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THE EAST CHANNEL OF NEW YORK HARBOR has been reported upon by Lt.-Col. William Ludlow, Engineer Corps, U. S. A., in regard to its improvement as an entrance to New York. Col. Ludlow favors the improvement of the East Channel, and thus differs from Col. Gillespie, who recommended the deepening of the Main Channel. He estimated that a channel 2,000 ft. wide and 35 ft. deep could be made for $3,200,750, including $800,000 for four powerful pump dredges. If this work should be let by contract, however, he would add 20% for profit to the above amount. A channel 1,000 ft. wide and 35 ft. deep could be made in 15 months, while the full width of 2,000 ft. would require from 2½ to 3 years for completion. In the detail report submitted Col. Ludlow says that the East Channel is a well-marked result of the ebb-flow and carries to sea the greater portion of the outflow from the Hudson River Basin. He considers it as the old bed of the river, and it maintains a broad channel over 30 ft. deep for 4½ miles below the 35 ft. contour of the deep water south of the Narrows; passing completely through the main crest of the bar. The present Main Ship Channel makes sharp angles and requires dredging, to a greater or less extent for deepening and maintenance. The East Channel is almost direct, and it would be comparatively easy to open it, as it is the natural main outlet for the ebb tide through the Narrows, and has the deepest and widest natural channel across the bar. Owing to its powerful discharge and to the directness and uniformity with which the tidal currents traverse it, both in ebb and flow, it has always maintained its natural superiority without artificial aid; and has, in fact, pushed its deep contours seaward. For commercial purposes it is also the shortest channel; the distance between the 35-ft. contours, inside and out, is 6¼ miles, or 5 miles less than by the present ship channel. For the 2,000-ft. wide, 35-ft. deep channel, the quantity to be dredged is estimated at 29,100,000 cu. yds., including allowance for slopes of 10 to 1, for wash and scour and 25% added for difference between scow and place measurement. The material is sand, gravel and mud, and this should be removed for from 3¾ to 7 cts. per cu. yd. The dredging steamer deepened the Gedney Channel at a cost of about 5 cts. per cu. yd.; and Col. Ludlow uses 7 cts. for work on the bar, with 10% added for contingencies.

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CONCERNING THE PORT ARTHUR SHIP CANAL project, referred to in our issue of March 31, we note the following from official sources: Major James B. Quinn, Engineer Corps, U. S. A., in his official report to the War Department, says that at the entrance to the proposed canal he found a cut 200 ft. long, 50 ft. wide and 12 ft., and no part of the canal more than 16 ft. deep, as yet. He also found the location of the canal dangerously near the lake and liable to erosion, and reported danger from silting from the lake and from Taylor's Bayou. Major Quinn recommended that the proposed bulkhead be built without openings after Mud Bayou is reached, and that a complete barrier be maintained at this point until a satisfactory scheme for a disposal of drainage is proposed by the company and approved by the Secretary of War. On March 24, the Chief Engineer of the Port Arthur Channel & Dock Co. filed with the Secretary of War a report, plans and specifications dealing with this subject, and had a personal interview with the Secretary. As a result, Gen. John M. Wilson, Chief of Engineers, acting under instructions from Secretary of War Alger, has now directed Major Quinn "not to interfere with the canal work of the Port Arthur Co., as projected, unless he feels sure that it will result disadvantageously to the government work at Sabine Pass." If such a question arises he is to report the facts with recommendations, by telegraph, to the Secretary of War. The objection to the plans are thus removed, for the time at least; and since the above order was issued the entire connection between Taylor's Bayou and the canal has been dredged. At the present time about 3½ miles of the canal are completed to a depth of 16 ft., and three hydraulic dredges are at work.

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THE SUGAR BEET INDUSTRY OF EUROPE is reported upon as follows by U. S. Consul-General Julius Goldschmidt, of Berlin: Germany, in 1896-97, operated 399 factories, consumed 13,721,000 tons of beets and produced 1,738,885 tons of sugar in the year. This is at the rate of 790 lbs. of beets to produce 100 lbs. of sugar. France, in the same year, consumed about half the amount of beets, and made 703,300 tons of sugar; and Austria-Hungary made 929,000 tons of sugar. Russia also produced 734,400 tons; and Belgium, Holland and Sweden added 280,000, 156,000 and 106,400 tons to this product, respectively. The wholesale price of raw sugar at Magdeburg, at 88%, has fallen from $6.80 per 100 lbs., in 1859-60, to $2.14 in 1896-7. The growth of this industry, in thirty years, is largely due to protection and bounties, which have stimulated scientific research, mechanical ingenuity and intelligent husbandry. Germany is now the largest sugar exporting country in the world. In 1896-97 she shipped abroad nearly 850,000 tons of beet sugar, over one-half of which came to the United States. Her own population of 52,500,000, in 1895-96, used over 30 lbs. per head (the consumption of the United States is about 54 lbs. per head). Deducting $4,334,000 paid in 1895-96 for export bounties, the total amount received by the country for its sugar exported in that year was nearly $25,000,000. The production of beets per acre has also increased from 11½ to 13½ tons, without exhausting the soil. The price paid for beets is now about $4 per ton.

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THE DEVELOPMENT OF THE SUGAR-BEET INdustry in the United States is being seriously promoted by the U. S. Department of Agriculture, and within the last year seeds were sent to over 10,000 farmers in different parts of the country, and 2,300 of the samples produced from this seed have been analysed by government experts. The best results came from the states of New York and Michigan, though the results in eight other states were generally favorable. The New York beets weighed about 30 oz. each, and contained about 19% of sugar on the average. The average yield of 41,272 acres for the year was almost 9½ tons of beets per acre; and the returns of the Department for 1897 show a production for the United States of 90,491,670 lbs. of beet sugar in that year. This is equivalent to 232 lbs. of sugar per ton of 2,000 lbs., or 11.6% of the weight of the beets. Secretary Wilson states that at least 80,000 acres will be planted with beets in 1898, and the expected yield is 800,000 tons of beets, or 180,000,000 lbs. of sugar, or nearly 4% of the total import of sugar, now amounting to about 2,000,000 tons per annum. During the calendar year of 1897 more than 1,373,000,000 lbs. of beet sugar were imported into the United States, and there is evidently room for the development of this industry, with profit to the country. The attempt to mix up this growing industry with the Hawaiian question, and against annexation as liable to ruin the industry, is met by the assertion that the sugar beet business of the United States would have to expand to 1,500,000 tons per annum before it would begin to compete with Hawaiian sugar. Mr. James T. Taylor, M. Am. Soc. C. E., and Chief Engineer of the Pecos Irrigation & Improvement Co., of New Mexico, writes that to produce in this country the 84% of sugar now annually imported from foreign countries, other than Hawaii, would utilize the beet production of 1,650,000 acres, at an average of 10 tons of beets per acre. At $4 per ton, the average price now paid for beets, this would represent $66,000,000 annually expended among our own producers.

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THE MOST SERIOUS RAILWAY ACCIDENT of the week occurred on April 6, on the Naugatuck Division of the New York, New Haven & Hartford R. R., about two miles above Thomaston, Conn. About 30 workmen were in the caboose attached to the rear of a wrecking train. One of the cars jumped the track while crossing the West Branch bridge, and was followed by the caboose, which crashed through the side of the bridge, killing three men and seriously injuring two.

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THE EXPLOSION OF A CAR LOAD OF DYNAMITE on April 7 killed three trainmen, wrecked a bridge and completely destroyed 10 freight cars. The accident occurred on the Montana Central Ry., at a place called Dry Forks, about 60 miles from Great Falls, Mont., and is supposed to have resulted from the jar caused by the dynamite car running off the track.

AN AVALANCHE ON THE DYEA TRAIL, Alaska, occurred about April 3, and, according to press reports, between 50 and 100 persons were killed. There were several small slides, and many persons were endeavoring to leave the vicinity when the large slide occurred, covering the trail for several hundred yards to a depth of 50 ft. It is estimated that 10,000 tons of outfits are buried under the snow and ice.

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THE BURSTING OF ONE OF THE LARGE GUNS at Morro Castle, Havana, is reported to have occurred on April 7 while target practice was in progress. It is stated that seven men were killed.

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THE NEW YORK GRADE CROSSING ACT OF 1897 will be carried into effect by an appropriation of $100,000 for the coming year,granted to the Railway Commission. Under the law the commission is authorized to expend $10,000 of this amount for a superintendent of bureau and other clerical assistance. This appropriation practically makes $400,000 available this year, as the state only pays one-fourth of the cost of all changes. At present there are no applications for grade crossing work before the commission; but owing to the uncertainty of the passage of the appropriations, little has yet been done by the commission in organizing the new bureau.

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RAILWAY MOTOR-CARS are being built by the Nord Railway, of France. Two types are to be constructed; one operated by steam, on the Serpollet system, and the other fitted with storage batteries and electric motors. The first type is intended for the postal service and will carry no passengers; and will enable the company to deliver mail at times when a regular train would be practically useless. But they are designed also to haul one or two light carriages for passengers should the demand arise. The second, or electric type, is intended exclusively for passengers; to be employed on temporary service at seaside resorts, in the season; for a permanent secondary service on the regular lines in or near large cities; and for light service on special feeding lines, or to run between trains on more important lines. These motor-cars are described at length in the "Revue Generale des Chemins de Fer" for March, 1898. In an experimental trip, with the Serpollet system, with a motor-car, one passenger and one baggage car, weighing in all 36.25 metric tons, an average speed of about 27 miles per hour was maintained for a two-hour trip. The consumption of briquette fuel and water per mile was 91 lbs. briquette fuel, and 4.3 gallons of water. The cost of the electric operation is not stated.

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A PATTON MOTOR CAR, built by the Patton Motor Co., of Chicago, for a street railway at Cedar Rapids, made its trip to the latter city under its own power. The run of 279 miles, over the Chicago Great Western Railway, was made in 16 hours, with a consumption of 58 gallons of gasoline. The car is operated by a gas engine directly connected to a dynamo, surplus current being stored by a set of battery cells, as described recently in our columns. Some of these cars are now being built for use at Chattanooga, Tenn.

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JAPANESE RAILWAY PROGRESS, says the "Japan Times," has been phenomenal. The first 18 miles of railway, between Tokyo and Yokohama, was built in 1872. Since that date the system has extended at an average rate of about 100 miles per year, and the total mileage was 2,446 miles on March 30, 1897. But in the last year 530 miles was added, making 3,000 miles in round numbers. The progress is due both to government and private enterprise.

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MUNICIPAL OWNERSHIP OF ELECTRIC LIGHT and power is in operation in the following cities of Germany, which own and manage the works: Bremen, Barmen, Cassel, Darmstadt, Dusseldorf, Elberfeld, Hanover, Cologne, Konigsberg, Lubeck and Pforsheim. Except Hanover, all these cities also own the gas works. Aix la Chapelle, Chemnitz, Frankfort, Strasburg and Stuttgart have all built their own electric works, but lease them for operating to private corporations; and with the exception of Chemnitz the gas works are also managed by private companies. In the following cities private corporations have built electric works, with the understanding that the cities can purchase them under certain conditions: Altoona, Dessau, Gera, Hagen, Heilbronn, Leipsic, Mulhausen, Stettin and Zwichau. The gas works are owned by private companies in Dessau, Hagen, Mulhausen and Zwichau.

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THE CENTRAL ELECTRIC LIGHTING STATIONS in the United States, according to the "American Electrical Directory," now number 2,594. Of this number 2,261 are owned and operated by private corporations, firms and individuals, while 333 are municipal plants. The former represent an investment of $229,938,605, and include 264,428 arc lamps, and 7,234,134 incandescent lamps, requiring 970,481 HP. of engines. The latter include 26,087 arc lamps, 371,440 incandescent lamps, and require 67,740 engine HP. for operation.

HOLLOW TILE FIREPROOFING IN THE PARK ROW SYNDICATE BUILDING.

The persistent opposition of the Board of Examiners of New York city to the use of concrete fireproof floor systems in office and mercantile buildings of the best class has been pretty fully discussed in past issues of Engineering News. Among the buildings concerning which this contest between the manufacturers of concrete floor systems and the Board of Examiners has been the fiercest is the 30-story Park Row Syndicate Building, now being erected at the corner of Park Row and Ann St., opposite the New York Post-Office, and within a stone's throw of the offices of Engineering News. The history of this dispute has been given from time to time in our columns, but a brief review of it will aid in making clear to the reader the full significance of the defective work illustrated in the accompanying cuts, which are reproduced from photographs recently taken in the building itself.

The architect's specifications for the Park Row Syndicate Building called for either the Roebling concrete floor (Eng. News, July 18, 1895), or a hollow tile floor. The first-named was preferred, owing to its being less costly (we understand the difference in price amounted to $20,000 on this building), and also some 30% lighter than tile, thus reducing the foundation loads about 4,500 tons, and considerably lightening the column loads. In designing the steel work the beam spacing was made only 5 ft., and all the suggestions of the Department of Buildings respecting the design of the ironwork to be used with the Roebling floor were carried out. Notwithstanding all this, the Board of Examiners successively denied three separate petitions filed for the approval of this construction, and absolutely refused to give any reason for its action. Finally a mandamus was obtained from the courts, compelling the Superintendent of Buildings to pass upon the question whether the concrete floor might be used. This he did in December, 1897, approving the Roebling system, but by that time hollow tile had already been placed in about half of the floors, that material being finally adopted to avoid delaying the construction of the building.

The views published herewith show the nature of these hollow tile floors, which the Board of Examiners preferred and which the Department of Buildings have passed as complying with the building laws. Taking these views up separately, Fig. 1 shows an arch with the key out of center, and in which some of the rings are discontinuous; one key and several blocks are broken; the ring-blocks are not on line with the skewbacks; the steel beam is only partially protected; and various joints are open and uncemented. There are plenty of other arches in the building like this one. Fig. 2 shows on the left side a broken skewback and irregular, eccentric key blocks. On the right hand side one skewback is broken and both sets of skewbacks are so much out of line with the rings that the ribs do not stand opposite ribs; some of the blocks are broken and some of the joints are open and uncemented. Fig. 3 shows naked main-girders; broken and discontinuous keystones; unsymmetrical rings, and skewbacks and ribs not opposite each other, while two keystones are not down to their proper level by at least 2 ins. Fig. 4 is especially bad in its defective blocks; use of spalls to fill up gaps, and a skewback set for "side construction."

These defects are chargeable both to the poor workmanship and to the use of imperfect material. Summarized briefly, the characteristic ones are the exposed portions of the steel work, the use of broken tile, eccentricity of keystones and carelessness in opposing rib to rib in the same arch ring, failure to cement joints properly, and generally poor workmanship. In other words, the defects are chargeable to the use of injured material and to the method of handling the material rather than to the nature of the arch material itself; and as many of these faults could be corrected by a more careful supervision of the workmen and a closer inspection and more careful handling of the tiles themselves, the makers of tiles are quite as much interested in better work as the owners of the buildings should be. The question now arises, why is work of this character not objected to by the Department of Buildings of New York? The law certainly contemplates and demands a different class of workmanship in these hollow-tile arches. In order that our readers may judge of the truth of this statement for themselves we quote Section 3 of the law, as published by the Department of Buildings:

> 3. All brick or stone arches placed between iron or steel floor beams shall be at least 4 ins. thick and have a rise of at least 1¼ ins. to each foot of span between the beams. Arches of over 5 ft. span shall be properly increased in thickness, as required by the Superintendent of Buildings, or the space between the beams may be filled in with sectional hollow brick or hard-burnt clay, porous terra cotta or some equally good fireproof material, having a depth of not less than 1¼ ins. to each foot of span, a variable distance being allowed of not over 6 ins. in the span between the beams. The said brick arches shall be laid to a line on the centers, with close joints, and the bricks shall be well wet, and the joints filled with cement mortar, in proportions of not more

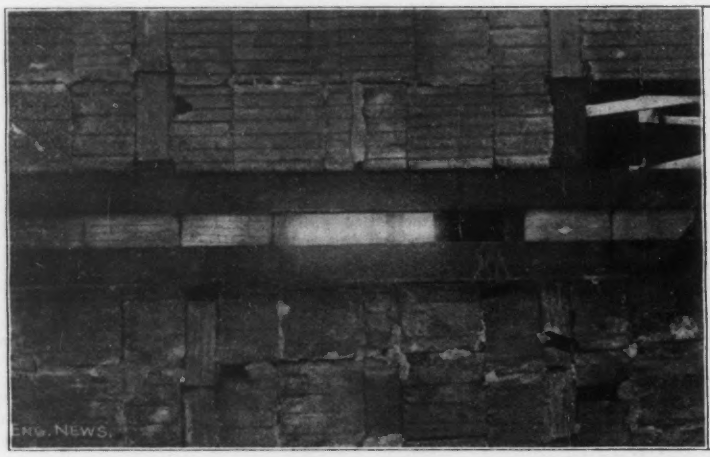

FIG. 1.—SHOWING BROKEN TILES, ECCENTRIC KEYS, DISCONTINUOUS RINGS AND OPEN JOINTS.

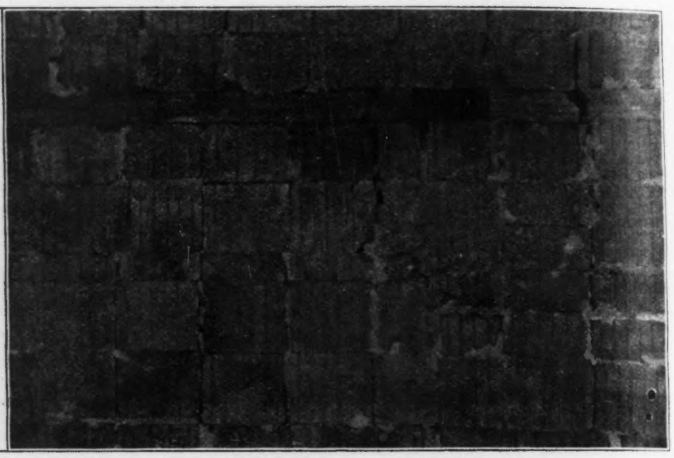

FIG. 2.—SHOWING BROKEN SKEWBACK, IRREGULAR AND ECCENTRIC KEYS, DISCONTINUOUS ARCH RINGS, BROKEN FLANGE TILE AND OPEN JOINTS.

FIG. 3.—SHOWING BADLY BROKEN TILE, DISCONTINUOUS RINGS, ECCENTRIC KEYS, HOLES FILLED WITH SPALLS, ETC.

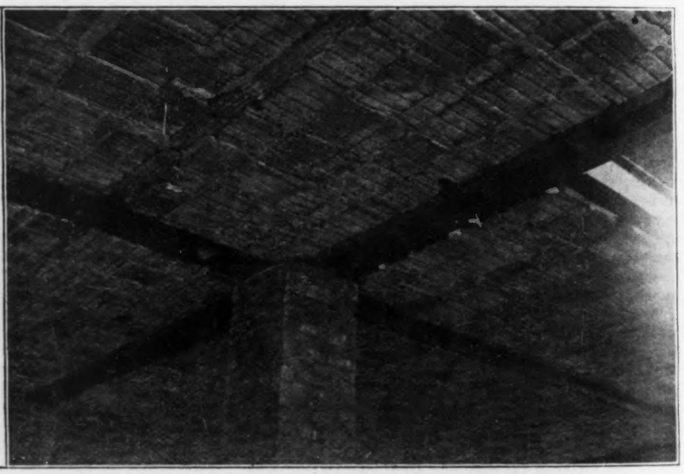

FIG. 4. SHOWING ABSENCE OF KEY, TWO KEYS NOT DOWN TO GENERAL LEVEL, SKEWBACKS DROPPED BELOW GENERAL LEVEL, BROKEN TILE, ETC.

VIEWS SHOWING BOTTOMS OF POROUS TERRA COTTA, "END CONSTRUCTION," FIREPROOF FLOORS IN THE PARK ROW SYNDICATE BUILDING, NEW YORK.

than two of sand to one of cement, by measure. The arches shall be well grouted and pinned or chinked with slate and keyed. The bottom flanges of all wrought-iron or rolled steel floor beams, and all exposed portions of such beams below the abutments of the floor arches shall be entirely incased with hard-burnt clay or porous terra cotta; or with wire metal lath properly secured, and plastered on the under side. The exposed sides and bottom plates or flanges of wrought iron or rolled steel girders supporting iron, steel or wooden floor beams, or supporting floor arches or floors, shall be entirely incased in the same manner.

Crude as this section of the building law is, in the light of present knowledge concerning fireproof floor construction, it does not in any way contemplate or countenance such defective work as is shown by the illustrations. It is perhaps but fair to assume, however, that some of these defects will be remedied in part at least. The exposed beam flanges may yet be covered with flange tile or protected by partition walls, besides the plastering which will of course cover them ultimately, but the structural weaknesses resulting from broken tile, keys out of center, and discontinuous arch rings, cannot be remedied except by reconstruction.

From the views and the section of the building law quoted above the fact is very clearly brought out that owing to inefficient inspection tile floor arches of even the best design may be erected in actual construction in a very different manner from that which their design contemplates. This fact is worth emphasizing here, for the reason that one of the leading arguments made by the advocates of clay tile floor systems against concrete floor arches of all kinds is that inferior material can so easily be used and that the strength of the construction depends so largely upon the manner in which the material is put into place. To the answer that proper engineeering supervision and inspection can easily prevent this, the reply of the tile men has been that the nature of their material and the rib construction of the usual flat arch made its perfect installation necessary and ensured sound floor arches even in the absence of inspection. How little basis there is for any such claim, the views which are published here show clearly.

A NEW PLANT FOR THE MANUFACTURE OF CALCIUM CARBIDE.

By John C. Temple.

(With two-page plate.)

The latest works for the manufacture of calcium carbide, from which the new illuminant acetylene is made, are those of the Willson Aluminum Co., located on the James River at Holcomb Rock, Virginia, twelve miles above Lynchburg.

Readers of Engineering News will recall that calcium carbide was first produced on a commercial scale at the works of the Willson Aluminum Co., at Spray, N. C., the discovery being made while making metallurgical experiments in the electric furnace. The works at Spray were destroyed by fire in the spring of 1896, and while they were partly rebuilt, it was deemed advisable, owing to the limited amount of power that could be commanded at Spray, to secure a water power located more conveniently to coke and lime and of a size commensurate with the possibilities of future development as well as affording better transportation facilities. Of all the sites examined, those on the line of the old James River and Kanawha Canal, now owned by the Chesapeake & Ohio Ry. Co., but abandoned for purposes of navigation, were considered to best meet the requirements.

