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THE END OF THE CENTURY STEAM ENGINE.

As the nineteenth century draws to a close the pen of the writer runs naturally to retrospection and comparison, and the astonishing advance which has been made in every sphere of human activity is being recorded in terms which can hardly err on the side of over-statement. Professor R. H. Thurston has recently enriched the steam engineering literature of the country by a characteristically elaborate and valuable paper, read at the last session of the American Society of Mechanical Engineers, on the steam engine at the end of the nineteenth century, in which are given the results of a careful test of a steam pumping engine of exceptional efficiency. By way of introduction, the speaker explained that the official trial of this engine exhibited such an unusually close approximation in efficiency to the Carnot cycle that arrangements were made for a scientific study of the machine as a thermodynamic engine, the tests being conducted as a part of the scientific work of the Department of Experimental Engineering of Sibley College.

It was in the first quarter of the present century that Carnot, a lieutenant of the French army, laid down the theorems of a perfect steam engine, the fundamental principle of which may be stated as follows: All heat received by the engine should be absorbed at the maximum temperature of the cycle; all heat rejected should be discharged at the minimum temperature of the cycle. The ideal Carnot elementary cycle is described by Prof. Thurston as one in which the work produced is the difference between that of expansion at constant maximum temperature and that of compression at minimum, constant, temperature; the work of compression with increasing temperature and that of expansion with decreasing temperature being means of adiabatically changing temperature between the limits of the cycle. Whether the alteration of temperature is affected by such temporary storage of energy in favor of either heat or of work, whether in a fly-wheel or in a regenerator, is unimportant, provided that all which is stored in the process of reduction of temperature is restored, by precise reversion of action, in the process of elevation of temperature.

On the question of return of heat to the boiler, the ideal feed-water heater is stated to be one which, taking heat from the expansion side of the cycle, restores it, at its own maintained temperature level, on the compression side, in such manner as to imitate, in a way and to a maximum extent, the "regenerator action," which is the ideal equivalent, economically, of the balanced expansion and compression energy transfers of the Carnot cycle. The problem is succinctly stated as follows: Could a way be found of taking out all the needed heat from the steam, between initial and back pressures, after the point of cut-off is reached, and of restoring it all, at unchanged temperature level, at the completion of the return stroke of the piston, equivalency with the Carnot cycle would be complete.

The wastes of our best engines to-day are usually not far from 20 per cent thermal and 10 per cent dynamic; whereas at the beginning of the century they were in Watt's best engines about 60 per cent thermal and 15 to 20 per cent dynamic. While the progress of the century has been mainly in the reduction of internal thermal wastes, the progress of to-day is mainly in the improvement of the thermodynamic efficiency by increasing the range of temperatures worked through, and by improving the cycle in the direction of approximation more nearly to Carnot's ideal. The outcome at the end of the century is a duty of about 160,000,000 foot-pounds per pound of pure carbon burned in the furnace of the best form of contemporary steam boiler.

The tests were carried out on a Nordberg four-cylinder, quadruple-expansion pumping engine, operating under 200 pounds steam pressure, and under a head of about 600 feet between well and reservoir, the capacity being 6,000,000 gallons per 24 hours. The efficiency measured against the perfect engine of Carnot was 84 per cent and the duty measured on a basis of 1,000,000 British thermal units was 163,000,000 foot-pounds. A comparison of these results with those obtained from other types of steam engines shows a steady and gratifying advance. Thus, a simple Corliss engine showed a duty of 93,000,000 foot-pounds per million B. T. U. supplied the engine. Compound engines show from 120 to 133,000,000 foot-pounds; triple-expansion engines, from 137 to 150,000,000 foot-pounds; while the quadruple engine under discussion has the record credit of 163,000,000 foot-pounds per million B. T. U.

A final summary of the limits of progress attained in the steam engine to date, in addition to the figures quoted, shows an economy, measured in B. T. U. per hour per horse power, of 11,160; an economy measured in B. T. U. per horse power per minute of 186; an economy in pounds of steam at 1,000 B. T. U. per hour of 11·16; and an economy of best fuel, 15,000 per pound; boiler at 80 per cent efficiency, pounds per hour of 1. The close of the century, therefore, in the opinion of the lecturer, finds the steam engine, though threatened in the view of many writers with displacement by other motors, the great motor of the age. Moreover, it has been so far perfected, and the practical limits of pressure are coming to be so nearly approached by steam boiler constructors and users, that but little more can be expected of the designer.

THE AMERICAN BRIDGE.

