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RETROSPECT OF THE YEAR 1900.

If it be tried by the test of the number and intrinsic value of the scientific discoveries and mechanical achievements that have been recorded during the past twelve months, the year which has just drawn to a close must be written down as one of the least conspicuous in the last and most brilliant decade of a notable century. Not since we commenced to give our annual review has there occurred a year so barren of sensational developments either in "art, science, mechanics, chemistry or manufactures;" for even in regard to the last named, it must be admitted that our phenomenal prosperity is merely the steady setting of a flood tide, which was running in full volume when last we heard the bells ring out the old, ring in the new.

THE TWELFTH CENSUS.

Among the many evidences of our growth and prosperity furnished by the record of the year, none is more significant than the figures of the twelfth census, which show that the population has grown from 63,069,756 souls in 1890 to 76,295,220 in 1900, a gain of 13,225,465 or 21 per cent in a single decade.

OUR EXPORTS.

The invasion of foreign markets by American exports, which was such a marked feature in the commercial record of the year 1899, has been carried on with increasing vigor during the past twelve months. Gratifying as was the total volume of our export trade for that year, it has increased no less than 28 per cent during the past twelve months, the value of the total exports of manufactured articles for 1900 being \$433,851,756. A comparison of the beginning with the end of the century shows that whereas imports for home consumption into the United States for the year 1800 were \$52,131,891, at the close of the century they have grown to \$685,441,892, an increase of 1,215 per cent, while the total exports have risen from \$31,840,903 to \$1,293,931,222, an increase of 3,681 per cent. An examination of the details of our exports of manufactures shows that it is in manufacturing and exporting metals that we are chiefly distinguished. The history of nations proves that groups of people frequently excel greatly in certain specified industries, and the growth of our exportation, as well as of our domestic production of manufactures, seems to point to the fabrication of metals as being our most successful line of work, especially at the present time. In 1889, manufactures of metals formed less than 20 per cent of our total exports of manufactures, whereas in 1900 it is nearly 50 per cent. A most interesting fact developed by an examination of our export figures is that the European countries in which manufactures have long been established, furnish as satisfactory a market for our manufactured goods as do the countries where manufacture has not yet been largely developed.

EXPOSITIONS.

France has left its mark on the closing year of the century by an Exposition which was conceived on the broadest lines and carried out with characteristic splendor. The official statistics show that the Exposition was a success, fifty million persons having passed through its gates as against a total of slightly over twenty-five million in the Exposition of 1889. The largest attendance on any one day was 600,000, and the total cost is estimated to have been somewhere between \$40,000,000 and \$60,000,000. Out of a total of 75,531 exhibitors, 42,790 received awards. The United States obtained 1,981 awards, of which 220 were grand prizes, 486 gold medals and 583 silver medals. Of the foreign exhibitors from the leading nations, the United States were by far the most numerous, the total number being 6,674 as against 3,188 for Italy, 3,113 for Russia, 2,686 for Germany, and 1,688 exhibitors representing Great Britain.

In this country work has been prosecuted with commendable dispatch upon the Pan-American Exposition at Buffalo, the advanced state of the construction at the opening of the new year giving substantial promise that this original and highly artistic conception of the architect and landscape gardener will be fully completed by the time set for the formal opening.

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CIVIL ENGINEERING.

Undoubtedly the most important work in contemplation under the head of civil engineering is the proposed isthmian canal to connect the Atlantic and Pacific Oceans. During the year what is known as the President's Commission has completed its labors and presented a report in which it is unanimously recommended that the Nicaragua route be adopted, the scope of the whole scheme being enlarged to include a depth of 35 feet throughout, with duplicate locks, 740 feet, by 84 feet, by 35 feet in depth. The total cost has been raised from the original estimate by Menocal of somewhat over \$60,000,000 to a total of \$200,540,000.

