SCIENTIFIC AMERICAN

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THE BOSTON SEWER SYSTEM AND MAIN DRAINAGE WORKS.

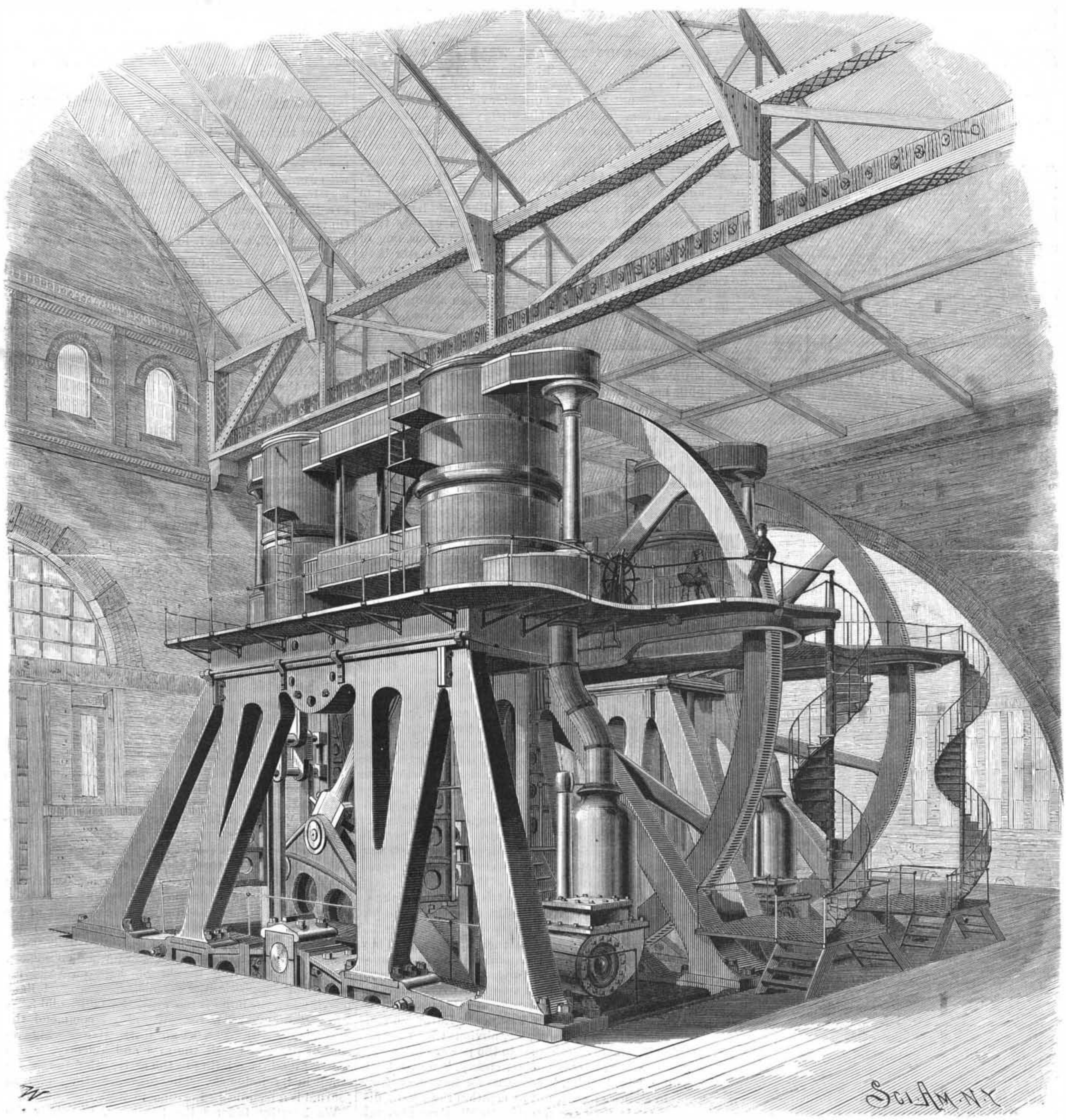
The city of Boston, Mass., has recently built and now has in full operation a system of sewage and drainage works that mark an important advance in sanitary engineering. A summary account of these works has already been published by us.* But as they include engineering work of the highest order, and as a number of perplexing problems are successfully solved in their construction, they appear to merit a fuller account.

By referring to the map of the city which accompanies this article, it will be seen that Boston lies upon a peninsula. On one side is the Charles River, separating it from Cambridge; on the other side are the waters of the South Bay; while a portion of its water front abuts directly upon the expanse of Boston Harbor. South Boston fills a second peninsula, which runs out into the harbor. Originally, the sewage was disposed of as in New York. It was allowed to run out into the water from numerous outlets. This was found objectionable. The water became contaminated, and the dock frontage was injured by the deposits of sludge. As the sewers were all constructed and in place, only the radical method of dealing with the problem seemed practicable. It was determined to surround the city with an intercepting sewer, which should receive the delivery from all the lines formerly discharging into the harbor and adjacent water. From this intercepting sewer, that was to encircle the city like a girdle, the sewage was to be taken to a distant point and, after proper clarifying, was to be discharged into the harbor.

Referring again to the map, the course of the new works, constructed in accordance with these ideas, may be traced. The old system, though still in place and in use, is not shown. The heavy black line encircling the city, and with branches running out into South

(*Continued on p.* 358.)

* See SCIENTIFIC AMERICAN SUPPLEMENT, No. 524.



