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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.

RAPID CONSTRUCTION OF THE RAPID TRANSIT SUBWAY.

Our congratulations are extended to the engineers, the construction company and the contractor of the New York Rapid Transit Subway, on the great skill and unprecedented dispatch with which they are prosecuting a work, which may justly be considered as being at once the largest and most difficult of its kind ever undertaken. Although this is not the first time that an underground system has been built in a metropolitan city under cast-iron conditions as to non-interference with the regular flow of traffic, it must be remembered that the tunnels constructed in London and Paris did not compare in magnitude with the New York system, and that many of them have been built at a depth below the surface which carried them clear of all surface pipes and drainage, and avoided altogether the difficult problem of providing for the ceaseless flow of traffic at the surface. For it must be borne in mind that the Rapid Transit Subway starts at the very busiest center of traffic in the whole city and runs for a considerable part of its total length of 20 miles beneath some of the most important thoroughfares of New York. Moreover, except for a few short stretches, it lies in close proximity to the surface, with little more than the depth of its steel-and-concrete roof intervening between the top of its cars and the wheels of the traffic above. Hence it has been necessary, before a stroke of work could be done upon the actual excavating of the tunnel itself, to provide an elaborate and massive system of falsework to hold the surface of the street temporarily in place. Add to this the fact that over the greater part of the route the contractors have had to make special provision for holding up the massive roadbed of a double-track underground trolley road, to say nothing of a perfect network of gas and water mains, and electric cable conduits, and it becomes evident, even to the lay mind, that the construction of this tunnel was an engineering problem of far greater proportions than can be expressed in mere statements of length and quantities.

In drawing up the contract, the Rapid Transit Commissioners set the date of completion at August 21, 1904, or four and a half years from the date, February 21, 1900, on which the contract was signed. Having in view what we might call the incidental difficulties of construction as mentioned above, to which, by the way, must be added the necessity of diverting and lowering some of the largest elements in the sewerage system of the city, it would not have been surprising if it had become evident, as the work developed, that an extension of time would be necessary. At any rate, it must be confessed that the history of earlier contracts of the kind rendered such a delay a decided probability. It is extremely gratifying, therefore, to learn that the work has been handled with such skill and pushed through with so much energy that to-day the contractors are several months ahead of their time, as will be seen from the following figures: Out of a total estimated earth excavation of 1,700,000 cubic yards, 800,000 cubic yards has been taken out, leaving only a little more than one-half of the total to be removed. Out of 1,300,000 cubic yards of rock, including both rock taken out in open cut and that removed in tunnel excavation, 366,000 cubic yards have been removed, or 28 per cent of the whole. On November 1 of this year $9,700,000 had been expended out of the total contract price of $35,000,000. As the amount paid out for work done is about the fairest way of estimating the rate of progress it may be said that about 28 per cent of the tunnel is completed. The fact that the amount paid out every month for work done is steadily increasing augurs exceedingly well for the early completion of the contract. In August of last year the total monthly payment amounted to $265,000, whereas in August of this year it had risen to $900,000, and there is a probability that it will increase as the months pass by. Bearing this in mind, then, we think that the engineers and contractors are perfectly justified in assuming that the subway will be completed by Christmas of the year 1903. In agreement with this estimate the contract for the power plant names January 1, 1904, as the date on which the whole of the installation of boilers, engines and generators is to be delivered. The power station is to be located at Fifty-ninth Street and the Hudson River, and the contractors, having an eye to the future probable extensions of the subway, have secured a plot of ground which will enable large additions to the plant to be made as required. The power station will be larger than the Metropolitan Street Railway Company's plant of 70,000 aggregate horse power, and larger even than the huge power station of 100,000 horse power which is now nearing completion for the Manhattan Elevated system.

PAINTING OF BIG BRIDGES.

The New York public has had the question of the painting of large bridges brought very forcibly and somewhat painfully to mind, of late, by the extraordinary disclosures of the report of the expert commission appointed by the District Attorney to examine the Brooklyn Bridge. In this connection a few facts regarding the system of painting adopted in the case of the largest and most important bridge in the world, the Forth Bridge in Scotland, will be of interest.

