parts, with six divisions to one degree. The engine was considered so important that an illustrated description of it was published in book-form, in 1858, detailing the methods employed in dividing the circle, cutting the circumferential teeth and in applying it to the division of the circles of surveying and astronomical instruments. The book contains a certificate by the late J. E. Hilgard, of the U. S. Coast Survey, attesting the accuracy of the work.

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*[The theoretical pressure due the velocity is $0.005\ V^2$ instead of $0.0025\ V^2$. The theoretical pressure produced by a jet of any fluid on a plane surface at right angles to the jet is equivalent to twice the head which would cause the velocity, or $\frac{2v^2}{2g}$, v being the velocity in feet per second (see Church's Mechanics, pp. 761, 803). If A = area of the plane in sq. ft., w = weight of 1 cu. ft. of air = 0.0761 at 62° F. and atmospheric pressure, and F = total pressure on the plane. $F = A\,w\,\frac{v^2}{g}$. If A = 1, w = 0.0761, and g = 32.2, $F = 0.00236\ v^2$. If v is taken in miles per hour, v = 22 ÷ 15, $v^2 = 2.15$, and $F = 0.00507\ V^2$. This correction will cause all the figures given by Prof. Goss to express the relation of observed to theoretical pressures to be divided by 2, but it makes no change in his formulas for resistance, which are based on experiment and not on theory.—Ed. Eng. News.]

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

We published in our issue of July 7 a report made by Mr. Henry B. Seaman, M. Am. Soc. C. E., on the condition of the various paints applied to the 155th St. viaduct over the tracks of the Manhattan Elevated Ry., in New York city. We accepted and published the report on the strength of Mr. Seaman's reputation, without taking measures to verify its accuracy; but as some severe criticisms of this report have been since presented to us, two members of the editorial staff of this journal visited this structure on July 16 and carefully examined it. As a result of this examination we are obliged to advise our readers that no conclusion whatever as to the relative merits of the various paints under test should be based on Mr. Seaman's report, and we regret having given publicity to it.

To explain more in detail, Mr. Seaman in his report said:

> In making the examination, a careful general scrutiny was given to each girder from the platform below, and each was given a percentage mark, denoting the amount of surface free from rust. These percentages were then carefully compared and reviewed so that they might correctly represent the comparative condition of each girder. When these tests were completed, a thorough inspection was made by climbing through the structure, and the character of rust was denoted for each girder.

In the table accompanying Mr. Seaman's report, the percentages of the surface of each girder free from rust varied from 99% to 25%, and some of these percentages differed by as little as 2% from each other. The editors of this journal who have examined the structure agree in stating that no such accurate estimate as these percentages would indicate is possible by examining these girders from the platforms; and in fact no reliable estimate is possible at all with the girders in their present condition. They have examined the structure from the platforms, and also climbed through it, as did Mr. Seaman. They find practically the entire steel-work covered with a coating of ash, dust, soot, etc., so that any accurate comparison of the conditions of the different paints is impossible. It must be understood that nowhere on the whole viaduct are there patches of deep red rust, such as are found on an iron structure after considerable exposure to the weather, and which stand out plainly against any dark paint. Such rust as is to be found on this structure is for the most part in the form of fine pin points, except where leakage from the floor overhead has spread rusty water on the iron and has discolored it or caused local rusting. To determine accurately the percentage of surface free from rust under these conditions and especially from the platforms 17 ft. below as Mr. Seaman claims to have done, is about as easy as counting the bees in a swarm. We do not mean to say that no differences in the condition of the various paints are discernible. On the contrary, Girders Nos. 3 and 8 are, as Mr. Seaman indicates, in much worse condition than any of the others; at the same time his percentages, 25% and 30%, as the surface of these girders free from rust, would in our opinion be more accurate if stated as 25% covered with rust. We allude to this merely to show that any estimate of the percentage of surface free from rust on the various girders of this viaduct is a matter of rough guess-work under present conditions, and probably no two experts could be found who would guess alike.

The test of paints in progress at this place promises to furnish some interesting and valuable data sometime; but we believe it is too soon yet to make any comparison of the conditions of these various paints that will be worthy of general acceptance by the profession. At least a dozen of these girders show trifling if any difference in their condition, and this is really to be expected, considering that this paint has not been on a year yet and it was applied to an iron surface as clean as the sand-blast could make it.

After the paint has been in service for two years or so, it would be an excellent idea for the committee of the American Society of Civil Engineers, which has in charge the subject of paints for metal work, to make a thorough examination of and report upon the condition of the various paints on this structure. Such a report would carry weight with the profession that could not attach to a report made by any city official or any single engineer, however expert.

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Judging from a communication in the Cleveland "Plaindealer," of June 30, one C. C. Merrill, Manager of the Mexican Clay Co., of the City of Mexico, has either been very unfortunate in the selection of his acquaintances; or, he should be at once employed in writing war despatches for Governor General Blanco. This party is making sewer-pipe for the Mexican government under a valuable concession, and, doubtless, for purposes of his own, indulges in fulsome and uncalled-for praise of the strict honesty of the Mexican officials with whom he has to deal. There is no particular harm in this; but he then goes on to draw comparisons between the Mexican and the American engineer, and says that in selling sewer-pipe in the United States, "I never found an American engineer that I could not buy, except he had been bought up by the man ahead of me." As to this statement, Mr. Merrill has either had an exceedingly limited experience as a selling agent; or, what is much more probable, he simply lies. There is no doubt from his own confession but that Mr. Merrill is venal enough, for in his statement he calmly acknowledges offering to a Spanish Chief Engineer terms of "mutual benefit." The mistake he makes is in measuring others by his individual standard.

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In the description of the process of liquefying air in use by Mr. Chas. E. Tripler, of New York City, in our issue of April 14, we described the method and apparatus by which a portion of the highly compressed air is made to furnish a refrigerating effect which causes liquefaction of another portion of the air.

An English inventor, Dr. W. Hampson, now claims to be the original inventor of this process of "Self-Intensive Refrigeration," as he terms it. In a paper printed in the "Journal of the Society of Chemical Industry, May 31, 1898, Dr. Hampson explains in detail his method of liquefying air, and gives his reasons for believing himself to be the original inventor of this process of liquefaction of air and other gases.

So far as we have been able to find, neither Dr. Hampson nor Mr. Tripler have taken out American patents on their inventions yet. Mr. Tripler has an English patent (No. 4210 of 1893), which Dr. Hampson alleges is actually a heating apparatus instead of a refrigerating one, and he further claims that Tripler's successful production of liquid air has all been done since the publication of the Hampson system and apparatus in 1895.

Those interested in the subject of liquid air will do well to secure a copy of Dr. Hampson's pamphlet, which is printed by Eyre & Spottiswoode, the well-known London publishers. We presume that the United States patent office will have to sift the question between the two claimants in an interference case.

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The vexed question of the improvement of the Chicago River in order to make it navigable for the large steamers now coming into use was brought up for discussion at the meeting of the Western Society of Engineers on June 1. At this meeting a paper was presented by Mr. G. A. M. Liljencranz, U. S. Assistant Engineer, describing the existing obstructions to the navigation of large vessels. A number of plans of awkward locations on the river were exhibited, on which the outline of a large steamer had been plotted, showing graphically the difficulty, and in some cases the impossibility, of such a ship getting through. The general situation and the relation of the Chicago River to the commercial interests of the city have already been fully presented in our columns, and it is only necessary here to state briefly the conditions. The narrow and tortuous channel, which is obstructed by numerous docks, bridges, bridge piers, the roofs of three tunnels, and numerous bends and sharp turns, passes through a business and industrial district, and is traversed by a very large tonnage of shipping in the trade with the freight wharves, grain elevators, coal and lumber yards, etc., which have been established along the stream. At present the river is practically a navigable sewer, the water being black and offensive and the bottom being a soft foul mud which is kept stirred up by the steamers. It is expected that this condition at least will be improved when the drainage canal is completed, but the filthiness and dilapidated condition of the surroundings will remain unless some radical steps are taken for the general improvement of the river. It is not generally known that there is an existing ordinance (passed in 1869), establishing certain dock lines, but this is absolutely a dead letter and docks are built far beyond the prescribed limits, without regard to the requirements of navigation. The drainage board will increase the waterway at some points, in order to secure the necessary amount of flow to the canal, but this will be done by means of covered conduits and will not improve the navigation. For the latter purpose, the U. S. government has undertaken to cut off corners and widen the channel at certain points, but this work will be of limited extent, and is but a temporary expedient. It will remain for the city to undertake the more extensive work of lowering the tunnels, and replacing the center-pier drawbridges with bascule bridges which will neither obstruct the channel nor interfere with the wharfage adjacent to the bridges. With this might and should come a general rectification of the channel and an improvement of the river front.

It certainly seems evident that the city should delay no longer, but at once take the matter in hand, as there is urgent necessity for the adoption of some definite plan for the improvement of the long-neglected river on a bold scale, and not by mere petty improvements which practically leave the general problem untouched. When once such a plan is adopted, the work of carrying it into effect can be done gradually as means will permit. The size of steamers employed in the lake traffic has shown a marked increase within recent years, and the government is now establishing a 21-ft. channel through the lakes between Duluth, Chicago and Buffalo. In recent reports, Major W. L. Marshall, U. S. Engineers, has shown that many of the large vessels whose length and beam enable them to pass through the Chicago River, cannot be given a full load on account of the limitation of draft by the tunnels, and cases are not infrequent where loaded steamers ground in the shallow water over these tunnels.

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The return to Spain of the 25,000 prisoners of war lately taken at Santiago seems to be not only the

FIG. 6. APPEARANCE OF MAHOGANY TIMBER AFTER NINE MONTHS' WORK BY TEREDO.

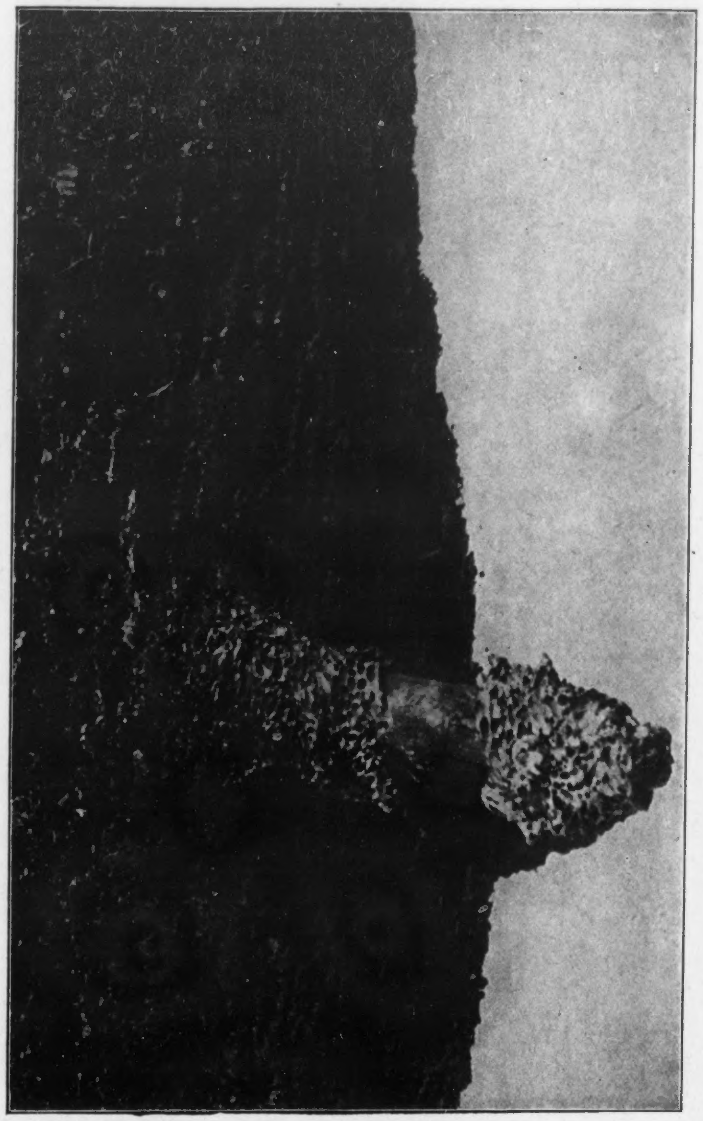

FIG. 8. APPEARANCE OF TIMBER INFESTED BY LIMNORIA.

FIG. 4. SURFACE OF TEREDO INFESTED TIMBER SHOWING SMALL SIZE OF INITIAL PERFORATIONS.

FIG. 5. INTERIOR OF TEREDO INFESTED TIMBER SHOWING ENLARGEMENT OF PERFORATIONS.

MARINE WOOD BORERS.

most economical method of dealing with the problem, but also an eminently wise educational step. These returning prisoners have met the Americans in battle; they have practically witnessed the destruction of Spain's best fleet; they know how our soldiers can fight and our sailors can shoot; and every man of them will be a missionary in Spain, helping vastly to dispel the dense ignorance concerning the United States, which is now one of the greatest obstacles to the restoration of peace. On the other hand, it is an economical plan, because the per capita cost of transferring these prisoners to a Spanish port is small compared with the expense of bringing them from Santiago to the United States, and then feeding and guarding them for an uncertain length of time. There is besides the added risk of importing disease should the prisoners be brought to this country.

◆

In our issue of July 7, in referring to the four Spanish cruisers sunk at the battle of Santiago, we stated that their armor was Harveyized nickel steel. A correspondent asks our authority for this, and we find on more careful investigation that the "Cristobal Colon" had a belt of 6-in. Harveyized armor, whether nickel steel or not we cannot say. The other three vessels had 12-in. side armor, of what material we are not informed, but, judging by the date the vessels were built, it probably was not nickel steel or Harveyized.

