SCIENTIFIC AMERICAN

ESTABLISHED 1845

MUNN & CO., - - Editors and Proprietors

Published Weekly at

No. 361 Broadway, New York

TERMS TO SUBSCRIBERS

One copy, one year for the United States, Canada, or Mexico......... $3.00
One copy, one year, to any foreign country, postage prepaid. £0 16s. 5d. 4.00

THE SCIENTIFIC AMERICAN PUBLICATIONS.

Scientific American (Established 1845).............................$3.00 a year
Scientific American Supplement (Established 1876)............. 5.00 "
Scientific American Building Monthly (Established 1885)........ 2.50 "
Scientific American Export Edition (Established 1878).......... 3.00 "

The combined subscription rates and rates to foreign countries will be furnished upon application.

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MUNN & CO., 361 Broadway, New York.

NEW YORK, SATURDAY, JULY 11, 1903.

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.

DESTRUCTION OF CITY REFUSE.

The question of the destruction of city refuse by burning and the utilization of the heat for power—a question that has attracted considerable attention and has been put to careful test in the older countries—is destined to receive widespread attention from the municipal authorities in America. Many years ago attention was drawn to the possibility of a city getting rid of its refuse by a method that would yield a valuable return, by the Borough Engineer of Southampton, England, who utilized the waste heat from a refuse destructor in driving the electrical plant for lighting the city. Since that time the world has been made familiar with the results obtained in one of the London districts, and a large amount of valuable matter has been written and data gathered upon this most important subject. It is now pretty well established that the value of city refuse as fuel for city lighting will vary with the locality and the general conditions. As a rule, it has been found that in England the destruction of refuse does not alone furnish sufficient heat to run the city lighting plant, and recourse has had to be made to the coal pile. When the duty to be performed is entirely that of electric lighting, the refuse destructor has not given such good results as when the plant was used for operating a street railway system. It has been found that the refuse destructor gives its best results when it is working at an even rate of combustion, and this condition is obtained where the load on the electric plant is not subject to extreme fluctuations.

Valuable information in connection with the working of the refuse destructor, when employed in raising steam for an electric plant, is furnished in a recent report by the Electrical Engineer of the Borough of Fulham, London, presented to the Council, in which it appears that the cost of burning 30,201 tons of city refuse was $27,100. As the electrical department was paid $19,230 for the work, the actual cost to the station was $7,870. As an offset to this there was a considerable reduction in the expenses for coal. The author of the report bases his estimate of the actual cost to the electrical lighting department of the refuse destruction, upon the workings of several electrical plants owned by corporations in the city of London, in which he finds that the average cost of the coal per unit works out at 2.10 cents, whereas, the cost of coal to the electrical plant of the Borough of Fulham for last year worked out at only 0.76 cent per unit. Basing his estimate upon these figures, he finds that there is a net profit from the destructor department of $3,442. Although these results are not so flattering as were predicted a few years ago, when this system was first put to the test, they do demonstrate that the sanitary disposal of city refuse by cremating can be carried out with a net profit to the user, where the plant is properly installed and the general conditions are favorable. The results, as we have said, will be largely modified by local conditions; and it is a question of vital interest to the great cities on this side of the Atlantic, as to how far this method of refuse disposal, which has every sanitary consideration to recommend it, can be carried out with similar economic results to those obtained in the plant under consideration.

THE STEAM TURBINE FOR OCEAN SERVICE.

