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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.

PORT ARTHUR.

The center around which revolves the whole complicated naval and military situation in the Far East is located at Port Arthur. The key to the situation is held by that heroic commander, Stoessel, and in a sense it may be said that by his stubborn defense he has locked up three of the most important elements in the war, namely, the Russian fleet within Port Arthur, the Japanese blockading fleet without the harbor, and the Japanese army of investment of 60,000 men. Incidentally, it may be said (still keeping to our metaphor) that Stoessel also holds the key to the deadlock into which the opposing armies of Kuropatkin and Oyama have fallen before the walls of Mukden.

There is, therefore, much more of method than of madness in the heroic stand taken by Stoessel and his gallant troops. At the present juncture there is no doubt that the Russian forces, and indeed the whole Russian plan of campaign, are in an exceedingly critical condition. It is also certain that if they can maintain the *status quo* for two or three months longer, the position may be entirely reversed, and the opportunity for a successful prosecution of the war by Japan be let slip forever.

As matters now stand, the last two great battles of the Manchurian armies seem to prove that they are so nearly matched that, in spite of her successes, it is impossible for Japan with her present forces to win an absolutely decisive engagement. It needs no intimate knowledge of strategy to understand that a decisive battle can be won by the Japanese only if they succeed in outflanking the Russian army and securing a strong position across the railroad, cutting off the Russians from their base of supplies. In the two great battles that have occurred at Liao-Yang and the Sha-Ho, flanking movements were made by Kuroki and by Kuropatkin, and in each case they failed for the reason that the flanking army was not powerful enough to cut loose from the main body with any hope of successfully effecting its object. There is no doubt that in planning the campaign, the Japanese strategists expected that by the time their Manchurian armies effected a junction before Liao-Yang, Port Arthur would have fallen, and the army of investment would have been available to give Japan the numerical superiority necessary for a great turning movement. It is the unexpectedly-stubborn resistance of Stoessel and his troops that has saved the situation for Kuropatkin. Every day that Port Arthur can hold out means the addition of so many thousand men and so many scores of guns to the Russian forces, and the more complete development of a successive system of entrenchments to which the Russians can retire, should it become necessary to fight a series of rear-guard actions.

Furthermore, judging from the slow work that has been made in reducing the outer line of forts at Port Arthur, it begins to seem fairly possible that the Baltic fleet, on its arrival in Chinese waters, may find the remnant of the Port Arthur garrison still holding the line of forts to the southwest of the city, on what is known as the Tiger's Tail and the Liau-Tie-Shan Peninsula; and although such possession would not enable the Baltic fleet to use Port Arthur for refitting, it would involve the retention of a large portion of General Nogi's troops that are badly wanted elsewhere. Moreover, it cannot be doubted that a certain amount of repair work is being done on the five battleships that were driven back into Port Arthur after the sortie of August 10. When the fall of the fortress itself is imminent, and these battleships are in danger of being sunk by Japanese high-angle fire, it is safe to say that they will make another desperate effort to break through Admiral Togo's fleet, and reach the sheltering port of Vladivostock. Every day that Stoessel can hold out is another day gained for putting these ships in condition for a running fight; and it is scarcely possible, even if the Russian fleet should be scattered or sunk, that Togo's battleships will come through the fight without more or less serious injury. If the dash for Vladivostock can be delayed for a few weeks longer, it will take place when the Baltic fleet is within a month's or even less than a month's steaming of Port Arthur—all too short a time for the Japanese navy, worn as it is with the stress of a long blockade, and just emerging from a fight against a superior number of battleships, to enter the drydocks in Japan and get in shape to meet a fleet of seven battleships, most of which are fresh from the builders' hands in the Baltic yards.