◆

THE DEMAND FOR FASTER BATTLESHIPS.

In our issue of June 23 we called attention to the serious blunder which our Navy Department has made in fixing upon a speed of only 15 to 16 knots for the three new battleships for which it is now asking bids. We then showed that every naval power in the world except the United States has increased its standard speed for battleships to from 17 to 19 knots; that there are already at least fifty foreign battleships afloat or under construction which have speeds one to three knots in excess of the speed of any of our battleships; and that for the United States at this time to build new battleships with speeds even lower than the speeds of its battleships now afloat will injure its naval prestige as much as the loss of a battle.

Our prediction that if the American public once understood the significance of this action by the Navy Department, a universal protest would go up, has been amply verified. The presentment of this matter by Engineering News has been copied and commented upon by the principal newspapers in almost every city in the country, and our urgent plea that the Navy Department should revise its action and make plans for our new vessels that will put them at least on an equal footing with those of foreign countries in the matter of speed has been unanimously approved.*

Moreover, the newspapers are ably continuing the agitation for a change in the Department's plans. A number of the leading journals throughout the country have taken hold of the subject in earnest, and by repeated editorial presentations of the subject have awakened a public sentiment which the Navy Department must sooner or later recognize. Such journals as the "New York Tribune," "Brooklyn Eagle," "Pittsburg Dispatch," "Washington Times," "Minneapolis Journal," "Buffalo Enquirer," "Cincinnati Commercial Tribune," and others of similar standing the country over are urgently demanding that the naval authorities shall change their plans and make the new battleships vessels in which the nation can take just pride.

The only attempt by the Navy Department to justify its decision in any way that has come to our notice, is a Washington dispatch in the "New York Times," of July 8, in which "high naval officials" unnamed are quoted at some length. The substance of this reply we quote verbatim as follows:

> The fixing of a sustained speed of 16 knots an hour for our battleships was made after careful consideration of the question in all its bearings. It is an easy matter to increase the speed of ships, but without sacrificing their offensive and defensive qualities it can only be done by increasing their size.
>
> In consequence of the limited depth of water in most of the harbors on the American coast, it has come to be an unwritten law of naval construction in this country that the draft of the largest of our warships, in their normal condition, shall not exceed 24 ft. Most of the big battleships of European navies draw 27½ ft. Depth is a most important factor in increasing displacement, and as it is limited in this country by the shallowness of our harbors to 24 ft., increased displacement must be sought in either length or breadth or both.
>
> In designing a battleship of more than 12,000 tons displacement with the draft limited to 24 ft., the increased volume, if gained by lengthening, would result in a vessel of too great length for efficiency, increasing the weight of defensive material and reducing her handiness in squadron evolutions. If the beam alone be increased, the vessel would be too wide for many of our docks, and would afford an uneasy and highly unsatisfactory gun platform.
>
> It is further held by many naval authorities to be extremely doubtful whether a higher speed than 16 knots an hour would prove of practical value to a heavy fighting ship. For steaming long distances such a speed could not be used, and no squadron ever manoeuvred or was any naval battle ever fought at as high a rate of speed as that.
>
> A great deal has been said of the superior speed of Admirl Cervera's late squadron, but while those ships were credited with a speed of 20 knots "on paper" they never, from the time they appeared at the Canaries, showed an ability to "get there" at a higher rate of speed than ten knots. The fact that all four of them were overhauled and sunk by our cruiser "Brooklyn" and battleships of far less nominal speed, although the Spaniards had the advantage of a start at full speed, is convincing evidence of the futility of their boasted swiftness.

It is one unfortunate feature of the astonishing naval victories which have been won by the United States fleets in the present war that they tend to beget in the popular mind an over-confidence in the powers of our present naval vessels, and a tendency to overlook the weak points in our national defence. It is natural enough that the non-technical public should take the results at Santiago and Manila as conclusive proof of the efficiency in every respect of our fleets; but it is surprising, indeed, to find such arguments used by "high naval officials."

Further, as a matter of fact, the Santiago battle offers conclusive proof to the veriest tyro in naval strategy of the enormous value of high speed in a fighting vessel. Had the Spanish cruisers been able to reach such speeds as their engine power should have given them, even with their barnacle-laden hulls, the chances are good that they would have got out of range before the American vessels on guard could get under way and stop them. As it was, the fastest of the four, the "Cristobal Colon," did outstrip the other vessels and get entirely away and out of effective range. It was then that the "Brooklyn" and the "Oregon" undertook a stern chase after the fleeing vessel. The former vessel has about the same speed rating as the "Colon," but was not her equal in armor or armament; and in a duel between the two vessels fought with equal skill on both sides, the "Brooklyn" would probably have been worsted. What the result would have been had the two vessels fought alone will never be known, for the "Oregon," running at a 16-knot speed, was able to come to the assistance of the "Brooklyn," and made the defeat of the Spanish vessel sure.

The newspapers are accepting the Santiago battle as clear proof of the value of speed in a battleship, and they are right. For that matter, the statement of the "high naval official" that no battle was ever fought at a greater speed than ten knots is disproved at once by this very conflict. As for other naval battles, it is probably true that few or none have been fought with greater speed than ten knots, simply for the reason that very few naval battles have been fought with modern high-speed naval ships. Everyone familiar with naval warfare, however, knows that numberless actions have been fought with one vessel or fleet making all possible speed to escape and the enemy using every effort to overtake them. These are exactly the emergencies for which high speed in naval vessels is demanded.

The "high naval official" quoted above seems to think that the falling off in speed which Cervera's ships showed, is proof that the speeds of contract trial trips are no index of what a vessel can really do. But because that proved true with the Spanish vessels, it does not follow at all that it is true in the American navy. In fact the "Oregon's" speed in her chase after the "Colon" was very close to that recorded on her trial trip, notwithstanding the more or less foul condition of her hull.

Practically the sole argument that deserves to be considered in the above statement by the naval officials is the claim that the depth of our harbors limits the draft of American battleships to 24 ft., and the width of our dry docks limits their beam. Let us see how much there is to this argument. In the first place, it should be understood that there are only a few harbors on the coast which a 24-ft. draft vessel can enter at low water anyway. The list of ports with a depth of water of 24 ft. or more at low tide on the Atlantic and Gulf coasts is as follows:*

Port.	Depth, mean low tide, ft.
Portland	29
Portsmouth	(Admits any vessel.)
Providence	25
New York	30
Baltimore	27
Norfolk	25
Newport News	25
Yorktown	33
Key West	25½
Tortugas	24
Pensacola	24
New Orleans	26
Sabine Pass	24
Galveston	24

It appears that there are only 14 ports on our Atlantic and Gulf coasts which our present battleships when loaded to 24 ft. draft can enter at low water; but we fail to see that this is a matter of any particular consequence. So long as a battleship can reach the naval stations and dry docks where she is to be equipped and kept in repair, it is a matter of little consequence whether she can enter the other home ports or not. A glance at the above table shows that she can enter nearly as many of the commercial ports drawing 26 ft. as she can drawing 24 ft., anyway.

As for being able to reach the naval stations, battleships of any desired draft can reach the Portsmouth and New York navy yards, and the same is true of the anchorages at Hampton roads and Dry Tortugas. To get up to the berths at the Norfolk yard, some dredging would be necessary for a vessel of 26 ft. draft or more; but if the United States can afford to spend as many million dollars as it proposes to upon new ships, it can afford whatever may be needed to dredge the channels leading to its principal naval stations. For that matter, if our largest battleships can reach the four stations named above we do not see that they need further accommodation.

Let us turn next to the matter of dry dock accommodation. At present we have just three docks on the Atlantic coast which can take in battleships of the dimensions now proposed (excluding the Port Royal and League Island docks, which are inaccessible to our present battleships by reason of shallow water). Congress has just appropriated the funds for five new docks. We know of no reason why these structures should not be made wide enough and deep enough to take in whatever size of battleship the conditions of National defence makes it wise for us to build.

When one really stops to think of it, how absurd seems the declaration, that this country has settled down to a basis of a 24 ft. draft and a 16-knot speed as a permanent limit for its battleships. Other nations may progress as they please, 16 knots is fast enough for us! How long is this standard to last, pray? Are we to continue placidly on that basis, no matter what progress other nations make, until perhaps in some future naval battle the superior speed and manoeuvering power of an enemy's fleet may win them the day?

There have been various conjectures as to the reasons why the Navy Department adopted this low rate of speed for the new vessels. It has been alleged that the three or four great shipbuilding firms who will doubtless take the contracts for them wanted to build duplicates of the vessels of the "Alabama" class now under construction to save the expense of duplicating drawings, patterns, templates, etc., and increase their profits. We do not believe this to be true. Neither do we believe that the Navy officials merely wished to save themselves the trouble of making new designs throughout for these three ships.

We believe the real reason is a sort of ultra conservatism that prefers to follow the beaten path to making any new ventures and prefers to sit comfortably down and rest content with 24 ft. draft and 16-knot speed, rather than to attempt to follow English and Continental naval designers

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*We say unanimously, but in the interest of absolute accuracy, we must record that one Philadelphia newspaper thinks 15 to 16 knots is fast enough.

*This list includes the depth of water up to the wharves in each case. Of course there are harbors of refuge, and places of anchorage all along the coast, as at Key West, Hampton Roads and numerous points all along the North Atlantic coast where vessels of any draft can lie at anchor in more or less shelter.

in the vast strides which they have made in the past four or five years.

We have abundant authority for declaring that the American people will not rest content with naval progress of such a sort. The people as a people want no wars; they vastly prefer the arts of peace. They want no huge naval establishment and had rather build schools than battleships and factories than fortresses. At the same time they will cheerfully and gladly contribute all that is necessary to make their national defence impregnable on land and sea; and, thanks to our fortunate position, far less suffices to effect this for us than for any other country. But in these national defences they will brook nothing of a second-rate order. American armor plate is equal to any in the world. American guns are on a par with those of any country. Why should not American battleships be made equal in speed and manoeuvering power to those of any nation? We have given the sole reason which has thus far been put forward, which deserves any credence, that of our shallow harbors, and we have shown that there is actually no serious obstacle in the way of adopting greater draft for our battleships if that is really an essential to their higher speed.

We have no doubt that a large factor in the decision of this matter made by the naval authorities was the fact that it was made at a time when the pressure of other duties was well-nigh insupportable. In the rush of providing for the actual immediate necessities of warfare last May, there was scant time to spare for the solution of any difficult problems in connection with the design of new vessels. But that rush is now past. We are in no serious need of these three new battleships, and do not want or expect to be. With the five vessels now nearing completion, our navy will be as strong in battleships as any nation in the world except England, France and Russia.

It will be vastly better for our national defence to wait a year longer, if necessary, for these three additional vessels, instead of rushing ahead with their construction on lines which every other naval power in the world has discarded as obsolete.

LETTERS TO THE EDITOR.

Springs for Freight Car Trucks.—Correction.

Sir: In the issue of Engineering News of June 23, p. 412, where the standard spring coils, recommended by the committee of the Master Car Builders' Association, are given, is there not an error of some sort? The spring marked "A" does not seem to harmonize with the rest. Perhaps it was 15-16-in. diameter of wire until the compositor got hold of it. I am likely to make some use of these figures and so am particularly interested in correctness.

Yours truly,
C. M. Spalding.

Schenectady, N. Y., July 6, 1898.

(The diameter of the wire in spring A should be 15-16-in., the error was made by the compositor, as our correspondent surmises.—Ed.)

◆

A Test of Mechanical Filters at Moscow, Russia.

Sir: After my inspection of American and European filters, I proposed to the Councils of the Municipality of Moscow to undertake experiments with different systems of mechanical filters. Both councils adopted this project, and at the session of June 21 appropriated for the experiments 65,000 rubles (about $32,500). This sum will be sufficient, because necessary pumps and boilers are already at our disposal. The general arrangement of the experiments will be similar to that which I, through the kindness of Mr. Chas. Hermany and Mr. Allen Hazen, have seen in Louisville, Ky., and Pittsburg, Pa.

I consider the matter of great importance, because according to the results of the tests the matter of our future Moscow River water supply (first for 10,000,000 and afterward for 40,000,000 gallons daily) will be settled; and I think that every large city, having a water supply from open sources, ought to undertake such tests, because the results of filtration are apt to be different, according to the conditions of the water to be filtered.

We immediately take steps towards the execution of the ordinance of the Municipality of Moscow, and shall continue the tests for about one year.

I remain very respectfully yours,
Nicholas Simin,
Chief Engineer of Moscow Water-Works.

Moscow, Russia, June 28, 1898.

◆

Cost of Heating a Factory Built of Steel and Glass.

Sir: Our attention has been called to an article published in your issue for July 7, 1898, describing our factory building, and we note your remarks in regard to the cost of heating the same. The power for running our shop is obtained from the local electric light company, so that our boiler is used for heating purposes only. During the past winter, from Nov. 1 to July 1, we burned about 86 tons of coal, costing $3.25 per ton, a total of about $280, and only about half of the fireman's time was chargeable to the care of the boiler and heating plant, so that we feel that $500 would cover the entire cost of heating the building.

In the description which you publish, no mention was made of the fact that the upper portion of all of the windows is double glazed, an air space of ¾-in. being left between the inner and outer panes of glass. The outer pane of glass is, as stated, of corrugated or roughened glass, and the inner pane of ordinary window glass. The lower part of every window is swung on the center instead of every other panel, as stated in your description. The lower sashes are at present single glazed, but are so constructed that another pane of glass can be inserted whenever desired, and it is probable that this will be done before next winter.