The unbroken success which has attended the application of the steam turbine to steamship propulsion, beginning with the experimental "Turbinia," and ending for the present with the handsome 22-knot Channel steamer which we illustrate on another page of this issue, is a sure guaranty that before long we shall see this remarkable engine installed in a first-class, high-speed transatlantic liner. Had there been any failure recorded in the last four or five years of experimental work; had the steam turbine shown any inherent and unsurmountable defect rendering it unsuitable for marine purposes, the great steamship companies would be justified in their hesitation to substitute the compact and self-balanced motor for the ponderous and at best but poorly balanced reciprocating engine. But no such obstacle has shown itself. It is true, the impossibility of reversing the turbine seemed for a while to be fatal to its introduction on steamships; but the present arrangement of installing a set of reversing turbines on the same shaft with the main engine has removed the difficulty, and the distribution of the motive power upon three shafts has provided all maneuvering power that can reasonably be asked for. A recapitulation of the experimental period referred to will show how unbroken the success of the marine turbine has been. The very first vessel to carry it, the "Turbinia," broke all existing records for speed, steaming at over 34 knots an hour. Then came the "Viper" and the "Cobra," whose turbine engines placed them so far ahead of all existing torpedo boats in point of speed as to put them in a class by themselves, the 37 knots achieved by the former boat never having been surpassed in an official and properly certified trial of any kind of vessel before or since. Then came the Clyde passenger steamers "King Edward" and "Alexandra," in which the conditions for comparative tests were most excellent, the boats being of about the same size and engaged in the same service as existing high-class vessels, the data of whose performance was well known to the companies who owned them. In these vessels it was proved that on a given displacement and coal consumption, it was possible to get about a knot extra speed by the use of the turbine motor, while the absence of vibration and the increased passenger accommodation were further distinct and very valuable gains in favor of the new boats. Quietness in running, economy in space and fuel are features which naturally attracted the attention of the yachting world, and to-day three Americans are owners of vessels which are among the fastest and most comfortable yachts afloat. "Tarantula," with a speed of 26 knots, and "Emerald" and "Lorena," with speeds respectively of 16 and 18 knots an hour, will probably be seen in these waters during the coming international cup races, where they will meet another successful turbine yacht in the "Resolution," which is driven by a turbine engine of a purely American design. The latest success is that achieved in the turbine steamer "Queen," recently put in service between Calais and Dover, which made her first cross-Channel trip at an average speed of 22 knots an hour. She is to be followed by other vessels of this type, which are now building for three different companies that ply across the stormy waters around Great Britain.

As a matter of fact, in view of the unbroken success that has attended the use of the turbine in the smaller classes of steamship, the hesitation of the large transportation companies to adopt this system for the big liners is to be attributed to a conservatism which, although it is not justified by the facts, is not unnatural in view of the great cost of these huge vessels, which each represent an investment of from three to five million dollars according to their size and speed. Nevertheless, so far from the installation of turbine engines on an ocean liner being in the nature of an experiment, the only condition that would be novel would be the increased size of the turbine as compared with those which have done such successful work in smaller vessels; and it has been asserted time and again both by Mr. Parsons, the designer, and by the builders, that the economy in space and weight and the absence of vibration which have been realized in the smaller boats, would be realized in greater ratio as the size and power of the vessel on which the turbines are installed increased. In other words, so far from there being any new conditions prejudicial to the turbine introduced by building them in the much larger units necessary to drive a transatlantic liner, the very increase in size would bring about a larger proportionate reduction in the weight and space per unit of power than has been realized in the vessels of 2,000 tons and under, that are now running successfully with turbine engines. Basing their calculations upon data already secured, it is estimated by the builders that in a vessel of the same displacement as the largest and fastest of the present transatlantic steamers, it would be possible, by the installation of turbine engines, to secure fully one knot more speed; and when we remember that the resistance of these fast vessels increases as something more than the cube of the speed, it will be seen how great would be the actual economy of a large capacity marine engine. Furthermore, from the passengers' point of view, there will be a great gain in comfort due to the absence of vibration; for it cannot be denied that the extreme vibration of the high-speed ocean liners of to-day, due to the reciprocating engine, is one of the most serious drawbacks of transatlantic travel.

GROWTH OF OUR RAILROAD SYSTEM.

It was to be expected that the present commercial prosperity would have a marked effect upon the railroad system of the United States, and the statistics for the last fiscal year of the Interstate Commerce Commission show that in every respect there has been a decided and very satisfactory growth. The total single-track railway mileage is 202,472 miles, an increase for the year of 5,234 miles, which is greater than that for any other year since 1890. For the service of the 2,037 railway corporations included in this estimate, 41,228 locomotives were required. The total number of cars of all classes in use at the close of the year was 1,640,-220, an increase of over 89,000 over the previous year. Of this total number, 36,991 were passenger cars, 1,546,132 freight cars, and 57,097 were devoted to the direct service of the railways.

