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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.

employing the regulation aerial wire for sending, the complementary apparatus using the horizontal wire.

The whole series of tests cannot here be cited in detail, yet the following will suffice to show in a measure the results secured. In one of the experiments the transmitter, having a spark length of about 2 cm. (¾ inch), was connected to a horizontal conductor 656 feet in length, supported at a height of 49¼ feet above the ground; the receptor was furnished with a wire of equal length 3¼ feet above the ground, and connected to one end of a magnetic receptor. Now, when the horizontal wires of both stations were in line, so that the maximum effects were obtainable, easily-read signals were heard at a distance of 25 km. (15½ miles). When the receiving wire was swung around to 12 deg., nothing could be heard even when the receptor was moved to within 12 km. (7½ miles) of the transmitter; and when placed within 5 km. (3.1 miles), the angles of the wires remaining unchanged, only weak signals were indicated.

In another trial the great Poldhu station with its vertical aerial was used for sending, and a receptor placed at Clifden, Ireland, 500 km. (310 miles) away, was provided with a horizontal conductor 754.6 feet in length, laid on the ground, and connected to one side of a magnetic receptor, the opposite side being grounded as previously explained. When the free end of the receiving wire pointed directly away from Poldhu, the signals were sharp and loud; but when the horizontal wire made an angle of more than 35 deg. with the line of Poldhu, the reception was absolutely *nil*.

In all of his experiments where the tests were made over considerable distances, Marconi employed his magnetic receptor; but where the distances were short, he utilized a Duddell thermo-galvanometer, since this delicate instrument permitted him to measure the current values of the electric oscillations set up in the receiving wires.

The horizontal wire, if it is proven to be anywhere nearly as effective as the usual aerial wire, will greatly reduce the expense of wireless telegraph installations, for the masts often cost as much or more than the instruments. The new arrangement will do much to further the commercial possibilities of this mode of transmitting intelligence if the mast can be eliminated, and the whole series of tests points to a new era of wireless telegraphy.

One of the noteworthy observations made by Marconi was that electric currents set up by distant atmospheric conditions can not only be detected, but the direction whence they originate determined; and this may mean that a new instrument is to be placed in the hands of the meteorologist. There are other aspects of the experiments which will be looked forward to with interest.

In the army and navy wireless telegraphy has proven an invaluable aid, and this has been due chiefly to the fact that messages could be sent and received over long distances, while the direction whence they came or whither they went was an impenetrable mystery to the enemy. Now all this is changed, and some extraordinary complications may be looked for. As a palpable problem it is a duplication of heavier armor plate, heavier guns; heavier guns, heavier armor plate, and so on to infinity.

THE MANUFACTURE OF TURPENTINE.

Turpentine or spirits of turpentine—to the old pharmacists everything volatile was a "spirit," thus "spirits of wine," alcohol—is a product of several varieties of pine tree, and the turpentines from the different species vary in their composition and properties. But in this country, or in the eastern three-fourths of it at least, we know but one kind, that produced from the yellow or long-leaf pine (*Pinus sylvestris*) of our southern seaboard and Gulf States.

When an incision is made through the bark of one of these trees at a season when the sap is flowing, a thick, clear, gummy juice exudes, and on exposure to the air gradually hardens into a friable but somewhat sticky mass. The odor of this juice, which in the trade is known as *gum thus*, or "virgin turpentine," is the characteristic turpentine smell, and its hardening is due to the evaporation of its contained turpentine, leaving behind its constituent gum resin or "rosin."

Formerly vast sections of all the States south of the Virginias and the Ohio and east of the Mississippi River were covered with immense forests of yellow pine, and during more than half a century these forests have been the chief source of supply for the turpentine and rosin consumed by the entire civilized world, with the exception of France, Russia, and eastern Europe, which are to some extent producers of turpentine for home consumption.

The effect of this immense drain upon our natural resources, coupled with primitive and criminally wasteful methods of production, has been to reduce the acreage of the pine forests from apparently exhaustless resources to a comparatively limited territory. A quarter of a century ago the principal center of the naval stores business ("naval stores" including turpentine, rosins, pitch and pine tree tar) was Wilmington, N. C. Later it gradually shifted to Charleston, S. C.; for a decade or more it remained at Savannah, Ga.; but during the past five years the Florida ports of Pensacola and Jacksonville have been slowly taking precedence. At the present time the "turpentine belt" is confined to the Gulf States. Though all the available territory in the adjoining States has not been exhausted, the end is plainly in sight unless the devastation can be checked.