It is possible that next winter we may make some tests as to the actual amount of steam required for a given temperature of atmosphere, and will be pleased to send you any data of this kind which we may obtain.

We are pleased with our building and would adopt the same method of construction for any similar buildings which we may erect hereafter.

Yours truly, The Veeder Mfg. Co.,
C. H. Veeder, Pres.

Hartford, Conn., July 11, 1898.

◆

Breakages of Electric Railway Car Axles.

Sir: Enclosed herewith please find an impress of the fractured end of an electric car axle which recently broke in this city. It is remarkable chiefly for showing that some previous action had taken place before the final rupture. That portion of the fracture most completely shaded was as smooth, when first observed after the accident, as if it had been cut with a cold chisel. The blank square spot in the impress is where the head of a key held the gear on the shaft. The rest of the fracture was that of a very fine grained steel and showed no marked peculiarities. A trace of rust was observable about the head of the key but not elsewhere.

In the past five years, five similar accidents have occurred to electric cars in this city. In two of them which came under my notice a similar condition (though not so marked) was shown, i. e., as if partly cut with a chisel. Is the same true of like fractures to seam car axles? Or is it only under the influence of electric power? In each case I have observed, it has been a driving axle which broke.

There were about 100 street cars in use when these accidents occurred; or, to put it another way, about 1% of the cars have had similar breakdowns. This would appear an excessive ratio.

The mileage run by the cars differed; but in all cases the length of run would seem to have been sufficient to have exposed any original inherent defects. It was usually more than 100,000 miles and less than 300,000. In the present case it was the forward axle under an electric dummy used to haul two flats loaded with wood through the city streets to the power house. A 20-HP. T-H. motor was geared to it at the line of fracture. The car ran on two four-wheel trucks, with a motor on each axle. It had run about 125,000 miles at the time of the accident.

Will some one else give information tending to throw light upon this subject? It may lead to some better method of inspecting than the present superficial one, and thereby assure greater freedom than at present from recurrence of such accidents.

Yours truly,
A. McL. Hawks.

Tacoma, Wash., July 8, 1898.

(The "impress" which our correspondent sends is an impression on paper made by the broken end of the axle after blackening it with something like printer's ink. The axle was 3½ ins. diameter. The smooth part of the fracture is about 0.4 of the total area, the division between the two parts of the fracture being nearly a straight line. This kind of fracture is not at all unusual in steam car axles; in fact it is the most common way in which any axle breaks. Sometimes the original break runs all around the circumference, making a smooth annular ring half an inch to an inch deep, this fracture being progressive through a long time, say a month or more, and then the final break takes place showing the ordinary steel fractured surface. It appears that the breakages of electric car axles are much mote frequent than those of steam car axles. We believe the reason is that they are not made strong enough for the work they have to do. They are subjected to both torsional and transverse strains in reversed directions, to sudden stoppings and startings, and to violent shocks from irregularities of track to a greater degree than the ordinary steam car axle. When the electric railway companies use the same precautions to insure the long life of their axles that the leading steam railways do the average life of the electric railway axle will be greatly increased.—Ed.)

◆

A New Moment Formula for Concentrated and Distributed Loads.

Sir: The communication on "A New Formula for Concentrated and Distributed Loads," in your issue of June 23, illustrates how complicated an extremely simple matter may be made to appear. It is a well-known law of mechanics that the bending moment is maximum or minimum (maximum in the case of a simple beam) where the shear passes through 0. Considering the case assumed, that of a simple beam (1) uniformly loaded for its entire length, and (2) carrying a single concentrated load, it is evident that the shears from (1) and (2) respectively are opposite in character only for the distance from the center of the span to the point of application of the single load. The section of maximum bending moment must lie then somewhere along this distance. Using the notation employed by your correspondent, the following equation follows directly from the law above stated:

$$\frac{P\,a}{s} = \frac{W}{s}\,y_1, \text{ or } y_1 = \frac{P\,a}{W}.$$

As stated by your correspondent, if y_1 is greater than $\frac{s}{2} - a$, the limiting case is indicated and the bending moment is then maximum at P.

Yours truly, E. M.

Philadelphia, Pa., July 1, 1898.

Sir: In your issue of June 23, 1898, there is a communication entitled "A New Moment Formula for Concentrated and Distributed Loads." This is similar to a formula which I have used and for which I submit the following proof, which is shorter than that given by your correspondent, and which it seems to me may be clearer to a part of your readers.

Let w = the uniform load per linear unit;
l = length of span;
P = the concentrated load; and,
a = its distance from the nearer support.

Then the expression for the bending moment at any point at a distance x, greater than a, from the same support is

$$M = \frac{P\,(l-a)\,x}{l} + \frac{w\,l\,x}{2} - P\,(x-a) - \frac{w\,x^2}{2}.$$

Placing

$$\frac{d\,M}{d\,x} = 0,$$

and solving for x, to find position maximum M, we obtain:

$$x = \frac{l}{2} - \frac{P\,a}{w\,l}.$$

To transform this into the form given by Mr. Lepper note that $w\,l = W$ and that $x = \frac{l}{2} - y_1$.

Yours respectfully, Elton D. Walker,
Asst. Prof. Civil Engineering, Union College.

Schenectady, N. Y., June 27, 1898.

Sir: In the issue of June 23, 1898, of Engineering News, is published a letter entitled "A New Moment Formula for Concentrated and Distributed Loads," the author of which thought he had discovered and given to the engineering world a new formula for finding the exact point of maximum bending moment of a beam, supported at both ends and loaded with a uniformly distributed and one concentrated load.

As a matter of fact, a diagram similar to the one given by the writer is found in Hatfield's "Transverse Strains," page 179; where he also deduces the same formula. Hatfield makes his parabola representing the bending moment due to the uniform load above the horizonal line connecting the reactions, and the triangle representing the bending moment due to the concentrated load below said line, while the article by the writer simply reverses this order. Hatfield then proceeds to find the greatest bending moment by drawing a tangent to the parabola and finding the longest line inside the figure formed by the curve of the parabola and the lines of the triangle. Then follows an analytical demonstration to determine the point of maximum bending moment, which I will not burden your readers with, as those who wish may find it on the page of Hatfield cited, but arriving at a conclusion giving the following formula:

$$h = \tfrac{1}{2}\,L + \frac{A\,m}{U},$$

in which L = span; A = concentrated load; m = distance from concentrated load to nearest support; U = uniform load; and h = distance of greatest moment from the most distant support.

This is the same formula as the writer's except that the latter's result gives the distance of the point of maximum bending moment from the center of the span, whereas Hatfield's result gives the distance from the abutment, or the former distance, plus one-half the span.

The edition of Hatfield referred to was published in

1877, and we have been using the formula for years, in fact ever since our engineering department was established. Yours very truly, Dudley McGrath,
Structural Engineer.

Office of Jno. B. Snook & Sons, Architects, 261 Broadway, New York city, June 25, 1898.

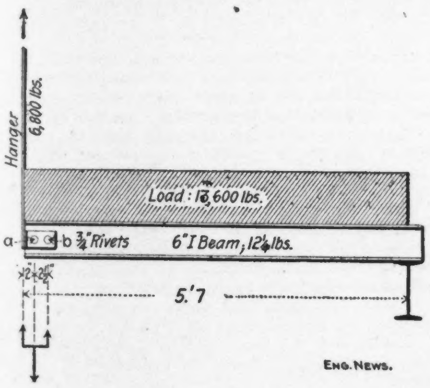
◆

Erroneous Data in Manufacturers' Hand-Books Concerning Structural Beam Connections.

Sir: The issue of a new and enlarged edition of their hand-book by the Cambria Iron Co. has brought to notice the fact that the hand-books issued by the Cambria Iron Co., the Carnegie Steel Co., Ltd.; the A. & P. Roberts Co., and Jones & Laughlins, while excellent in most respects, all contain a table of "minimum spans of I-beams for which the standard connection angles may be safely used with I-beams loaded to their full capacity," which is seriously in error.

This table has been prepared on the assumption that all the bolts or rivets joining the connection angles to the ends of a beam are strained to equal amounts and in the same direction. The fallacy of this assumption was shown in the Engineering News of May 16, 1895, in an article on "Standard Beam Connections." It is due to the authors of the table in question to state that in preparing it they have followed the method in general use. It probably has not occurred to them to question its practical accuracy, and they will doubtless be surprised on investigation to learn how seriously it is in error.

The table indicates in all cases a greater capacity for the connections than they would have under the limits for bearings and shearing on which the table is alleged to be based, the errors being comparatively small for deep beams and very great for shallow ones. As an illustration of one of the cases of great error, the length and load given as corresponding to the standard connection for a 6-in. beam is taken from the Cambria Iron Co.'s hand-book (the books of any of the companies mentioned could be used with substantially the same result), and the maximum bearing stress is analyzed.



As the safe load (as shown in the accompanying cut) is 13,600 lbs., the end reaction is 6,800 lbs., and the load on rivet a is found, by taking moments about the center of rivet b, to be 12,300 lbs., or 71,000 lbs. per sq. in. of bearing surface, as compared with an extreme fiber stress in the beam of 16,000 lbs. per sq. in.

While this analysis shows clearly that the table greatly overstates the capacity of the connection, it is not expected that the result obtained indicates the actual facts with mathematical precision, because no account has been taken in the analysis of the stiffness of the hanger or the clamping effect of the rivets.

In the article in Engineering News above referred to a method for determining the capacity of beam connections is proposed which, while open to criticism, gives much more reliable results than that on which the table is based.
Respectfully, Henry S. Prichard.
Trenton, N. J., May 6, 1896.

(In accordance with our usual practice a proof of Mr. Prichard's letter was sent to the publishers of the different pocket-books mentioned in order that any reply they might desire to make to the criticisms therein might be published in the same issue. With the exception of the Pencoyd Iron Works, whose answer we append below, only one reply was received to our letters, and this firm has not yet sent us any matter for publication. We therefore, publish the matter thus far received without waiting for further replies.—Ed.)

Sir: It is of such importance in steel floor beams and similar structures that the end connections should have as great a carrying capacity as the beam itself, that the criticisms made by Mr. Prichard, under date of May 6, 1898, and more fully in your issue of May 16, 1895, are entitled to careful consideration.

Opportunities occasionally occur in finished structures where it is possible to compare the strengths of the beam and its end connections, and we do not know of any instance where the joints indicated such weakness as Mr. Prichard has suggested. In Vol. XXXVII. of the Transactions of the Am. Soc. C. E., Mr. Julius Baer records the effects on buildings of the St. Louis tornado, and especially notes the persistence of the riveted end connections of beams when the supported beam was entirely destroyed, and remarks: "Any standard floor beam connecting angle is probably of ample strength if subjected to only such treatment as it will receive in a floor." This accords with isolated cases within our own experience.

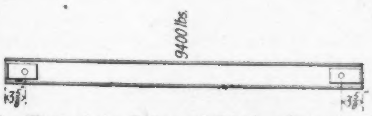


Fig. 1.—Test of the Effect of Friction Between Angle Connections and Web of Beam.

Mr. Prichard probably underestimates two elements of resistance—the frictional resistance, caused by the grip of rivets, and also the partial "fixedness" or continuity due to the rigid attachment of the end angles to their outer supports. Experiments have proved an increased strength of about 10% of a riveted joint over a similar joint held by fitted pins without heads. This refers to rivets ¾-in. diameter; the gain is less on smaller and more on larger rivets. As the friction is presumably constant, it would probably represent about one-fourth the total working resistance of the joint.

To test the effect of the friction between the angles and web of the beam, a 6-in. I-beam had angles riveted on with a single rivet, as shown in Fig. 1. These were ¾-in. rivets filling 13-16-in. holes, spaced 3⅝ ins. from the end of angles or midway between the two rivets of the standard joint. Pressure was applied at the middle and it was found to require a load of 9,400 lbs. before any indication of slipping between the parts was observed. This corresponded to a turning moment of 17,000 in.-lbs. due only to friction.

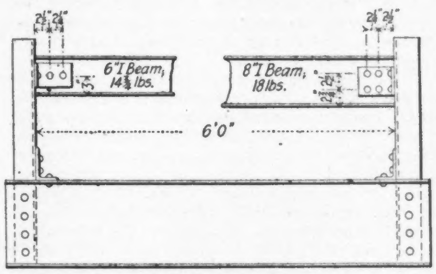


Fig. 2.—Test of Standard Angle Connections.

The following experiments were made on 6-in. and 8-in. I-beams, these small sizes being taken, as the criticism referred to says the "error is very great for shallow beams." The spans were about the minimum recommended by the hand-books. The beams were connected to a stout frame, which represented the usual conditions of end attachments, the attaching angles being the standard of the Pencoyd Iron Works, as shown by Fig. 2. These beams were subjected to pressure at mid-span in the testing machine. No visible effect in either case was discernible at the joint until the elastic limit was much exceeded, when the deflection of the beam caused a yielding of the angles near the root and bending of the exterior flanges around the connecting rivets, as shown in the photographs, Figs. 3 and 4. But when the bending was carried so far that the beams were entirely destroyed, there was still no indication of the slightest yield by slippage or otherwise of the attachment of the angles to the web of the beams.

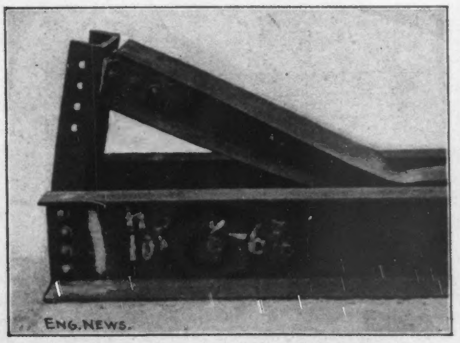


Fig. 3.—Condition of Connecting Angles on 6-in. I-Beam After Failure of Beam.