It is gratifying to learn that of the total number of freight cars as given above, 1,204,929 were fitted with train brakes and 1,521,000 with automatic couplers. The total number of employes at the close of last year was 1,189,315, an increase of 118,146. There was paid out during the year in salaries and wages $676,028,592. The amount of railway capital outstanding was $12,134,182,964, and the amount of dividends declared during the year was $185,391,655. This is equivalent to a dividend of 5.55 per cent on the amount of stock on which some dividend was declared. The number of pasengers carried during the year was 649,-878,505, an increase of 42,600,384, and the number of tons of freight carried was 1,200,315,787. The gross earnings of the railways for the year were $1,726,380,-267, and the income from operation, or net earnings, was $610,131,520, an increase over the previous year of over $52,000,000. The unpleasant feature of the statistics is reached when we consider the record of railway accidents for the year. The total number of casualties for the twelve months was 73,250; the number of persons killed having been 8,588, and the number injured 64,662. Of these totals, nearly 3,000 railroad employes were killed and over 50,000 were injured—truly a ghastly result; one that should bring a blush to the cheek of every patriotic American. It certainly looks as though the charge often laid against us, that we are brutally indifferent to the sanctity of human life, is only too true. The number of passengers killed during the year was 345, while 6,683 were injured. This is a great increase over the year preceding, when 283 were killed and 4,988 pasengers injured. Referring to the total figures of killed and injured, the number of killed amounts to one-seventh of the total number of men in the United States army, and the number of injured is greater than the number of men in the army by nearly 5,000. As for the risks incurred by the trainmen on American railroads, their work is certainly the most perilous of any in the world, not even excluding that of the soldier in time of warfare; for our railroads kill in a single twelvemonth one employe out of every 135, and they injure one out of every ten.

PROGRESS OF THE UGANDA RAILROAD.

The Uganda Railroad, which was commenced in December, 1895, by the British government, following the taking over of the East Africa Protectorate and Uganda from the British East Africa Company in 1894, is now completed so far as the actual track is concerned. This railroad extends from Mombasa on the East Africa Coast to Port Florence on Lake Victoria Nyanza, a total distance of 584 miles. In many ways the building of this railroad constitutes a remarkable engineering achievement, the route for the most part lying through very difficult country and jungle. When the railroad was projected it was estimated that its total cost would amount to $15,000,000, but the expense of the undertaking has considerably exceeded the anticipated cost, as the money already devoted to the work is over $25,000,000. This works out about $43,000 per mile—a by no means expensive outlay considering the engineering magnitude of the undertaking.

One of the most notable incidents in connection with the construction of this railroad was the large order of twenty-seven steel bridges placed in this country. These have all been erected and finished and the only uncompleted section of the railroad is the substitution of steel bridges for a number of insignificant temporary wooden structures.

Already the railroad is exercising a beneficial influence upon the country through which it passes, while the maritime traffic upon the Victoria Nyanza is being rapidly developed. Both Indians, Italians, and Germans have large vessels trading upon the lake. A twin-screw steamer is already in service and a sister vessel is in course of erection at Port Florence for a similar purpose. The vessels each measure 176 feet in length, have a draft of 6 feet, and a displacement of 600 tons, and passenger accommodation for 100 passengers. These vessels were designed and built at Paisley on the Clyde, then dismembered and transported in sections to Port Florence, where they were reassembled. The first of these two twin-screw steamers on its trial trip from Port Florence to Entebbe—the Uganda administration headquarters on the opposite side of the lake—and back again occupied two days, including time for discharging cargo at Entebbe.

At present a through train runs twice a week each way between Mombasa and Port Florence, and the new steamers run across the lake in connection with the up and down trains as traffic demands. According to the official statement the returns amount to $15 per mile per week or roughly $9,000 weekly for the entire line. It is stated that the working of the railway will represent a saving to the Uganda and East Africa Protectorates of $175,000 per annum in transport expenses.