The reason for this deplorable condition will be understood from a brief description of the methods commonly pursued by "turpentine farmers" in collecting the "crop."

The turpentine season opens in the early spring, when the sap begins to rise in the trees, and continues until late in the fall, when cold weather puts an end to the return flow. The turpentine farmer goes into the forest and selects a space containing the number of trees he proposes to work, and leases from the owner the acreage desired. Hiring the requisite number of negroes, he sets them to work "boxing" the trees. A few feet above the ground a shallow "box" or excavation is cut into the tree trunk, and above this box for some distance the bark is removed and the sap wood scarified. Often a second similar "box" is cut on the opposite side of the tree. The sap gradually exudes from the scarred surface or "face" and collects in the boxes, from which it is dipped out from time to time and collected at a central point. When the flow ceases or becomes sluggish, the face of the cut is scraped and rescarified to prevent the healing of the wound. During successive seasons the cuts are deepened and extended in height, until the tree dies from exhaustion or is blown over by a storm because of the weakening of the trunk.

Meanwhile, at some convenient central point in the "orchard," a crude still has been erected for the treatment of the collected sap. Into this still or series of stills the sap is charged, and live steam being passed through it, the turpentine passes over with the steam through a condensing "worm," and is collected as it drips from the condenser. The residue in the still is rosin, which after remelting and straining to remove twigs, leaves, and other impurities, is run while fluid into large rough wooden casks made on the spot. The sap from the first year's boxing produces the so-called "pale grades" of rosin, known in the trade as "water white" or "W. W.," "window glass" or "W. G.," "N.," "M," and "K" rosins. As the age of the "box" increases, the grade or color of the rosin deteriorates through the letters of the alphabet up to "D," "C," and "A" rosins, constituting the darkest and cheapest grades. This, roughly speaking, is the cause of the classification, though other influences help to determine the color and grade of the product.

Tar is made by a crude process of distillation applied to pine chips, twigs, etc., by direct heat, and is merely an occasional incident in the industry.

The product, both "spirits" and rosin, is sold largely to neighboring grocers and country storekeepers, either in exchange for supplies or for cash, and is by them shipped from time to time to the central markets, the principal "naval stores ports" being, in addition to those already named, Mobile, New Orleans, and Tampa. New York is also an important market, but the receipts at that port are all reshipments from southern ports.

From the foregoing outline of the methods pursued by the pine-forest devastators, with the added element of carelessness as to fires, it will be easily understood how the area of the long-leaf pine has in fifty years been reduced from millions of acres to hundreds of thousands. The government, through its Department of Agriculture, has lately intervened with an attempt to introduce more economical methods, by means of a simple device which is not only more efficient and cheaper than the old practice, but calculated to maintain the yield of sap indefinitely; but until the strict supervision of France, which enforces the replacement of the destroyed trees by new ones, is introduced, the extinction of our pine forests will be merely delayed, not averted.

Combinations of producers and factors or merchants have had some effect upon prices in recent years; but no combination, however effective, in an industry so widespread as this, could have raised the price of a product from an average level of from 25 to 35 cents to the present current prices for turpentine, which ranged in the past year from 55¾ cents to 79 cents per gallon; or of the pale rosins from an average of under \$3 to \$5 and \$6; and of the low grades from a high limit of \$1.50 to \$3 or \$4 or over. The end of American turpentine and rosins is in sight unless the waste be promptly checked.

The chief use of turpentine is in paints and varnishes, where it is employed as a volatile thinning agent. It evaporates very quickly, leaving no residue. It has the peculiar property of forming ozone, which is practically a condensed form of oxygen, and as oxygen is the cause of the drying of paints and varnishes, turpentine to this extent serves a double purpose. Its rate of evaporation also is slower than that of benzine and similar products, so that for most uses it is somewhat preferable on that account; but aside from purely technical advantages, it is doubtful if it serves any better purpose in paints and varnishes than is obtained from the use of benzine and similar volatile thinners. At any rate, a prepared paint or a varnish is not necessarily inferior because it is not thinned with turpentine, and it is becoming a very serious question with all manufacturers of such goods whether the time is not at hand when the consuming public will have to be educated to the use of benzine instead of turpentine in their products. The objection is in reality rather to the odor of the first-named product than to any lack of efficiency.

