ENGINEERING NEWS AND AMERICAN RAILWAY JOURNAL.

VOL. XLI. No. 10.

TABLE OF CONTENTS.

THE RESTORATION OF THE HARBOR OF VICKSBURG, Miss., destroyed by the cut-off of 1876 across the base of the bend at this point, is proposed in connection with the formation of a new outlet into the Mississippi River for the various streams forming the present Yazoo River system. This work is under the charge of Major J. H. Willard, Engineer Corps, U. S. A., and proposals were invited on Feb. 27 for removing about 7,500,000 cu. yds. of earth under a continuous contract. The proposed cut is about 9.3 miles long, and would start at the junction of the Yazoo with a former bend in the Mississippi River, and follow the "wrong end of the Old River"; cut through a neck of low land to Lake Centennial and across this lake, around the head of De Soto Island, to the former Mississippi River channel in front of Vicksburg, and down this old channel to deep water at Kleinston Landing. The cut is to be 3.5 ft. deep at the extreme low stage, and is to be 98.4 ft. wide at the bottom, with side slopes of 1 on 5, or less; in front of Vicksburg the channel is to be widened to permit the turning of boats. Bids will be received until April 5 and the full advertisement will be found in our Proposal Columns.

THE NEW ORLEANS LEVEE BOARD, at its meeting of Feb. 27, reported the Mississippi at a height of 14.3 ft. on the Canal St. gage and against the levees in many places. Mr. L. W. Brown, Engineer of the Third Levee District, reports that the work done under his orders in protecting the existing levees from cutting are, in his opinion, most satisfactorily carrying out the objects of the work. The main current of the river, opposite his work, is now well riverward of where it was prior to the commencement of the protection, and his investigations show that very marked improvements in the slope of the river bank are now being made. Mr. Brown will shortly submit to the Board a detailed description of this work, which we trust to give later. In brief, his plan proposes to restore an even and easy curve of flow for the river, on the inside of the great bend made by the river at this point, and to do away with the dangers resulting from the irregular line of the present levees, with their many angles exposed to cutting action, as follows: The line of curve is fixed outside of the present levees, or including those farthest out; and to this line extend lines of braced piles driven in rows perpendicular to the shore line. The theory, as we understand it, is that these piles serve as current deflectors, turning this current out towards the mid river in even, easy curves; and at the same time the loss of velocity, due to striking these piles, permits the deposit of material on the slope and builds up the slope riverward.

THE PROPOSED DAM ACROSS THE OHIO RIVER, near Cullom's Riffle, below Cincinnati, the survey for which was ordered by Congress, would cost $1,050,000, according to the survey and estimate made by Major W. H. Bixby, Corps of Engineers, U. S. A. The purpose of the survey was to secure a channel depth of not less than 6 ft. at low water stage. The preliminary survey, only, has been made, as the existing high stage of water prevents final work.

MORE WHARVES FOR HAVANA are recommended by the American military authorities. Jose Pujals, Chief Engineer of the Harbor, suggests six new piers near the general wharf and the improvement of the channel. The present docks are overcrowded, and much lightering is necessary.

A PONTOON-BARGE TO CARRY STEEL CANALBOATS will probably be built late this year by the Cleveland Steel Canalboat Co., Chas. E. Wheeler, Secretary and Manager, of Cleveland, O. As designed this barge will be 360 ft. long, 45 ft. beam and 24 ft. deep, with double bottom and sides for water ballast. This barge would carry six canalboats in two rows of three each, and these boats would be floated in at the stern, while the barge is partly submerged; the opening would be then closed by gates and the barge pumped out. The estimated cost of the barge is $125,000, and with minor alterations it could be converted into an ore carrier. It is intended for carrying canalboats between Cleveland and Buffalo; and the trip is to consume 45 hours, at the rate of about 4 miles per hour, with a steamer and three consorts. At present these canalboats are towed through Lake Erie in fleets; but this navigation is seriously interfered with by storm and ice, and the new barge is supposed to be able to make the passage in any weather.

FREIGHT TERMINALS FOR OCEAN STEAMSHIPS in South Brooklyn are proposed by John W. Ambrose and his associates, as one of the resultants of the deepening of the main ship channel and the Red Hook and Bay Ridge channels of New York harbor, now authorized by Congress. The plan proposes a great freight terminal at the foot of 39th St., Brooklyn, with an extension of the South Brooklyn & Terminal Ry. to Jamaica; and from Jamaica over the New York Connecting Ry. to Port Morris, and by a transfer-boat system to the New York Central and New York, New Haven & Hartford railways.

THE MOST SERIOUS RAILWAY ACCIDENT of the week occurred on the Mobile & Ohio R. R., near Tupelo, Miss., on March 2. Six coaches of a train loaded with several hundred of the 2d Missouri Volunteers returning to their homes were overturned from some cause not known. Two men were killed and six others seriously injured.

A PECULIAR RAILWAY ACCIDENT occurred on the Pennsylvania R. R., near Huntingdon, Pa., on March 5, in which two men were killed and two others were seriously injured. The accident was due to a land slide, resulting from heavy rains, into which a west-bound freight train ran at full speed. In the rear of the freight was a newspaper train, which dashed into the wreck, and almost at the same time an east-bound freight ran into the wreckage which covered both tracks.

A 50-TON FLYWHEEL BURST at the South mill of the Lackawanna Iron & Steel Co., Scranton, Pa., on Feb. 23. This wheel was 60 ft. in diameter, and the broken parts, some of them weighing several tons, were thrown to some distance. Only one man was killed, although the accident occurred when the mill was running and there were many men in the vicinity.

A POWDER MAGAZINE near Toulon, France, blew up on March 5, killing 50 persons and seriously injuring many others. It is stated in press reports that 110,000 lbs. of black powder were in the building at the time of the explosion. The cause of the accident is not known, but is attributed to chemical decomposition or revenge on the part of some soldier.

THE FIRE AT THE BROOKLYN NAVY YARD, of Feb. 15, will cost the government $1,125,000, according to the appropriation asked for by the Bureau of Yards and Docks and Steam Engineering. It will cost $375,000 to restore the steam engineering building, and $750,000 for steam engineering plant destroyed, including machine tools, cranes, power plant, boiler and blacksmith shops, experimental and testing laboratories, office equipment, etc.

THE NAVAL STONE DRY-DOCK controversy has had varied experiences in the Senate and House conferences. The question of stone and concrete or timber dry-docks was at first referred to the Secretary of the Navy for decision, but Secretary Long insisted that it was for Congress to select the type of construction. Commodore Endicott, Chief of the Bureau of Yards and Docks, recommended stone or concrete faced with stone, and explained to the committee that while the first cost of stone and concrete docks was from 25 to 30% in excess of the cost of timber structures, the stone dock cost little for maintenance, and was practically everlasting, while wood meant costly repairs and a limited lifetime. He also stated that it was possible to build stone docks even superior in form to timber dry-docks. The House bill of March 2 appropriated $800,000, to be applied in four equal parts, to commencing the construction of granite and concrete dry-docks at Boston, Mass.; Portsmouth, N. H.; Mare Island, Cal., and League Island, Pa.; the limit of cost in each case was $1,100,000. This bill was finally amended in conference so that "one of the dry-docks in addition to that at Boston may, in the discretion of the Secretary of the Navy, be built of stone, or concrete faced with stone." This would seemingly leave two timber dry-docks to be constructed.

THE LIMITATION IN THE PRICE OF ARMOR-PLATE to $300 per ton of 2,240 lbs., inserted in the Naval Appropriation bill near the close of the session, applies only to the new vessels authorized by the bill, which were three battleships, three armored cruisers and six protected cruisers. The armor for the "Maine," "Missouri," and "Ohio," which were authorized by Congress last spring, and for the four monitors, authorized at the same time, may be purchased at the rate of $400 per ton. The law further provides that contracts for the hulls of the new vessels just authorized shall not be made until the contract for the armor is made. If the armor manufacturers refuse to sell armor for $300 per ton, the contracts for such of the new vessels as require armor cannot be made until Congress reassembles next December, and takes action to relieve the situation. From the prevailing sentiment in Congress, it is by no means unlikely that this action may take the form of an appropriation for the construction of a government armor plant.

THE NAVAL PERSONNEL BILL has finally passed the Senate and House and is a law; but until the bill as finally passed is before us it is almost impossible to state in full what has actually been done. Among the final changes made in the conference committee, however, are the following important enactments, aside from the very radical one of absorbing the steam engineering staff into the line: No appointments shall be made in the Civil Engineers Corps on the active list in excess of the present number—21. After June 30, 1899, line officers and officers of the pay and medical staff shall receive the same pay and allowances, except forage, as are awarded Army officers of corresponding rank; on shore duty the naval officers shall receive the allowances, but 15% less pay than when at sea. Naval Chaplains, who do not possess relative rank, are to rank as Lieutenants in the Navy; and all officers, including warrant officers, appointed from civil life, shall be credited with five years' service in computing their pay. All laws authorizing the distribution of prize money among officers and crew are repealed, including bounty heretofore paid for sinking or destroying the vessels of an enemy.

THE MASSACHUSETTS METROPOLITAN WATER Board has sent us the following information regarding contracts to be let by it during the early part of the year: The first work to be let is the completion of an intercepting sewer, reservoir and sewage pumping station at Clinton, Mass., which has been abandoned by the original contractor. A notice of the letting will be found in our advertising columns. Considerable work is to be done near Clinton in connection with the construction of the Wachusett Reservoir; one of the early contracts will be the stripping of surface soil from the reservoir near the north dike, and some excavations for the dike, requiring in all the removal of 315,000 cu. yds. of earth; another is a small contract, requiring the removal of 20,000 cu. yds. of earth for the completion of some railway grading; still another is the surfacing of about three miles of road along the margins of the reservoir with broken stone. All of these contracts will probably be let within a month. Later in the spring it is expected that a contract will be let which will involve the stripping of 3,000,000 cu. yds. of soil from the surface of the reservoir, and there will be other contracts for earth work at the reservoir, the largest one involving the removal of 150,000 cu. yds. of earth, more or less. Plans are in preparation for the improvement of Spot Pond, which is located seven miles from Boston, and is to be used as a distributing reservoir. This work will involve the removal of 750,000 cu. yds. of earth. Filter beds, having an area of about 15 acres, for filtering the water of a brook, are to be constructed near Marlborough Junction. About 2½ miles of cast-iron water pipes, 24 and 20 ins. in diameter, are to be laid to supply water to the town of Arlington. The large masonry dam of the Wachusett Reservoir will not be let this spring. We are authorized to state that due notice of the lettings of the above work will appear in the advertising columns of the Engineering News.

TYPHOID FEVER AT PHILADELPHIA has assumed alarming proportions, there having been 321 deaths from this cause during the nine weeks ending March 4 and 49 for the single week closing on that date. During the whole of 1898 there were 639 deaths from the disease in Philadelphia, but this was within 32 of the number in Greater New York, with its immense population. The responsibility for deaths in such criminal numbers is placed primarily on the character of the water supply, and that in turn on the city council, which persistently refuses or neglects to take effective steps for its improvement.

WATER POWER PLANTS WITH LONG-DISTANCE ELECTRIC TRANSMISSION IN SOUTHERN CALIFORNIA.

I.

By C. E. Fowler, M. Am. Soc. C. E.

(With full-page plate.)

The long-distance transmission of power by electricity has been carried out to a greater extent in Southern California than in any other region of the United States.

for irrigation, and the works for impounding, storing and carrying the water from the mountains to the lowlands serve for one as well as for the other.

In cases where irrigation works has been undertaken apart from power development, the great difference in elevation between the source of supply in the mountains and the lands to be irrigated has in many cases necessitated very long and devious canal and flume lines to take care of the

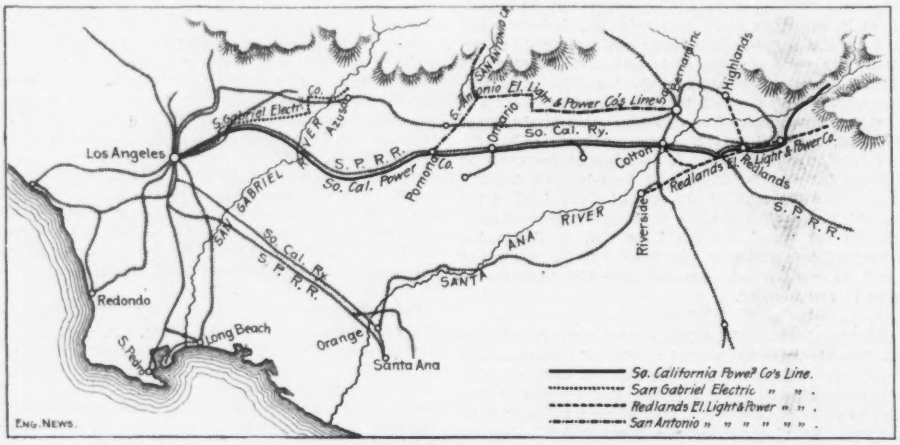


FIG. 1.—MAP SHOWING THE PRINCIPAL ELECTRIC POWER TRANSMISSION LINES IN SOUTHERN CALIFORNIA.

While the plants are not of large size, the distance over which the electric currents are carried are much greater than have been found commercially practicable elsewhere. The reasons for this

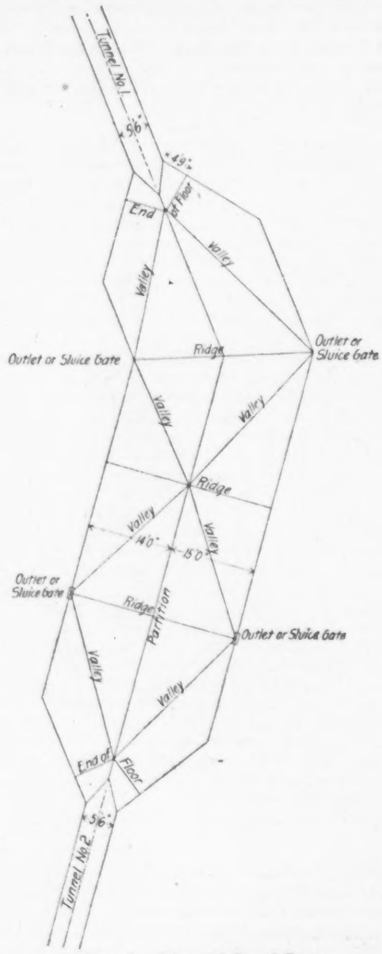


Fig. 4.—Plan of Sand-Box.

are, first the high cost of steam power in Southern California owing to the high price of coal. This has made it possible to dispose of electric power transmitted over long distances at prices which would not be possible in any place where steam power is of ordinary cost. Again, the water used to develop power is also of value

fall. Where the water is first used for power, however, practically all the drop is taken care of at one point, the penstock leading to the power station, and a much shorter course for the canals is possible.

The longest line for the commercial transmission of power ever put in operation is that recently completed by the Southern California Power Co. This company takes water from streams in the San Bernardino Mountains, carries it in canals and tunnels about 2½ miles, develops power from it under a head of over 700 ft., generates electric current and transmits it at a pressure of 33,000 volts to Los Angeles, 80 miles away.

The San Bernardino Mountains, near the junction of Bear Creek and Santa Ana River, where the headworks of the Southern California Power Co. are located, are very rocky and precipitous, so that the construction of an open flume from the intake to the power house would have been very expensive. Besides this, the length of flume required would have been very great, entailing a corresponding loss of head. The mountains which intervene between the intake and the power house site consist of a series of spurs, or "hog backs," which are approximately parallel, and the canal is located to intercept them. Thus 80% of its length is in tunnel. The rest of the line consists of 1.2% of open masonry canal, while the balance is practically all timber flume. There are 18 tunnels, with a total length of 11,555.4 ft., the longest being No. 8, which is 2,074.2 ft. long. The flumes, which connect these tunnels, deliver the water to tunnel No. 1 and carry it to the reservoir from the last one, are 20 in number with an aggregate length of 2,661.6 ft.; the longest—connecting tunnels 4 and 5—is 956.4 ft. long. The remainder of the 2.53 miles of the line consists of 167.1 ft. of open masonry canal, 121.5 ft. for the sand-box between tunnels 1 and 2, and 56.9 ft. of reservoir and forebay at the head of the penstock.

The elevation near the Grand Junction, where water is taken from the river, is 3,422 ft. above sea level, the junction being about seven miles below the famous Bear Valley dam, while the elevation at the power house is 2,670, a difference of 752 ft. The grade of the canal is 9.5 ft. per mile, which leaves a static head of 728 ft. in the pipe line at the power house.

The streams which supply the water to the flume are the Santa Ana River and Bear Creek. Eventually the water from both these streams will be diverted with the aid of a dam to be built just below their junction in the narrows shown in Fig. 3, and it will probably be carried to such a height as to form a storage reservoir. At present, however, there are separate intakes on the two streams. The Santa Ana is diverted by a low masonry dam topped with sand bags, which will wash off in a flood and increase the waterway. This dam throws the water to a masonry intake supporting a heavy grating of old railway rails, below which is a pair of gates for regulating the amount of water admitted to the timber flume. This flume is cemented into the masonry intake upon which it also rests, and extends 372 ft. to the junction with the Bear Creek flume, the size being 5 ft. wide by 3 ft. deep. The top is completely covered with plank for a distance of 90 ft. from the intake, or until the bed of Bear Creek is low enough to allow water to flow beneath, the cover being used to allow flood water to run over the flume without causing damage.

The flow from Bear Creek is diverted without using a temporary dam, but the head of the flume has a masonry intake, a grating of rails, and regulating gates, like the other; the size being the same for 93 ft. to the junction, beyond which the width is 6 ft. for the remaining 195 ft. In this portion of the flume there is a hopper-shaped depression, with a discharge gate, to trap bowlders and the like, and allow of their removal. These flumes are built so as to be easily repaired, and it is believed they will gather more water than a

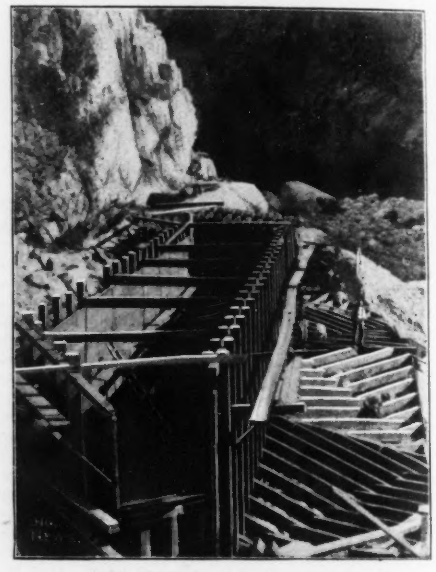


Fig. 4a.—View of Sand-Box Under Construction.

temporary dam below the junction, besides creating better conditions for the building of the permanent dam next season.

The entrance to tunnel No. 1 has a masonry portal (Fig. 2), the arch ring being built of bowlders spawled off to the approximate shape of arch stones. The portals of all the other tunnels are similar to this one. This tunnel is provided with a heavy gate at its entrance, which can be closed in times of exceptionally heavy flood if necessary.

The sides of the tunnels are vertical to a height of 4 ft. 6 ins. above the horizontal floor, which is 4 ft. 6 ins. wide. The roof is semicircular, thus making the height 6 ft. 9 ins. (See Fig. 6.) This section was adopted to make the junction with the flumes easier, while the width resulted from the necessity for lining, advantage being taken of the smoother cement surface to reduce the width from 5 ft. 6 ins. to one foot less. The tunnels are in granite rock, some of which was very hard, while some contained a large percentage of mica, and was softer as well as much disintegrated. Hand drilling was used on nearly all the work, and was quite difficult. As the rock was full of large fissures, the blasting broke it badly, leaving the surface very rough, and in some cases large holes were made.

Compressed air was used on a portion of Tunnel No. 8 to operate power drills, resulting in larger blasts being used, which shattered the walls and roof. The compressor was located down in the canyon, and the contractor operated it by a steam engine. Later, however, water was piped from a point up the stream and a 30-ft. head was obtained for operating Pelton wheels to run the compressor. The air was piped up the mountain side from the receiver, which was located near the compressor.

Quite a large percentage of the tunnel work had to be timbered, and sets of timbers were put in place about 4 ft. apart and left until the concrete lining reached them. They ranged in size from 4 × 6 ins. to 8 × 8 ins., and the roof supports were three segments.