The work of surveying the German portions of the Victoria Nyanza is also well advanced. The whole of the British portion is already mapped out, and it is anticipated that the German survey will occupy at least another year. A vast expanse of new country will be opened up, and new tribes visited.

NICKEL-STEEL.

BY CRITTENDEN MARRIOTT.

The public has heard of nickel-steel chiefly, if not solely, as a material for making armor plate of unprecedented hardness and toughness; the engineer has heard of it as also possessing greater strength and elasticity than ordinary steel, and as therefore enabling lighter machinery to be used to do the same work; but only a few scientists are as yet familiar with its most important quality of all—that of being (when combined in certain proportions) nearly if not quite exempt from expansion and contraction through heat and cold.

It is almost impossible to grasp at once the full significance of this far-reaching exemption. Every other substance in the world varies in volume with every degree of change in temperature, by an amount known as the "coefficient of expansion" of that substance—an amount supposedly constant within ordinary limits of temperature. Within these limits, brass has a coefficient of about .000018 (that is, it increases by eighteen-millionths of its length for every degree Centigrade by which its temperature is raised); steel has a coefficient of about .000011; nickel of .000013; silver of .000019; platinum, least expansible of all ordinary metals, of .000009. But a combination of 36 parts of nickel with 64 parts of steel has a coefficient of only .000001. The alloy with this low expansion is already made commercially, though on a small scale, and its inventor, Charles Edward Guillaume, of the International Bureau of Standards, a distinguished French scientist, asserts that it can be made with no coefficient of expansion at all.

The importance of what has been attained already is clear when it is said that there is probably no single cause in tool making, machine work, and construction of every sort, that gives so much trouble to the engineer as does the phenomenon of expansion and contraction on account of changes of temperature. To allow for it requires complicated calculations, difficult mechanical adaptations, and much expense. Bridges must be built with one end, at least, free to move; rails must be laid so as to allow some "play" when the weather changes; watches and clocks must be fitted with compensating balances or pendulums if they are to run true in both hot and cold weather. In problems of exact linear measurement, the temperature of the measuring tape or rod must be allowed for if correct results are to be attained; a surveyor's tape will vary quite enough between winter and summer to cause a law suit unless the proper correction is made; even the mere heat of the hand may set at fault the delicate measurements of the micrometer calipers for noting the thread of tiny screws and the like. When two metals, or two pieces of one metal, come in contact, their unequal expansion may prove ruinous; a great steel building may tear itself to pieces within a few years unless some movement of its parts is allowed; a "hot box" may stop a train for hours, not because the axle is hot, but because it is hotter than the journal in which it works and the two bind in consequence; no screw of one metal can be sunk in another having a very different coefficient without either breaking its own threads or cracking the other at the first marked change of temperature. Obviously, any discovery of a metallic alloy that is reasonably cheap, and that either does not alter at all or alters much less than any substance in common use, is of tremendous import to the mechanical world, even if it has no other good qualities to recommend it. But nickel steel, made with more than 25 per cent of nickel, has many other good qualities. Not only has it, in certain proportions, less than one ninth the expansive coefficient of platinum, but it also takes a high polish, is elastic, very difficult to rust, and though hard, is yet easily worked with the file or the lathe.

The discovery of these good qualities was not made by chance, nor was it due wholly to one man, although one man has brought them to the point of practicality. The key note of the whole lay in certain curious phenomena relating to magnetism, first noticed some ten years ago, which drew attention to the alloys and led to the discovery that an alloy of 22 per cent of nickel and 3 per cent of chrome with 75 per cent of steel had only half the coefficient of expansion of brass. In 1896, M. Guillaume found that a 30 per cent alloy had a less coefficient than platinum. This led him to investigate the whole subject.

As the magnetic qualities of the alloys presented some startling contradictions to general laws, it was to these that he first turned his attention. He found, broadly speaking, that alloys with less than 25 per cent of nickel can be rendered either non-magnetic or be given a degree of magnetism which they will retain without regard to their temperature; that alloys containing between 25 and 35 per cent of nickel have a magnetism that varies with the temperature; and that alloys of more than 35 per cent of nickel remain permanently magnetic at their maximum capacity for all ordinary climatic temperatures.