It seems that ever since this structure was opened for traffic, eleven years ago, the work of painting it has gone on without any interruption. A staff of about thirty-five men is employed on the work. They commence painting at the southern end of the structure (which, by the way, comprises two main spans of 1,710 feet and two shore spans of 700 feet), and the work proceeds daily, except on Sundays and in unusually stormy weather, until the northern end of the structure is reached. It takes three years to cover the full length of the bridge, which, in the cantilever portions alone, is about one mile in length. Hence it will be seen that this period of thirty-six months represents the useful life of the paint, since one coating is no sooner completed than the work is begun again. Already the huge structure is receiving its fourth coat. To enable the painters to conveniently reach every part of the structure, the engineer in charge has devised a system of ladders and steam hoists. Where possible, ladders attached to the great struts and ties are made use of, but for reaching the loftiest portions of the cantilevers, which rise to a height of 360 feet above the piers, a series of permanent elevators have been installed. These are operated by means of steam winches which are placed a little below the level of the roadway. In proximity to each elevator there is erected a house in which the paint is mixed. For painting the under side of the roadway permanent wire ropes are stretched along each side of the structure, from which the painters' platforms are suspended in such a way that they can be drawn along the rope very much after the manner of a cableway. Evidences of the thoroughness with which the work is done is seen in the fact that, so far, no portion of the bridge has shown any signs of decay or need for renewal.

This method of painting certainly has its advantages over a system in which the repainting is only done as various parts of the structure seem to call for it; since it precludes the possibility of any detail being overlooked for any considerable period of time. An ideal system would be that which combines a periodic painting of the whole structure with a special coating, in the interim, for such parts as are particularly exposed to the action of the elements or traffic, such, for instance, as, in the case of the Forth Bridge, the first 20 or 30 feet of the steel towers above the salt waters of the Firth of Forth, or in the case of the Brooklyn Bridge, the articulated portions of the structure which are subject to movement and those portions of the floor system in which mud and water are liable to collect and set up a rapid oxidation.

ANNUAL REPORT OF THE BUREAU OF ORDNANCE.

In the annual report of Rear-Admiral O'Neil, Chief of the Bureau of Ordnance, it is stated that increased efficiency for the larger naval guns must be looked for, not in the direction of larger size and weight of the guns themselves, but rather in increasing the weight of the projectile and in improving the smokeless powder; in other words, we must endeavor to increase the striking energy of the shell per ton weight of the gun. The latest types of guns, of both large and small calibers, are so heavy and large, that any further increase of weight or length will seriously hamper the design of warships, by making a too large demand upon displacement. The report states that the ordnance equipment for American naval vessels is up to the highest standard attained in foreign navies for vessels of corresponding date and class. Rear-Admiral O'Neil says that he knows of no guns afloat, or shortly to be put afloat, that will equal in energy those which are being built for the United States navy. It is gratifying to know that the manufacture of guns and other ordnance fittings is well in hand, and that the outfits will probably be completed when the vessels are ready to receive them. During the last fiscal year 143 naval guns were completed, and 256 are at present under construction. We are also pleased to learn that there is a steady improvement in naval smokeless powder, that of to-day being considerably superior to the grade manufactured twelve months ago.

Speaking on the subject of submarine boats, Rear-Admiral O'Neil is of the opinion that this type is receiving undue prominence; an opinion in which we heartily concur. He states that if these craft are to have any permanent value, it will be as an adjunct to a system of coast defense. They are, as yet, purely in the experimental stage, and he believes that they will never take the place of ships of the regular type, or render a reduction in the fleets of the world possible. We are pleased to learn from the report that the latest armor contracts are extremely advantageous to the government, the price being lower than that paid abroad, and the armor the best that can be procured.

Interesting light is thrown upon the present controversy which is raging in naval circles over the designs for our new battleships and cruisers. We had thought that the point at issue was that of the double versus the single turret; but Rear-Admiral O'Neil, who is president of the Board, states that the issue is as to the relative merits of the new 7-inch gun as against the 8-inch and 6-inch guns, he himself being a strong advocate of the lighter piece. The arguments in favor of the 7-inch gun were given in our issue of August 10, 1901, when firing diagrams, showing the concentration and total energy of the gun fire obtained with two types of ship, one carrying the 7-inch gun and the other the 8-inch and 6-inch guns, were given. We hope in a later issue to take up this question in fuller detail.

IMPORTANT APPLICATION OF ELECTRIC POWER IN RAILROADING.