This canal, built by the state of Virginia in the early '50's, was completed and opened for navigation as far as Buchanan, 198 miles from Richmond; although there may still be seen the ruins of several locks between Buchanan and Clifton Forge, which were in whole or in part completed in advance of the canal.

For a considerable part of the distance to Buchanan, navigation was maintained by slack water pools on James River, the dams varying in height from 8 to 22 ft. Some of these dams were splendid masonry structures, while others, as also some of the locks, were built either entirely of timber or partly of timber and partly of rubble masonry with wood coping.

The dam known as "Pedlar" from the Pedlar River, about 200 yds. above it, together with two locks and a stretch of 2,700 ft. of canal between them were the best structures along the line of the canal, and it was decided to locate the plant at this point, using the canal for a head race and placing the power house at the lower lock, where a fall of 18.75 ft. could be obtained. Messrs. Locher & Co. had for some years operated cement works at the lower locks, using vertical wheels under about 14 ft. head. This location was known as "Holcomb Rock Switch."

The dam has a length of 457.5 ft. on the crest, a height of 15 ft. above low water, and is of cut granite face with rubble backing. The coping has a width of 6 ft. and a slope up stream of 0.05 ft. per foot. The flat slope of the coping, together with its having been rather insecurely anchored to the masonry below, caused a part of the coping to be washed off during one of the heavy freshets for which the James is noted, and as no repairs were made, successive floods enlarged the breaks until they reached the proportions shown in Fig. 1. The break through which the water is shown to be flowing is 5.7 ft. deep and 107 ft. long and included, besides the coping, two courses of masonry. The other breaks were each 2.8 ft. deep and 67 and 140 ft. long, respectively.

In the fall of 1896, before the writer took charge of the work, efforts were made to restore the damaged parts with masonry, but a succession of freshets carried away what had been put on before an opportunity was had to securely anchor it. Nothing further was done till the following fall, when, owing to the lateness of the season, it was decided to replace the damaged parts with timber and fill the pockets with concrete, sheathing over with 5-in. oak, the latter being given a slope of 2 ins. to the foot. Fig. 2 shows the design of the timber work and method of anchoring it to the old masonry. There were used in the construction 45 M. ft., B. M., of oak timber and 260 cu. yds. of concrete. The concrete was composed of 1 part James River cement, 2 of sharp sand and 5 of broken stone and thoroughly rammed in 8-in. layers.

The restored dam backs the water to the foot of Coleman Dam, a distance of two miles. The average width of the river between the two dams during the summer flow is approximately 400 ft., giving a pondage area of about 100 acres.

The guard lock and the guard and wing walls are of cut granite and rise to a height of 18 ft. above the crest of the dam. After a flood in 1870 an additional guard wall of rubble masonry was built across the head of the canal between the lock and the bluff to protect the canal from flood water.

The gates for controlling the canal level are placed in the upper end of the lock in the space occupied by the former lock gates. Fig. 3 shows the design of the framing for carrying the gates, the lower sills being anchored to the rock bottom and the side frames fitted into the gate recesses in the lock wall. The combined area of the gate opening below the crest of the dam is 195 sq. ft., or sufficient for 1,200 HP. under 18 ft. head, with a velocity of 3 ft. per second.

The drainage area of James River above Pedlar Dam is 3,475 square miles, according to the 10th Census Report on Water Powers of the United States. Assuming the flow of the river in ordinary dry seasons to be equivalent to ⅓ cu. ft. per second per square mile, there are available 1,158 cu. ft. per second. It is the intention to put in additional gates in the line of the rubble guard wall, giving a total area of 570 sq. ft., or sufficient to pass 1,700 cu. ft. at 3 ft. per second. Gagings show that this quantity of water may be relied upon eight months of the year. Under 18 ft. head this would produce 2,800 HP., using wheels of 80% efficiency.

Canal.

The canal, following the bluff and the river on the right, is separated from the river by an earthen embankment, and in its whole length makes a turn of 90°, the lower lock being almost exactly parallel to the dam.

The embankment is protected on the river face by a hand-laid stone pavement, but prior to the removal of the dam at Bald Eagle, about 2 miles below Holcomb Rock, the embankment was subject to overflow during extremely high water and was often washed out in places; repairs were made by taking material from the side next to the bluff and these repeated borrowings from one side have increased the width of the canal to over 100 ft., and this, with its depth of 8 ft. below the crest of the dam, gives an ample cross section to carry the maximum quantity of water required. The embankment as lately repaired has a top width of 8 ft., an inner slope of 2 to 1, and an average outer slope of 1½ to 1. The top of the bank at the lower end is 4 ft. above the canal level and rises with a grade of 1 in 400 for a distance of 1,700 ft. and is level for the remaining distance, to the lock, this profile conforming closely to that of the river surface from the dam to the power house.

The power house occupies the site of the lower lock and is 126×27 ft. in the clear. Fig. 4 is an outline plan and Fig. 5 a cross section of the building. The elevation of the crest of the dam relative to the elevations shown on the cross section is 118.00. Fig. 6 is from a photograph of the side of the building on which the head gates are located, taken during construction. Fig. 7 is a view of the completed building taken from the opposite side and showing the openings for the escape of the water from the wheels.

The original lock walls had a thickness of 12 ft. at the base and 3 ft. at the top, the width between walls being 14 ft. In order to accommodate the wheels and also to obtain an outlet for the tail water, the wall next to the river was taken down to a depth of 4.5 ft. below low water level and rebuilt with seven openings 11 ft. wide in the clear, the piers supporting the arches and wall above being 4.5 ft. by 5 ft. in section. The arches are four rings of brick laid in rowlock bond. This wall is carried up in stone to elevation 115.50; above this an 18-in. brick wall with 4-in. pilasters is carried up to the bottom of the main floor beams, the ends of these beams being supported on the brick work by a cast iron bearing plate 12×16 ins. and 1½ ins. thick. An additional opening for the discharge of the tail water was made at the lower end of the building, the wall above resting on an arch of 15 ft. span. (See Fig. 7.) A similar arch at the upper end permits the water from the canal waste gates to reach the tail race The lock wall on the opposite side was taken down to receive the "thimbles" (Fig. 8), which are 9.5 ft. diameter, and submerged 2 ft. below the canal level; at the same time the gate frames and the lower I-beams which support the wheel flumes were placed in position. The wall was rebuilt with an uniform thickness of 8 ft. to a height of 18 ins. above the canal level, then 3.5 ft. thick to the bottom of the main floor beams. The main floor beams are 15-in. I-beams, weighing 60 lbs. per foot, spaced 16 ft., c. to c., and project over the bulkhead wall to form a support to the platform carrying the flume gate hoists. Each thimble or flume is provided with two gates and a central timber support common to two gates is held in place by two 4 × ⅜-in. steel angles bent U shape and riveted to the top and bottom of the thimble, as shown in Fig. 8.

The walls of the power house are of brick and are 13 ins. thick with 4-in. pilasters under the roof trusses. The head room under the trusses is 13 ft. 4 ins. The roof trusses, eight in number, are of steel, spaced 14 ft. 1½ ins. c. to c. and are designed to carry a roof load of 60 lbs. per sq. ft. and an additional load of 4,000 lbs. at any point on the lower chord. Suspended from the lower chord and over the center line of the generators is a 9-in. I-beam (Fig. 5) carrying a geared traveler and hoist.

Between the bulkhead and the railroad a basin forming a continuation of the canal was excavated the full length of the power house, 50 ft. in width, to a depth of 13 ft. at the bulkhead and 6 ft. deep at the opposite side. Retaining walls were built at the end and side, which form also the foundation for the furnace buildings. At the lower end a wooden trestle bridge, 12 ft. wide, gives access to the power house.

Turbines.

The power house will contain six pairs 39-in. and one pair of 27-in. turbines and a single 27-in. turbine. All will be of the McCormick pattern and mounted on horizontal shafts. Each pair of 39-in. wheel develops 402 HP. under 18 ft. head at a speed of 144 revolutions per minute. The pair of 27-in. wheels develops 202 HP. and the single 27-in. 101 HP. Each pair of turbines is mounted on a cast-iron central draft chest which is supported by a cast-iron cradle to which the draft tube is riveted. The wheels and draft chests are contained in a steel outer case of 5-16-in. plate with a cast-iron head plate having a removable cover and stuffing box. The cases are really a continuation of the thimbles and are of the same diameter, 9.5 ft. The wheel cases are spaced 16 ft. c. to c. and supported by a pair of 15-in. beams spanning the wheel pit. For a pair of 39-in. wheels the cradle supporting the draft chest is carried on a pair of 12-in. I-beams resting on top of the 15-in. beams. The cradle for the 27-in. wheels is carried in similar manner on a pair of 10-in. beams. The shafts of the 39-in. wheels are 6.5 ins. diameter, hammered steel, bossed to 8 ins. to receive the rope wheels, which are 114 ins. diameter, grooved for 20 1¼-in. ropes. The weight of the rope wheel and shaft is supported independently of the wheel case head by a pair of heavy cast-iron yokes resting on I-beams framed into the main beams, the journal boxes being rigid and self oiling. The pair of 27-in. wheels are of the same general design, except that the driving pulley is 80 ins. diameter and grooved for 15 1-in. ropes. From each rope wheel, the ropes lead directly to the generator pulleys on the floor above, the line between centers forming an angle of about 30° from the vertical.

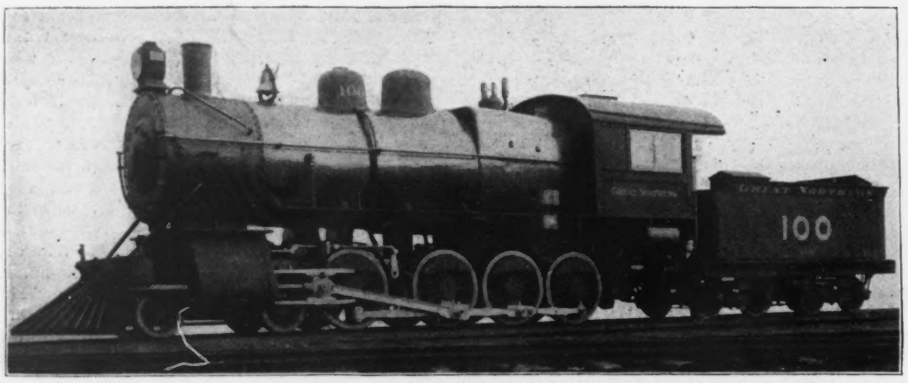

FIG. 1.—TWELVE-WHEEL LOCOMOTIVE OF 106 TONS WEIGHT. GREAT NORTHERN RY.
The Brooks Locomotive Works, Dunkirk, N. Y., Builders.

The alternate beams carrying the wheel cases are supported in the center by a B_2 Phoenix column ¼-in. thick, while the other beams are supported on a bracket formed in the filler plate of a B_2 column ⅜-in. thick. These latter columns extend to the main floor beams above and are in line with the centers of the generators.

The single 27-in. wheel is contained in an iron outer case 6.5 ft. in diameter, riveted to the side of the case containing the pair of 27-in. wheels. This wheel discharges into a quarter-turn draft tube and the power is transmitted by a rope wheel 54 ins. in diameter, grooved for five 1½-in. ropes. This wheel drives the crushing plant.

The pair of 27-in. wheels drives a 150 K-W. Eddy direct current generator delivering current at 110 volts pressure. The current from this machine is used in the furnaces for making metallurgical experiments, for which there is an entirely separate plant.

Each pair of 39-in. wheels will drive a 300 K-W. alternating current dynamo delivering current at 100 volts to the electric furnaces. The dynamos are supported on four 15-in. steel I-beams, one under each slide, framed into the main floor beams. The columns under the main floor beams were introduced to prevent an excessive vibration due to the high speed of the generators.

In addition to the four 15-in. beams under the generators the floor is supported by 4 × 15-in. yellow pine joists spaced 3 ft. c. to c., resting on the lower flanges of the main floor beams. The flooring consists of a layer of 2½ × 12-in. pine, covered with 1¼ × 3-in. matched pine.

In addition to the above wheels there is a 25-in. "Victor" driving the crushing machinery for the experimental department and a 12-in. "Hercules" driving a centrifugal pump supplying water to the laboratory. These wheels are on vertical shafts and placed in a wooden flume under the laboratory building, which adjoins the experimental furnace room, water being taken from the canal through a 30-in. steel pipe.

The output of calcium carbide, using the 6 pairs of wheels, will be 10 tons per day of 24 hours, which allows 240 HP. per ton per day.

The contractors for the masonry were Messrs. Lane Bros. & Co., Scottsville, Va.; for steel work, the Phoenix Iron Company, Phoenixville, Pa., and for turbines, the S. Morgan Smith Co., York, Pa.

106-TON TWELVE-WHEEL LOCOMOTIVE; GREAT NORTHERN RAILWAY.

Within the past few years there has been a marked movement in the increase of the weight of locomotives, especially for freight service, and a number of exceptionally heavy engines have been described and illustrated in our columns. It would seem, however, as though the climax had been reached (at any rate for economical operation under present conditions of track and roadway) in the enormous locomotive for the Great Northern Ry., which we illustrate herewith. This engine is of the twelve-wheel type, and weighs 212,750 lbs., with 172,000 lbs. on a driving wheel base of 15 ft. 10 ins. The maximum wheel load is 22,500 lbs. on each of the main driving wheels, and the effect of such a concentrated load on the rails and rail joints, and upon the track generally, may readily be imagined, especially when it is remembered that there are three other wheel loads almost as great. This is not, however, the heaviest wheel load on record, as the mogul engines of the Delaware, Susquehanna & Schuylkill Ry. have a load of 24,500 lbs. on each of the main driving wheels, and the single-driver express engines of the Philadelphia & Reading R. R. have 24,000 lbs. on each driving wheel. Neither is the total weight nor the total adhesive weight of the Great Northern engine the highest on record, for the Johnstone double-boiler engines of the Mexican Central Ry. have a weight of 230,000 lbs., with 200,000 lbs. on two separate driving wheel bases. These engines, however, are of a special type (Eng. News, March 26 and April 9, 1892), and the Great Northern Ry. engine undoubtedly holds the record of weight for locomotives of the ordinary style of construction. The following table shows a comparison of weights of a few engines of exceptional size:

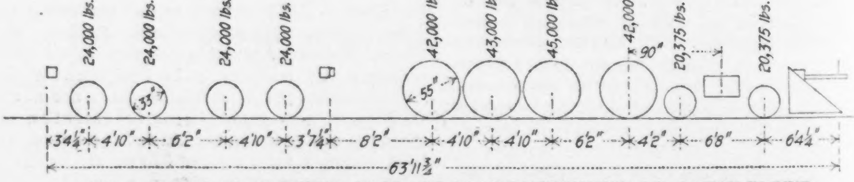

FIG. 2.—DIAGRAM OF WHEEL-BASE AND LOAD DISTRIBUTION OF 106-TON ENGINE.

Railway.	Type.	Total weight, lbs.	W't on drivrs, lbs.	No. of drivers.	Driv'g wheel-base, ft.	ins.
Great Northern ...	12-wheel.	212,750	172,000	8	15	10
Indian State	Double-end tank.	206,276	155,932	10	16	0
St. Clair Tunnel...	Tank.	195,000	195,000	10	18	3
Mexican Central ..	Double-end	193,450	145,200	8	13	0
Erie	Decapod.	192,000	170,000	10	18	10
Northern Pacific ..	12-wheel.	186,000	150,000	8	15	6
Del., Sus. & S.....	Mogul.	151,000	135,900	6	14	0

This engine, however, is remarkable not only for its weight, but for its dimensions. The boiler is 6 ft. 6 ins. diameter in the barrel, and carries a working pressure of 210 lbs. per sq. in., for which reason the cylinders are given the great length of stroke of 34 ins., in order to allow for sufficient expansion of steam delivered at such an exceptionally high initial pressure.

This is not the largest size of cylinders ever employed in locomotive work, as the noted "El Gobernador," built by Mr. A. J. Stevens, of the Central Pacific Ry., in 1883, had cylinders 21 × 36 ins. This engine had ten driving wheels and four truck wheels, and weighed 154,000 lbs., with 130,000 lbs. on the drivers. The Great Northern Ry. engine, therefore, ranks second in size of cylinders, and next to it come the ten-wheel engines of the Southern Pacific Ry., with cylinders 19 × 30 ins. and 18 × 30 ins. (Eng. News, Dec. 24, 1896). These latter engines have the Stevens duplex valves.

The engine is one of two built for the Montana Central line of the Great Northern Ry. by the Brooks Locomotive Works, of Dunkirk, N. Y. The general plans were prepared by Mr. J. O. Pattee, Superintendent of Motive Power of the G. N. Ry. The general design and appearance of the engines are shown in Fig. 1, while Fig. 2 is a wheel load diagram. We are informed by Mr. J. F. Stevens, Chief Engineer of the Great Northern Ry., that the Montana Central line has maximum grades of 2.2%, the length of the longest maximum grade being 11 miles. The sharpest curves are of 10°, and about 50% of the line is composed of curves. The track is laid with 75-lb. rails on 16 ties per rail length, the ballast being generally rock. Some 80-lb. and 100-lb. rails are to be laid this season. The engines haul train loads of 650 tons over the heavy grades, and their work has been so satisfactory that eight more have been ordered.

The boiler is of the Belpaire-Player type, having a throat sheet connection between the barrel and the firebox, and the firebox is entirely above the frames. Bituminous coal will be used for fuel. The dome is mounted on the throat sheet and has no fitting attached to it, the whistles and safety valves being mounted on a separate fitting. The smokebox has Mr. Snowden Bell's spark arresting device. Asbestos lagging is used for the boiler, cylinders and dome.

One of the most interesting features about the engine is the use of piston valves, and Fig. 4 shows the details of the valve. The cylinder, steam chest and half-saddle are cast in one piece as shown in Fig. 4, while Fig. 5 shows the details of construction of the cylinder and steam chest. The piston valve has a cylindrical body 4½ ins. diameter, with two piston heads 14½ ins. diameter over the packing rings. Its length over all is 28¼ ins. The piston heads slide in two bushings inserted in the steam chest, and a tail rod in the front head works in a bushed sleeve in the front cover of the steam chest, but does not pass through the cover. The valve rod is bent at each end so that the rod will pass over the top of the front driving wheel. The piston has a hollow steel piston rod 4¼ ins. diameter, and a tail-rod 3¼ ins. diameter, the latter extending through the front cylinder head and being enclosed by a length of 4½-in. wrought iron pipe. The pistons, cylinder heads, crossheads and guide-yoke ends are of cast steel, and the cylinder head casings are of pressed steel. The piston rods, crosshead pins and crank pins are of open-hearth steel, and are all hollow, as are the forged iron rockers. The connecting rods (of I-section), and the fishbellied coupling rods (of rectangular section) are all of forged iron. The driving and truck wheels have cast steel centers, with Krupp tires 3½ ins. thick for the former and 3⅛ ins. thick for the latter. The tires of the first and third pairs of driving wheels have no flanges and are 6½ ins. wide.

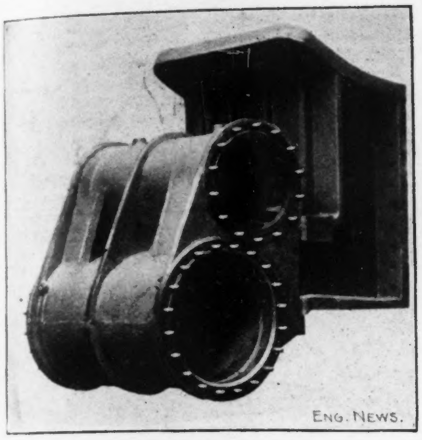

Fig. 3.—View of Cylinder Casting.

The following is a list of dimensions of these great locomotives:

Dimensions of Twelve-Wheel Locomotive; Great Northern Ry.

Running Gear:	
Driving wheels (8), diameter	4 ft. 7 ins.
Truck wheels (4), "	2 " 6 "
Tender wheels (8), "	2 " 9 "
Driving wheel centers	Cast steel
Truck and tender wheels	Steel tires
Engine truck	Rigid center
Journals, driving axles	9 × 11 "
Wheelbase.—Driving	15 ft. 10 "
Truck	6 " 8 "
Total engine	26 " 8 "
Tender	15 " 10 "
Engine and tender	54 " 3¼"
Engine truck-pin to cen. lead'g driv'g wheel.	7 " 6 "
Wheels having blind tires	2d and 3d pairs
Weight in Working Order:	
On driving wheels	172,000 lbs.
On truck wheels	40,750 "
Engine, total	212,750 "
Tender, empty	37,050 "
" loaded	96,000 "
Cylinders.—Number	Two
Diameter and stroke	21 × 34 ins.
Crosshead and guides	Alligator pattern
Connecting rod, length between centers	8 ft. 10 ins.
Valve Gear	Link motion, piston valves
Ports, steam ...1¾ × 18 ins.; Ports, exhaust	9 × 50 ins.
Bridges, width	6¾ "
Slide valves, maximum travel	6½ "
" " inside clearance	⅛ in.
" " outside lap	1⅛ ins.
" " lead (full forward gear)	None
Boiler.—Type	Belpaire-Player
Diam. barrel, inside smallest ring	6 ft. 6 ins.
Dome, diameter	2 " 6 "
Thickness, barrel plates	⅞ and 15-16-in.
" smokebox tube-plate	¾ "
Horizontal seams	Sextuple riveted
Circumferential seams	Triple "
Lap or butt joints?	Lap
Height from rail to center line	9 ft. 5 ins.
Length of smokebox (including extension)	5 " 7 "
Spark arresting device	Bell's improved
Injectors (2)	New Nathan and Monitor
Working steam pressure	210 lbs.
Firebox.—Type	Belpaire, above frames
Length inside...10 ft. 4 ins.; width inside	3 ft. 4½ ins.
Depth at front... 7 " 2½" depth at back	6 " 7 "
Thickness, side plate..⅝ in.; back plate	⅜ in.
" crown plate	7-16 "
" tube plate	⅝ "
Kind of crown stays	Belpaire
Is fire-brick arch used?	No
Water spaces:	
Width at front—bottom, 4 ins.; top	4 ins.
" back—bottom, 4 ins.; top	5 "
" sides—bottom, 4 ins.; top	7 "
Tubes......Charcoal iron; Number	376
Diameter, outside	2¼ ins.
Length over tube plates	13 ft. 10⅜ "
Heating Surface and Grate Area:	
Heating surface, tubes (interior area)	3,043 sq. ft.
" " firebox	237 " "
" " total	3,280 " "
Grate area	34 " "
Ratio of total heating surface to grate area	96 to 1
Ratio of interior tube area to firebox heat. surf.	12 to 1
Miscellaneous:	
Exhaust nozzle (single), diameter	5⅛, 5⅜, 5⅝ ins.
Exhaust nozzle, distance below center line boiler	6 "
Smokestack, diameter at top	1 ft. 6 "
" diameter at base	1 " 3⅞"
" height above smokebox	2 " 8½"
" height of top above rail	15 " 6 "
Capacity of tender tank	4,670 gallons
" coal space	10 tons

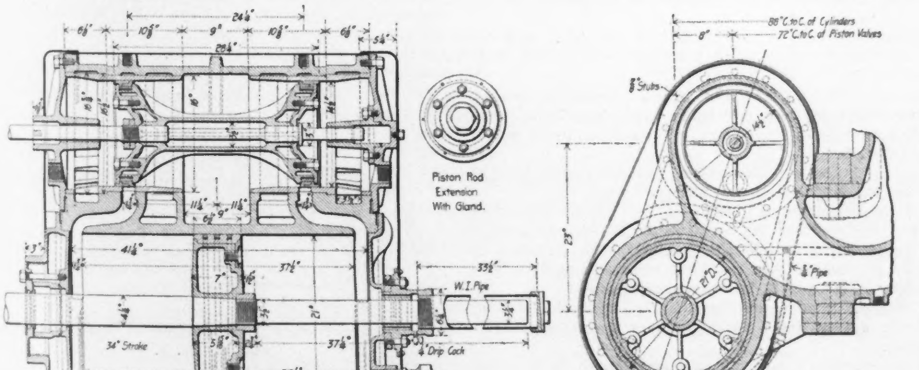

FIG. 4.—DETAILS OF CYLINDER, STEAM CHEST AND PISTON VALVE.