The year has seen the opening of the Chicago Drainage Canal, 34 miles in length, by which the drainage of the city has been diverted from Lake Michigan to the Mississippi River, and the Chicago River has been transformed from a great open sewer to a stream of fresh running water. Another problem of far-reaching importance is the question of deepening and enlarging the Erie Canal. Early in the year Gov. Roosevelt strongly indorsed the recommendation of a special committee on canals of this State, that the system be enlarged to accommodate boats of 1,000 tons burden, and that the improvements be pushed to completion at a cost of \$62,000,000. Special interest attaches just now to this subject, because of the recent completion of the Soulanges Canal, which has been under construction for seven years and has cost \$5,200,000, an event which marks the completion of the last link in the chain of improvements by locks and canals of the St. Lawrence River on the Canadian side, the immediate result of which is that vessels 255 feet in length and of 12 to 14 feet draught and 2,200 tons capacity can now pass from the Lakes to Montreal.

Work upon the Croton dam has been prosecuted steadily and the structure is now well above the original bed of the river. The prospects are that by the close of next year this, the greatest dam of its kind under construction, will be completed. Another important scheme of the kind is the Wachusett dam for the supply of the city of Boston, which, while not so lofty or massive a structure as the Croton dam, will serve to impound a larger volume of water. The work of stripping the surface soil and digging the drainage for the dam foundation is now well under way. Work has been actively prosecuted during the year upon the great Nile dam and barrage, on which some 25,000 men are employed. The foundations are now laid, and the superstructure is growing rapidly to its designed level. These magnificent works will render possible the irrigation of a vast area of the fertile Egyptian valley which hitherto has of necessity lain idle. The great Simplon tunnel through the Alps is progressing as fast as men and plant can be crowded upon the work. The total penetration at the present time is about 20,000 feet, and about 12,000 feet of the tunnel has been fully completed.

The construction of the East River Suspension Bridge has made fair progress during the year. The anchorages have been completed, the two main towers have been carried to their full height, and the saddles placed in position ready for the cables, the preparatory work for the stringing of which is now under way. The construction of a third suspension bridge over the East River has been authorized and the plans drawn up. It will be of 1,500 feet span and will be erected near, and approximately parallel, to the Brooklyn Bridge.

The most notable bridge to be opened was the handsome Alexander Bridge at Paris, while in this country another magnificent bridge has been added to the many that span the Mississippi River. This is a steel railroad bridge of the typical American pin-connected type which forms the crossing of the Davenport, Rock Island, and Northwest Railroad. With its approaches it has a total length of 3,157 feet. Another important piece of bridge work was the reconstruction of the famous Kinzua Viaduct, one of the most lofty structures of its kind in the world. The new viaduct replaces an iron bridge erected in 1882. It has a length of 2,100 feet, and the base of the rail is 301 feet 6 inches above the normal level of the Kinzua Creek. Mention should also be made of the strengthening of the historical cantilever railroad bridge across the Niagara Gorge, which in the lapse of time had become inadequate to carry the increased loads of modern railroad traffic. During the summer the Secretary of War accepted the final plans for the proposed memorial bridge to be built across the Potomac at Washington. This truly magnificent structure, should it ever be built, will take rank as one of the finest efforts of the engineer-architect on record, and as a "tribute to patriotism" will worthily commemorate the men who have been distinguished in the foundation and development of the republic.

MECHANICAL ENGINEERING.

In the field of mechanical engineering, the subject which gives promise of attracting most attention in the immediate future, at least in the field of steam engineering, is the development of the steam turbine. Opinions may vary as to the value of its performance when installed in such boats as the "Turbina" and the "Viper," with which trial speeds of 32½ and 37 knots an hour were accomplished; but when it comes

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to be shown that there are turbines which under test have shown as low a consumption of steam as the best forms of multiple cylinder reciprocating engines, it must be admitted that our present standard type of steam engine has a most formidable rival in the field. In recent trials, the 500 horse power Parsons turbine, constructed by the Westinghouse Machine Company, developed at full load a steam economy of 16¼ pounds per electrical horse power per hour, and of 22 pounds per electrical horse power per hour at one-quarter load. The turbine has proved its special fitness as a direct-connected drive in electrical power and light stations, and it is possible that the present year will see it applied to passenger ships of 1,000 to 2,000 tons displacement.