Only 12% of the tunnel work was left wholly unlined, and this was all above tunnel No. 5, while 12% more was only walled and floored, the balance, 76%, was walled, floored and arched. The concrete for the lining was made of one part Colton Portland cement, which is manufactured about 20 miles from the work, and seven parts for walls and five parts for the arches of a splendid gravel, most of which was found in the canyon near tunnel No. 12. The cement was used in such quantity that it was very fresh from the works—about 8,500 barrels being used—and the unslaked lime which was present caused it to set so quickly that water had to be piped into the tunnels and the concrete mixed there. The cement and gravel were first mixed dry outside and were then run in on push cars, directly to the place where the concrete was to be used.

Much of the gravel was put into sacks at the gravel bed, and placed on the line of the work by the incline railway shown in Fig. 7, which was built by a firm of contractors who originally undertook the construction of the work, but later abandoned it. The water was pumped from the river at this incline through small pipes to a height of 550 ft. by two force pumps connected in tandem. At tunnels No. 7 and No. 9 the water was hoisted in barrels by means of cableways. At No. 8 water was pumped from the tunnel for a time by a force pump operated by compressed air, but as the supply proved insufficient the pump was moved to the foot of the hill and water was forced through the pipe that had been used for compressed air; the water used in the upper end of tunnel No. 8 was bailed from the floor and conveyed in tank cars to the work; the water used above tunnel No. 5 was raised by a hydraulic ram.

The concrete mold frames for the sides (Fig. 5) were formed by 2 × 6 in. uprights about 5 or 6 ft. long, placed 4 ft. apart, braced across the top in pairs by 2 × 3 in. struts held in place by wedges driven between the uprights and the rock wall, and at the bottom by wedging against the tramway track. The lagging boards were 1¼ × 12-in. by 12-ft. They were surfaced on one side, and two edges were placed in position behind the frames as the concrete lining of 6-in. minimum thickness, was tamped in behind them. The boards were allowed to remain in place between two and three days for the concrete to set. The arch forms for the roof were supported on string pieces carried on short posts about 4 ft. apart. On the forms, narrow strips of lagging 12 ft. long were laid in on each side about 12 ins. width at each time, behind which the concrete was tamped as on the sides. For a width of about 18 ins. at the center the strips were only 4 ft. in length, and the key was filled in from the end. The arch forms were left in place about one day longer than those for the sides.

The average thickness of the concrete was about 5 ins. for the floors, 7½ ins. for the walls and 8 ins. for the arches. Where there were large cavities in the rock they were filled with stone in good sized pieces and as the concrete was packed in they were cemented together to a certain extent. Where the roof was insecure the thickness of the arch was increased. The surface was quite smooth after the molds were removed, and the bottom was rendered smooth by a 1½-in. layer of cement mortar troweled on. Where the floors were wet and for the work in the penstock, Alsen's cement was used.

The abrupt character of the country at tunnels Nos. 1, 2, 3 and 4 prevented the use of the usual surface location lines and their ends were located on line and grade by traverse lines or by triangulation. The headings in all the tunnels met practically exact, although only ordinary care was used in instrumental work. The alinement is a tangent in all the tunnels except 2 and 3, which contain about 40° of a 12° curve.

The flumes connecting the tunnels were 5 ft. 6 ins. wide (see Fig. 8), except the one connecting tunnels 10 and 11, which was only 44.2 ft. long and was narrowed to 4 ft. 6 ins. The additional foot in width in the longer flumes was added to compensate for bends and roughness. The posts

Fig. 7.—Temporary Incline for Hoisting Gravel.

and caps of the flumes are 4 ins. × 6 ins. redwood; the bottom is made of 2 in. redwood plank, as are also the sides, which are at present four 12-in. planks high with provision for two more planks when it is desired to increase the capacity. All the joints are calked with oakum and tarred with 1 in. × 4 in. strips outside to retain the oakum. The curves were made by a slight deflection in each plank length comprised in the curve.

The flumes are supported on concrete piers or walls placed transversely to the line, carried down in some places to a depth of 12 ft. or deep enough to guard against settlement or undermining. On top of these walls are three concrete pedestals about 14 × 16 ins. under each sill. These foundations are usually placed 13 ft. 8 ins. apart; but on benches they are only half this distance. The crossing of gullies was accomplished by spans of 27 ft. 4 ins. of hog chain trusses.

The longest flume, of which a view is shown in Fig. 5, is located between tunnels 4 and 5, and is 956.4 ft. in length. It is partially roofed over with sloping plank, to protect it from slides of rock. It is proposed to change this flume next season to a side hill tunnel, as it is conceded by all engineers experienced in this work that tunnel construction for power canals is the only permanent method, besides avoiding the chance of a long shut-down of the plant, which would involve an enormous loss. In the case of an irrigating plant a shut-down is of small moment, as the delay until the flume can be replaced need cause little damage. The timber of the flumes connects directly to the masonry of the tunnel portals, being supported by it and the joint made tight by cementing.

From the end of tunnel No. 18 a flume 265.5 ft. long and six boards high carries the water to the reservoir at the head of the penstock. A short distance above this reservoir a spillway is provided by leaving off the top plank for a distance of 38 ft. The water falls into a concrete chamber and is carried from this by a 24-in. diameter No. 8 gage pipe about 400 ft. to a rocky ravine, which in turn carries it to the river in the canyon above the power house. This pipe is joined by a 12-in. pipe, about 100 ft. from its upper end, leading from the drainage gate in the reservoir.

The purpose of the reservoir is to give a quiet entrance of the water to the penstock and keep the mouth of the latter always submerged, so that air will not be carried into it.

The reservoir is triangular in shape, 60 ft. on each side and 9 ft. deep. Two of the sides are formed by concrete facing on the sides of the excavation, while the third or enclosing side is a concrete wall about 2 ft. thick at the top and founded 16 ft. below the surface at a point where the rock debris is well packed. The forebay is at the bluff side of the reservoir, and has two compartments, from one of which the 30-in. pressure pipe carries the water to the power house.

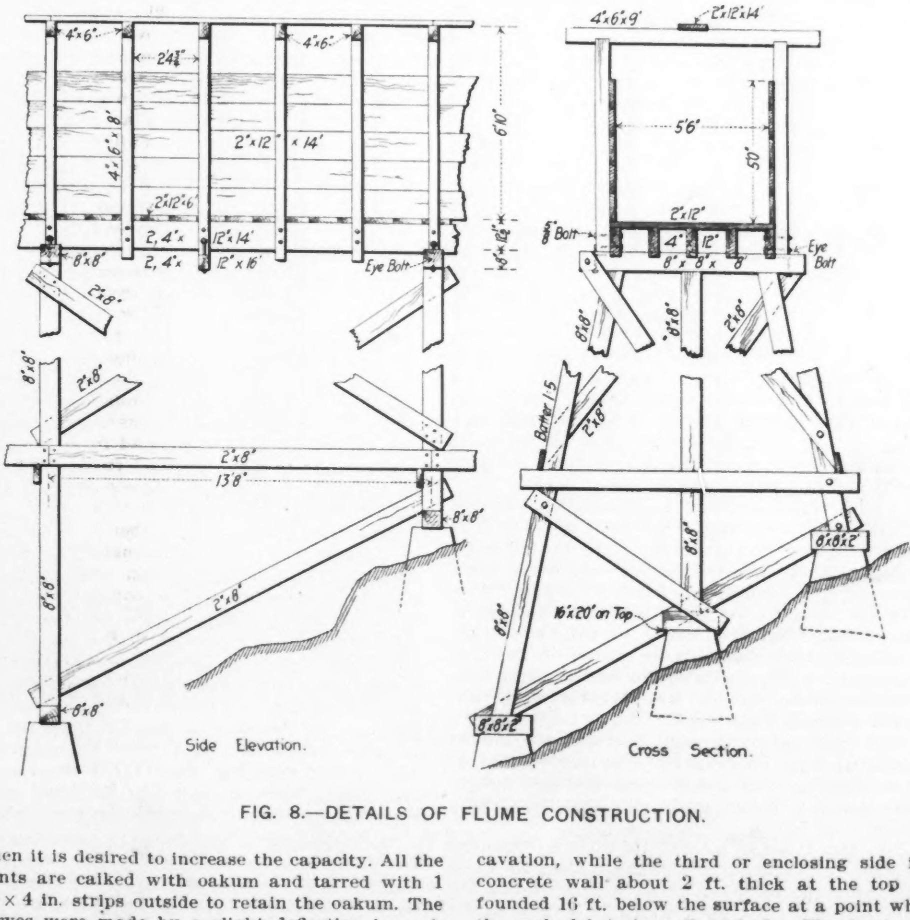


FIG. 8.—DETAILS OF FLUME CONSTRUCTION.

The other compartment is designed for a second 30-in. pressure pipe when it shall be required.

The removal of the sand from the water, which would injure the water wheels, is accomplished by a sand box (Figs. 3 and 4), 121.5 ft. in length, which occupies practically all the distance between tunnels No. 1 and No. 2. This structure is 29 ft. in width, and is divided by a central partition into two compartments, one 14 ft. and the other 15 ft. wide, each one having a gate at each end. Each compartment has two hopper-shaped depressions, 5 ft. deep at the shallowest place and 9 ft. deep at the discharge gates, towards which the hopper bottom slopes from all directions. The reduction of the velocity of the water as it flows through these compartments allows the sand to drop to the bottom, from which it is flushed out through the discharge gates from each compartment alternately, while the canal flow is shut off by the end gates from that side.

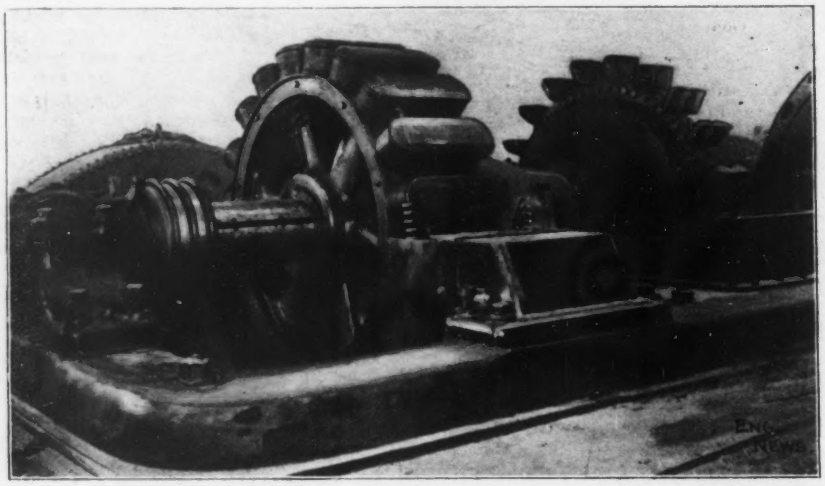


FIG. 11.—PELTON WATER-WHEEL AND DIRECT-CONNECTED DYNAMO IN PROCESS OF ERECTION.

Such sand as finds its way down the canal can be removed through a gate in the bottom of the reservoir, a by-pass being provided to run the water around to the penstock.

Mention has already been made of the incline built by the contractor (Fig. 7). This was very expensive for the comparatively small amount of work required, and when the company took charge of the work cableways were built at other points for the transport of material. A ¾-in. wire rope was passed around and clamped to an old sheave wheel anchored to a dead man or large bowlder at the bottom, while at the top it was passed over the timber shear and anchored on the bluff. There were three of these cableways, the longest span being about 900 ft., and the trolley was operated by a single drum engine using compressed air piped a distance of 1,600 ft. The next longest was operated by a single drum steam hoisting engine, while the shortest was operated by a team of horses making a direct pull.

During the construction trails were built around all the tunnels, making it possible for the zanjero to pass along the entire line. The necessity for completing the line before the next season made it necessary to work on Sundays and holidays; and part of the force worked at night during the last seven months, previous to Dec. 1. As the Chief Engineer was also in charge of the construction, it was necessary for him to camp near the line in the canyon and give the work constant personal supervision.

The building of the pipe line and the power plant were in charge of the superintendent of the company, only the surveys and location of the pipe line being made by the engineering force.

The pipe line has a length of 2,214 ft. from the forebay to the face of the flange of the gate valve adjoining the receiver, which is just outside the power house. The pipe, which is 30 ins. in diameter, varies from No. 10 gage steel at the top by graduations of sixteenths of an inch to 9-16-in. thickness at the bottom, and is all laid in trench not less than 5 ft. deep, thus avoiding the necessity of anchoring and changes in length from temperature. The vertical and horizontal changes in direction were concentrated at the same points as far as possible to reduce friction loss. The pipe was coated with two coats of asphaltum before being laid. The junction at the receiver is at right angles, with an Eddy gate valve, while there is a second tee and valve a short distance away for connecting a duplicate pressure pipe. The receiver is cylindrical and 30 ins. in diameter, lap-welded and having flange joints. Ludlow valves are placed in this and in the outlet pipes to supply six water wheels. The flange joints were all machined and no leaks have occurred in them nor in the piping, with the gage reading 314 lbs. per sq. in., which corresponds to an effective head of 723 ft. While no accurate experiments have been made it is believed that even with lap joints in the pipe line and right-angle junctions of the inlet and outlet pipes, the loss of head will be less than was calculated.

The power house (Fig. 9) is 41 × 130 ft., and the walls are of monolithic concrete, made of 1 part Portland cement to 5 of gravel, while the floors are concrete with cement surface. The walls are 2 ft. thick to a height of 4 ft. above the floor, above which point they are 18 ins. thick, except on the side next the mountain, where the thickness is 2 ft. 6 ins. up to the offset for the crane rail. The roof trusses are of steel riveted construction, with wood purlins carrying galvanized corrugated iron covering on the roof and gables. The building is lighted from the high windows in one side and from the monitor. A hand power traveling crane of 15 tons capacity and 26½-ft. span is carried at the inner end by a steel beam runway supported on steel columns.

The outlets from the receiver to supply water to the wheels are tapered from 10 ins. down to 6 ins., where the nozzle connects. The largest nozzle is 3¾ ins. in diameter. The wheels are of the well-known Pelton impulse type, and are 82 ins. in diameter. Fig. 10 shows one of the wheels before being enclosed in the casing which covers it. To each wheel is fitted a Lombard water-wheel governor which controls the nozzle and deflects it from its most effective position as the load falls off. As Fig. 10 also shows, the General Electric alternator which is driven by the Pelton wheel is secured to the same shaft and mounted on the same base-plate. The alternator is of the type in which the fields revolve while the armature remains stationary. The massive construction of the spider for the field coils is especially noticeable.

As seen in Fig. 11, there are at present four of these generators installed, while foundations are provided for two more. They are of the three-phase type with 20-pole revolving fields. Each machine is of 750-K-W. capacity, running at a speed of 300 revolutions and delivering current at a tension of 750 volts. The exciters for these machines are General Electric 30-K-W. generators, with a voltage of 125, driven by 50-HP. Pelton wheels with automatic governors, which were designed by the superintendent of the company. These exciters, three in number, have a separate panel on the switchboard, and can be worked on two sets of bus-bars as well as to excite the field of each generator. They also furnish current to light the power house.

Each of the main Pelton wheels discharges its water through a separate tunnel under the floor into a separate tail-race (Fig. 13), and each tail-race discharges into a common reservoir 8 ft. wide, which in turn empties into the river through a sluice gate.

At a point farther down the stream, the water is again withdrawn from the river and used for irrigating purposes. It is claimed that the amount available is much greater than in the case of ordinary river flow, or an irrigating canal, as the careful construction of the power canal prevents the great loss from seepage or evaporation, incident to an ordinary open canal, and also the loss from underground flow, which happens when the water is carried in a mountain stream.

Each tail-race is lined with plate steel, and covered by timber, while a wooden buffer is placed on the wall of the reservoir opposite each race, this protection being necessary to protect the concrete from injury when the water is first turned out to the wheels, the force of the discharge being very great until the power system is loaded.

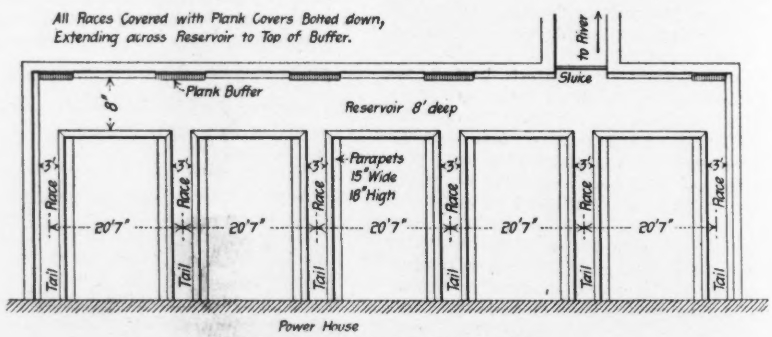


FIG. 13.—PLAN OF TAIL-RACES.

The low-tension switchboard (Fig. 14) has a panel for each one of the large generators, each panel being provided with three single-pole quick-break switches, which are so connected that any machine in the plant can be operated on either set of bus-bars. The switchboard, besides having the usual voltmeters and ammeters, has recording volt and ampere meters and a Thompson recording watt-meter for each set of bus-bars.

The transformers (Fig. 15), twelve in number, are arranged in banks of three, while foundations are in place for two more banks. They rest on foundations of steel beams and concrete, 30 ins. above the floor, to provide an air duct beneath, as they are of the General Electric air-cooled type, and also to allow room for connecting up the low tension wires. These transformers raise the potential of the current from 750 volts to 19,000 volts and are connected in Y to produce a final result of 33,000 volts on a three-phase circuit. The required air pressure of ⅜-oz. is provided by two

80-in. Buffalo blowers,each one driven by a 3-HP. General Electric induction motor.

The low-tension side of the transformers may be operated from either set of bus-bars for two kinds of work without interference. The high-tension side of the transformers are provided with a high-tension switchboard (seen at the top of

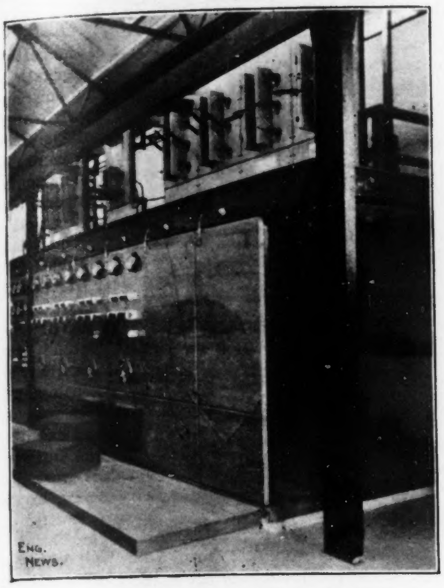


Fig. 14.—Switchboards in Power-House.

Fig. 14), which consists of two complete boards, each one naving a line panel and three groups of line panels, with a connecting panel between so that the two sets of bus-bars may be thrown together to make one complete board. Just to the right of this are the six fuses, one for each line wire. The fuse wires are No. 20, pure aluminum 3 ft. long. Each passes through a wooden tube having switch contact at each end with the line wire, and provided with a screw socket at the center into which the wooden handle for removing them may be screwed.

The current, at 33,000 volts, is carried to Los Angeles, a distance of slightly over 80 miles, by two 3-wire circuits, of No. 1 copper wire, arranged in the form of an isoceles triangle. The top cross-arm (Fig. 16) is 5 ft. 1 in. long and the bottom 6 ft. 8 ins., with braces to the pole. The insulators are bell shaped, glazed porcelain, of extra large size, slightly over 6 ins., manufactured at Trenton, N. J., especially for this work. They are screwed onto a wooden pin which is fastened to the cross-arm by a bolt passing through a cone-shaped porcelain sleeve 4 ins. above the cross-arm. The wires are spiral one-third of a revolution every 88 poles on the south circuit, and one-third of a revolution on the north side in the opposite direction every 41 poles. The two-wire telephone line is carried by ordinary bracket insulators, 5 ft. below the main lines, and to prevent induction the wires are transposed vertically every fifth pole. The line has 44 poles to the mile, of white cedar, from 35 to 65 ft. high, with 8-in. tops. It follows the Santa Ana canyon to its mouth and then crosses the mesa to Crafton on the Southern Pacific Ry., a distance of over nine miles. From here it follows the railway company's right of way to Pasadena and Los Angeles. The line is built to withstand, in the language of the superintendent of the company, worse conditions than exist in the East, as for a large proportion of nights every year there are dense fogs nearly the whole distance, while the California cloud bursts are phenomenal, and the snows in the canyon are heavy enough at times to break down the line.

During the writer's visit to the power house, one wheel was started up with a 2¼-in. nozzle and another with a 3¼-in. nozzle, the latter being used to deliver current to the station at Los Angeles. The Lombard governor was connected to the main valve lever and as the load was applied in Los Angeles the lever was moved along by the governor, opening up the valve, but so perfect was the regulation that the tachometer showed practically no variation in the speed of the main shaft. The water was discharged into the tail-race with great force before the load was on, the water foaming and splashing into the air, to a height it was said of 30 to 40 ft. before the wood cover was used. As the load was applied, however, it flowed quietly from the wheels.

