influx of water became so great as to require more powerful pumping engines, and then the contractors, discouraged, sought and received permission to relinquish the work.

Then the directors attempted to continue on the Windsor end by means of two parallel trial drifts, and to begin a second one at the shore shaft, at a level 10 feet above the grade of the drainage tunnel, leaving the latter to be used as a sand holder in case of further irruption, the idea being that, in either one or the other drift, some progress might be made. Experience, it seems, had shown that a stream of sand and water flowing into the tunnel at one point would never be accompanied by a troublesome one flowing in at another. It is unnecessary to enter into the details of the last effort. The actual advance in new ground during the last two months was only 64 feet, and the cost about $7,500, or more than 6½ times the contract price, and the directors, in turn discouraged, abandoned the enterprize.

Mr. Chesborough answers various criticisms on the mode of carrying on the work, and states reasons why the orifices through which the irruptions occurred could not be stopped. A shield, he remarks, could not be used to advantage, nor could success have been assured by the pneumatic process. The causes of the irruption were springs and water courses, having their source 100 feet higher than the tunnel, and much above the level of tide water. Mr. McAlpine notes a similar case in the building of the dry docks at Brooklyn, N. Y., where fresh water came in with a head of 50 feet higher than that of the salt water. The water entering at Detroit was sulphur water, and without doubt owed its origin to Sulphur Springs at Sandwich, below Detroit, where the level rises from 30 to 40 feet above that of the river.

A HILL OF SULPHUR.

One of the most remarkable deposits of native sulphur, as yet discovered, is a great hill composed of the almost pure article, found some two years ago at a distance of thirty miles south of the Union Pacific Railway and nine hundred miles west of Omaha. This marvelous deposit is found to consist almost wholly of sulphur, containing only 15 per cent of impurities. The best deposits heretofore available are those found in Sicily. The principal supplies for the manufacture of sulphuric acid come from there; the deposits contain 35 per cent of impurities and 65 per cent of sulphur. Our western sulphur hill, therefore, is much the most valuable, and promises to become ere long of great importance to the country.

THE LAUNCH OF THE CITY OF PEKING.

The country has good cause for self-congratulation in the efforts which our prominent shipbuilders and capitalists are putting forth to regain the commerce which, during the war, passed from under our flag. Another great vessel has been launched, one of the largest ships ever constructed, save the Great Eastern, which is to form part of the Pacific Mail steamship line; a second vessel of similar proportions is on the stocks, and the same builders, we learn, are maturing plans for a line of European steamers. The City of Peking, which was recently successfully launched at Chester, Pa., was constructed by the Delaware River Iron Shipbuilding and Engine Works, of which Mr. John Roach is President, and is without doubt one of the most magnificent vessels, in construction, form, and fittings, ever built. Her length is 420 feet, beam 47 feet 4 inches, and tunnage 6,000 tuns. She has compound engines of 4,500 horse power, and a Hirsch four bladed screw 20 feet 3 inches in diameter. There are four decks, with accommodations for 2,000 passengers, fitted up in almost palatial style. No improvement in interior conveniences has been omitted; the machinery, soon to be inserted, is said to be a masterpiece of workmanship.

The ship is entirely of iron, five million pounds of the metal being used in her hull. She has four masts, three of which are of iron and are used as ventilators, and she spreads 33,000 square feet of canvas. Her estimated consumption of coal under her ten boilers is estimated at between fifty and sixty tuns per twenty four hours, and her speed will be about fifteen and a half knots.

The ceremony of launching was made the occasion of a holiday in Chester, and the town was thronged with visitors from New York, Philadelphia, and Washington. Large numbers of prominent men were present, including senators, representatives, chiefs of bureaus and other government officials. The ship, as the last shore was removed, glided into the water in splendid style, and was duly christened by the daughter of the builder, breaking the traditional bottle of wine over the bows. Speeches were afterwards made by Senators Cameron and Bogy, and by Mr. Roach, the latter gentleman detailing the operations of the company since its formation two years ago. The City of Peking will be commanded by Captain Jefferson Maury, and will shortly be brought to this city to receive her machinery at the Morgan Iron Works.

THE CHARACTER OF METALS AS EXHIBITED BY THEIR FRACTURE.

BY PROFESSOR R. H. THURSTON.

In an article published in the SCIENTIFIC AMERICAN of January 17*, a series of finely executed engravings illustrated the value of an inspection of the fractured surfaces of test pieces of metals broken by torsion as a means of judging of their character.

During the research there referred to, of which the results are given at length in a paper now in course of publication by the American Society of Civil Engineers, in the "Transactions" of that society†, the effect of various changes of condition, in production of alteration in the characteristics of fracture, has been found to present an interesting and useful study.