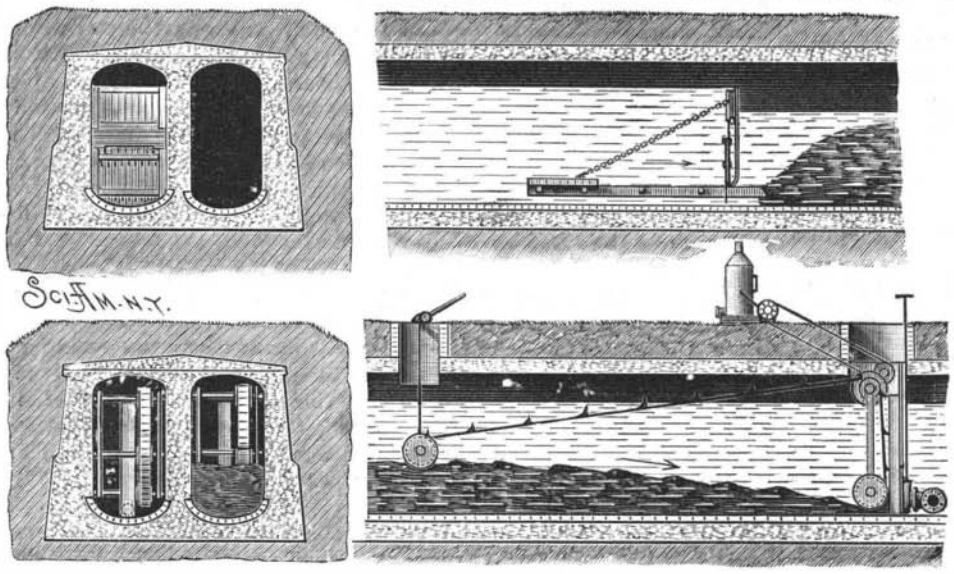
MAIN PUMPING ENGINE OF THE BOSTON SEWAGE SYSTEM.

THE BOSTON SEWER SYSTEM AND MAIN DRAINAGE WORKS.

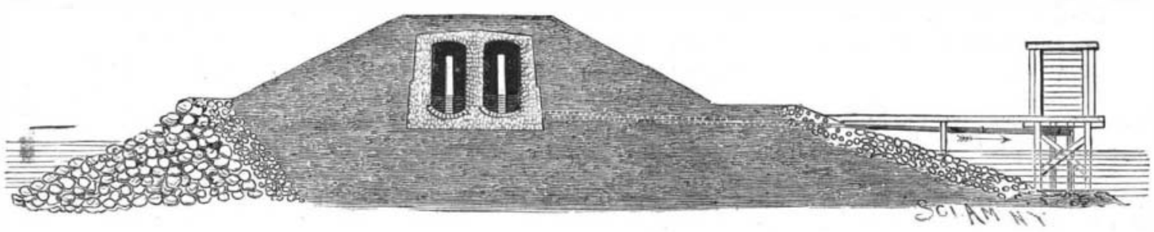
(Continued from first page.)

Boston, indicates the intercepting sewer. While it was constructed so as to cut off the discharge into the waters of the bay of all ordinary drainage, the old outlets were not completely closed. They are preserved, and, by means of dams or gates, are arranged to discharge all over a certain amount. This amount is made great enough to allow for all ordinary flow and for the lighter rain storms. In case of heavy falls of rain, the overflows come into action, and permit part of the water to run directly away into the bay.

From the city the transit lines run eastward, and reach eventually a low, marshy piece of land called the "calf pasture." Over this a causeway, marked Mt. Vernon Street on the map, has been built. Under its roadway the sewer runs for about a mile. At the end of this line the pumping station is established. Up to this point in the main and intercepting sewers, devoted to the city of Boston and environs, a length of 13½ miles is included. The diameter of the main line varies from 7½ to 10½ feet. Its mean descent is 1 in 2,500. The bottom of its delivery end at the pumping station is 14 feet below low water level.

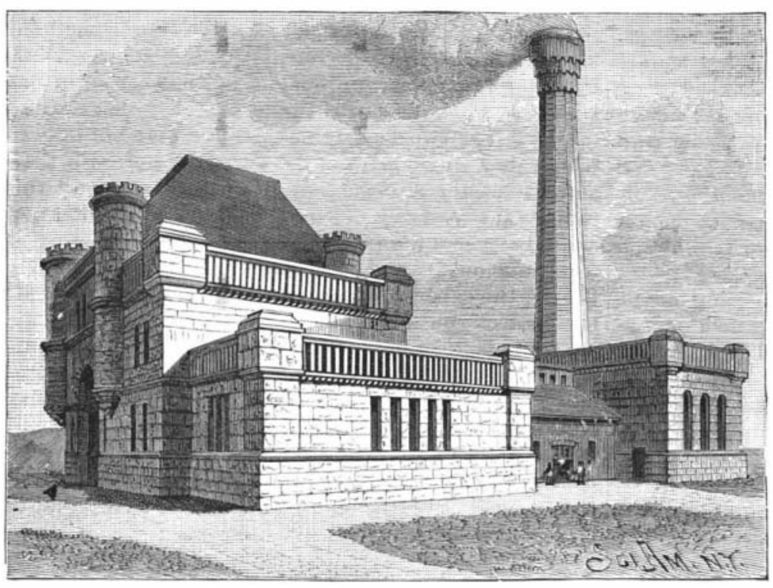


CHAIN FEEDER AND MOVABLE SCRAPER.