Alloys under 25 per cent will be of great use in several ways, but they are useless for the purpose under discussion, as they have high coefficients of expansion. Those over 25 per cent, however, are of great use. As their magnetism at ordinary temperatures increases, so also their hardness and elasticity increase and their expansion coefficients decrease, until at a little more than 36 per cent, when they are perfectly magnetic, this coefficient sinks to .000001, the lowest known.

The first hint of this remarkable quality was made public by M. Guillaume in an article in a French scientific paper in 1899, but the matter was not set forth in its entirety until the meeting of the International Geodetic Society at Paris last fall. It seems to have escaped the attention of the American press, the first extended news of it having been brought to this country by Mr. Isaac Winston, of the United States Coast and Geodetic Survey, who was a delegate to the meeting of the Association.

The first attempt to take advantage of it in this country is due to Mr. E. G. Fischer, also of the Survey, who conceived the idea that this non-expansible alloy would be very valuable in constructing surveying levels, which are always more or less damaged by the expansion and contraction of their working parts due to the changes of temperature to which they are subjected. Parts that fit closely at first, soon become loose and cause no end of trouble by giving rise to inaccurate observations. Inquiry showed, however, that it was not possible at that time to get the tubes and castings needed from France, and, there being no steel foundry at hand, Mr. Fischer, as chief of the Instrument Division of the Survey, engaged a brass founder to make for him some nickel iron. The comparatively low temperatures which alone could be obtained, caused the first experiments (which were made with ordinary machinery steel and with steel filings) to give impure mechanical results, although the coefficient obtained was as low as .000003. Cast iron was then tried, and as much less heat was required with this, excellent mechanical results were obtained; the coefficient, however, had risen to .000005. So a fourth attempt was made altering the percentage of nickel from 36 (Guillaume's proportion with steel) to 33 1-3; the result gave an exceptionally fine material with a coefficient of .000004, only one-third that of ordinary steel. It is rather brittle, easily worked with lathe and file, entirely malleable, resisting rust to a marked degree, and affected by no acid except aqua regia. The smoothness with which it works against itself, contrary to the general experience, is remarkable.

Nickel steel (or nickel iron) will thus reduce the error of measurements due to temperature to one-eleventh of that of steel, leaving it at a figure so small as to be within the "personal" error of observation which is considered to be inevitable, and thus permitting temperature to be ignored altogether. The only thing that seems to stand in the way of its general use is its cost, due to the scarcity of nickel, the world's annual production of which is only about 7000 tons. The price of nickel is steadily rising, having increased by about one-third in the last two years. A ton of 36 per cent nickel-steel would now cost about three times as much as a ton of ordinary steel, a price that is prohibitory so far as building or machinery is concerned. There is no reason, however, why it should not be used extensively in instrument making, its price being still less than that of brass and only a fraction of that of platinum. Its use would add only a few cents to the cost of a surveyor's tape or to that of a pair of micrometer calipers and would save an immense amount of calculation. What its use would save in measuring base lines for fine geodetic work may be imagined when it is stated that at present an entire portable university is required for these, including heavy bars of platinum packed in melting ice, all of which could be dispensed with if nickel steel base bars were employed.

A PRIZE OFFERED FOR A RESPIRATOR.

Owing to the dangerous methods of inhaling contaminated atmosphere dangerous to the health, incidental to certain industries, the Society of Arts, London, offers a prize for the best dust arresting respirator for use in connection with such dangerous trades. The devices submitted must possess the following characteristics: The apparatus must be light and simple in construction; must be cheap, so that the filtering medium or the entire respirator can be inexpensively renewed from time to time as necessity demands, or should be of such construction that it can be quickly and easily cleaned; no air must enter the lungs either by the nostrils or mouth except through the filtering medium; it must not permit exhaled air to be rebreathed; the filtering medium must be of such construction that while an efficient dust arrester it does not impede respiration after being worn for several hours, through the medium's becoming clogged; and it must not be unsightly in appearance. All inventions must be submitted not later than December 31, 1903, and if the devices submitted have been in use, the experience of such utilization must be recorded.

