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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 re-