It has lately transpired that in June last the "Yashima," one of the Japanese battleships, was sunk by a mine off Port Dalny. This leaves the Japanese with but four available battleships to oppose the five battleships in Port Arthur and the seven that are included in the Baltic fleet; and the longer that Stoessel can hold out at Port Arthur, the more will these four ships (all too few for their work) stand in need of refit and repair. If, on the other hand, Port Arthur should fall to-morrow, Nogi's troops would be rushed to Mukden, and the Russian Manchurian army would in all probability, be driven back beyond Mukden, if not into Harbin itself, in a succession of flanking movements. Port Arthur would be closed to the Baltic fleet, and the ships that it shelters scattered or sunk, while the Baltic reinforcements, should they determine to continue on their mission, would find Admiral Togo's and Admiral Kamimura's combined fleets, fresh from a thorough overhauling at the Japanese dockyards, settled down to the blockade of Vladivostock—the only port in which the newly-arrived relieving fleet could hope to find harborage. One would have to search far into the history of naval and military wars of the past to find a situation where the fate of a whole campaign on land and sea depended so immediately and utterly upon a beleaguered fortress, as does the issue of the present war upon the brave troops and indomitable commander at Port Arthur.

HYDRAULIC JET PROPULSION.

It sometimes happens in the world of engineering, that a system is condemned in the earlier stages of its exploitation on the ground that it is wrong in theory when, as a matter of fact, it is the mechanical appliances through which it is endeavored to render the system practicable that are at fault. It would seem as though a case in point were that of the jet propulsion of vessels, which was so uniformly unsuccessful in its earlier attempted applications as to lead to the general belief that it was inherently wrong in theory. Vessels were propelled by the hydraulic jet; but under such low efficiency as to render the system useless for commercial purposes. The improvements which have been made of late years in hydraulic apparatus, and the better understanding of hydraulic principles, have led an English firm to make an extensive series of tests, which have enabled them to install a system of jet propulsion, whose efficiency, according to figures given by our esteemed contemporary the Yachtsman, rival the performance of the screw propeller. The firm in question, in designing the motive power of a small auxiliary yacht, directed their attention expressly to the question of suitable propellers; and among other methods that seemed to offer a satisfactory solution for the vessel in hand, the hydraulic jet propeller received careful attention. The British naval authorities, it was found, had twice already made practical tests of the jet. The first was made half a century ago in a small gunboat, and the second in 1883, in a second-class Thornycroft torpedo boat. In both cases the results were discouraging because of the low efficiency secured, which, in the latter case, amounted to only 0.32, as compared with a similar screw-propelled boat which gave an efficiency of 0.50.

Apparently these results settled the fate of jet propulsion forever; but in examining the experiments more carefully, it was found that the inefficiency was not in the type of propeller, but in the faulty machinery employed. To explain more fully, it should be understood that hydraulic jet propulsion involves the use of a water pump (generally of the centrifugal type) which draws in water through an inlet in the bottom of the vessel and expels it astern as a jet, the reaction of the water driving the vessel ahead. In the jet propellers tried in the British navy there was a loss of efficiency, first, at the inlet of the water, second, in the pump, and thirdly, in the jet. In the Thornycroft experiments the pump losses amounted to 54 per cent, and the loss in the jet to 30 per cent. In view of the great improvement that has taken place in pumping machinery, the low efficiency did not seem so very discouraging, as the latest types of centrifugal pumps were known to show a much higher efficiency than 0.46, while it seemed certain that the loss of 30 per cent in such a simple matter as a jet could be considerably reduced. Inquiry among the leading makers of the world showed that several firms were prepared to supply pumps of 10 horse-power and upward of a guaranteed efficiency of not less than 80 per cent.

