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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.

AN 18-000-TON BATTLESHIP.

Despite the storm of criticism with which it has been assailed, the large-displacement battleship continues to grow both in size and in favor. Proof of this is to be found in the huge 18,000-ton ships which are to form the most important feature of the new building programme of the British navy. In 1882, six battleships were included in the British naval construction estimates, each of 10,600 tons. In 1892, the displacement had risen to 14,150 tons, which was the size of the "Royal Sovereign" class. Then followed the "Majestic" class of 14,000 tons; the "Formidable" class of 15,000 tons, and the "King Edward" class of 16,350 tons; while to-day the designs for 18,000-ton battleships will soon be in the builders' hands. The policy of building battleships of large size is favored in our own navy, the "Connecticut" and "Louisiana" having a displacement of 16,000 tons.

In other respects than that of size, there is a tendency on the part of American and British designers to reach a common type, with certain clearly-marked characteristics. This is particularly noticeable in a comparison of the new 18,000-ton ships with our own 16,000-ton vessels; for it must be confessed that in these last ships the British designers have shown a desire to follow our lead in the make-up and disposition of the armament, as will be seen from the following description:

The main armament of the new ships will consist of four 12-inch guns, located in two barbette turrets, forward and aft, and eight 9.2-inch guns, mounted in four barbette turrets, one at each corner of a central citadel, within which will be carried ten 6-inch rapid-fire guns. This armament will be more powerful than that of the "King Edward" class by four 9.2-inch guns. As compared with the "Connecticut," it will be seen that the armament will be about the same in power; for while the eight 9.2-inch guns constitute a much more powerful battery than the eight 8-inch guns of the "Connecticut," this preponderance is largely offset by the fact that the "Connecticut" carries twelve 7-inch guns as against the ten 6-inch guns of the British vessel. The 8-inch gun is very popular with the officers of our navy, and it is amply sufficient for the attack of armor covering the secondary batteries of the latest foreign vessels. On the other hand, the 9.2-inch is a much more powerful piece; it throws a 380-pound projectile with a muzzle velocity of 2,900 feet per second, and a muzzle energy of 22,160 foot-tons. Our new naval 8-inch piece of 45 calibers throws a 250-pound shell with a velocity of 2,800 feet per second, and an energy at the muzzle of 13,602 foot-tons. The lower power of our piece would be compensated for somewhat by the greater rapidity with which it can be handled; on the other hand, the 9.2-inch gun can pierce any waterline armor afloat at ordinary fighting range. The total muzzle energy of a single round from the main batteries would be 409,552 foot-tons for the "Connecticut" and 417,680 tons for the 18,000-ton ships.

It is chiefly to the increase of its defensive qualities that the extra 2,000 tons displacement of the British ship has been devoted, the protection being of quite an exceptional nature. In addition to the protection of 9 inches of Krupp steel from stem to stern at the waterline, this 9-inch armor covers the whole side of the vessel to the upper deck, giving the equivalent of waterline protection to the whole of the 6-inch battery, the bases of the 9.2-inch and 12-inch gun barbettes, and to the ammunition hoists and the bases of the smokestacks. The whole of the personnel will therefore fight the ship from behind not less than 9 inches of Krupp steel. The speed of these huge vessels is to be 19 knots, and they will each cost $7,000,000 to build and equip.

THE NEW COKE INDUSTRY.

In the past quarter of a century coke has become one of the most important factors in our iron and steel manufacturing interests, and its value for other purposes where a smokeless fire is required has appreciably increased with its extended use. As a statistical factor it was of little more importance than charcoal prior to 1880; but in 1901 nearly 20,000,000 tons of coke were produced in this country. The present demand is even greater, and the production and consumption for the current statistical year will probably exceed anything heretofore noted in our industrial history.

The coke furnaces of the country have an estimated capacity of production for the current year of 25,000,000 tons, and if this sells at the average rate of $2.50 per ton, as it did in 1902, the total output will represent $62,500,000. But coke, like coal, has increased rapidly in value in the past few months, and to-day it is hard to get it at $3 and $4 per ton for furnace coke, and $5 to $12 for foundry coke. These abnormal prices, however, are not likely to continue long. The chief difficulty in the coke industry has been the shortage of railroad cars to move the material to the furnaces for manufacturing, and then delivering the finished product to the consumers. So greatly handicapped have the coke furnaces been in this respect, that nearly half a million tons of coke are held up in the yards for lack of transportation facilities.

