SCIENTIFIC AMERICAN

ESTABLISHED 1845

MUNN & CO., - - Editors and Proprietors

Published Weekly at
No. 361 Broadway, New York

TERMS TO SUBSCRIBERS

One copy, one year for the United States, Canada, or Mexico $3.00
One copy, one year, to any foreign country, postage prepaid. £0 16s. 5d. 4.00

THE SCIENTIFIC AMERICAN PUBLICATIONS.

Scientific American (Established 1845) .... $3.00 a year
Scientific American Supplement (Established 1876) .... 5.00 "
American Homes and Gardens .... 3.00 "
Scientific American Export Edition (Established 1878) .... 3.00 "

The combined subscription rates and rates to foreign countries will be furnished upon application.
Remit by postal or express money order, or by bank draft or check.

MUNN & CO., 361 Broadway, New York.

NEW YORK, SATURDAY, MAY 26, 1906.

The Editor is always glad to receive for examination illustrated articles on subjects of timely interest. If the photographs are *sharp*, the articles *short*, and the facts *authentic*, the contributions will receive special attention. Accepted articles will be paid for at regular space rates.

CONDITIONS OF THE RAPID TRANSIT TUNNEL.

It has been rumored for many months that considerable difficulty was being experienced, during the driving of the Rapid Transit tunnel below the East River from the Battery, Manhattan, to Joralemon Street, Brooklyn, in preserving the tunnel at the predetermined grade. It is a fact that, as now constructed, a considerable portion of the tunnel, about fifteen hundred feet in all, on the Brooklyn side varies from the re-established grade by amounts that increase from a few inches to twelve inches, the variations consisting in a series of depressions or hollows in the grade, giving the latter something of a wave-line profile. Also, in this section of the tunnel, the cast-iron lining has cracked longitudinally, chiefly at the top, and sometimes at the bottom. The effect of the latter mishap has been to throw the cast-iron lining from a true circle into an ellipse, the lateral axis being greater than the vertical axis by varying amounts which reach, in the worst places, a maximum of six inches. That is to say, each side of the shell is in places as much as three inches outside of its true position, while the top and bottom are each three inches inside the true line.

It is claimed by the Rapid Transit engineers that the result is due to the difficult nature of the material at this part of the river bottom, and also to the unusual methods employed by the contractor in driving the tunnel, methods which were not suited to the particular character of material through which he was working. The contractor, on the other hand, claims that the tunnel cast-iron lining, or shell, was not designed of sufficient strength to withstand the distortion stresses to which it is subjected, and that it was bound to crack and get out of line in the way that has happened. On the other hand, the engineers claim that where the contractor's methods were suited to the material through which the tunnel was driven, no trouble was experienced, that portion of the completed tunnel standing up to its work in satisfactory shape.

The effect of the depressions in the grade is that there is not sufficient clearance at these points to permit the cars to pass through without touching the roof of the tunnel. The matter is being remedied by taking out those sections of the floor which are too high to accommodate the re-established grade, and to a less extent sections of the roof are also being taken out. In each case new segments are being built in place, and the tunnel everywhere throughout the defective 1,500 feet is being restored to its proper internal diameter. It might be supposed that, when the sections of the floor were taken up, the sand would flow into the tunnel; but this is prevented by the air pressure which already exists for the regular driving process. For the roof repairs, which are of considerably less extent than those of the floor, the material above the roof is frozen before the plates are removed, the rigidity thus imparted to the overlying material serving, with the internal air pressure, to hold up the sand until the new roof has been put in place.

We wish to contradict the impression which has gone abroad as the result of the Mayor's statements at the last meeting of the Rapid Transit Commission, that these repairs are likely to entail either any delay in the completion of the work, or any increased expense to the city. The Rapid Transit Commission has held back $200,000 due upon this work, to cover the expenses of renewal, and the repairs are being carried on simultaneously with the driving of the 1,000 feet of tunnel which remains to be completed before a junction is effected below the center of the East River. It is confidently expected by the engineers that the tunnel will be completed by the end of the year, and that the first cars will be run through early in January next.