The current at Pasadena is reduced in voltage by six Westinghouse 150-K-W. oil-cooled transformers, located at the plant of the Pasadena Electric Light & Power Co. The drop is from 33,000 down to 2,200 volts, and at the latter pressure it operates a General Electric 525-K-W. synchronous motor, which is controlled direct from the switchboard. This is directly connected to a 525-K-W. generator for supplying direct current at low tension and is also belted to a countershaft from which are driven two old lighting dynamos which were formerly run by steam power.

The current at Los Angeles is transformed at the Second St. station of the Edison Electric Co. by six General Electric 250-K-W. step-down transformers (which are cooled by one blower with motor) from 33,000 to 2,200 volts, at which tension it is carried to the new Fourth St. station of the same company. (Fig. 17.)

This building, 37 ft. 2 ins. by 87 ft. 10 ins., has brick walls, cemented over on the inside and outside, steel hip roof covered with corrugated iron, lighted by skylights and having a double wooden floor on wood joist over a 7-ft. basement.

The basement is used for the inlet and outlet wiring, and has a concrete floor. The main room above is 14 ft. high to the square and is provided with a traveling crane half the width of the room, over the machines.

The station has at present two sets of machines with a room for a third. Each set has a 300-K-W. General Electric synchronous motor using current at 2,200 volts, operating two generators directly connected to it on the same base, which supply current for lighting at 110 and 220 volts. The current for residence lighting is distributed direct from the Second St. station at 2,200 volts, and is stepped down by ordinary transformers used at each house.

Fig. 16.—View of Pole Line for 80-Mile Transmission.

The mains of this company are Edison tubes, which are fed through lead armored cable feeders, and are fused at the distributing boxes which are located in the 4x7-ft. manholes. The pressure wires are the ordinary rubber covered.

The writer's acknowledgments are due to Mr. Edward M. Boggs, civil and hydraulic engineer, who was chief engineer of the canal line and in charge o[illegible]ruction, to whom he is indebted for the data of that part of the work as well as for drawings and some of the photographs. Mr. O. H. Ensign, Superintendent of the company,who designed and constructed the power plant, and the pipe line, as well as the other mechanical and electrical work,favored him with voluminous data and various courtesies during the

Fig. 17.—New Electric Power Station of Edison Electric Co., on Fourth St., Los Angeles, Cal.

preparation of this article. The writer is also indebted to Mr. John B. Miller, treasurer, and Mr. H. H. Sinclair for courtesies extended, and to Mr. H. C. Thaxter, Supt. of the Edison Electric Co., of Los Angeles,for information furnished concerning the plant of that company.

THE RELATIONS OF VELOCITY AND PRESSURE IN CENTRIFUGAL BLOWERS.

By Alton D. Adams.*

On page 513 of Kent's "Mechanical Engineer's Pocket Book," the following quotation is made from W. P. Trowbridge (Trans. Am. Soc. M. E., Vol. VII., p. 536): "By increasing the number of revolutions of the fan, the head or pressure is increased, the law being that the total head produced is equal (in centrifugal fans) to twice the height due to the velocity of the extremities of the blades, or $H = \frac{v^2}{g}$ approximately in practice"; and later, on the same page, this quotation is indorsed in the text.

On page 514 of the above book, tables of air pressure and velocity are given, calculated from the formula $v = \sqrt{2gh}$, by Henry I. Snell (Trans. Am. Soc. M. E., Vol. IX., p. 51).

Matter has appeared from time to time in the technical press conforming to each of the above views, and as both cannot be correct a proof of the correct one will here be attempted.

To investigate this subject properly the difference between static and dynamic pressures in fluids should be held clearly in mind. Static pressures in fluids, due to their own weight or applied pressure are exerted in all directions with the same intensity. Dynamic pressures are exerted by moving fluids against surfaces which check their velocity or change their direction, and have no components 90° from the line of flow.

The relation between static pressure and velocity may be illustrated by Fig. 1, in which a jet, J, flows vertically upward from an orifice to a height nearly equal to h, the head of water on the orifice, the difference being due to friction.

Did the jet reach the height h, it would have at the orifice a velocity equal to that acquired by falling through the height h or $v = \sqrt{2gh}$, and since $h = \frac{\text{pressure}}{\text{density}} = \frac{P}{d}$ the relation between velocity and pressure becomes $v = \sqrt{2g\frac{P}{d}}$.

*Box 1377, Boston.

(There is a fallacy here in supposing that the formula $h = P \div d$ is general and applies to falling or moving fluids. In fact, it applies only to fluids at rest. We discuss this subject editorially elsewhere in this issue.—Ed. Eng. News.)

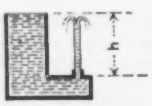


Fig. 1.

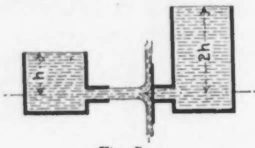


Fig. 2.

An exact demonstration can be had by considering the work of a thin layer of water falling through the height, h, and the work represented by the same water moving with a velocity, v, at the orifice: let w be the weight of water delivered through the orifice per second, then wh represents the energy imparted to water in falling through h; but the energy of water moving from the orifice, friction losses being disregarded, is represented by $\frac{w v^2}{2 g}$, v being the velocity per second.

Now, as the energy of the jet must be that acquired by falling through the height, h,

$$w h = \frac{w v^2}{2 g},$$

therefore, $h = \frac{v^2}{2 g}$ and $\frac{P}{d} = \frac{v^2}{2 g}$ as before.

The dynamic pressure of a jet of water, which follows the same law as air is illustrated in Fig. 2, where a jet flowing under a head, h, holds in position a plate at right angles to it over an orifice of equal size under a head of 2 h. If a slanting plate with faces at angles of 60° from the direction of jet be used as in Fig. 3, the dynamic pressure of the jet will just equal the head required to produce the jet; a smaller angle will give less dynamic pressure.

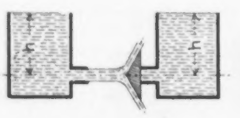


Fig. 3.

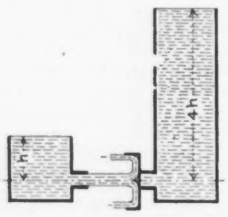


Fig. 4.

Again, if the plate is so formed as to turn the jet parallel to it first direction, as in Fig. 4, the head of water supported by the plate will be four times that required to produce the jet; still again, in Fig. 5, the jet being again turned against the plate over orifice and then away parallel to the first direction, the head of water over the orifice may be eight times that required to produce the jet.

Dynamic pressures may be produced in curved pipes, and follow the same laws as with open jets.

To find the true pressure head the tube should be inserted in the pipe or conduit at right angles to the line of flow, as at A, Fig. 6, for if the tube is inclined in the direction of the flow, B, the dynamic pressure increases the true head, while if inclined against the flow, C, dynamic pressure makes the reading too small.

From the above it is evident that a stream or jet of air or water may produce dynamic pressures less, equal to or greater than the static pressure under which the jet moves, on surfaces properly placed, and no work will be done unless the velocity of the jet is changed.

The practical value of dynamic pressures and reactions is in their connection with moving surfaces as in wind mills and water wheels. Blowers are used for the purpose of moving air, and the pressure under which air moves through the blast wheel is the one of main interest.

The dynamic pressure which a stream of air moving at a given rate can produce against a fixed or moving surface in its path is of little or no interest in the movement of air for purposes of heating and ventilation.

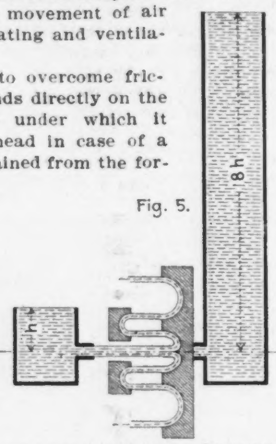


Fig. 5.

Capacity of air to overcome friction in pipes depends directly on the head or pressure under which it moves, and this head in case of a blower can be obtained from the formula $v = \sqrt{2 g h}$, in which v equals the velocity in feet per second of the blast wheel at its periphery, $g = 32.16$ and h equals the height of air column corresponding to the pressure required.

There are several ways in which it can be proved that the above formula expresses the correct relation between v and h.

Air at ordinary temperature and 2,116 lbs. per sq. ft. pressure has been found by experiment to flow into a vacuum at a velocity of 1,292 ft. per second, and the formula $v = \sqrt{2 g \frac{2,116}{.0807}}$ gives nearly the same result, .0807 being about the weight of air per cubic foot, so that $\frac{2,116}{.0807} = h$, hence from this case $v = \sqrt{2 g h}$.

As air leaves the periphery of the blast wheel it has equal velocity with the wheel, and the work done by the wheel on the weight, w, of air passing per second is $\frac{w v^2}{2 g}$; the pressure of blower being p pounds per square foot, the area in square feet of orifice being a, and velocity in feet per second, v, then the work represented by, w, weight of air passing the orifice per second is p a v. Neglecting friction, the work done on, w, weight of air by the blast wheel must equal the work on the same air at the orifice, so that $\frac{w v^2}{2 g} = p a v$; but taking n for weight of air per cubic foot $w = a v n$, so that $a v n \frac{v^2}{2 g} = p a v$. Dividing by a v, there remains the formula $p = n \frac{v^2}{2 g}$ or $\frac{p}{n} = \frac{v^2}{2 g}$, therefore, as $\frac{p}{n} = h$, $h = \frac{v^2}{2 g}$, which represents the relation between head and velocity of air from blowers.

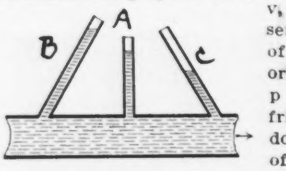


Fig. 6.

Why the dynamic pressure corresponding to $H = \frac{v^2}{g}$, against a surface at right angles to impinging jet, has been selected in some quarters, to represent head under which air moves, instead of one of the several other dynamic pressures a jet may produce, the writer has not been able to learn.

EXPANSION JOINTS FOR RETAINING WALLS ON THE ST. CHARLES AIR LINE RY., CHICAGO.

In carrying out the elevation of the tracks of the various railways entering Chicago, the method most commonly employed, as our readers will recall from previous descriptions of the work in this journal, is to carry the tracks on a raised embankment with masonry retaining walls at the sides, and cross the streets by steel bridges. In the work upon the St. Charles Air Line Ry. a novel feature was introduced in the construction of the retaining walls, which is of much interest to every engineer interested in masonry construction.

The work in question was carried out under the supervision of Mr. H. W. Parkhurst, M. Am. Soc. C. E., and Engineer of Bridges and Buildings for the Illinois Central Railway Co.

Comparative estimates were made of the cost of constructing elevated tracks on steel superstructures throughout, and of building them on embankments between retaining walls, with steel superstructure over the streets and alleys. The latter plan was decided upon; and bids were obtained for concrete, rubble and cut-stone masonry. It was found that the most favorable proposal was one making the street abutments of first-class masonry and the retaining walls of second-class coursed ashlar, backed with derreck rubble. The foundation masonry of concrete was already in place, and a contract was finally made with Paterson & Co., of Chicago, for the character of work described. The stone used was sandstone from Williamsport, Ind., and from the Barea quarries, near Cleveland, O. This work has been completed, and a recent personal inspection by a member of the staff of this journal shows it to be of excellent character, with little difference in the outward appearance of the first-class abutment work and the coursed ashlar second-class masonry, except that in the latter work wales were permitted on the face for handling with stone tongs.

The novel feature in the retaining wall construction above referred to is the cutting of the retaining wall, at about 100 ft. intervals, by vertical joints extending to the foundation masonry. These joints extend entirely through the wall, and before the slag filling was put in place behind them, the back of the joint was calked with a yielding material to prevent the entrance of any stone or rubbish into the joint. Several important ends were served by this vertical division of the walls. In the first place, Mr. Parkhurst had observed considerable expansion and contraction in sandstone masonry, between the extremes of heat and cold prevailing about Chicago, and this joint limited the effect of any such longitudinal variations upon the mortar joints and coping. Second, the foundation soil of Chicago is none too stable, and any local settlement would tend to be confined to one or two sections of the walls, without materially disturbing the masonry and joints. In the third place, and an important consideration, with the coursed ashlar used in the face work, this disposition permitted the builder to better select and use his stone; as it was not at all essential that the courses should be continuous in height over adjoining sections of the walls.

To the best of our knowledge these vertical joints are a novelty in retaining-wall construction; and while they in no way affect the stability or appearance of the wall, they have several decided advantages, as above outlined.

THE SLOW SAND FILTRATION PLANT OF THE BERWYN, PA., WATER CO.*

By J. W. Ledoux.†

The American Pipe Manufacturing Co. has lately constructed for the Berwyn Water Co., at the Pickering Creek pumping station, a sand-filter plant having a nominal capacity of 1,500,000 gallons per day. With the exception of some outside earthwork, grading, sodding, and a floor in the gate-house, which were postponed on account of the weather, the work was completed and the filters put in operation about Jan. 1, 1899.

Previous to that date the water was filtered through mechanical filters of the Warren gravity type, having a nominal capacity of 750,000 gallons per day, and located in a building forming an extension of the main pumping station. The mechanical filters have always given satisfaction, and the water furnished by this company to their consumers along the main line of the Pennsylvania Railroad from Glen Loch to Bryn Mawr is justly celebrated for its uniform clearness and purity. The consumption of water from the Pickering Creek station is less than 500,000 gallons per day; but having in mind future increase, and wishing to have the two best recognized systems of filtration for constant comparison, the Berwyn

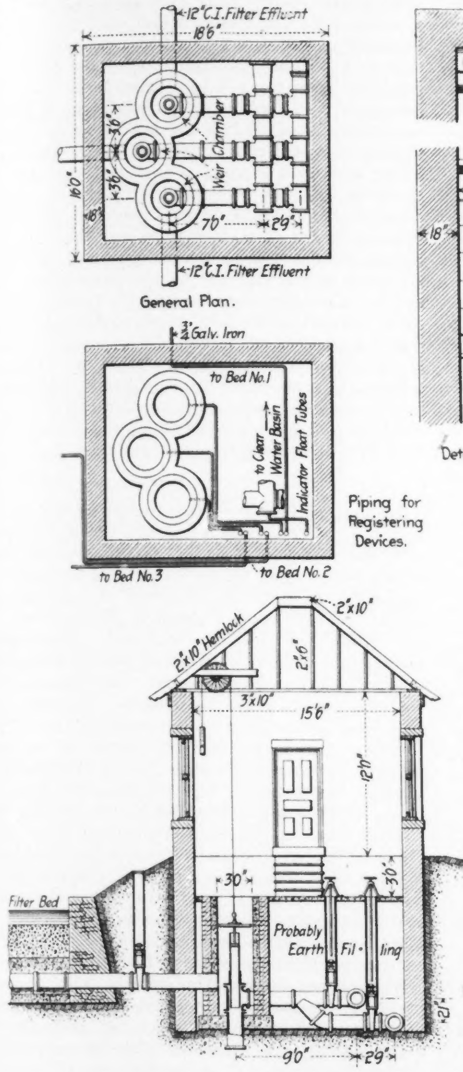
*Abstract of a paper read before the Engineer's Club of Philadelphia, Feb. 18, 1899.

†Chief Engineer, the American Pipe Manufacturing Co., 112 North Broad St., Philadelphia.

Water Co. installed the sand-filter plant, which, it is believed, has been designed and constructed according to good modern practice.

The sand-filters are built in three compartments, each containing 7,500 sq. ft. of effective filtering area, and arranged so that any one can be cut out or operated wasting the water without interfering with the others. About 600 ft. to the south of the filters is a masonry dam across Pickering Creek from which the water flows down the headrace to the pumping station. Opposite the center of each filter compartment is located the screen chamber, influent pipe and chamber. The top of the influent chamber is on a level with the top of the sand. A vertical section through the filter-beds shows 30 ins. of sand, 6 ins. of gravel, 3 ins. of concrete, and 8 ins. of puddle. The main drains are vitrified bell sewer-pipes 12 ins. in diameter, and laid with water-tight cement joints. The laterals are ordinary terra cotta 4-in. tile drains without bells made in 12-in. lengths and simply butted together. They are spaced 6 ft. apart and kept from moving out of place laterally by means of a handful of cement mortar placed under each side of every length.

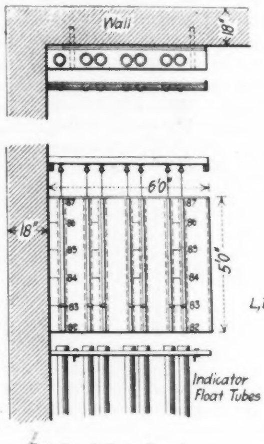
The laterals are placed in depressions in the concrete so that there is over each about 4 ins. of gravel. The gravel was screened and washed, and graded from pea-size to 1½ ins., the smallest sizes, of course, being placed on top. Just inside the masonry walls the main drains terminate in cast-iron pipe of the same diameters. The side walls and division walls are composed of rubble masonry, consisting of stone from a nearby quarry, and hydraulic cement mortar one to two. Outside of the masonry retaining walls is the earth embankment, composed of material excavated from the enclosure, which also contained suitable material for puddle. The gravel and sand were dredged from the Delaware River in the vicinity of Gloucester, N. J., towed in barges to a wharf on the Schuylkill near Race St., and from thence shipped via the Philadelphia & Reading Railroad to Phoenixville, from whence it was hauled by wagons to the site. The quality of sand was such that no washing or screening was required. The gravel had to be washed, screened and graded to the proper sizes. The sand was frequently tested, and proved very uniform in quality. One test was to determine the quantity of filtered water per acre that would pass through one foot of the sand, under an effective head of 12 ins. of water. The average showed about 60,000,000 gallons per acre per day. The effective size was 0.25mm. and the uniformity coefficient 1.82. Many samples of different qualities of bar sand and Jersey sand were examined before deciding on Gloucester white sand. An apparatus for determining the rate of percolation which is nearly as good as the one used, and much cheaper, is made by placing in a cylindrical tin tube, three or more ins. in diameter and 2 ft. long, two bottoms about 1 in. apart. The upper bottom is a brass cloth sieve, of No. 40 mesh, soldered in place. Between the two bottoms a ½-in. nipple, to which is attached a piece of rubber hose, is placed. In this tube is placed the required sand to a depth of 1 ft. The cylinder is then set under a spigot and the open end of the hose raised until the difference in level between top of cylinder and of hose is 1 ft. The spigot is then opened, the water falling on a lip at top of cylinder so as not to disturb or agitate the surface of sand, and the rate of percolation may be measured by means of a gallon measure held under end of tube, always being careful that spigot is opened wide enough so that a small amount of water constantly runs over the top of cylinder.



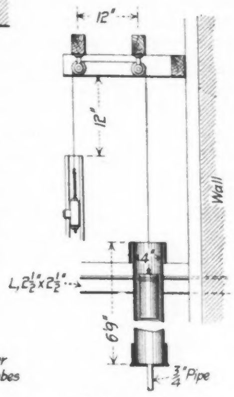
General Plan.

Piping for Registering Devices.

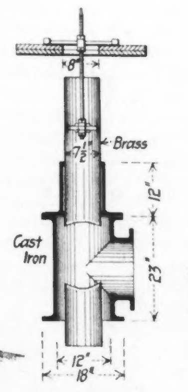
Vertical Section of Regulating Chamber.



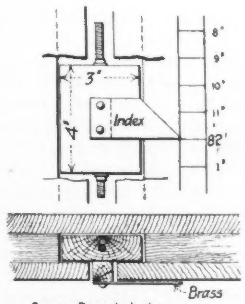
Details of Gage Board.



Indicator Float with Index Attachment. (Enlarged)



Automatic Regulating Weir. (Enlarged)



Gage Board Index. (Enlarged)

REGULATING AND REGISTERING DEVICES, SLOW SAND FILTRATION PLANT, BERWYN, PA.

J. W. Ledoux, Chief Engineer, American Pipe Manufacturing Co.

Provision is made to secure a uniform rate of percolation through the filter-beds. The regulating apparatus consists of a brass tube open at both ends and hanging to a float which rises and falls with the water-level in the effluent chamber. The top of the tube may be considered a submerged circular orifice or weir, whose distance from the float is constant but adjustable. The float and sliding tube are counterweighted as shown. As the sand bed becomes clogged by sediment deposited thereon, the water-level in effluent chamber will lower, and thus increase the effective head, or difference in level between the water on filters and in effluent chamber. When this difference becomes 4 ft., the surface of the sand bed must be scraped. Ordinarily, this period, at normal rates, will be twenty or more days, which is the length of time between scrapings. In the gate-house an indicator board is provided having seven indicators, one for each filter-bed, one for each effluent chamber, and one for the clear water basin. The difference in level between the water on filter-bed and that in the corresponding effluent chamber, which also indicates the loss of head, is shown at a glance. The board is graduated in feet and inches from ocean tide as a datum. (The details of the regulating apparatus are shown by the accompanying illustration.—Ed.)