* * *

MECHANICAL TUNNEL VENTILATION FOR LONDON UNDERGROUND RAILWAYS.

On Feb. 2, 1897, the London Board of Trade appointed a committee to inquire into the existing system of ventilating the tunnels of the Metropolitan Railway, and to report as to what steps could be taken to add to the efficiency of this system. Major F. A. Marindin, R. E., was the chairman of this committee, and its other members were Earl Russell, Sir Douglas Galton, Sir Charles Scotter and Dr. John Scott Haldane. The conclusions of this committee have been published, together with the evidence setting forth the case for mechanical ventilation.

The first report to Major Marindin is made by James Keith, Assoc. M. Inst. C. E., who was the special expert selected in 1896 by the directors of the Metropolitan District Railway to advise them in regard to the ventilation of the underground tunnel sections. Mr. Keith has had many years experience in ventilation practice and has especially studied the problem in the London railways. As originally designed, he says the underground railway was to be operated by "hot-water locomotives," and no special provision was made for ventilation. As a matter of fact, however, these locomotives were never used, and coal or coke burning locomotives have always been employed. Ventilation was a troublesome problem from the opening of the first section in 1863, and all sorts of plans were tried. Among these were the denuding of the Portland Road Station of its domes, the removal of the side-lights at other stations and finally, in 1871-72, the formation of the so-called "blow-holes" above the tunnel. With a traffic of forty trains per hour, at times, says Mr. Keith, natural ventilation is quite impossible, and he recommends mechanical ventilation as the only solution to the problem.

The two fan installations now operated work only during certain hours in the day, and they wire-draw the air from the large tunnel section through an opening only 6½ ft. diameter, or 8 ft. in the other case. They discharge the air against considerable resistance up the comparatively small shafts, to the top of the houses, and thereby cause vibrations and give results utterly inadequate to their requirements. One set of fans only changes the tunnel air to the extent of one-third, and the other to the extent of about one-tenth of what Mr. Keith deems necessary.

Mr. Keith claims that to be efficient, mechanical ventilation must be carried on on a large scale when a heavy steam traffic has to be dealt with. He proposes to make the present openings at stations, etc., entrances for fresh air, instead of exits for foul air; and to extract the latter from about the center of any one tunnel section. As a general principle, the whole air of the tunnel must be made to travel as short a distance as possible to keep down the velocity of the air current and minimize friction. The points of extraction should have an area equal to the tunnel section, and they should be carried to the tops of adjoining houses.

The extracting fan should be large and open, revolve at a very slow speed and change the whole air in the contents of a tunnel section in 2½ minutes; or in about the time a train would travel through this section. He figures that the fresh air would flow in towards the center of the section at a rate slightly exceeding 3 miles an hour. For a special half-mile section, between Westminster Bridge and St. James Park stations, he proposes a fan 27 ft. 6 ins. in greatest diameter, and 7 ft. 6 ins. wide over all; the circular inlet opening would be 18 ft. 6 ins. diameter. This fan would discharge at the periphery, and at 40 revolutions per minute it would extract from the center of the tunnel and deliver into the open air not less than 295,000 cu. ft. of air per minute, or 17,700,000 cu. ft. per hour, at an expenditure of from 30 to 40 brake HP. A series of such fans could be run by electricity from a central station; or by steam, oil or gas engines placed within the shaft superstructure. As the discharged air would be spread over a large area above the roofs of the houses, it would be practically invisible and comparatively pure and clean. The approximate cost of one large special fan and its wrought iron framework, but exclusive of the shaft sinking and builder's work, would be about $5,000.

Mr. Keith says of the South London Electric Railway that, while it is deep and underground and cross shafts connect the two tunnels at frequent intervals between stations, he found the atmosphere in the tunnel and stations "musty, heavy and oppressive." He says that here again some positive and special appliances are needed to constantly draw off this vitiated air.

The Caledonian Railway in Glasgow is prohibited from making "blow-holes" above its tunnel, or from having open spaces. Mr. Keith says good ventilation is secured by the use of a fan 40 ft. in diameter. The traffic, however, is comparatively light. The Mersey and Lime St. tunnel in Liverpool is also ventilated in this manner, though the fans are old-fashioned and inefficient. The fan proposed by Mr. Keith is of the Sturtevant type.

From the context of this publication Mr. Wolfe Barry and Sir Benjamin Baker are opposed to mechanical ventilation, though their argument is not given place here. After a session of 14 days spent in the actual examination of witnesses, the Board of Trade committee concluded as follows: That by far the most satisfactory mode of dealing with the Metropolitan tunnels would be the adoption of electric traction; it would be practicable to ventilate the tunnels by fans between stations, but the cost would be considerable; the provision of the openings proposed in the Metropolitan Bill of 1896, would only be satisfactory were the number of openings proposed in the bill largely increased, with a corresponding increase in cost. In view of the probable adoption of electric traction in the near future the committee finally recommended, as a temporary measure, that the construction of the proposed additional street openings over the tunnel be allowed; but only upon condition that either electric traction or some satisfactory system of artificial ventilation be introduced within three years from the passage of the Act authorizing the openings.

* * *

A CHANCE FOR IDLE LABOR TO WORK OFF TAXES is proposed by the authorities of Mahoney City, Pa. About 2,300 lin. ft. of 18 in. sewer are to be built under these conditions, according to information received from Mr. M. D. Bowman, Cy. Engr.

AN AUTOMATIC FEED-DEVICE FOR GAS-PRODUCERS.*

By C. W. Bildt, Worcester, Mass.

During many years of service in the iron and steel industry I have frequently found, as have also many other engineers, that the common devices used for feeding coal into gas-producers are not what they ought to be in order to secure the best economy.

The hopper-and-cone so generally used has several serious faults. The charging is intermittent, and depends entirely upon an attendant. When the hopper is frequently emptied, it may work fairly well, but even then it suddenly discharges into the hot producers a large body of coal, which is often violently converted into gas, that rushes into the furnace, and, as the damper for the combustion-air cannot be regulated every time the producer is charged, there will be an excess of gas, which goes up the chimney unburned.

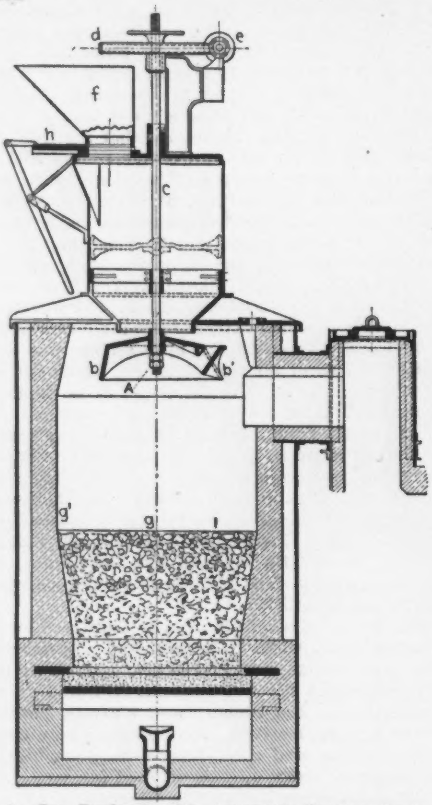

Fig. 1.—Gas Producer with Automatic Feeding Device Invented by C. W. Bildt, Worcester, Mass.

Between the chargings the quantity of gas generated decreases, and there will often be an excess of air in the furnace,which carries off the heat and causes oxidation of the metal. In either case there is a loss of fuel.

The cone will never distribute the coal evenly over the charging-surface in the producer. It will sometimes deposit more on one side than on the other, or more on the sides than in the middle, resulting in a body varying in thickness, through which the air flows where it meets the least resistance. The result of this is a poorer gas, often carrying an excess of carbonic acid, and continually varying in its chemical composition.

This defect of uneven distribution can, of course, be remedied to a certain extent by poking, but that is not a satisfactory remedy, and involves hard labor, which the attendant often shirks as much as possible.

Remembering these defects, we easily find that an ideal feed-device should possess the following features:

1. It should be continuous, steadily supplying during a certain period of time an amount of coal that will produce the amount of gas required during the same length of time.

2. It should distribute the coal uniformly over the surface in the producer, making a body of equal thickness, throughout which the air meets with an equal resistance. It should also be simple in its construction, needing very little repairs, so that it may be run by unskilled labor.

The author believes that the feed-device constructed and patented by him, and already put to long and severe tests in several places, will meet the above requirements.

It consists, as will be seen from the cuts, of a coal-holder resting upon and attached to the top of the producer, below which is placed a rotating distributing-disk, A, provided with specially constructed blades b and b', serving to distribute the coal evenly over the charging-area I. The disk A is rotated by the shaft c resting upon the top of the coal-holder, and the worm-gearing d, which in its turn is driven by cone-pulleys e, by which the speed can easily and quickly be changed to feed more or less coal, as may be required. To suit different sizes of coal, the opening between the discharging-mouth of the holder and the disk is adjusted by lifting the vertical shaft, which slides through the worm-gear. This may be done by a screw-wheel, as indicated in the drawing, or by any other suitable arrangement.

The size of the coal is immaterial so far as the charging is concerned; lumps, dust or both mixed, are equally well distributed.

The top of the rotating-disk can be made level or sloping (not exceeding the angle of friction between the disk and the coal). The speed of the disk is about one revolution in four minutes.

The holder, which can be made large enough to receive any desired quantity of coal, is filled through hopper f and sliding-damper b from any larger deposit supplied by a coal-conveyor, or by any other convenient method.

As the distributing-blades b b' are the most important part of the apparatus, I wish to explain how they are constructed. The action of the apparatus is based upon a spiral, according to which the coal sliding down the blades is distributed upon the surface below.

The spiral goes from the periphery to the center of the charging-area, and is constructed as follows: Divide the surface of the producer into any number of annular rings of equal area by drawing concentric circles. Then divide the same surface by radii forming equal angles into as many parts as there are rings, and by a line connect the points of intersection between the circles and the radii, as shown in Fig. 5.

When this spiral has been constructed of such dimensions that the distance from the center, g, of the circles to the extreme point, g,' on the curve is equal to the radius g g' of the circular charging-surface of the producer, the distributing-blades or flanges can be adjusted to the charging-disk A. As, at the same time, equally large quantities of coal pass equally large divisions on the surface of the disk, it follows that those parts of the spiral intersected by equally large angles,with their verticea directed toward the rotary shaft of the apparatus, receive equally large quantities of coal during the same period. If we now construct the distributing-curve in such way that these equal parts shall, in their motion around the axis,at any moment,cover equal surfaces of producer, the coal will naturally be evenly distributed. The parabolas which direct the coal in its discharge from the lower edge of the blade to the surface must be taken into consideration in the construction of the distributing-blades. As the blades are arranged on the drawing, the blade b distributes the coal over the surface outside of the distributing-disk A, and the blade b' discharges the coal directly under the disk A.

The apparatus can be applied to producers of any size, as it distributes the coal equally well over a large or small area.

A large producer should, therefore, be used. It is cheaper to build, takes less room, requires less labor in tending, and the loss of heat by radiation is smaller than in several producers with corresponding aggregate area.

In order to obtain the best results it is important that the producer be proportioned to the furnace which it shall supply. In practice I have found that an open-hearth furnace requires 3½ sq. ft. of grate-area per ton of capacity. For heating-furnaces 5 sq. ft. of grate-surface is allowed per ton of steel heated per hour. These dimensions depend, of course, somewhat on the material to be heated and the quality of the coal.

This feed-device is now used, and has been used for some time, at several places in Sweden, where it has given excellent results.

At the Stridsberg & Bjorck Works, Trollhattan, Sweden, one producer has been operated in connection with an open-hearth furnace for three years. The saving of coal is 15% over the old type.

At the E. Bocking Walswerken, Mulheim am Rhein, Germany, one producer runs a heating-furnace.

At the Washburn & Moen Mfg. Co. Works, Worcester, Mass., one producer has been run for the last six months in connection with a heating-furnace. The grate-area is 20 sq. ft., and the capacity of the furnace is 40 to 50 tons of 4-in. billets per 10 hours, charged cold.

The gas is of an excellent quality, steady in its flow, making a long flame which preheats the material thoroughly.

The testimonials received may be summed up in a few words: Gas of uniform and excellent quality, steady supply, increased furnace-capacity, lower coal-consumption per ton of material heated, and reduced furnace-waste, labor and repairs.

This feed-device is covered by U. S. Letters Patent No. 442,676, Dec. 16, 1890, and No. 498,229, May 30, 1893.

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*Condensed from a paper at the Atlantic City meeting of the American Institute of Mining Engineers, Feb., 1898.

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TESTS OF THE M. C. B. COUPLER.*

By Gustav Giroux.

The advantage accruing from the use of drop tests of couplers is not properly appreciated. Possibly the tests are quite severe, but this is only to provide an extra safeguard, just as the tests of wheels and axles are also more severe than the shocks which the wheels and axles will receive in service. The drop test for couplers represents more nearly the treatment which the couplers receive in service than do the drop tests for wheels and axles represent what these parts will stand in service, and such tests have been productive of good in detecting badly constructed wheels or poor material in wheels and axles. Such advantage having resulted in these two cases, the drop test will certainly give equally good results for couplers.

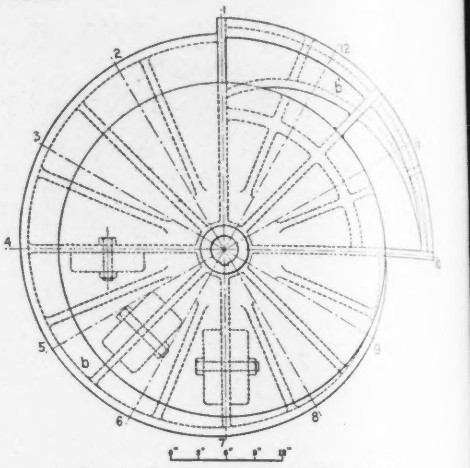

Fig. 4.—Top View of Distributing Disk.

To get comparable data, the tests must be made under exactly similar conditions, and the conditions which mostly affect the results are: quality of foundation, weight of hammer, rigidity of machine, and the means employed in holding the coupler under the drop.

The quality of foundation and weight of hammer are certainly of great importance, and apparently are given proper attention; in fact, these two factors seem to be given all the attention, as is evidenced by the fact that generally specifications for couplers read as follows: "Test couplers to be placed upon a large cast steel anvil, which rests upon a heavy stone foundation, and to be struck with a 1,640-lb. weight."

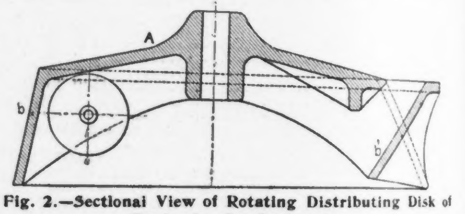

Fig. 2.—Sectional View of Rotating Distributing Disk of Feeder for Gas Producers.

No tests made with a drop weight are more severe on the foundation, and on the upper construction or body of the drop machine than tests upon couplers. This is clearly indicated by the shaky condition of the testing machine after a small number of tests have been made, unless the machine is made exceedingly strong and rigid. When a machine becomes a little shaky and the vertical supports spring at their lower ends when the test coupler receives the blow, the conditions are more favorable to the coupler than were the machine very rigid.

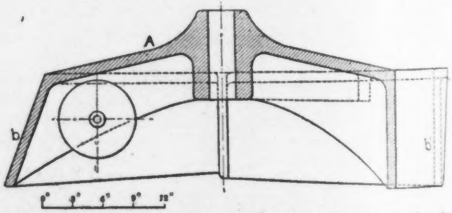

Fig. 3.—Distributing Disk, Section at Right Angles to that of Fig. 2.

The Chicago Tire & Spring Co., of Melrose Park, Ill., was the first to build a machine that met all requirements, and one on which a variety of tests, including the jerk test, could also be made with rapidity. The Chicago & Northwestern Ry. then built a similar drop, as did also Shickle, Harrison & Howard, of St. Louis. These last two drops have not the jerk test arrangement, but are similar in other respects. The bed plate used for this style of drop is a large steel casting, 6 × 6 ft., and weighing over 8,000 lbs. It rests on a stone foundation. Near each side of the bed plate are cored two square recesses to receive the legs or uprights of the machine, which, as is usual, are square timber; these timbers are, for a height of 8 or 9 ft., incased in heavy steel castings, which

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*Extracts from a paper by Mr. Gustav Giroux, presented at the March meeting of the Western Railway Club.

fit tightly into the recesses in the bed plate. Near the bed plate are two heavy steel braces, one at each side of the drop, that extend from one leg to the other, and are securely bolted together. A similar brace is at the top of these steel castings, leaving enough room between the uprights and the tie braces to set the coupler to be tested. The space between the stem of the coupler and the braces of the drop is filled in with iron blocks, which hold the coupler in a rigid position.

The means employed sometimes to hold the coupler in an upright position under the drop is to put a wooden block at each side of the stem of the coupler, then iron blocks and wedges so as to keep everything solid; others dispense with the wooden blocks and use iron blocks and wedges only. If the center line of the striking weight corresponds with the center line of support of the coupler, the kind of blocking used makes little or no difference, but because these lines do not coincide, the blocking affects materially the results of the tests. This is a point that seems to have been overlooked.

When the drop strikes the guard arm, the force of the blow will have a tendency to make the bar lean over and the bar will resist the force of the blow according to the amount of cushion it gets from the blocking used next to the stem. If wood is used the wood will afford a good cushion to the bar; this is clearly shown in tests by the way the wood is crushed. If only iron blocks are used they will not give that cushion and the tests will be more uniform and more severe, as has been proved by actual tests.

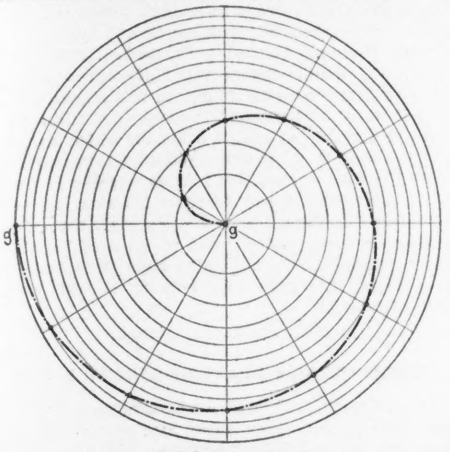


Fig. 5.--Construction of Spiral of Equally Distributed Areas

Unless these facts are brought out and made public we cannot make intelligent specifications for couplers. With a little attention, and more rigid specifications, this lack of uniformity in coupler tests can be reduced to a minimum.

I do not see why the knuckle test, as made to-day, is so commonly asked for; that is, three blows at 3 ft. and two blows at 15 ft. Before a coupler is adopted by a railway it might be good practice to make a few of these tests to ascertain if the construction of the head, or the back, or side wall of the head against which the tail of the knuckle rests when locked, is made strong enough to stand the shocks. After this is settled the knuckle test is of no great value, because it does not show the strength of the knuckle under service conditions. A much better way to show the ductility of the material is to drive the lugs together. Knuckles passing these tests also stand the present complete coupler knuckle test; that is, three blows at 10 ft. and two blows at 15 ft. without cracking. The guard arm test is certainly the best test for the bar, for it shows the strength of the guard arm and the stem, as well as the quality of the material.

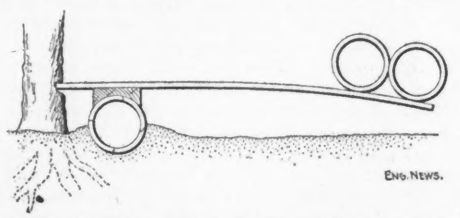
Up to this date very few jerk tests have been made,. There are some good points in favor of this kind of a test, and it represents closely the jerks the coupler receives in service.

TEST OF CRUSHING STRENGTH OF CEMENT PIPE.

By Arthur S. Bent.*

In 1892 an important irrigation system was constructed in Riverside Co., Cal., which included a four-mile line of 30-in. and 28-in. cement pipe. The contract for making this was let to the Pacific Clay Manufacturing Co., of Los Angeles. While in charge of their work I made the following tests of crushing strength as the result of a discussion with the engineer as to the amount of fill the pipes would stand when laid. We found no data to govern us on this point, excepting those made under entirely different conditions, and on pipe manufactured much more carefully than is customary here in the West. This pipe was made of one part Portland cement (Gillingham) and 3½ parts sand and gravel, the latter being taken just as mixed by nature in the dry bed of an adjacent mountain stream. It was a white, sharp, quartz sand, plentifully mixed with stones up to the size of a hen's egg, and, being fairly clean, was not washed. The mortar was mixed by hand in boxes holding about half a yard and was hoed over three times dry and three times wet. It was then tamped into sheet iron molds by hand with an iron tamp weighing about 17 lbs. A gang of 25 men made two miles of 28-in. pipe in two weeks, the need of water for trees compelling us to manufacture at a tremendous speed and send the pipe over rough hills to the trench when only three weeks old. These facts are mentioned to show the unscientific manner in which the pipe was made, and are in marked contrast to the careful English methods described in Reid's "Treatise on Concrete." It is interesting to notice that Reid emphasizes the danger of having the mortar overwet so that tamping could not be solidly done, while our tests showed the highest efficiency in a pipe which had been made so wet that it had settled out of shape when the mold was withdrawn, and the water had been squeezed to the surfaces, leaving it looking rough and puddled. It is also a tradition among pipe-makers that the wet pipes are the strong ones, though this is contrary to all theories I have seen.