The study of jet efficiency was carried on by utilizing different forms of jets, connected by flexible rubber tubing to the supply pipe, and held in the direction of the flow of water by a spring balance, which recorded the jet reaction. In this way efficiencies ranging from 0.65 to 0.90 were obtained. The latter striking result was given by a jet which has turbine guide blades inserted in the discharge orifice, whereby the issuing water is accelerated in velocity and deviated in direction, and discharged in a number of thin, broad jets, each equal in propelling power. In this form of propeller an efficiency of 85 was easily obtained, and over 90 per cent was actually recorded. Comparing these results with those obtained in the Thornycroft torpedo boat of 1883, in the latter case the efficiency of the pump of 0.46 and of the jet of 0.7 gave a total efficiency of 0.32, whereas the results of the 1904 experiments gave a pump efficiency of 0.80 and a jet efficiency of 0.85, making a total efficiency for the jet propulsion of 0.68. This seems to bring hydraulic propulsion, in the sizes thus experimented with, well up to the level of the efficiency of screw propulsion. It is claimed by Mr. Rankin Kennedy, the engineer by whom the experiments were carried through, that the data given above is borne out by experiments with water jets made at the Massachusetts Institute of Technology, in which, by improving the forms of the jets, an efficiency of 99 per cent has been observed. If such jets could be applied as propellers, with pumps of 80 per cent efficiency, it is argued that taking, say, 95 per cent as a practical jet efficiency, a total efficiency of 0.76 would be secured, as against an efficiency of 0.71, which, according to this authority, is the highest efficiency observed in tests on the best screw propellers under most favorable conditions. The results obtained by the jet in these experiments are certainly very remarkable, and show a great advance on previous performances; but we think it is doubtful if the same efficiency will be obtained under conditions of actual service.

THE VAST RAILROAD SYSTEM OF THE UNITED STATES.

Although the total mileage of the railroads of the United States exceeds 200,000 miles, the building of new roads shows no signs of abatement. The total length, on December 31, 1903, according to Poor's Manual for 1904, was 206,886 miles. This represented a net increase on all railroads, during the year, of 4,774.61 miles. The liabilities were made up of capital stock, amounting to over $6,000,000,000, a funded debt of $6,000,000,000, and other smaller items that served to bring up the total liabilities to about $15,000,000,000. The principal assets consisted of $11,000,000,000, representing the cost of the railroads and equipment, and over $2,500,000,000 representing investments. On this huge system there were carried over 696,000,000 passengers, and about 1,300,000,000 tons of freight. The earnings derived from passenger traffic amounted to $429,000,000, while the earnings on freight reached a total of $1,338,000,000, other items bringing up the total traffic revenue to $1,908,857,826. The net earnings reached a total of $592,000,000, and other receipts brought up the total available revenue to $682,000,000.

The operation of the system requires the services of 44,529 locomotives, 28,648 passenger cars, over 10,000 baggage and mail cars, and no less than 1,524,150 freight cars. The growth of this stupendous system, with the exception of two or three periods of stagnation, has been remarkably even. In the year 1830 there were 23 miles of railroad in operation, in 1850 there were 9,121 miles, in 1860 the total had risen to over 30,000 miles, and in 1880 to over 93,000 miles. Fifteen years later, or in 1895, the trackage had doubled to 181,065 miles. The largest annual increase of mileage was in 1887, when 12,876 miles of new track were built. The next largest increase was in 1882, when 11,569 miles were added. The increase in the twentieth century seems to have settled down to a steady rate of between 4,000 and 5,000 miles each year. The growth of the equipment presents some interesting figures. In 1880 there were 17,949 locomotives, 12,789 passenger cars, and 539,255 freight cars. Fifteen years later these figures had more than doubled, the total number of locomotives in 1895 being 36,610, of passenger cars 26,419, and of freight cars 1,230,798. The full significance of the above statistics can only be realized, when it is borne in mind that with the increase of mileage and equipment, there has been a steady improvement in the quality of roadbed, structures, cars, and engines. The best of the railroads of the United States are fully the equal in most respects of the best European roads. In some respects they are superior, and in others not so good. In comfort of travel our cars are acknowledged to be unsurpassed; but there is still room for improvement in respect to the number and speed of our scheduled express train service. It is not, however, improbable that this country will be the most active in the extensive practical application of electric traction on trunk roads, just as it was the pioneer in the development of the trolley car; and should this happen, we shall easily lead the world in the rapidity of our express service.

