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PROGRESS OF THE NEW YORK RAPID TRANSIT TUNNEL.

Although five months have passed since the contract for the construction of the New York Rapid Transit Tunnel was signed, there is as yet but little evidence of the general upheaval of the streets of this city, which it was popularly supposed would follow immediately upon that event. This has not been due to any lack of zeal upon the part of the contractor-in-chief, or the sub-contractors, but it is to be laid to the charge of the steel works which have undertaken the task of supplying the 78,000 tons of structural steel and steel rails which are necessary for the tunnel. The plans of the tunnel call for a subway, the side walls and roof of which consist of steel posts and girders embedded in and backed with concrete. With the exception of three or four miles of straight rock tunneling, the whole of the excavation will lie so near the surface that it will constitute what is known as cut-and-cover work; that is to say, the excavation will be made from the surface down, and the side walls and the roof will be built in the deep cut thus opened up through the middle of the various thoroughfares. As work of this class demands more or less complete suspension of traffic, a clause is inserted in the contract by which no section of the tunnel below Sixtieth Street is to be kept open for more than thirty days at a time.

From the very nature of the construction of the tunnel, it is necessary that the steel should be on the ground if only thirty days is to elapse between the breaking of the ground and the roofing in of the tunnel; and it is mainly for this reason that the sub-contractors have so far devoted their efforts merely to the lowering of the sewers, and the building of storage sheds for the accumulation of the excavating and other contractors' plants. It is stated by the engineer-in-chief for the contractor, that the question of the rapidity of the construction of the tunnel will be a question of the rapidity of the delivery of the steel; and just as soon as this material begins to arrive in any quantity the people of New York will see immediate evidence that this, the largest undertaking of its kind in the world, is being vigorously prosecuted. At the present writing the whole of the sub-contracts have been let, and the work of lowering the various sewers, which at present intercept the line of the tunnel, is being pushed forward. The most important diversion is that of the Canal Street sewer, which is more than half completed. The sewers at Mulberry Street, Bleecker Street, and Tenth and Twenty-second Streets, have been lowered, while the change of the sewers at One Hundred and Tenth Street, One Hundred and Twenty-fourth Street and One Hundred and Fifty-seventh Street is approaching completion. In spite of the serious delay which has already been occasioned by the non-delivery of steel, the contractors express themselves as perfectly satisfied that the road will be finished before the contract date set for completion.

HIGH-LIFT LOCKS FOR THE ERIE CANAL.

The question of the introduction of high-lift locks on the Erie Canal, in place of the low-lift locks at present in use, is being investigated by a special board of engineers. Three different types have been considered. The first of these is the Dutton pneumatic balanced lock, illustrated in the SCIENTIFIC AMERICAN of February 3, 1900, which was reported upon favorably by the canal officials in 1896. This system contemplates the use of two balanced lock chambers, placed side by side, with a lift in the case of the locks at Cohoes of 150 feet, and of the locks at Lockport of 66½ feet. Each lock chamber is carried on a huge inverted air-tight caisson, which works vertically in an excavated chamber filled with water. The system is so arranged that when one lock chamber is elevated to the upper level, the adjoining chamber is at the lower level. The air caissons are connected by a system of pipes and intersecting valves, so arranged that when an excess of weight is placed upon the upper tank, it will descend, driving the air from its own air caisson through the connecting pipes into the adjoining caisson, which in its turn is raised to the upper level. Plans were also inspected, which have been presented by Messrs. Morse & Brown, for two distinct designs of locks; one worked on a cable counterpoise system, and the other calling for a system of hydraulic-lift locks. The design provides for balancing one lock chamber with another which is exactly similar, the two being connected, not as in the case of the Dutton system by large air pipes, but by a number of wire cables which pass over a system of sheaves and are provided with safety appliances to prevent a sudden drop in the case of the failure of any part of the balancing gear. The plans for the hydraulic lift call for two lock chambers, each of which is raised and lowered by means of three hydraulic plungers and cylinders, the locks being arranged to counterbalance each other by means of the suitable manipulation of connections between the two sets of cylinders. There is also under consideration, by the Board, plans of Mr. William R. Davis for a counterpoise lift lock, in which a pair of counterbalancing tanks are raised and lowered upon a dozen steel towers, at the top of which are 24-foot sprocket wheels, on which travel the flat link chains which support the tanks. The latter, which weigh about 5,500 tons each when loaded, are to be raised and lowered by electric power, which is to be developed by turbine wheels operating under the head of water due to the total difference of the level of the canals. One of the most important subjects under consideration by the Board is the question of the amount of water and the total time which are required for effecting the entire lift with locks of the different kinds above described.