BOSTON DRAINAGE SYSTEM—DEPOSIT SEWERS.

The pumping station, of which we give an exterior and interior view, is a fine structure. It is built of granite, and in its architectural features is worthy of all commendation. Its general plan includes two wings, with a connecting building. One wing is devoted to coal storage, and from within it the large chimney rises. The capacity of the coal bins is 6,000 tons.



BOSTON DRAINAGE SYSTEM—PUMPING STATION BUILDING.

In the connecting building the boilers, four in number, are placed. Each pair is of 250 horse power, and can supply all the steam required in ordinary working. They are built of steel; each one has 45½ square feet grate surface and 1,826 square feet heating surface, giving a ratio of 40:1. Exhaustive tests of efficiency were made in the spring of 1885, showing an evaporative power of 10·43 lb. of water per pound of dry coal from water of the actual existing temperature; reducing to a commercial efficiency of about nine pounds. During these tests the boiler under trial was indicating from 112 to 134 horse power.

In the other wing are situated the pumping engines. These are divided into high duty and low duty engines. Of each class there are two, each engine having two cylinders.

On the first page of this paper we illustrate the great high duty pumping engines, designed by Mr. E. D. Leavitt, Jr. They are impressive structures, and present an imposing appearance, as the great flywheels ceaselessly rotate, and the engines quietly do their duty and dispose of the drainage from nearly ten square miles of territory.

They are compound beam engines. The pumping cylinders, of which there are two, are directly below and in line with the high and low pressure steam cylinders. The low pressure steam cylinder is situated at one extremity, the high pressure cylinder at the other extremity of the walking beam. This secures a very even disposition of the main working parts of the engine. The walking beam is pivoted at about the floor level. From one of its ends the pitman rises to the crank. The pitman end of the walking beam is provided with an oblique extension or horn of suitable angle to secure the best working of the connections. The fly wheel journal is nearly on a line with the lower heads of the steam cylinders. The leading dimensions of these engines are as follows:

Diameter of high pressure cylinder..	25¼ in.
Diameter of low pressure cylinder....	52 "
Diameter of plunger...	48 "
Length of stroke....	9 ft.
Distance between centers of cylinders.	15 " 2 "
Radius of beam to end centers.....	8 " 3 "
Radius of crank.....	4 "
Diameter of flywheel.....	36 "
Weight of flywheel.....	36 tons.
Nominal capacity of each engine,	25,000,000 gallons a day.
Speed for capacity....	11 revolutions per minute.

They were tested at the same time with the boilers, and gave a very high efficiency. Each test extended over 24 hours' running. In one trial an indicated power of 251 H. P. was obtained, in the other 290 H. P. In sewage lifted with no allowance for slip of pumps (8·5 per cent to 4·6 per cent to be added), an actual power of 219·9 and 243·5 H. P. respectively was attained. Per indicated horse power an average of 1·34 pounds of coal was burned per hour. With new valves, the slip of the pumps reduces to 2·5 per cent. A portion of the steam was used to drive the feed water pump. Allowing for this, the duty of the pumping engine reduced to 122,500,000 foot pounds per hundred pounds of coal. This gives an extremely high efficiency, and speaks well for the design of the pumps. They were built by the Quintard Iron Works, and cost $115,000 each. The low duty engines were built by Henry R. Worthington & Co. They cost $45,000 each. The leading data for each one is as follows:

Nominal capacity.....	25,000,000 gallons a day.
Speed for capacity....	12 double strokes per minute.
Diameter of high pressure cylinder.....	21 in.
Diameter of expansion cylinder.....	36 "
Diameter of plunger.....	45 "
Length of stroke.....	4 ft.
Guaranteed duty, in foot pounds per 100 lb. of coal,	60,000,000.

They are of the well-known horizontal type of these makers, with a new style of hydraulic valve gear.

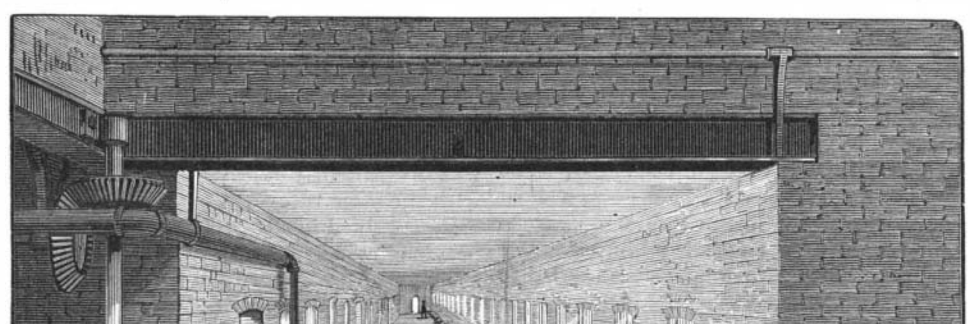
The pair of high duty engines cost $140,000 more than the pair of low duty engines. The total coal burned in 1886 cost $7,789.55. They cannot well be credited with a saving of over this amount during the year. Doing this, their saving will represent only a little over 5 per cent on their excess of cost over cheaper low duty engines. This is supplemented, of course, by a saving on boiler capacity; but the latter is of minor account. Hence they probably illustrate one of those cases in engineering where capitalization of improved apparatus is barely paid for by the increased economy effected. Still, every hydraulic engineer aims for high efficiency, and it seems only fitting that such a great city as Boston should have the most perfect engines that are procurable for money.