Poor transportation facilities affect the coke makers more than almost any other class of manufacturers, for besides requiring cars to carry the finished product to the consumer, the raw materials must be brought to the furnaces over the same lines of traffic. The hauling of coke to the iron and steel mills must necessarily determine to a large extent the cost of smelting. This has in the past year been out of all proportion to the actual conditions which prevail in normal times.

The future requirements of coke can be partly measured by the unparalleled development of our iron and steel trade. It takes on an average about one ton of coke to make each ton of pig iron. In the last statistical year—that of 1901—the total pig-iron product of the country was 15,878,354 long tons. Not all of this, however, was smelted with coke. Some of it was made with anthracite coal, charcoal, bituminous coal, and charcoal and coke mixtures. But the excess of coke produced over pig iron represents to a large extent the actual demand for coke in other lines of work. The conditions of the iron and steel industries in this country at the beginning of the year were never so promising, with the exception of the high cost of coal and coke. While the maximum capacity of the pig-iron plants of the country for 1902 was about 350,000 tons per week, that of 1903 will be much greater, owing to the completion of some twenty-five new blast furnaces, with an estimated capacity of 2,500,000 tons of pig iron a year.

The demand for coke by the blast furnaces for the current year will consequently be much in excess of that of any other year, and to meet this consumption coke makers have made extraordinary additions to their plants. Up to the first of 1901 there were 64,000 coke ovens in this country, with a trifle over 5,000 in the course of construction. During 1902 about 15,000 new bee-hive coke ovens were built, and several thousand more planned for 1903. These new ovens averaged 600 tons each per annum, which would increase the output of coke some 9,000,000 tons.

The by-product coke ovens have in the past few years become important factors in the situation. These ovens are peculiarly arranged and built to use coals that are not suitable for the bee-hive oven. They have been designed recently so that they can coke coals which were formerly considered of no value for this purpose. In 1901 there were 1,165 of these by-product coke ovens, with a total capacity of nearly 1,180,000 tons; but in 1903 there will be some 3,500 of the by-product ovens in operation. This will enable the makers to nearly double their output. The by-product coke output is immeasurably smaller in this country than in any of the coke-making countries of Europe, the percentage being about 5 per cent here against 40 per cent in Germany, and 20 per cent in England. This is due to the fact that the quality of the coals found in this country is relatively higher than in Europe, and the need of such ovens has not been so urgent here. It is also due largely to the fact that the question of economy in fuel has always been studied more carefully in Europe than in the United States.

Coke has found entirely new fields of use in the electrical field in recent years. In the many electrochemical industries established by the harnessing of Niagara, coke is employed for building the electrical furnaces, and for fusing with the different materials in the furnaces. In the manufacture of carborundum coke forms an important part of the mixture, and it is also used for packing the walls of the furnace. The very highest grade of coke is demanded for these electrochemical industries, and some coke ovens make a specialty of supplying products just for them. These industries include the manufacture of such commercial articles as caustic soda, sodium, aluminium, artificial graphite, zinc, and manganese. The demand for the finest coke for these practically new industries is increasing so rapidly that a number of coke ovens have been established near the scene of manufacturing.

The development of the gas engine in the past year has its bearing on the coke industry. The modern blast furnace gas engine is a marvel of modern invention and ingenuity. It takes the gas from the furnaces and utilizes it for generating power for different purposes. This gas used in the modern gas engine performs nearly or quite double the work obtained from it when used for steam heating purposes. In time the gas engine in utilizing the blast furnace gases will make the profits of pig iron production more than doubly profitable. Indeed, it is believed by some that the blast furnaces may in time be erected primarily as great gas generators, and only secondarily for making pig iron

PROPOSED REPAIRS TO THE EAST RIVER BRIDGE CABLES.

The report of the Board of Engineers appointed last November to decide what repairs should be made to the cables of the Williamsburg Bridge, which were damaged by fire, has found that the annealing of the wires by the heat of the fire left one of the cables, known as cable A, 2.5 per cent weaker than it was before the fire, while cable B was weakened by 6.5 per cent of its original strength. They suggest a method of repairs or reinforcement which will restore cable A, so that it will be only one-quarter of 1 per cent weaker than it was before the fire, while cable B will only lose 2 per cent of its original strength.