WATER-CURTAIN FIRE PROTECTION.

Water-curtain protection against fire has been applied to a building in the city of London. During a practical demonstration of the new system made before representatives of the fire insurance companies, its value was so clearly established that a material reduction was secured in the premium. The system is simple in construction and operation. Every outside wall of the building carries, near the roof line, a horizontal water pipe, which is perforated on its under side. These pipes are supplied by a vertical standpipe, and each line is controlled by a valve, which enables any particular wall to be protected by a flow of water, or not, as the exigencies of the fire may demand. In the case of the London building, the horizontal pipes are supplied from a main standpipe, which is under a pressure of 80 pounds to the square inch. Another system of spray pipes is so arranged that a sheet of water may be thrown laterally over the roof, thus rendering it possible to envelop the whole building in a practically continuous curtain of flowing water. The perforations are spaced so closely, and the pressure under which the water is discharged is so great, that the water curtain has proved to be amply sufficient to prevent the flames from passing through it, to attack the building which it shelters. In the particular building referred to in London, the system is supplied by a separate pump installed for the purpose in the building.

At the present time, when the city engineers are at work on the designs for a salt-water main system of fire protection in New York city, it would be opportune for the owners of costly buildings that are particularly exposed to the dangers of conflagration in surrounding buildings, to consider whether the installation of water-curtain pipes would not at once form an excellent protection against fire, and an effective means of reducing the fire insurance premium existing on those buildings. The salt-water main system involves the erection of central pumping stations, from which water at very high pressures will be available. Therefore, the expense to the individual property owner would be merely that of erecting one or more standpipes, and running around the building the necessary horizontal perforated pipes of the water curtain. It would not be necessary, as in the London building, to erect a separate pumping plant, for the reason that the central pumping plant would furnish the necessary pressure.

LOADS ON FACTORY MOTORS.

Average loads in factories are often thought to be greater than they really are. This is due to the assumption in many cases that steam engines work near their full capacities most of the time, though this is seldom true.

Uncertainty on these points often makes factory owners hesitate to contract for electric power to operate their machinery, even at rates that represent large savings over the cost of operating steam plants. It is easily seen, of course, that a rate for electric power that brings its daily cost above that of operating a steam plant, on the assumption that the average is nearly up to the maximum load, may bring the actual cost of operation much below that of steam, if the average load is only one-half or less than one-half of the maximum. A definite conclusion as to the probable average load in any case is all the harder to reach because the ratio of average and maximum loads varies much in different lines of manufacturing work. To illustrate these facts, the following examples of power and energy consumption in three distinct lines of manufacture are given, with the circumstances of each.

In a large factory devoted to the printing of fine cotton fabrics seven induction motors that ranged from 1 to 75 horse-power each and had a combined capacity of 346 horse-power were employed almost exclusively for this work. In order to operate the printing machines a speed with wide variations was necessary, and this was obtained by driving direct current dynamos with the induction motors, and then using current from these dynamos to supply motors that were direct connected to the printing machines. During 260 hours of regular working time at this factory, the consumption of energy by the seven induction motors of 346 horse-power aggregate capacity amounted to 26,461 electric horse-power hours. If these motors had been in continuous operation at full load during the 260 hours, they would have done $346 \times 260 = 89,960$ horse-power hours of work. As the actual consumption of energy by these motors during this time was only 26,461 electric horse-power hours, it appears that the average rate at which the motors absorbed electrical energy from the supply line was only $26,461 \div 89,960 = 0.294$, or 29.4 per cent of their rated capacity. It is to be noted here that the consumption of 26,461 horse-power hours included all losses in the motors as well as the mechanical work done by them.