The low duty engines are used when a heavy rain sends a large volume of drainage to the station. The bulk of the work is done by the high duty engines.

The sewage is pumped out of the delivery sewer, first being screened through cages of one inch mesh. Here one or two cubic yards daily of material is arrested. It is collected from time to time, pressed in a hand press, and burned under the boilers.

From the pumps the screened sewage is delivered through mains four feet in diameter, one for each engine, to two parallel lines of deposit sewers. The latter are built of concrete masonry, forming a monolithic mass, and each one is 1,260 feet long, 8 feet wide, and 16 feet high.

Through them the liquid flows at a rate of about 3 inches per second. The fine material held in suspension is almost completely deposited in the first 600 feet. About midway of their length a twelve inch pipe enters them, from one side, connecting with vertical trunks. One trunk is in each sewer, with two gates near the lowest level. On opening one or the other of these gates, the lower layers of water rush out with high velocity, carrying with them the solid material that has accumulated. To assist in feeding it up to these trunks, a chain feeder is employed and also a movable scraper. Both are illustrated. The chain feeder, constructed on the principle of a chain pump or grain elevator, draws the material along to the mouth of the discharge pipe, which engulfs all that comes near it. The movable scraper consists of a dam or screen that approximately fits the sewer. An extension platform runs back from its base, and when the machine is in use, receives 4,800 pounds weight to keep the end

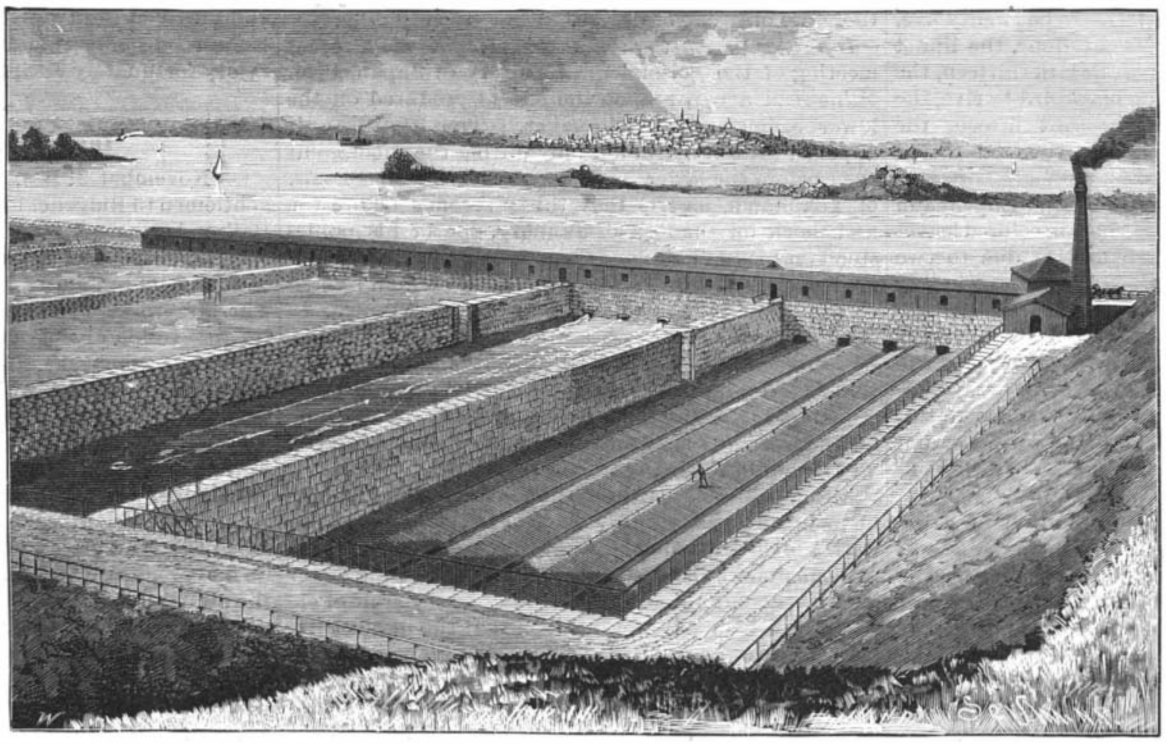


BOSTON DRAINAGE SYSTEM—GATE HOUSE AT MOON ISLAND.

down. A chain holds the gate upright against the pressure of the water. This machine is put in position at the end of the sewer nearest the pumps and the sewage is turned in. It runs over the gate and also to some extent around and under it, pressing the scraper forward at the same time. The pressure and scouring action of the water work and force the deposit forward until it reaches the outlet trunk. To replace the scraper, the weights are removed and it is floated back.