The apparatus used for breaking the pipes, as shown by the accompanying sketch, consisted of a lever made of two 6 x 6-in, scantlings 32 ft. long, one end of which was inserted in a hole in the trunk of a tree, the pipe to be tested being placed 3 ft. in the clear from this fulcrum. A bearing surface for the lever was made out of a redwood block which fitted down over the pipe 6 ins. and was flat on top. A couple of sacks were folded between this block and the pipe to make the bearing more uniform. The pipes to be broken were bedded in sandy soil up to one-third of their diameter, with the exception of No. 5, the object being to approximate the conditions of the trenches in which they are ordinarily laid. The strain was brought by rolling other lengths of 28-in. pipe (weighing about 400 lbs. each) out on the lever. This was done as slowly and steadily as possible, the lever having been previously scaled off in feet and inches. The point was noted where the weight rested when each pipe broke. The whole apparatus was afterwards taken to a platform scales, the conditions exactly duplicated, and the different weights ascertained. In the test, all of the pipes sustained the weight of the lever plus one length of pipe at its extreme end. A second joint of pipe was then rolled out on the lever and the point of breaking marked as stated.



Sketch of Apparatus Used to Determine the Breaking Strength of Cement Pipe.

The pipes were made of one part of cement to 3½ parts of sand and gravel. They were 28 ins. inside diameter, in 2-ft. lengths, with shell 2½ ins. thick, and were about three weeks old when broken. Three of them were taken at random the day made, and set aside and treated as follows:

No. 1 was kept constantly wet for seven days, including the day of making. It cracked with the first weight at the end, and the second weight at 18 ft. from the end; = 6,400 lbs.

No. 2 was wet twice daily for five days. It cracked with the first weight at the end, and the second weight 12 ft. from the end; = 7,000 lbs.

No. 3 was wet for three days, four or five times a day, and dried out some during intervals if sun was hot or wind blowing. It cracked with the first weight at the end, and the second weight 14 ft. from the end; = 6,820 lbs.

Pipes were all made and left in open air without protection. These three were made of ordinarily dry mortar, which showed no water marks on surface after being tamped.

Nos. 4 and 5 were taken at the time of the test from pipe made three weeks before, lengths being chosen whose rough surfaces and uneven length showed they had been made of very wet mortar. Pipe No. 4 cracked (after swaying lever) with both weights at the end; = 7,720 lbs. Pipe No. 5 (not back filled) crushed with the first weight at 14 ft. from the end; = 4,010 lbs.

None of the bedded pipes crushed. They cracked in four lines, one each at center of top, bottom and sides, the cracks running nearly straight through the length of the pipe. They then took their bearings and held all the weight we were able to put on them without further fracture. Owing to a strong wind we were unable to prevent some swaying of the lever, which, of course, made the actual breaking strain greater than the subsequent weights showed. I know of no way to estimate this added strain.

Pipe No. 4, which showed the highest strength, was not cracked when two weights had been rolled to the extreme end of the lever (7,720 lbs.); but the timbers began to crack in an ominous manner, and for fear of a general smash-up we did not roll on another weight. Instead, the lever was gently swayed up and down with the weights until the end was describing an arc probably 3 ft. long, at which No. 4 cracked. Pipe No. 5 was not supported by any backfilling whatever.

These tests were made in a mountain canyon, many miles from a town, and were necessarily clumsy. We had to use such appliances as were at hand. But in the subsequent weighing we made careful effort to exactly duplicate the conditions of the test.

It may be of interest to know that a portion of the line for which this lot of pipe was made, cracked after being laid; presumably when water was first run through. The cracked portion was under no water pressure whatever, and had a fill over it of not more than 3 to 4 ft. Other portions under a slight water pressure and a fill of 8 to 10 ft., remained intact. It was afterwards demonstrated that the failure was due to careless backfilling. The entire line has, however, been in successful operation for seven years and does not show an appreciable loss of water in a length of four miles.

RECORDS OF COST AND RATE OF WORK IN TUNNEL CONSTRUCTION WITH SHIELDS.

In a recent article in "Le Genie Civil" on the use of the shield in tunnel construction, condensed from a work on this subject, written by M. R. Legouez, the following interesting tabular statements occur, relating to the speed of advance attained in the construction of various tunnels, and the cost per linear unit:

Rate of Advance in 24 Hours.

Name of tunnel.	Rate Maximum. ft.	Rate Average. ft.
Concorde Siphon, Paris	9.84	7.05
Tower Tunnel, London	8.98	8.46
Clichy Siphon, Paris	8.20	5.90
Mersey Tunnel, Liverpool	7.87	4.92
Riviero de l'Est	7.87	4.00
City and South London Ry.	16.00	11.55
Glasgow District Subway	16.00	3.28
Waterloo and City Ry.	16.00	10.00
Glasgow Harbor	2.95	1.97
Hudson River Tunnel	9.97	4.92
St. Clair Tunnel	15.32	7.61
Blackwall Tunnel	12.50	8.20
Clichy Collector, outside Paris	29.85	17.88
Clichy Collector, inside Paris	19.68	10.50

Cost per Lineal Foot of Work Executed.

Location.	Diameter of shield, ft.	Wght. castings, pr lin. ft., lbs.	Cost cstgs, $40 pr metric ton.	Cu.yds. per lin.ft., c.yds.	Net cost, Excavation, per c.yd.	Net cost, Per lin. ft.
Concorde	5.90	873	$15.85	1.00	$36.58	$109.75
London Tower	6.56	941	17.07	1.24	7.37	40.24
Clichy Siphon	7.54	1,411	25.61	1.64	23.32	121.95
Kingston	8.33	...	16.46	2.00	4.60	40.24
City & So. London	10.20	1,881	34.15	3.01	5.42	75.20
Glasgow district	11.00	2.217	40.00	4.16	8.69	134.20
Waterloo & City	12.50	2,352	42.34	4.57	8.60	140.24
Glasgow Harbor	16.07	4,569	82.24	7.44	2.74	134.20
Hudson River	18.00	6,383	114.90	9.35	7.98	304.85
St. Clair Tunnel	19.81	9,340	168.12	11.35	6.22	347.50
Blackwall	25.00	10,550	189.90	18.10	15.85	914.60

The above tables have been translated from Metric into English measures. Our contemporary does not give the authorities from which its figures were obtained.

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A memorable naval battle in Hampton Roads, on March 9, 1862, practically revolutionized the building of warships throughout the world; for though the French ship "La Gloire" had been launched two years previously, with 4½ ins. of rolled iron plates on a heavy wood backing, the struggle between the "Monitor" and the "Merrimac" was the first actual combat between armored ships. The previous destruction of wooden warships by the Confederate ironclad proved to the world that the long boasted "wooden walls" were powerless in the face of an adversary of that class, and England, France and other nations at once began that struggle between armor-plate and guns that has resulted in the present wonderful development and power of ships of war. Many failures marked the path of this advance; and while there has only been one actual naval battle between fleets of modern war vessels, that of the Japan-Chinese war, is it not possible that the limit has about been reached in the building and armament of these terrible engines of war? The displacement of these ships has reached 14,000 tons and more; 18 ins. of a high quality of solid steel armor protect the vital parts; guns of 13-in. caliber throw projectiles with a muzzle velocity of 2,000 ft. per second; high explosives are employed in shells and torpedoes; and engines of 10,000 HP. give these heavy hulls a speed of 17 knots or more. Guns and ammunition are now so heavy that machinery must be employed for handling them; and electric power and electric light find place in the equipment along with many minor applications of the latest development of the science of war. Even with all the advance in the treatment of materials and the resultant cheapening of the product, the cost of these ships is now enormous, as is shown by the fact that within the last thirty days three great nations have appropriated $240,000,000 to be expended upon their navies.

The exigencies of the Civil War produced the "Monitor" and the "Merrimac," and undoubtedly hastened, if they did not compel, the changes in the building and arming of warships which has taken place within the last thirty odd years. It would be a strange coincidence if a somewhat similar emergency should now bring about an American development of another type of vessel that would destroy these same great battleships, and stop the expenditure of money upon them from mere commercial considerations. The advent of a thoroughly manageable submarine torpedo boat, fitted for operating in comparatively deep water and capable of effectively delivering torpedoes or dynamite projectiles, will settle the question of battleship attack upon the ports of a country. The certainty of destruction would be so great that no nation could afford to invest five or six millions in an armored battleship that may be sunk by a vessel costing so little that a fleet of a hundred of them could probably be built for the price of one battleship. The idea itself is as old as the days of James I. of England; and late experiments by France, Spain and Germany have been failures. But we again have faith in the same American inventive genius that caused such an upturning of methods, following the events of 1862; and late trials with the Holland submarine torpedo-boat would seem to warrant this presumption. The inventor of to-day has great advantages over his predecessors, in improved methods of construction, compressed air, storage batteries and gasoline fuel for surface work; and while the problem is many-sided and difficult, it is by no means impossible of solution, and an urgent demand for the services of such a vessel would mean its ultimate successful development.

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What a revolution in naval warfare such a craft would bring about. It would practically abolish three of the most advanced types of warships, the battleship, the torpedo boat and the torpedo boat destroyer. The first of these brought out the second as a means of attack upon the battleships of the enemy; and the third was introduced as a defence measure against the second. The fast, lightly-armored cruiser would probably be left, as a commerce defender, but against this type of ship the torpedo is practically useless, hence there would be practically no further use for torpedo-boats. It is difficult to see what measure of defence could be devised against such an unseen submarine, but powerful enemy; and to find and attack this underwater craft with another vessel of the same type would be practically impossible and add an additional element of terror to a warfare that is terrible enough as it is. The Holland boat is intended not only for attack upon the hull of a ship by automobile torpedoes, but she is fitted to hurl dynamite projectiles both above and from below the surface. She has thus three separate means of attack, and a successful hit by any one of these projectiles would mean the certain sinking of the vessel attacked. The great value of submarine boats as a means of defence would be their cheapness and rapidity of construction; and the ability to thus attack in a swarm, with the chance of escape for the enemy correspondingly small. But if battleships cannot attack a fortified port, cruisers certainly could not, and submarine torpedoes or short range dynamite projectiles would be useless against land works armed with modern high-power guns. This assumption would confine naval battles between heavy ships to the high seas, and from a political point of view the result of such a battle would be valueless; and the submarine boat might even be so developed as to enter into a combat of that nature by being carried to the vicinity of the scene of combat on the battleship. So it may again be said that the man who invents and builds a workable submarine torpedo boat will as thoroughly drive the battleships and their dependents from the naval lists of the world, as the advent of armorclads and rifled guns made useless the ships of Nelson's time.

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The photographs of tile arch construction in the highest office building in the world, which are shown in another page of this issue, will be examined with interest, we are sure, by every engineer interested in the matter of fireproof floor construction. The question which most engineers are certain to ask is, do these represent anomalous and exceptional examples of tile arch construction, such as would be condemned by a competent clerk of the works or city building inspector; or, on the other hand, are they merely ordinary examples of tile floor construction, such as can be found in odd corners around any first-class fireproof building? We are assured by competent authority that the latter is the case, and all the evidence seems to point strongly in this direction. The construction shown in our photographs appears to have attracted no attention whatever from those in charge of the construction of the building, and it is in the hands of men experienced in the construction of high office buildings. Further, we are informed that similar defects can be seen in the tile floors of half a dozen buildings now going up in New York city, and are passed without question.

Suppose we accept this view of the case, that tile construction of this sort is common, or at least frequent in fireproof buildings. If this be true, then it follows that our knowledge of the strength of such floors is to say the least very imperfect; for all the tests which have been made of the strength of such floors have been made on arches carefully constructed, with sound and symmetrical blocks, properly bonded with mortar. That such construction as is shown in our photographs is far weaker than floors built like the test arches, no one would think of denying. Perhaps it is still strong enough for safety; that is a matter which we shall not attempt to decide; the point of importance is that tile floor arches are just as capable of being built in a careless and defective manner, not contemplated by their design, as any other sort of engineering construction; and in view of some of the extravagant claims which have been made for tile floors, this point, we believe, is well worth establishing.

LIQUID AIR AS A MEANS OF STORING POWER.

Elsewhere in this issue we present an account of the methods by which liquid air, which was until recently a laboratory curiosity obtainable only with great difficulty at an enormous expense, is now manufactured with ordinary commercial apparatus and at a comparatively small cost. The question which naturally suggests itself is, to what practical uses can liquid air be applied? Very likely some special uses may be found for it in the manufacture of chemicals or explosives or other processes in the arts; but the two uses that apparently promise to be of the greatest importance are refrigeration and the storage of power. For ordinary refrigeration it is quite unlikely that the ammonia machines at present used will be supplanted, as tests have shown them, if we mistake not, to be more efficient than any form of compressed air machines; but for special refrigerating purposes, where very low temperatures are desired, or where it is desired to store a large amount of refrigerating effect in a small space, liquid air would seem to be admirably adopted. We have as yet no figures for the latent heat of evaporation of liquid air, and therefore it cannot be stated what is the refrigerating effect a given weight of liquid air as compared with that of an equal weight of ice.

The most important by far, however, of the probable future uses of liquid air appears to be the storage of power. At the present time there are only two methods known to engineers by which considerable amounts of power can be stored with apparatus of moderate weight and bulk. These are the electric storage battery and compressed air tanks, both of which have only been developed so as to be commercially practicable within the last few years. It now seems probable that in liquefied air we are to have a new method of storing power, considerably more expensive, it is true, than the older systems, and returning a smaller proportion of the power originally applied; but having the very great advantage of storing several times as many foot-pounds of energy in a cubic foot or a pound as the older systems.

It may be well to point out why liquid air would be superior as a means of storing power to the compressed air system, in which air is stored under pressures of about 2,500 lbs. per sq. in. In

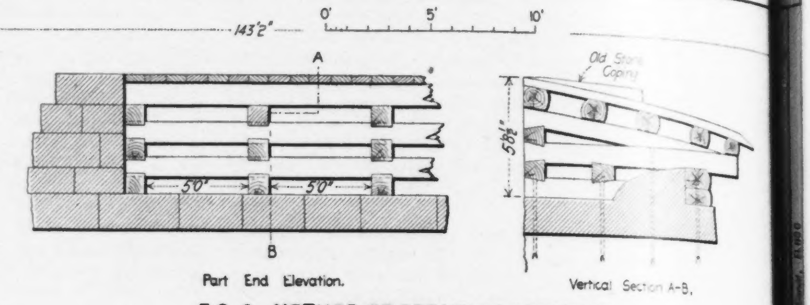

FIG. 2. METHOD OF REPAIRING BREAKS IN PEDLAR DAM, WITH TIMBER CRIBWORK.

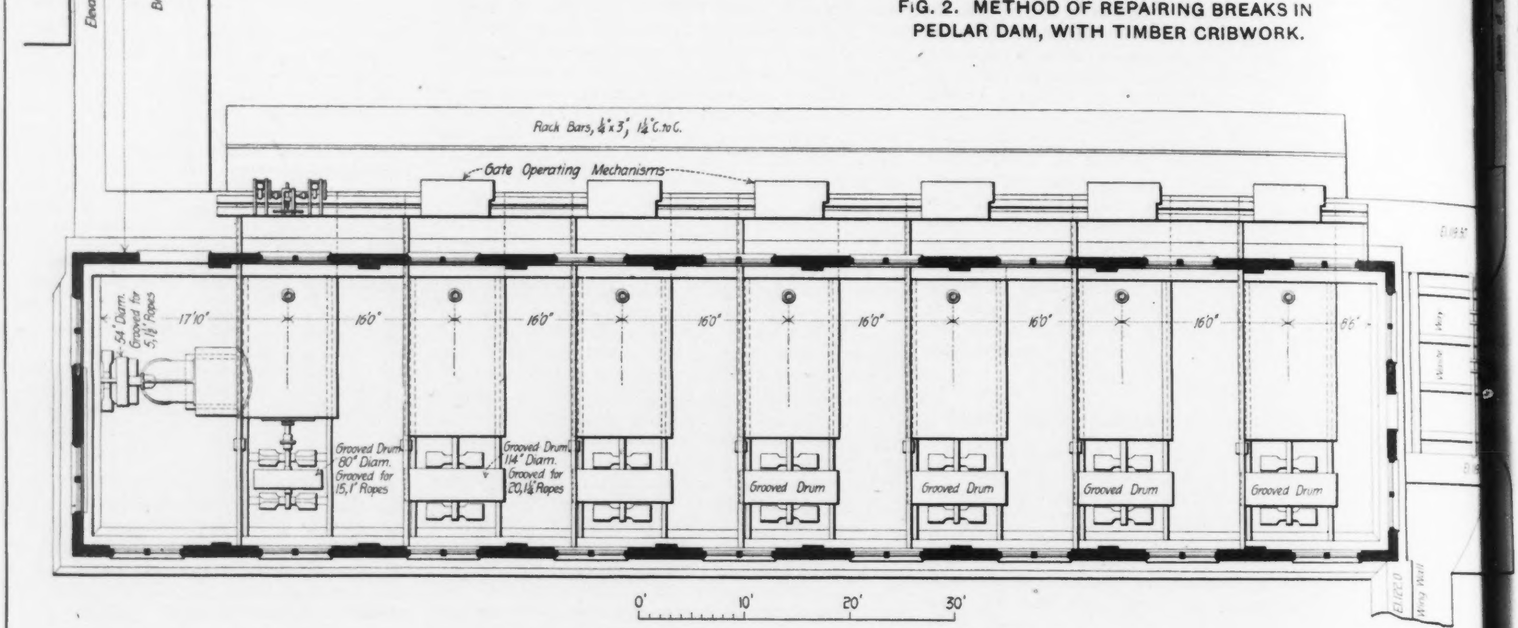

FIG. 4. OUTLINE PLAN OF POWER HOUSE.

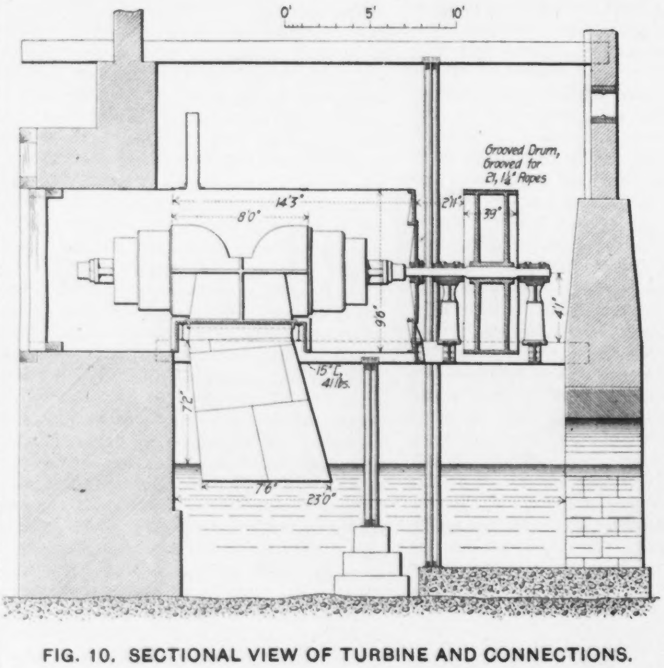

FIG. 10. SECTIONAL VIEW OF TURBINE AND CONNECTIONS.

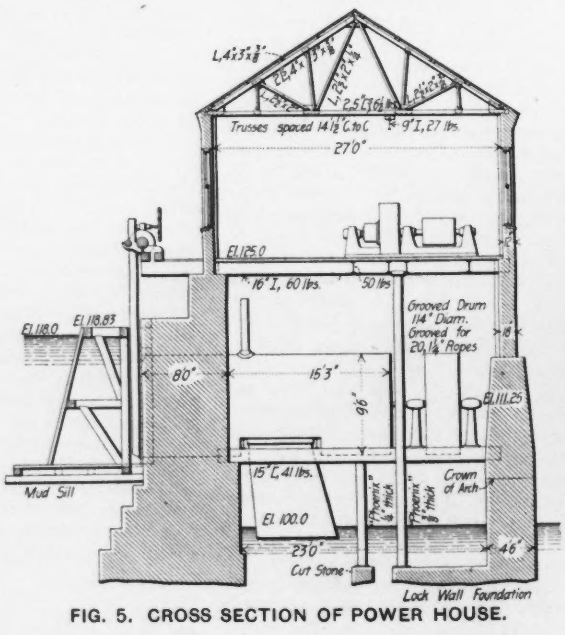

FIG. 5. CROSS SECTION OF POWER HOUSE.

FIG. 6. VIEW O WE OM H

WATER POWER PLANT OF THE WILLSO LU

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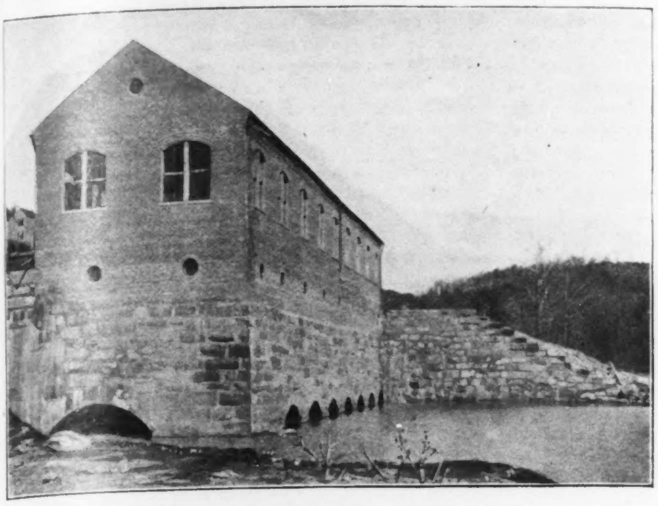

FIG. 7. VIEW OF COMPLETED POWER HOUSE FROM TAIL RACE SIDE.