Another case illustrating an entirely different line of work from that just considered was a large plant devoted to the construction of heavy machinery. During one month of 26 working days, or very nearly 260 hours of operation, this plant drew 77,000 electric horse-power hours from the supply line. At this time there were in use about the plant 21 induction motors that ranged from 10 to 100 horse-power each, and had a combined rating of 590 horse-power. If these motors had all been fully loaded during the 260 hours that the plant was in operation, their output would have amounted to $590 \times 260 = 153,400$ horse-power hours. As the energy actually consumed by the motors during this time was 77,000 horse-power hours, the average load which they took from the supply line was $77,000 \div 153,400 = 0.5$ nearly, or 50 per cent of their total rated capacity. Here again the figures given for the consumption of energy include all motor losses.

Still different conditions and results are presented by a third case, which was that of large mills engaged in weaving cotton cloth. In this case the motor equipment of the mills included 27 machines that ranged from 5 to 300 horse-power capacity each and had a total rating of 3,412 horse-power. This capacity was made up of induction motors for all except 200 horse-power in the synchronous type. During 273 hours of mill operation, this being the regular working time in a certain month, these motors absorbed 833,469 electric horse-power hours from the supply line. If all of the motors had operated continuously at full load during the 273 hours under consideration, they would have done $273 \times 3,412 = 931,476$ horse-power hours of work. As the actual consumption of energy reached only 833,469 horse-power hours in this time, it follows that the average power drawn from the supply system was only $833,469 \div 931,476 = 0.89$, or 89 per cent of the total motor rating, all losses included.

These three illustrations are taken from plants that were operating under normal conditions, and evidently cover quite a range of practice. The print works may be taken to represent approximately a large class of plants in which the demand for power is very intermittent, and in such cases it seems that the consumption of energy may drop to about one-third of what it would be if the motors were fully loaded during the hours of operation. In machine shops the rate at which energy is drawn from the supply line may be approximately equal to one-half of the rated power of the motors employed. As might be expected from the constant nature of the work, motors employed in weaving cotton cloth show an average power consumption well up toward their normal rating, in the above case 89 per cent.

If the average powers actually delivered by the motors in the above cases had been considered, their percentages of the motor capacities would have been smaller than those found above because there is a loss of energy in the motors themselves. The percentages as found, however, are what the prospective user of electric power most wants to know, because they approximately represent the ratios of his average consumption of power to the rating of the motors in use. In this connection it is well to have in mind certain facts relative to the rates usually charged for electric supply, and their relation to the net service which the customer actually gets. Lighting rates are usually made for electric energy delivered on the premises of consumers at a voltage suitable for the operation of lamps. Thus if the consumer uses 110-volt, 16-candle-power lamps that take 50 watts each, he can operate twenty of these lamps one hour for each kilowatt-hour of energy that he buys, because $50 \times 20 = 1,000$ watts. This takes no account of losses in the wiring of buildings which should not usually be more than 1 or 2 per cent. When it comes to electric heating the current from the supply lines will probably still be delivered at about 110 volts, and if the heaters are designed for a lower voltage the consumer may have to provide his own transformer. As there will probably be a loss of at least 5 per cent in the transformer, the heaters will get 3,438 heat units less about 5 per cent for each kilowatt-hour that is paid for. Electric motors are rated according to the power they deliver, not the power they absorb, so that an electric horse-power-hour of energy from the supply line cannot yield a horse-power hour of mechanical work. At full loads the efficiencies of good motors, both direct-current and induction types, range from approximately 75 per cent in the one horse-power to 92 per cent in the 100 horse-power size.

At partial loads efficiencies drop, but a mixed lot of motors, among which are some operating at one-half load, should have an efficiency of as much as 80 per cent. On this basis one horse-power-hour drawn from the supply line would yield 0.8 of a brake horse-power during one hour, or one kilowatt-hour from the line would yield 1.07 horse-power-hours, since the horse-power is 0.746 of the kilowatt.

A result of this motor loss is to make the cost per brake horse-power greater than the cost per electric horse-power from the line. Thus, if the motor efficiency is 80 per cent and the rate paid is two cents per electric horse-power-hour, or $60 per working year of 3,000 hours, the cost per brake horse-power is 2.5 cents per hour, or $75 yearly.