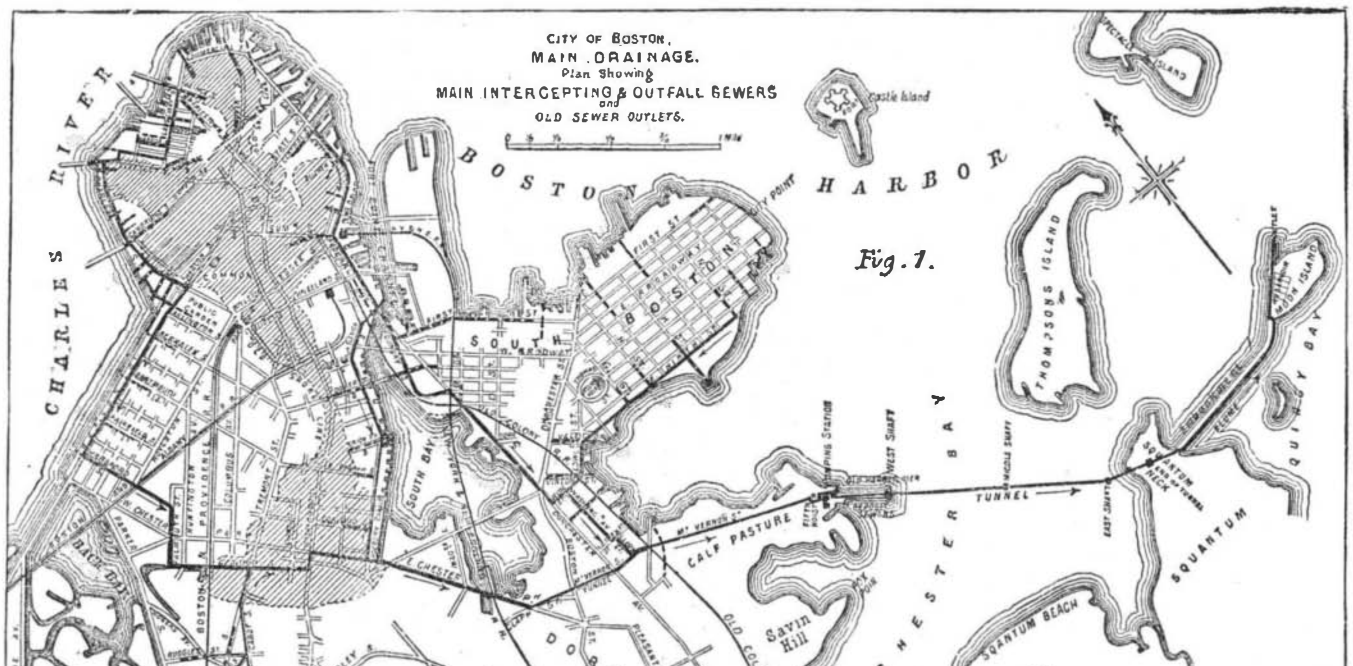
The current through the outlet pipe is sufficient to carry a half brick with it, and sticks can even be carried by it around the bends. The sludge is delivered to a tank. As much water comes with it, this, after settling, is permitted to flow on and into the sewer again, beyond the deposit lines. The sludge is taken out to sea in a barge, and dumped into the water.

In 1886 the maximum daily amount pumped was 111,537,337 gallons, the average daily amount was 36,866,129 gallons. The cost for labor, fuel, repairs, and general expenses, no interest or depreciation being included, was for 1886, $29,168.34. The lift varies from 35 to 45 feet, and the cost per million gallons lifted one foot is put at $0.059, or about six cents. Some seven or eight cubic yards of sludge are collected daily from the deposit sewers. The sewage, now almost clean water, is carried through a 7½ foot sewer, 7,160 feet long, across Dorchester Bay, then through a temporary flume, 11 feet high and 12 feet wide and about 6,000 feet long, to the reservoirs on Moon Island. Here it is collected and impounded. These reservoirs cover 5 acres. Their floor is 1 foot below high water mark, and their walls are 16 feet high. Their capacity is 25,000,000 gallons. About one hour after high tide, the outlet gates are opened, the nearly clear drainage rushes out, and in forty minutes they are emptied. The drainage is then allowed to accumulate for another tide.



BOSTON DRAINAGE SYSTEM—RESERVOIRS AT MOON ISLAND.

The gates are worked by a long shaft, nearly 600 feet long, that carries bevel cog wheels in pairs, one pair for each gate. By setting these, the shaft, though revolving in one direction, can be made to either open or shut the valves. The shaft is driven by a turbine wheel, which is turned itself by the drainage water, a portion of which is diverted for this purpose. A steam plant is provided also for use when the turbine is laid up. The bottoms of the reservoirs are shaped so as to favor perfect drainage. To flush them, drainage is allowed simultaneously to enter at one corner and flow out at the other. This scours them perfectly, leaving the masonry bare and clean. Samples of the fluid collected here are as clean as rain water, except for a slight deposit. The fluid has quite a strong odor, however. The men in charge make no complaint, and their health seems perfect. The flume leading from Squantum to Moon Island, and which we have referred to as only temporary, is carried by a new embankment. When this shall have settled and reached a definite level, a permanent masonry structure will be built and the system will then be complete.



NEWS comes from Prescott, Arizona, of the discovery of a wonderfully rich ledge of gold bearing rock 20 inches wide, on the Hassayampa River. The assay shows $100,000 per ton. The pieces of the rock, when broken, hang together by the gold in them.

Electrical Notes.

Role of Electricity in the Production of Hail.—An endeavor has often been made to bring in electricity as one of the determining causes of the formation of hail, through the more rapid cooling that electrified liquids undergo—an effect that was pointed out a long time ago by (among others) Abbot Nollet and Guyten de Morveau.

Mr. Govi has taken up these experiments, and has demonstrated that the electrification of even a liquid cannot produce such an effect. In order that such effect be produced, it is necessary that, through the action of the neighboring points of the surface, an electrical wind shall occur, which then, in renewing the strata of air in contact with the liquid, shall hasten the evaporation, and consequently the cooling of the liquid.