President James J. Hill, of the Great Northern Railway, is preparing to operate a 66-mile section of that railroad through the Cascade Mountains with electricity instead of steam. If the project proves successful it is proposed to operate an entire division from tide-water at Everett to Wenatchee on the Columbia River, a distance of 141 miles, with electric motors. This accomplishment, railroad men believe, will be but the beginning of the equipment of the entire main line with electricity. The plan of substituting electricity for steam, which has been forced upon Mr. Hill by his long tunnel and peculiar conditions, was first proposed to the railway world, as applied to long distance, by Henry Villard nearly ten years ago. Mr. Villard was at that time in control of the Northern Pacific Railroad and had become greatly impressed with the possibilities of electricity through his association in a business way with Thomas A. Edison. Early in 1892 Mr. Villard gave instructions for George W. Dickinson, then assistant general superintendent of the Northern Pacific at Tacoma, and one or two high officers of the engineering department, to meet him in New York, whence they were taken to the works of the General Electric Company for a conference with Mr. Edison and other electrical engineers regarding the feasibility of introducing electricity on the Northern Pacific. To these officers Mr. Villard unfolded a plan which he had partially matured for operating first a broad-gage electric railroad between Milwaukee and Chicago. He had under consideration either the building of an entirely new line between those cities or the substitution of electricity on that portion of the Wisconsin Central which was then controlled by the Northern Pacific. Mr. Villard figured that the line could be placed in operation by the summer of 1893 and could thus be used by thousands of visitors to the Columbian Exposition at Chicago. The consummation of this plan was prevented by the gradual tightening of the money market which preceded the stringency of 1893, and in consequence of the receivership which followed, the Northern Pacific passed out of Mr. Villard's hands.

The investigations on the same subject by the Great Northern cover a period of over three years and have been under the direction of J. N. Hill, the eldest son of President J. J. Hill. The matter was first brought to the elder Hill's attention by the reports of his civil engineers to the effect that it might be found impracticable to operate trains through his two-mile Cascade tunnel by means of coal-burning locomotives, on account of its extreme length and the fact that there would be no means of effectively ventilating the tunnel when finished without going to the expense of installing and permanently operating compressed-air motors. The investigations which followed have convinced the officers of the road that a great saving can be made by operating trains by water power con-

verted into electricity. This fact is shown by the extension of the original plans to a long section of the railroad through the mountains as recently announced by President Hill. His present plans as announced contemplate the application of electricity to that portion of the road extending from Leavenworth on the east side of the Cascades to Skykomish on the west side, 66 miles. It is understood that if the electric motors prove as successful as anticipated, the electric system will be further extended so as to include the mountain division, from Everett on Puget Sound to Wenatchee, 141 miles. This would be the beginning of an electrization which might eventually include the entire mileage of the system.

The section of the road chosen for the first application of the experiment is the most difficult and expensive portion of the road to operate on the entire system. It runs through the wild and rugged Cascade where the grades are very heavy, and where every winter there are numerous slides of earth and rock which come down the steep mountain sides to cover the track and endanger the operation of trains. One of the most important causes of the Great Northern's desire to secure cheaper motive power is the fact that its tributary coal supply is very limited. In the matter of cheap fuel the Great Northern is being operated at a tremendous disadvantage as compared with the Northern Pacific or the Oregon Railway and Navigation Company, its Washington rivals. The Northern Pacific owns the largest coal mines in the State at Roslyn, thereby securing its fuel at a cost not exceeding $1 to $3.25 per ton. The advantage of the Oregon Railway and Navigation lies in its gravity route down the Columbia River from the Rocky Mountains. On the other hand, the coal used by the Great Northern costs about $2.75 per ton for the ordinary product, while for the Crow's Nest Pass coal, which is used on all trains through the tunnel, the cost is much greater.

For about thirty miles of the mountain climb on the Cascade division each loaded train requires the assistance of one or two helping engines. The coal consumption of this division is something enormous, amounting to upward of 2500 tons a day, or nearly a million tons a year. With a difference of $1.50 per ton in favor of the Northern Pacific, it will be readily seen that the older road has in the matter of coal supply alone a great advantage over its newer rival. As the water for the generation of the electric power for the operation of trains under the new system will be taken from one or more of the numerous rivers heading in the Cascade Mountains near the Great Northern lines, the innovation contemplated will reduce the coal bills of the division very greatly, if not eventually doing away with them entirely.

The details of President Hill's plan are now being worked out, and it is understood that active work toward the installation of the electric power will be commenced next spring. The successful long distance transmission of electric power generated at Snoqualmie Falls, forty miles from Tacoma, has been a powerful object lesson to the Great Northern.

The street railway systems of both Tacoma and Seattle, together with the electric lighting system of Tacoma and the vast machinery of the great Tacoma smelter, are all being operated successfully and economically with Snoqualmie power. A. W. C.

THE HEAVENS IN NOVEMBER.

BY HENRY NORRIS RUSSELL, PH.D.