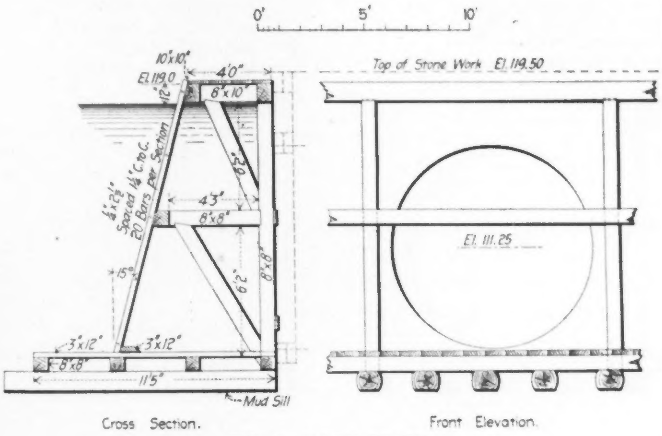

FIG. 9. RACK FRAME.

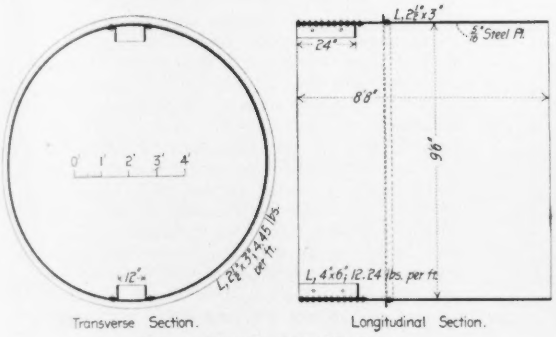

FIG. 8. STEEL THIMBLE IN FRONT WALL OF POWER HOUSE.

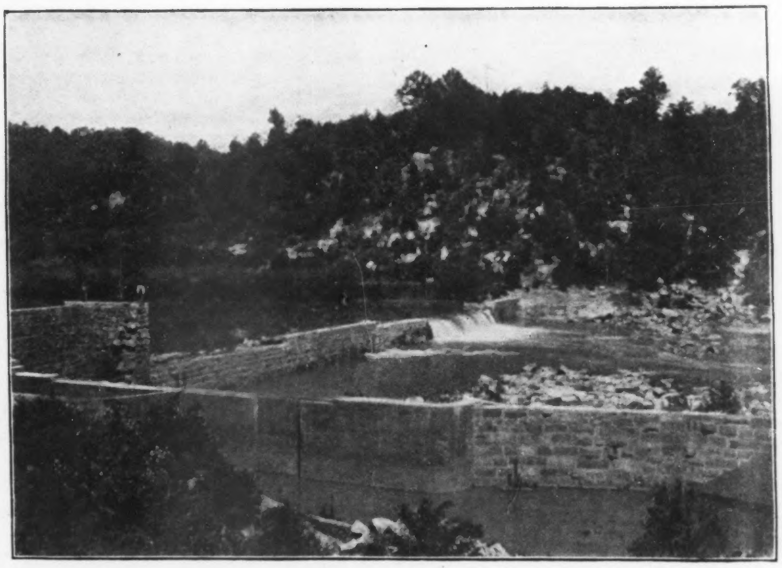

FIG. 1. PEDLAR DAM, ON THE JAMES RIVER, BEFORE REPAIRS WERE MADE.

. 6. VIEW O WER HOUSE UNDER CONSTRUCTION,
OM HEAD RACE SIDE.

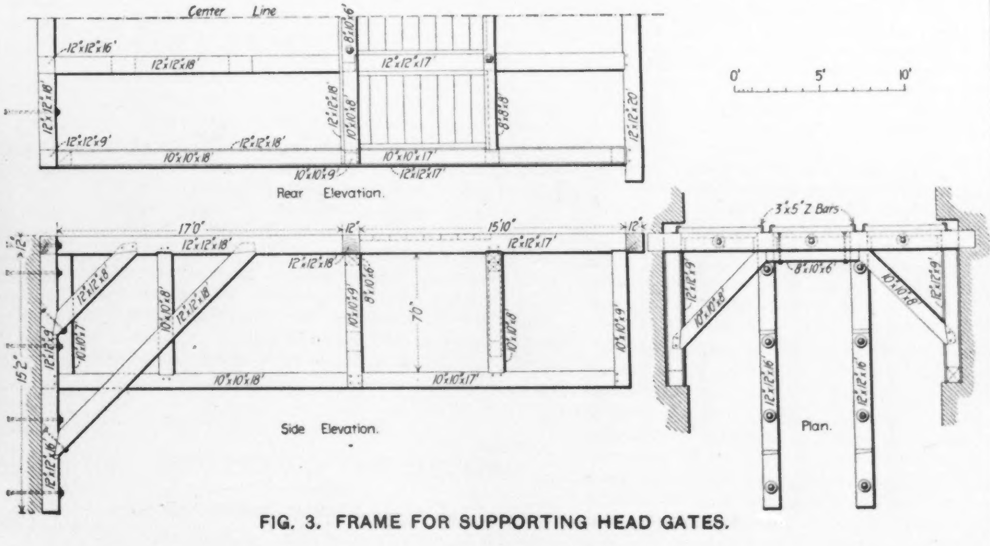

FIG. 3. FRAME FOR SUPPORTING HEAD GATES.

WILLSO LUMINUM CO., HOLCOMB ROCK, VA.

Temple, f Engineer.

these systems the tanks in which the compressed air is stored must be made very heavy to withstand the enormous pressure, and the weight and bulk of these tanks is the chief difficulty in the application of the system. But liquid air occupies only about one-fourth the space of air at 2,500 lbs. pressure, and if the tank containing it is thoroughly jacketed, it can be kept for a considerable time. The tank containing it may be designed to sustain the pressure at which the air is to be used and supplied with safety valves so that any increase of pressure beyond this point will blow off harmlessly. The economy in weight and space of this system compared with the system of storing the air at enormous pressures and drawing it through a pressure-reducing valve as it is required for use will be manifest.

It may be of interest to discuss the amount of power that is stored in a pound or a cubic foot of liquid air. It will be understood, of course, that to cause this power to be generated the liquid must be allowed to absorb heat, or heat must be applied to it. The volumetric relation of free air at atmospheric pressure and of liquid air are approximately (according to Mr. Tripler) 741 to 1. That is to say, if a cylinder 741 ft. long had a piston placed in its end and forced down (the air being cooled by proper means as the piston moved down) when the piston came within a foot of the opposite end of the cylinder, the space remaining would be filled with liquid air.

Again, if in such a cylinder the last foot be filled with liquid air and heat be supplied to it, the piston will be forced outward. What pressure might be reached in the first foot or two of its travel, we have no means of knowing, since we have no records of experiments showing the relation of pressure and volume of air at pressures near its point of liquefaction, but for our present purposes it is not important. Assuming that the Marriotte or isothermal law, pressure × volume = a constant, holds true for pressures up to 2,000 lbs., which is nearly, if not quite true, then when the piston had moved outward about 4½ ft., the volume of the air increasing from 1 to 5½ cu. ft. if the area of the piston is 1 sq. ft., then the absolute pressure would be 2,000 lbs. per sq. in., or 136 atmospheres. This follows from the Marriotte equation, for 1 atmo. × 741 cu. ft. = 136 atmos. × 5.45 cu. ft. If this 5.45 cu. ft. of air, at 2,000 lbs. per sq. in. is used on an engine expanding down to the atmosphere, heat being supplied to keep the temperature constant, the mean absolute pressure would be calculated from the equation:

$$Pm = p_1 \frac{1 + \text{hop log } R}{R},$$

in which Pm is the absolute mean pressure, p_1 the absolute initial pressure, and R the ratio of expansion:

$$Pm = 2{,}000 \frac{1 + 4.91}{136} = 86.9 \text{ lbs.}$$

Subtracting the back pressure, which is that of the atmosphere, or 14.7 lbs., we have for the mean effective pressure 72.2 lbs. per sq. in.

Neglecting the work of expansion during the first 4½ ft. of the stroke, or that of the expansion from liquid air to air of a pressure of 2,000 lbs. per sq. in., and assuming that the mean effective pressure of 72.2 lbs. per sq. in. is the mean for the whole stroke of 740 ft., we have for the work done by 1 cu. ft. of liquid air 72.2 × 144 × 740 = 7,693,632 ft.-lbs., or 7,693,632 ÷ 33,000 = 233.1 HP. minutes, or 1 HP. for 3 hours and 53 minutes. The above computation of course takes no account of the heat to be supplied, neglects friction losses and considers the expansion as isothermal.

The density of liquid air compared with water is $\frac{741}{836} = 0.887$ and as water weighs 62.35 lbs. per cu. ft. a like quantity of liquid air would weigh 62.35 × .887 = 55.3 lbs. Dividing, now, 7,693,632 by 55.3 we have 139,100 ft. lbs., or 4.25 HP. minutes as the energy stored in a pound of liquid air.

In using these figures for the power stored in liquid air, it must be borne in mind that they represent rather what could be obtained by the most perfect method possible of developing this energy rather than the foot-pounds of work which could actually be obtained if it were used in existing types of compressed air motors. Thus we have assumed that it would be possible to develop power in the expansion from 2,000 lbs. down to ordinary steam pressures; but in the present compressed air power systems all this expansion takes place through a reducing valve and much energy is thus wasted. On the other hand, we have allowed nothing for the gain in power which may be made by heating the expanding air above atmospheric temperature, and it would probably be quite feasible to heat the air sufficiently to offset the losses due to the failure to utilize completely the higher pressures generated in the expansion.

It may be of interest to compare the power stored by liquid air and that stored by an equal weight of other mediums. At present the electric storage battery is in far more extensive use for storing power than any other system. A pound of storage battery stores from 8,500 to 15,000 ft. lbs., or in round numbers only one-tenth to one-twentieth the power that is stored in liquid air.

A system of power storage which has been used to a limited extent is the storage of heated water. If we have a pound of water stored under a pressure of 400 lbs. and at a temperature of 445° and allow it to expand and use the steam thus formed in doing useful work we find (assuming 20% of its heat to be turned into work) that we obtain about 43,000 ft. lbs. Thus it appears that the hot water or "stored steam" system stores only about one-fourth as much energy for a given weight as liquid air.

On the other hand, it is true of liquid air as of other mediums of storing power that the mechanical work which can be obtained from a pound is much less than can be obtained from a pound of any good fuel used to develop power in a steam or gas engine. To show this clearly we have prepared the following little table, showing the approximate heat values per pound of various fuels, and also the approximate energy which each would produce, assuming that its heat were used in a gas engine of 15% efficiency or in the case of coals, in a steam engine of 10% efficiency.

Material.	Heat energy per lb., B.T.U.	Ft.-lbs. pr lb. of material.
Natural gas	24,000	2,800,800*
Illuminating gas	22,600	2,637,300*
Petroleum	20,000	2,334,000*
Water gas	7,061	823,900*
Producer gas (Bit.)	2,380	277,600*
Producer gas (Anth.)	2,100	244,950*
Anthracite coal	12,500	972,500†
Bituminous coal	8,000 to 14,500	622,400 to 1,128,10 †
Water, 400 lbs. press. & 445°F.	......	43,000§
Storage battery	......	8,500 to 15,000
Liquid air	......	139,100

*If used in a gas engine of 15% efficiency.
†If used in a steam engine of 10% efficiency.
§If 20% of its heat is transformed to power.

In conclusion, it may be well to repeat that our figures represent rather the possibilities of liquid air rather than what is now attainable. Very much will depend, of course, on the efficiency which may be finally attained in its production and the consequent reductions in the cost of the process. The success already attained, however, makes it reasonable to expect that the near future will see liquid air used to store power for such purposes as torpedo propulsion, where cost is a secondary consideration, and perhaps also for the propelling of bicycles and motor carriages, and similar purposes where the storage of the maximum power with the least weight and bulk is more important than expense.

◆

LETTERS TO THE EDITOR.

A Simple Method of Computing Maxima and Minima.

Sir: The following simple method of finding the value of a variable which will make a function of its first and second powers, or of it and its reciprocal, a maximum or a minimum has doubtless been used by others, although I have never seen it published, probably because those using it deemed it too simple for publication. But when Bodmer, wanting a maximum value of a function of the first kind, says "The calculation of this value is somewhat complicated, requiring the use of the differential calculus" (Hydraulic Motors, 2d ed., p. 72), and Waddell, to find a minimum value of a function of the second kind, differentiates once to get the value of the variable and then has to differentiate a second time to determine whether this value gives a maximum or minimum of the function ("De Pontibus," pp. 31 and 35), the method may be worth publishing.

Let $y = a + b x + c x^2$ be a function of the first kind, a, b and c being positive or negative constants. Putting this equation in the equivalent form

$$y = a - \frac{b^2}{4c} + c \left[x + \frac{b}{2c}\right]^2,$$

we see at once, since the square of $x + \frac{b}{2c}$ is always positive, that if c be positive, y is a minimum when $x = -\frac{b}{2c}$ and if c be negative, y is a maximum for this value of x.

Similarly by putting $y = a + b x + \frac{c}{x}$ in the form

$$y = a + 2\sqrt{bc} + \left\{\sqrt{bx} - \sqrt{\frac{c}{x}}\right\}^2$$

we see that y is a minimum when $b x = \frac{c}{x}$.

Yours truly,
W. H. Schuerman.

Engineering Department, Vanderbilt University, Nashville, Tenn., March 22, 1898.

◆

Equivalent Static Loads Corresponding to Impact.

Sir: Regarding the query by L. H. B. in Eng. News, of March 3, 1898, concerning the effective blow of a hammer, it seems to me that it is possible to arrive at a practical expression for the relation between the effect of a blow and weight of a static load by comparing the work performed or the results in each case.

Thus we can conceive of a weight of 100 lbs. falling 10 ins. and breaking a beam which is just broken by a much greater static load. In Cotterill's Mechanics I find a formula of which the following expression is the equivalent; $x = x_1 + \sqrt{2 x_1 h + x_1^2}$ in which x is the maximum elongation within the limit of elasticity caused by a load P falling through a height h, and x_1 is the elongation which P causes, considered as a static load. In the expression from which the modulus of elasticity is derived we have $P L = A x_1 E$, P being load, L length of test bar, A area of same; E, modulus of elasticity, and x_1 elongation within (as above) the limit of elasticity. Now, we can find x from these equations and substituting this value in the second instead of x_1 we get a value for P, which is the equivalent static load producing elongation x. This equivalent static load we will call P_1.

Of course part of the kinetic energy of the blow is absorbed in producing elongation, but as I understand the formula it measures the maximum elongation at the point where the force of the blow is reduced, and the resistance is increased sufficiently to exactly balance each other.

It is, therefore, seen that a longer bar, with correspondingly greater resilience per square inch will give a lower value for P_1 than a shorter bar. Take the specific case of a 100-lb. hammer falling 5 ins. and tending to elongate a 1 × 1-in. steel bar of 40 ins. and 50 ins. lengths, respectively. Taking E = 30,000,000, and solving the equations we get (roughly) the following approximate values for x and P_1: In a bar 40 ins. long P_1 = 26,000 lbs., and x = 0.035-in.; in a bar 50 ins. long P_1 = 24,000 lbs., and x = 0.040-in.

It is, of course, possible to run these values of P_1 higher or lower by taking shorter or longer bars, as long as the value of P_1 is within the limit of elasticity, but for practical purposes they are probably well selected. In any case the test piece should be selected to suit the conditions. Tests measuring the actual deflection would also be useful for specific cases, care being used to keep the tests always within the elastic limit. J. C. Meem.

64 Montague St., Brooklyn, N. Y., March 11, 1898.

(The argument in the above letter appears to be correct as far as it goes, but, nevertheless, it only shows that the "effective blow of a hammer," expressed as the equivalent of a static load, is an indeterminate quantity, except in the exceedingly rare case of the deformation of the body struck being within the elastic limit, and at the same time capable of being measured or calculated. Even in this case the "effective blow" is not a simple function of the weight of the hammer and the height of its fall, but it depends also on the shape, size, and resistance of something independent of the hammer, namely of the body or bodies struck. It is proper, therefore, to say that the "effective blow" of a hammer is an indeterminate quantity and cannot be expressed in pounds. The form in which the question usually is asked is "What is the striking force of a hammer weighing 100 lbs. falling 10 ft." To this form of question no direct answer can be given, but if to the question is added the words, "the blow being delivered in such a manner that its whole energy is expended in elongating within the elastic limit a bar of length L area A and modulus of elasticity E," then Mr. Meem's letter furnishes an answer to the question. —Ed.)

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The Shape and Effect of a Stream of Water Flowing Over a Dam Having an Ogee Downstream Face.

Sir: Many years ago a prominent hydraulic engineer berated me soundly for having designed the stone dam for the Connecticut River at Holyoke, Mass., shown in "The Transactions of the American Society of Civil Engineers" for August, 1886, p. 576. Said he (making a sketch that showed the water passing the crest of the dam in a spouting stream, as though it issued from an orifice), "The water will strike the bottom of the apron; will tear it up and wash it away." See Fig. 1.

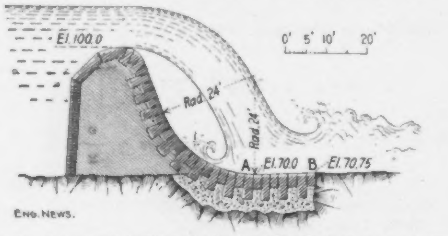

Fig. 1.—Asserted Action of Water Flowing Over a Dam With an Ogee Down-Stream Face.

I could not believe that my observation and experiments up to that time had been all wrong, or had totally misled Fig. 2 shows about 6 ft. in thickness going over this ogee-faced, wooden, log dam.

The Pejepscot Paper Co. lost two predecessors of this dam, in quick succession, these having been in horse-shoe shape in plan, and on a gravel and boulder bottom. The effect of these dams was to wash out the bottom of the river down to bed-rock, downstream from, and in fact all over the site of these dams. It was then decided to make the third dam straight across the river, and to widen the river channel down to the level of the crest of the dam, at the same time giving the downstream face of the dam an ogee shape. This is more difficult to accomplish in wood than in stone, but the results have in every way vindicated this form of construction.

Since the dam was completed the river-bed has built up a dozen or more feet high immediately downstream from the dam, where previously the natural bottom had washed out down to bed-rock. In the foreground of Fig. 2 may be seen the junction of the tail-race, with the river below the dam. By the well-known principle of the "lateral communication of motion to fluids," a sort of hydraulic "induction," the water in this tail-race is sucked out about 1½ ft., by the water which leaves the ogee face of the dam in a stream of straight line particles, or filaments, contributing not immaterially to the power of the mill, and, perhaps, a unique instance of the water wasting over the dam, helping to run the mill.

The principal reason, as is now clear to me, why such sheets of water approach or adhere so closely to the downstream face of the dam they waste over, is the fact that the air between their under side and the dam, is speedily entrained into and away with the water, thus causing the pressure of the air on the outside to press down the whole sheet of water and causing it to adhere to the dam as it passes over.

Having referred above to the stone dam now building at Holyoke, Mass., it is proper to add that I do not wish the inference to be drawn that I recommended the construction of this dam, in the manner and in the situation in which it is now being constructed. The design as made me, and Engineering News of Nov. 10, 1892, relates some observations I took to check, and as it turned out, tending to confirm, my previous views. I then inferred that the depression of the water surface at the crest of the dam, from the static level of the water upstream from the dam, reaching back sometimes 150 ft. or more, and amounting to 30% or more of the thickness of the sheet of water as measured between the level of the crest and the static level, was the main cause that made it impossible for the sheet of water to spout out beyond the crest of the dam, according to parabolic theories of spouting velocity. (See Merriman's "Treatise on Hydraulics," p. 122, and Hamilton Smith's "Hydraulics," p. 112.)

Since then two things have happened: The Holyoke Water Power Co. is spending a large sum of money in the construction of the stone dam designed by me as a preliminary study for that work in 1885, and I have had the pleasure of designing, seeing it built, and of actually testing the effect of such a dam on the Androscoggin River, being the dam of the Pejepscot Paper Co., near Brunswick, Me. by me was a preliminary study, and totally unlike the dam which I later designed for the same place.

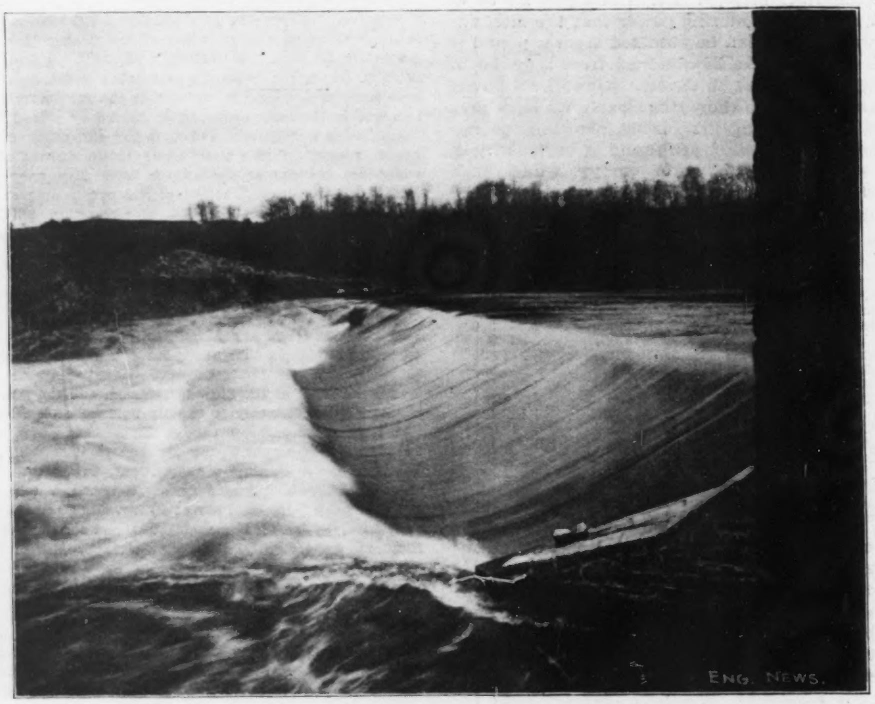

FIG. 2.—DAM OF THE PEJEPSCOT PAPER CO., NEAR BRUNSWICK, ME., SHOWING A 6-FT. SHEET OF WATER FOLLOWING THE OGEE SHAPED DOWN-STREAM FACE.

Clemens Herschel, Hydraulic Engineer.

2 Wall St., N. Y., March 26, 1898.

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QUANTITATIVE ESTIMATION OF MICRO-ORGANISMS.*

By Prof. Albert H. Leeds, Ph. D.

The microscopical examination of waters is necessarily subdivided into two entirely distinct parts:—the first part concerns itself with the direct study by means of the microscope of those animals and plants which cannot be seen with the naked eye, or which, if visible at all, require the aid of the microscope for their satisfactory differentiation. These organisms are most conveniently described as micro-organisms, to distinguish them from the macro-organisms, which make up the visible aquatic life.