It is a distinct tribute to the originality of the American engineer and mechanic that so many of the forms of construction which are common to the world at large should have, when made in this country, such strong individual characteristics that they are best described by the mere prefixing of the national name. The American locomotive, the American car, the American bridge, the American buggy, the American machine-tool, are a few of the objects upon which we have stamped the national impress so deeply that they are far more strongly differentiated from similar objects, as made in Europe, than the various European types are from one another. Thus, to apply this statement to the subject of the present article, a French bridge, as far as any distinctive characteristics in its design and construction are concerned, might have been built in England, Germany, or Russia; but a European engineer coming to this country and examining a typical pin-connected truss bridge would know at once that its proportions were not determined or its parts fashioned in any European draughting office or bridge works.

The most elementary form of bridge, as represented by the plate girder, did not in the early days of American bridge building receive the attention which was bestowed upon it in Europe, where it was employed in spans of much greater length than in this country. The cause probably lay in the superior facilities for the manufacture of iron and steel plates afforded by the mills and shops of the older countries. To-day, however, we are building plate girders of over 100 feet in length, and our work in this direction is well abreast of that of the rest of the world in quality and superior to it in economy of manufacture.

For spans of much over 100 feet it becomes necessary to abandon the plate girder, economy demanding that the material of the solid plate web be concentrated in vertical and diagonal members by which the stresses will be constrained to travel back and forth between the flanges on their way to the abutments. Now it is just here, in determining the number, shapes, length, and inclination of these web members and the method of their connections, that the American truss has drawn so far away from the European type. The latter, modeled with characteristic conservatism after the plate girder, is shallow in proportion to its length, and has its material massed in heavy chords answering to the flanges of the plate girder. The web is often made up of numerous flat diagonal bars, with multiple intersections, and is known as the lattice web, which is practically a double plate web lightened by the removal of surplus material. Such a bridge with its riveted connections is costly both in material and labor, nor can its strains be calculated with the exactness which is obtainable in the type of bridge which has been evolved in this country.

When it came to designing bridges of greater length than was desirable in the form of the plate girder, American engineers, after preliminary trials of an astonishingly wide variety of types, settled down to the pin-connected truss with great depth between the chords and great width of panel. The proportions adopted were entirely scientific and represented the arrangement of metal which would give the greatest carrying capacity for the least amount of structural material. The result, as compared with the typical riveted, multiple-intersection European bridge with its ratio of depth to length of 1 to 10, was a wonderfully light, skeleton structure with a ratio of depth to length of 1 to 6, whose web material was concentrated in a few vertical posts and diagonal bars which intersected nowhere except where they met at the top and bottom chords. The substitution of the pin for rivets at the connections contributed to accuracy, facility and cheapness of construction, and of erection at the site, and enabled our engineers to put up bridges at a low cost which could not be approached by European builders. Indisputable proof of our position was given at the close of the last decade, when in a world-wide competition the contract for the great Hawkesbury Bridge in Australia was awarded to an American firm.

For spans of over 500 or 600 feet the truss is superseded by the cantilever and the braced arch. While we have erected some notable bridges of the former type, they are of course surpassed in dimensions by the huge cantilevers of the Forth Bridge with their two main spans of 1,710 feet each; although plans have been drawn for a 2,000-foot cantilever across the Hudson River at New York, which embodies the characteristic features of standard American bridge work, and would be relatively a less costly structure than the structure at the Firth of Forth. In the development of the braced arch, however, we hold the leading position, the 840-foot bridge across the Niagara Gorge being by far the largest structure of this type in existence. In this connection it should in justice to European practice be admitted that in the design of our later long-span bridges there is noticeable a tendency to reduce the extreme depth between chords, and shorten the panel width, using riveting connections more freely than in the strictly typical American construction.

It is in the design of the longest bridges, of 1500 feet span and over, that America has made its most important contribution to the art of bridge-building. The American wire-cable suspension bridge, with stiffening truss, is incomparably the most economical type, and the easiest to erect where great distances have to be bridged in a single span. Its fitness is due to the fact that its main members are subjected to purely tensile strains, and therefore require no bracing to preserve their integrity, whereas in all other systems, whether of the truss, the cantilever or the arch type, the main members must be reinforced by a mass of bracing which adds enormously to the weight and cost of the structure. The suspension cables may be assembled in the form of innumerable small wires with a tensile strength of 200,000 pounds to the inch, which is by far the strongest form into which structural steel can be fabricated. The difficulty of deformation under moving loads may be absolutely eliminated by the provision of deep stiffening girders of the kind that are to be carried by the new East River Bridge.

For a fuller study of this subject, reference is made to an illustrated lecture on Long-Span Bridges, by Prof. Burr, of Columbia College, which, commencing in the current issue of the SUPPLEMENT, will run through three successive numbers, and contain views and diagrams of the most noted long-span bridges in Europe and America.