Whether the proposed enlargement of the Erie Canal is carried out or not, it would certainly be of enormous advantage to the canal system, as it now exists, if the low-lift locks could be abolished at Cohoes and Lockport and a system of high-lift locks established. At Lockport there are five locks with an average lift of 11½ feet, while at Cohoes there are no less than sixteen locks with an average lift of 9 feet. At these two locks alone it is estimated that over half a day is lost in the passage of a single tow.

RECENT ARMOR PLATE BIDS.

The Secretary of the Navy has rejected the bids which were made for furnishing armor for the fourteen battleships and armored cruisers which are either building or authorized, and for the three authorized cruisers of the protected type. Advertisements for new bids have been issued, and the opening will take place within about a month. The bids were rejected, not on the question of price, but because of the somewhat complicated nature of the three proposals which were submitted to the Department. The three bidders were the Midvale Steel Company, and the Carnegie and Bethlehem Companies. The Midvale Steel Company stated that it would not accept a contract for less than 20,000 tons of armor, while the Carnegie and Bethlehem Companies stated that they each would not accept a contract for less than 18,250 tons of armor. As the total amount of armor asked for by the Department was about 35,000 tons, to give a contract for 20,000 to the Midvale Company would leave about 15,000 tons only to be divided between two companies, who had each refused to accept a contract for less than 18,250 tons. This would have involved that new bids for at least 15,000 tons must have been advertised for. While this could have been done, and would have been more liable to satisfy the Department, there was a difficulty in the way due to the fact that the Midvale Company asked for twenty-six months in which to perfect an armor plant, and begin making deliveries.

In view of the fact that the armor for the three battleships of the "Maine" type will have to be delivered at an early date if the Department is to avoid delay in their construction, it will be seen that the acceptance of the bid of the Midvale Company was altogether out of the question. The Carnegie and Bethlehem Companies agree to begin making deliveries of armor in six months from the date of the contract, and the Department has, therefore, rejected all the bids in the hope that they will procure satisfactory bids for an amount smaller than 18,250 tons each from the last named companies.

There is much satisfaction to be derived from the fact that the bidding came well within the limit of the price laid down by Congress. The Secretary is authorized to buy the best armor procurable for $445 a ton, but if he could not get it at that rate, he might accept a bid as high as $545 a ton, and if he could not get it at the higher figure, he was authorized to erect a government armor factory. On opening the bids it was found that both the Bethlehem and Carnegie Companies asked the same price for their armor, namely, $490 a ton, with the royalty paid by the bidder, or $445, with the royalty paid by the government. This is a considerable and a very satisfactory drop from the $545 per ton formerly demanded by these two companies. The bid of the Midvale Company was somewhat less than that of the others. It is gratifying to know that a third large steel concern is prepared to undertake the manufacture of armor plate with the stipulation that if it undertakes to supply armor, it shall receive a contract for the large amount of 20,000 tons. This reservation is due to the very natural desire of the company to make sure that, as soon as it erected its costly armor plate mills, it would be enabled to make sufficient armor to recoup itself for the outlay. At the same time it was simply impossible for the government to tie itself up to a delay of twenty-six months in the receipt of this particular consignment of armor. We sincerely trust that the new bids will include some provision which may include the Midvale plant and be mutually agreeable to the company and the government.

LOWERING OF THE ATLANTIC RECORD.