The second part is restricted to those exceedingly minute plant growths included under the general name of bacteria, and which cannot be satisfactorily studied with the microscope alone, inasmuch as they require cultivation in a variety of media, to develop the characteristics essential to their classification, and inasmuch as they also demand a variety of tests of a chemical character, to ascertain the nature and extent of the changes that they are capable of effecting in the various culture-media in which they are grown.

The study of the bacteria cannot be carried beyond its earlier and simpler stages, without the aid of a laboratory specially equipped for bacteriological investigation. But no engineer, whose duties as superintendent of water-works requires that he should keep himself familiar with the daily changes occurring in the waters under his management, should forego the great pleasure and advantage of familiarizing himself with the aquatic micro-organisms and with the simple apparatus and appliances for their quantitative examination.

This is more especially important for the reason that the tastes and odors of waters are neither adequately accounted for, or investigated, in the chemical and bateriological part of an investigation into their quality. These tastes and odors are usually due to the micro-organic life. They are capable of being brought to such intensity, by the extremely rapid growth of the organisms which produce them that, in a few days, or even hours, the whole of a city water-supply, previously palatable and sweet, may become nauseating and unpotable. Armed with a microscope and no more apparatus than can conveniently stand on the corner of his office table, the engineer can find endless pleasure and profit in his leisure moments, in studying the exquisitely beautiful forms, the strange motions and the wonderful transformations visible in the botanical and zoological garden comprised within a drop of water. And when some ill-tasting and smelling organism appears, he is in a position to detect it and institute appropriate remedies, before popular outcry and complaint has heaped upon him and his professional work, unmerited contumely and abuse.

These considerations are of increasing weight, now that public opinion in this country has at last been educated to the point that it has long since attained in Great Britain and on the Continent—that water supplies, except when they are of unusual and extraordinary purity, should be filtered. Whenever a water is not clear and limpid; whenever it is turbid and develops a sediment, it is not in a proper condition for delivery to consumers, and the microscope is an invaluable aid in revealing the nature and amount of the impurities, which filtration should be called upon to take out. Will a certain water be improved or injured by being kept in incessant circulation? Will it be benefited or otherwise by mechanical aeration? Should it be exposed as much as possible to the light, or should it be kept in as nearly entire darkness as possible? These are some of the questions whose solution is most intimately bound up with the study of the micro-organisms that either flourish or decay, as either rest or motion, oxygen or want of oxygen, light or darkness, are the agencies best adapted to stimulate or deaden them.

Unfortunately there is an impression prevalent among engineers that to do any good work with a microscope, a costly instrument, with high-power objectives and many expensive acessories, is requisite. Just the opposite is the case.

For practical results in the study of waters, the object is not to study exhaustively the appearance and functions of plants and animals. This is the task of a specialist both in natural history and microscopy. It has already been done; the results are recorded in books, and the water chemist and engineer have only to make practically valuable the immense store of observations which have hitherto been left unutilized. The chief needs are: (1) A rapid and easy method of collecting all or some known fractional part of the whole number of organisms in a given volume of water, upon one slide at one and the same time; (2) to register and estimate their kinds, their number and their volume.

We shall not stop to give an historical account of the earlier attempts to solve the first part of this problem. They were all more or less imperfect attempts, depending upon collecting the sediment in a tall jar or examining the deposit left by filtering the water through a sieve or cloth. The first practical method was that of Mr. A. L. Kean (Eng. News, March 30, 1889). He used a funnel stopped by half an inch of sand, the sand being held back by a plug of wire gauze, and when a definite volume of water had been filtered through the sand, the plug was removed and the sand and the organisms washed down into a watch-glass. After the sand had settled the water standing above it was transferred to a cell of 1 cu. mm. in volume and the number of organisms counted.

The Kean method was greatly improved by Prof. Wm. T. Sedgewick,* who used a much larger cell, its inner dimensions being 50 mm. in length, 20 mm. in width, and 2½ mm. deep. The bottom of this cell is ruled into 1,000 squares, each 1 sq. mm. in area. The sand and organisms are both washed into this cell, the sand uniformly distributed over the bottom, and then the number of organisms is ascertained by counting those visible in say 10, 20 or 50

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*From the "Stevens Indicator," January, 1897, with slight condensations.

*"Recent Progress in Biological Water Analysis." Jour. New Eng. W.-W. Assoc., p. 50, 1889..

squares, and estimating the total in the entire 1,000. The method has been still further improved by Mr. G. W. Rafter, and it is with the method in this advanced form that we have to do at present.

The first matter to be considered is the apparatus for filtration; then that for counting, and finally the method for observing and recording.

The filtering funnels are best made of cylinders 2 ins. inside diameter and 10 ins. high, drawn down into a funnel 3 ins. on its side and ending in a straight funnel tube ½-in. inside diameter and 3 ins. long. They are closed with a rubber stopper 1 in. long, ½-in. wide at narrow, and 1⅕ ins. wide at broad end. The stopper has an 0.1-in. perforation, which is covered on its upper side when in use with a disk 0.3-in. diameter, struck out of fine bolting cloth with a common hand-punch.

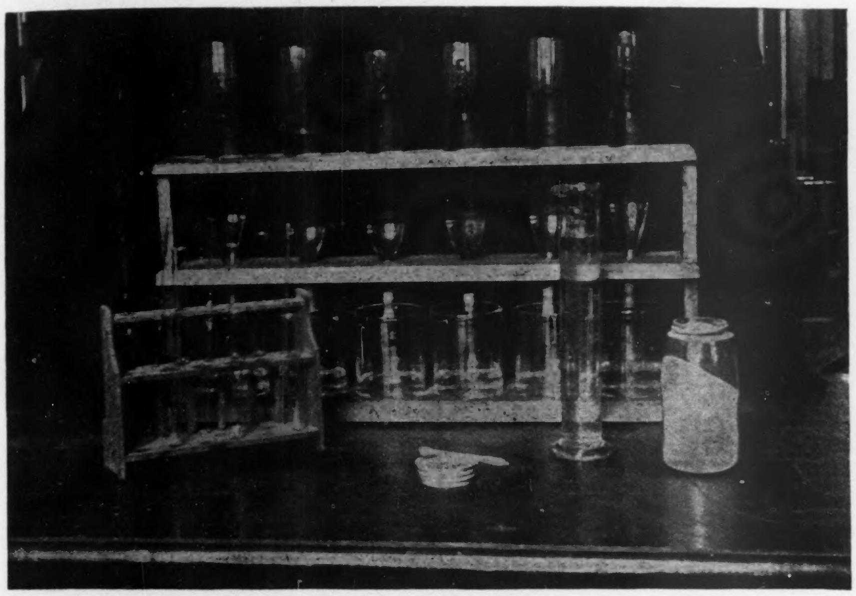

FIG. 1.—VIEW OF APPARATUS FOR SECURING MICRO-ORGANISMS BY FILTRATION.

These arrangements are the result of the suggestions of a number of workers, and, as illustrated in the cut, Fig. 1, are similar to those which the experiments of Mr. D. D. Jackson have indicated to be the most satisfactory.

The best sand for filtering is that manufactured by the Berkshire Glass Mfg. Co., of Cheshire, Mass. It is made of crushed quartz and is screened out by sieves, so as to take that yielding between 50 meshes to the inch and 100 meshes to the inch. Sand of this coarseness will do for the ordinary run of organisms; in exceptional cases a little finer sand, that yielding between the 80 and 120 mesh limits, can be thrown on top of the other at the time of filtering. A depth of about ¾-in. of sand is sufficient; it arrests about 95% of the organisms, amorphous matter, etc.

Six or more of these filter-cylinders are supported on a rack, as seen in Fig. 1, with a broad shelf at the bottom, the rack figured being 26 ins. long, with the supports 3½, 5, and 6 ins. in width and provided with six battery jars 4 ins. in diameter and 4½ ins. deep. Sometimes a suction tube is attached to the perforated stopper of the funnel, when the filtration is slow, but this is rarely necessary or desirable.

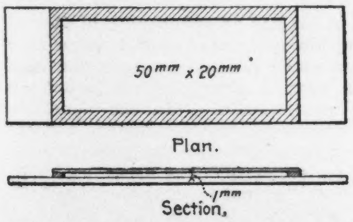

Fig. 2.—Cell for Counting Micro-Organisms.

The counting cell, Fig. 2, is an ordinary glass cell to which is cemented a brass cell 50 mm. long, 20 mm. wide and 1 mm. deep. It is covered, when in use, with a cover of No. 3 glass 0.02 to 0.01-in. thick, and should then contain exactly 1 cu. cm.

Usually 500 cu. cm. of the water is filtered and after it has all run through, the stopper is carefully removed, and the end of the funnel inserted into a test tube of somewhat larger diameter. The adherent sand is washed down with the discharge from a 5 cu. cm. pipette; if the organisms are very numerous, a 10 cu. cm. pipette is used, or if they are few, a 3 cu. cm., or even a 1 cu. cm., pipette may be employed. On shaking the sand briskly the organisms are diffused through the water, which is then briskly decanted into another test tube and the latter put aside for counting and microscopic examination.

Now, with reference to the microscope equipment. The writer has employed the largest and finest of Zeiss stands with a mechanical stage, but any good solid stand with an ample stage is entirely adequate. And, moreover, he has not found a special mechanical stage, with a millimeter movement for racking the cell through a fixed distance, of any material advantage in making the counting. He has simply pushed the cell from left to right and back again by hand through approximately equal intervals until the organisms in as many square millimeters have been counted as seemed necessary to make a fair count. Then a survey has been made of the whole field, for any forms casually omitted, and a fair allowance made for them in the final estimate. In observing, the precaution should not be neglected, of racking the objective up and down, at each millimeter count, so that the forms floating up to the under side of the cover glass may not escape counting.

The only essential part of the microscope outfit for doing this particular work, is an eye-piece micrometer ruled in a square, as shown by Fig. 3. The outside square should be ruled into a square of such a number of millimeters on the side, usually from 5 to 7, that with the particular objective used in counting, the sides of the square as seen in the eye-piece micrometer, should exactly subtend 1 mm. as viewed on the stage micrometer when the draw-tube is drawn out to an observed number of divisions. For example, such an eye-piece micrometer used by the writer and ruled by Leitz, is 7 mm. on the side. When placed in the No. 3 Zeiss eye-piece (focal length 30 mm.), and used in the Zeiss stand Ia with the Zeiss objective A (focal length 30 mm.), it requires a tube length of 149 mm. The same micrometer and eye-piece with a Reichert's No. 3 objective (focal distance 18 mm.), and with the Reichert stand No. 111 B, which is a very excellent one for doing this class of work, requires a tube length of 147 mm.

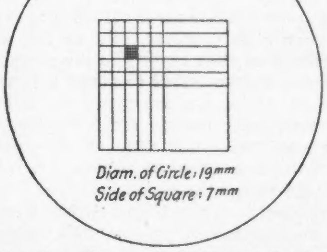

Fig. 3.—Eye-Piece Micrometer With Counting Unit of 400 sq. Microns.
(One micron = 0.001 mm.)

An inexpensive substitute for the ruled glass micrometer may be made by cutting out a square of the desired size in a sheet of thin copper, aluminum, platinum foil, or even tin or cardboard, and inserting this in any ordinary eyepiece.

Besides the 18 mm. objective, with a magnification for this tube length of 70 times, it is a great convenience to have mounted at the same time, in a double nose-piece, a 10 mm. objective having a magnification of 84, for the purpose of more minutely studying an object apart from the counting, while it remains in the cell.

As originally proposed by Mr. Rafter, the eye-piece micrometer was ruled with one square only. This answered satisfactorily, so far as the mere counting of the number of micro-organisms is concerned. But a difficulty was encountered when an attempt was made to estimate the amount of amorphous matter. The plan recommended was for the observer to carry in his mind a sort of mental standard as to the unit of area covered by one mass of amorphous matter. But it is very evident that the actual area covered by different individuals of one species is very different, as is also the area covered by different species of the same genera. Thus a filament of Anaboena or Oscillaria may be long or short, or narrow or wide. Under the head of Synedra, there may be visible at the same time Synedra Pulchella, which is a small diatom, and Synedra Ulna, which is many times larger. So, besides the number of organisms, the area covered by them as well as by the irregular masses of amorphous matter, becomes of much importance.

Mr. Geo. C. Whipple proposed one fixed definite unit which should be the same for all persons, and decided upon 400 sq. microns as a convenient value for it. It was convenient, because, to facilitate the counting, the one square on the micrometer introduced by Mr. Rafter, had been first subdivided into four ¼-sq. mm., and then one of the four quarters into 25 smaller squares. The side of the smallest division is 0.1 mm. long, or 100 microns. Now one-fifth of this distance, which is 20 microns, is easily estimated by the eye, and the corresponding square, or 400 sq. microns, becomes a very convenient unit of area. This is now, and has been for a number of years, the unit used by the Boston water-works, and it appears to us in every way preferable to using exactly one-quarter of the smallest divisions, or 2,500 sq. microns, which is the unit subsequently adopted by the Massachusetts State Board of Health. The objection to the latter unit is that it is inconveniently large, the greater portion of the micro-organisms being of much smaller area.

The writer has proposed to make the 400 sq. micron unit a visible one, and relieve the mind from the burden of carrying it, by subdividing the middle one of the 25 small squares again into 25 squares. Each one of these smallest squares is 20 microns on a side, or 400 sq. microns in area, and the micro-organism or amorphous matter can be measured directly by superimposing upon it the image of this visible unit, which for convenience of having a name, might be called the Area Counting Unit. Such a micrometer is shown by Fig. 3.

In counting, a blank table modeled on the work of Mr. Rafter, Mr. Whipple and the Massachusetts State Board of Health, is necessary. The plant forms are entered under the heads of Diatomaceæ, Chlorophyceæ, Cyanophyceæ, and Fungi. The animals under the classes of Rhizopoda, Infusoria, Rotifera, and Crustacea. Other organisms, such as ova, starch grains and vegetable tissue are entered under the head of miscellaneous, and the amorphous matter is placed at the bottom of the list.

The total number of organisms under each head is summed up and the totals entered in the proper column. In making the computation, if ten squares have been counted, the total would correspond to 0.01 of a cubic centimeter. Then if 500 cu. cm. of the water has been filtered, and the washings are all contained in 5 cu. cm., the degree of concentration is 100 times. But the number observed being only 0.01 of those present in an entire cubic centimeter, the totals become in this instance, the number of organisms per cubic centimeter, and are entered without change in the column so designated.

To change the figures in this column to units per cubic centimeter, it is necessary to have recourse to a table in which is given as far as possible the average dimensions of the organisms in units. I give below such a table showing the ordinary value, in standard units, as determinted by Mr. G. C. Whipple, of some of the organisms found in the Boston water supply:*

		Diatomaceæ.			
Asterionella		0.4	Navicula	.0.2 to	1.0
Cyclotella	.0.1 to	1.0	Stephanodiscus..		1.0
Diatoma		0.3	Synedra	.0.2 to	2.5
Fragillaria		0.8	Tabellaria		0.9
Melosira		0.5			
		Desmidieæ.			
Closterium	.0.8 to	6.0	Xanthidium ...		3.0
Staurastrum		1.8	Micrasterias ...		6.0
Cosmarium		3.8			
		Chlorophyceæ.			
Coelastrum		4.0	Protococcus ...		1.2
Gonium		2.0	Raphidium		0.8
Pandorina		7.0	Scenedesmus ...		0.3
Pediastrum		5.0			
		Cyanophyceæ.			
Anabaena	.2.0 to	5.0	Coelosphaerium	.5.0 to	50.0
Chroococcus		1.3	Microcystis ...	.2.0 to	10.0
Clathrocystis ...	.10. to	100.0			
		Fungi.			
Crenothrix		2.0	Beggiatoa		2.0

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*"A Standard Unit for Micro-organisms."—"Monthly Microscopical Journal," 1894, p. 379.

Rhizopoda.

Amoeba	4.0	Difflugia	7.0
Actinophrys	3.0		

Infusoria.

Codonnelia	6.0	Peridinium	3.5
Cryptomonas	1.0	Synura	2.0 to 10.0
Dinobryon	0.5	Tintinnidium. . .	7.5
Maliomonas	1.0	Tracboeimonas. .	1.0

By way of illustration I shall select (see accompanying table.—Ed.) from the laboratory records the results of the microscopical examinations of the waters of New York city, Jersey City and Hoboken, collected on the same day, Dec. 5, 1896:

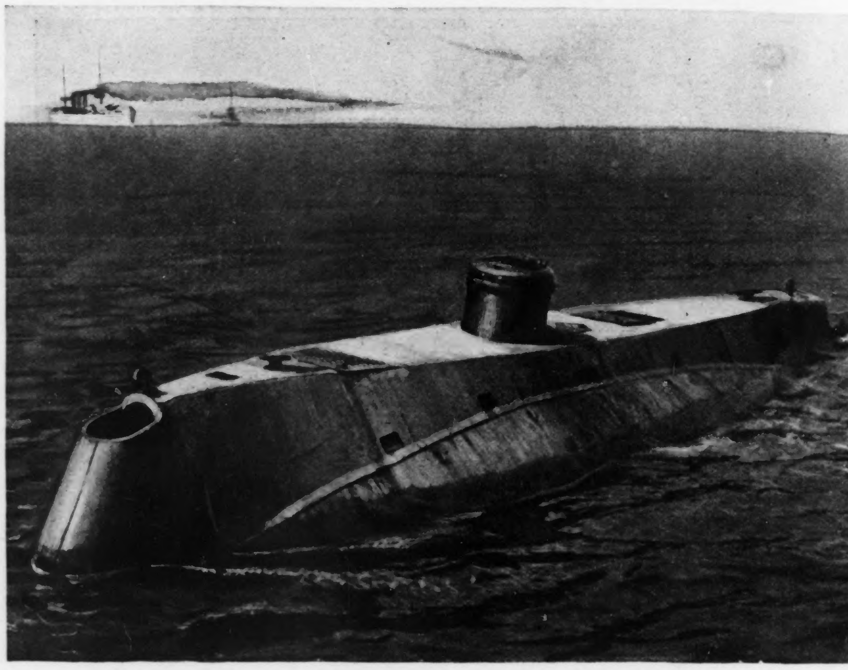
Results of Microscopical Examination of Water from the Public Supplies of New York, Jersey City and Hoboken, Collected Dec. 5, 1896.

	New York.		Jersey City.		Hoboken.	
	No., per c.c.	Units, per c.c.	No., per c.c.	Units, per c.c.	No., per c.c.	Unts, per c.c.
Asterionella	112	45	176	71	8	3
Cyclotella	7	1	2	1	1	1
Diatoma	3	2	..	..	..	..
Fragilaria	..	..	..	..	1	1
Melosira	132	66	886	443	33	17
Navicula	2	2	4	4	..	..
Synedra	14	10	4	3	13	10
Tabellaria	30	30	4	3	..	..
Nitzschia	15	15	1	1	..	..
Stephanodiscus	9	9	1	1	..	..
Cymbella	1	1	..	..	..	..
Surirella	..	..	2	10	..	..
Pleurosigma	..	..	..	..	1	3
Closterium	4	12	..	..	..	..
Pediastrum	1	10	..	..	..	..
Protococcus	8	8	2	2	..	..
Raphidium	5	5	..	..	..	..
Scenedesmus	2	2	..	..	..	..
Staurastrum	24	48	..	..	1	2
Dictyosphærium	1	5	..	..	..	..
Spirogyra	20	20	..	..	..	..
Sphærozosma	10	10	..	..	..	..
Conferva	..	..	..	..	5	5
Anaqæna	34	34	..	..	..	..
Coelosphærium	26	26	8	8	..	..
Microcystis	15	15	..	..	..	..
Oscillaria	20	20	..	..	5	5
Cladothrix	..	..	..	..	2	2
Codonella	1	5	1	5	..	..
Dinobryon	3	2	..	..	..	..
Mallomonas	2	2	..	..	..	..
Monas	..	..	1	1	..	..
Peridinium	1	5	..	..	..	..
Synura	5	5	1	1	2	2
Trachelomonas	8	8	..	..	1	1
Cryptomonas	1	1	1	1	..	..
Coleps	1	5	..	..	..	..
Nassula	1	10	1	10	..	..
Glenodinium	1	1	..	..	..	..
Vortriella	1	10	..	..	..	..
Titinnus	..	..	1	10	..	..
Anuræa	1	15	1	10	..	..
Polyarthra	1	15	..	..	..	..
Rotofer	1	10	..	..	..	..
Ova	1	10	..	..	..	..
Vegetable tissue	..	..	122	122	150	150
Total	523	500	1,224	716	221	200
Amorphous matter	250	250	330	330	230	230

THE HOLLAND SUBMARINE TORPEDO BOAT.

At the present time engines of war are exciting unusual interest in the United States, and among those which seem to have great possibilities is the latest example of the Holland submarine torpedo boats, which was lately launched and is now undergoing trial in the waters of Staten Island Sound, near New York. This boat is the sixth one invented and built by Mr. John P. Holland, of New York, since 1877. The first of these vessels was only 14 ft. long; the second, built in 1879, was 31 ft. long and 6 ft. in diameter; the third was a working model, 16½ ft. by 30 ins. in diameter; the fourth was the Zalinski boat, built at Fort Lafayette, and 40 ft. long by 8 ft. in diameter; the fifth is now under construction for the government at Baltimore, Md., and is 85 ft. long by 11½ ft. diameter, and has 168 tons displacement; and the sixth is the one here illustrated. This last boat is 53 ft. long, 10 ft. 3 ins. in diameter, and has a displacement of 75 tons.

The hull, as will be seen from the illustration, is cigar-shaped and is made of ½-in. to ⅝-in. steel plates riveted to steel frames. The top is flat, with two hatches and a central telescopic conning tower 2 ft. in diameter and 3 ft. high. Steering is done by two sets of rudders, one vertical for steering on the surface and the other horizontal for regulating the depth of submersion. There are three sources of power for propelling the boat above and below the water, expelling water, discharging torpedoes and dynamite guns, and lighting the ship internally and externally, namely, compressed air, gasoline and electricity. The most important agent is compressed air, without which it would be impossible to operate the boat under the sea. The air compressor used is an Ingersoll-Sergeant Drill Co.'s single acting compressor belt driven from a gasoline engine when the boat is on the surface, and from an electric motor switched to a storage battery when the boat is submerged. The compressor is capable of compressing air to 2,500 lbs. pressure; the diameter of the low pressure cylinder being 6 ins., and of the high pressure cylinder 1¾ ins. with 8 ins. stroke. Both cylinders are immersed in a water box, which cools the air during compression.



VIEW OF HOLLAND SUBMARINE TORPEDO BOAT RUNNING ON THE SURFACE.
John P. Holland, New York, Inventor.