Each cable contains thirty-seven strands, and each strand is made up of 208 wires, making a total of 7,696 wires in each cable. The specifications called for an ultimate strength of 200,000 pounds or more to the square inch, but this strength actually ran much higher, being from 8 to 10 per cent greater than the specifications called for, the ultimate strength being from 216,000 to 220,000 pounds to the square inch. The result of the heating of the wires was to anneal and also to lengthen them, the heated wires, after the fire was over, being more or less bowed out from their proper position and not lying parallel with the mass of the cable. The annealing resulting from the fire reduced the strength so greatly, that, in extreme cases, the strength amounted to only 80,000 pounds to the square inch, which was about the ultimate strength at which the wires are drawn in the mill. The heat annealed the wire more or less completely for a depth of four layers. Thus specimens cut from the outer layers showed that, while the uninjured wire had a strength of 223,800 pounds to the square inch, the most injured portions of the burnt wires showed a breaking strength of only 89,900 pounds to the square inch. The reduction of strength decreased in the second, third, and fourth layers, where it fell from 234,000 pounds to the square inch to 210,500 pounds to the square inch, which, by the way, is 10,500 pounds per square inch greater than the specifications called for. A count made of the injured wires shows that 500 have been affected in cable B and 200 in cable A. The injured wires on the top of the cables where they pass over the saddles will be cut out and replaced by new wires, which will be spliced by sleeve nuts to the uninjured ends.

As the injury has taken place at the bend of the cables over the saddles, where the strength should be the greatest, it has been decided, after the wires have been spliced, to add 25 additional wires to cable A, and 200 additional wires to cable B. As the ends of these wires cannot connect with any of the wires in the cables, these being spliced to their own new sections that will be put in, it has been decided to attach these additional wires to the cables by friction. A series of steel bands will be clamped around the cables, at varying distances from the saddle, to the adjoining suspenders on either side, and a certain number of additional wires will be attached to each clamp. There will be three bands on each side of the saddle on cable A and eleven on cable B. Thus twenty wires will run to the outermost band furthest from the saddle and adjoining the first suspender; then twenty wires will be attached to the next band; twenty to the next, etc. On cable B the first band will cover 200 wires, none of which will be fastened to it; the second band will cover 180 wires, twenty of which will be fastened to it, etc. Furthermore, it has been recommended that fireproof flooring be used throughout the whole length of the bridge. It is gratifying to learn that the injury to the cables of this magnificent structure is such that it can be entirely repaired, the bridge as repaired being indeed, because of the high quality of the steel, stronger in its cables than was called for by the contract.

A HARVARD GRANT FROM THE CARNEGIE INSTITUTION.

A grant has recently been made by the Carnegie Institution, for the study of the collection of photographs at the Harvard College Observatory. For many years, two photographic doublets of similar form have been in constant use, photographing the sky night after night. The aperture of each is eight inches, and the

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focal length about four feet. The first of these photographs was obtained with the Bache telescope in 1885, and since 1889 this instrument has been mounted in Peru, first near Chosica and later at the Arequipa Station of this Observatory, and employed mainly in the study of the southern stars. The 8-inch Draper telescope has, in the same way, been mounted in Cambridge, and used on the northern stars since 1889. About 30,000 eight by ten-inch photographs, each covering a region ten degrees square, have been obtained with each of these telescopes. Photographic charts have been made with these instruments, covering the entire sky on from one hundred to two hundred nights, and showing all stars brighter than about the twelfth magnitude, besides many that are fainter. During the last four years, this work has been supplemented by taking photographs with two anastigmat lenses having clear apertures of about one inch. Each photograph covers a region 30 degrees square, and in general shows stars of the eleventh magnitude and brighter. The number of times the entire sky is covered has thus been greatly increased. The amount of material thus collected has required a special building for its accommodation, and the means of the Observatory have so far permitted but a small part of the astronomical facts contained on the photographs to be gathered. The Henry Draper Memorial has enabled the most important results to be derived from the numerous photographs of the spectra of the stars, and the past history of many of the objects discovered here to be studied. When any object of interest is discovered, the photographs permit its brightness and position to be determined on one hundred or more nights, during the last twelve years, and many important facts not recorded at any other observatory are thus determined. By the aid of the grant mentioned above, a corps of assistants will be organized, whose duty will be the study of the photographs as regards any objects of special interest.

THE STEAM TURBINE.

BY H. M. GLEASON, ASSISTANT NAVAL CONSTRUCTOR, U. S. N.

The steam turbine, although old in principle, is comparatively young in its application to commercial power generators. Since Watt's development of the reciprocating engine, all inventive energy has been employed to perfect a form of power generator which is wrong in principle. If Watt had achieved as great success with a primitive form of rotary engine or steam turbine as he did with the reciprocating engine, it is safe to say that to-day we should have a highly perfected form of steam turbine, and the reciprocating engine would have been looked upon as one of the many queer inventions of the past.

So great has been the inventive genius of the age, that to-day we have a very efficient reciprocating engine, as efficient, perhaps, as this kind of engine will permit of; but who, with any idea of mechanical simplicity, can go into the engine room of any modern steamer without wondering at the ingenious complexity represented there?