To demonstrate further the influence of rigidity at the end attachments, two beams of the same section, with the end supported but not rigidly attached, were tested with the angle attachments resting freely upon supports, Fig. 5. The initial deflections on the beams of the same size showed little difference due to the nature of the end supports, and the measurements were not made with sufficient accuracy to establish this difference. As the stresses approached the elactic limit the differences were more marked, and the beam with riveted ends sustained about 20% more load than the similar beam with free ends before any permanent set occurred.

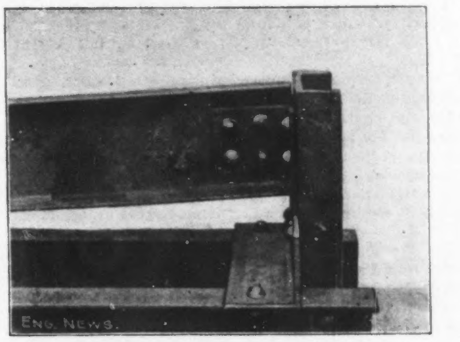


Fig. 4.—Condition of Connecting Angles on 8-in. I-Beam After Failure of Beam.

Table Showing Pressures at Which Permanent Set Began.

Size of beam, ins.	Wgt. per ft. in lbs.	End connections.	Load in lbs.
6	14¾	Free ends.	15,000
6	14¾	Rigid ends.	18,000
8	18	Free ends.	25,000
8	18	Rigid ends.	30,000

In the free end beams, as in those with rigid ends, there was no indication of the least yield between the angles and the web of the beams.

The shearing and frictional resistances act in conjunction, and the strength of the joint is represented by their sum.

The influence of the rigidity of end attachment depends on its extent. If the attachment was sufficiently rigid to render the beam as strong at the ends as in the middle, the moment at the rivets would be as great as at the center of the beam with a concentrated central load. But a connection whose influence was less than aforesaid would only tend to counteract the moments proceeding from the reaction. The influence thus exerted in the case of beams tested had probably one-fourth the effect of fixed ends.

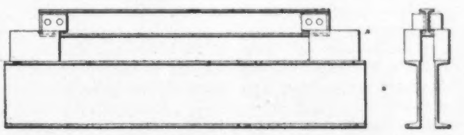


Fig. 5.—Test to Determine the Influence of Rigid End Supports.

A. & P. Roberts Co.,
Per James Christie,
Mechanical Engineer.
Philadelphia, Pa., June 18, 1898.

◆

OBSTRUCTIVE BRIDGES AND DOCKS IN THE CHICAGO RIVER.*

By G. A. M. Liljencrantz, Mem. W. S. E.

The Chicago River has been and is of enormous value to the commerce of the city, through its large and extensive lake traffic. Its dimensions some 30 years ago were ample for the commerce and traffic of that time, but in recent years almost everything in the city been "kept up with the times"—except the river. To be sure, it has been improved. Miles of docks have been built, periodical dredging has been done, and improved bridges have been built, but the question is: "Has the improvement of the river been kept abreast with other improvements in this great and rapidly growing city?" And another question which, in the writer's mind, is still more serious: "Are existing conditions such as to admit of an improvement of the river that will be commensurate with a metropolis of three or four million inhabitants, as Chicago no doubt will be but a few decades hence?" When studying the conditions we find much cause for discouragement.

Increased depth has been secured to some extent by occasional dredging, but it is again regularly decreased by the unceasing deposits from the numerous sewers emptying into both branches of the river, as well as by

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*Abstract of a paper presented at the meeting of the Western Society of Engineers on June 1. The abstract is published by permission of the Society, and the paper in full, with the discussion, will be published in the Society's "Journal."

constant sweeping and dumping of refuse in various ways into the channel, requiring frequent redredging. But this removable material forms the least serious obstacle in the way of the vertical improvement. Not less than three tunnels cross the river, with their crowns at an elevation which, at the time they were built, allowed sufficient draft for the navigation of that day, but which now form the gravest obstructions to the much larger vessels of deeper draft of the present time.

Docks are frequently built with more consideration as to cheapness in first cost than to future needs and are thus made only of strength enough for the existing depth of water, and are accordingly subject to undermining, whenever the channel is considerably deepened. An extensive deepening, even if the obstructive tunnels did not exist, would accordingly involve great expense to individual owners, in addition to the direct improvement by dredging, and to make such improvement practically permanent it will be necessary to dispose of the sewage by a different method from that now employed, or provide for continuous maintenance by dredging.

Let us next look at the difficulties we encounter in planning to widen the channel. Vessels of even the greatest dimensions in use until about 1890, and which still constitute the great part of the lake fleet, easily pass any part of the navigable river, but some of those built within the last few years find it impracticable to enter either of the branches of the river, or, when loaded, to pass the first of the "artificially constructed reefs," the La Salle Street tunnel. The manner in which a long vessel has to move to make this passage possible is illustrated in Fig. 1, showing the river between Clark and Wells Sts., with the tunnel half way between. The available channel is here in the middle of the stream. A vessel 48 ft. beam and 432 ft. long (which is the length of the longest boat now navigating the lakes) represented as coming through the north draw of Clark St. bridge, turning to the deeper channel in the middle, over the tunnel. It is compelled to proceed thence across to the south draw of the bridge at Wells St., because the turn to the north draw of that bridge is practically impossible, for there is only 500 ft. between the two bridges, and the center channel has a depth of 17 ft. at low-water over the restricted width of only 62 ft. on the line of the center piers of the bridges. Center piers and projecting docks obstruct the channel at numerous points. The Chicago & Alton R. R. bridge, north of Archer Ave., is a striking example of how some bridges are constructed without the least regard for the demands of navigation. Too narrow are also the draws of the three bridges in close proximity at Kinzie St., in the north branch of the river, as well as at the Indiana St. bridge. Nothing larger than a tug can pass the east draws of the first named three bridges, which, in fact, had never been dredged until in April of this year. At the Division Street bridge neither draw can be used, nor can those of the North Ave. bridge be used by such large vessels.

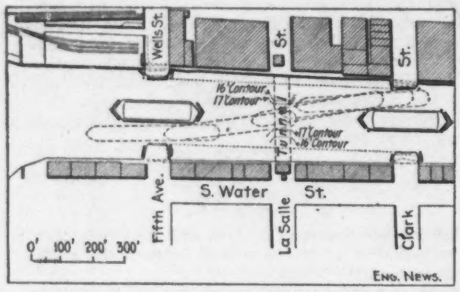


Fig. 1.—Course of a Large Steamer in Crossing the La Salle St. Tunnel; Chicago River.

One of the worst places on the north branch is the sharp bend forming an S-curve at the crossing of the C., M. & St. P. Ry. bridge, south of Clybourn Place, and nothing but the most radical alterations can make this part of the river, or that above, accessible to vessels of the type here represented, and it is therefore thought unnecessary to occupy more time and space in describing the obstructions found above this place, which are generally equally bad, and some perhaps even worse.

The chief reason for the deplorable condition of the river, as regards its many obstructions, I consider to be the total absence of any well defined system of improvement, by way of legally established dock, or channel lines. The owners of water front along the river seem to have built their docks with the sole consideration for their own individual advantage, in such manner as to make as much land as possible, out of what should properly be the channel, apparently in utter disregard of the demands of navigation. Dock lines have been established, to be sure, in detached places, but as far as I have been able to discover, not in conformity to any general system. By an ordinance passed June 11, 1869, or 29 years ago, there were established certain dock lines along a portion of the south branch. Provisions were made in this ordinance for assessments to pay for the condemnation and purchase of land, required to comply with the terms of this document, but nothing further has been done in the matter, and numerous docks have since that time been constructed without the least regard to the dock lines so established, judging by the conditions now existing.

By an act of congress of June 3, 1896, making an appropriation of $50,000 for improving the Chicago River "from its mouth to the stock yards on the south branch and to Belmont Avenue on the north branch as far as may be permitted by existing docks and wharves," the work of improving this river by the United States government was inaugurated.

The only work that could be done, however, in compliance with the wording of the bill, was dredging. Bids were advertised for and received, and contracts let for the execution of this work, which commenced in November, 1896. The project approved by the Secretary of War contemplates the deepening of the channel to 17 ft. below the city datum, the bill providing for dredging to admit passage by vessels drawing 16 ft. of water. The existence of the tunnels would make a greater depth useless.

The work of dredging has been done from the mouth to the stock yards in the south branch, and a part thereof has been redredged, viz.: From the south limits back to Twelfth St., and this work is now nearing completion towards the harbor. In the north branch the work has been done from the junction to Fullerton Ave., and when the northerly limit is reached the whole of that branch will also be redredged.

Up to May 1, 1898, there have been removed from the main and south branches, in round numbers, 540,000 cu. yds. and from the north branch 658,000 cu. yds., or a total of 1,190,000 cu. yds. The sum of $113,000 was appropriated in a later act of congress, for the completion of this part of the river improvement, and authority was by this later act also granted for entering into contracts for work in widening the channel, such work to be limited by the sum provided for that purpose, to-wit: $700,000, including the amount required for the dredging. This work is thus confined to the removal of only the most obstructive of the many protruding dock corners.

The greatest obstruction to navigation are the tunnels and bridges, which are corporate property, and it is questionable whether the government would ever consider the navigation in the river so necessary to the general commerce of the nation to condemn such valuable property, and either to compel the removal of the obstructions caused thereby, at the expense of the owners thereof, as can be done under existing laws, or to undertake the enormous expense of rebuilding or remodeling the structures at the expense of the public treasury.

To decide upon a plan of improvement, which will furnish the greatest relief to navigation, authorized by the bill and at the same time keep the cost within the prescribed limits, a study was made, on the maps, of the various corners and bends in the river to learn to what extent these would interfere with the passage of a vessel of the type described. The vessel was represented by a pasteboard model made to the same scale as the map. In this manner the most obstructive dock corners were selected and improvement of these places recommended, consisting in the removal of a sufficient amount of the protruding land to facilitate the passage of the largest vessel.

Examples of this work are shown in Figs. 2 and 3. At the so-called "Collision Bend," some 700 ft. east of Halsted St. bridge, Fig. 2, 15,965 sq. ft. have already been removed by the Sanitary District and 7,702 sq. ft. are to be removed by the government. The name of this place is a brief but fair intimation of the conditions here. Fig. 3 shows the Illinois Steel Co.'s property, the north part of which forms an obstruction to the passage of vessels through the west draw of Archer Ave. bridge, and is to be removed. The river is furthermore very narrow all along this property and in all 18,790 sq. ft. are to be taken off therefrom. Across the river from the steel company's land is a protruding corner, where 1,693 sq. ft. are to be removed, as shown.

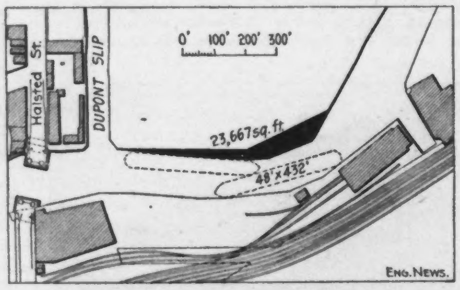


Fig. 2.—Improvement of the Chicago River at "Collision Bend." (U. S. Government Work.)

The whole project contemplates the purchase and removal of 123,100 square feet of land and the construction of 4,790 linear feet of dock, in front of the removed land.

All the principal preliminaries for this work have been completed. All that is needed for commencing active operations is the necessary appropriation; and Congress holds the electric button, a touch upon which will set the wheels of activity in motion.

THE DURABILITY OF MARBLES AND GRANITES.

At the meeting of the Civil Engineers' Club of Cleveland on July 12, Mr. Oliver S. Hubbell read a paper on the above subject, in which he described his investigations as architect for the Wade Memorial Chapel and Receiving Vault. His instructions from his client were to find a building stone which would last for 500 years. We abstract the paper as follows:

The surface of marble soon disintegrates in the climate of Cleveland, and becomes granular as well as discolored. Old tombstones in the city graveyards show this. However, a protective fluid may be used, with which the marble may be saturated, so as to become weather-proof and thoroughly durable. South Dover and Tuckahoe marbles are used in New York city. The Lee marble is largely used in Washington and Philadelphia, but this has a bluish gray tinge. It has certain defects called "shakes," and contains some particles of magnesia, which dissolve in wet weather and leave the surface pock-marked. The Vermont marbles were examined also, in the quarries and in buildings. No old marble was found in New York city that is not more or less discolored and disintegrated. The top surfaces are both rough and dark, while the under sides of projections are in good order. The Vermont quarries are probably the largest marble quarries in the world. These are at Proctor and East Rutland. The buildings of the Quarry Company are built of marble taken at random without selection. They are therefore quite mixed in color, and give a really fine architectural effect. The Rutland marble is easily cut into fine lines and ornamental figures. On the other hand, Georgia marble is hard to cut, and unless great care is used large crystals will break out in cutting.

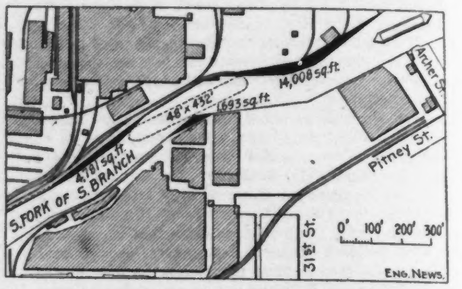


Fig. 3.—Improvement of the Chicago River, near Archer Ave. (U. S. Government Work.)