Referring to that article, the reader will observe the marked difference between numbers 16 and 22 as exhibiting the effect of a difference in thoroughness of working, the former being a good iron badly worked, and the latter being the most perfectly worked piece of iron which has ever come under the observation of the writer. Nos. 23 and 30 show the difference between a cast iron highly charged with carbon and a specimen containing a minimum percentage, while still other illustrations exhibit the low steels 58, 68, 71, containing only iron and a low portion of carbon, and the malleableized cast irons, 33, 35, which are steels which retain the impurities of cast iron, and are somewhat irregular in structure.

The effect of cold upon the properties of iron has been but little understood. One party of experimenters claim to have proven an increase, others a decrease, of strength with decrease of temperature. In a paper, originally prepared for the *Iron Age** and since republished by several other periodicals,† the writer collated such information, as then existed, from both scientific and engineering authorities, which showed that the general effect of low temperature seemed to be a decrease in power of resisting blows and an increase in power of resisting a steady strain, these seemingly contradictory effects being the consequence of increased tenacity accompanied by a simultaneous and yet greater decrease of ductility. Subsequent experiments by the writer, with the autographic testing machine designed by him for the Stevens Institute of Technology, in which errors of observation are avoided by so arranging the apparatus that the specimen tested shall write legibly its own story, have to some extent confirmed those deductions, but have revealed some reversals of the rule and have indicated that good materials are better in both respects at temperatures not far removed from zero.

The paper referred to was called forth by the request of the editor of the paper in which it first appeared, to whom Mr. Oliver Williams had forwarded a specimen of metal which had been broken at one point at a temperature of 75° Fah., and at another place when at a temperature of 20°. This specimen was afterwards placed in the cabinet of metals and minerals, in the lecture room of the writer, at the Stevens Institute of Technology. The method of fracture is stated to have been precisely the same in each case. The difference in appearance is very remarkable. The fracture at 70° is a strikingly perfect illustration of the fibrous, as that at 20° is of the granular, fracture.

Judging from general experience, I should be inclined to consider this iron far less reliable in cold than in warm weather. Careful experiment, however, is daily convincing engineers that the distinction, here so well shown, is a far less reliable indication of the strength and ductility of iron than was formerly supposed.

A kind of fracture which is probably always indicative of brittleness is generally, and possibly correctly, termed crystaline. It is supposed to be produced by a long continued succession of shocks, which, straining the metal to the elastic limit, permit the crystaline grouping of molecules to take place. Dr. Percy, the leading metallurgical authority of the world, seems to have been fully convinced of the possibility of the formation, in this way, of true crystals; but direct experiment is still desirable to fully determine it. A singular instance of this peculiar molecular action recently occurred at the Morgan Iron Works, New York. While a powerful steam hammer was at work upon the red hot end of a very large shaft, originally designed for the engines of a large naval steamer, a piece of the opposite end, which was cold, and which was supposed to be strong enough to transmit several thousand horse power, dropped off. This was an extraordinary event, but not unprecedented. In all such instances, the fracture seems to follow a plane passing through a comparatively sharp angle at the side of a collar or at the end of a journal.

The effect of cold is not always observable, particularly with ductile iron, of which two specimens were tested, one, at 10° Fah., and the other at 70° Fah. The metal was a cheap grade of wrought iron, quite cold-short, and very irregular. Two specimens from the same bar of good tool steel were also tested, one having been broken at 18° Fah., and the other at 70°.

The purest irons and low steels, and even the shear steels, do not usually show a change in form of fracture with change of temperature. At all temperatures likely to be experienced in this latitude, at least, they are equally reliable.

Two specimens of copper were also tested. The first was cast in dry sand and broken at 10° Fah., the second was cast in green sand and broken at 70°. The beautiful crystaline structure of the former is apparently due, principally, to low temperature. The unsound structure of the latter is the consequence of using a damp mold, and exhibits the advisability of using dry sand whenever possible. The two are very characteristic specimens. Copper is strongest at low temperatures and seems to lose none of its ductility. Forged specimens of copper, in all but color, resemble, when fractured, the toughest and most ductile kinds of iron.

The wonderful difference in properties of steel, under different methods of treatment, is shown by two specimens from the same bar of fine cast steel. The first has been carefully annealed, the second as thoroughly hardened. The close resemblance of the former to the low steels, shown in the former communication, was at once noticed. It does not appear like a true steel, not having even the faintest resemblance to the hardened specimen, which presents the uneven fracture and fine grain characteristic of the best tool steels.