A modification of the steam engine which excited considerable interest was that described in a paper by Prof. E. Josse at the Centennial Anniversary of the Royal Technical High School at Charlottenburg. This consisted in a process for increasing the efficiency of steam engines by utilizing the heat of the exhaust steam for evaporating a liquid having a lower boiling point than water. In the case of the engine described sulphurous acid was used; and the professor stated that a typical compound engine of modern construction which developed 34 indicated horse power under a steady load, showed with the sulphurous acid attachment an increase of 56 per cent in horse power for the same steam consumption, the steam consumption being reduced by the auxiliary attachment from 18.96 pounds to 12.13 pounds per indicated horse power. During the year the work of installing the 6,000 horse power engines and dynamos of the great power house of the Metropolitan Street Railway Company has been satisfactorily carried forward, while the Broadway cable line has been relaid entirely with 107-pound steel, and the necessary changes in the superstructure of both this and the Lexington Avenue line for the change of power from cable to underground trolley have been completed. Another mammoth power house, with an estimated capacity of 100,000 horse power, is being erected at Seventy-sixth Street and East River, for supplying current to the Manhattan elevated railways of this city. A trial train has been tested with good results, and it is expected by the close of the present year the whole of this system will be electrically equipped. The development of the gas engine, especially in the direction of larger sizes, and the practicability of utilizing furnace gases, is concentrating attention upon the possibilities of the gas engine as a direct rival of the steam engine and water power. A recent review of the comparative cost of the three systems has shown that the best results actually recorded for water, steam and gas power give for the first a cost of \$6.25 per hour per annum; for the second, \$20 per hour per annum; while in Germany, with gas engines using furnace gas, the lowest estimated cost is \$20, and in England, with the use of the producer gas, the lowest estimated cost is \$25 per hour per annum. The water turbine is to day the cheapest of our prime movers, except when the first cost of the hydraulic plant is heavy or the transmission line exceeds a certain length, when the difference in the relative cost of the three powers gradually disappears.

The water tube boiler in a variety of forms continues to demonstrate its superiority for certain classes of work, and although it may seem to have been something of a failure in the British navy, the result of the present searching inquiry which is being made by a special board will doubtless develop the fact that the failure has been more one of handling than of design or construction. The Scotch boiler still maintains its ascendancy in the merchant marine, and, where it is associated with heat at forced draught, it shows an economy of fuel which cannot be approached by the water tube type, as witnessed in the daily record of the Hamburg-American liner "Deutschland," where the consumption of fuel per indicated horse power per hour for the main engines has fallen to 1.33 pounds.

ELECTRICITY.

In the electrical world progress has been made chiefly along familiar and well established lines. Considerable advance has been made in telephony and telegraphy, and more particularly that branch of the latter which is associated with the name of Marconi and his fellow workers. Marconi's efforts have been directed more to synchronizing his messages and constructing a transmitter, the messages from which can be recorded only by the apparatus which has been tuned to receive them, and he appears to have successfully solved the problem. The Pollak-Virag rapid electric and photographic telephonic system is reported to have given phenomenal results, notably in a test between Berlin and Offen-Pest, when a message of 220 words was transmitted in nine seconds, the development of the sensitive paper requiring between 4 and 5 minutes. Another most important development is to be recorded in Dr. Pupin's system of long distance telephony, in which, by the introduction of inductance coils, it is possible to make an extraordinary increase in the distance over which telephonic messages may be sent. Dr. Pupin established the correctness of his theories by means of 250 miles of artificial lines arranged with

inductance coils. Another notable contribution to telegraphy is that of Donald Murray, an Australian inventor, whose high-speed page-printing telegraph has shown a capacity, with the Morse telegraphic key, of 50 words, and using the Phillips code, of 65 to 70 words per minute. The Paris Exposition served to introduce to the public the Poulsen telephone, in which magnetic pulsations are caused to act upon a steel wire, and the magnetization as thus effected is conversely caused to act upon the telephone receiver and to reproduce the original sounds.