Not a little excitement is prevalent just now in shipping circles over the steady reduction which is being made in the time of trans-Atlantic passage. The "Kaiser Wilhelm der Grosse" and the new "Deutschland" have been cutting down the time of the passage between New York and the English ports by hours at a trip. The former vessel, which prior to the advent of the "Deutschland," held all records across the Atlantic, made a magnificent run on her last trip to the eastward. She left Sandy Hook at 12:23 P. M. on Tuesday, August 7, and arrived at Cherbourg at 12:57 P. M. on the following Sunday, covering the course of 3,184 miles in five days nineteen hours and forty-four minutes, at an hourly average speed for the whole trip of 22·79 knots an hour. On her best previous record run her average hourly speed was 22·61 knots per hour. The "Deutschland," which, it will be remembered, on its first return trip attained a speed of exactly 23 knots an hour, left New York on Wednesday, August 8, passing Sandy Hook at 3:35 P. M., and arrived at Plymouth at 8:30 A. M., on the following Monday, having covered the course in five days eleven and three-quarter hours, at an average speed of 23·32 knots an hour. The best day's run was 552 knots.

An interesting fact in connection with these records, is that the "five-day-boat" is now an accomplished fact, for a speed of 23·32 knots an hour, if maintained over the route from Sandy Hook to Queenstown, would bring the record down below five days, or to be exact, to four days twenty-three hours and six minutes. The record over this route is now held by the "Lucania," which covered the distance of 2,778 miles in five days seven hours and twenty-three minutes. The "Lucania," however, is now a relatively "old boat," having been built in 1892–1893; and as the interval between "Lucania" and "Deutschland" is about eight years, we may say that the reduction in the time of the trans-Atlantic passage has been proceeding at the approximate rate of an hour a year.

COMPRESSED AIR TRACTION IN NEW YORK CITY.

An important change is being effected in the compressed air system of traction on certain lines in this city, by the substitution of what is known as the Hardie motors for those now in operation, which were built under what are known as the Hoadley patents. What might be called the modern development of compressed air traction in New York dates from about the year 1897, when the promoters of the two types of motor mentioned above were engaged in active experimental work, the Hardie system being tried on the Third Avenue Railroad, and the other on the lines of the Metropolitan Street Railway Company. Both motors operate under extremely high pressures of from 2,000 to 2,500 pounds to the square inch; but here the difference ends. In the Hardie system two long-stroke, single-expansion engines are employed, which are directly connected to one axle of the car, the other axle being driven by side rods. The air, after being reduced to the working pressure by a reducing valve, passes through a tank of hot water, and is then led in a super-heated condition to the cylinders. The Hoadley motor differs from this mainly in the fact that a complete two-cylinder, compound engine is carried on each truck and drives a shaft which is geared down to the car axle. Instead of passing the air bodily through the tank of hot water, a small jet of water is sprayed into the air pipe between the reducing valve and the cylinders.

The Hoadley system was adopted by the Metropolitan Street Railway Company, while the Hardie system has been for some time in successful operation on the North Clark Street Railroad, Chicago. The recent amalgamation of the two companies has resulted in the adoption of a motor designed chiefly upon the lines of the Hardie system, which will shortly replace the motors now in use upon the crosstown lines of the Metropolitan Street Railway system. The present compressing station, which is located at the foot of West Twenty-fourth Street, will be utilized, and it is expected that before very long the new motors will be in operation. Mr. Hardie, who is the chief engineer of the Consolidated Compressed Air Company, which now has control of the patents covering both systems is one of the oldest and most indefatigable workers in the field of compressed air traction, and the success of the new venture will be watched with considerable interest by the Metropolitan Street Railway Company, to whom the development of a really satisfactory independent motor for their crosstown lines seems to be almost an imperative necessity.

LIMITS OF ELECTRIC TRANSMISSION.

BY ALTON D. ADAMS.