It should be explained that the difficulty in keeping a subaqueous tunnel of this character to true line and level is not by any means peculiar to this work under the East River. The same problems were experienced in the tunnels that have been driven below the North River, where the tube not only showed a tendency to get out of line, but was so distorted by the pressures to which it was subjected, that it was necessary to resort to a system of internal tie rods in order to hold it to circular form. Moreover, there need be no apprehension as to the future stability and safety of the East River tunnel. Although it might have been advisable to make the shell heavier, it is reinforced by concrete on the inside and by grouting on the outside, until the total thickness of the combined iron and concrete is on an average about twelve inches. After the work has been concreted and grouted up in this way, the material of the river bottom has no tendency to produce any further displacement or distortion of the tunnel.

EFFICIENCY OF THE AMERICAN LOCOMOTIVE.

It is not likely that another series of locomotive tests as elaborate as those which have recently been published by the Pennsylvania Railroad Company, will be undertaken for some time to come. The plant was of the most modern pattern, and expense was not considered in providing every form of apparatus that could conduce to the accuracy of the results. Moreover, no less than forty engineers, skilled in investigations of this character, were continuously employed on the work. A summary of the conclusions, recently published, proves that the American locomotive, at least in some of its forms, is efficient and economical to a degree that was not generally supposed; and the fact that it has shown its ability to produce a horse-power for the consumption of 2 pounds of coal per hour brings it almost into line with the average of modern stationary steam engines. In the first place, it was found, contrary to common belief, that the large modern boilers with which locomotives have been supplied, evaporate as much steam per square foot of heating surface, even when forced to maximum power, as the smaller boilers. Most of the boilers tested delivered 12 pounds of steam per square foot of heating surface per hour, and one of the largest boilers delivered as high as 16.3 pounds. It was found in all the boilers that a high quality of steam was produced, and that the greatest evaporative efficiency was shown when the power developed was the least. When they were running under conditions of maximum efficiency, most of the boilers evaporated between 10 and 12 pounds of water per pound of dry coal. There was a gradual fall of efficiency as the rate of evaporation increased, which was, of course, to be expected, until, when the boilers were being pushed to the limit, the efficiency fell to between 8 and 6 pounds of water per pound of dry coal.

When the fuel was being burned at a low rate, the temperature of the firebox was found to be between 1,400 and 2,000 deg. F. The temperature increased slowly with the increase in the rate of combustion, the maximum observed firebox temperatures being between 2,100 and 2,300 deg. F. The smokebox temperature when the boilers were being worked at moderate power was about 500 deg. F. for all of the boilers. It increased gradually as the boiler was forced, until in the locomotives under test it reached from 600 to 700 deg. F.

On the important question of grate area it was proved that the boilers which have the largest ratio of grate surface to heating surface, have the greatest capacity. There was found to be but little loss of heat through imperfect combustion, always excepting the amount of fuel that was drawn off through the stack unburned, in solid particles. There seems to be no advantage in increasing firebox heating surface beyond a certain ratio in proportion to tube surface, the latter being capable of absorbing such heat as is not absorbed by the firebox surface. The draft in the front end, when the locomotive is running under low power, does not exceed about 1 inch of water, but it increases rapidly as the boiler is pushed, until maximum pressures of from 5 inches to as high as 8.8 inches are reached.

The indicated horse-power, shown in these tests, reached a maximum of 1,100 in the simple freight locomotive, and in the compound passenger locomotive it exceeded 1,600 horse-power. The steam consumption per indicated horse-power showed for a simple freight locomotive an average minimum of 23.7, the consumption, of course, depending upon speed and cut-off.

Compounding has again fully vindicated the theories upon which it is based, the compound locomotive consuming from 18.6 to 27 pounds of saturated steam per indicated horse-power per hour. When superheated steam was used, the minimum consumption was reduced to 16.6 pounds. The fact was brought out, furthermore, that while the steam consumption decreases with increase of speed in the simple locomotive, in the compound locomotive it increases, a condition which experience with the compound had led us to expect. Experiments with the throttle and cut-off proved that the locomotive performance is best, when carrying the same load, if a full throttle and a short cut-off is used.