During the year the work of utilizing the water power of the world has been proceeding apace. The 50,000 horse power plant at Niagara is being exactly duplicated by the construction of a second 50,000 horse power wheel-pit on the opposite side of the canal. There is nearing completion at Massena, N. Y., another of these vast hydraulic electrical enterprises. As much of this plant as will be completed next year will have a capacity of 37,500 horse power, and the extension which is immediately to be made will bring up the equipment to 75,000 horse power. Another great plant of the kind is that which is known as the Sault Power Canal, where a vast power house 1,400 feet long is being constructed, in which 60,000 horse power will be developed on 320 turbine wheels. In this connection mention should be made of the hydraulic system of air compression, which is nothing more or less than a modern development of the ancient Catalan furnace water blast. Several plants of the hydraulic-pneumatic type are in course of erection, in which air pressures will be developed of from 25 to 85 pounds per square inch, the depth of the shaft in one case being 203 feet and the diameter of the compression pipe 13 feet.

During the year some most important electrical traction schemes have been either commenced or completed. The most notable of these is a \$35,000,000 contract which was let early this year for the construction of 20 miles of subway and tunnel in this city. This is by far the largest contract of the kind ever undertaken, and when the work is completed, which will be in about four years' time, New York will possess the most perfect rapid-transit system in the world. The year has seen the opening of electrically-operated underground railways in London and Paris, both of which have thus far proved to be an unqualified success, while at the close of the year comes the announcement that the celebrated Metropolitan Underground Railway, of London, is at last abolishing its steam locomotives and substituting electric traction.

TRANSPORTATION.

So great has been the increase in the application of electricity that much that might have been said under the head of transportation has been anticipated under electrical traction. The steam railroad, of course, easily maintains, as it will long maintain, its position as the chief method of long distance transportation. The total length of our railroads is now 190,833 miles, an increase for the year of 3,981 miles. Great as were the locomotives and cars in 1899, they have increased in 1900, until the heaviest locomotive now weighs 125 tons and has a net hauling capacity on the level of 10 miles an hour of 7847 tons. The Paris Exposition brought before the public a certain number of "freak" locomotives, but on the whole the designs were of great merit and showed that the national types of locomotives are gradually approaching a common standard. Thanks to the Camden and Atlantic City trains, the credit of running the fastest trains in the world is still due to this country, although the French railroads have the greatest total number of long-distance fast expresses. The Camden-Atlantic City trains are run at a speed of 64.3 miles an hour. The fastest long distance train in the world is the Orleans and Midi train from Paris to Bordeaux, which covers a distance of 496¼ miles at a speed including six stops of 54.13 miles an hour. But little has been heard of the steam electric locomotives of French design, and it is likely that even less will be heard in the future. Experience during the year with the compressed-air cars which are being run on cross-town lines in this city has not been such as to give any emphatic promise of the extension of this system in the future, although we believe that the Hardie cars which are at present employed are giving fair satisfaction. Experiments are now being carried on with a superheated water motor of improved design, in which, instead of taking steam from the top of the hot water storage tank, hot water is taken from the bottom of the tank and expanded into steam in the cylinders. No records of the tests of this motor, which are being made on a New York suburban line, are yet available. A somewhat ambitious attempt to produce a satisfactory single-rail suspension railroad is the structure which has been built through the Wupper Valley between Barmen and Elberfeld, Germany. This is a double track elevated road, with cars suspended from electric trucks. The motors are of 36 horse power, and the maximum speed between stations is to be 25 miles an hour.

BICYCLE AND AUTOMOBILE.

