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Contents.

(Illustrated articles are marked with an asterisk.)

TABLE OF CONTENTS OF THE SCIENTIFIC AMERICAN SUPPLEMENT,

No. 74,

For the Week ending June 2, 1877.

I. ENGINEERING AND MECHANICS.—New British Torpedo Steamer "Lightning," 1 engraving.

Wave-Making Resistance of Ships, by W. FROUDE, with several figures. An important and interesting paper. Feathering Screw Propeller, by H. S. EYRE, with engravings.—Submarine Blasting with Dynamite; New Method of Clearing Rivers, with engravings.—Steel Rail Product of the Lackawanna Mill.—Testing Steel Iron Welds.

Boiler Tests, Manchester Steam Users' Association, 11 illustrations; with dimensions and full description of Tests.

Proposed New Bridge between New York and Brooklyn; McDonald's design; 1 large engraving.

II. TECHNOLOGY.—Wool Dyeing, by GEORGE JARMAIN. An able, valuable, and practical paper; showing the latest, best, and most economical processes, including a general statement of the requisites for practical success, the proper water, and how to remove impurities therefrom; Clark's Soap Test; Logwood as a Reagent for Water Impurities; the Dyeing Test; Influence of Impurities contained in Water on Scouring, Rinsing, and Dyeing; Influence on Mordanting and Dyeing; Impurities in the Form of Iron Salts, Alkaline Carbonates, Organic Impurities, Free Acids and Salts; how to Purify and Correct Waters that are to be Used in the Treatment of Wool; Exposure to Air, Subsidence, and Filtration; Clark's Softening Process for Hard Waters; Wanklyn's Method; Treatment of Hard Waters with Soap; Correction of Waters in the Dye Bath; Purification of Refuse Waters from Woolen Mills; Scouring, and Scouring Materials; Wool Scouring; Yarn Scouring; Cloth Scouring; Wool Bleaching.—On the Sizing of Cotton Goods, by WM. THOMSON, F.R.S.E.

Notes on Gas Making. By R. H. PATTERSON. Being a New Mode of Working Washers and Scrubbers.—Asphaltum Manufacture.—How to produce Photo-mezzotint Engravings. Full Description of the Process.—History of the Art of Coachbuilding. By G. A. THRUPP. Describing American Carriages, Principles of Draught, Springs, etc. Preservative against Dry Rot in Wood.—Design for Ornamental Table, 1 engraving.

III. LESSONS IN MECHANICAL DRAWING.—By Professor C. W. MACCORD. Second Series No. IX. With several engravings.

IV. ELECTRICITY.—Gigantic New Induction Coil; with 1 engraving.—Printing Telegraph Instruments. Interesting History of their Improvements.

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THE HUMAN MACHINE AND ITS FUEL.

Dr. Joule has pointed out that not only does an animal much more nearly resemble in its functions an electromagnetic engine than it resembles a steam engine, but he also has stated that it is a much more efficient engine—"that is to say," says Professor Tait, "an animal, for the same amount of potential energy of food or fuel supplied to it, gives you a larger amount converted into work than any engine which we can construct physically." In other words, the duty—by which we mean the percentage of the energy of the fuel which it can convert into the useful or desired form—is greater in the case of animal mechanism than in that of any other engine in which fuel is employed. The work we obtain in the form of heat, constructive power, nervo-muscular action, mechanical motion, and the like: and here the analogy between the body and a machine ends, because the food in the animal is not merely a source of energy, but it enters into the development and maintenance of the body itself. It follows, therefore, that two classes of food are necessary; first, the organic, which alone is oxidizable or capable of generating potential energy, and secondly, the inorganic, which, though not oxidizable, is essential to the metamorphosis of organic matter which takes place in the animal economy. The organic constituents of food are generally divided into nitrogenous, fatty, and saccharine compounds, and the inorganic into water and saline matters.