SCIENCE NOTES.

News comes from abroad that Dr. Lunden claims to have experimentally proved that rays reflected from radium enable the blind to see partially.

A well-equipped eye dispensary will soon be traveling through the length and breadth of Egypt. Sir Ernest Cassel provided for this by a recent gift of about $100,000, and the Sanitary Department of the Egyptian government adopted the suggestion as the best means of carrying out the wishes of the donor. The dispensary will be supplied with all the most modern and approved apparatus, and will be housed in a tent, which will be moved from place to place as found desirable.

In a recent number of the Apotheker Zeitung H. Kuhl discusses the value of hydrogen peroxide as a disinfecting and deodorizing agent in toilet preparations and recommends as tooth-paste—calcium carbonate, 5 parts; soap, 1 part; rubbed up with glycerin and hydrogen peroxide solution, equal parts, to a suitable consistence. For a tooth-wash—glycerin, 2 parts; hydrogen peroxide solution, 2 parts, and rose water, 1 part, are recommended. For salves or skin-creams a basis of lanolin may be employed, with the addition of zinc ointment or cold cream.

In a recent number of the Gardener's Chronicle, W. C. Worsdell gives an interesting account of experiments that have been made to ascertain the means by which some plants are protected from the attacks of slugs and snails. Tannin appears to be one of the substances objectionable to them. Experiments made by Stahl showed that carrot, which from its sweetness and absence of tannin is particularly attractive to slugs, if treated with a 1 per cent solution of tannin remained practically untouched by the common small garden slug *Limax agrestis*, and if a solution of 1 in 1,000 of water be sprinkled on the animal, it rapidly disappeared from the scene of operation. Similarly, it was found that the leaves of *Valisneria*, *Trapa*, and other water plants containing tannin were avoided by the water snails, *Paludina*, *Limnæa*, and *Planorbis*, but if the tannin were extracted the leaves were speedily eaten. Acid sap has a similar effect; *Rumex acetosella*, *Oxalis*, and *Begonia* are disliked on account of the potassium binoxalate they contain. This was proved by soaking pieces of carrot in a 1 per cent solution of the salt and putting them before the slugs *Arion hortensis* and *Limax agrestis*, and the snail *Helix hortensis*, the pieces being untouched after a lapse of several days. A solution of the salt of 1 part in 1,000 of water was found to irritate the animals, and cause them to remove to other quarters. Plants with hairs secreting acids are similarly avoided, as in *Cicer arietinum*, *Oenothera*, etc. Ethereal oils are similarly protective; leaves of *Rue*, *Acorus calamus*, and *Mentha piperita* are carefully avoided by snails, but if the oil is extracted they are readily eaten. Bitter substances are also protective. Young leaves of *Gentiana lutea* and *Menyanthes trifoliata* are scarcely touched, though extracted leaves are at once devoured. But in autumn the bitter substances appear to be no longer efficacious.

THE CURRENT SUPPLEMENT.

The current SUPPLEMENT, No. 1436, opens with an excellent article on the Pyrmont Bridge at Sydney, Australia. Good illustrations accompany the article. The presidential address of James Swinburne before the Institution of Electrical Engineers is published. The address discusses some limits in heavy electrical engineering. To the engineer, one of the most interesting articles in the SUPPLEMENT is that which describes the Monarch system of engine stops, by means of which engines are immediately shut down in cases of emergency, so as to avoid accidents and the attendant loss of life and damage to property. The system described is remarkable for its simplicity and ingenuity. E. O. Hovey presents a very fully illustrated description of his explorations of the volcanoes of Martinique and St. Vincent. Sir William Crookes' striking address on modern views of matter, delivered before the Congress of Applied Chemistry at Berlin, is also published. Sir William Crookes discusses his subject with the eloquence which has always characterized his written work. The Paris correspondent of the SCIENTIFIC AMERICAN, continuing his description of the Paris-Madrid racing automobiles, describes in this installment the Mors automobile.