The indicators slide in vertical grooves and are attached to No. 26 copper wires which run over brass pulleys. Attached to the other end of the wires are floats composed of 3-in. nipples capped at both ends. These work in float pipes having ½-in. pipe connections with the water on filter-beds, in effluent chambers, and in clear water basin. (The clear water basin is close to the filter beds, not covered, and has a capacity of about 1,250,000 gallons.—Ed.)

The sand-washing apparatus is on the jet principle. Sand scraped from the filter-beds is shoveled or otherwise conveyed into the first compartment, into which also runs a stream of water. The jet carries the sand up through the vertical pipe into the second compartment, and the dirty water flows over the top to a depression connected with the waste-pipe. In the same manner the sand is forced by jets successively through all the compartments, and finally through a pipe to the point where it will be stored or back to the filter-bed at will. The pressure on the jet pipes is about 20 lbs. With ¼-in. jets three tons per hour can easily be washed clear with this apparatus. The actual cost of the whole work is as follows:

Filter Beds.

	Quantity	Cost, Per unit.	Total.
Excavation,(1,850 yds.gradg)	6,772 cu. yds.	0.241	$1,631
Masonry: Stone (filter basin)	528.3 " "	5.541	2,927
Brick (filter basin)	2.4 " "	9.16	22
Concrete (filter basin)	304.5 " "	6.153	1,873
Plastering & forming gutters	2,432 sq. yds.	0.2428	592
Drain tile: 4-in., in place	3,200 lin. ft.	0.0648	207
12-in., collecting, in place	246 " "	0.654	161
12-in. ter. cotta clean-out drn	286 " "	1.198	343
C. i. inlet and outlet pipes	281 " "	1.5714	442
14-in. c.-i. filter discharge	200 " "	2.1918	438
Puddle	542 cu. yds.	0.709	385
Gravel, in place, filter bottom	655.65 tons.	2.115	1,387
Sand, in place in filter bottom	2,696.834 "	1.639	4,420

Gate House.

	Quantity	Per unit.	Total.
Masonry: Stone	97.2 c. yds.	7.234	703
Brick	10.75 "	7.380	79
Excavation*	125.3 "	0.985	123
Roofing, woodwork and painting			211
12-in. pipe, gaskets & bolts	9,584 lbs.	0.0309	296
Register and weir apparatus, in place			272
6 to 12-in. valves, with boxes and hand wheels			255
Three intake screens			40
Superintendence and engineering			729
Incidentals			1,000
Total			$18,536

*30 cu. yds. rock and 95.3 cu. yds. earth, including back fill.

THE INFLUENCE OF THE SIZE OF TEST PIECE ON THE COMPRESSIVE STRENGTH OF CAST IRON.

As many of our readers will remember, a committee of the American Foundrymen's Association is conducting an exhaustive series of experiments upon cast iron as a basis upon which to formulate a set of standard specifications for testing cast iron. The committee consists of Dr. Richard Moldenke, of the McConway & Torley Co., Pittsburg, Pa., chairman, and Messrs. Thos. D. West, Sharpsville, Pa., James S. Stirling, Wilmington, Del., Jos. S. Seaman, Pittsburg, Pa., and J. S. McDonald, Allegheny, Pa.

The committee has just completed its tests of Cast A, an ingot mold iron of soft Bessemer mixture. The 192 bars cast from this furnished 256 test pieces, and 280 separate tests.

We are enabled to give herewith, through the courtesy of the committee, the results of the compression tests. The test-bars were all square bars, cast vertically in dry sand molds, and of sections varying from ½-in. square to 4 ins. square, as shown by the table. From these test-bars were cut ½-in. cubes, the cut extending along a line at right angles to the sides of the test-bar. Thus, no cube retained a corner of the original test-bar except that which was cut from the ½-in. bar. The table makes clear that the metal cast in small molds is of much greater compressive strength than that cast in large molds.

Compression Tests of ½-In. Cubes of Ingot Mold Iron, Soft Bessemer Mixture.

Approximate cross-section of test-bar from which cube was cut, ins.	Crushing strength in lbs. Middle ½-in.	From edge First ½-in.	Second ½-in.	Third ½-in.	Fourth ½-in.
½ × ½	29,570	......	......	......	......
1 × 1	20,010	21,990	......	......	......
1.5 × 1.5	17,180	17,920	17,180	......	......
1 × 2	13,810	13,750	13,880	......	......
2.5 × 2.5	10,950	12,040	11,430	10,950	......
3 × 3	9,830	11,200	10,270	10,430	......
3.5 × 3.5	9,350	10,770	9,830	9,540	9,350
4 × 4	9,100	10,340	9,950	9,570	9,360

ENGINEERING NEWS
AND
AMERICAN RAILWAY JOURNAL.

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

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

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

A. B. GILBERT, - - - - - - ASSISTANT MANAGER.

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

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

PUBLICATION OFFICE, 220 BROADWAY, NEW YORK.
CHICAGO OFFICE, 1636 MONADNOCK BLOCK.
BOSTON OFFICE, 299 DEVONSHIRE ST.
CLEVELAND OFFICE, OSBORN BUILDING.
LONDON OFFICE, EFFINGHAM HOUSE, 1 ARUNDEL ST., STRAND.

SUBSCRIPTION RATES: United States, Canada and Mexico, One Year, $5.00; 6 months, $2.50; 2 months, $1.00. To all other countries in the Postal Union: Regular Edition, One Year, $7.60 (31 shillings); Thin Paper Edition, One Year, $6.31 (26 shillings). SINGLE COPIES of any number in current year, 15 cents.

In ordering changes of mailing addresses, state BOTH old and new addresses; notice of change should reach us by Tuesday to be effective for the issue of the current week. The number on the address label of each paper indicates when subscription expires, the last figure indicating the year and the one or two preceding figures the week of that year; for instance, the number 329 means that subscription is paid to the 32d week (that is the issue of Aug. 10) of the year 1899; the change of these figures is the only receipt sent, unless by special request.

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

The action finally taken by Congress in the closing hours of the session with respect to the construction of a trans-Isthmian ship canal under control of the United States, was to insert in the River and Harbor Bill the following sections:

Sec. 3. That the President of the United States of America be, and he is hereby, authorized and empowered to make full and complete investigation of the Isthmus of Panama with a view to the construction of a canal by the United States across the same to connect the Atlantic and Pacific Oceans; that the President is authorized to make investigation of any and all practicable routes for a canal across said Isthmus of Panama, and particularly to investigate the two routes known respectively as the Nicaraguan route and the Panama route, with a view to determining the most practicable and feasible route for such canal, together with the proximate and probable cost of constructing a canal at each of two or more of said routes; and the President is further authorized to investigate and ascertain what rights, privileges, and franchises, if any, may be held and owned by any corporations, associations or individuals, and what work, if any, has been done by such corporations, associations or individuals in the construction of a canal at either or any of said routes, and particularly at the so-called Nicaragua and Panama routes, respectively; and likewise to ascertain the cost of purchasing all of the rights, privileges, and franchises held and owned by any such corporations, associations and individuals in any and all of such routes, particularly the said Nicaraguan route and the said Panama route; and likewise to ascertain the probable or proximate cost of constructing a suitable harbor at each of the termini of said canal, with the probable annual cost of maintenance of said harbors, respectively; and, generally, the President is authorized to make such full and complete investigation as to determine the most feasible and practicable route across said Isthmus for a canal, together with the cost of constructing same and placing the same under the control, management and ownership of the United States.

Sec. 4. To enable the President to make the investigations and ascertainments herein provided for, he is hereby authorized to employ in said service any of the engineers of the United States Army, at his discretion, and likewise **to employ any engineers in civil life, at his discretion, and** any other persons necessary to make such investigation, and to fix the compensation of any and all of such engineers and other persons.

Sec. 5. For the purpose of defraying the expenses necessary to be incurred in making the investigations herein provided for, there is hereby appropriated out of any money in the Treasury not otherwise appropriated, the sum of $1,000,000, or so much thereof as may be necessary, to be disbursed by order of the President.

Sec. 6. That the President is hereby requested to report to Congress the results of such investigations, together with his recommendations in the premises.

We believe this provision will commend itself to the people of he United States as on the whole a wise and conservative measure and one well calculated to carry out the undoubted public demand for the construction of a ship canal under the control of this government across the Central American isthmus. There will be more or less disappointment, we presume, especially upon the Pacific Coast, that some bill providing for an immediate beginning of the work of construction was not passed; but such disappointment really proceeds from a misunderstanding of the status of the enterprise. So far as Nicaragua is concerned, the United States has at present no more legal right to undertake canal building there than it would have to build a canal in France or Russia. Further, while the detailed results of the work of the Walker Commission are not made public, enough is known to justify the statement that much more extensive surveys and investigations must be made before the government could safely let contracts for construction. We believe, therefore, that if the phraseology of Section 3 is construed according to the evident intent of its framers,* practically everything can be done for the furtherance of the canal enterprise during the nine months before Congress reassembles, that could have been done had the Hepburn bill been made a law.

The responsibility for the next step toward a trans-Isthmian canal now lies with President McKinley. Congress has committed to him the task of selecting from the engineering profession men of such great ability, broad experience, and absolute impartiality that the nation can safely be guided by their opinion and the results of their investigation in undertaking the greatest engineering work of modern times. The problems which these engineers will have to consider are as difficult as have ever been presented to the profession. Both the Nicaragua and the Panama enterprises must be studied in all detail. On the former such difficult propositions as the great Ochoa dam, the San Francisco basin embankments, and the Greytown Harbor, not to mention many others, must be given an exhaustive study; and a final decision concerning them must be made. The same thing applies at Panama to such matters as the proposed great water storage basins for controlling the Chagres floods, and the probable effect of the climate upon the labor supply and the cost of construction.

It needs no argument to prove that for the solution of all these questions the highest order of engineering ability which can be procured is demanded. The President will fulfill the wishes of the country if he makes merit and fitness the sole criterions in the selection of the engineers to conduct this work.

As was to be expected, the cutting and trimming of the Army Bill to adjust the differences of opinion in the two houses of Congress, and, unfortunately, to serve the personal ends of individual members, has resulted in a piece of makeshift legislation, full of defects which promise to make plenty of trouble in the future. As it was finally passed, with the Gorman amendment reducing the army in 1901 to its former limits of size, it throws all promotion into confusion and exposes many of the promoted officers, long in service, to the danger of being thrown out of the army entirely on that date. The bill corrects none of the evils of permanent staff appointments, so vigorously denounced by Senator Proctor, and leaves this department open as before to all the dangers of political influence, which may and does place young officers in life positions above the heads of others superior in rank and better qualified to perform the duties of the office. The bill itself contains evidence of special legislation, and political pull, in one clause which applies only to two officers in the army, and was evidently inserted by Senator Allen for the benefit of these two men alone. This clause innocently enough provides that:

Any officer now in the army who was graduated at the head of his class at the U. S. Military Academy, and who is not now in the Corps of Engineers, may be appointed to the Corps of Engineers with the same grade and date of commission that he would have if he had been appointed to the Corps of Engineers on graduation.

As pointed out by General Wilson, the Chief of Engineers, in a letter to the Secretary of War, this would promote Captain Williams over the heads of eight majors, and nearly all the captains of the corps, and would jump Capt. Rogers Birnie, of the Ordnance Department, over the heads of thirteen majors and all of the captains of the Corps of Engineers. Judging by the length of the "jump" alone, these men have long been out of touch with the technical duties of the Corps of Engineers, are wholly unfitted to perform the duties of an officer in that corps, and the action proposed is a gross injustice to those who have laboriously and patiently passed through all the service and training necessary to make efficient officers and are now subjected to the danger of losing a step in promotion that rightfully belongs to them. These favored men may be accomplished officers in their particular branch of the service, but it is very safe to say that they are not experienced engineers; and consequently have no legal or moral right to the promotion which this special legislation would give them. The reported threat of Senator Allen, to filibuster to defeat the passage of the bill, if his amendment were not accepted, only makes the iniquity of the proposed action more apparent. As the amendment reads "may be promoted," we sincerely trust that the letter of General Wilson may so influence the President that no action will be taken.

We present to our readers in this issue a full description of the longest electric power transmission line in the world, that of the Southern California Power Co. Water power is developed from mountain streams east of San Bernardino, and drives impulse wheels under a head of over 700 ft. These are directly connected to three-phase alternating current generators, which deliver current at 750 volts to air-cooled transformers which are arranged to raise the potential to 33,000 volts. The present capacity of the station is 4,000 HP., but this can be increased to 6,000 HP. or more when the demand warrants the installation of additional machinery. The transmission from the power station to Los Angeles, a distance of a little over 80 miles, is over six No. 1 copper wires (about 9-32-in. diameter), and it is of much interest to inquire what loss in current (and consequently in power) will occur in this long line transmission and also in the entire plant from the water applied to the wheels to the final application of the current for light or power in Los Angeles.

We are not informed as to the exact arrangement of the connections between the generators, transformers, line wires, etc., but assuming the arrangement to be such that the full conductivity of the line wires will be used to the best advantage, our computations show a loss of only about 2¼% when the plant is operating at one-fourth the full load, or 1,000 HP. When the plant is operating at its full capacity, or 4,000 HP., this loss is increased to about 8.6%. Of course, these are merely approximate figures based on the line resistance, approximate impedence, and current alone, and it is quite likely that unequal loading of the wires, leakage from the line, etc., may somewhat increase the above figures in actual practice.

Let us next compute the probable efficiency of the entire plant, making use of the figures already obtained for loss in the line. We have assumed the percentages of efficiency of the several elements in the generation and transmission of the power as follows:

Item.	Per cent. Efficiency.	Per cent. Net power.
Impulse wheel	70	....
Three-phase generator	93	65.1
Step-up transformer	95	61.8
80-mile line (assumed avg. loading)	92	56.8
Step-down transformers	95	53.9
City line	96	51.8
Lighting transformer	93	48.2

The above applies to the alternating current distributed directly from the Los Angeles sub-station at 2,200 volts pressure for residence lighting. A part of this 2,200-volt current, however, is taken to another station where it drives a synchronous motor connected to a direct-current low-tension

---

*Whoever drafted Section 3 was apparently under the impression that Nicaragua was upon the Isthmus of Panama, whereas, by the usual interpretation, the Isthmus is not considered to extend beyond the borders of Costa Rica. As the Isthmus boundaries are geographical and not political, however, and as the context makes the intent clear, there will be no question, we presume, that both projects are to be investigated upon the same footing.

generator. We may follow the efficiencies through this chain also as follows:

Item.	Per cent. Efficiency.	Per cent. Net power.
Step-down transformers	95	53.9
Line between sub-stations	96	51.8
Synchronous motor	93	48.2
Direct-current generator	93	44.8
Low-voltage line	90	40.3

We have assumed a rather low efficiency for the water-wheels in the above computation, since the method of governing under the very high head used is necessarily by deflecting the nozzle from the wheel. All the efficiencies are assumed to represent average conditions of loading. It will be seen that the line loss will decrease as the load is reduced. On the other hand, the percentage of efficiency of the other elements in the transmission will fall off somewhat when they are worked at less than their rated economical capacity. It will also be noticed that we have taken no account of the power used in driving the exciter dynamos, and the blowers for cooling the transformers. On the whole, therefore, it is safe to conclude that the electrical current finally delivered to the consumer in Los Angeles represents not more than 40% to 50% of the power in the power originally available in the water at the power station.

It will be noticed, however, that the line loss is a very small proportion of the total. In fact, the figures of efficiency given above are about as good as can be expected in any power transmission system where the voltage is high enough to make necessary the use of both step-up and step-down transformers.

The increased demand for iron and steel has at last brought the long-expected and feared rise of prices, which now has all the appearance of a "boom" similar to the one which the trade experienced in the latter half of 1879. The following list, from "The Iron Age," shows a comparison of prices at the three dates given:

	March 2, 1898.	Feb. 1, '99.	March 2, '99.
Foundry pig, No. 2, Phila.	$10.50	$11.75	$13.50
Bessemer pig, Pittsburg	10.30	11.00	13.50
Gray forge, Pittsburg	8.90	10.00	12.50
Steel billets, Pittsburg	15.25	17.25	22.00
Steel rails, heavy, Eastern	18.00	19.00	23.00
Old steel rails, Phila.	10.50	11.50	12.75
Old iron rails, Phila.	12.50	13.50	15.00
Refined iron bars (cts. per lb.)	1.07½	1.20	1.25
Steel bars, Pittsburg	0.95	1.05	1.25
Tank plates, Pittsburg	0.97½	1.40	1.60
Beams, Pittsburg	1.15	1.30	1.40
Sheets, No. 27, Pittsburg	1.90	1.95	2.10
Wire nails, Pittsburg	1.50	1.50	1.85
Tin plate, domestic, 100 lbs., N. Y.	2.90	3.44	3.69

The rise in prices does not mean, as may be supposed, great profits to the iron and steel manufacturers. Most of them have enough orders taken at the low prices which prevailed during the whole of last year to run their mills for six months or more; and are not in shape to accept the orders for prompt delivery at the present quoted prices. If they increase the rate of driving or blow in additional blast furnaces, they are confronted with the scarcity and high prices of such ores as are not already contracted for. There are likely to be exciting times in the trade during the next month or two, and there is no telling how high prices may yet go. One thing is to be expected, however, and this is that after prices reach their maximum point, whether this happens a month or six months hence, there will be a sudden drop, and at some time, either next year or within two or three years, the prices of 1898 will prevail again.

All the metals, as well as iron, have advanced far beyond the prices of last year. "The Iron Age" figures are as follows:

	March 2, 1898.	Feb. 1, '99.	March 1, '99.
Copper, New York	$11.87½	$17.00	$17.75
Spelter, St. Louis	3.95	5.40	6.00
Lead, New York	3.70	4.65	4.30
Tin, New York	14.20	25.00	24.00
Antimony, New York	7.50	9.00	10.00
Nickel, New York	33.00	38.00	38.00

THE PRESSURE DUE TO VELOCITY OF CENTRIFUGAL FANS AND PUMPS.

The question "What is the correct formula to express the relation between the velocity of the tips of the blades of a centrifugal fan or pump and the maximum pressure resulting from such velocity?" is one that is frequently raised. It is brought to our attention now by the paper of Mr. Alton D. Adams, which we publish in another column.

The question is of interest especially from the fact that technical writers continually differ as to whether the head due to the tangential velocity of the blades of a centrifugal fan is $v^2 \div 2g$, or $v^2 \div g$. Most of the text books do not treat of this precise question, and it is a rather difficult question to solve by inferences drawn from the general formula of the relation of velocity to head, $v = \sqrt{2gh}$, and from the laws of impact of fluid streams. It is no wonder, therefore, that Mr. Snell's formula, mentioned by Mr. Adams, and the tables derived therefrom, published twelve years ago, met with no criticism in the somewhat extensive discussion of his paper before the American Society of Mechanical Engineers, or that no one, so far as we know, ever pointed out their error in any text book or other publication. Prof. R. C. Carpenter, of Cornell University, however, at the recent meeting of the American Society of Heating and Ventilating Engineers, in a conversation on the subject, stated that he had found their error, and Mr. Kent said that he would correct them in the next edition of his "Pocket Book."

The statements made on p. 513 of Kent's "Pocket Book," to the effect that the correct theoretical formula for the relation of pressure to the velocity of the fan blades should be derived from $v = \sqrt{gh}$ and not from $v = \sqrt{2gh}$ are correct. Mr. Snell's formula, quoted on p. 514, is in error, and Mr. Adams is also in error in his conclusion that the correct formula is $v = \sqrt{2gh}$, as we hope to make clear below.

The first proof that the pressure produced by the fan blades is greater than that due to the velocity, or greater than $h = \frac{v^2}{2g}$, is obtained from Buckle's experiments, in 1847, quoted by Kent, p. 513. These experiments give $0.617\ v^2 \div g$, which is 1.234 times the head due to the velocity. Buckle's experiments are confirmed by Prof. Carpenter, who, in his paper on "Investigations of a Blowing Fan," read at the meeting of the Heating and Ventilating Engineers (Eng. News Feb. 2), said:

> I have found by a comparison of Buckle's formula as above with actual tests that the maximum pressure which is produced by a given peripheral velocity is greater than that stated by Buckle by an amount which varies in different conditions from 1 to 15%.