Granite is refractory and has to be tooled by hard and patient labor. Pneumatic tools have been invented for under cutting, but plain surfaces are generally worked by hand. Granite does not lend itself to fine ornamental lines, and its gray color prevents the best effects of light and shadow.

Of all the granites, the North Jay seems to have the lightest color. Grant's tomb and the new Bowling Green Building, New York, are built of this. It is, however, rather porous and soft, and occasionally discolored by iron. A few defective blocks may spoil the effect of an entire building. Westerly granite is the darkest of all. The Concord granite is used in the Library Building at Washington. It contains some particles of magnesia. The Troy, N. H., granite is light and sound and of good quality. The Halliwell granite was used in building the State Capitol at Albany. Barre has the most prolific quarries in America, but the product is liable to have iron in it, at least in the sap. Small specks of iron hardly detected in the first instance will later dissolve and streak the whole surface. However, it has been used for twenty-five years, and some monuments built of it are still as good as new. The Halliwell granite is the best and most expensive, and is largely used for monumental work. It is homogeneous, all sections presenting the same appearance in whatever direction they are taken.

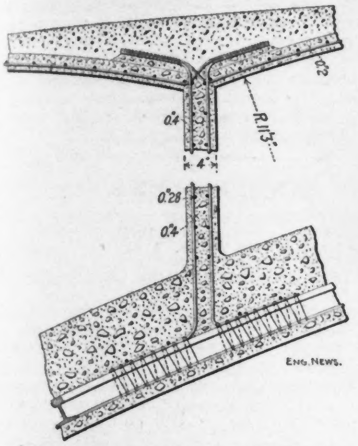
It was finally decided to use either the Troy or the Barre granite in the Memorial Chapel.

In conclusion Mr. Hubbell stated that although Mr. Wade was recommended by friends to go to New York, or even to Europe, to select his architect, he nevertheless decided that this building should be designed and constructed by Cleveland architects.

The speaker exhibited one sample of white Italian marble, which had been exposed to the Cleveland climate for years, till its surface was black, and it had so far disintegrated that it could be crumbled between the thumb and finger.

A NOVEL EXAMPLE OF CONCRETE AND METAL BRIDGE CONSTRUCTION.

The accompanying cut illustrates a novel manner of employing concrete and metal in the construction of a foot bridge, which is described in a recent issue of the "Zeitschrift des Oesterreichischen Ingenieur und Architekten Vereins." This bridge serves the purpose of carrying a footpath across a double-track railway in the vicinity of Copenhagen, Denmark, and it has a clear span of 21.85 m. (71.7 ft.), with a rise of 2.58 m. (8.45 ft.). The depth of the arch ring at the crown is 25 cm. (9.8 ins.), and at the springing lines 36 cm. (14.2 ins). The intrados of the arch has a radius of 23.54 m. (77.23 ft.) at the crown which is increased to 26.68 m. (87.53 ft.) at the abutments. The concrete arch is stiffened by five parallel ribs, spaced about 0.75 m. (2.5 ft.) apart; the ribs being bent rails joined together longitudinally and weighing 28 kg. per m. (18.8 lbs. per ft.). The walk across the bridge, which is 3.14 m. (10.3 ft.) wide, is carried by Monier arches 5 cm. (2 ins.) deep, and having spans of 2.24 m. (7.35 ft.) These arches are supported by pillars only 10 cm. (4 ins.) thick, standing upon the main arch ring.



Sketch Showing Method of Employing Concrete and Metal for a Foot Bridge at Copenhagen, Denmark.

The iron net in the Monier arches is made of wires 5 mm. (0.2 in.) thick, spaced 10 cm. (4 ins.) apart. In each of the pillars there are two nets composed of 10 mm. (0.4 ins.) square vertical rods, tied together by 7 mm. (0.275 in.) thick horizontal wires. As shown in the cut, these nets are secured at the feet of the pillars to the iron rails by wire wrapping, while at the top they are connected with the net in the main arch. The proportion of concrete used in the main arch, the small Monier arches, and the pillars, was 1 part Portland cement to 3 parts of gravel. For the abutments and the filling over the small arches the proportions were, 1 part cement, 4 parts sand and 7 parts gravel.

The bridge was built in the spring of 1879, and cost about 8,000 marks, or about $1,900. It is stated by our contemporary that a similiar but larger bridge, designed by Mr. Melan, is to be built in Austria. This bridge will have a roadway 6 m. (19.7 ft.) wide for street traffic. The span will be 42 m. (137.8 ft.), with a rise of only 2.85 m. (9.35 ft.). The main arch will be reinforced by lattice girders, and will be hinged both at the center and at the ends.

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TWO NEW SAFETY APPLIANCES FOR DERRICK ENGINES.

We illustrate herewith a safety lock and a friction clutch recently applied, by the Lidgerwood Mfg. Co., New York city, to the derrick hoisting engines which it builds. These devices are attached respectively to the foot brake of the boom fall drum and to the hoisting drum and are designed to enable the operator to control the hoisting and boom motions more certainly than with the ordinary appliances. It is claimed that with these attachments the engineman can handle the engine with much more rapidity and with perfect safety to the men below the derrick.

The new engine is substantially the Lidgerwood standard friction drum engine with the addition of the safety lever lock attached to the foot brake of the boom fall drum and the friction lever latch on the hoisting drum. The friction lever latch (Fig. 1) enables the engineman to hold the drum in any desired position, as, for example, when taking up a load with the hoisting fall and desiring to lower the boom at the same time. In such a case the friction is thrown in on the hoisting drum and it is impossible through any slip or inattention for the load to drop, and the operator may give his whole attention to the lowering of the boom. With the safety lever lock (Fig. 2) on the foot brake of the boom fall drum one motion of the foot sets the brake, which cannot be released without throwing the friction in position, and when this is done it automatically releases the foot brake and holds the catch away from the brake till the boom is put in the desired position, when the brake is again set with the foot. By the old method the engineman had to give his attention to the two friction drum levers, two foot brake levers, two ratchets and pawls, and the steam lever, gathering himself into an awkward position in which it was almost impossible for him to follow the load and watch the signal man at the same time. In operating a double drum derrick engine, where the safety appliances have been attached, the engine man stands erect, and in a natural and easy position, and is thus enabled to see every signal whether given from the pit or from the point where the load is dumped, both hands and feet being available for handling the boom while the load is being hoisted.

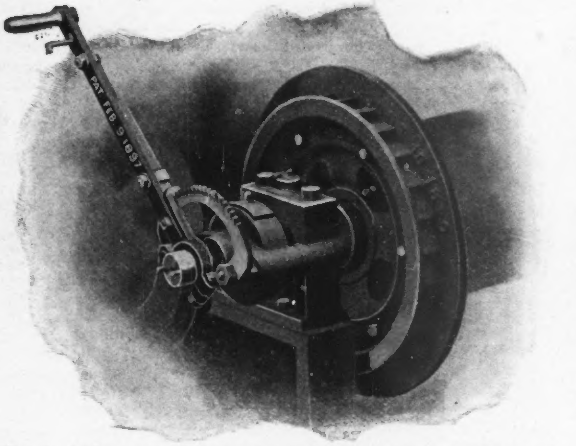

Fig. 1.—Lidgerwood Friction Lever Latch for Hoisting Drum of Derrick Engine.

We are indebted to the Lidgerwood Mfg. Co. for the illustrations and for information from which this description has been prepared.

◆

THE PNEUMATIC MAIL TUBES across the Brooklyn Bridge are practically completed, and it is expected that a test will be made before the end of the week, although it will be several weeks before the line will be put in continuous operation. It will be remembered that this installation consists of two 8-in. pipes between the New York and Brooklyn post offices, together with the compressors and other auxiliary apparatus.

◆

THE USE OF DRY PAPER INSULATION for telephone cables in Paris, France, to cheapen the cable investment, has made it necessary to adopt means to keep the paper dry. This is done by closing the ends of the lead-encased cables and forcing air, which has been passed over calcium chloride, through openings in the casing. This pressure is kept at about 45 lbs. per sq. in. and the air besides keeping the paper insulation perfectly dry acts as a safety device since a puncture is at once shown by a drop in the pressure gage.

◆

THE THIRD AVE. RY. CO., New York city, is about to adopt electricity on its 74 miles of track. At present 29 miles of this are operated by cable, the rest being horse-car lines. So far as possible the old cable conduit will be utilized, and the old 7-in. rails will be taken up and new rails weighing 104 lbs. per yd. will be laid. The new portions will employ the system which is proving so satisfactory on Madison Ave. Current will be supplied from a temporary plant until a large three-phase system can be installed. The power house for this will be at Kingsbridge, from which current will be transmitted to a number of transforming sub-stations.

◆

THE CONDUIT ELECTRIC SYSTEM is to be adopted by two more of the surface street railways of New York city. On July 20 cars will stop running on Sixth and Eighth Avenues and the roads will be turned over to the contractors. It is expected that by Sept. 15 both lines will be ready for operation by electricity.

◆

THE STREET RAILWAYS of Baltimore paid the city a total of $69,520 for the quarter ending June 30, 1897. This sum is 9% of the gross receipts of the company and goes to the park fund of the city.

◆

SEATS FOR ALL PASSENGERS, in elevated or surface street cars and stages within the limits of New York city, is the requirement of a resolution now before the Municipal Assembly and referred to the Law Committee. This ordinance, if passed, would require the transportation company to display a sign when the car is filled, and would impose a penalty of $25 for each offence for taking aboard more passengers than they could seat. No passenger need pay unless a seat were provided. Councilman Christman, in introducing this resolution, said that it was in response to popular demands; but if passed it will be very unpopular with those who have to wait on the sidewalk for a car having empty seats.

◆

A COMPARISON OF GROSS RECEIPTS for 1896 and 1897 of a number of American street railways is made in the "Street Railway Journal" for July, the figures for which were obtained from the 1898 edition of the "American Street Railway Investments." Of the 175 roads considered 26 had a gross income for 1897 of $1,000,000 or over; 19 earned between $500,000 and $1,000,000; 46 from $100,000 to $500,000; 51 from $50,000 to $100,000, and 33 from $25,000 to $50,000. Four systems, the Union Traction Co., Philadelphia; Manhattan Ry. Co., New York; the Metropolitan Street Ry. Co., New York, and the West End Street Ry. Co., Boston, have incomes ranging from $10,480,646 in the first case to $8,719,032 in the latter. The total income for these 175 companies having net earnings above $25,000 was $113,394,903, which was an increase of 1.9% over 1896.

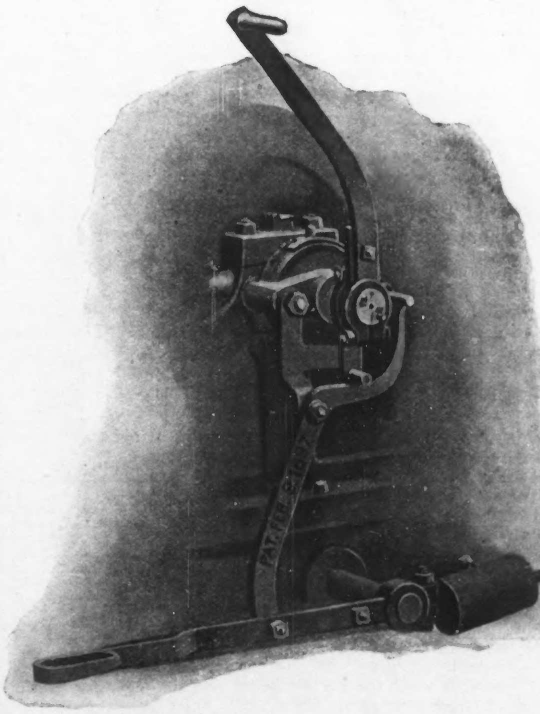

Fig. 2.—Lidgerwood Safety Lever Lock for Foot Brake of Boom Fall Drum of Derrick Engine.

◆

THE CONTRACTS FOR A MUNICIPAL ELECTRIC lighting plant which were awarded by the Board of Public Works of Grand Rapids, Michigan, on May 12, were vetoed by Mayor Perry on July 6. The reason given for this action is that sufficient consideration had not been given the question; that the engineers designing the plant were regarded by some as inexperienced; that the specifications were so worded that competition was impossible, and that it was estimated the cost would exceed the appropriation from $8,000 to $10,000.

◆

THE COST OF ELECTRIC CURRENT in the case of several street railways which buy the "juice" to operate their lines, was given in a recent issue of the "American Electrician" as follows:

Location of road.	—No. of— Motor cars.	Trailers.	Miles of track.	Price paid.
Georgia..........	24	9	18	$0.011 per K-W. hour.
Ohio............	4	..	3½	$12.50 per mo. per car.
Ohio............	5	At times	6	$2.10 per car day (18 hours).
Kentucky.......	10	"	6	(4) $2, (6) $1.50 per day
Maryland.......	5	"	..	$12.50 for 5 cars or less, $2 each addit'n'l car.
New York......	10	"	6½	$0.015 per car-mile.
Texas..........	11	"	..	$0.015 per K-W. hour.
Texas..........	14	2	7½	$3.00 per car per day.
Massachusetts...	..	..	..	$0.02125 per car-mile.
Massachusetts...	..	..	..	$0.03 per car-mile.
New Hampshire.	60	12	20½	$0.03 per K-W. hour.
Pennsylvania...	14	..	8	$3.00 per car per day; $2.50 p'r car p'r day.
Pennsylvania...	7	..	7	$2.75 per car per day (18 hours).
Vermont........	3	..	..	$0.023 per car-mile.
Michigan........	5	..	10½	$2 per 18 hrs. each car, $1.85 each ad't'l car.
Michigan........	..	..	..	$2.50 per car per day.
Florida.........	2	..	3	$3.25 per car per day.
Alabama........	4	..	7½	$3 per car per day (16 hours).
Nebraska.......	3	..	1½	$4 to $4.50 per car per day.
Tennessee......	2	..	4	$3.00 per car per day (15 hours).