The electrified drops of water of the clouds can evidently do nothing of the kind, and electricity, therefore, cannot play the part that has sometimes been assigned to it.

Decomposition of Water by Electricity.—The same physicist has recently performed a curious experiment that permits of rendering very perceptible the decomposition of water by the electricity of ordinary machines or the induction apparatus of Belli, Holtz, Wimshurst, and others, without having recourse to the exceedingly fine gold or platinum wires used for this purpose by Wollaston in 1801. It is simply a question of preserving the acidulated water of a voltameter from atmospheric pressure. The two gases are observed to disengage themselves in abundance from the platinum wires as soon as the latter are connected with the positive and negative sources of electricity whose chemical action it is desired to demonstrate. The use of a battery permits the phenomenon to be rendered visible to a large audience.

Electro-metallurgic Deposit of Aluminum.—Mr. H. Reinbold gives the following process: Prepare a bath containing 50 parts of alum (potassic) to 300 of water, add 10 parts of chloride of aluminum, heat to 100° C., and then allow to cool. After this add 39 parts of cyanide of potassium to the solution.

The object to be plated, after being properly cleaned, as in the processes of gilding, etc., is suspended in the bath from the positive electrode, and a plate of aluminum is used as a negative electrode. The current should be quite feeble.

After being polished the deposited metal will be exceedingly brilliant, more so even than silver.

Joints of Electrical Conductors.—When the extremities of copper conductors are joined by simply twisting the wires around each other, it is not rare to see a slight deposit of oxide form, which increases the resistance.

Mr. Matignon, of Eynesse, secures a perfect contact of the wires by depositing, through electrolysis, a layer of copper at the point of contact, and covering the whole with an insulating substance.

Protecting Iron against Rust.

It is well known that this long-standing evil of paint and composition peeling off has more particularly manifested itself of late in consequence of the substitution of steel for iron plates, all new vessels invariably throwing off their first coat. This may in part be attributed to the smooth surface of the plates and in part to the existence of a "bloom" on their surface, which after a short time detaches itself and falls off, carrying the paint with it, and so exposing large portions of the plates to the deleterious action of the salt water. This is aided by the continuous chafing between wind and water caused by lighters and quay walls, and in the bows by the anchor chains, whereby large surfaces of paint are removed and much rusting results.

The Admiralty and a few private ship-owning firms have attempted to overcome this lack of adhesion between plate and paint by pickling the plates in a weak solution of hydrochloric acid before riveting them on the frames, thus removing the "bloom" and producing a slightly porous surface on which the paint can get a readier hold. This process, in addition to its expense, requires very careful handling, as an appreciable amount of metal is lost if the plates remain too long in the acid, while even under most favorable conditions the surface produced is not sufficiently rough to secure the adhesion of the paint when subjected to outside chafing. It has been reserved to Messrs. Holzapfel & Co. to devise a thoroughly practical and, at the same time, simple and inexpensive method of surmounting this difficulty, their plan consisting in simply rough-rolling all the plates to be used in the construction of a vessel. This is done at the rolling mills, where the rolls, instead of having smooth, cylindrical surfaces, are formed so that their rolling faces somewhat resemble a fine file, corresponding indentations being of course formed in the plates as they pass between them.

By having the surface of the iron roughened in this manner, the minimum of scale would be formed, while the paint, which could be applied at once, would find a suitable surface for permanent adhesion. Again, when chafed, the injury would be localized by the roughening, and only a very small quantity of paint being displaced, the consequent rusting would be insignificant.

Natural History Notes.

The Longevity of Birds.—The human race is not the only one that has the privilege of furnishing centenarians. There are several birds that have the pretension to easily reach the age that Mr. Chevreul has attained. Among the canditates for the prize of longevity, says the *Eleveur*, must be cited the eagle, the swan, and the raven, which live for over a century. The perroquet, as well as the heron, is content to become a sexagenarian. The sparrowhawk lives to the age of forty, which is the age likewise reached by the duck and pelican. The pea fowl lives to be twenty-five, the pigeon twenty, the crane twenty-four, the linnet twenty-five, the goldfinch fifteen, the lark thirteen, the black-headed warbler fifteen, the blackbird twelve, the canary bird twenty-four, the pheasant fifteen, the thrush ten, the domestic cock ten, the red throat twelve, and the wren three.

The Color of Colored Leaves.—Dr. T. W. Engelmann has investigated the cause of the color in colored leaves where the coloring is normal. He finds it due to two different causes: a variation in the color of the assimilating chlorophyl grains and the occurrence in the leaf of special pigments in addition to the normal chlorophyl. In the first case the coloring matter appears to be invariably of a light shade, and either pure yellow or yellow-green, with every transition between this and ordinary chlorophyl green. In the second case it is usually red-brown, dark purple-brown, purple-red, or violet.

In the first group of cases the proportion of coloring substance is often nearly uniform in the same species. In the yellow variety of the elder the tint does not appear to be due to a pure xanthophyl, but to a mixture of chlorophylan with a small quantity of true chlorophyl. In more refrangible light (about $\lambda = 0{\cdot}53\ \mu$) the yellow cells decompose relatively, if not absolutely, more carbon dioxide than the green cells do; while in red and green light the green cells decompose, both relatively and absolutely, more than the yellow.

