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*, *Limnœa*, 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.