Two astronomical events of great interest occur during the present month, but, unfortunately, one of them lies outside the range of our observation. This is the annular eclipse of the sun, which takes place on the 11th. It is noteworthy for the very long duration of the annular phase, which is, at maximum, a little over eleven minutes. The moon is so much farther away than usual that she hides only about 6-7ths of the sun's surface, even when she is directly in front of him, so that there will be plenty of light left to see by, even in the middle of the eclipse. The annular phase is visible along a belt of country about 200 miles wide, extending from Sicily past Cairo, over Arabia, Ceylon and Siam to the neighborhood of Manila. A partial eclipse is visible generally in eastern Europe, Asia, and northern Africa.

More interesting to us is the remarkable series of planetary conjunctions which happen later in the month, when the three brightest planets will be close together in the evening sky.

Jupiter has for months been slowly overtaking Saturn, and, just before he reaches him, Venus, whose eastward motion is much swifter, catches up with them both. She passes Jupiter on the night of the 17th, and Saturn on that of the 18th. The two are about a degree apart, while she is three degrees south of them, so that all three planets are crowded into a space no larger than the belt of Orion. The group which they form will be by far the most conspicuous thing in the evening sky, and will remain in sight for two hours and a half after sunset.

Though these three heavenly bodies seem so near together, their real distances from us are, of course. vastly different. Venus is very much the nearest, being but 74,000,000 miles distant. Jupiter is more than seven times as far away, his distance being 540,000,000 miles. Finally, Saturn is almost 1,000,000,000 miles from us—as far beyond Jupiter as Jupiter is beyond Venus.

It is to her nearness, both to us and the sun, that Venus owes her great brightness, for she is but one-eleventh as large as Jupiter, and, were she at his distance, she would not be as bright as the pole-star.

If she were as far off as Saturn, she would be invisible to the naked eye. It would be a mistake, however, to conclude from this statement that Venus, as she actually is, would be invisible from Saturn, for, in her present position, she receives from the sun about two hundred times as much light as she would if removed to Saturn's distance, and is correspondingly brighter. She would, in fact, appear considerably brighter to an observer on Saturn than Saturn himself does to us.

On the other hand, if Jupiter were in Venus' place, he would show, at favorable times, as a crescent about one-quarter the size of the moon, and would give us a pretty fair sort of moonlight. We may well be thankful, however, that such is not the case, for the attraction of so great a planet, so near us, might so change the earth's orbit as to bring us uncomfortably near the sun, or to send us so far from him that we should all be frozen.

Such a conjunction as the one which we now have the privilege of viewing is a rare occurrence. Jupiter revolves about the sun in twelve years, and Saturn in thirty. Twelve years hence, Jupiter will be in the same part of the sky as at present, but Saturn will have gone nearly half way round, and will still be ahead of Jupiter. It will take the latter twenty years in all to catch up with Saturn again, in which time he makes one and two-thirds revolutions to Saturn's two-thirds. So it will not be till 1921 that we will see Jupiter and Saturn close together again, and such conjunctions will recur every twenty years. But the two planets, when closest, may be in any part of the zodiac. Now, since Venus never goes more than about 45 deg. away from the sun, if they are more than that distance from him, they cannot be near Venus. If they are to be visible in the evening they must be east of the sun, and at least 15 deg. from him. This narrows down the region within which a conjunction like the present one is possible to about 30 deg., or one-twelfth of the whole circumference. It follows that, on the average, one conjunction of Jupiter and Saturn out of twelve will be such that an event like the present *may possibly* happen. But when such a conjunction occurs, Venus may not be in such a part of her orbit that she *actually does* come into conjunction with the others. There is only one chance in five or six that she will be. Therefore, on the average, only one out of sixty or seventy conjunctions of Jupiter and Saturn will be marked by the presence of Venus also. That is, such a display as occurs this month will happen, in the long run, once in about twelve hundred years. The actual intervals between two such conjunctions are very variable, some being much longer than the average, and some much shorter.

Jupiter and Saturn are closest on the 27th, when their distance is less than the moon's diameter. They will be very near one another throughout the last week of November.

There is a possibility that the lost Leonid meteor shower may turn up on or about the 13th of this month, but the chances seem to be much against it.

THE HEAVENS.

At 9 P. M. on the 15th, Gemini has just risen in the northeast, and Orion in the east. Auriga is above Gemini, and Taurus over Orion. Eridanus and Cetus fill up the southeast. Andromeda is directly overhead, with Cassiopeia on the north, Perseus on the east, Aries on the southeast, and Pegasus on the southwest. Aquarius and Capricornus are below and to the west of Pegasus, and Fomalhaut is the only conspicuous star lower down. Cygnus, Aquila and Lyra lie near the Milky Way in the west. Ursa Major is on the horizon below the pole, and Draco is above and to the right.

THE PLANETS.