Solid disks serve for fly wheels. The space occupied is only 6 ft. and 5 ins. long and 2 ft. high.

The most important use of the compressed air is for the respiration of the crew, numbering ten men. For this purpose the air is expanded through two reducing and one regulating valves and is set free at the normal atmospheric pressure. Six times the requisite volume of air is available, the surplus being used to counteract the deleterious effects of the ventilating pumps, which would produce a near approach to a vacuum, if the air supply from the tanks was interrupted in its even flow. The steering and diving rudders are operated by compressed air, which also maintains the air pressure throughout the boat to equalize the pressure of the sea when the boat is submerged. The boat is quickly submerged by admitting sea water to a series of steel tanks connected with the compressed air system. To bring the boat to the surface air is forced into the water tanks under high pressure, and as the water is expelled the boat rises swiftly to the surface. The air tanks have been tested to stand a pressure of 3,000 lbs per sq. in., and are calculated to hold out for a submergence lasting ten hours, but if the supply should fail after nine or ten hours, the tanks can be replenished by means of a tube projected to the surface as a suction pipe.

The armament of the boat consists first of an aerial torpedo ejector, at the bow, capable of throwing to a distance of one mile, a projectile weighing 180 lbs. and carrying 100 lbs. of a high explosive. Immediately under this is an expulsive tube for a Whitehead torpedo, with the usual charge of 200 lbs. of gun cotton; and pointing to the rear is a dynamite gun capable of throwing 100 lbs. of a high explosive 100 yds. or more through the water. When equipped for service the "Holland" would carry three Whitehead torpedoes, six shots for the forward gun and five for the after gun.

Thus far all the trials made with the new submarine craft have been of an experimental nature conducted by the inventor to determine the best trim and the proper amount of ballast for successful operation. In these trials the vessel has proved to be perfectly manageable when running on the surface and with only her conning tower above the water. A speed of 10 knots per hour has been made easily when running with the top awash. In diving the boat has shown herself less capable of management, as would naturally be expected, but a number of runs of from 250 yds. to one mile have been made entirely under water at speeds as high as six knots per hour, and as most of the trouble which has occurred thus far has been due to errors in the amount and location of the ballast it is reasonable to anticipate that still more successful results will follow from future trials. On April 14 it is expected that the boat will receive an official test witnessed by officials of the U. S. Navy at Washington, D. C., for which place she has already sailed.

The proprietary interest in the Holland boat is vested in the Holland Submarine Torpedo Boat Co., of New York, having a capitalization of $1,000,000. We are indebted to the Ingersoll-Sergeant Drill Co., of New York, who built the air compressor for the new boat, for the illustration which we publish herewith.

RANDOM ENGINEERING NOTES.

Shear Leg Swing Bridge.—While at Trenton, N. J., the writer had an opportunity of observing the construction and operation of a rather novel form of the common bob-tail swing bridge which was used to carry a number of the principal streets across the Delaware & Raritan Canal in that city. The accompanying sketch, Fig. 1, made from memory, indicates the construction of this bridge quite clearly. The shear leg or A-frame A is placed diagonal to the axis of the bridge and has its top guyed by wire ropes running inshore to suitable anchorages. At the top of the A-frame is a pivot carrying a loose sheave to which the rods B B are attached. The opposite ends of these rods are connected to the ends of a transverse trussed beam which carries the two sets of suspenders C C and D D. The bridge proper, which is built of simple trussed longitudinal beams, swings on a pivot casting. Concentric with this pivot a circular rack is bolted to the bottom of the bridge, which serves to operate the bridge by means of a horizontal shaft carrying the necessary spur wheels and operated by hand. One man operates the bridge, opening or closing it easily in 16 seconds. The whole construction is very simple and inexpensive and the structure would seem to be adapted to many conditions where a cheap temporary or permanent swing bridge is needed.

Trenton Iron Co., Trenton, N. J.—The works of this company occupy about 17 acres of land on the bank of the Delaware and Raritan Canal, and are devoted to the manufacture of wire, wire rope, cableways and cable haulage and transportation systems of all kinds, with their accessories. One of the specialties of this company, as many readers of Engineering News doubtless know, is its Patent Locked Wire Rope, in which by the use of special shaped wires the surface of the rope is made comparatively smooth, thus reducing the wear and giving a smooth running surface for traveling sheaves. The form of the wire used and the method of twisting them may be seen clearly from the accompanying sketch, Fig. 2. It may be noted here that the method of drawing these special shaped wires is in all respects the same as for drawing the common round wire. In making flat wires for clock springs and other purposes the process of manufacture is simply to roll a round drawn wire flat, this rolling being, of course, done cold. Recently the company has been devoting considerable attention to the development of cableway systems having an electric traveling and hoisting carriages, in which the electric power is conveyed to the carriage motor direct, the cable simply acting as a track, hoisting ropes and all other accessories of the ordinary hoisting cableway being done away with. In a future issue we expect to describe some examples of the company's work in this direction more in detail. One of the features of the plant which was noticed particularly was the extensive use of electric trolley tramways for transporting material in and about the different shop buildings.

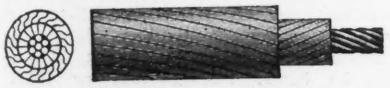


Fig. 2.—Patent Locked Wire Rope. Trenton Iron Co., Trenton, N. J.

Pennsylvania Ave. Subway, Philadelphia, Pa.—Reports of rapid progress with this immense work led to a trip along the whole line of excavation from the Philadelphia & Reading Terminal Station, at 12th and Market Sts., to the end of the tunnel in Fairmount Park. As a full description of the main structural features was given in Engineering News of April 16, 1896, these matters will not be touched upon here. Practically all of the masonry work, with the exception of the brick roof arch for the tunnel, has been completed, and the contractors are now busy with the bridge work and excavation. As originally planned, the method of work was to build the retaining walls in trenches and then to excavate the earth core between them. At the crossing of the subway at Broad St., considerable progress had been made upon the bridge work. Here a system of plate girder spans carry a Z-bar and plate, rectangular trough floor 113 ft. wide over all. Practically the same type of bridge will be used for all of the street crossings.

The great problem which had to be met in designing this work was to preserve the business of the railway, with the large manufactories like the Baldwin Locomotive Works; Wm. Sellers & Co.; Bement, Miles & Co., and others whose works were situated on both sides of its tracks. Under the old conditions shipment was made to and from these works by the easy means of surface sidetracks and switches, but the lowering of all tracks about 25 ft. below the street level changed these conditions of access very materially. The solution adopted was to build inclines from the subway level to the street level at each of these factories, or, where inclines were not possible, to construct hydraulic lifts. The importance of this feature of the new subway was quite clearly indicated in the article published in Engineering News of April 16, 1896, but it becomes still more impressive in an examination of the actual construction, even in its partially completed state. Each incline consists of two parallel retaining walls of rubble masonry, gradually increasing in height from the lower to the upper end, filled between with earth. Generally these inclines are for a single track only. The hydraulic lifts are capable of lifting and lowering one loaded freight car between the subway and surface levels.

This one feature of the Pennsylvania Ave. subway work makes prominent a fact which is not always remembered to the credit of the railways when the question of depressing or elevating their tracks in city streets comes up for solution. It is a simple matter to demand that railways shall remove their tracks from the street level, and usually it is easy enough for the railways to construct a subway or elevated structure which will accomplish this by itself, but to accomplish this without forfeiting valuable business connections is a far more difficult problem. If any engineer needs to be impressed with this truth he has only to study the ingenuity displayed and observe the expense undertaken to solve satisfactorily this feature in the Pennsylvania Ave. subway work. It will repay even more close attention than will the more purely structural features of the work.

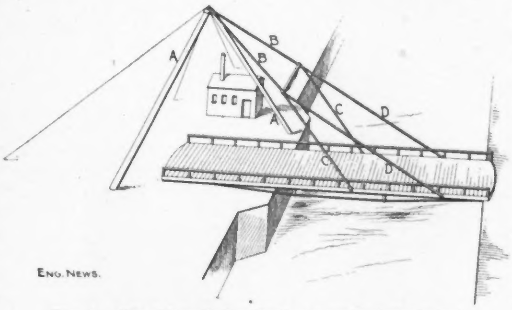


Fig. 1.—Shear Leg Swing Bridge Over Delaware and Raritan Canal, Trenton, N. J.

The chief difficulties in the masonry construction, it was stated by the engineer, arose from the necessity of underpinning and supporting the building walls adjacent to the excavation. In many instances the retaining walls for the subway were close to the building walls, and as they always extended below the old building foundations, these had to be reconstructed. In other cases the entire adjacent building wall was torn down and rebuilt.

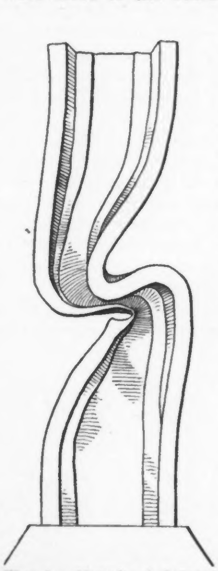


Fig. 3.—Sketch of Column Distorted by Heat and Impact in Warehouse Fire at Pittsburg, Pa.

A Novel Instance of Column Distortion.—Having in mind the destructive warehouse fire of the Chautauqua Lake Ice Co., which had occurred a few days previous, the writer, while in Pittsburg, Pa., took an opportunity to examine the ruins in a superficial manner, and in doing this observed a remarkable case of column distortion. As stated in the description of this fire, published in Engineering News of Feb. 17, 1898, the second floor of this building and the columns below were steel, the floor arches being brick, and the column protection of clay tile. These columns were made up of Z-bars and plates and were about 15-in. columns. The particular column which attracted attention had assumed the form indicated roughly by the accompanying sketch; that is, it had buckled and shortened up about 1 ft., causing a plainly observable depression or dishing of the floor above. The distortion or bending of the column laterally was very small, the shaft above and below the immediate point of buckling being nearly in its original position. Adjacent columns, though bent, showed no such appearance of buckling, and it is, perhaps, fair to presume that this particular column, heated by the fierce fire, must have sustained a direct blow from falling debris in the collapse of the floors above. This fact, however, the writer was unable to verify, as there was no access to the floor above.

The incident, however, is most interesting for the manner in which it brings out the reliability of steel as a structural material. Despite its severe distortion, this column still remained in position, and from all appearances was still in condition to carry a pretty heavy load. In the same place a cast-iron column would probably have failed entirely by breaking in two. This fact of toughness was still further evidenced by a close examination of the distorted plates and flanges, which, so far as could be observed, did not show a single crack, though in some places they were bent double. Another noticeable feature was that none of the rivets had been twisted or sheared off by the distortion, though this was sufficient to cause the edges of riveted plates to spread apart between the rivets far enough for the finger to be inserted, while directly at the rivets the two plates were still in contact.

THE COMMERCIAL MANUFACTURE OF LIQUID AIR.

General attention has been recently attracted to the subject of liquid air by more or less inaccurate newspaper accounts of the work of Mr. Chas. E. Tripler, of New York city. Although air has been liquefied frequently in the past, first by Faraday, who succeeded in securing very small quantities in closed tubes, by Dewar in 1893, and by many other physical investigators, it has only been possible to produce it in small quantities and at enormous cost. The most successful experimenters, until recently, were Dewar and Fleming, who employed liquid air in a series of experiments to determine the electrical resistances of various materials at low temperatures. It is stated that in their experiments it cost £500 or $2,500 for a quantity ranging from a cupful to a quart.

While Mr. Tripler has been experimenting along various lines some 20 years it was not until 1889 that his efforts were turned especially towards the production of cold and the liquefaction of gases. His experiments continued, and during the winter of 1890-91 he succeeded in developing the present form of liquefier which has made it possible to produce liquid air on such a scale and at such a low cost, comparatively speaking, as to attract universal attention, and to warrant the hope that liquid air may become a cheap commodity in the near future. In speaking of his work during this experimental stage, Mr. Tripler said that he had succeeded in liquefying all the well-known gases except hydrogen, which he further said could now be done. Continuing, he estimated that his investigations had cost $30,000, Dewar, of England, had expended fully $50,000 along the same line, and that all in all it was safe to say that about $1,000,000 had been spent by different investigators in liquefying gases.

The following brief description of the apparatus located at 121 W. 89th st., New York city, is based on actual observation by a member of the staff of this journal, and upon statements made by Mr. Tripler and his two engineering assistants, Messrs. W. H. Dickerson and Marcus Fredericks. To all outward appearances the process is simplicity itself, and indeed, aside from the special piece of apparatus termed by the inventor a "liquefier" is an ordinary compressed air plant. The laboratory, an interior view of which is shown in Fig. 1, contains a boiler supplying steam at about 85 lbs. pressure, to a Norwalk straight line compressor rated at 90 HP. at 150 revolutions per minute, although ordinarily the speed is considerably below this, ranging in the vicinity of 100. The steam cylinder is 16 × 16 ins. The three air cylinders are arranged tandem, with the pistons all on the same rod. All of them are cooled by water jackets. The low pressure cylinder is $10\frac{1}{2}$ ins. in diameter, is double acting and raises the pressure from that of the outside atmosphere to between 55 and 65 lbs. The intermediate is single acting, $6\frac{7}{8}$ ins. in diameter and compresses to between 350 and 400 lbs. The high pressure cylinder is $2\frac{5}{8}$ ins. in diameter, single acting, and delivers the air at a pressure ranging rom 2,000 to 2,500 lbs. per sq. in., and although it is claimed that liquid air can be produced with a pressure as low as 1,500 lbs., the gage usually shows from 2,200 to 2,300 lbs.

To insure clean air the compressor takes its supply from the roof through a dust separator, Fig. 2, an arrangement of baffle plates over which water is constantly trickling. From the high pressure cylinder the air passes to a cooling tank which is simply a spiral coil of copper pipe immersed in a tank of running water. In this way the heat stored in the air during compression is removed and the air passes on at the temperature of the cooling water. Emerging from the cooler the air next passes to a separator whose function is the removal of the moisture originally in the air and any that may have been absorbed up to this point, either in the duster or elsewhere in the apparatus. Aside from being made very heavy to withstand the high pressure this separator differs little from some common forms of steam separators. The next piece of apparatus is termed the "Liquefier," and it is in this that the actual work of transforming the now cool air at a pressure of about 2,200 lbs. per sq. in. into liquid air at atmospheric pressure and a temperature of about 312° F. below zero, is performed. In the present laboratory there are two of these "liquefiers" differing only in constructional detail, the principle being the same in both. At present, for business reasons, Mr. Tripler prefers not to publish their actual details. The action, however, is about as follows: The comparatively cool air under pressure enters at one end of the liquefier, Fig. 3 (which is simply a diagram drawing), and passes through an arrangement of coils of pipe towards the other end, where a peculiar expansion valve allows a certain amount of air to escape into the surrounding casing. The expanding air passes backward in an opposite direction to the entering air. In passing in and about the coils this expanding air absorbs heat from the incoming air, greatly reducing its temperature. The process may be spoken of as regenerative or accumulative, since the more the entering air is cold the greater the cooling effect of the expanding air circulating about the containing coils. This accumulative action continues reducing the temperature of the air more and more until finally its critical temperature (given as — 220° F. by Dewar) is reached and a portion of the air collects at the bottom of the liquefier in the form of a fluid, while the remainder passes on expanding and performing its share of the cooling. Outwardly these liquefiers in no way suggest their operation, resembling as they do sections of covered steam pipe. This idea is enhanced at times when the valve at the bottom is opened and the liquid air which runs out is accompanied by a cloud of semi-liquid or vaporous air resembling the cloud of water vapor about an open steam valve.

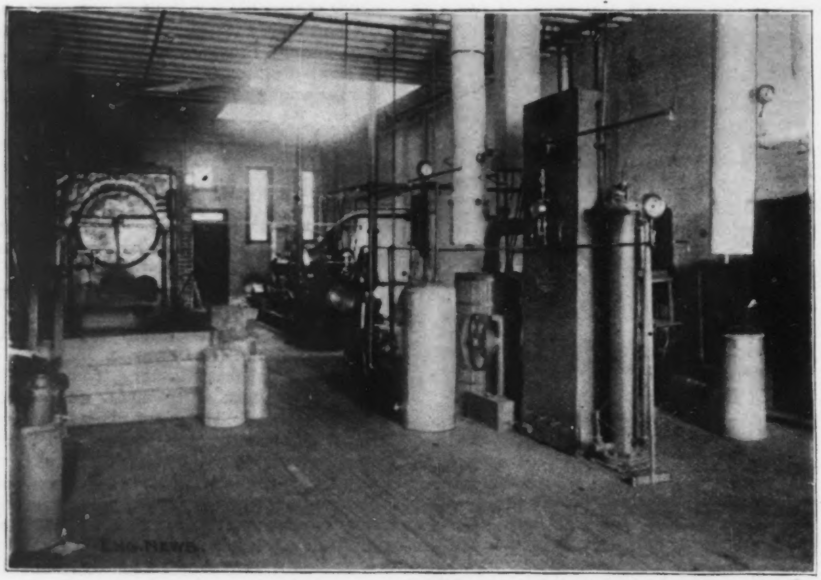


FIG. 1.—INTERIOR OF THE LABORATORY OF MR. CHAS. E. TRIPLER, NEW YORK CITY.

As at present operated the plant can produce between three and four gallons per hour with no apparent effort on the part of either boiler or compressor, and Mr. Tripler states that he has ample power to produce a much larger quantity. So far as known, no economy tests or cost runs have been made. Experiments along the same line are being conducted by a German investigator, Linde, the inventor of the well-known refrigerating machine. These, however, Mr. Tripler states, are a direct infringement on his own patents. A description of the Linde method was recently given by Prof. J. A. Ewing before the Society of Arts, London, and abstracted by "Engineering" in its issue of March 11. Linde causes the air, which has undergone cooling by being made to flow through a constricted orifice, to pass back through a long pipe surrounding a second pipe conveying the unexpanded air to the orifice. Hence, when the apparatus has been working some time (20 minutes in the Tripler apparatus), the unexpanded air reaches the orifice at a lower temperature than the atmosphere, and is further cooled upon its escape and expansion. This again still further cools the incoming air to be expanded, and an accumulative effect is thus attained which rapidly reduces the temperature at the point of escape below the critical point. It is thus seen that in both cases currents of air pass in opposite directions, the entering air constantly losing heat to a minimum point, about — 140° C., while the expanding air is constantly increasing in temperature as it passes towards the waste orifice, where it passes out at a temperature slightly below that of the surrounding atmosphere. As the fall of temperature at the orifice may be taken as proportional to the difference of pressures at that point, and the work done by the compressor proportional to the ratios of the two pressures, and as the actual output of Mr. Tripler's apparatus and the calculated output of Linde's new liquefier are about the same, it may be of interest to note that the latter uses a difference of pressure of about 2,205 lbs. per sq. in., or 2,940 lbs. on one side of the expansion valve and 735 lbs. per sq. in. on the other.

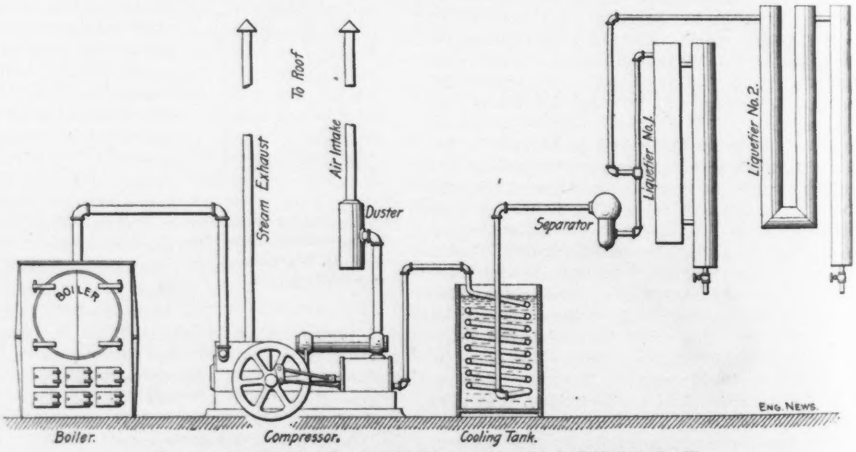


FIG. 2.—DIAGRAM OF APPARATUS USED FOR LIQUEFYING AIR.

In a letter printed in London "Engineering" (March 25, 1898), Mr. W. Hampson makes a comparison between the small 3-HP. machine employed by Dr. Linde and an air-liquefying apparatus constructed by himself for the Brins' Oxygen Works, 69 Horseferry-road, Westminster, S. W., England. The machines, while differing in detail, employ the same method of intensifying refrigeration. The comparison is as follows, L. meaning Dr. Linde's apparatus, as described in "The Engineer," Nov. 20, 1896, and H. that of Mr. Hampson:

	L.	H.
Weight of coils	132 lbs.	14½ lbs.
Time to liquefy air	2 hrs.	16 mins.
Quantity of liquid air pr hr	0.9 liter.	1.2 liter.
Air compressed per hr.....	22 cu. m.	13⅔ cu. m.
Liquefied	3.8%	6.6%
Compression of air	190 atmos.	120 atmos.
Time for liquefaction with 130 atmospheres.......	.....	10 mins.
Preliminary refrigeration removing moisture ...	Ice and salt[1]	None used.[2]
Means of clearing liquid from impurieies.	Filtration.	None required.
Time for liquefaction with with preliminary cooling by carbonic acid...	Nearly 1 hr.	1 min.
Liquid oxygen from 1 cylinder of oxygen at 120 atmos. after using carbonic acid	Not obtnble.	125 cu. cm.
Size and portability.......	Stands on 6 sq. ft., and heavy.	Stands on 1 sq. ft. of floor, and easily carried.
Convenience in working...	3 gages. 3 valves.	1 gage. 1 valve.
HP. hrs. used from the start to produce 0.75-liter of liquid air.....	9	3

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[1] Possibly — 20° C.

[2] Initial temperature + 20° C.

Comparing the quantities of liquid produced in the case of Mr. Tripler's apparatus and the new Linde machine, and using Prof. Ewing's figures for the latter, now being constructed for the Rhenania Chemical Works at Aix-la-Chapelle, 50 liters, 13.2 gallons, or 105.6 lbs., of liquid air per hour, requiring for its production 120 HP., or about 0.88 lbs. per HP. hour. Considering the dimensions of the American plant, we have 44.5 HP. producing 4 gallons, or 32.6 lbs. per hour, or 0.73 lbs. per HP. hour. It is thus evident that the two systems are practically identical.