Taking up these constituents in their order, Dr. George Wilson, in his recent admirable work, "A Handbook of Hygiene," states that the nitrogenous portions of food have for their main functions the construction and repair of tissues, besides possessing other functions of a regulative and dynamic nature not well defined. Fatty constituents play an important part in the maintenance of animal heat and in the conversion of food into tissue. The oxidation of fat in the blood generates to a great extent the energy which is rendered apparent in locomotion and manual labor. It, besides, renders the human machine elastic, and supplies lubricating material. The saccharine constituents of hydrocarbons (cellulose, starch, and sugar) are directly subservient to the maintenance of animal heat and the production of animal energy. Water in the animal economy dissolves and conveys food to different parts of the system, removes effete products, lubricates the tissues, equalizes the bodily temperature by evaporation, and regulates the chemical changes which take place in the processes of nutrition and decay. Saline matters, on the other hand, are the chief media for the transference of the organic constituents throughout the body. They are largely concerned in the consolidation of the tissues, and are supposed to convert unabsorbable colloids into highly diffusive crystalloids.

As we have already stated, the potential energy of food is the sole source of the active energy displayed in mechanical motion or work. And consequently, up to certain limits, the diet must be increased as the work increases. The question for the economist is then, first, on how much food can a man subsist and live: and second, how much more food must be added when certain work is to be performed. Dr. Edward Smith has determined that the Lancashire operatives during the cotton famine managed to live on 3,888 grains of carbon and 181 grains of nitrogen per day. This is equivalent to about 2 lbs. of baker's bread. On the other hand, a man, who could live on this amount during idleness, while at work requires (according to Dr. Letheby) 6,823 grains of carbon and 391 grains of nitrogen. This is equivalent to 2 lbs. of beef, with 1 lb. of potatoes, 1 lb. of beer, and about ¼ lb. of sugar.

Of course the quantity of the food required differs not merely with the amount of work done, but with its quality. Dr. Smith has prepared a table showing the weekly dietaries of low-fed operatives. Needlewomen, for example, in London average 124 ozs. breadstuffs, 40 ozs. potatoes, 7·3 ozs. fats, 16·3 ozs. meat, 7·0 ozs. milk, 0·5 oz. cheese, and 1·3 ozs. tea per week. This diet is richer in meat than that of the English farm laborer. The Macclesfield silk weavers are quoted at 3·2 ozs. meat per week. The Irish farm laborer gets but 4·5 ozs. meat weekly, but he has 326 ozs. breadstuffs and 135 ozs. milk. The Scotch farm worker eats over twice as much potatoes as the Irishman, despite the supposed fact that the tubers constitute the principal article of diet among the peasantry of the Emerald Isle. The table compiled by Dr. Smith includes silk weavers, shoemakers, farm laborers, and needlewomen, and the average diet per day for all is 4,881 grains of carbon and 214 grains of nitrogen. We can contrast with this, data obtained by Dr. Playfair covering the diets of English railway navvies, English and French sailors, soldiers in peace, prizefighters, hard-worked weavers, and blacksmiths. This shows that the average is 5,837 grains of carbon and 400 grains of nitrogen per individual per day. There are many suggestive comparisons to be made here. Take for example the figures relative to weavers. There is one class of these operatives who do light work on a daily average of 3,861 grains of carbon and 157 grains of nitrogen; when at hard work, this becomes 6,020 grains of carbon and 375 grains of nitrogen. As shown above, the first-mentioned quantities are no more than barely sufficient to sustain the body; and work here practically means a wearing away of the human machine. Now when the work becomes harder, 2,159 grains of carbon and 218 grains of nitrogen more are consumed; and these are the food equivalent for the extra work performed. In the case of the prizefighter in training, the daily average in point of carbonaceous matter is less than that of the low-fed operative, but the nitrogenous matter—flesh and muscle manufacturing material—the average is 690 grains, or over three times greater. The proportions of the training athlete's daily food are flesh formers 9·8 ozs., fats 3·1 ozs., starch and sugar 3·27 ozs.

It will be seen from the foregoing that it is quite possible to construct dietaries, especially suited to sustaining the animal mechanism, in accordance with the work to be accomplished. This subject we shall consider in another article.

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WANTED—TORPEDO DEFENCES.