A greater proportion of the cylinder power appears as pull in the drawbar at low speeds than at high speeds. Thus it was found that at 40 revolutions per minute, the maximum percentage at the drawbar is 94 and the minimum 77; whereas at 280 revolutions per minute the percentages fell to 87 maximum and 62 minimum. It was found, furthermore, that the loss of power between cylinder and drawbar depends largely upon the character of the lubricant, the substitution of grease for oil on the axles and crank-pins increasing the friction from 75 to 100 per cent.

Coal consumption per dynamometer horse-power hour in a simple freight locomotive was found at low speeds to vary from 3.5 to 4.5 pounds. For the compound freight locomotive tested under similar conditions, the consumption fell to between 2 and 3.7 pounds. The two-cylinder compound, run at high speed, showed a consumption of 3.2 to 3.6 pounds per dynamometer horse-power hour; while for the four compound passenger locomotives it varied, according to running conditions, from 2.2 to over 5 pounds per hour. In all of the locomotives the consumption increased rapidly with the speed.

Finally, it was proved, in a comparison of the compound freight with the simple freight locomotive, that the economy of the former is greatly superior. Under similar conditions the least economical compound shows a saving in fuel over the most economical simple locomotive of about 10 per cent, while the best compound showed a saving over the poorest simple locomotive of nearly 40 per cent. It is only fair to state that the conditions of the trials, which provided for continuous operation of the locomotives at constant speed and load, were all favorable to the compound. We are pleased to note that these valuable tests are now being continued at Altoona, where the plant has been placed in its permanent location.

DIRECTED WIRELESS TELEGRAPH MESSAGES.

The transmission and reception of two or more wireless telegraph messages simultaneously in the same zone of action, or selectively, as it is called, is a problem second only in its abstruseness to the telephonic relay, that scientific will-o'-the-wisp over which inventors have struggled ever since Bell devised his apparatus to send and receive articulate speech over wires.

Many solutions, electrical, mechanical, and electro-mechanical, have been provided to secure selectivity, but at the end of a decade of wireless telegraphy it seems that all the labor expended in this direction has been virtually in vain, in so far as the coveted goal is concerned, though through the researches in electrical resonance excellent results have been achieved in tuning and syntonization, which important factors are largely accountable for the present degree of advancement in long-distance wireless signaling.

Since it is sometimes more convenient to enter a window than to go through a door, many inventors have ceased trying, at least for the time, to discover the "open sesame" of selectivity, and have confined their efforts to the easier task of directing, within certain limits, the wireless waves. Artom, of Italy, was the first to evolve such an arrangement and attain favorable results; this he did by means of circularly polarized electrical radiations*, which he produced without resorting to reflection grids, as is necessary in the case of light waves.

Much simpler than this Italian physicist's method is one recently made public by Marconi, while the experiments of the latter indicate that a wider range of usefulness will be given the previously inflexible wireless transmitter and receptor than has yet been known. Briefly, the scheme is this: When one end of an insulated horizontal wire (the other end of which is free) is connected to one side of a spark gap of an induction coil, and the other side of the gap is earthed, the electric waves emitted by the wire will reach a maximum in the vertical plane of the horizontal wire, and proceed principally from the end connected to the spark gap, the radiation being imperceptible in any other direction approximating 100 deg. from that in which the maximum effect takes place.

Similarly, if an insulated conductor is laid on the ground, or placed a short distance above it, and the end nearest the sending station is connected to one side of an electric wave detector, the other side of which is earthed—leaving the opposite terminal of the wire free—the maximum effect will be evident only when the receiving and transmitting wires are in alignment with each other. Marconi further points out that if the receiving horizontal wire is so arranged that it can be turned in a circle about its earthed end in a horizontal plane, the maximum and minimum effects observed during the process of swiveling will enable an operator to easily determine the direction of any transmitting station within the field of radiation.

A number of trials were conducted to ascertain the best lengths of the horizontal wires for both transmission and reception, the distance these wires should be elevated from the earth, and finally the greatest distance obtainable between stations thus equipped. The experiments were further varied by

* Editorial SCIENTIFIC AMERICAN, October 7, 1905.