◆

A BOILER EXPLOSION at the National Starch Mfg. Co., Buffalo, N. Y., on July 15, killed 7 persons and injured 35. Both the engineer and fireman were killed and the five tubular boilers were completely destroyed.

◆

THE PRICE OF STEAM COAL IN THE EAST has greatly decreased in the past half dozen years. The following figures show the average New York selling price for the years given:

Year.	Bituminous coal.	Anthracite steam coal.
1892	$2.60	$2.07
1893	2.75	2.53
1894	2.65	2.18
1895	2.25	2.12
1896	2.50	1.93
1897	1.97	1.91
1898	1.75	1.82

◆

THE NEW YORK, WYOMING & WESTERN RAILWAY Co. is a new company incorporated in Pennsylvania to carry anthracite coal from the Wyoming, Scranton, Wilkes-Barre and Lackawanna coal fields to tidewater at or near New York. The detailed plans are not yet made public, but it is reported that the company is to acquire the Lehigh & Hudson Railway, running from Belvidere, N. J., to the Poughkeepsie bridge over the Hudson, and thus gain an entrance into New England. It is to be a coal road only, passengers and other freight than coal being refused; and the rate is to be 60 cts. per ton to tidewater. The estimated cost of the road is $10,000,000, and the officers named are as follows: President, E. V. Sturges; Vice-President, L. A. Waters; Secretary, Thos. E. Jones; Treasurer, Thos. H. Watkins. All of the officers, including directors, are individual coal producers.

◆

ANOTHER DECISION in favor of the Denver Union Water Co. has been rendered in the lower court in the suit of the city of Denver against the company. This time the court holds that the purity and pressure of the supply furnished by the company are up to the standards named in the contract. These standards were a chemical analysis of the supply furnished in 1889 and a hydrant "pressure equivalent, taking the elevation of the surface of the ground into account, to 115 lbs. at the hydrant in front of the Union depot in said city, provided: The city shall not be in default with said company upon any of its agreements." The company did not deny that the stipulated pressure had not been maintained, but urged that the introduction of a gravity system, in which the city acquiesced, and the substitution of larger distributing mains, gave a far more abundant and regular supply, affording better fire protection than could have been given at the contract pressure with the old system. The Judge accepted this view, although his language is a little at fault in using pressure as he did when he said the company "has and does supply a pressure fully as adequate for fire purposes as that provided for under the contract." The only testimony introduced regarding pressure showed that it was but 90 lbs. at the Union Station, instead of 115 lbs. We leave it to our readers to decide whether a contract provision calling definitely for 115 lbs. pressure is satisfied by 90 lbs., simply because the quantity of water available is greater at the lower than at the higher pressure? The previous decision of the court in this Denver case declared that the rates charged by the company were not in excess of the provision of the contract on this point. (See Engineering News, Feb. 24 and March 3, 1898, for editorial discussion.) It is said that the city will appeal the case.

◆

BIDS FOR A NEW GRAVITY WATER SUPPLY for Jersey City will be received on Aug. 18. The bids are to be made on the basis of first constructing works of sufficient capacity to deliver 50,000,000 gallons of water daily at the Bergen reservoirs, in Jersey City, at an elevation 210 ft. above mean high tide, through a single pipe line, but the drainage area must have a capacity of 70,000,000 gallons a day. If the city so orders at any time during the contract the capacity of the reservoirs and conduits must be increased to be able to supply 70,000,000 gallons and in case a masonry conduit or tunnel is provided for the original supply it must have a capacity of 70,000,000 gallons, but if this conduit is of steel it may be of 50,000,000 gallons capacity, to be supplemented, if so ordered, by a 30,000,000-gallon steel pipe. The city will buy water by the million gallons, with the option of purchasing the works at the end of 5, 10 or 15 years. Mr. Geo. T. Bouton is Clerk of the Street and Water Board.

◆

A JOINT OUTLET SEWER is proposed in New Jersey for South Orange, Vailsburgh, Irvington, a portion of Newark, and possibly West Orange. It is stated that an engineer will be employed to make a report at an expense not to exceed $1,250. South Orange bought land for sewage disposal by intermittent filtration several years ago, but the land was located in another township, the people of which opposed the plant and secured general legislation prohibiting the location of a sewage disposal plant in any municipality of the state without first securing permission from the authorities of such municipality. The courts upheld the act. Newark has already constructed one outlet sewer jointly with East Orange, after the completion of which that township abandoned its sewage disposal works. The city of Orange, together with Montclair, Bloomfield and Glen Ridge, use a joint outlet sewer discharging into the Passaic River.

◆

MUNICIPAL OWNERSHIP OF THE WATER-WORKS of Des Moines, Ia., is to be voted on at an election to be held Aug. 19. The proposition is to buy the plant of the Des Moines Water-Works Co. for $850,000, this price having been agreed upon by representatives of the bondholders, the city council and the Citizens' Association. If the purchase is made, a long controversy between the city and the company will be ended.

◆

THE THEORY OF THE DIESEL OIL ENGINE, as given by Mr. Diesel, has been criticised in a paper read by E. Capitaine at a meeting of the Verein deutscher Ingenieure, at Frankfort, in April. He also attacks Diesel on the ground of priority of invention. Diesel's patent is dated February, 1892. In May, 1891, Capitaine took out two patents for an engine burning heavy oil injected into compressed air, and in the same year he built an engine, but its development was hindered by want of means. Diesel was fortunate, not only in obtaining pecuniary support, but in obtaining a pressure of 30 atmospheres in his engine, while Capitaine obtained only 15. The compression space in Diesel's engine in only half that in Capitaine's engine, and this, says Capitaine, constitutes the sole difference between the two motors. "The Engineer," which discusses Mr. Capitaine's paper at length, sums up the matter as follows:

> To sum up the matter, the novel points in the Diesel motor are perhaps not so many as its admirers claim for it. To start an explosion engine by compressed air is a method familiar to most engineers, as also to regulate its working by injecting varying quantities of combustible into compressed air, thus varying also the amount of air in excess. But it is scarcely correct to assert, as Capitaine does, that its sole claim to originality consists in diminishing the compresson space of an oil engine. We cannot go into the question of the commercial competition between these well-known inventors. But the fact must not be overlooked that Diesel has produced a practical engine, giving the highest heat efficiency and lowest consumption of combustible yet realized, namely, 0.52 lb. of oil per brake horse-power per hour at full power, with a 20-HP. engine; actual heat turned into work on the brake, 26%; and heat turned into indicated work, 34¾%.

◆

THE KOCH HEAVY-OIL MOTOR-CARRIAGE, lately tested at the Paris motor-car exhibition, is thus described: The motor can be used equally well with crude petroleum, or with distillates like kerosene or naphtha. The two cylinders are placed end to end, with one explosion chamber in the center; the one explosion operating both cylinders. The piston rods are each connected by cranks and connecting rods to the fly-wheel shaft, which is fixed centrally below the cylinders, and the engine is thus exactly balanced. The motor runs at 600 revolutions, develops 6 brake HP. and weighs, with its fly-wheel, about 3½ cwt. Power is transmitted from the motor-shaft to a jack shaft by spur-wheels running in an oil-bath, and from the jack shaft to the rear wheels by the usual chain and sprocket gear. There are three forward speeds, of 5, 10 and 18 miles per hour, and one backward gear. This carriage, carrying four passengers, is said to be capable of mounting 10 to 12% grades with ease. The steering is done with the forward wheels, operated by a standard with a long, single handle.

◆

A BUILDING ON CANTILEVERS, of peculiar design, has lately been erected in Birmingham, England, to utilize a valuable frontage that overhung the tunnel of the Great Western Ry. This tunnel was so near the surface as to forbid the use of girders spanning it, and the house could not be built upon the tunnel masonry. In this emergency Mr. R. Heaton, architect, devised a system of cantilevers to support a three-story warehouse with the front overhanging the tunnel 25 ft. at one end and 4 ft. at the other. The building is 44 ft. deep, and thus only 19 ft. rests upon the ground at the point of greatest overhang. The steel girders which support the building rest upon a pier, with its face 25 ft. from the frontage line; and as the overhang part of the girder in front is longer than the rear portion, a concrete counterweight is suspended from the rear member. The first cantilever, of the six used, supports 270 tons, and carries 160 tons of suspended load. The second cantilever carries the greatest load of 375 tons, and from this point the load decreases with the decrease of the overhang to 4 ft.

BOOK REVIEWS.

HISTORY AND DESCRIPTION OF THE WATER SUPPLY OF BROOKLYN.—Prepared and Printed by Order of the **Commissioner of City Works. I. M. de Varona**, Engineer of Water Supply. Cloth; 12 × 15 ins.; pp. 306, and 81 tables, unpaged; 104 plates, some folding. City Document.

This very handsome volume contains a vast amount of useful and interesting information regarding the water supply of the former city of Brooklyn, now a part of the Greater New York. It is, of course, impracticable to enumerate in detail the contents of the volume, as it includes, as the title states, a "History and Description of the Water Supply of Brooklyn." Many tables, reproductions of photographs, maps, diagrams and other drawings contribute their part to make up a book which does honor to those who prepared and published it, as well as to the city for which it was designed.

The Brooklyn water-works possesses many interesting features. One of these is the large number of driven-well stations, intended originally only as temporary means of supplementing the surface supplies.

The volume contains biographical sketches of the various chief engineers of the works, up to but not including Mr. de Varona, and a good portrait of Mr. Jas. P. Kirkwood, Chief Engineer of the Brooklyn works during their construction. The various rules and regulations of the works are given, including those for the sanitary protection of the water supply. One of the most interesting of the many tables in the book is one giving a detailed statement of the yearly receipts and expenditures of the works. The total cost of construction up to the close of 1895 was $22,102.701 Other valuable tables are rainfall records for Brooklyn and vicinity, and detailed statistics regarding the various pumping plants and their operation. The consumption of water was 12 gallons per capita in 1860; 47 in 1870; 54 in 1880; 67 in 1890; and 75 in 1895. The first figure should not be given much weight, as the works were completed in 1859.

THEORIES DE L'ELECTROLYSE.—Par Ad. Minet, Ingenieur-Chimiste, Directeur du Journal L'Electrochimie. Paris: Masson et Cie. Paper; 7½ × 4½ ins.; pp. 175. One of the series of "Encyclopedie Scientifique des Aide-Memoire."

The author takes up the history of electrolysis from 1772, when Paets, of Troostwyk, discovered that he was able to decompose water by means of the current furnished by the great static electric machine at Harlem. But investigators were then studying the mechanical rather than the chemical effects of apparatus of this kind, and Paets's discovery of the electrolytic phenomenon was regarded as of secondary importance. Faraday, later, laid down the broad law, and the investigations of Weber, Mascart, Kohlrausch, Lord Rayleigh and Sedgewick definitely fixed the quantity of electricity necessary for the decomposition of an amount of electrolyte equal to its equivalent expressed in grammes, and according to Becquerel's law. The author broadly defines electrolysis as the phenomenon of decomposition engendered by the passage of an electric current through certain chemical compounds of determined function; and all substances susceptible of being thus decomposed by the current are known as electrolytes. The latter must fill two conditions; they must be conductors of electricity and be sufficiently fluid. The general laws and physical theory of this phenomenon are then discussed at length. The second part deals with the constitution of electrolytes, and the modern chemical theories as here applied; and the next division discusses the electrolytic constants, methods of measuring the resistance and conductivity of electrolytes; effect of saline mixtures; and the electrolytic transport of the ions. The work closes with a very full biography and an excellent table of contents.

ANNUAL MEETING OF THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.

The 15th general meeting of the Institute was called to order in the Bee Building, Omaha, Neb., on the morning of June 27 by Mr. A. E. Kenneally, the president. Mr. W. W. Bingham, President of the City Council; Mr. G. W. Wattles, President of the Exposition; Mr. E. Rosewater and Col. J. J. Dickey were introduced and made appropriate remarks, to which the president replied and then read his address. The growth of the electrical industry during the last 15 years was traced, and the progress in the industry which, in 1884, involved only $1,000,000, and now over $900,000,000 was interestingly outlined.

Mr. C. P. Steinmetz then read a paper entitled "Dielectric Strength of Air," which was a description of a series of tests of striking distances in air with different forms of terminals and a mathematical discussion of the data obtained. In conclusion Mr. Steinmetz said:

1. At constant voltage and constant wave shape, that is constant ratio between maximum and effective E. M. F., the striking distance is a constant, especially between sharp points, where the tests have been repeated over and over again, and independent of the atmospheric condition, the frequency, etc., to such an extent that the striking distance between needle points offers the most reliable means to determine very high voltages.

2. No physical law has been found to represent satisfactorily all the observations. Some point to the existence of constant dielectric strength of air, analogous to the tensile strength of mechanics. Others point to the existence of a spurious counter E. M. F. of the spark or transition resistance from electrode to air.

3. Constant dielectric strength. Cylinders of 1.11-in. diameter give an average disruptive strength of air of 60 kilovolts per in. Cylinders of .315-in. diameter, an average dielectric strength of 77. Spheres at very small distance point toward the latter value. As a disturbing factor in this case, enters the electrostatic brush discharge, which by a partial breakdown of the air surrounding the electrodes changes and increases the size and decreases the distance of the effective terminals.