Mr. E. J. Reed, late Chief Naval Constructor of the British Navy, in a recent lecture before the Society of Arts, took occasion to express an opinion which, we think, every one who has given any thought to the method of waging future maritime wars has already more or less definitely reached. Coming from an engineer who has been so closely identified with the building of the ironclad navy of Great Britain, the views enunciated will assume greater force. They could not be more radical or more direct. Mr. Reed says, in substance, simply that, until a way of protecting vessels from the effects of torpedoes is invented, ironclad ships, notwithstanding their 24 inch armor and 100 ton guns, are anachronisms, and that their construction is waste of time and money. "Neither the suspension of chain nets, nor additional bulkhead divisions in ordinary forms of ships, will be a sufficient, nor anything like a sufficient, defence against this deadly submarine instrument of attack. The naval Whitehead torpedo delivers a most terrible blow; it moves for the space of some hundreds of yards with a speed double that of the fastest ironclads; its path is so sure and true that at that distance a second torpedo can be made to pass through the hole which the first has made; and whereas it has been assumed that, in ordinary conditions of weather and naval warfare under steam, a ship could not have more than a few feet of her depth below water attacked, the torpedo has the whole immersed bottom of the ship exposed to its assaults." Mr. Reed goes on to say that the days of war ships, more or less long and narrow, and with deep bottoms of thin iron containing the steam boilers and powder magazines, are numbered. He advises his government to reconsider its intention of beginning the building of a vessel of the Agamemnon class; and finally he concludes that modern naval necessities are "first, the construction of our large ships on principles which make them as little destructible by torpedoes as by guns, which I believe to be quite possible; and secondly, the building of all our other war ships of small and handy types." By the latter he means small vessels which can be manœuvred with sufficient rapidity to avoid torpedoes.

Mr. Reed unfortunately fails to mention the plan for protecting ships against torpedoes, the knowledge of which he implies that he possesses. It will be seen, however, that in his opinion a total reconstruction of the English navy is necessary, and that consequently the enormous sums of money which have been expended on its development are entirely thrown away. This is not cheering intelligence to the British taxpayer; and we doubt whether its purport will be acquiesced in until inventors, the world over, confess themselves vanquished by the problem of devising an efficient system of torpedo guard. So long as enormously heavy artillery is to be used, vessels must be built both capable of carrying the guns and likewise capable of resisting them. Already it is contemplated to build cannon which will dwarf the 100 ton gun; and the English iron founders, on the other hand, promise 40 inch rolled plates. If war ships must carry such loads of metal as these, it is difficult to see how they can be built light enough to dodge torpedoes. There is certainly little to be gained by building vessels possessing the latter advantage, if at the same time they are to be rendered easily vulnerable by heavy guns.

We agree with Mr. Reed in the belief that it is possible to protect large vessels against torpedoes, although we have no especial project to propose. The subject is one which we would particularly commend to the attention of inventors. It is obvious that the necessary protections can be obtained in two ways: first, by devices outside or extraneous to the vessel, and second, by modification of the construction of the ship itself. The simplest outside device is the torpedo netting constantly used by our vessels during the war. This is simply a network of chain or rope supported on booms at some distance around the ship and extending down into the water deep enough to guard the entire bottom. To prevent the access of torpedo launches, the ship may be surrounded by heavy spars also attached to the booms, and from these chain nets, as already described, may depend. These devices are obviously of little use or altogether impracticable when the vessel is in motion. To avoid stationary torpedoes anchored in channels, ships have used forked catchers protruding from the cutwater, to grasp and cause the explosion of the obstruction. Rafts pushed in front of ordinary vessels likewise serve a similar end. Under the second plan, war ships are built in watertight compartments. The Inflexible, for example, has 127 such sections. Or, as in the case of Admiral Porter's boat, the Alarm, there is a double hull with the space between divided up, while the entire hold of the ship may, through the watertight bulkheads which cross it, likewise be converted into separate sections. A torpedo, it is supposed, might injure a few compartments, while those still staunch would perhaps float the vessel. With iron ships there is not much surplus of buoyancy, however, and the racking effect of a blast might cause results much worse than the direct injury to the compartments immediately adjacent. Probably the means of defence, nearest to security, lie first in keeping the vessel constantly