A head 15% greater than that given by Buckle's formula, would be $1.15 \times 1.234 = 1{,}418$ times the "head due to the velocity," or $1.418\ (v^2 \div 2g)$.

Prof. Carpenter also says:

> The maximum pressure which may be produced is the only one which can be considered as positively depending upon the peripheral velocity, since the actual pressure in any given case depends very largely upon the resistances to a free discharge corresponding in the case of the experiments cited to the area of outlet. The more freely the air is discharged, or in other words the less resistance, the less the pressure that will be produced by the fans. Buckle's formula, however, is usually a safe one to employ, since the pressure given by it is less than can be realized in practice, provided the resistance to the flow of air is at a maximum.

That the correct theoretical formula for maximum head or pressure produced by a fan is $h = v^2 \div g$, and not $v^2 \div 2g$, may be shown as follows:

Let W lbs. of air be taken from rest and expelled from the fan case at a constant velocity of v ft. per second. The work done in simply giving velocity to this air is $\frac{1}{2}\frac{W}{g}v^2$. The momentum of W lbs. moving at velocity v is $\frac{W}{g}v$, and if this velocity is acquired in one second, the momentum is numerically equal to the constant force or pressure producing it, $= F$. This force represents the pressure exerted by the fan upon the air and the reaction of the air upon the fan. The product of this force into the distance through which it moves in a second at the uniform velocity of v ft. per second is the work done per second, $= F v = \frac{W}{g}v^2$, or twice the work done in simply giving velocity to W lbs. of air. The pressure F is, therefore, twice that required to do the work $\frac{1}{2}\frac{W}{g}v^2$, or twice the "pressure due to the velocity" as calculated from the formula $h = v^2 \div 2g$.

Let us interpret more closely the meaning of the above formula $F v = W v^2 \div g$. The force, F, is the constant force exerted by, or the resistance overcome by a fan blade or a piston moving a quantity of air at a constant velocity v for one second. The distance moved by the fan blade and by the air in one second $= s_1 = v$. The ordinary formula for the energy of a falling body is $F s = \frac{1}{2} W v^2 \div g$, in which $v^2 \div 2g = h$, the distance through which the body falls to acquire the velocity v. Also $v = g t$, in which t is the time of fall. If $t = 1$ second, $v = g$. Since in falling bodies F, the force, $= W$, the weight, the formula $F s = \frac{1}{2} W v^2 \div g$, gives $s = \frac{1}{2} v^2 \div g$, and when $t = 1$ second, $v = g$, and $s = \frac{1}{2} v$. That is, the distance fallen in 1 second equals half the velocity acquired at the end of the second. In this case the velocity is not uniform, but increases during the second from 0 to v, with the constant rate of acceleration g ft. per second. The case of the falling body, with a gradually increasing velocity, is, therefore, quite different from that of the fan blade, which moves the air in front of it with a uniform velocity, in which latter case $s_1 = v$, as shown above. For the fan we have $F v = F s_1 = W v^2 \div g$, and for the falling body, $F s = \frac{1}{2} F v = \frac{1}{2} W v^2 \div g$. The distance s passed through by the falling body is one-half of the distance passed through by the fan blade, or $s_1 = 2 s$, when the time in both cases is 1 second.

Also, since $F s_1 = W v^2 \div g$ for the fan, and $F s = \frac{1}{2} W v^2 \div g$ for the falling body, we find that the constant force, F, acting on a falling body for 1 second will do only half the work that the same force, F, exerted steadily by a fan will do on the air, and, therefore, since v and $v^2 \div 2g$ are the same in both formulas, the weight of air moved by the fan is twice the weight of the falling body.

Perhaps this may be made still more clear by considering the case of a falling body of water. Suppose we have a tank 16.1 ft. $= \frac{1}{2} g$ ft. high, full of water, and take 1 cu. ft. = 62.4 lbs. out of the top of the tank, and let it drop outside of the tank. It will fall with a gradually increasing velocity, reaching the level of the bottom of the tank in 1 second, the acquired velocity being $g = 32.2$ ft. per second. The acting force equals the weight of the water, $= F = 62.4$ lbs. The work done in 1 second $= F h = 62.4 \times 16.1$ ft.-lbs., $= \frac{1}{2} W v^2 \div g$. Now, instead of removing the water in this way, let a hole be cut in the side of the tank 16.1 ft. below the water level, of an area of $1 \div 16.1$ sq. ft., and let the hole temporarily be closed by a plate. The pressure exerted on the plate is that due to the head of 16.1 ft. of water, and its total amount is $1 \div 16.1 \times 16.1 \times 62.4 = 62.4$ lbs., the weight of 1 cu. ft. of water. We now have the same force, F, exerted to push the plate away that was exerted to cause the fall of the 1 cu. ft. of water. We now remove the plate and the water flows through the opening with a theoretical velocity (no allowance being made for the contracted vein or for friction), due to the head of water, of $v = \sqrt{2gh} = 32.2$ ft., the same velocity which was acquired by the falling water after it had fallen 16.1 ft. The quantity of water that will flow in 1 second will be the product of the area of the hole by the velocity $= 1 \div 16.1 \times 32.2 = 2$ cu. ft. per second, or just twice as much as was removed by letting the water fall freely through the air. The energy of the flowing water is $\frac{1}{2} W v^2 \div g = \frac{1}{2} \times 2 \times 62.4 \times 32.2^2 \div 32.2 = 62.4 \times 32.2$, or twice the energy acquired by the water let fall from the top of the tank. Twice as much water flows, and twice as much work is done. How can we explain this, since the force F seems to be the same in each case? In the first place we note that the water flows from the hole with the uniform velocity $v = 32.2$ ft. per second, while in the case of the falling water this velocity was only acquired at the end of the second, and the mean velocity was only $\frac{1}{2}$ v. Let us apply the equation of momentum, $F T = M V = W v \div g$, T being 1 second, $F = W v \div g = 2 \times 62.4 \times 32.2 \div 32.2 = 128.4$ lbs., or twice the force exerted by gravity upon the plate before it was removed from the hole. This means that the instant the plate was removed from the hole, the static force, F, or 62.4 lbs., which tended to push the plate outwards, and which was due to the fluid pressure of the head of 16.1 ft. of water, was replaced by an impelling force 2 F, or 128.4 lbs., pushing the water out of the hole.

Since action and reaction are equal, if there is a force of 128.4 lbs. pushing the water out of the hole, there must be an equal reaction somewhere in the tank, acting in an opposite direction. That this reaction exists is proved experimentally, as shown in Weisbach, Vol. I., Coxe's Translation, p. 1004. Weisbach proves theoretically that "the reaction of a horizontal stream is equal to the weight of a column of water whose cross-section is that of the stream, and whose height is double that due to the velocity." The experiment quoted showed that with an orifice the shape of the contracted vein the reaction was equal to the weight of a column of water 1.77 times the height due to the velocity.

When a quantity of air is taken from rest by means of a fan blade, and given a certain pressure and a certain velocity of discharge, there are two separate kinds of work done, as follows:

Let

W = weight of air put in motion in 1 second.
v = velocity in ft. per second.
d = density of air lbs. per cu. ft., = 0.08.
p = pressure of the air against which the weight W is moved in lbs. per sq. ft., = h d.
h = head of air in ft. = $p \div d$.
A = area of orifice in sq. ft.
g = acceleration due to gravity.
Q = volume of air in cubic feet, = $W \div d$.
$W = A\ v\ d = Q\ d$.

Work of putting W lbs. of air in motion = $W\ v^2 \div 2\ g$.

Work of moving W lbs., or A v cu. ft. against a resistance of p lbs. per sq. ft. = $A\ v\ p$.

Total work of putting air in motion and of moving it against the resistance = $W\ v^2 \div 2\ g + A\ v\ p$.

But $A\ v = W \div d$, and $p = h\ d$, therefore, $A\ v\ p = W\ h, = W\ v^2 \div 2\ g$, if $h = v^2 \div 2\ g$.

The total work is, therefore, $2 \times W\ v^2 \div 2\ g$, or twice the work done in simply giving motion to the air.

Exactly the same reasoning applies to centrifugal pumps, by simply substituting 62.4 lbs., the weight per cubic foot of water, in place of 0.08 lb., the weight per cubic foot of air.

Suppose we have a horizontal cylinder of 1 cu. ft. capacity opening into the bottom of a large tank which is filled with water to the height of 16.1 ft., or ½ g ft. above the axis of the cylinder. A piston moving at an exceedingly slow speed from the outer end of the cylinder, pushing the water into the tank, would have to overcome the resistance of 16.1 ft. head, and it would do work equal to the product of the volume passed through by the piston, in cu. ft. by the pressure per sq. ft., or to the product of the weight of water moved by the head, or 62.4 lbs. × 16.1 ft. This work we may call the "pressure work." Let it now be required to push the water into the tank at a lineal speed of 32.2 ft., or g ft., per second. The piston will now meet an increased resistance due to the additional work of giving velocity to the water. This extra resistance is equivalent to the head due to the velocity, or $h = v^2 \div 2\ g, = 16.1$ ft., and the work due to the velocity alone, independent of the "pressure work," is $\frac{1}{2}\ W\ v^2 \div g, = 62.4 \times 16.1$ ft.-lbs., an amount exactly equal to and additional to the pressure work.

Referring now to the discussion in the paper of Mr. Adams: His treatment of the subject of impulse of flowing streams, as illustrated in his drawings, is quite correct. The fallacy in his argument to show that the theoretical formula for pressure due to velocity in the case of centrifugal apparatus is that he assumes that because the work done in giving velocity to the air is equal to the work of expelling it against the head corresponding to that velocity; that is, $h = \frac{v^2}{2\ g}$, therefore these two works are one and the same, and, therefore, the formula $h = v^2 \div 2\ g$, is established. The fact is that these are two entirely different and separate works, only happening to be numerically equal to each other, and they should be added together to get the total work done.

The formula $v = \sqrt{2\ g\ h}$ is often erroneously used as the true theoretical formula for a Pitot tube. The correct formula would be $v = \sqrt{g\ h}$ if the fluid striking the opening were diverted in a plane at right angles to the axis of the stream, as shown in Fig. 2 in Mr. Adams's paper. In practice the formula $v = \sqrt{2\ g\ h}$ is often found nearly correct, but this is due to the fact that some of the energy of the stream striking the orifice is used up by friction or is diverted in some other direction at right angles to the axis of the stream. The actual relation of v to h varies with different shapes and sizes of openings and other conditions. The formula that should be used is $v = c \sqrt{g\ h}$, in which $\sqrt{g\ h}$ is the theoretical value of v, and c is an experimental coefficient.

LETTERS TO THE EDITOR.

Ice Obstruction at the Plant of the Niagara Falls Hydraulic Power and Manufacturing Co.

Sir: I notice on the first page of Engineering News of March 2 an item which was first published by the "Buffalo Commercial" in regard to our plant. The first part of this item is correct, down to the point where you say that our power house was practically shut down, and proceed to give reasons for it. Both of the statements as to the water backing up in the tail-race, and the penstock freezing, are totally untrue. There is no basis of truth in them. Nothing of the sort happened. We were at first inclined to think that the item in question which appeared in the "Commercial" was simply the vagary of a reporter, but it has been circulated so persistently that it almost looks as though there was malice at the bottom of it. To anyone acquainted with our plant, the idea that any such thing could happen is very ridiculous.

Truly yours, W. C. Johnson, Engineer.

Niagara Falls, N. Y., March 1, 1899.

Finding the Center of a Group of Shots.

Sir: Referring to the editorial comment under the heading, "Finding the Center of a Group of Shots," in the Engineering News of March 2, p. 138, the center obtained by the method given in the issue of Feb. 2 is called the "center of least string measurement." The group of shots which gives the least value of the sum of the distances of the several shots from this center is said to be the best (each of the groups compared containing the same number of shots).

The distance spoken of between this center and the center of the target simply affords a measure of the amount the sights of the rifle are out of adjustment for the prevailing conditions, subject to a correction for personal equation.

The center which should be used as a point from which to measure the distances to the several shots is the center of gravity of the group, as shown by "E. E. W." in the same issue.

Yours respectfully,
R. F. Bennett.

193 Warren Ave., Boston, Mass., March 2, 1899.

The Schlicht Process of Combustion.

Sir: It was with some surprise that I read your article on the Schlicht process of combustion in your issue of Feb. 16, 1899, in view of the fact that a device similar to that shown in Fig. 1 of your article has been in successful operation during the past month at the residence of Mr. A. R. Brink, of this city.

This residence is heated by a combination hot water and hot air heater placed in the cellar. At the time that I examined the operation of this process the temperature outside was 25° below zero, while inside I found the house evenly and comfortably warmed from cellar to garret. The fuel used in the heater was soft coal, but Mr. Brink stated that without the device mentioned he had not been able to use soft coal successfully during extremely cold weather.

I examined the heater and found the temperature of the water to be 150°, while all the doors and drafts were tightly closed so that the only way in which air could have reached the fire was through the top of the chimney.

In your article you seem to assert that the combustion products and the air cannot travel the same passages in opposite directions, but if they cannot, will you kindly explain how combustion could have been produced in the case which I have described. Very truly yours,

L. P. Wolff.

Red Wing, Minn., Feb. 25, 1899.

(We have not questioned the possibility that two air currents may travel in opposite directions in a flue for some distance, provided the velocity is low enough; and in the case cited by our correspondent, it is quite likely that enough air went down the sides of the chimney to suffice, with the air which leaked in through the smokepipe joints, ashpit doors and other crevices, for the combustion of the coal. There are very many house-heating furnaces, and for that matter many steam boiler plants, where the present arrangement of drafts, etc., is so wasteful and inefficient that almost any change would be an improvement. Mr. Schlicht is correct in claiming that heating the air used for combustion by the waste heat in the chimney gases should produce a saving; but we are inclined to believe that where his device has shown successful results, as in the case quoted above, it has been chiefly due to other causes than the actual heating of a current of air descending the sides of the chimney, while the hot gases are passing up the center. It would be a very nice thing if the air would go down without mixing with the furnace gases passing in the opposite direction and abstract heat from them on its way; but we have never seen any air currents sufficiently intelligent to behave that way. In this connection a letter published in our contemporary, "Power," for March, is of interest, and we quote from it as follows:—Ed.)

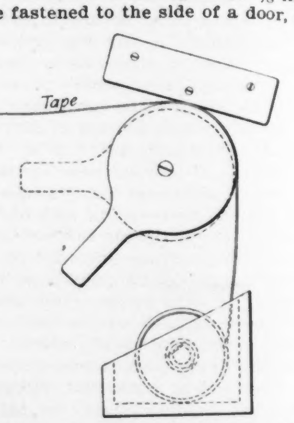
This process was tried at the Low Service pumping station, Brookline Water-Works, West Roxbury, Boston, Mass., under the personal supervision of the inventor. The average evaporation per pound of wet coal from 212° and at 130 lbs. for eleven days preceding the installation of the apparatus was 10.27 lbs.; for the eleven days with the apparatus in use, the evaporation was 10.2 lbs. The same apparatus has been tried at the United States Hotel in Boston, and at the plant of R. H. White & Co., and been rejected in both instances.

Notes and Queries.

In the letter entitled "Engineering Notes in Southern California" in Engineering News of Feb. 2, 1899, the valustion of $826,940 placed by the board of engineers upon the plant of the Los Angeles water-works should have been stated as not including, instead of including, 10% for engineering, supervision and contingencies.

A SIMPLE DEVICE FOR HOLDING A STEEL TAPE FOR CLEANING.

The accompanying sketch shows a simple and inexpensive device for holding a steel tape in a convenient position for cleaning when, as is frequently the case, that troublesome but necessary task has to be performed by a single person. As every engineer knows, steel tapes will, with the best of care, get rusty and when they are rusty about the only successful way to clean them satisfactorily is to scour them with oil and emery. With two persons, one to hold the tape while the other does the scouring, the task is a comparatively simple one, but where it has to be performed by one person it develops peculiar and exasperating annoyances of its own, as every one who has undertaken it knows. It is here that the value of the "grip" which we illustrate comes in. This "grip" is made from ¾-in. or ⅝-in. wood and can be fastened to the side of a door, or window recess, or other place convenient for operation. As will be seen from the sketch, the circular block is fastened with a screw which is placed eccentric to the center of the block so that when the block is in the position shown by the broken lines the tape slides freely, but is held fast when the block is in the position shown by the full lines. The knowledge of this simple device has been furnished to us by a correspondent who vouches for its convenience, but denies all claims to having been its inventor. We pass the information along for the sake of the peace of mind of those unfortunate ones of the field party upon whom falls the task of keeping its outfit of steel tapes in clean working order.



Sketch Showing Device for Holding a Steel Tape While It Is Being Cleaned.

THE PRESENT STATUS OF THE CENTRIFUGAL PUMP.

By Henry P. Jones, M. E.

During the writer's experience in engineering work connected with the installation of centrifugal pumps for various purposes the fact has frequently been evident that the centrifugal pump is regarded with more or less mystery by the average purchaser, due, perhaps, to the variable character of the data and information published by different manufacturers and also possibly to the nature of the technical literature upon the subject, in which the discrepancy between theoretical calculations and results of actual practice is usually given prominence.

In one case noted by the writer a "nominal" capacity was also given in addition to a "maximum" and a "minimum" "economical" capacity, and it amounted on an average to 5.6 times the minimum quantity. The horse-power required is usually given per foot or lift for a certain stated capacity.

In the installation of any pump a prime factor to be considered is the length and nature of the pipe through which flow is to be maintained, as this will determine the velocity of flow allowable without excessive loss in economy which results from high velocities in pipes of considerable length or frequent sharp bends.

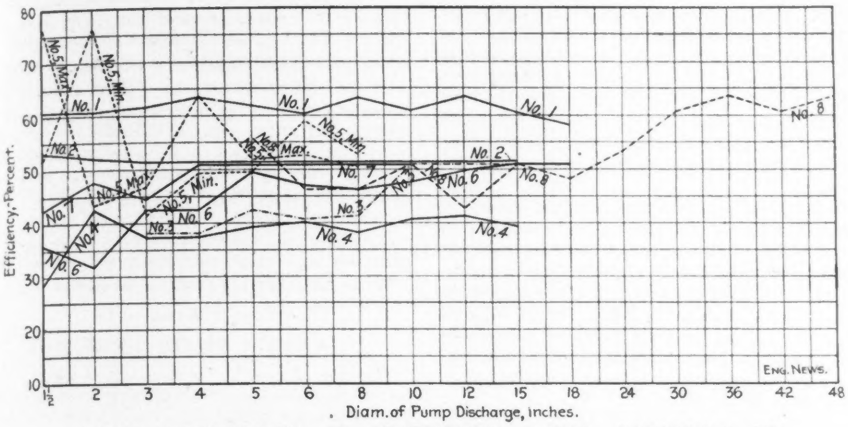


FIG. 1.—EFFICIENCIES OF CENTRIFUGAL PUMPS, ACCORDING TO MAKERS' CATALOGUES.

It is not the purpose in this article to enter upon a discussion of the merits of the various types of centrifugal pumps, nor is it intended to discuss at length the calculations necessary in their design; but a study and comparison of collected data is certainly interesting and may be of value.

In the opinion of the writer, centrifugal pumps may be divided into two general classes, one class consisting of those pumps, usually of large size, specially designed for certain conditions of service in connection with important work. They require experience and skill in their design and construction, and with close attention to the actual conditions to be met, a comparatively high efficiency may be attained; it being, of course, understood that these actual conditions of service are within the limits of the field in which centrifugal pumps are economically adaptable.

The remaining class of pumps is the class which will be discussed in this article, and it may be generally stated to include all those pumps to be found in the market as a "commercial article," not built for particular conditions, but being of the nature of a compromise in design, to meet varying conditions and intended to satisfy a general demand from contractors and others.

The centrifugal pump lends itself so readily to the conditions to be met in dredging and to the handling, in suspension, of various solids, that many are used for such purposes; but owing to the number of important factors to be considered in connection with such work, a discussion of "dredging" or "sand pumps" will be deferred until a future time.

The prospective buyer of a centrifugal pump is at once confronted by various catalogues and circulars setting forth certain data to aid in the selection of a pump. The accompanying diagrams are the result of a study of such data, eight different styles of pumps being represented, the said pumps being the product of six different manufacturers.

Centrifugal pumps are usually designated as to size, by the diameter of discharge at pump, and the capacity is stated in gallons per minute, an "economical" capacity usually being given. The "economical" capacity, in some instances, is stated as varying from a "minimum" to a "maximum," the maximum quantity exceeding the minimum quantity by an average of from 33% to 46%, though the difference is in some cases as great as 100%.

In constructing the accompanying diagrams similar conditions have been adhered to in all cases, in order that a fair comparison should result, and water has been assumed as the liquid handled and all velocities have been taken at the discharge orifice of pump.