PRE-COLUMBIAN REMAINS IN MASSACHUSETTS.

The evidences that Northmen were in Massachusetts in pre-Columbian days are derived from two sources—geography and archæology. The archæological evidence is obtained by comparing certain ruins of Massachusetts with ruins of the Saga time in Iceland, and also with the native and early European ruins on the coast of North America. The geographical evidence is found by comparing the descriptions of the country called "Vinland," in Icelandic literature, with the coast of North America. A most interesting paper on this subject was read before the Viking Club, of London, and also before the Section of Anthropology of the American Association for the Advancement of Science at the Boston meeting by Professor Horsford. Appleton's Popular Science Monthly publishes this paper, with elaborate illustrations and diagrams, in the December number, and from this source we derive our information.

The geographical data for the paper are taken from the three oldest manuscript versions of the Story of Vinland. The author then takes the descriptions given in the Icelandic texts and compares the various localities from Labrador down. Cape Cod seems to be the only cape north of Sandy Hook which corresponds with the description in the Saga, and near here we should look for Vinland. In the "Flat Island Book" it is stated the Lief Erikson's party "came to a certain island which lay north of the land." That Lief Erikson should have thought that Cape Cod was an island is excusable, because it is impossible from the Cape to see the southern shore of Massachusetts Bay, twenty miles away. The chronicle afterward says: "They sailed into that sound which lay between the island and the promontory which jutted northward from the land; they steered in west past the promontory. There was much shallow water at ebb tide, and then their ships stood up, and then it was far to look to the sea from their ship." The author of the paper then compares various localities on the New England coast which match this description. If the coast of North America should repeat the same geographical features, it would be obviously impossible to determine the site of Vinland by geography alone.

At Boston we find in the Charles River and Boston Back Bay, a river flowing through a lake into the sea, where great shallows at its mouth are a conspicuous feature, and it is "far to look to the ocean." Here then at Cambridge we can look for pre-Columbian remains. The battle with the natives is then described, which also seems to confirm the supposition that the site was near Boston. When Prof. Horsford first visited the site which his study of maps and literature had led him to believe that this locality was Vinland, he found a few hollows in the hillside and also some broad, low ridges on the level ground, indicating that a building about 66 feet long by 16 feet broad once stood there. No digging was done here until after Prof. Horsford's death, with the exception of a few trenches across the supposed site of Lief Erikson's house on the other side of the creek. In 1896, during a visit of Dr. Gudmundsson and Mr. Erlangsson, of Copenhagen and Iceland, extensive excavations were made, leaving practically nothing unexamined at this site. Three kinds of earth were revealed, black loam, yellow soil and finally clay and gravel. The ruins were at the junction of the two top layers. Throughout the black loam to the bottom were scattered fragments of china, glass, glazed pottery, pipe stems, broken bricks, etc., all belonging to the occupation of this region by the English. Two fireplaces were found, entirely unlike each other; one of these was an Indian clambake neatly paved and piled with ashes and unopened clamshells. The second was about four feet square and was surrounded by upright stones at the four corners, and it resembles the cooking fireplaces of the Icelanders. Although the outline of the walls can only be suggested, the few stones which were found at the base of the old walls were placed about five feet apart, as in the walls of the Saga-time. This, so far as it is known, is peculiar to that people and race. While this hut was being dug out, the attention of the explorers was called to stones protruding through the turf a short distance away and nearer to the water. When the earth was cleared away, it proved to be a rude, stone-laid pathway leading along the margin of the old creek to the river. Here at the landing place a similar pathway branched away in another direction, stopping suddenly near the supposed house of Thorfinn Karsefni. This pathway is called in Iceland a "path to the sea." It has a wide margin of pebbles on one side and small heaps of stone on the other. This point of land is believed to be the only one on the coast of North America which has been found to correspond with the description of the site of Thorfinn Karsefni's house. Ruins have been dug out which bear peculiar features characteristic of the period in Iceland known as the Saga-time and differing in certain essential features from the handiwork of all the native races of North America, and, as far as is known at present, from all other races in Europe or in America in post-Columbian days.

THE RECENT WELSBACH DECISION.

On the 7th instant an opinion by Judge Shipman was handed down by the United States Circuit Court of Appeals for the Second Circuit, affirming an order of the Circuit Court granting an injunction *pendente lite* against the American Incandescent Lamp Company in an action brought by the Welsbach Light Company under the Rawson patent, No. 407,963, which covers the process of coating the well known incandescent gas mantles with paraffine or other suitable material to protect them from breakage in packing or handling.