The electric transmission of power at pressures that render the conducting wires luminous, cause hissing sounds, and produce a certain sensation in the observer at several feet distant, is being ably exploited. Referring to the subject, a recent writer has said: "The most fundamental present question is the limit of practicable voltage." Again it is stated that, referring to experiments with electric transmission at high pressures, "The carrying out of such experiments has a vital interest far beyond the mere utilization of distant water powers. It may, and very possibly will, open up the way for the wholesale transmission and distribution of power from coal." To fairly consider this question, the clear distinction between the long distance transmission of power and its distribution should be held clearly in mind.

It may, for example, be shown that a cheap and distant power is, or can be, transmitted to a center of population and there distributed to consumers at a profit; but this is not the question at issue. The real problem is whether the cheap and distant energy can be delivered at one or more convenient points, in or near the center of population, at a cost per unit that shows a saving over energy there generated from coal. It is a well-known and demonstrated fact that a central electric generating station in or near a town or city can supply power to a great number of small consumers on a sound economic basis for all concerned, because the generating station can develop power from fuel at a much less cost per unit than can the small user. It remains, however, to be proved that energy from a cheap source, 100 or 200 miles distant, can be transmitted to this central station and there used to drive the dynamos for the local service, thus displacing their engines, at a profit. If the transmitted power is to be used in a great manufacturing establishment, the question remains about the same as when it is destined for a distributing plant, since in either case power can be economically developed from coal at the point of delivery.

When a source of cheap fuel invites the transmission of power there developed to great centers of distribution or consumption, the saving in the cost of fuel per unit of energy delivered over that produced at that center is the chief economic reason for the transmission. The real question of electric power transmission, in large units, over great distances, is whether the saving in fuel warrants the investment in line and machinery and their attendant losses. In power production, the cost of fuel is neither the only nor in most cases the largest expense, and a part of the fuel cost is all that can be saved by the electric transmission. The long distance transmission of power is an undertaking that involves a large investment, and it is only fair that when the cost of power generated near the point of use is to be compared with that of the transmitted power, figures should be based on first-class results in a local plant conducted on a large scale. Considering two steam plants, one at a long distance, where fuel is cheap, and the other at the center of use or distribution, an equal economy in the weight of fuel consumed per unit of energy developed should be assumed, the cost of fuel in each case per unit of delivered energy computed, and the difference found. The price of steam coal that will develop a horse power hour at the engine shaft, in a first-class steam plant, on a consumption of 2·5 pounds, is not more than $3 per ton of 2,000 pounds in most cities of the Central and Eastern States.

Allowing 3,000 working hours per year, the cost of coal per horse power per year is $(2·5 \times 3000 \times 3) \div 2000 =$ 11·25 dollars. If the steam generating plant is moved to the vicinity of the mine, this same quality of coal can be had at a much lower figure, say $1 per ton, and the fuel cost per brake horse power hour will then be $(2·5 \times 3000 \times 1) \div 2000 = 3·75$ dollars. The apparent saving in fuel by this change of location for the generating plant cannot all be realized, because, to deliver one horse power at the point of use or center of distribution, more than this rate of work must be maintained at the shaft of generating engines to make up for transmission losses. To determine these losses, the elements of the electric transmission system must be considered. To take power in the form of mechanical motion at one point and deliver it as mechanical motion at another point a long distance from the first, by electric means, requires at the generating station dynamos and step-up transformers; at the receiving station, step-down transformers and electric motors; also a line of conductors connecting the two stations. A good average efficiency under the varying conditions of load for the dynamos and motors is 90 per cent each, and for the transformers 95 per cent each. The efficiency of the line will vary inversely with the outlay for conductors, but would seldom be more than 85 per cent for a very long distance transmission.