There is evidence that the so-called bicycle craze is

over and that this most useful device has now taken its place as one of the regular means of transportation and as a source of healthful recreation when used with proper discretion. It has evidently reached its standard form as to general proportions and details, and we must look for novelties henceforth in the direction of the motor bicycle, which is probably destined to enjoy a fair measure of popular favor. The development of the automobile proceeds apace, the improvements being in the direction of reducing weight and giving increased rigidity where experience has shown it to be needed. Just now in this country the different varieties of steam-driven automobiles seem to be exciting more interest than any other type, although it is likely that the different forms of motors (electric, gas and steam) will each have their own particular sphere of work, the electrically-driven automobiles being popular for city and suburban use, and the gas and steam-driven machines for country use and extended touring. The efforts of the builders of electric automobiles are directed to the improvement of storage batteries in the way of reducing the weight and increasing the capacity; and the indications are that in the near future electric automobiles will be on the market which will have a capacity of from fifty to seventy-five miles at a single charge. The gas-driven machines have the advantage in radius of action over any others, while the makers of steam carriages are looking for a suitable condenser, which shall enable them to use the same charge for water continuously.

NAVAL.

The close of the year finds the United States navy occupying the same relative position among the navies of the world that it did twelve months before, and, indeed, if anything, our standing as the fourth in rank is somewhat strengthened. The settlement of the unfortunate armor-plate controversy has enabled the government to make contracts for the construction of no less than fourteen warships of the largest size in their respective classes, all of which have been illustrated in recent issues of this journal. Among these vessels are included the five battleships of the "Georgia" and "Rhode Island" classes, of 19 knots speed and 15,000 tons displacement. The six armored cruisers of the "California" and "Maryland" types are of about 14,000 tons displacement and 22 knots speed, and three protected cruisers of the "St. Louis" type are 9,700 tons displacement and 22 knots speed. All of these ships are to be armored with Krupp steel, and they will carry guns of the 45 and 50 caliber type which have recently been tested at Indian Head with such splendid results. During the year the "Albany," which was purchased during the war with Spain, has been completed and is now in commission, and the battleship "Kentucky" has also been commissioned, while several of the new torpedo boat destroyers have either been completed or are getting ready for their trials. The four new monitors and the six semi-protected 16½-knot cruisers are still under construction, and there is the same satisfaction in knowing the objectionable features inherent in vessels of both classes, in the way chiefly of their slow speed, are somewhat offset by the excellent quality of the armament which they will carry, the four monitors each mounting a pair of new 12 inch guns, which lately showed at the proving ground a muzzle capacity of about 48,000 foot-tons. In a general survey of the navies of the world perhaps the most striking fact is the great increase which is taking place in the speed of all classes of warships. Among the smaller vessels the "Viper" and the "Cobra," each propelled by Parsons turbines, stand first with an official record of 36½ knots per hour, the "Viper" having covered a mile at 37.1 knots per hour. Eighteen and 19 knots have come to be the accepted speeds for battleships, while 23 knots is the speed required in the modern armored cruisers. The protected cruiser seems to have fallen quite into disfavor, and all vessels of the cruiser class are now protected with a belt of armor at the waterline. In spite of the comparative failure of the "Belleville" boiler in the British navy, it is likely that the water tube boiler as such will be used exclusively on all future warships.

MERCHANT MARINE.

In the annals of the merchant marine the closing year of the century will be memorable for the truly splendid performance of the great liners which ply between the old and the new worlds. Whatever may be said of the folly, the cost and the risk of running at speeds of 22 to 24 knots per hour across the Atlantic, there is no question that the general public is deeply interested in such performances, and that the traveling public patronizes these fast vessels. The notable ship of the year has been the Hamburg-American liner "Deutschland," which commenced to make new records on her maiden trip and was the first to maintain a speed of 23 knots an hour from port to port. The fastest passage made by this vessel was an eastward trip from New York to Plymouth, the voyage being made at the rate of 5 days, 7 hours and 38 minutes, at an average speed of 23.36 knots an hour. The average indicated horse power of the whole trip was 36,913, and the consumption of coal including the auxiliaries of 145