The efficiencies are plotted for each size of the eight different styles of pumps, and they represent the ratio of the *actual* water HP. per foot of lift, for the stated capacity, to the HP. stated as *required* per foot of lift for that capacity.

The velocities of discharge for the different pumps are shown in the diagram of velocities by lines bearing numbers corresponding to pump numbers on the efficiency diagram.

The different makes of pumps, numbered from 1 to 8, may be briefly described as follows:

No. 1. A single capacity for each size of pump and the corresponding horse-power required per foot of lift are stated. While the efficiency line is fairly even it will be noted that the velocities are excessive, reaching a maximum of 31.92 ft. per second in case of the 4-in. pump.

No. 2. A maximum and minimum capacity for each size of pump and the corresponding horse-power required per foot of lift for the minimum capacity are stated. The efficiency and velocity lines are therefore plotted for the minimum capacity. The efficiency line is even, and the highest velocity is 12.25 ft. per second in case of the 5-in. pump. The average excess of maximum capacity over minimum capacity is about 33%, varying from 40% to 20%, the latter occurring in case of the 5-in. pump. The velocities would, of course, be increased by the same per cent. in discharging the maximum quantity.

No. 3. A single "rated" capacity for each size of pump and the corresponding horse-power required per foot of lift are stated. The efficiency is lowest for the 3-in. and 4-in. pumps, being about 38%, and reaches the highest point for the 10-in., 12-in. and 15-in. pumps, being about 51%. The velocity reaches the highest point for the 6-in. and 15-in. pumps; being 9.08 ft. per second.

No. 4. A maximum and minimum "economical" capacity for each size of pump and the corresponding horse-power required per foot of lift for the minimum "economical" capacity are stated. The efficiency and velocity lines are, therefore, plotted for the minimum quantity. It will be noted that the efficiency line runs from about 28% for the 1½-in. pump to about 43% for the 2-in. pump.

The low velocity line shows that the maximum "economical" capacity, which exceeds the minimum "economical" capacity by an average of 46.5%, would not produce an excessive velocity; but a "nominal" capacity is also given, averaging 5.6 times the minimum "economical" capacity, which would give an excessive velocity.

No. 5. A maximum and minimum capacity for each size of pump and the corresponding horse-power required per foot of lift for each case are stated, therefore efficiency and velocity lines are plotted for both maximum and minimum quantities. It will be noted that both efficiency lines show great irregularity, running from 51.6% to 76.4% to 46.2% for the minimum capacity, in case of the 1½-in., 2-in. and 3-in. pumps, respectively, similar irregularities occurring in the efficiency line for the maximum capacity.

The velocities are generally excessive, the lowest being in case of the 1½-in. pump discharging the minimum quantity, when it is 13.61 ft. per second; for the maximum quantity it runs the same as in the No. 1 pumps, No. 1 reaching 31.92 ft. per second for the 4-in. pump.

No. 6. A single economical capacity for each size of pump and the corresponding horse-power required per foot of lift are stated. The efficiency line is irregular, dropping to about 32% for the 2-in. pump and reaching 49.5% for the 5-in. pump. The highest velocity is 13.61 ft. per second for the 6-in. pump.

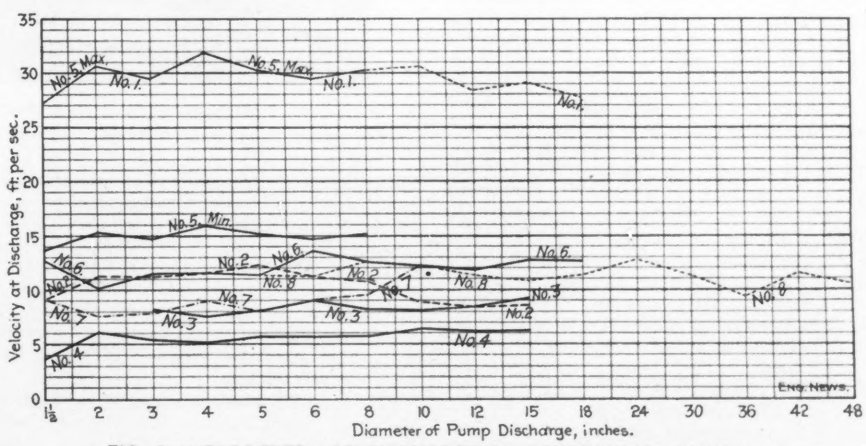


FIG. 2.—VELOCITIES OF DISCHARGE OF CENTRIFUGAL PUMPS, ACCORDING TO MAKERS' CATALOGUES.

No. 7. A maximum and minimum "economical" capacity for each size of pump and the corresponding horse-power required per foot of lift for the maximum "economical" capacity are stated, therefore, the efficiency and velocity lines are plotted for the "maximum" "economical" capacity. The efficiency line is even, after passing the 4-in. pump. The velocity line is fairly low, going above 10 ft. per second only in case of the 10-in. pump, when it reaches 12.25 ft. per second. The minimum "economical" capacity averages 36% less than the maximum "economical" capacity and velocities lower by that amount would result. A "maximum capacity" is also given, averaging 3.2 times the minimum "economical" capacity.

No. 8. A single "economical" capacity for each size of pump and the corresponding horse-power required per foot of lift are stated. The efficiency line is irregular, dropping from 55.7% for the 5-in. pump to 42.7% for the 12-in. pump, reaching its highest point, 63.6% for the 36-in. pump. The velocity line is lowest for the 15-in. pump, being 10.89 ft. per second, and highest for the 24-in. pump, being 12.77 ft. per second.

It is a very general practice to use discharge and suction pipes of larger diameter than the discharge and suction orifices of the pump, and it will be seen from an inspection of the above data that, on account of the high velocities, such an arrangement would in many cases be imperative, if the percentage of applied power actually effective in lifting water is to be kept within reasonable limits.

Some manufacturers recommend a certain velocity of flow for all sizes of pipe and base the "economical" capacities of the different sizes of pumps upon this one velocity. A diagram is given

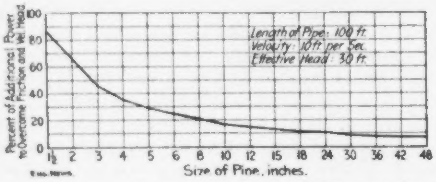


Fig. 3.—Loss of Power in Pipes of Different Sizes, with the Same Velocity of Flow.

which has been plotted from the following assumed conditions, and it shows the results which follow this method. The actual length of pipe was assumed in all cases at 100 ft. The velocity of flow assumed was 10 ft. per second. The corresponding velocity head is included in the calculations, but "entry" head, bends and minor sources of loss are omitted as not affecting the diagrams so far as purposes of comparison are concerned. The "effective" head is assumed to be 30 ft., the term "effective head" meaning the actual height the water is to be elevated.

It will be seen from the diagram that under these similar conditions of pipe length, velocity and "effective" head, the power consumed in overcoming friction and velocity head varies greatly in the different sizes of pipe; an amount equal to about 87% of the power actually required to lift the water being consumed in case of the 1½-in. pipe; 25.7% in case of the 6-in. pipe and about 8% in case of the 48-in. pipe.

It is, therefore, evident that, if it is desired to fix upon a certain economical percentage of the total applied power as a reasonable loss to be allowed for in overcoming friction and velocity head, the said fixed percentage to be adaptable to the different sizes of pipes, the velocity of flow must vary in these different sizes of pipes and a uniform velocity for all sizes cannot be recommended.

For a stated length and size of pipe and stated velocity of flow the amount of total applied power lost in overcoming friction and velocity head, measured in percentage of the power actually required to lift the water will vary inversely as the "effective" head.

For example, the diagram shows that for a 6-in. pipe and an "effective" head of 30 ft., an amount equal to 25.7% is consumed, then for an "effective" head of 40 ft. the amount consumed would be about 19.3%.

The meaning of the term "efficiency" as applied to a centrifugal pump is frequently indefinite. The efficiency of the pump itself would be represented by the ratio of the actual water horsepower measured at the pump discharge, to the horsepower applied at the pump shaft, the conditions to require no suction lift. If suction and discharge piping is included and the pump is to discharge at a certain elevation, the efficiency becomes that of the installation, being the ratio of the actual water horse-power to the horse-power applied at the pump shaft, the actual water horse-power being found in terms of the height the water is elevated and the quantity discharged. If the power applied at the pump shaft be given as the indicated horse-power of the engine or other motor, it is obvious that the efficiency of the engine or motor itself and also the loss due to friction, velocity head and other sources in the installation are combined with the efficiency of the pump to give the resultant efficiency. Therefore, when it is stated that a centrifugal pump will give a certain efficiency it must be remembered that such a statement can be made intelligently only when the conditions of installation are known and have been given careful consideration.

In the case of reciprocating pumps, sufficient important dimensions are usually given, so that by making due allowance for tightness of pistons and valves and for friction, slip, etc., the probable efficiency may be calculated. In case of the centrifugal pump a different problem is presented. Even if data relating to the different designs were published it is doubtful if calculations would lead to reliable results and the purchaser is therefore obliged to rely upon the conservatism of the manufacturer, whose statements as to efficiency must be accepted.

The economy of a centrifugal pump is known to be greatest under conditions of low lifts and large capacities, and guarantees of economy in case of lifts of from, say 75 to 100 ft. and guarantees of efficiencies above 60%, except, perhaps, in case of specially designed pumps, should be well investigated before receiving serious consideration. It is probable that in actual practice the majority of centrifugal pumps give an efficiency of not more than 50%.

The question of speed at which a centrifugal pump should run is dependent upon the total head to be pumped against, including friction, velocity head and other resistances in the installation, and upon the allowance to be made for slip, etc., in the pump itself. The theoretical peripheral speed of the revolving "disk," in feet per second which is required to overcome the total head is equal to 5.674 times the square root of the total head, stated in feet. To this speed must be added a certain amount necessary to overcome the above-mentioned slip, etc., of the pump, and this amount will depend upon the design of the pump and can be found only by trial.

The question is often asked "how high can a centrifugal pump actually raise water?" and while a definite answer cannot be given without making the experiment, yet it may be stated in general that water will cease to flow from the discharge pipe when the height of the discharge is such that the static pressure of the column of water contained therein balances the greatest pressure obtainable in the pump, excessive slip preventing further flow. The pump is assumed to be located at the source of supply, otherwise the suction lift would, of course, further diminish the height possible. If the construction of the pump be sufficiently strong to allow the disk to continue to revolve under these conditions, the work done by it will be expended in raising the temperature of the water contained in the pump casing.

A table of speeds recommended for different heads is usually given, the diameters of the pump "disks" however not being stated. From a knowledge of the diameters of the disks in certain cases the writer is able to state that the tabulated speeds exceeded the theoretical speeds for given heads by an average of about 50%, that being the amount allowed for slip, etc., in the pump, though in some cases the recommended speed fell considerably below this per cent.

On account of the ease with which a centrifugal pump may be direct-connected by coupling to an engine or other efficient motor and on account of the resulting economy in space and the elimination of loss of power due to the slipping of a belt, which is often excessive on account of the exposed and frequently damp location of the pump, such an arrangement is to be strongly recommended when first cost or other conditions are not prohibitive.

In concluding, it may be well to state that the formulas used in the few calculations which have been made above are as reliable as the present knowledge of hydraulics permits, and, while experimental data, systematically obtained and intelligently set forth, would prove a valuable addition to such knowledge, yet the writer feels that all statements and comparisons have been made with fairness, and that they represent correctly the present status of the centrifugal pump.

A HEAVY GEARED LOCOMOTIVE.

The use of geared locomotives is quite common on short steep-grade mountain lines, sometimes for passenger traffic, but mainly for lumber and ore traffic, and we illustrate a large geared engine recently built for the St. Paul & Tacoma Lumber Co., of Tacoma, Wash. The line on which it runs

50-TON SHAY GEARED LOCOMOTIVE FOR THE ST. PAUL & TACOMA LUMBER CO.
Lima Locomotive & Machine Co., Builders.

is of standard gage, with grades of 4 and 6%, and 70° curves, the engine being able to haul a train load of 106 tons up the 6% grades.

The engine is of the Shay type, having vertical inverted cylinders on one side of the firebox, driving a line shaft with bevel pinions which gear with bevel spur wheels attached to the face of the wheels. There are 12 wheels, and all the axles are driven by the gearing. The wheels are ranged in three swiveling trucks, one under the boiler barrel, one under the rear tank and coal bunker, and one under the tender. Each truck has a shaft carried in bearings secured to the truck frame, these shafts being connected with the crank shaft by intermediate shafts and universal couplings, thus allowing for the vertical and swiveling motion of the trucks.

The engine was built by the Lima Locomotive & Machine Co., of Lima, O., and we are indebted to that company for photographs and particulars. The general dimensions are given below, in our standard form.

Dimensions of Shay Geared Locomotive.

Running Gear:

Driving wheels (12), diameter ....2 ft. 8 ins.
Driving wheel centers, cast iron; Tires.............Steel
How are driving-wheel tires secured?.....By shrinkage
Journals, driving axles ....5 x 7 ins.

Wheelbase—Driving (each truck)............. 4 ft. 4 ins.
Total, engine and tender ....35 " 8 "

Weight in Working Order:
Total, engine and tender ....123,400 lbs.
Engine, empty .... 94,000 "
Water in boiler .... 4,800 "

Cylinders—Number ....Three
Diameter and stroke ....12 × 12 ins.
Crosshead and guides..Turned crosshead, bored guides

Valve Gear—Type ....Link
Ports, steam....¾ × 10 ins; Ports, exhaust..1½ × 10 ins.
Bridges, width.. ¾-in.; Eccentrics, throw.....2 "
Slide valves......balanced; Maximum travel ......2 "
" " inside lap, none; Outside lap ......11-32 "
" " lead (full forward gear and full backward gear) .... 1-32 "

Boiler—Type ....Wagon top
Barrel, diam. inside smallest ring.........3 ft. 9⅛ ins.
Dome, diam.................................2 " 0 "
Thickness, barrel plates and smokebox tube-plate .... 7-16 "
Horizontal seams and circumferential seams......... Double riveted
Joints ....lap; Rivets, diam...........¾-in.
Height from rail to center line............6 ft. 2 ins.
Length of smokebox (including extension)..4 " 8⅝ "
Spark arresting device......Diamond stack with netting
Injectors, two ....No. 7 Monitor

Firebox:
Length inside..6 ft. 1¼ ins; Width inside ....3 ft. 6 ins.
Working steam pressure ....150 to 160 lbs.
Depth at front ....5 " 3 "
Depth at back, above grates, at both ends. 4 ft. 7 11-16 "
Thickness, side plates and back plate..........5-16 "
" crown plate, ⅜-in.; Tube plate.......7-16 "
Crown stays ....Flat bars and braces
Grate bars ....Rocker, with plate
Firebrick..
At sides and backs, covering grates for burning wood
Stay bolts (solid); diameter, ⅞-in.; pitch.........4 ins.
Water spaces, width at front, back and sides.....3 "

Tubes........Charcoal iron; Number 129
Thickness...No. 13 W. G.; Pitch ....2 9-16 ins.
Diameter, outside ....2 "
Length over tube plates ....9 ft. 0 "
Total area of tube openings..................228 sq. ft.

Heating Surface and Grate Area:
Heating surface, tubes (interior area)......550.23 sq. ft.
" " firebox ....125.59 " "
" " total ....675.82 " "
Grate area .... 21.55 " "
Ratio of total heating surface to grate area...... 31.65
Ratio of interior tube area to firebox heat. surf. .018
Sq. ft. of total heat. surf. to 1 cu. ft. of cyl. vol.287.50
Sq. ft. of box heat. surf. to 1 cu. ft. of cyl. vol. 53.40
Sq. ft. of tube heat. surf. to 1 cu. ft. of cyl. vol.234.10
Sq. ft. of grate area to 1 cu. ft. of cyl. vol...... 9.08

Miscellaneous:
Exhaust nozzle (single), diameter............. 3½ ins.
Exht. nozzle, distance below center line of boiler.12¾ "
Smokestack, diam. at top, 40 ins.; diam. at base.12 "
" height above smokebox.......... 4 ft. 6 "
" height of top above rail........12 " 9 "
Capacity of tender tank ....2,000 gallons
" coal space ....8,000 lbs.
Brake fittings ....Lima steam brake
Tractive force per lb. of effective pressure on piston.179
Total tractive force with effective pressure equal to 85% of boiler pressure 24,344
Total adhesive tractive power at ¼ of weight on driving wheels 25,000
Ratio of tractive force to weight on driving wheels.0.2434

Gearing:
Pinions ....19 teeth, 2 ins. pitch
Spur wheels ....42 " 2 " "
Ratio of gearing 2.2105

NOTES ON THE OPERATION OF A LIGHT MINERAL RAILROAD.*

By James Douglas,† M. Am. Inst. M. E.

As the operation of light railroads is important to the mining industry, the following statistics of the Arizona Southeastern R. R. may be of interest:

When the traffic of the Bisbee copper-mines reached 20,000 tons per year the necessity of better transportation than that afforded by eighteen and twenty-horse and mule teams became imperative on the score of both cheapness and convenience. Before deciding on the construction of a railroad, the Copper Queen Co. made a thorough experiment in transportation with the traction-engine. A compound engine made by John Fowler & Co. was imported, having cylinders 6½ and 11¼ ins. in diameter and 12-in. stroke, constructed to run under a pressure of 140 lbs., and possessing a tank capacity of 220 gallons. It was put on the road between Fairbank and Bisbee, a distance of about 30 miles, with long grades of 10%. It soon became apparent that this engine was utterly unsuitable for long-distance haulage in an arid region. It could plow its way with difficulty through sand, but after the lightest rain its wheels revolved and it became utterly powerless on a muddy road. If a rain-storm occurred on a clayey stretch of ground the engine came immediately to a standstill. In order, therefore, to secure regular service in all weathers, a hard road-bed was essential. Although the machine was splendidly built, repairs were of course more frequently needed than on an engine running smoothly upon rails, and therefore it could not be used without liability to serious delays at a distance from a machine shop. The water supply for such an engine in an arid region also presents considerable complication. Under favorable conditions, however, it hauls very much more economically than animal teams. For some months it picked up the coke-loads of two 18-mule teams (the gross weight of loads and wagons being about 20 tons), hauled them over the Mule Mountain toll-road, up long 10% grades, and returned daily over the same grades with a load of copper, making a total distance of 18 miles. The same engine is now hauling 30 tons of ore daily, in two trips, from a mine three miles distant from Globe, over a hard, rolling mountain-road, at a cost, for labor, fuel and oil, of 27 cts. per ton.

*A paper read at the Buffalo meeting of the American Institute of Mining Engineers.
†11 Cliff St., New York city.

The general use of traction-engines having been abandoned, a railroad to the Copper Queen mine was decided upon, and two routes from Fairbank to Bisbee (a distance in a straight line of under 30 miles, but, on a deflected line around the south of the Mule Mountain pass, of 37 miles) were surveyed. The shorter line with heavy grades and narrow-gage track was located over the Mule Pass mountain, following substantially the route of the toll-road. The longer line for standard-gage, with 2.5% maximum grades, was selected. One motive for adopting the longer and more expensive line and the standard-gage was to avoid the transfer of fuel at the junction, and thus escape the heavy loss in coke involved by every handling, especially when using the friable product of the Colorado ovens.

As a 40-ton locomotive would haul the estimated amount of freight, namely, 30,000 tons annually, in one train daily, and as a 40-lb. rail was considered heavy enough to carry safely a locomotive of that size, drawing cars loaded up to the maximum capacity of even 60 000 lbs., it was decided to adopt a 40-lb. rail. The rails were made at the Joliet works of the Illinois Steel Co.

The first section of the road, 36.3 miles in length, was built from Fairbank to Bisbee in 1887. This was extended to Benson on the Southern Pacific in the summer of 1895. Most of the rails, therefore, have been in use for ten years. The road runs with easy grades for 30 miles up the valley of the San Pedro, and then commences to climb up long 2.5% grades. There are 98 curves of an aggregate length of 10.2 miles, the maximum being 12°. Of the 55.3 miles of road there are 45.1 miles of straight track and 10.2 miles of curves. There are 38.1 miles of ascending grade, 10 miles of descending grade, and only 7.2 miles of a level road-bed. The road is therefore exceedingly trying on both track and locomotives, and consequently the 40-lb. rails have been put to a severe test. The work they have done is shown in the following table:

Weight and Work of Engines.