A NEW AND CHEAP PROCESS FOR GENERATING HYDROGEN.

Consul-General Frank H. Mason makes a report from Paris on a new process for producing hydrogen, as follows:

At a recent meeting of the French Academy the eminent physicist, Mr. Moissan, presented a report from Mr. Georges F. Joubert describing a new and thus far secret process for the manufacture of hydrate of calcium, a product which, by reason of its convenient fertility for the generating of hydrogen gas for ballooning and other purposes, is likely to play an important role in the field of applied chemistry.

It appears that the Société d'Electrochemie, at St. Michel de Marienne, has succeeded, like the Electrotechnical Company, at Bitterfield, Germany, in producing by electrical process calcium metal on a commercial scale and at a price so moderate as to permit its use for various industrial purposes.

The invention of Mr. Joubert consists in a process by which the reaction of metallic calcium upon a metallic salt produces the new form of hydrate of calcium, or, as it is commercially known, "hydrolithe." This resembles in appearance and qualities calcium carbide, with the difference that whereas the carbide with the addition of water evolves acetylene gas, the hydrolithe upon contact with water evolves hydrogen gas. When pure, 1 pound of hydrolithe will generate 18.46 cubic feet of hydrogen. When of the ordinary commercial grade of purity, 1 pound of hydrolithe will create 16.05 cubic feet of gas.

Its most ready and obvious use is thus far for inflating balloons for military and other purposes. It is safe and easy to handle, can be used for generating gas wherever water can be obtained, and for long flights can be carried as ballast instead of sand, and employed at will for refilling the balloon, which may thus be kept in flight almost indefinitely. As an illustration of the economy of weight that has been accomplished by the substitution of hydrolithe for the purposes of military balloon service, it may be stated that an ordinary field balloon contains, when inflated, about 17,657 cubic feet of gas, the generation of which by the means hitherto employed requires the employment of materials and apparatus which fill three wagons, each one of which weighs when loaded 3½ tons, and requires in a campaign to be drawn by six horses. All this cumbrous and costly equipment can now be replaced by a two-horse wagon carrying a ton of "hydrolithe," which, with the addition of water that can be obtained anywhere, supplies instantly and in controlable quantities whatever gas may be required.

A RUSSIAN GASOLINE-ELECTRIC TRAIN.

Experiments have been lately carried on at St. Petersburg with a train using a new system of gasoline-electric locomotive, in which a gasoline engine is combined with an electric motor outfit. The train is made up of six steel cars mounted on two double-axle bogies. The platforms are connected with the bogies by means of ball-bearing pivots. The gage of track is 30 inches and the wheel diameter 12 inches. The rails of the Vignole type weigh 12 pounds per yard. Each car weighs 0.7 ton, and the load is about 2 tons. At the head of the train is placed a car which is like the others on the outside, but it contains in the interior a generating set consisting of a German gasoline motor of 35 horse-power running at 800 revolutions per minute. To the motor shaft is coupled a Bergmann dynamo. The gasoline motor is of the four-cylinder type and has 5.6-inch bore and 6.4-inch stroke. Copper water jackets are used on the cylinders. Speed regulation is secured by varying the proportion of gas in the mixture. The dynamo is designed to furnish 142 amperes and 120 volts at a speed of 780 R. P. M. The weight of the gasoline motor is 0.4 ton, and that of the dynamo 0.8 ton, while the total weight of the locomotive car, including 40 gallons of water, is 2.3 tons. On each of the bogies of the cars of the train is suspended an electric motor, which drives the axle by a 1 to 5 reduction gearing. These motors weigh 110 pounds each, and they operate on a current of 60 volts which is furnished by cables from the dynamo in the locomotive car. The two motors of each car are connected in series. Their speed is 1,000 R. P. M. A four-conductor cable connects all the cars with the locomotive. The motorman can regulate the speed of the train by a controller placed on the front car. This new system is said to operate well.