per horse power per hour. Two fast steamships are building for the North German Lloyd Company, one slightly smaller than the "Deutschland," but designed to be about the same speed, and the other to be about 706 feet long and to have 38,000 horse power and a sustained sea speed of 23.5 knots. There is also good reason to believe that one of the English companies has also under consideration a pair of fast ships with which an attempt will be made to win back from the German companies the distinction of owning the fastest ships on the Atlantic. As distinct from these fast vessels there are being placed upon the Atlantic in increasing numbers ships of the "Pennsylvania," "Cymric," and "Ivernia" type, vessels of over 20,000 tons displacement, moderate speed, and large cargo and passenger capacity. There is no doubt that each type has its sphere of work and that neither type will become predominant to the exclusion of the other. Although the coastwise and lake shipping of the United States is enormously prosperous, there is no evidence as yet of any great revival in our deep-sea shipping, the cheaper cost of construction and operation of the foreign ships making it impossible for the United States to compete successfully in the deep-sea carrying trade. The Subsidy Bill now before Congress would seem to be an absolute necessity to assist our shipping interests (at least in the early years of its struggle) in regaining its former proud position.

AERONAUTICS.

The past year has been a notable one in many respects in the field of aeronautics, where interest has been greatly stimulated by the competition for the Henri Deutsch prize of \$20,000 which has been offered for the best dirigible balloon. At the present time three balloons of this type are receiving their finishing touches at Paris preparatory to entering the contest, one for M. De Santos-Dumont, another for M. Aime, and a third for M. Roze. The Santos-Dumont balloon consists of a cylinder below which is suspended a trussed frame which carries the motor, the propeller and the operator. That of Roze consists of two cylinders placed side by side in the same horizontal plane, with the operator's car suspended between them, the ascent and descent being controlled by vertical propellers operated from the motor that drives the horizontal propellers. Much has been heard during the year of the Danilevsky machine, which has been built under the auspices of the Russian government. It consists of a vertical cylindrical balloon below which is suspended a series of controlling planes and the steering and propelling mechanism. The inventor claims particular advantage in this type in respect of controlling the ascent and descent, particularly the latter. The greatest interest of the year attached naturally to the Broddnagian balloon of Count Zeppelin, which is 38 feet in diameter and has the enormous length of 416 feet. In the latest trials it was shown that in a breeze of moderate strength, the inventor is able to control the vast structure, rising, descending, and performing various aerial evolutions with apparent ease; but nothing was done, or has yet been done by any balloon, to show that it is possible to control an airship, whether of the balloon or aeroplane type, in every kind of weather, and propel it against the strongest winds. Progress in the field of aeronautics is slow; but when we keep in view the enormous difficulties of the problem, it is perhaps as fast as can reasonably be expected.

MISCELLANEOUS.

Limitations of space prevent any extended reference to many events of the year which are of distinct importance. Exploration, both Arctic and Antarctic, is being carried on or projected with a zeal and liberality which has never before been witnessed. Peary is still in the far North engaged in establishing his line of communications, from the extreme outposts of which, with a few chosen companions, he will make his final dash for the pole. The intrepid explorer had met Sverdrop, who has taken Nansen's ship, the "Fram," into the Arctic seas. The latter is supposed to be now wintering in Jones Sound, and it is supposed that Peary is wintering at Fort Conger. Letters have been received from Peary dated March 31, 1900, in which he stated that he was in good condition and that he would push on from Conger in the hope of accomplishing his task by last spring, and making his return during the past summer; these letters were written to Mrs. Peary, who has started to join her husband. Of the fate of Andr   nothing is known; the possibility of his return is now considered to be very slight. What is known as the Jesup North Pacific Expedition has started for the northeastern part of Asia for the exploration of the country north-east of Amoor River. An expedition has been planned which, under the direction of Herr Von Drygalski, will start at the end of August, 1901, for the magnetic and meteorological exploration of the Antarctic regions; and the steamer "Southern Cross," with Borchgrevink and the survivors of the southern polar expedition, returned during the year to New Zealand, with the important announcement that the magnetic pole had been located.