Year ending June 30,	Mileage loaded cars.	Mileage empty cars.	Total tonnage.	Weight of engines, tons.
'89....	34,547	24,634	17,018	36-28
'90....	65,943	43,536	32,934	36-28
'91....	68,924	40,088	31,339	36-28
'92....	73,530	48,474	32,345	36-28
'93....	76,703	50,022	32,470	36-28
'94....	80,689	59,982	38,014	36-28
'95....	138,164	108,110	48,425	36-52-28
'96....	218,539	152,185	65,905	36-52-28
'97....	245,116	188,733	83,659	36-52-28-42
'98....	263,344	156,365	84,739	36-52-28-42
Total..	1,265,499	872,129	466,848	....

The rails have now been taken up and are being relaid on an extension where light service will be required of them. Only five have broken during the ten years of use, and to-day they are in perfect condition—neither surface-bent, nor kinked, nor buckled. Only the outside rails which were laid on heavy curves are somewhat worn. The fish-plates and bolts were often found broken, especially in the winter, when expansion and contraction are excessive, owing to the extraordinary diurnal variation of temperature, which often exceeds 60°.

Of course, the preservation of the rails has been secured only by laying them on a well-made gravel and clay road-bed, and bestowing more than ordinary care on the maintenance of the same. Two section-gangs are employed on the 55 miles. The rails were laid on split redwood ties 6 × 6 ins. by 8 ft., 2,640 to the mile. These have been cut into by the rails, but show no signs of decay, and, except those on the heavy curves, can be turned over and are good for many years more of light traffic. We are, however, laying our new rails on redwood ties with Servis tie-plates interposed.

Of the four engines used on the light rails, varying in weight from 56 to 32 tons, one, No. 3, is a Baldwin compound engine with four pairs of driving-wheels, a single wheel-truck and 13-ft. 7-in. wheel-base. The high-pressure cylinder is 12 × 24 ins. and the low-pressure, 20 × 24 ins. The engine weighs, when in working order, 105,000 lbs., and the weight on the driving-wheels is 89,-860 lbs. It has done with equal ease at least 50% more work than No. 2, a single-expansion Mogul engine, with a single truck and four drivers on a 14-ft. 2-in. wheel-base, the cylinders being 16 × 24 ins., and the weight of the engine, in working order, 76,000 lbs. But extra wear and tear, and the longer period of idleness in the shops, more than compensate for the economy in fuel. In the arid district, where the road is of necessity almost always dusty, and where sand-storms are frequent, locomotives with the fewest wearing-parts are to be preferred. An objection which we encountered with light rails, when using heavy rolling-stock, was, of course, the unduly rapid cutting of the tires of the driving-wheels.

The change from 40 to 60-lb. rails was incident to increased traffic. On the 2.5% grades a locomotive of safe weight could haul only five cars, carrying an average load and a passenger coach, or the tonnage on which we commenced operations, of about 30,000 tons a year. To handle, therefore, the increased tonnage indicated in the above table, three engines and three train-gangs were kept in almost constant service, and the operating expenses were reduced, through the larger business, only in the item of maintenance of way.

Economy, therefore, lay in the substitution of heavier rails and heavier locomotives, and a train which would do substantially all the work with one crew. The point of interest which I think worth recording is the amount of work done by the lighter rails, and the adaptability, therefore, of a rail of that weight to branch-roads of moderate traffic. It must be confessed, however, that to-day, with the wonderful diminution in the cost of rails, the inducement to economize in that item of construction is not so great as formerly.

REPORT OF THE NEW JERSEY RIVER POLLUTION COMMISSION.

In August, 1898, the Governor of New Jersey appointed a commission of eight members to consider means for the prevention of stream pollution. This action was taken under a statute passed by the legislature the preceding April. The commissioners were to receive salaries of $1,000 a year, and were authorized to employ necessary engineering, legal and clerical assistance, the cost to be assessed upon the communities benefited. The provisions of the act relating to the raising of funds proved inoperative. The commission, consequently, has been greatly hampered and apparently has concluded that a smaller body, working under a different plan, could do more effective work. It has therefore submitted a report to the legislature in which it strongly urges the need for immediate steps to regulate the discharge of sewage into the streams of the state, and the creation of a state sewerage board of three members to whom all plans for new sewerage systems would be submitted and which would supervise the operation of all sewage purification works.

The commission points out that the lower Passaic River is in greater need of attention than any other stream in the state. In fact, it was the pollution of this stream that led to the appointment of the commission, which, by the way, is the third one that has had the matter under consideration since 1896. This part of the subject is reviewed and discussed by the commission as follows:

Previous Experience.

The subject of river pollution and better methods of sewage disposal first came before the Legislature at the session of 1896. The Passaic River, from the Great Falls at Paterson to Newark Bay, receives the sewage of the cities of Paterson, Passaic, Orange and Newark; of the towns of Montclair, Bloomfield, East Orange; of parts of Rutherford, Kearney, Harrison and East Newark, besides some other drainage. A population of 436,423 (census of 1895) resides in the drainage district, and the discharge of the sewage into the river at that time was estimated to be about 70,000,000 gallons a day. The lower river, which has been abandoned as a source of water supply on account of the pollution, became so foul that in a period of drought in the summer of 1895, the stench from it, throughout its length, was such as to make it a nuisance and to imperil public health. In consequence of the complaints a commission of three was appointed by Governor Griggs, under authority of the Legislature, to examine into the pollution of the Passaic and suggest a remedy. The members of that commission, Messrs. Marsh, Herold and Hunt, are also members of the present body. They reported in February, 1897, and presented an act for legislative consideration. They had the advice of eminent engineers (A. Fteley, M. Am. Soc. C. E., of New York, and Chas. Jacobsen, since deceased, of Newark.—Ed.) and able counsel, and while the time was limited and the investigation was not as complete as they desired, they were convinced that the Passaic River pollution was a nuisance which required prompt remedy. They recommended the construction of a trunk sewer, draining the sewage of the district from Paterson to Newark, to discharge for the present into Newark Bay, the sewer to be further extended to lower New York Bay if found necessary in time, and the sewage to be subjected to treatment for the removal of solids, if objection arose before an extension was practicable. Under the law then proposed, the whole question was to be considered anew, and finally decided by a permanent commission to be appointed by the Governor.

A special message of the Governor, Hon. John W. Griggs, was sent to the Legislature shortly after the submission of this report, recommending that the report should be considered by the several municipalities interested, and that a special committee of the Legislature should also consider it. The great importance of the work and the necessity of the careful consideration of all its details was set forth.

In accordance with the Governor's recommendation, a legislative committee was appointed, and several sessions were held at various municipalities in the Passaic River district. A report was made to the Legislature, session of 1898, setting forth that objections had been made to the discharge of the sewage in Newark Bay and to the large cost of the trunk sewer (estimated at $6,500,000), and recommending that a new commission should be appointed. The act under which the present commission was appointed was then passed, and the undersigned eight commissioners were appointed.

Evil Conditions.

Meanwhile, the condition of the Passaic River has been getting worse, and during the last summer the conditions were even more intolerable than during the drought of 1895. At the same time complaints of other localities were heard, and there were also serious difficulties encountered in the protection of the water supplies of the cities of Newark, Paterson and Jersey City, drawn from above sources of the pollution of the Lower Passaic. It was made evident that a law which would reach this difficulty was also necessary, and such measures as are required, beyond the provisions of the act accompanying this report, are respectfully urged for the consideration of of your honorable body. In this connection, it may be well to direct attention to the recent use of the Passaic River Water by the City of Newark, to supplement its supply of pure water, which fell short in the cold weather. It is an illustration of the fact which has been repeatedly impressed upon your commissioners, that a large body of polluted water adjacent to great populations constitutes a peril, and that emergencies will arise by which the filth will be disseminated, no matter how careful the precautions may have been.

Treatment of Sewage.

While the present commissioners have not had the engineering advice which would enable them to make specific recommendations for any of the several cases of pollution which exist, a statement of a few apparent facts may be disirable. The trunk sewer system proposed for the Lower Passaic district by the former commission we regard as practicable, and the estimated cost is not prohibitory. As reported by the former commission and its engineers, a further and detailed engineering examination would, of course, be essential before work was begun, and this is necessarily the case in all preliminary examinations. It has been made evident, however, that there would be immediate and effective objection to emptying the crude sewage into Newark Bay, and a modification of the original plan in that regard would be necessary, to provide for sewage treatment by the removal of the solids before it entered the bay; or, by such an extension of the trunk sewer as would reach deeper water. The conditions which prevailed in 1896 have been somewhat modified also by the proposed construction of a trunk sewer draining South Orange and other towns in Essex county and Union into Arthur Kill. Objections have been raised to this latter place of deposit, and it would apear to be wise in the proppsed State Sewerage Board to consider whether combined action to secure a proper place of deposit for the sewage of both the Lower Passaic and Upper Rahway watersheds might not be advisable.

It is to be remembered that whatever system may be adopted for the disposal of the sewage of the Lower Passaic watershed, the construction of intercepting sewers to collect the sewage of each city or town and carry it to a place of treatment would be necessary, and that a large part of the cost of the trunk sewer work would be for this purpose. The advisability of all the towns and cities of that district uniting, is one to be finally determined only after further detailed investigation. That separate treatment by the several places is also practicable is believed by many, and in the case of some of the towns there is a strong desire in that direction. The proposed act we submit herewith gives the widest possible latitude and allows the greatest degree of independent control which is possible with due regard to the public convenience and welfare, and the rights of others.

There are several methods of treatment of sewage which might be applied to the Lower Passaic district, so that each community could deal with the problem on its own behalf. But whether broad irrigation, intermittent filtration, chemical precipitation and purification, or the later experiments in biological processes be attempted, experience has shown that they should be subjected to a close supervision by independent state autnority, clothed with full power, and that this should extend not only to the approval of plans but to the subsequent management of the sewage-disposal plants. For lessons in this regard it is not necessary to go beyond the borders of our own state. Under such regulation, the question as to the choice of methods becomes one of expense and thoroughness, to be determined by very close examination of all the conditions. In a general way, it may be stated that the prevailing opinion now favors the collection of the sewage and its decomposition as rapidly as possible, by promoting bacterial life, thus rendering it as nearly innocuous as possible, before finally depositing it. This is expensive, but is regarded as complete. Extensive experiments are now being made in this direction, and developments of value in solving our own difficulties may be expected therefrom.

Quite a large amount of space is devoted by the commission to the diversion of water from the Passaic and its tributaries for the supply of Newark, Jersey City, and other municipalities, and the effect of this upon the lower reaches of the river. The commission states that this diversion is claimed by some to cause a serious diminution in the flow of the river below Paterson, thus affording less dilution for the sewage and intensifying the nuisance caused by the latter. As the East Jersey Water Co. is developing a large water power pumping station at Little Falls, a few miles above Paterson, the commission asked the company for information regarding the amount of water it proposed to divert from the river and also for its views regarding the pollution problem. The company gave no definite figures regarding the amount of water it proposes to take from the river, but stated that with the proper development of storage reservoirs (regarding which it made no promises) the river flow would be better maintained than heretofore. The company also argued that it is folly to talk of depriving cities of pure water in order that communities below the intake may have a sufficient volume of flow to dilute their crude sewage. The pollution of the lower Passaic, the company said, ought to be stopped at once.

The members of the commission are as follows: Wm. T. Hunt, chairman, Newark; Jas. A. Exton, M.D., secretary, Arlington; William Kent, M.E., Passaic; Elias J. Marsh, M.D., and John Hinchliffe, both of Paterson; H. C. H. Herold, M.D., Newark; Chas. F. Harrington, Lyndhurst; Chas. W. Fuller, Bayonne.

The legislative act proposed by the commission is a lengthy one. It provides for the appointment of a state sewerage board of three members, with $1,500 salary each, to have general supervision of sewage disposal. The plans of sewerage systems now in existence are to be submitted to the board, and any changes hereafter made are to be submitted to it for its approval with reference to the pollution of streams. After five years the discharge of sewage into the waters of the state is to cease, except as permitted by the board, and measures for the removal of the sewage pollution are to be taken by the cities, and sewerage districts, subject to the approval of the board. If two or more municipalities prefer to join together, a petition to that effect is to be made to the board, and the district is to be defined and set off. A board of five commissioners is then to be elected to have charge of this local work. The board is to have a right to supervise the operation of sewage disposal systems so as to prevent pollution. The expenses of the local work are to be borne by the communities interested, and provisions are made for dividing the cost. The expenses of the State board, which are limited to $5,000 a year, above the $4,500 allowed for its three members, are to be borne by the State.

AN IMPORTANT DECISION ON RIVER POLLUTION BY SEWAGE IN NEW JERSEY.

An important decision in the history of stream pollution has just been rendered by the Chancery Court of New Jersey. The suit was brought against the city of Paterson about a year ago by riparian owners between the Great Falls of the Passaic River, at Paterson, and the Dundee Dam at Passaic, with whom was joined Jersey City, as riparian owner on the tidal portion of the Passaic, and as having certain rights to take water from the river for a public water supply. The plaintiffs asked that Paterson be enjoined from discharging sewage into the river from existing or future sewer outlets, but the effect of the decision only prohibits any increase in the present volume of sewage, leaving the complete stoppage of the use of the river as a place of sewage deposit until the final hearing of the case. Altogether, the decision is as complete a victory for those striving to protect the Passaic River from pollution as could be expected at this stage of the litigation. After stating the case, the Chancellor continues as follows:

Assuming that all the complainant relators except the Mayor and Aldermen of Jersey City are owners of portions of the banks of the river above the point to which the tide goes, their ownership extends to the middle of the stream, and they are entitled to have the water flow to them unpolluted, that they may use it for their ordinary domestic purposes and, within reasonable limits, for business or other purposes. Their common injury, beyond the discomfort and ill-health occasioned by the noxious and offensive odors arising from the water, is in the pollution and consequent deprivation of the uses of the water to which they have a right.

The Mayor and Aldermen of Jersey City, merely as riparian owner upon a tidal stream, has no right in the waters of the stream distinct from the rights of the general public therein. The adjacency of its property to the water merely affords convenience in the enjoyment of common rights. The water and the land under it, where the tide ebbs and flows, is the property of the State subject to the right of navigation.

As grantee of the State, of the right to take "pure and wholesome water" from the river at the location of its pumping plant for the uses of its inhabitants, Jersey City suffers special injury from the pollution of the stream. That injury lies not alone in the depreciation of the value of the plant erected for the purpose of utilizing the right given by the statute, but also in the deprivation to the inhabitants of Jersey City of the use of the waters of the Passaic River, for whose benefit the grant was made, and whom the corporate relator and complainants represent.

Thus it appears that the pollution of the Passaic River affects injuriously all the relators and complainants in depriving them of their respective lawful uses of the water.

It is objected by the demurrer that the relators and complainants, being the owners of distinct parcels of land along the Passaic, cannot join in such a suit as this. From what has been said of the allegations of the bill, it is perceived that they all suffer a common injury—the loss of the same pure and wholesome water and the substitution for it of a polluted and offensive water; from a single cause—the pollution from the Paterson sewers; for which one redress is sought in this suit—the stoppage of such pollution.

The same is true as to the baneful effect of the noxious odors that arise from the polluted waters. Until the Mayor or Aldermen of Jersey City ceased to make use of their pumping plant, the smells from the water affected all complainants, even the inhabitants of Jersey City, through the water delivered to them, in the same way, and now affects all other complainants than the Mayor and Aldermen of Jersey City in this way.

* * * * * * * * * * *

Each complainant has the right to have the identical water reach him in its pure, natural condition, except as the proper domestic and reasonable uses of the riparian owners above him may affect it. Above them all a riparian owner, for its own advantage, deliberately defiles, pollutes and corrupts that water, so that when it passes to those below it is burdened with noisome stenches and is utterly corrupted and unfit for the uses they each had the right to make of it. Can they not join, as may those affected by the common air defiled by the smells of a slaughter-house, in an appeal to this court, not to award each his damages, but to stop the defilement?

This last question was asked because one of the demurrers was to the effect that individual suits should have been brought, instead of a joint suit.

After disposing of this claim, the decision continues:

It is objected, also, that the defendant has the right to empty its sewers into the Passaic River, whatever the consequences may be. This contention rests in part upon the ground that it is a natural and reasonable use of the river, and in part upon the insistence that legislative authority to the city of Paterson to construct sewers contemplated their discharge into the Passaic and impliedly authorized it.

The sewage in question, it is remembered, is discharged into a stream above tide and where the stream is not navigable. It does not naturally flow to the stream. It is gathered by the municipality of Paterson in sewers from numerous buildings, cesspools, culverts and drains, over a large area of land, and by uniform artificially-constructed grades is gravitated to and discharged into the river. It is vastly more than the mere natural drainage of riparian owners. I cannot conceive of any tenable ground upon which such drainage can be classed as either a natural or reasonable use of the river.

An examination of the legislative acts authorizing Paterson to construct sewers shows no reference to the ultimate disposition of the sewage, nor the use of the Passaic for that purpose, nor do they license either public or private nuisances. The Chancellor then says:

As to private rights, I need only say that they have constitutional protection against such legislative enactment. In England, where the power of Parliament is omnipotent in matters of this kind, both as to public and private rights, it is well settled that legislative authority to merely drain into a stream does not authorize the contamination of the water. Legislative license to create a public nuisance of the kind considered must be given in express terms, or by absolutely necessary implication.

That the city of Paterson has any right to pollute the waters of the Passaic River by the discharge of its sewage into them is clearly an untenable position.

Another claim of the defendant was that the neglect of the plaintiffs to take action earlier was a reason why relief should not be sought in an equity court. This is dismissed because the facts seem to show that Paterson has gained rather than suffered through the delay, and that there was reason for the plaintiffs to assume that the pollution would not be allowed to continue until a nuisance resulted, besides which there has been since 1896, public action through local and legislative commissions for an alleviation of the conditions.

The last objection on the part of Paterson is stated and disposed of by the Chancellor, and the demurrer overruled, as follows:

Another objection made by the demurrer is that owners and occupiers of houses in the city of Paterson, connected with the sewers constructed, should be made parties to this application. The sewers do not belong to those persons. They are the property of the defendant, and the defendant is charged with the duty of keeping them in repair and suitable condition to afford drainage for the properties connected with them. The question considered is not the destruction of the sewers, but as to the disposition of the sewage they are designed to carry off. Moreover, if those who have paid for the sewers by assessments or their grantees are proper parties, the fact that they constitute a very numerous body, and are well represented by the defendant, their trustee, is a sufficient excuse for not making them defendants.

I will overrule the demurrer, with costs.

Having disposed of the demurrer, the Chancellor likewise brushes aside the objection that the whole case is one for a law rather than an equity court, and concludes his decision in the following language:

The defendant has presented affidavits which, with the affidavit annexed to the bill, show very conclusively to my mind if an intolorable nuisance does not already exist above the Dundee dam, a pollution that is well-nigh intolorable does exist, and that it is principally caused by the defendant's sewage. Some filth flows into the river directly from factories in the city of Paterson, but the bulk of the polluting matter above the Dundee dam comes from the defendant's sewers.

Below the dam, where the tide ebbs and flows, and sewage from other cities and from towns and factories may be washed by the tide up the stream, it is more difficult to say that the stoppage of the drainage of the defendant's sewers into the river would abate the nuisance. A large portion of the filth there comes from cities and towns, whose combined sewage is more than double that of the city of Paterson.

As I calculate, from the data before me, the volume of the pure water in the Passaic River below tide water is upon the ratio of 100,000,000 gallons to between 60,000,000 and 70,000,000 gallons of filth. The proof appears to indicate that both above and below the Dundee dam the potability of the water without the use of some means of purification is destroyed, and also that noxious smells arise from the polluted water, which, though perhaps not yet unhealthy, produce general discomfort to the inhabitants along the river, and that with the ever-increasing sewage of the defendant, must come a corresponding increase of discomfort, and presently disease.

In this situation it appears to be very plainly my duty to take cognizance of the case, and now restrain the defendant from doing anything that will increase the quantity of its sewage pending final hearing herein. Further relief should await the final hearings, not only because full and final relief should be withheld until then, to admit of all possible light being thrown upon the subject, but because of the impossibility of immediate provision of other means for the disposition of the sewage.

The Legislature, since 1896, has had its commission engaged in efforts to solve the question, what should be done with the 60,000,000 or 70,000,000 gallons of sewage now draining in the river, without satisfactory result, and it would not be just to require the defendant to act upon this difficult proposition without reasonab.e time or deliberation. The English courts have so treated cases of this kind. So also this course was adopted in Morgan vs. City of Danbury.

An injunction may issue as indicated.

It is reported that the case will be taken to the Court of Errors and Appeals on technical points, which will delay the final hearing on the permanent injunction.

REPORT ON THE WATER PURIFICATION EXPERIMENTS AT CINCINNATI, O.