These figures give the complete transmission system, from engine shaft to motor shaft, an efficiency of $0·90 \times 0·95 \times 0·85 \times 0·95 \times 90 = 0·62$. For each horse power delivered at the motor shaft, the engine must, therefore, supply $1 \div 0·62 = 1·61$ brake horse power, costing for fuel alone $3·75 \times 1·61 = 6·03$ dollars. As the plant located in a large city consumed fuel to a value of 11·25 dollars per brake horse power year, the saving as to fuel by the power transmission is $11·25 - 6·03 = 5·22$ dollars per horse power year delivered by the motor. To effect this saving in the cost of fuel, the capacity of the steam plant has been increased 61 per cent and the entire electrical equipment added. The items of interest, depreciation, and repairs should now be computed for these additional investments. As the idea seems to prevail, in some quarters, that electrical transmission on a grand and general plan will be commercially practical, if only a sufficiently high working voltage can be employed to hold in bounds the weight and cost of line conductors, the cost of connecting wires and supports is entirely omitted from the following estimate, this being more favorable to the long distance electric transmission than any increase in pressure can possibly be. This omission is made with confidence that the necessary investments and losses, aside from the line, are so heavy as to forbid the delivery of electric power, from a great distance, in competition with that from coal at ordinary prices. Counting the brake horse power capacity of the motor at the point of delivery as one, the capacities of the several other elements in the electrical transmission are as follows: Step-down transformer, $1 \div 0·90 = 1·11$; step-up transformer, $1·11 \div (0·98 \times 0·85) = 1·38$; dynamo, $1·38 \div 0·95 = 1·45$; and engine, $1·45 \div 0·90 = 1·61$, as found above. The combined capacity of the dynamo and motor in terms of the brake horse power delivered by the latter is, therefore, $1·45 + 1 = 2·45$, and the combined capacity of the transformers in the same terms is $1·38 + 1·11 = 2·49$, so that $2·45 + 2·49 = 4·94$ times the rate of power delivery must be installed in capacity of electrical apparatus. A moderate price for the dynamos and motors installed with necessary attachments is $25 per horse power capacity, and on this basis their cost per brake horse power delivered at the motor shaft is $2·45 \times 25 = 61·25$ dollars. Allowing $10 per horse power capacity of transformers, installed, their total cost per delivered horse power at the motor shaft is $2·49 \times 10 = 24·90$ dollars, making the total investment for electrical equipment, apart from the line, $61·25 + 24·90 = 86·15$ dollars per available horse power at the point of use or center of distribution. But the engine at the generating plant is shown above to require a capacity 1·61 times that necessary if it is located where the power is used or distributed to local lines, and the investment in steam plant is, therefore, increased 61 per cent to make up for losses in the electrical transmission. A fair price for a first-class steam power plant may be taken at $60 per brake horse power capacity, exclusive of buildings, making the value of 0·61 horse power capacity $0·61 \times 60 = 36·60$ dollars. The total additional investment for machinery equipment in a long distance electric transmission system, over that for a local plant, making no charge for line conductors or buildings, is $86·15 + 36·60 = 122·75$ dollars per each horse power delivery capacity at the receiving station. To compensate for this great increase of investment, there is a yearly saving of 5·22 dollars per delivered horse power. Assuming the very low figure of 16 per cent on the investment, to cover depreciation, repairs, insurance, taxes, and interest, makes the annual charge for these items $122·75 \times 0·16 = 19·64$ dollars for each horse power delivered at the point of use or distribution. As the amount saved in the value of coal consumed is only 5·22 dollars per delivered horse power, the yearly outlay of 19·64 is nearly four times the saving.

This comparison is very favorable to the transmission system, because no charge is made for the additional buildings necessary with it or for the line. It should also be noted that, while the labor of operation for the generating and receiving stations and the care of the line will no doubt require more expense than the labor of operation in a steam plant at the place of use, no charge has been made for this increase. As the total cost per brake horse power in a first-class steam plant, using a fair grade of steam coal at $3 per ton, about its cost in many cities, was found to be only 11·25 dollars per year, the extra expense resulting from the equipment for long distance transmission from free fuel is $19·64 - 11·25 = 8·39$ dollars per delivered horse power per year. That is, if absolutely free fuel could be had at a point 100 miles from some of our great cities, the electric transmission of steam generated power from this fuel to the cities would involve a yearly loss per delivered horse power of more than 8·39 dollars. So much for long distance transmission from the coal mines to great cities.

THE CHEMISTRY OF SOOT.