44.5 HP. would, in the case of a simple non-condensing engine similar to the one used require about 4 lbs. of coal per HP. hour. Selecting a period of 10 hours to allow the plant to settle down to steady running we have:

45 × 4 × 10 = 1,800 lbs. of coal at $3 per ton, or $2.70; one engineer at $2.50 per day, and one fireman at $1.75; a total of $5.95 as the present cost of producing 40 gallons, or 326 lbs. of liquid air. This gives 1.84 cts. per lb., or 14.3 cts. per gallon, not counting interest, rent, insurance, cost of cooling or feed water, depreciation, etc., all of which are somewhat variable, and are present in any refrigerating plant. Average practice of such plants using ammonia compression gives about 6 lbs. of ice per pound of fuel consumed against about ¼ lb. of liquid air per lb. of fuel. It should, however, be borne in mind that liquid air has a far greater refrigerating power than ice, and is at present in an experimental state, while ammonia refrigeration apparatus stands to-day as the result of a great amount of study and expensive experi-

ment. The properties of liquid air are not fully known. The critical temperature of air, according to Dewar, is about — 220° F. In various experiments made by Mr. Tripler the temperatures reached at times have been estimated as low as — 400° F., while the liquid air in quantity may be regarded as standing at about — 312° F. or 344° below the freezing point of water. On evaporation of the liquid, which occurs continually at temperatures far below the freezing point of water, the nitrogen escapes first, so that the percentage of oxygen remaining in the liquid progressively increases. When 60% of the liquid has evaporated, that remaining has 50% of oxygen, and when 95% has evaporated the residue still contains 90% of the oxygen present in the original solution, and consists, therefore, of 88% of oxygen, and 12% of nitrogen, still present as a liquid, and carbonic acid gas as a solid in minute white particles which can be filtered off, but, of course, rapidly evaporates, leaving nothing upon the paper after a few moments. If the evaporation of the liquid is assisted slightly, both the nitrogen and oxygen will pass off, leaving the carbonic acid gas, as before, in the form of snow.

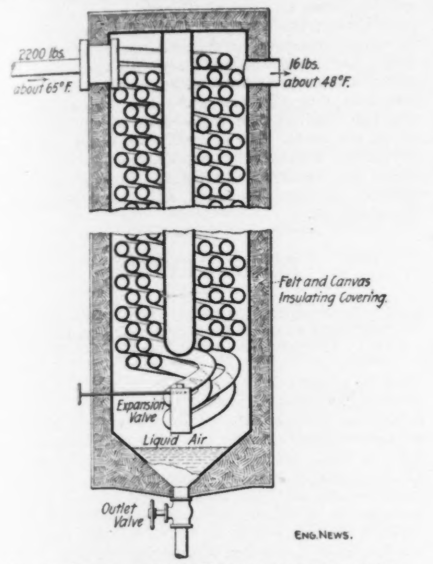

Fig. 3.—Diagram Illustrating the Operation of the Tripler Liquefier.

The filtrate when enclosed in a "vacuum bulb" (a bulb placed inside of another bulb from which the air is exhausted to about $\frac{1}{1,000,000}$ the ordinary density) has a peculiar faint cobalt-blue tinge. It is difficult to get this air in a quiescent state otherwise, as the moisture in the atmosphere persists in condensing upon the outside of the containing vessel in the form of snow, while the warmth of the room and surrounding objects keeps the liquid constantly boiling and bubbling. The particles of solidified carbonic acid also add to the difficulty of seeing it as it really is. Under ordinary conditions, no better description can be found than to compare it in color to unfiltered lime water, and to say that it pours much like vichy from a siphon. This may give the idea that it is very unstable, but, on the contrary, everything considered, it is just the opposite. It is, however, quite essential to carefully insulate the liquid from heat, and glass or tin vessels well wrapped in thick, soft felt packing afford the best means of carrying or temporary storage. In such reservoirs liquid air has been transported in quantities varying from 4 to 10 gallons, from New York to Lynn, Mass., Washington, D. C., and Philadelphia several times, where fully a barrel of the liquid has been used for experimental and lecture purposes. While no actual experiments have been made to determine the life of the liquid, it is quite certain that when carefully insulated one gallon under ordinary fall, winter or spring conditions will last about five hours; this of course under atmospheric pressure in open vessels.

Of the possible uses one has been mentioned—refrigeration; another is that of an explosive agent for blasting purposes. If liquid air containing 50% or more of oxygen is mixed with powdered charcoal, it can be fired with a detonator and gives explosive effects comparable with those of dynamite. Experiments have been made in Munich and practical tests on a large scale have been conducted for some months at a coal mine at Penzburg, near Munich, which indicate its usefulness in this direction. Its chief advantage as an explosive is its cheapness; and the fact that its power gradually disappears is also an added advantage in the case of hanging fire, or "missed holes." On the other hand, unless a large amount of blasting is to be done at one place, it is neither convenient nor economical.

The mention of a few experiments illustrating the intense cold of liquid air may not be out of place. Fig. 4 illustrates the condensation of ordinary air by boiling liquid air in a vacuum. In this experiment a large test tube is partially filled with liquid air and attached to a vacuum pump. As soon as the gage records about 15 ins., and from that on up to 25 ins., which is as high as the exhaustion was carried, a heavy white vapor formed about the outside of the test tube and flowed down the sides towards the lower end where the vapor turned into drops which could be collected. These drops were not moisture from the air, as the moisture collected on the tube as snow, but were drops of condensed air formed by the rapid evaporation of the already intensely cold air in the tube which reduced the temperature of the outside air surrounding the tube far below the critical temperature of the atmosphere. Mercury and alcohol are frozen with the greatest ease; a soft rubber ball when immersed for a few seconds becomes as hard and brittle as porcelain, while various metals lose their elasticity and crumble, or break under a blow like glass or highly tempered steel. A jet of steam allowed to pass into liquid air changes almost instantly into ice, meaning that a temperature change of 1,636° F. occurs in a fraction of a second, i. e., 967 heat units necessary to convert water to steam are returned in condensing the steam to water at 212° F.; the 180 units in reducing the temperature to the freezing point, 144 units in solidifying, 32 units to reduce the temperature to zero, and a further reduction of 312° due to the cooling property of the liquid air, make the total mentioned. If air in this fluid condition is poured over ice the air boils furiously and rapidly becomes vapor; with a difference in temperature of 344°, the ice is hot in comparison with the liquid air. On the other hand, if the liquid air is thrown into boiling water the latter becomes ice at once. In the course of a lecture delivered on March 26, before the Brooklyn Institute, by Prof. W. C. Peckham, of Adelphi College, Brooklyn, N. Y., the effect of liquid air upon the tensile strength of wire was tested, and in a general way it was shown that such strength was increased by cooling. It was also shown, in a popular way, that the electric resistance of certain materials decreased, and that liquid air was an insulator rather than a conductor. These observations are not new and simply substantiate statements made by Dewar several years ago.

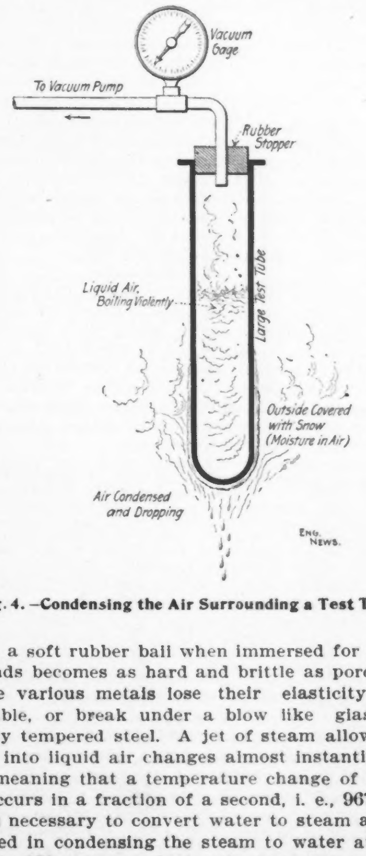

Fig. 4.—Condensing the Air Surrounding a Test Tube.

The question, "What is the utility of liquid air, and what part can it or will it pay in the arts? is one that cannot be answered at present; there is little doubt, however, but that when further experiments have perfected machinery for its production, and its cost is small, it may play a very important part in manufacture and medicine, as a refrigerating material, a means of storing energy, for use in surgical work, and in many other directions. At present, however, owing to its considerable cost, its uses are limited to a somewhat small field, comparable to that of aluminum a few years ago.

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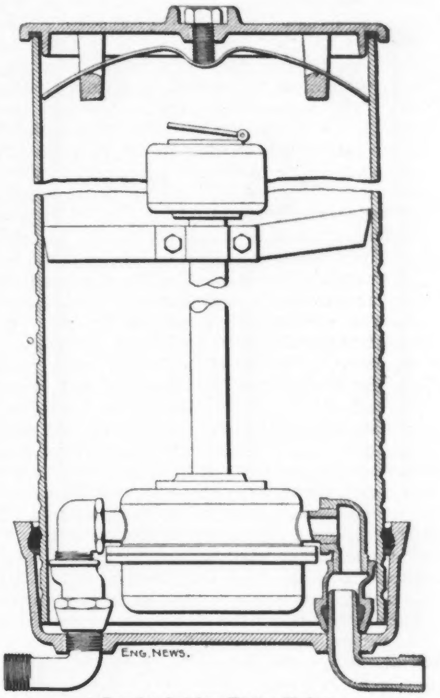
THE HOPPES METER BOX.



A Box for Setting Water Meters.
The Trump Manufacturing Co., Springfield, O., Makers.

A new meter box, said to be in use in connection with more than 50 water-works plants, is shown by the accompanying illustration. The box proper is composed of a cylindrical shell, top and bottom cap. The bottom cap is leaded on. Some adjustment in length can be effected by the telescopic joint, and the cylinder can be shortened by cutting off a piece, if desired. The top cap is made water-tight by a groove and asbestos rope, into which the shell fits. It is held down by means of the cap bolt and bow spring, shown in the illustration.

The connections between the meter and the service pipe are plainly shown in the cut. The sockets into which the vertical nipples fit are provided with rubber packing rings. To prevent lifting of the meter or moving out of center a cross-bar with a joint is provided just below the dial box. The offsets on the coupling between the nipples and the elbows screwing onto the meter spuds affords a means for adjusting the connections to different lengths of meters. The boxes are made by the Trump Manufacturing Co., of Springfield, O.

* * *

NOTES FROM THE ENGINEERING SCHOOLS.

Purdue University.—The Richmond Locomotive Works has presented to the university a full-sized model of the front end of a 2-cylinder compound locomotive, the intercepting valve of which is sectioned so that its operation may be seen. The cylinders are 20 and 30 ins. diameter, and the saddle is surmounted by a full-sized smoke-box and stack. The model is the same one that was exhibited at the annual meeting of the Master Mechanics' Association at Old Point Comfort last summer. A new building is being erected for an addition to the present engineering laboratory. It is to be known as the railway laboratory, and is the last of the series or seven engineering laboratories which were provided for in the original plan of the present group. Each of the seven laboratory rooms has a floor space of about 5,000 sq. ft. They are: A wood-working room, foundry, forge-room, machine-room, steam engineering laboratory, locomotive laboratory, and railway laboratory. The last-named is to be occupied by apparatus for testing the strength of materials and by the Brake-Shoe Testing Machine, of the American Master Car Builders' Association, which is soon to be deposited at Purdue. Other apparatus for engineering research along lines of interest to car builders and to superintendents of motive power will be given a place in this building.

New York University.—The Engineering Department announces the opening of a testing laboratory for commercial work at the new quarters of the University, on Morris Heights. The laboratory is equipped with the most modern machinery. Tension, compression and bending tests can be made from a 200,000-lb. limit down to the more delicate requirements of cement testing. Torsion tests are made on a machine newly devised by Tinius Olsen, of Philadelphia. This machine can handle bars up to 2½ ins. diameter under a maximum load of 230,000 inch-pounds.

The increased machinery needed for the new University buildings affords opportunity for tests of engines, boilers, dynamos, pumps, etc. Testing is also done from time to time on some of the large plants in and about the city, and reports are published regarding their economical operation.

The New York University executive committee has received a gift of $10,000 from Miss Helen Gould for increasing the endowment of the Engineering school. A year ago Miss Gould made another gift to the school, but this latest one is entirely separate from the scholarship which she founded then. The total amounts contributed by Miss Gould which are available for the School of Engineering now amount to nearly $60,000.

Cornell University.—Governor Black has signed a bill which authorizes the University to establish branch departments in any part of the state. This bill has special application to the establishment by the University of a school of forestry in the Adirondacks, for which an appropriation has recently been made by the legislature. The trustees of the University have appropriated $40,000 to the extension and equipment of the chemical laboratory. The new addition will be used chiefly for assaying and inorganic and physical chemistry.

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PROPOSED BRIDGE OVER BURNETT RIVER, BUNDABERG, QUEENSLAND, AUSTRALIA.

The Department of Public Works of Queensland has drawn up plans and received tenders for a bridge over the Burnett River, at Bundaberg. This bridge is described as follows: It will consist of eight 170-ft. spans of steel girders, carried upon two concrete abutments and seven piers, each of these made up of two cast-iron cylinders. The girders are of the hog-back-lattice type, 22 ft. deep at center and 10 ft. deep at ends, and braced overhead for about half the length. The roadway will be 24 ft. wide between centers of girders, and 33 ft. above ordinary spring tides, and 5¾ ft. above the flood level of 1890. The one 6-ft. footway on downstream side will be carried on steel cantilevers. The total weight of steel and iron used, including piers and superstructure, will be 2,065 tons, the whole of which is to be made in the colony.

The pier cylinders will be sunk to rock, from 54 to 65 ft. below high water, and they will be 7 ft. in diameter from bottom to high-water level, and reduced to 5 ft. above the latter level by a molded base casting. All of these cylinders will be filled with Portland cement concrete. Wrought-iron, riveted diaphragm bracing, of great strength, will connect the two cylinders in any pier; and heavy iron spandrels will further brace them below high water level. The bridge floor will be made of Lindsay steel troughs, filled with cement concrete, and upon this will be tarred metalling for a roadway. The 6-ft. footway will be built of corrugated steel plates, covered with cement and coke concrete and coated with asphalt. The parapet rail will be wrought iron, with a hardwood hand rail. The bridge and its approaches are to be lighted with gas, and on each span there will be two overhead lamps, and on each abutment four large lamps, all fitted with Welsbach burners. The earthwork approaches, including paving and fencing, are included in the contract.

The five tenders received, and the engineer's estimate, are as follows:

A. Ovrend & Co., Brisbane	£74,869	13	1
G. C. Willcocks, Brisbane	71,599	11	7
W. M. Thompson & Co., Brisbane	69,693	2	0
Murphy, Kirk, Hopkins & Co., Brisbane	68,334	15	0
H. McKenzie & Sons, Melbourne	61,973	6	0
J. McCormick & Son, Brisbane (accepted)	59,070	16	0
Engineer's estimate	62,740	15	3

For the above information we are indebted to the courtesy of Mr. Alfred B. Brady, M. Inst. C. E., Government Engineer for Bridges, of Queensland.

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THE LORAIN STEEL CO. is the name of a new concern which has been formed to acquire the property of the Johnson Co., at Lorain, O. The capital stock is $9,000,000, of which one-third is cumulative preferred and two-thirds common stock. $5,000,000 first mortgage 5% gold bonds will be issued to provide capital for the erection of two blast furnaces and a coke oven plant, work upon which has already been begun. The Johnson Co. will continue to operate the present plant until Dec. 31, 1898, when it will be turned over to the Lorain Steel Co.

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THE PANAMA MANGANESE MINE, says the San Francisco "Chronicle," is a valuable deposit of this mineral opened up within the last two years by Baltimore capitalists. The mine is situated on the Atlantic coast of the U. S. of Colombia, about 40 miles north of Colon. It is worked by a company with $200,000 capital, in which the chief stockholders are Mr. John K. Cowen, of the B. & O. Railway Co.; Mr. F. W. Wood, President of the Maryland Steel Co., and Mr. Henry Parr, of Baltimore. It is easily mined, and is carried by a cableway to the foot of the mountains and by nine miles of railway to the shipping port of Nombre de Dios. Within the last 18 months the company is said to have shipped 24,000 tons to the United States. According to the "Chronicle," the cost is about $4.00 per ton landed in Baltimore, where it is worth from $14 to $15 per ton, according to quality. Mr. E. B. Williams, of Connecticut, is in charge of the mines and employs about 300 men.

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COAL PRODUCT OF THE UNITED STATES for 1897, according to a statement made by Mr. E. W. Parker, of the U. S. Geological Survey, amounted to approximately 198,250,000 short tons, valued at $198,100,000, or a trifle less than $1 per ton. During 1896, 191,980,000 tons were mined. The production of hard coal in Pennsylvania decreased from 54,346,081 tons in 1896 to 52,122,408 in 1897, the average price per short ton at the mines being $1.65.

"The Journal of Commerce" says:

> The fact that the bituminous production should have shown an increase of 8,500,000 tons in spite of the prolonged strike in the competitive fields of Pennsylvania, Ohio, West Virginia, Indiana and Illinois (four of them being the largest coal producing states, aggregating nearly 100,000,000 tons, or more than two-thirds of the entire output) may be taken as an evidence of the wonderful capacity of our developed bituminous mines.

The combined product of hard and soft coal from Pennsylvania amounted to 106,000,000 short tons, or nearly 54% of the total yearly output of both kinds, and about 37% of the total output of bituminous, or 54,000,000 tons. Illinois produced 20,000,000; West Virginia comes third, with something less, followed by Ohio, Alabama, Iowa, Maryland and Indiana, in the order named.

◆

A DEPARTMENT OF FORESTRY in the Ohio State University is being proposed, as a substitute for the State Forestry Bureau, which was established in 1885, but is said to have done little or no work of any value during the past few years. A bill with this purpose has been introduced in the State legislature. The department is to have one director, who will not only have educational duties, but will have charge of certain of the University lands which can be utilized for tree culture.

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THE STATE CAPITOL OF NEW YORK, authorized in 1863, and commenced in 1867, has cost to date $23,769,410, including $533,449 for land. The State Capitol of Connecticut, at Hartford, commenced about the same time, cost only $4,000,000 for a very handsome and commodious building; and the building committee handed back to the State some few thousands of the original appropriation on the completion of the work. Rhode Island, on the other hand, in 1892, voted $1,500,000 for a new capitol; added $800,000 to this amount within a few weeks, and it will cost at least $3,000,000 when completed. Pennsylvania is to build a new capitol, and is apparently preparing itself for an experience similar to the last.

THE COMPULSORY ADOPTION OF THE METRIC System of Weights and Measures was advocated by a special committee of the National Association of Manufacturers, at its third annual meeting in New York. The committee goes over familiar ground in arguing for the adoption of the metric system, as being in accordance with our money system and as simplifying many problems of commerce. Statistics are given showing a population of over 423,500,000 now employing metric measures. The committee finally resolved, that as the eventual adoption of this system by England, Canada and the United States is inevitable, the Association should strongly recommend legislative enactment to that end, taking effect on Jan. 1, 1901. The exceptions made are: In the survey of public lands and in existing dies, gages, drawings, etc., which cost more than $10, and which may be used until worn out, but must be then replaced by others conforming to metric standards. The committee reporting was made up of Albert Herbert, Boston; Charles A. Schieren, ex-Mayor of Brooklyn; Charles A. Harding, Philadelphia; Andrew Carnegie, Pittsburg, and Henry Fairbanks, St. Johnsbury, Vt.

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BOOK REVIEWS.

SANITARY ENGINEERING.—By Wm. Paul Gerhard, C.E., Consulting Engineer for Sanitary Works, etc. etc. New York: Published by the Author, 36 Union Square, East. Cloth; 5 × 7½ ins.; pp. 132. $1.25.

This is a reprint of an address by the author delivered before the Franklin Institute, Feb. 15, 1895. It reviews briefly, the various duties of the sanitary engineer, and indicates the broad, general principles to be followed in performing them. Besides this, it gives many good suggestions on a variety of matters pertaining to the subject. As might be expected, the book is semi-popular rather than technical in character, but engineers turning from other branches of engineering to sanitation, and students also, will find much instruction in this little volume.

STREET CLEANING and The Disposal of a City's Wastes: Methods and Results and the Effect upon Public Health, Public Morals and Municipal Prosperity. By Geo. E. Waring, Jr., (late) Commissioner of Street Cleaning in the City of New York. New York: Doubleday & McClure. Pasteboard; 5 × 7 ins.; pp. 230; 30 illustrations.

The greater part of this interesting little book is devoted to an account of the marvelous changes effected in the condition of the streets of New York under the author's administration as Commissioner of Street Cleaning and the equipment and organization employed to effect that change. The duties of the department are broader than its name indicates, including, besides street sweeping, the collection and disposal of ashes, garbage, paper, old bottles, cans, leather and rubber goods; in fact, nearly all the motley cast-off matter incident to a great city, with the exception of sewage and of stable manure. All these wastes are discussed in the book, especial attention being given to the recovery of everything of commercial value.

Garbage is here used to denote only vegetable and animal kitchen wastes. The final disposal of this by burning, and more particularly by processes designed to recover salable grease and fertilizing material in the garbage, is discussed at some length.

Prominence is given to the methods employed in removing snow, of which work Colonel Waring did far more than any of his predecessors, greatly to the increased comfort, convenience and healthfulness of the citizens of New York; as can be said of all the work of his department.

An interesting section is also given describing the organization and work of the juvenile aid societies. These bands of school and other children have taken a very active and helpful part in preventing the littering of streets with rubbish., They make individual protests against such action, pick up paper, banana peels and other litter, and carry into their homes new ideas and standards regarding the appearance of the streets which doubtless will go far towards developing a public sentiment that will not tolerate a return to the dirty streets of the past. This section of the book was written by one of Colonel Waring's assistants, and several other sections were contributed by other assistants.

Although this book is confined to New York, among American municipalities, about one-third of it is devoted to the collection and disposal of street dirt, snow, garbage, ashes and other refuse in European cities. This part of the book was prepared from observations made by the author on a special trip abroad, and contains much that is of interest. The principal cities included in this section are Vienna, Buda Pesth, Berlin, Paris, London, Birmingham and Brussels. Perhaps the greatest lesson to be drawn from the accounts of this class of work in foreign cities is the advantage of carrying it out on a business rather than a political basis. In fact, this is the greatest lesson of the whole book.

The volume presents an unusually fine typographical appearance. The illustrations are mostly fair and some are excellent, but a few of the half-tone views are poor. The book, like all of Colonel Waring's writings, is very readable. If every city official in anyway responsible for street cleaning, garbage and refuse disposal, would read the book, and profit by it, civilization, health and comfort would be advanced to a marked degree.