This opinion is of more than ordinary interest, since it establishes, for this circuit at least, the doctrine that in an infringement action where the invention covered by the patent was made in a foreign country, the patentee, to avoid the effect of prior use in this country, may, under certain circumstances, carry his invention back to the actual date of invention abroad. In this case the inventors filed an application for a British patent September 1, 1886, which was published July 23, 1887. The application for the patent in suit was filed in this country on August 21, 1888, and the defendant's contention was that the patent was void because Welsbach (the original inventor of the lamp) had used the Rawson process in this country prior to the date on which the British patent was published.

After reciting the facts, Judge Shipman says:

"This question arises: Can an infringer defeat letters patent of the United States to an original inventor in a foreign country by proof that a few days before the date of a prior foreign patent to the same inventor, but not before the date of the application for such patent, and less than two years before the date of the application for a United States patent, the invention was used in this country by a person who did not invent it?

"It is contended by the defendant that under Section 4886 of the Revised Statutes the Rawson patent was void, on the ground that the improvement was known and used in this country before the invention thereof, because the actual inventor is not permitted to show that the date of his invention was prior to the date of his foreign patent. . . . We are of the opinion that the language of the section refers to the actual and not an artificial date, and that where there is no contest between inventors, if knowledge in this country did not precede the actual date of the invention, unless it had been used in this country for two years before the application, the inventor was entitled to a patent. . . .

"Our conclusion is that as against an infringer the patentee in a United States patent for an invention previously made by him and patented in a foreign country may, to avoid alleged use in this country by an infringer before the date of the foreign patent, show the date of the application for the foreign patent, for the purpose of showing the actual date of his invention in a foreign country."

This summary of the Court's conclusion apparently limits the application of the decision to cases where the prior use in this country is relied upon to defeat the patent, used by an infringer, but it would seem that in this case Welsbach was called an "infringer" only because it was not affirmatively and conclusively proved that he was an original inventor of the method.

THE POLLOK LIFE-SAVING PRIZE.

A decree arranging for the international competition for the best life-saving devices in cases of disaster at sea was signed December 9 by the Commissioner-General of the Paris Exposition, M. Picard, and Ferdinand W. Peck, United States Commissioner-General. The first article provides for the opening of the competition for the best life-saving apparatus or devices for use in cases of disaster at sea. The competition will also include devices designed to save life by preventing vessels from sinking at sea as the result of collisions. All the competitors must be exhibitors in the proper class, which is "equipment for the merchant marine." It is also necessary to make a special application for participation in the competition, which application is to be addressed to the Commissioner of the country to which the competitor belongs. This must be filed before March 1, 1900. The devices may be exhibited, or working models of the same or drawings on a reduced scale will also be accepted. The competitors must explain their exhibits by full and detailed descriptions of the construction and methods employed, the dimensions and names of the parts, their weight, cost of experiments, etc. The prizes will be 100,000 francs ($20,000). The competition will be judged by an international jury, according to the rules set forth in the regulations of the Exposition. The jury will have the right to require a trial and tests, and will furnish facilities for this purpose, but all expenses connected with the trial and testing of the apparatus will have to be borne by the competitors themselves. The jury will take into consideration the value of the devices as preservers of life, not only when once in the water, but also in the case of appliances which depend upon the aid of others than those rescued, such as boats, rafts, etc. Special attention will be paid to the facilities for carrying the devices upon the vessel, their seaworthiness, durability, cost, ease of maintenance, etc. The jury may award the entire amount to one person, if they deem it of sufficient value, or the prize may be split up among two or more inventors as the jury may think best. If none of the devices presented shall be deemed by the jury of sufficient merit to justify the award of the prize, the jury may reject all, but may reimburse any competitor they deem proper. The decision of the jury will be made known to the Secretary of State of each country, and this official will attend to the payment of the sums of award by the jury. The regulations will be distributed through the Commissioners-General.

REPORT OF THE WEATHER BUREAU.

The annual report by Willis L. Moore, Chief of the Weather Bureau of the Department of Agriculture, is always filled with interesting particulars regarding the work carried on by this important branch of the government service.