To be sure, any machine should be designed for the use intended, and in this way the reciprocating engine is especially adapted for use on certain machines using power exerted in a straight line. The great majority of machines, however, require circular motion, and here the reciprocating engine is handicapped. It may be said, then, that the chief aim in power generation is to develop it along the line of circular motion. For this purpose, leaving other considerations aside, the steam turbine is eminently fitted.

The advantages of the steam turbine over the reciprocating engine are, in general, as follows:

1. The effort of the steam is applied directly without any intervening mechanisms for conversion of motion. This avoids their attendant friction, their costly fitting, and probable lost motion.

2. There being no reciprocating parts, there is no inertia to overcome at the beginning of the stroke, with the necessary consumption of energy required to accelerate them.

3. The absence of reciprocating parts makes it possible to run the shaft at vastly higher speeds than are attainable in a reciprocating engine.

4. The turbine engine becomes very compact from the absence of converting mechanism, and it consequently occupies very little room.

5. The engine has no dead center, but will start from rest in any position.

6. The engine has either no valve gearing, or that which it has is of the simplest character.

7. The simplicity of the engine and absence of expensive mechanism make it cheap to build and, therefore, it should be cheap to buy.

8. Very little skill is required to run the engine, and fewer engines are needed, and there is a consequent saving in the cost of handling.

9. The absence of reciprocating rods and dead-centers results in a construction in which the pressure of condensed steam in the engine does no harm. Water does not stop the engine from turning, it cannot endanger the engine casing. The engine can be started, even if under water, by simply opening the valve which admits pressure to the turbine blades; it will start with solid water as in the case of the water turbine.

10. Its incased construction and the above peculiarity adapt it for outdoor service and places exposed to low temperatures. Weather does it practically no harm, and its protection from outside injury makes it particularly serviceable in mining and stone quarrying.

11. The turbine is easily controlled; it is stopped by simply turning off the steam by means of an ordinary valve, and started again by turning on the valve.

The above advantages apply to its use in general, but for the propulsion of ships it has especial advantages:

1. The absence of vibrations, which are so troublesome in reciprocating engines. The study of vibrations in a reciprocating engine has called forth many valuable and scientific papers by engineers who have made this subject a special study. The necessity of the balancing of engines in ships need not be commented upon, for who has not suffered from it, even on the largest and best designed of our present-day passenger steamers. The continual shaking which the hulls and fittings of ships are subjected to is one great cause of their frequent need of repairs, some, it is true, of minor consequence, but the loss of time incurred in making these seemingly minor repairs results in an appreciable decrease in the vessel's earning capacity. And, when balanced at one speed, it does not follow that the same condition will follow at other speeds; in fact, it generally does not follow. With the turbine engine, all this loss of time and inconvenience is avoided.

2. The use of the turbine engine effects a great saving in weight of machinery. The question of weights on a ship is a very important one, and where a saving can be made in the propulsive machinery, a consequent gain can be effected in cargo or passenger accommodation, in the case of a merchant vessel, or, in the case of a warship, a gain in guns, armor or coal. The weight of machinery per I. H. P. in the case of the "Turbinia" is 21.3 pounds, while in the best designed modern vessels the average weight per I. H. P. is about 150 pounds. These figures show what advantages the turbine has in this connection. Where the weight problem is so vital, as in the case of a battleship, the use of turbines would mean a great gain in offensive or defensive qualities.

3. The perfect balancing of the turbine engine does away with increased weight in construction of engine bedding and hull fittings, which are necessary to withstand continual vibrations and strains.

4. The increase in stability gained by the use of the turbine is greatly due to the low position of the center of gravity of the engine. This is a very important feature in the turbine, as it enables vessels to carry heavy weights on the upper decks without endangering the stability of the vessel. In the case of a warship this would allow heavy guns and armor to occupy a position of greater elevation than is admissible now; and, in the case of a merchant ship, would enable her to go to sea in a light condition in greater safety. The turbine situated well down in the ship's body would be protected from injury in action without the necessity of armor decks, beyond protection from falling projectiles.

5. The lives of the engine-room crew are not endangered by intricate, fast-moving parts. It is not necessary to call to mind the marine disasters that have been caused by the breaking of a shaft and the consequent racing of the engines, resulting in completely wrecking the engine room and not infrequently injuring the hull seriously. From all this the turbine is free.

6. A much smaller engine-room force is required. This results in a great saving in running expenses, and, in the case of a warship, would enable more men to be carried to man the guns.