Still another illustration of a peculiar modification of iron produced by special methods of treatment is seen in a piece of iron which had been subjected to the process of cold rolling. The effect of this action is to produce a marked increase of strength and of elasticity. In precisely what way this effect was produced was long a disputed point. No change of density had been detected, and some of the most talented and distinguished scientific men and engineers who had occasion to examine this singular material, as members of the International Jury at the Vienna Exhibition, found it exceedingly difficult to credit the claims made for it, although sustained by reports of experiments made upon it by well known authorities at home and abroad.

It has lately been shown by the writer that the effect of cold rolling is to render the iron more perfectly homogeneous and to produce such a disposition of internal strains as to greatly increase its elastic resistance.*

The thready appearance of the side of the broken specimens, and the toughness and compactness, of which good evidence is seen by an inspection of the end of the test piece, are the peculiar characteristics of this material. Those of the readers of the SCIENTIFIC AMERICAN who have occasion to adopt the method of testing metals, described in the issue of January 17, will be interested in learning the effect of varying the proportions of copper, tin, and zinc, in bronze, brass, and other compositions.

An alloy of ten parts copper to one part tin has two thirds the strength of iron and about one half its ductility. Such a metal is very valuable wherever strength and toughness are required in a cast metal. An increased proportion of tin produces increased hardness and a loss of ductility. Sixty-nine parts copper to thirty-one parts tin is an alloy which is very hard and as brittle as glass. Increasing the proportion of copper gives greater ductility at the expense of strength, and castings become liable to unsoundness.

Zinc is a brittle metal of crystaline structure, and vastly different from tin. Yet an alloy of zinc and copper may be made of considerable strength and of great ductility, as is the case with wire brass where the proportions are about two of copper to one of zinc, and with an unusually beautiful special grade of brass made at the Stevens Institute. This specimen exhibits characteristics common to all the more ductile alloys as well as of the metal tin. The curious, irregularly wavy appearance of the exterior, and the half fibrous, half granular fracture, are seen in gun metal, soft brass, oroide, phosphor bronze, and many other alloys which have been tested. Metal workers often make a free working and fine looking alloy by uniting copper, tin, and zinc. For some purposes such a mixture is well adapted, but it often happens that, without suspecting it, the workman seriously injures his material by adding, for appearance sake, zinc to a bronze in proportions seemingly too small to effect its mechanical properties.

The writer has found the addition of but a fraction over one per cent of lead, to a good brass, to reduce its strength nearly a half, and to cause a corresponding loss of ductility, thus making it but about one fourth as valuable in resisting blows as the clean alloy.

A good bronze, containing about ten of copper to one of tin, to which less than three per cent of zinc was added, was also tested in comparison with a brass in which lead was thus a component. The former is a metal of fine looking exterior, works well and takes a good polish. Its strength is slightly increased by the addition of the zinc, but its ductility is hardly a sixth that of the pure copper and tin alloy. The fracture shows this change to the eye with unmistakeable clearness. Instead of the toughness and extensibility shown so plainly in the specimen with lead in it, is exhibited a ragged, dull, irregular break like cast iron.

Such experiments as these are exceedingly instructive; and every worker in metals, every iron and brass founder, would find himself well repaid for time expended in such researches by the discovery of the mixtures best fitted for his work; and if each were to make public the results of his work, whenever evidently important, he would benefit the world without loss to himself.

Dr. Arnott.

The decease is announced of the celebrated Dr. Neil Arnott, at the advanced age of eighty-five years. He was not only a physician of eminence, but an author, a scientist, and an inventor. His "Elements of Physics," published in 1827, was largely circulated, and greatly promoted the study of the sciences. His researches upon warming and ventilation, and his inventions of stoves and ventilators, have greatly added to human comfort, and have led the way to various other important discoveries. Dr. Arnott was the recipient of many honors, and no one more justly deserved them. His life was a most useful one.

TO NEW SUBSCRIBERS.

It has been our custom to commence at the beginning of the year, all subscriptions received previous to the first of April, and to send the back numbers from the first of January. Hereafter the paper will be sent from the date of receipt of subscription; but to those who wish them, the back numbers from the commencement of the volume will be furnished, and the subscription dated from the first of the year.

*Testing the quality of iron, steel, and other metals without special apparatus.

† March 1874, *et seq.*

* *Iron Age*, June, 1873.

† *Van Nostrand's Engineering Magazine* July 1873; *Journal of the Franklin Institute*, September, October, 1873; London *Iron*, January 1874, etc.

* Trans. Am. Soc. C. E., March, 1874.