In the second group the seat of the pigment is usually the cell sap, less often the cell wall. In the latter case the coloring is mostly confined to small portions of the surface, causing variegated leaves, as in the zonal pelargoniums. Of leaves colored by soluble pigments, Dr. Engelmann has examined about fifty kinds. These may be divided into two sections, connected with one another by intermediate forms: those in which the leaves are normally colored during the whole or the greater part of their existence and those which are colored only when young. In both these cases the coloring is usually, but not always, spread over the whole surface of the leaf. That cells containing a purple sap can decompose carbon dioxide as energetically as those which contain pure chlorophyl is shown by the vigor exhibited by the copper beech, the various species of *Coleus*, etc.

Effect of an Eclipse on Birds.—The last eclipse of the sun seems to have produced more effect upon animals than upon man. *La Nature* says that, at Berlin, birds that were in full song at sunrise suddenly became silent, and, when the darkness was deepest, showed their inquietude by cries of fear. It was remarked by observers that perroquets were the most alarmed, while canary birds appeared to be the most indifferent to the astronomical phenomenon.

Bobolinks.—The bobolink is a favorite field songster in our Northern States, but when he goes southward he changes his name to "reed bird" and "rice bird," and puts on a most rapacious, vicious, and destructive character. In turn, he becomes the target of pot-hunters, by whom millions are destroyed for table use. The bobolink, transferred to the South, lives daintily on the rice fields, and this industry is actually crippled by these birds, which appear in innumerable hosts at seed planting and again at harvest time. No one would imagine that our well favored "Robert o' Lincoln" comes to us from a most fearful raid on rice, and departs from us with the same evil intent. The rice crop by the last census was valued at $6,607,000, the product being 110,000,000 pounds. The loss by the rice birds is estimated at $2,000,000 annually. Thousands of men and boys are employed to shoot these trespassers, and the rice fields are shadowed by a "sulphurous canopy," as if some grand battle was in progress. The last report of the Commissioner of Agriculture has some startling facts in regard to the ravages of these birds. The rice planters are in despair. Individual losses are often fifty per cent of the crop, and from five to ten dollars an acre is not uncommon. The flight of these birds is always in the night. They appear in the spring in the last half of April, and return punctually in South Carolina on the 21st of August and the two or three days following.

Stipules.—A lengthy research on the nature and origin of stipules is given by Mr. G. Colomb, in the *Annales des Sciences Naturelles*. He considers that various organs, such as the spines of *Xanthium spinosum* and of the orange tree, and the tendrils of sarsaparilla, have been considered on too slight grounds to represent stipules. Having examined the structure of the stipular organs of various plants, he has been led to the conclusion that the name of stipule should be limited to any appendage inserted on the stem of which the vascular system is exclusively formed of branches of the vascular bundles passing into the petiole. He regards the stipule as forming a portion of a ligule. The ligule he defines as consisting of three parts, viz., sheathing, axillary, and stipular portions. When the stipular portions exist only, these are to be considered as stipules; when the axillary portion is also present, the term axillary stipule may be used; and when the sheathing portion is also present, the name of ligule in applied. The difference in structure of the ligule and stipule is therefore only one of degree.

Influence of Earthquakes on Animals.—At a recent meeting of the Seismological Society of Japan, Prof. Milne read a paper upon the effects produced on the lower animals by earthquakes. The creatures, it appears, exhibit alarm not only during the shocks, but even before the latter have been felt. Mr. J. Bissett, of Yokohama, asserts that thirty seconds before the first shock on the 15th of January, one of his ponies stood on his hind legs and kept rearing in his stall, an evident prey to terror. Another pony at Tokio acted in the same way. The professor had ascertained, on several occasions, that pheasants utter cries of fear before earthquakes, and several observers had told him that under such circumstances frogs suddenly cease croaking. Of all animals, it is said that geese, swine, and dogs are the ones that announce the approach of an earthquake most markedly. Several birds exhibit restlessness, hide their heads under their wings, and behave in an extraordinary way. Prof. Milne supposes that the lower animals must recognize very feeble movements that escape man. He thinks that the terror that intelligent animals exhibit may be the fruit of experience, which has taught them that the lightest tremors are the prelude to more alarming movements. These slight tremors serve to explain the restlessness of pheasants, geese, and frogs. As for the strange uneasiness exhibited by animals several hours before an earthquake, Prof. Milne thinks that that must be attributed to accidental causes. In volcanic districts it sometimes happens that, before an earthquake, emanations of gas through fissures in the earth occur, and small animals are not only frightened, but are also killed by such premonitory phenomena.

Glands of Labiatæ and Compositæ.—Dr. Tschirch, of Berlin, in a paper on the receptacles of secretion in plants, and the origin of some secretions, pointed out that the epidermal glands on the leaves, flowers, and stalks are of two distinct types in the *Labiatæ* and *Compositæ*, so that they might serve as diagnostic of these two natural orders. In the *Labiatæ* the epidermal glands have in their interior a compact circle of secreting cells, which are always in a multiple of four, and are usually eight or sixteen in number. The upper cell of the gland is also divided by radial walls perpendicular to its surface. The glands of the *Compositæ*, on the other hand, have superimposed layers of secreting cells, though the term is often only strictly applicable to the two uppermost. The whole of the secreting cells are divided in two by a median radial wall, which is usually at right angles to the longitudinal axis of the organ. The number of secreting cells is consequently four, in two layers, or six, in three layers. Seen from above, the oil glands of the *Labiatæ* show a circle of usually eight cells around a central one, while those of the *Compositæ* exhibit a long oval cell divided in the middle of the gland.