SCIENCE NOTES.

The Slaby-Arco-Braun system of wireless telegraphy is in use across Lake Baikal.

A new molybdenum compound has been discovered by Prof. Moissan. It is obtained by heating charcoal with melted molybdenum and aluminium in the electric furnace. The resultant metallic mass is treated with a concentrated solution of potash, says the Engineering and Mining Journal, and well-defined needle-shaped crystals of the new compound are obtained. The substitution is very hard, and resists all acids but nitric. It is not decomposed by water or steam at a temperature below 600 deg. C. It resembles tungsten carbide. It is hoped that the new compound may be useful in making molybdenum steels.

For some time past the scientific cultivation of the potato, i. e., the selection of the best and most fecund varieties for seed, has been in progress in Great Britain, and this year the experiment has been attended with highly successful results. One farmer, who has been engaged in several trials with new species, has this year lifted a tuber weighing 4½ pounds, while another has obtained a specimen of another variety weighing 4 pounds, 7 ounces. One farmer who planted 12 pounds of seed of a special variety has gathered in a crop of over 750 pounds. Investigations are now being carried out to obtain a "disease-proof" potato, as the predominance of disease wreaks considerable havoc among the crops, and is responsible for a heavy percentage of waste.

With reference to the suggestion advanced by the Hon. C. A. Parsons at the recent British Association meeting, that deep borings should be made into the earth's crust for the purposes of investigation of the earth's interior, and that a shaft such as this might be sunk to a depth of 12 miles, another scientist has pointed out that the pressure of the rock at such a depth represents some 40 tons per square inch and would render the task impossible, owing to the inward viscous flow of the rock material. In reply the Hon. C. A. Parsons suggests an experiment to solve the problem. He points out that the crushing stress required to make hardened steel flow lies between 120 and 300 tons to the square inch, while for tough brass or cartridge metal the flow is at about 80 tons per square inch pressure. His experiment would be to take a column of granite or quartz rock and carefully fit it into a steel mold. A small hole would then be bored through its center, and a pressure of 100 tons per square inch then applied, to observe what shrinkage would result. Such a pressure as this would correspond to that encountered at a depth of 38 miles.

The climate of Manchuria plays an important rôle in the war between Russia and Japan. Up to the present, we have had but little precise information upon this point. M. J. Ross has lately given some indications as to the climate of that region, and the character of the different seasons. He states that in the months of March and April there are strong southwest winds which bring with them heat and moisture. At the end of March the winter season ends. The under-soil is still frozen at this time, but the ground can be worked for agriculture. April appears to be the only month of spring. At the end of this month the sowing of wheat commences. Summer begins in May, and at the end of June or the beginning of July the wheat is cut. Up to the end of June rain is rare and the sky is generally clear, while cloudy weather is an exception. The heat reaches a maximum at the end of July and first part of August. Afterward come heavy rains or storms. It often rains for several days and nights without stopping. The soil is completely saturated and inundations are frequent. September is the harvest month, while October gives some of the finest weather of the year. At this time the heat is agreeable during the day and the sky is clear, with bracing air, while vegetation is at its height. At the end of the month the first night frosts begin to appear, and in November the cold weather commences and keeps up until March. At Mukden, the temperature sometimes goes down as low as —33 deg. C. During the day, however, the cold is not excessive, and sometimes in the middle of winter the sun's rays become very warm, on account of the southerly position of that locality. The maximum temperature of summer is 98.6 or 100.4 deg. F. About ten months of the year are dry for the most part, and the excessive wet season only occurs during a month or so. At Niutschwang, on the north shore of the Gulf of Liao-tung, the mean winter temperature is 16 deg. F., and the mean for the summer, 74.8 deg. The mean annual temperature is 47.1 deg. F. The Russian maritime provinces have a very low mean annual temperature. Thus at Vladivostock the average for the winter is 10.2 deg. F., and for the summer it is only 39.9 deg. F.