The closing months of 1898 were specially stormy on the Great Lakes and the New England coast. The most severe storm in the memory of the living swept along the Massachusetts coast, November 26 and 27, causing a loss of at least 200 lives and many vessels. This appaling loss of life was mainly due to the foundering of the "Portland," which entailed the death of 150 persons. The captain of this vessel left Boston Harbor at the regular time, as he had been in the habit of doing for years, although storm signals had been flying since eleven o'clock in the morning, and marine interests had been completely notified of the coming storm. The disasters of this storm will not be soon forgotten, and the memory of it gives emphasis to the fact that the warnings of the Weather Bureau should be implicitly heeded by all mariners, for had attention been given to the danger signals, the "Portland" would be afloat to-day. The extension of the usual time limit of night forecasts from thirty-six to forty-eight hours has marked an important change in the forecast work of the Bureau. The forecast officials were directed that beginning March 1, 1899, the period covered by night forecasts should be increased to forty-eight hours. The success already attained has fully justified the issuance of the order. The new stations in the West Indian region gave important news of the great hurricane of September 10. The warnings were of the utmost value, and saved vast quantities of life and property. The Weather Bureau work on the Great Lakes has also been most successful during the year, and the storm signals kept many vessels in port and prevented many casualties and large loss of property. The success which has attended the issuance of the frost warnings during the year has also been marked, and have proved very useful to farmers, orchardists and gardeners. Among the most important cautions issued by the Weather Bureau are those which give notice to agricultural and commercial interests of the approach of abnormally low temperatures. Warnings of this class have been particularly successful during the past year, and a not unimportant feature of the advices has been the estimates of the probable continuation of this injuriously low temperature. The recognized accuracy of the temperature forecasts has caused them to be closely watched by various interests, and in the commercial centers owners of perishable goods are almost absolutely controlled by advices received by the Weather Bureau; and the special reports and newspaper comments give unquestionable evidence that the warnings prompted protective measures whereby crops, live stock, perishable goods and merchandise of the value of hundreds of thousands of dollars were saved. One warning which was issued to the truck growers in the South fifteen hours in advance of a cold wave saved $500,000.

The river and flood service did not develop any features of special interest during the year. The West Indian service is now in good running order, and the natural conservatism of the inhabitants of the several islands in the West Indies and the Spanish Main has at last been broken down, and people are beginning to realize that the warnings are of the utmost value. Many expressions of thanks and gratification have been received from the local government officials and citizens for the inauguration of the service in the West Indies, the expense of which is borne by the United States government.

A convention of Weather Bureau officials was held at Omaha, Nebraska, October, 1898, and the discussions covered a wide range of subjects, all of which had an important bearing upon the practical work of the Bureau. The exchange of views and the discussion of methods indulged in, were mutually helpful and stimulating. The convention was attended by eighty-three delegates, and a complete report containing all the papers and discussions was printed and extensively circulated. The personnel of the Bureau is kept up to its former high level and the discipline in the Bureau is admirable.

The number of deaths by lightning stroke in the calendar year 1898 was 367, and the number of injuries 494. Nine hundred and sixty-six barns, sheds, etc., 735 dwellings, stores, etc.; 95 churches and schools and 70 other buildings were struck and damaged by lightning, the approximate loss being $1,500,000. Of the buildings struck, 40 were provided with lightning rods; 855 were unprotected, and in 952 cases it could not be ascertained whether the buildings were provided with lightning rods or not. The value of stock reported killed was $48,257, and 964 head of cattle were killed.

At the close of the last fiscal year 17 kite stations were in operation, and 249 ascensions had been made, in each of which the elevation attained exceeded 1,000 feet. The work was continued until about the middle of November, 1898, at which time 1217 ascensions of 1,000 feet and over had been made. There is a steady increase in the number and excellence of meteorological papers offered for publication in the Monthly Weather Review, which is admirably edited by Professor Cleveland Abbe.

THE PROPOSED TUNNEL UNDER THE STRAITS OF GIBRALTAR.

We are in receipt of a pamphlet describing the project of M. Jean Berlier, C.E., of Paris, for an intercontinental tunnel under the Straits of Gibraltar, making a connection with the railways of Morocco. The plan is a most interesting one, although in our estimation the great cost of the same, which would be not less than $25,000,000, would hardly seem to warrant the expenditure. The amount of traffic between Spain and Morocco would necessarily be rather small at first. Africa is at present the seat of many of the most important engineering enterprises of the day, and there is no doubt that it has a great future in store for it. Morocco is an ideal winter resort, and doubtless, if it could be easily reached, would prove a competitor of Algiers or even Egypt. The building of a new tunnel and railway line would undoubtedly largely develop the French colonies. The tunnel is to have its northern terminal at Baqueros, Spain, on the Cadiz-Malaga line, to the westward of Gibraltar. The southern terminus would be at Tangier, which lies very near the west coast of Africa. The tunnel proper would be twenty miles long and the approaches would add over five miles more to the length. The pamphlet is accompanied by elaborate maps and profiles showing that the tunnel is perfectly possible from an engineering point of view. The scheme is an interesting one and should awake considerable discussion.