The impression generally prevails that soot is simply carbon, but although carbon is its chief constituent, there are present many other elements among which are hydrogen and nitrogen. Soot may be considered as an impure hydrocarbon, containing a very large proportion of carbon relatively to the amount of hydrogen. The smell of soot suggests ammoniacal compounds, and The London Lancet states that a recent analysis has shown that soot contains no less than 7·4 per cent of ammonium salts. This fact amply accounts for the value placed on soot for agricultural purposes. Soot on burning in a confined area, as in a chimney on fire, evolves a characteristically persistent and nauseous smell. This characteristic is probably due to the presence of nitrogenous organic compounds.

PARIS EXPOSITION NOTES.

The United States Publishers' Building, which has been erected in the grounds adjoining the main buildings of the Esplanade des Invalides, contains a number of exhibits which characterize the printing and other industries of this country. The building itself presents a handsome exterior; it is of square form, and the different facades are constructed of a series of arches resting upon columns. Two doors at each end give access to the interior. A number of exhibits are grouped in the center, surrounded by a passageway, leaving space for a considerable number of exhibits around the walls. The center is occupied by the Publishers' Headquarters, containing a number of desks and chairs for the use of publishers and others; the building is under the immediate charge of Mr. Charles Simms, Assistant Director of the Liberal Arts Section; Mr. A. S. Capehart is Director of this department. Nearby is the installation of The New York Times, which prints a Paris edition on the large Goss printing press, driven by an electric motor in the basement; a model printing office is shown in actual operation, the most interesting feature of which is the series of Morgenthaler linotype machines; there are five of these in actual operation, each being driven by an electric motor mounted directly upon the machine. To the right of the entrance is the exhibit of the Mutual Life Insurance Company of New York; the cases are finished in hard wood and ornamented with reliefs and statuary; the walls are lined with framed charts showing either by figures or graphically the different statistics relative to insurance and kindred subjects, with charts showing the growth of the United States in its various resources. Near it is the exhibit of the Equitable Life Insurance Company, which also shows a number of charts, besides photographs of its various office buildings. A number of typewriters, including the Yost, Remington, Smith Premier and Century, are shown in actual operation. A number of printing presses are also shown, most of which are running; among these are the Campbell, Babcock, the Mickle, which prints in colors, and others. Among the phonographs the American graphophone and the Columbia Phonograph Companies are represented, with a number of machines. The United States Express Company has an exhibit showing the system by a number of photographs or charts. Outside the main building is a model stereotyping pavilion, containing the melting furnaces, presses and all the necessary appliances. Another small building contains the reading room; most of the principal American newspapers are on file, and the cases contain bound volumes of illustrated journals. All of the SCIENTIFIC AMERICAN publications are to be found here.

EXPERIMENTS WITH X-RAYS IN ELECTROSTATIC FIELD.

The well-known fact that light movable bodies, when placed in a Crookes tube, enter in movement under the action of the cathode rays, is used to support the hypothesis that these rays are formed of material particles moving with a certain velocity. Nevertheless, it is remarked that the presence of cathode rays is not necessarily connected with the production of the movements, for these are observed to commence before the rays appear, and to cease when the rarefaction is pushed to a certain point, even though the cathode rays are still very intense. It is more probable that the movements are due to electrostatic action, especially if they are compared with those which have been studied by Groety in the case of Roentgen rays. This experimenter disposes a very light movable body, carried on the point of a needle, between the two plates of a charged condenser. In this constant field the body remains at rest, but when Roentgen rays are brought into the field, it enters into rotation, which lasts as long as the rays continue to act. With condensers of small dimensions and a movable arrangement formed by two disks of coppor foil united by an insulating cross-piece, the direction of rotation is found to change with the direction of the electrostatic field. The position of the tube emitting the rays also affects the sense of rotation. The two plates of the condenser are not indispensable in the experiment; they may be replaced by a small sphere, or even suppressed altogether, and the vanes placed in the air in the neighborhood of a Crookes tube. The rotation is not a direct effect of the Roentgen rays, for it ceases when a sheet of ebonite or aluminium is placed between the tube and vanes, the rays still passing through this screen.