A Plant Heilostat.—Prof. B. D. Halstead calls attention, in Coulter's *Botanical Gazette*, to the heliotropic power possessed by the leaves of *Malva borealis*, a common weed in Southern California. The leaves follow the sun during its daily course, and present their upper surfaces to the descending rays. The blades face eastward in the morning, and, as the day advances, the laminæ turn to the south and become more nearly horizontal. During the afternoon the blades approach the vertical, and at sunset they face the western sky. In short, the malva leaves are living heliostats.*

Birds Killed by Monuments.—Prof. Ridgway, of the Smithsonian Institution, speaking of the birds sent to the Institution killed in large numbers by flying against the Bartholdi statue beacon in New York harbor, says that the specimens were mainly of the "warbler" or note-uttering family of different varieties, which were insectivorous, and also field birds, such as the madow lark, but none of the specimens is rare. These birds migrate by night, and, although they fly high, Prof. Ridgway says that they are attracted from all sides down to the electric light. Many birds, mostly crows, have recently been picked up dead near the Washington monument. A few wild ducks also have been destroyed in the same manner. The crows fly low and migrate at dawn, and the mist hides the monument from sight.

* Cf. SCIENTIFIC AMERICAN SUPPLEMENT, No. 615, p. 9860.

Explosive Power of Nitro-Glycerine.

An instance of the extraordinary explosive power of a small quantity of nitro-glycerine is recorded by Dr. Gorup Besamez. The incident was the explosion of only ten drops of the substance in his laboratory, and the astonishing effects he records as resulting from this explosion are well calculated to give a most respectable and respectful notion of the properties of nitro-glycerine. One of the doctor's pupils, in the course of an investigation, placed the above mentioned quantity (?) of the substance in question in a small cast iron dish heater over a small Bunsen gas burner in common use in laboratories. While so engaged the nitro-glycerine exploded with extreme violence, breaking forty-six panes of glass in the windows of the laboratory, hurled the iron dish against the brick wall, the iron stand upon which it was supported partly split and partly twisted out of shape, and the tube of the Bunsen burner split and flattened. Those in the laboratory fortunately escaped without injury.

Interesting Brake Trials.

On November 21 last, a special train took about 300 gentlemen to Ridgefield Park, N. J., on the West Shore Railroad, where a number of tests were made by the Westinghouse Air Brake Company of the new application of its system of braking to long freight trains. The air brake has been used very successfully on freight trains of not more than 25 cars, but it was found that when this number was exceeded the bumping of the rear cars, which had not yet been stopped, against the cars in front was so serious as to set a limit to the system's utility as far as freight trains were concerned. While it took ten seconds for the application of the air brake to reach the front part of a train of 50 freight cars, it took 15 seconds for it to reach the rear part, and it was to demonstrate that he had practically annihilated this difference and made the air brake's advantages available on long freight trains that Mr. Westinghouse took the visitors out for a trip on the West Shore Road.

Just beyond Ridgefield Park the road has a straight stretch of double track about 2 miles in length, with a grade of 53 feet to the mile throughout the entire distance of the track. Upon this the various tests were made. Between the two tracks, a half mile north of the station, a white board was set up. This was the stopping point. South of it, at distances of 50 feet apart, were measuring posts, the last marking 600 feet from the stopping post. A freight train of 50 cars, 1,900 feet long, and weighing 2,000,000 pounds, drawn by a mighty engine of the Chicago, Burlington, and Quincy road, and the 12 car passenger train which had brought the party, completed the railroad apparatus involved in the experiments.

An emergency stop, with the freight train running 26 miles an hour, was the first test. The brake was applied at the instant the post was reached. Twelve and a quarter seconds later, at 200 feet from the post, the train was at a standstill. The next test was made with similar conditions, except that the train was run at a speed of 41 miles an hour. This time the train was stopped in 20 seconds, and at a distance of 674½ feet from the post.

The third test was of the rapidity with which the brakes were applied, the train standing still, so that observers could tell the time which elapsed between the engine whistle which announced the application of the power and the sound of the moving brake at various distances along the train. The cars numbered in order from front to rear of the train, and to persons who stood opposite car No. 31, the two sounds described were synchronous.

Another test with the passengers on board was made with the train running 41 miles an hour, when the stop was effected at a distance of 672½ feet, and in 20 seconds, as before. A fifth test showed that after the train had come to a stop the brakes could be released and the train set moving again in 4 seconds.

To show the difference between the air brake stop and the old hand brake style, a test of the latter, with six brakemen on the train, was made. The train moved at 21 miles an hour, but it had traveled for 85 seconds and covered a distance of 2,137 feet before it was brought to a standstill, after the signal had been given. Then the train was broken in two while in motion. After the separation it traveled a very short distance, and when both portions came to a stop in 26½ seconds, they were only 45 feet apart. These tests were made with the braking power so low that it would not slide the car wheels. A high pressure test, with the train running 22 miles an hour, resulted in its being pulled up in 6 seconds, 91 feet from the stopping post.

The last test was, spectacularly, the best of the afternoon. It was intended to show the relative stopping power of the old brakes, as used on the 12 coach passenger train, and the new brakes on a 20 car freight train. Down the tracks, chimney and chimney, came the two trains. Forty-five miles an hour was the speed at which the trains were going as they neared the stopping post, and the freight train was only about three feet in front as they passed it. The brakes on both were applied simultaneously, but the new brake distanced the old one, the freight train stopping in 13½ seconds, at a distance of 495 feet, while the passenger train went on traveling until its engine was 1,204 feet from the stopping post.—*New York Times.*