7. Last, but not least, of all, the turbine requires very little lubrication, resulting in a great saving of lubricating oil, which in a large vessel is no small item.

The best-known turbines to-day are the Parsons-Westinghouse, the DeLaval, and the Dow. All these different classes of turbines are designed to derive the maximum effect of the kinetic energy of steam under expansion, and this requires that the turbine shaft revolve at a very high speed. This makes the turbine specially adaptable for electric generators, and its use in this connection is becoming general.

For marine propulsion, a high speed of revolution of the propellers is not desirable beyond a certain limit, at which cavitation results. Thus, in some cases, it is necessary to reduce the speed by gearing down. The propellers of the "Turbinia," at a speed of 34½ knots per hour, made 2,000 revolutions per minute. From the limited experience with high-speed propellers, it has been found that under certain conditions the ship does not answer to her helm in the usual way; but this difficulty can be overcome by putting the rudder forward of the propellers.

The question of efficiency is one to be considered. Comparing it with a compound or triple expansion condensing engine, the steam turbine over the widest range of loads is, for general purposes, the most desirable. This the steam turbine has done, as proven by trials, in which the efficiency from full load to half load varied but 8 per cent; this is a far better performance than any attained by reciprocating engines. With the improvements in design that are sure to be made, the turbine's efficiency will be demonstrated even to the most skeptical engineers.

The great problem in steam turbine design is to devise a perfectly reversible one. This is done in marine turbines at present by having a separate turbine on the same shaft—the reversing turbine running idly in a vacuum when the ahead turbine is working, and *vice versa.*

There is nothing that can stay the improvement and popularity of a machine or process which saves money; thus we can see for the steam turbine a great future, both in commercial power generation, and marine propulsion. The reciprocating engine, although very highly developed and universally used, has a dangerous rival in the simple turbine, and there is nothing that appeals to the American mechanic more than simplicity.

SCIENCE NOTES.

Profs. Haga and Wind, of Holland, in 1899 announced that the X-rays were subject to diffraction. They have recently repeated their experiments and have again proved the existence of diffraction phenomena, and conclude that there is no longer a doubt that the X-rays are, like light waves, perturbations of the equilibrium of the ether. They have sought to evaluate the wave-lengths of the X-radiations, and conclude that these radiations have wave-lengths of the same order of magnitude as light waves.

Most people are aware of the power of egg shells to resist external pressure on the ends, but not many would credit the results of tests recently made, which appear to be genuine. Eight ordinary hen's eggs were submitted to pressure applied externally all over the surface of the shell, and the breaking pressures varied between 400 pounds and 675 pounds per square inch. With the stresses applied internally to twelve eggs, these gave way at pressures varying between 32 pounds and 65 pounds per square inch. The pressure required to crush the eggs varied between 40 pounds and 75 pounds. The average thickness of the shells was 13-1000 inch.

The recommendations of the Advisory Board of the Carnegie Institution are of exceptional interest. Prof. S. P. Langley tells of the wide discrepancy of results obtained in an effort to determine the solar constant, the unit of heat exerted by the sun's rays on a given surface in a given time. He gives as the probable cause of the divergence, the absorptive qualities of different layers of atmosphere which absorb heat from the sun's rays. He also suggests a possible periodic variation in the power of the sun. In view of the important effect of the heat imparted by the sun's rays on all life, Prof. Langley advocates the establishment of two laboratories close to the equator, at the greatest possible difference of altitude and yet within sight of each other, so that, under like atmospheric and other conditions, simultaneous observations could be taken, and the variation produced by difference of altitude accurately recorded. Dr. D. S. Jordan advocates the sending of an expedition to study ichthyology in the Pacific Ocean and to make a marine biological survey similar to that being conducted by the United States Fish Commission in American waters. Prof. C. K. Gilbert, of Washington, proposes a deep boring in plutonic rock for the purpose of ascertaining the temperature gradients in the earth's crust. He recommends that a mass of great age be selected, one which has not for many periods been subjected to change, and that a boring be made with some instrument similar to the diamond drill, so that the core produced could be made the subject of special investigation. With such a boring completed to a great depth, temperature observations could be taken at numerous levels, which would contribute largely to geological knowledge, and might prove of great value in the study of seismic disturbance. Dr. Ladd, of Yale, recommends a certain line of work in his special department of psychology and philosophy. Of most importance he considers a bureau of information, a sort of psychological clearing house for the interchange of not only definite results, but of attempted investigations, partial results, etc., with a view to keeping all psychologists posted as to what is being done. Dr. C. O. Whitman, of the University of Chicago, recommends a biological farm for the study of heredity, variation, and evolution.

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