Seldom in the history of engineering has there been such an addition to the literature of one of its most important branches within a short period as has been the case with water purification during the past five months. In our issues of Oct. 27 and Nov. 10, 1898, we reviewed the report of the experiments made at Louisville, Ky., while on Feb. 23 we published an abstract of the Pittsburg report. Below we present, through the courtesy of Mr. Geo. W. Fuller, Chief Chemist and Bacteriologist of the Cincinnati "Commissioners of Water-Works," a summary of the work in the same field which was concluded at Cincinnati in the latter part of January. The full report will not be published for some weeks to come.

Some facts regarding the Cincinnati experiments were published in our issue of Dec. 8, 1898. They were entered upon with the belief that it would be eminently wise to spend an equivalent of about a year's interest on the estimated cost of the purification works in securing more definite information for use in their design. Such studies were almost imperatively needed, owing largely to the fact that the engineer commission of 1896 had recommended subsidence and slow sand filtration, while the subsequent experiments at Louisville threw doubts upon the adequacy and economy of this plan for the Ohio River water.

The experimental plant had a capacity of 100,000 gallons a day. It included the following: Four 100,000-gallon steel settling tanks; 15 filter tanks having an area of 0.0025 acres each; a chemical and bacteriological laboratory; meters, gages and other apparatus. The plant as a whole was operated continuously from March 28, 1898, to Jan. 25, 1899. A total of 1,205 samples of water were examined chemically and 9,855 bacterially. From Dec. 3, 1897, when Mr. Fuller began to plan the work, until Jan. 31, 1899, the total cost of the experiments was $38,260, summarized as follows: Settling tanks, filters, piping system and buildings, $20,857; laboratory and office fittings, apparatus and supplies, $4,323; salaries, $12,973; incidentals, $108. The laboratory and office force included, besides Mr. Fuller, six trained assistants and two attendants.

On Aug. 1, 1898, 7 of the 15 filters were stopped, 5 permanently. Two of the filters were reconstructed and put in operation on Aug. 8, to be used with a coagulating and subsiding basin, the latter having a capacity of about ten hours normal flow of water for these filters. This part of the plant was operated as a modified system of slow sand filtration, the coagulant being used, in addition to subsidence, only when the river water was muddy. During September all the remaining eight filters, except the most efficient one, were stopped. On Sept. 14 tests were begun of a small mechanical filter, using a coagulant, in order to get results to compare with those obtained in August with modified slow sand filtration.

Where it is strictly applicable to the waters to be treated, says Mr. Fuller at the opening of his "Final Resume and Conclusions," the evidence shows that slow sand filtration is not only satisfactory, but "ordinarily somewhat more efficient and more economical for water for which it is readily applicable than any other process of purification which has received serious attention." But for waters laden with silt and clay, slow sand filtration has decided limitations. The tests indicate that as a somewhat arbitrary limit, though the best available, slow sand filtration alone is insufficient for the Ohio River water at Cincinnati, when suspended matters exceed an average of 125 parts per 1,000,000 in weight. Daily analyses show that during 1898 there were only 136 days, or 36% of the total, when this limit was not exceeded, and that except during June, July, September and October the suspended matter was not below the limit for ten days at a time.

Emphasis must be laid on the fact that the 125 parts of suspended matter is named on the supposition that the figure would be reached only occasionally. The constant amount of suspended matter compatible with slow sand filters would range from 30 to 70 parts per 1,000,000, averaging say 50. Allowing for a 75% removal by subsidence for three full days, the suspended matter would have been 50 parts per 1,000,000 on 197 days. Crediting the filters with an ability to handle, for short intervals, water containing more than 50 parts of matter in suspension, Mr. Fuller concludes, from a study of the records, that three days' subsidence, followed by slow sand filtration, would have sufficed on 231 days, or 64% of the time.

Some of the specific difficulties experienced with subsidence and slow sand filtration alone were as follows: The water was deficient in organic matter capable of forming gelatinous films on the sand grains when most needed, which, together with the fineness of the clay particles remaining after three days subsidence, allowed the latter to penetrate far into the beds, instead of remaining at the surface where the fouled sand could be removed in thin layers. At times of prolonged freshets, the effluent was so turbid as to be brown, sometimes containing 30 parts per 1,000,000 of suspended matter. Under such conditions "there was a marked tendency towards a diminution in the bacterial efficiency of the filters." Fish, earth worms and other forms of animal life sometimes disturbed the surface of the filters, causing irregularities in the rate of filtration. These difficulties, it seems to us, would also occur in mechanical filtration, unless the stirring of the sand in washing prevented the development of such life.

Sedimentation for more than three days would not be practicable because: (1) The fine clay particles remaining after 72 hours settlement subside very slowly, the percentage of decrease per day being seldom more than 5% of the original for the fourth day and steadily decreasing thereafter; and (2) the cost would be excessive. These conclusions being reached nothing remains but to employ a coagulant, for which purpose sulphate of alumina is considered as the best available. The use of a coagulant is perfectly feasible with either a modified system of slow sand filtration or with mechanical filtration. In the former, it would be necessary only half the year or less, or with the more turbid waters, and with the latter, increased turbidity would be met simply with the use of more sulphate of alumina.

The character of the Ohio River water at Cincinnati is such that no serious effects are to be expected through the use of sulphate of alumina.

If the modified slow sand filtration system were to be used it would be preferable to introduce the coagulant to the river water, when required, on the passage of the latter to the subsiding basins, rather than to provide a small basin for effecting coagulation after subsidence. This is necessary in order that the clay particles, so far as possible, may be thrown down in the settling basin rather than on the bed. With mechanical filters the coagulant would be added after subsidence in the larger basins, but from ½ to 6 hours should be allowed, according to the turbidity of the water, for coagulation and further subsidence before filtration begins. As the water enters the mechanical filters it must contain a certain amount of coagulant, either from the primary or a secondary application.

For either system of filtration, 48 hours of plain subsidence is recommended. Theoretically, it would be cheaper to increase the coagulant rather than to pay the capital charges on more than 24 hours subsidence, but oftentimes a second day's subsidence is very effective, while if this amount of reservoir capacity is available it may enable the shutting down of the pumps during the muddiest stage of the river.

Either method, modified slow sand or mechanical filtration, would give satisfactory purification, the deciding factors being those of expediency and cost. Mr. Fuller believes the mechanical filters could be handled more easily than the other system, with such muddy waters as those at Cincinnati, because: (1) The coagulant may be adjusted more readily to the subsided than to the more variable river water; (2) if too little coagulant is used more can be admitted just before the water reaches the mechanical filter, which course would quickly clog the slow sand filters; and (3) the mechanical filters obviate all possible difficulties caused by winter weather.

As to efficiency, assuming good management in each case, either system would remove an average of more than 99% of the bacteria, with slightly higher results at times for the slow sand filtration, although scarcely affecting the annual average. The removal of organic matter and clay should be "perfectly satisfactory" with either system.

The relative costs of the two systems are based on a daily capacity of 80,000,000 gallons, and cover only the expense from the time the water is discharged into the subsiding basins until it leaves the clear water reservoir on its way through the gravity conduit to the main pumping station in the city. No allowance, in either case, is made for the cost of land, which is already owned by the city. The estimates in detail are given in the accompanying tables. The settling reservoirs are on the basis of 48 hours average subsidence, or 96 hours actual capacity (320,000,000 gallons). The net rate of filtration is 3,000,000 gallons per day for the slow sand, and 125,000,000 gallons for the mechanical filters.

Estimated Cost of Subsidence and Slow Sand Filtration, per 1,000,000 gallons Capacity.

Construction:	
Reservoirs, 48 hours average subsidence....	$16,000.00
Pipe connections outside beds	500.00
Filter beds (3,000,000 galls. per acre per day net), chemical devices, piping, laboratory, etc.	16,667.00
Clear water reservoirs, total cap., 20,000,000 gallons	1,250.00
Total, per 1,000,000 galls	$34,417.00
Interest and sinking fund, 5% per year......	$4.72

Operation and Repairs:	
Salaried attendants*	$0.72
Scraping 20 times a year, 325 man-hours per scraping at 20 cts. per hour	1.19
Ice removal, etc.	.30
Washing sand, 1.75 cu. yds. at 40 cts.	.70
Replacing sand, 1.75 cu. yds. at 20 cts.	.35
Sulphate of alumina, 0.95 gr. per gall., at 1.4 cts. per lb.	1.90
Repairs, 0.5% of cost per year	.47
Total	$5.63
Capital charges	4.72
Grand total	$10.35

*One superintendent at $4,000 per year; 1 assistant superintendent, $2,400; 2 analysts, $1,500 each; 3 assistants and clerks, and janitor, $600 each; 1 night watchman, 3 reservoir, 3 filter attendants and 1 storekeeper, $720 each; 5 chemical attendants for 6 months per year, $360 each; extra labor, $1,500; total, $20,860.

Estimated Cost of Subsidence and Mechanical Filtration, per 1,000,000 Gallons Capacity.

Construction:	
Reservoirs, 48 hours average subsidence	$16,000.00
Pipe connections outside filters	500.00
Coagulating and supplementary subsiding reservoir, total capacity 20,000,000 galls. with piping	1,500.00
Filters complete (125,000,000 galls. per day net capacity), filter house, laboratory	7,500.00
Clear water reservoir, 20,000,000 galls. cap.	1,250.00
Total	$26,750.00
Interest and sinking fund, 5% per year	$3.67
Operation, Repairs and Renewals:	
Salaried attendants*	$1,17
Wash water, 5% of filtered water at $15 per 1,000,000 galls.	.75
Coal for power, and light	.15
Sulphate of alumina, 1.6 grs. per gall., at 1.4 cts. per lb.	3.20
Repairs and replacements, machinery and chemical devices, 10% per year on $2,500	.69
Other repairs, 0.5% of cost per year	.33
Total	$6.29
Capital charges	3.67
Grand total	$9.96

*Including, besides superintendent, assistant superintendent, analysts, assistants and clerks, janitor and reservoir attendants and extra labor, as under other system, the following: 15 attendants for filters and chemical devices and 3 firemen at $720 a year each; 1 mechanic and 3 engineers at $1,440 a year each; total, $34,180.

The total cost of each system, as shown by the tables, would be $10.35 for slow sand filtration and $9.96 for mechanical filtration, with large subsiding reservoirs in each case. Enlargements of a slow sand plant would be more expensive, relatively, than of a mechanical plant, owing to the topography of the land.

In conclusion, Mr. Fuller states:

The evidence obtained during these investigations shows that it is practicable to clarify and purify the Ohio River water in a satisfactory manner by either the modified English system or by the American system (meaning slow sand and mechanical filtration, respectively.—Ed.). Of these two systems, the experience and data indicate clearly that the American system would be the less difficult to operate; would be somewhat cheaper; would give substantially the same satisfactory quality of filtered water; and could be much more readily and cheaply enlarged for future requirements. It is therefore considered that the American system of clarification and purification would be the more advantageous to adopt for the local water supply.

NEW WATER-WORKS FOR ST. JOSEPH, MO., were authorized by popular vote a few days ago. The vote was a ratification of a franchise granted by the city in January to R. E. Culver and others and also of a contract for hydrant rental. The franchise and contract are designed to secure municipal ownership of the works. The contract for building the plant is said to be let to the Seckner Contracting Co., of Chicago. The city has been supplied with water since 1880 by the St. Joseph Water Co., which is now controlled by the American Water-Works & Guarantee Co., of Pittsburg, Pa. The old company applied for an injunction to prevent the holding of the election, but it was denied. There is likely to be more litigation before the works are built.

TYPHOID FEVER AT PATERSON, N. J., is again causing alarm. In December, 1898, there were 76 cases (not deaths) of the disease, as compared with an average of 4.7 cases in December for the ten years 1886 to 1895, inclusive. In December, 1896, there were 105 cases, attributed to the water supply, and in December, 1897, there were 122 cases, due to an infected milk supply. These figures were furnished at our request by Dr. John L. Leal, Health Officer, of Paterson. Dr. Leal attributed the cases last December to a temporary infection of the milk supply. This epidemic died down, but late in February another outbreak began, with about 10 cases a day reported, according to press dispatches. The present outbreak is also debited to the public water supply. In December quite an outcry was made against a camp of Italians at Little Falls, N. J., about five miles above Paterson. Hundreds of men were at work there during last season on the water power pumping plant under erection by the East Jersey Water Co. It was claimed that the men while at work and in camp polluted the stream. Inquiry of the contractor, made by this journal, resulted in assertions that the trouble at Paterson could not arise from any such cause, owing to the location and care of the privies for the use of the men. Dr. M. J. Synnott, Health Inspector of Little Falls, informed us that there had been no cases of typhoid among the Italians. He believed the December outbreak was due to dredging operations in the Passaic River, in connection with the power pumping plant. The deposits of years were being stirred up, only some five miles above the Paterson water-works intake. The same theory has been advanced by others. Against it is to be urged the fact that Little Falls has no public sewers and that comparatively few houses are so located that private sewers are likely to reach the river. A rumor is abroad to the effect that Paterson itself is responsible for these outbreaks through the discharge of sewage into the river from its city hospital, or in some other manner not stated.

THE TUNNEL UNDER THE EAST RIVER between New York and Brooklyn is under consideration by the Railroad Committee of the New York State Legislature in respect to the new legislation which is asked making the franchise of the New York & Brooklyn Tunnel Co. perpetual instead of terminating in 25 years as required by the section of the charter of Greater New York relating to railways. As will be remembered (Eng. News, Jan. 14, 1897) this projected tunnel originated in the efforts of the city of Brooklyn to abolish the numerous grade crossings over the Long Island R. R., which enters Brooklyn along Atlantic Ave. The commission appointed to devise plans reported in favor of partly elevated and partly tunnel lines, and the Long Island R. R. Co. accepted this solution and had very complete plans prepared for the work. As designed the work on Atlantic Ave would cost $2,500,000, of which the city and railway would each pay half, and the tunnel under the river to New York would cost $6,000,000, of which the railway would pay all. It has refused, however, to go ahead with the work unless it could get a perpetual franchise for the tunnel line, and a bill recently introduced into the Legislature and now before the Railroad Committee provides for this. Several hearings have been held by the committee, at which representatives of the grade crossing commission, the railway company and various business organizations of Brooklyn have urged that the required legislation should be granted. The railway company has announced its intention of going right ahead with the work as soon as the Legislature gives it the required perpetual franchise. The committee has not yet taken action on the bill.

A NEW BRANCH TO THE BOSTON SUBWAY is proposed by a bill introduced in the Massachusetts Legislature on petition of Mayor Quincy. It would run from Harvard Bridge, which leads to Cambridge, to Scollay Square, thus relieving the crowded Park St. station of hundreds of cars a day that now pass beneath the Boston Common. Coupled with the proposed subway is the construction or widening of the Charles River embankment along or near Beacon St. The subway would be placed in the new embankment during the construction of the latter.

TRAINS MUST STOP where state legislatures order, according to a decision of the U. S. Supreme Court on Feb. 20. The Ohio legislature passed a law requiring all railways to stop at least three trains per day (if it run so many on its line) at each town of 3,000 inhabitants or over. The Lake Shore & Michigan Southern Ry. refused to stop its trains at the town of West Cleveland, and the suit which was brought to compel it to do so has just reached the above final decision. Four of the judges dissented from the opinion.

THE BRITISH RAILWAY ASSOCIATION, according to a London item, will send five prominent railway officials to the United States to investigate the facts upon which the English government bases a bill compelling the adoption of automatic couplings on all the rolling stock of British railways after five years from the date of enactment. The estimated cost of this equipment is about $50,000,000.

AN EXHIBITION OF ROAD MAKING METHODS and appliances will be held in London on April 26 to May 6, in connection with the Building Trades Exhibition at the Royal Agricultural Hall. The road exhibition will be conducted under the auspices of the "Surveyor and Municipal and County Engineer," 24 Bride Lane, Fleet St., London, E. C. The main divisions of the exhibit will be as follows: Historical, road design and laying out, including engineers' instruments, materials for roads and streets; drainage, road making machinery, traction records, manhole and similar covers, tools, curbs and gutters, tramway rails, street and other signs, lamp and fire alarm posts, sprinkler stand-pipes, kiosks, shelters and seats; dust and orderly bins beneath the streets, literature of road and street construction, cleansing and maintenance.

AN INTERNATIONAL EXHIBITION is to be held in Glasgow in 1901. It will be held on the site of the exhibition of 1888 and under similar control; this site covers 67 acres in Kelvingrove Park and the Bunhouse Grounds. The sections of exhibits will include fine arts, history and archæology, locomotion and transport, electricity, labor saving machinery, marine engineering, the woman's section, and sports. All communications should be addressed to Mr. H. A. Hedley, General Manager and Acting Secretary, Glasgow, Scotland. Regulations for exhibitors are already published and can be had upon application.

AN 80-TON GRANITE MONOLITH, 65 ft. high, 6 ft. 8 ins. square at the base, 3 ft. 4 ins. square at the top, was recently quarried by Wetmore & Morse, of Barre, Vt., and transported by rail on two gondola cars to Cleveland, O. This monolith was ordered by Mr. John D. Rockefeller for erection in his lot in Lake View Cemetery, in close proximity to the Garfield monument. At Cleveland, Mr. Joseph Carabelli, proprietor of the Lake View Granite Works, contracted to transport it to the cemetery and erect it. The stone, enclosed in oak frames, was taken from the cars by soaped ways and is being transported over 3,000 ft. of highway to the cemetery by means of specially designed trucks. The front truck has four wheels, each ½ ft. in diameter and 13 ins. face, on axles 4 ins. diameter; the rear truck has eight similar wheels and two 18×18 ins. timbers connect the two trucks and support the shaft, which is being moved point first. The trucks run on planks laid on the road, and by means of a horse-capstan and five men it is being moved at the rate of about 10 ft. per hour. This monument will cost about $20,000 in place.

THE GREATEST HEIGHT REACHED BY A KITE was obtained at the Blue Hill Observatory, at Readville, Mass., on Feb. 28, when the recording instrument marked a height above sea-level of 12,507 ft. This is 383 ft. higher than the previous record, made last August at the same place, and which has been until now the world's highest record.

THE LICENSING OF CIVIL ENGINEERS is the purpose of a bill lately introduced into the Massachusetts Legislature by Mr. Leonard W. Ross, of Boston. The bill would require an official recognition of proper qualifications as a prerequisite of practice.

AN EARLY WORK ON SURVEYING has lately come into the possession of Mr. Joseph Kemper, City Surveyor, of Utica, N. Y. The title condensed is, "The Compleat Surveyor; containing the whole Art of surveying Land, by the Plain Table, Theodolite, Circumferenter, Peractor, and other Instruments, etc. Third Edition. By William Leybourn, Philomathe. London: 1674." This William Leybourn was originally a London printer; but later became quite a noted mathematician, and edited the works of Edmund Gunter, the inventor of the logarithmic rule, or the Gunter's scale. Leybourn also published the "Cursus Mathematicus," or "Mathematical Course," and the "Traders Guide." He died in London in 1693. An earlier publication on surveying was noted in this journal some years ago. It was entitled, "The Moste Profitable and Commendable Science of Surveying of Landes, Tenements and Hereditamentes; drawn and collected by the Industrie of Valentine Leigh." It was published by Andrew Mansell, in London, in 1577.

WASHINGTON NATIONAL PARK, near Mt. Ranier, in the State of Washington, is the subject of bills before Congress, proposing to set aside an area of about 18 miles square to be reserved as a public park. The House Committee on Public Lands has recommended its passage.

THE TOTAL DEBT OF LONDON, for 1897-98, says the Finance Committee of the London County Council, is $204,353,195, involving a charge on rates of $12,981,220; of this latter amount, $5,942,800 is interest, and the remainder repayment. The total debt is equivalent to 113¼% on the annual rateable value, and the charge is equal to an average rate over all London of 1s. 5¼d. in the pound. The debt of the City Corporation of London is not included in the above, and was $24,646,500, with an annual charge of $1,445,700.

ATMOSPHERIC OR ETHER VIBRATIONS were discussed in a paper lately presented by Mr. F. W. Branson to the Leeds Naturalist Club and Scientific Association, of England. He made experiments to illustrate the dissimilarity of the radiations of the atmosphere and of the ether; and presented the following table to show the gradations which may be observed between sound, light, heat and electrical waves:

	Vibrations per second.
Röntgen rays	288,224,000,000,000,000
Photographic limit of solar spectrum	1,125,899,906,842,624
Green light	562,949,953,421,312
Infra red	281,474,976,710,656
Heat rays of solar spectrum	70,368,744,177,664
Electric oscillations in Hertz resonator	67,108,864
Audible vibration	32,768
Music, highest note	4,096
Music, lowest note	32
Water surface waves of minimum velocity	16