4. Counter E. M. F. of the sparks. The tests with sharp points give 22 kilovolts, or 11 kilovolts for a single transition from terminal to air. Spheres give curves pointing to a similar phenomenon. Electric conductors inserted at right angles into or parallel with the discharge, point to the existence of a counter E. M. F. of the same magnitude. The beginning of the electrostatic brush discharge is at a potential of this magnitude also.

5. Potentials of 160,000 volts effective and even up to 170,000 volts have been experimented with. They are probably the highest voltages ever reached by man at ordinary frequencies with alternating currents of considerable power.

Mr. John W. Howell read a paper entitled "Two-Wire Distributing Systems and Lamps at 220 to 240 volts." This paper described the saving in copper resulting from the use of a two-wire system in connection with the higher voltage lamps and recounted some of the troubles encountered in the use of 220-volt. lamps. The statement was made that the future of 200-240-volt systems depended upon the development of a more economical lamp, as all other elements of the system were already provided or could be produced with the means or knowledge now at our command. The third paper, "A Capillary Electrometer for Electrical Measurements," by Mr. Charles F. Burgess, was read by the Secretary. Mr. Burgess' instrument depends upon the change of surface tension of two liquids (preferably mercury and dilute sulphuric acid), which are in contact in a capillary tube. The meniscus which is found at the separating surface moves upon the application of a potential to the liquids. This movement can be measured, as can also the potential producing it, and the instrument is in this way calibrated. The methods of measuring insulation and electromotive force were described.

The afternoon and evening were given up to visits to the Grant Smelting Works and the Union Pacific Shops and the night illumination of the Exposition Grounds.

The morning session of June 28 was devoted to papers, the first of which, entitled "A Modern Central Station," was read by Mr. Geo. A. Damon (Eng. News, July 14, 1898). Dr. Francis B. Crocker followed, reading the Preliminary Report of Committee on Standardization, a committee appointed some time ago to draw up a code to govern the construction of certain electrical apparatus. Such quantities as efficiency, rise of temperature, insulation, regulation, variation and pulsation, rating, classification of voltages and frequencies, etc., are included in this report. The report is a tentative one, and was presented to give members an opportunity to criticize and submit suggestions. The afternoon and evening were devoted to sight-seeing.

The first paper the next morning, June 29, was by Mr. Ernest J. Berg, on "Transmission and Distribution of Power for Railway Service." This was a somewhat mathematical discussion of alternating current systems for railway work with especial reference to generation and transmission, and the available means of regulation from the generating station.

The next paper presented, "Some Phases of the Rapid Transit Problem," by Mr. Albert Armstrong, dealt with train acceleration, train energy and breaking. A number of curves plotted from certain average assumptions were included with accompanying explanations. Mr. D. C. Jackson's paper "The Commutated Curve of a Composite Wound Alternator" was read by title.

The morning of the last day, June 30, was devoted to the following papers: "The Graphic Treatment of Alternating Currents in Branch Circuits," Henry T. Eddy.; "Air Core Distribution," Prof. W. E. Goldsborough, and "High Voltage Power Transmission," Chas F. Scott.

The attendance at the convention was small, as was to be expected by reason of the long distance from the electrical centers of the East. The papers are published in full in the May number of the Society's "Proceedings," which can be obtained from the Secretary, Mr. R. W. Pope, 26 Cortlandt St., New York city.

SUMMER MEETING OF THE AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS.

The first summer meeting of this society was held at the Hotel Irvington, Atlantic City, N. J., July 15. Two sessions were held, one beginning at 2.50 p. m. and the other at 8 o'clock in the evening. The attendance was disappointingly small.

The afternoon session was called to order by President A. R. Wolff, with few appropriate introductory remarks, in which he explained that the summer meeting was intended to be largely of a social nature.

The first paper, "Some Accepted Tests of Ventilation—Are They Reliable?" was read by the author, Mr. T. C. Northcutt. We condense it as follows:

Most of the methods and instruments by which we measure the results of ventilation have come into use within a generation. They are comparatively new and to some extent defective. We are not to abandon methods of testing because they are defective until we have found other methods that are less defective, but I think it important to recognize their shortcomings.

Carbonic Acid Gas Tests.—To discover the degree of impurity of air in occupied rooms it is usual to determine the proportion of carbonic acid gas. The excess of this gas over that which is normal to outside air in a clean locality is taken as showing the degree of impurity. This test is only approximate.

Carbonic acid gas is not the only, nor the worst, poison discharged into the air of an occupied room. An eminent authority states that "a man of average weight throws off through the skin during 24 hours about 18 ozs. of water, 300 grs. of solid matter and 400 grs. of carbonic acid gas." This is nearly 3 lbs. of poisonous matter discharged into the surrounding air by every vigorous adult in each 24 hours. But less than one-third of this is carbonic acid gas. It is well known that the solid matter of excretion in an occupied room is a most deadly poison. We have no accurate means of testing its volume, except by laborious processes in the laboratory not available or practicable for general use. Yet the test for carbonic acid gas in vitiated air is, under carefully guarded circumstances, approximately correct, and, if rightly used, is of great value. This is true because an excess of carbonic acid gas is ordinarily a close companion of all other forms of crowd poison. Its presence indicates the presence of its ally.

Lime Water Test.—This test aims to determine the presence of carbonic acid gas. It does not, except by inference, determine the presence of other forms of crowd poison. It depends upon the fact that carbonic acid gas passed into and through lime water will precipitate the lime in the water, making the water which was at first absolutely clear to be more or less clouded and dense with chalky matter. The amount of carbonic acid gas discharged through the water determines the degree of density.

With the Wolpert Air Tester, for example, you are to determine the volume of carbonic acid gas that is passed through the water by the number of times you have discharged a bulb full of contaminated air through the lime water before the water becomes so dense that a black spot at the bottom is obscured. It is evident that the experimenter may, or may not, exhaust the bulb, or air pump, to the last degree at each filling. He may, or may not, fill the bulb from that limited area of air immediately surrounding his own head, and into which he has just that instant discharged the contents of his own heated lungs. This does not impeach the honesty of the operator. It is simply a question of his knowledge, his skill and precision.

Again, to determine when the black spot can no longer be seen through the lime water is a question of vision, and everyone who has made use of this test knows how difficult it is to be quite sure when the vanishing point is reached. The various lime water tests in popular use are thus defective. But this test is not without great value, and we must continue to use it until something better is known. We should look with some degree of skepticism, however, upon any such test made by the inexperienced.

The Anemometer.—The anemometer is the most useful instrument in determining the results of ventilation. I mean a good anemometer. I have seen some that are no better than an old-fashioned fanning mill. It should be carefully kept in adjustment. Ventilation is, more than anything else, dilution, and so after all the best test of adequate ventilation is the anemometer test. And yet the anemometer, even if a good one, in the hands of an inexperienced or injudicious person, is an unscrupulous liar.

We must continue to use tests which are recognized as in some measure defective. We continue to use them because they are the best known. We must be careful, however, to make these tests with a full knowledge of their shortcomings, and a disposition to carefully watch for every affecting circumstance. In the meantime we will urge inventors to find better instruments for our purpose.

Mr. Jellett, in the discussion, said that his experience demonstrated the approximate nature of tests made with the anemometer. In one case where a delivery of 40,000 cu. ft. per minute was called for in the specifications, his test gave 41,000, while that made by the engineer in charge gave 47,000, and someone else might have obtained 37,000. In the case in question the flue velocities were found to vary considerably, owing to offsets in the flues, and the delivery was altered by the opening or closing of dampers in side flues. Attention was called to the fact that all 3-in. anemomenters seemed to have the same friction coefficient (30) and the reason for this was briefly discussed without arriving at any conclusion.

Mr. Henry C. Meyer, Jr., questioned the accuracy of the author's statement that the carbonic acid gas would rise, and the other exhaled material would settle. It was explained that the separation was only temporary and resulted from a difference of temperature, the CO_2 being hotter than the other products when exhaled.

The Secretary then read Mr. McClellan Davidson's paper, "The Use of Draft Regulators," which was intended to open a topical discussion.

This paper considered in a general way the question of draft regulators for domestic service, stating that any regulator to be of service must be simple, quick to respond to temperature changes, and thoroughly reliable, conditions not completely fulfilled by any regulator in the market as far as his experience went. The best system at present in use employed a thermostatic device, but it was a mistake to claim, as some manufacturers of regulators were doing, that one type was suitable for all purposes, and all systems of heating. With steam heaters the changes were apt to be rapid compared with hot water systems. It was therefore necessary to employ special forms of regulators each suitable for a certain set of conditions.

Others stated that hot water regulators were slow to operate, all closing too slowly and opening too quickly. As an example of the uncertainty of automatic regulators, the case of the operating room of a hospital was mentioned. This room had a large skylight and the sun's passing under a cloud would cause a variation of the room temperature of 5°, notwithstanding the automatic regulator in use.

A paper on "Boiler Furnaces," by Mr. M. C. Huyett, of Detroit, Mich., was read by the secretary. The following is an abstract:

Boiler Furnaces for Steam Power Installations.

The Central High-School Building, Detroit, Mich., has been used two winters. The power plant has four horizontal tubular boilers, aggregating 428 HP. The furnaces were plain grates, hand fired. From September, 1896, to March 1, 1897, 1,093 tons of soft coal were burned, costing $2,892. From March 1 to the end of school term, 190 tons of soft coal were burned at a cost of $536.

The building is in a fine residence part of the city, and complaints of "smoke nuisance," and threats of suits were frequent. The use of anthracite coal was considered favorably and the consulting engineer for the board estimated that 1,000 tons would be required. Proposals were advertised for, and the lowest bid was $4.88 a ton. At the same time proposals were asked for Jackson Hill (Ohio) nut and slack. The lowest bid was $1.69, delivered in the building.

Mechanical furnaces were installed in August, 1897. From September, 1897, to March, 1898, 806 tons Jackson Hill nut and slack were burned at a cost of $1,362.14. The engineer then estimated that 150 tons would complete the school term, at a cost of $253.50. Total $1,615.64.

If the engineer's estimate for the incomplete part of the term proved to be correct, the economy in favor of the mechanical furnaces and cheap bituminous coal would be $1,811.

The known quantity is the two school terms to March 1—$2,891, $1,362 or $1,529 economy.

It is safe to assume that had anthracite been used 1,000 tons would have been required, and fuel cost have been $4,880.

There has not been a single complaint of smoke nuisance whilst burning the 1,000 tons of bituminous nut and slack coal. Almost continuously the chimney top has been absolutely smokeless.

When working a boiler at full duty rating of 100 sq. ft. of heating surface per horse-power with a mechanical furnace 3.16 lbs. Pocahontas R. M. was burned per HP. hour; 3.74 lbs. Jackson nut and slack was burned per HP. hour; 4.4 lbs. Hocking Valley slack was burned per HP. hour; 3.65 lbs. Belmore pea was burned per HP. hour; 4.1 lbs. Cherokee, Kan., slack was burned per HP. hour.

I have test data with slack coal, hand fired, and like coal mechanically fired. The economy favored the mechanical furnace 20%.

Mechanical furnaces require slack or nut and slack, or nut sizes of coal, and with only reasonable attention for some types, and no attention for another type, will consume such sizes of bituminous coal with stack conditions ranging from some smoke—but no smoke nuisance—to absolutely smokeless almost continuously. At no time will chimney gas escape be opaque.

Bituminous slack and screenings coal can be burned so satisfactorily as to not cause a nuisance to occupants of adjoining properties, and with such economy as to fully justify the large money investment required for a modern mechanical furnace plant.

Mr. A. Harvey mentioned the case of the Michigan Central R. R. station at Detroit, Mich., in support of the automatic stoker as against hand firing. In this plant, 1,200 tons of hard coal were formerly required, while with mechanical stoking 1,000 tons of slack were used, thus effecting a saving of about $5,000 a year.

Mr. Jellett called attention to the fact that the economy resulting from the use of mechanical stokers depended upon the locality in which they were employed, the entire question hinging on the relative cost of hard and soft coal, and while stokers made such a fine showing in Detroit, where hard coal cost so much, the saving would be greatly reduced in a place like Philadelphia, where hard coal is cheap.

In opening the evening session, the President announced the following as members of a committee to collect data concerning school-house heating and ventilation in their respective cities: A. E. Kenrick, Boston; Geo. I. Rockwood, Worcester; Ernest Glantzlong, Springfield; Mr. Strangerland, New York; Wm. M. Mackay, Newark; T. C. Northcutt, Syracuse, Rochester, Elmira and Buffalo; H. R. Harvey, Detroit; John Gormly, Philadelphia; B. H. Carpenter, Wilkes Barre, Scranton; Henry Adams, Baltimore and Washington; J. A. Larydon, Pittsburg; H. D. Crane, Cincinnati; D. M. Quay, Chicago; Prof. J. H. Kinealy, St. Louis; Charles T. Tay, San Francisco; David N. Nesbitt, London, England, and A. B. Reck, Copenhagen, Denmark.

The first paper of the evening, "A Suggestion for Determining the Heating Surface of Indirect Radiators," by Mr. H. Eisert, was read by title only, owing to its technical nature, which would require some personal explanation by the author. It will be published in full in the annual proceedings.

A topical discussion, "What is the Best Means of Advancing the Interests of Our Society?" was taken up and considerable time was devoted to considering the objects of the Society, the classes of engineers eligible to membership, and the number of such engineers. Entrance requirements were discussed and the resulting feeling was that everything considered, for a young Society with a high standard for admission, the American Society of Heating and Ventilating Engineers was holding its own.