Mercury is in conjunction with the sun on the 4th, and is invisible till the middle of the month. On the 20th he reaches his greatest western elongation, and is well seen as a morning star, rising nearly two hours before the sun.

Venus is evening star in Sagittarius, and increases in brightness throughout the month. Her conjunctions with Jupiter and Saturn have already been described. Mars is evening star, too faint and near the sun to be easily seen. Jupiter and Saturn are evening stars in Sagittarius. Uranus is too near the sun to be seen. Neptune is in Gemini, well placed for telescopic observation.

THE MOON.

Last quarter occurs on the night of the 2d, new moon on that of the 10th, first quarter on the morning of the 19th, and full moon on the evening of the 25th. The moon is nearest us on the 25th, and most remote on the 11th. She passes Mercury on the night of the 9th, Uranus and Mars on the 13th, Venus on the forenoon, and Jupiter and Saturn on the afternoon of the 15th, and Neptune on the 27th. The moon, Venus, Jupiter and Saturn, all in close proximity, will afford a fine spectacle on the evening of the 15th.

SCIENCE NOTES.

Prof. William T. Richards, of Harvard University, has received a call to the newly established research professorship of chemistry in the University of Göttingen. It is especially gratifying to note that one of the greatest universities in Germany should offer the chair to an American.

About 250,000 pairs of glasses will be purchased by the State committee in Maryland for use in polling booths. Politicians have found that both in the city and country districts a large number of voters of the poorer classes can read sufficiently well to ballot, but their sight is so defective that in the dimly lighted booths they are unable to read the long list of contestants on the ballot. Capable men will be provided at every polling place to adjust the glasses for the voters.

A cheap and rapid method for concentrating the enormous quantities of blood collecting in abattoirs is described by its inventor in the Technische Rundschau. The blood is injected in a finely pulverized state into an oven-shaped chamber, open at the top, and brought into contact with a current of hot air ascending from below. All the water is evaporated in this manner, and the blood powder is carried to the receiving chamber. According to the inventor, the powder thus obtained is tasteless and contains 74.8 per cent of digestible albumen.

The committee has not yet decided whether M. Santos-Dumont is entitled to the prize of 100,000 francs or not. No decision will be made before November 1, as the competition remains open until October 31, so that if in the meantime another competitor should appear and fulfill the conditions he would share in the prize. The persons who are prominently identified with aeronautical matters are of the opinion that M. Santos-Dumont has really won the prize, and M. Deutsch is convinced that the commission will award it to the young Brazilian.

Carrier pigeons have been put to novel use by a physician of Rockland, Me. On one occasion he was called to an island some twenty miles distant to attend a patient who was seriously ill. To reach this island he was obliged to make a dangerous trip. Before he returned to the mainland he gave the family of his patient six homing pigeons which were to be used as messengers to inform him of the patient's condition. A pigeon was dispatched as often as necessary, carrying assurances to the physician of the patient's steady progress toward recovery.

A series of observations by the late Prof. A. von Kerner has been published on the variations in the time of the opening and closing of flowers. He states that the fact that some flowers remain open for a longer period in summer than in spring is not due to the direct influence of an increase in the light, but to a rise in temperature due to the absorption of light. With many flowers the opening is not the result of growth, but of changes in turgidity due to transpiration. In *Hemerocallis flava* and *Hibiscus trionum* the flowers remain open only for a single day in the summer, while in autumn they open for two or three days in succession.—Oesterr. Bot. Zeitschr.

A new explosive, which is safe from detonation, has been invented by M. Fiedler, of Moscow, Russia. His explosive comprises a fluid and a solid, and the two have to be mixed before they will explode. The former is composed of nitrol-benzol 80 parts and turpentine 20 parts. The solid consists of potassium chlorate 70 parts and permanganate of potash 30 parts. To form the explosive 20 parts of the liquid are added to 80 parts of the solid. The former is packed in soldered tins, and the latter in packets waterproofed with chromic glue. A very salient feature of this explosive is that even when mixed, should it become ignited by contact with flame, the substance will burn away quietly.

An English aeronautical engineer, Mr. T. Hugh Bastin, of London, is to make an attempt for the Deutsch prize. This aeronaut in his invention has emulated the movements of birds while in flight, thus following in the footsteps of Langley, Hargraves, and Lilienthal. He practically utilizes huge wings for driving his vessel through the air. The wings are immense framework structures, sufficiently rigid and strengthened to overcome atmospheric resistance, with a covering of silk. These wings or fans have two movements at right angles to the direction of flight, precisely the same as a bird, with the same results. The front of the machine is pointed, so that it can readily cleave its way through the air. In flying the aeronaut avails himself of the oscillating movements of nature.