The fourth topic, "The Consulting Heating and Ventilating Engineer—His Relation to Owner and Contractor," was discussed by Mr. Jellett who quoted from a paper on the same subject read by Mr. Wm. H. Bryan before the meeting of the American Society of Mechanical Engineers, held at Niagara Falls in June (Eng. News, June 2, 1898). He stated that the consulting engineer bore the same relation to the owner that the architect did, and at the same time, like the architect, must have the confidence of the contractor. The duties of a consulting engineer were outlined, and the common practice of accepting bids in which it was quite certain the contractor had made some mistake, afterwards holding him to his contract and thereby making him lose, was condemned. Such action usually resulted in poor work somewhere which would eventually bring the cost up to what should have been allowed.

The consulting heating and ventilating engineer is a recent growth. In most cases he is qualified to do what is claimed by his title. There are, it is true, many equally competent engineers connected with manufacturing firms, but these from this business connection are not in a position to occupy a proper relation to the customer, and hence could not be called consulting engineers.

ANNUAL MEETING OF THE INTERNATIONAL MINING CONGRESS.

The first annual meeting of the Congress was held at Salt Lake City, Utah, on July 6, 7, 8 and 9.

This organization is a result of the gold mining convention which met a year ago in Denver, at which it was decided to extend the scope so as to include all mining and to adopt the more comprehensive name.

At the first session on Wednesday, July 6, there was a rather small attendance. Addresses of welcome were made by the governor of Utah and the mayor of Salt Lake City and were responded to by Col. B. F. Montgomery, of Colorado. The president of the Congress, ex-Gov. Bradford T. Prince, of New Mexico, gave an able address, in which he pointed out that by extending the latitude of the convention to include all mining interests, $750,000,000 in annual product was now represented instead of only $60,000,000 for gold alone.

It was also pointed out that of the five principal metals—gold, silver, copper, lead and iron—the United States today produces more than any other country. Her copper production is greater than that of all the rest of the world. At the afternoon session J. W. Neill, mining engineer of Salt Lake City, read a paper on "Advances in Methods of Concentration." At this session was presented the report of the committee on revision of the Federal mining laws, the most important matter brought before the Congress. The chairman, Chas. J. Moore, mining engineer, of Colorado, presented the majority report and made a strong speech in support of it.

The report was very voluminous, but the principal change recommended in the existing law was the entire annulment of the so-called "apex law" at present applied to lode claims.

By this law the owner of a mining claim is allowed extra lateral rights, that is, he has the right to go beyond the side lines of his claim in following the vein on which he has located. Mr. Moore said in part:

> In the year 1879, only seven years after the passage of the present mining law on May 10, 1872, the evils resulting from its operation had become so great that Congress appointed a public land commission, which investigated most thoroughly the causes of the troubles arising from the present law, and made an exhaustive report. This testimony before this commission showed great evils then existing: and they have grown worse during the 18 years since that commission's report.
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> To eliminate the "apex-law" would be to return to the common law, which declares that the owner of any portion of the earth's surface is entitled to everything enclosed by vertical lines or planes reaching from his surface boundaries down to the center of the earth, but to nothing outside of them.
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> By the abolition of the apex law we destroy at once the principal source of the most expensive, harassing and disastrous litigation in our Western States and Territories; but we would compensate those who think they should have possession of every vein throughout its entire depth when its apex is within the surface boundaries of their location, by doubling the size of the maximum location over that of the present law, making it 40 acres instead of 20 acres; and further by expanding the manner of discovery and permitting a location to be taken in any form, thus eliminating all difference between side lines and end lines. The apex law was a legacy from Spain, which we inherited when we acquired the Spanish colony of California, and all the Spanish-American countries except Bolivia have now abandoned it.

Another principle advocated in the report is that of entirely segregating as soon as possible any portion of the public domain upon which a discovery of precious or useful minerals may be made, by requiring the owner of a mining claim to patent his ground within five years from the date of location. Adverse claims are to be adjudicated at the time of location, the original survey of the latter to be now made an official act, and to serve without any subsequent survey as that upon which the patent shall ultimately issue.

In the proposed new law the tunnel-site feature is retained, but its provisions are limited to the ownership of veins not previously covered by surface locations, and are expanded to include the right of possession of the underground places on the beds of ancient rivers, such as are called in California "deep placers."

The discussion of the majority and minority reports of the committee was undertaken at the afternoon session on Thursday, July 7.

The two reports had been printed for distribution among the members, and the minority report was presented by Judge W. B. Heyburn, of Idaho, who made a vigorous speech in its support.

This report recommended the retention of the apex law and of practically the present system of laws, with the abolition of local rules.

The speaker asserted that the "square" claim law (vertical sides) had been in effect in British Columbia since 1891, but that they now desired to change back to the American system. He claimed that the recommendations of the majority report, if enacted into law, would work untold hardship on the prospector who was generally of humble means and who could never begin to comply with the seven notices required, and with the $50 preliminary deposit which the U. S. Surveyor-General required at the time of making the location. He gave examples of the location of certain claims that had laid the foundations of some of the greatest camps in the world, where the locators had barely enough money to pay the recorder's fees. The minority report recommended the establishment of a base line for every ledge as follows:

> The end lines of the first location made upon any ledge shall govern as to the direction of the end lines of all subsequent locations upon the same ledge.

In concluding, Judge Heyburn urged that, though there had arisen many difficult questions in the past in connection with our mining laws, that they had stood the test of a quarter of a century during which they had been interpreted at a cost of millions of dollars, and that it was unwise now to enact any new ones.

Prof. W. S. Keyes, geological expert of California, made an argument for the majority report. Among other things he said:

> I look upon the extra-lateral permission of the law as the chief vice of our present mining code. It has caused more heartaches, more law suits and more rascality and perjury than any dozen laws upon our statute books. On the authority of a former Surveyor-General of Nevada, Mr. S. H. Marlette, there was expended in litigation on the Comstock lode during the years of 1860-'65 inclusive, not less than $9,000,000—one-fifth of the total product of the mines, and, considerably more than was declared in dividends during the same time. Senator William Stewart estimates the cost of litigation carried on by the Chollar and Potosi mining companies, prior to 1866, at $1,300,000, and the expenses of the Ophir-Moscow war at nearly $800,000. The total costs of litigation in the Washoe district up to Jan. 1, 1896, he computes at $10,000,000. As a part of the litigation there sprang up a horde of greedy, conscienceless "standing witnesses," ready, for pay, to swear to anything. Dr. Raymond, in "The Mineral Industry," says: "The full development of the mineral resources of the West will never come to pass until the capital it requires is better protected by definiteness in title and boundaries of mining property. And that cannot be done, in my judgment, by any amendment of the present law, which shall leave in it the present abnormal, irregular, indefinable, precarious, and mischievous extra-lateral right." It is bad enough to be obliged to take the usual mining chances, but when, in addition to this—to use the words of Chief Justice Beatty of California, long on the bench in Nevada—we have the certainty of a law suit, provided the mine proves to be of any value, the outlook for the legitimate miner and investor is far from encouraging.

Professor Keyes then answered the objection that the adoption of the "square" claim would tend to the monopolization of a district by asking why it was that all the other nations of the earth used the system; and why it was that the system was used in all the states to the east that produced the commercial metals.

Among the lawyers, he asserted that the giants at the bar were a unit on the question, and that the "Engineering and Mining Journal,' of 'New York, and the "Mining and Scientific Press," of San Francisco, were both enthusiastically in favor of reform. In closing, he asserted that under the square or surface location no disputes could arise except such as could be determined by a competent surveyor.

The discussion of the reports was not concluded at this session, and it went over until Friday morning, July 8. It was evident that neither report could be approved, and ex-Congressman C. E. Allen, of Utah, offered a resolution as a substitute for both, which was adopted. This simply stated that it is the sense of the Congress that the mineral laws should be so amended as to do away with extra-lateral rights in mining claims, and instructed the President and Secretary to forward to the proper committees and officers at Washington, when Congress convenes in December, copies of the resolution. The main fight against any change in the laws was made by the prospectors.

At the Thursday morning session, Manuel Elquera, secretary of the Peruvian Legation at Washington, and a mining engineer, read an interesting paper on "The Mineral Resources of Peru." Mr. Elquera described the geographical situation and topography of Peru, and explained that of the vast mineral wealth of the country but little is really known. He had traveled a great deal in Peru in the practice of his profession and had journeyed for days at a time through regions where the earth at any place could be taken and washed, and would show particles of gold.

This paper was followed by one entitled "Some Remarks on the Cyanide Process," by Louis Fade, chief chemist and director of the Raessler & Hasdecker Chemical Co., of New York. Among other things the speaker said:

> So-called coarse gold is acted on by cyanide so very slowly that the process is applicable only to ores which contain the metal in a very finely divided state. The selective action of a dilute cyanide solution on gold ores in preference to the sulphides of base metals with which they may be associated, is so wonderful that, from a chemical point of view, we may say that it is possible to extract the gold from all low-grade ores by means of cyanide, with the exception of ores containing copper, zinc and antimony combinations. In these cases the treatment becomes difficult, if not impossible.
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> On first thought one is inclined to believe that the finer the ore is crushed the better it is for leaching purposes, but this is very often a wrong conclusion. It may be all right for very hard silicious ore, but not for an ore containing, for instance, alumina and magnesia, which are very apt to form slimes when coming in contact with the cyanide solution, and thus render the ore impenetrable. A very good example is the experience of the now world-renowned Mercur mine in Utah. Some six or seven years ago when the process was being developed at the plant of this mine—which, by the way, was the first cyanide extraction plant in this country for the treatment of ore—the managers were advised to grind the ore to about 600-mesh in order to attain the highest possible extraction. The result was the saving of only about 40% of the assay value of the ore. After many attempts and experiments to solve this perplexing problem, it was decided not to crush the ore so fine, on account of its porous nature and its considerable percentage of talc and alumina, which latter rendered the ore difficult of penetration by the cyanide solution. The result was that the coarser the ore was crushed the higher the extraction became, and now it is found that the highest extraction—about 85%—is obtained when the ore is crushed to about ¼-in. cubes.

At Friday morning's session, a paper on the mineral resources of Venezuela was read by Francisco Yanes of that country. Señor Yanes gave an interesting topographical description of that country. He said that notwithstanding mining was still in its incipiency there were 226 mines which furnish 42 different metals. Attention wos called to the rich copper mines of Aroa and El Callao, which have proved astonishingly productive. The richest gold-bearing region is that of Guiana, where the fabulous land of "El Dorado" was located, which attracted so many adventurers to the coast of Guiana in the fifteenth century. There are 62 gold mines in Venezuela, all of which are high-class producers. There are also coal and asphalt mines and petroleum deposits, which have been worked at a profit.

Mr. Yanes was followed by T. W. Gibson, Secretary of the Bureau of Mines and Mining of Ontario, Canada, who, took occasion to preface his talk on the mineral resources of Ontario, by referring most feelingly to the sympathy of Canada for the United States in the present war, and to the close relationship between the two countries.

At the afternoon session on Friday, a paper entitled "Official Geology and its Relation to the Mining Industry," prepared by H. H. Stoeck, editor of "Mines and Minerals," of Scranton, Pa., was read by Prof. Arthur Lakes, of Colorado. The writer told of the first established geological survey—that of North Carolina—begun in 1823, from which the idea developed in different states. The Association of American Geologists was formed in 1840. For years in different states the surveys dragged on, often crippled for want of funds, until after the Civil War. Then came a revival of geological activity until work along this line is done in nearly every state of the Union.

A paper on "Mine Legislation and Mine Inspection in the Anthracite Coal Region of Pennsylvania," was then read by Mr. G. M. Williams, of Pennsylvania.

The speaker told of the beginning of all mine inspection in this country at the anthracite mines; of the opposition of the mine owners at first, and how much benefit it had caused, not only in saving of life and limb, but in the more vigorous health and increased capacity for work of the miners.

At this session Milwaukee was chosen as the place for the next annual meeting, getting about 70% of the vote cast, and Sept. 7 to 10 inclusive, 1899, was fixed as the time.

Mr. Richard H. Terhune, superintendent of the Hanauer smelter, near Salt Lake, read a paper on "Recent Advances in Silver-Lead Smelting," in which he gave the results of numerous experiments he had made.

At Saturday's session a resolution, offered by Prof. S. B. Christy, of California, was adopted, which recommended a liberal increase in appropriations for carrying on the U. S. Geological Survey, and also the co-operation of surveys now carried on by the states independent of the national survey. A vote of thanks to Director Walcott and his assistants was included. A resolution petitioning Congress for the creation of a Department of Mines and Mining, was also passed.

It was decided to establish a headquarters for the Congress at Salt Lake for the coming year, until it becomes time to remove them to Milwaukee to begin the preliminary work for next year. Mr. W. D. Johnson, of Salt Lake, the Secretary-elect, is to be in charge. Col. B. F. Montgomery, of Cripple Creek, Colo., was chosen President for the ensuring year.

The sessions were pleasant and fairly harmonious, notwithstanding the hot weather, which deterred many from sitting through them when there were more attractive resorts outside and at the lake. There were 28 states and 2 foreign countries with delegations in attendance. The greatest attendance at any one time was about 130.

A mineral exhibit was made at a hall near by, at which were shown some of the choicest products of some of the principal mines of Utah, and also some mining machinery.

On Saturday, an excursion was run to Bingham to inspect the Highland Bay (principally copper) mine and others. On Sunday excursions were run to Park City, to Tintic and to Mercur. At the latter place they had the rare privilege of going through the great Golden Gate cyanide mill, illustrated in Engineering News of May 19, 1898.