of great future results as is its employment, for separating the saline contents from sea water.

Already, he states, MM. H. Merle et Cie, the great salt makers of the department *Du midi*, have arranged to employ it on a very large scale. By slow congelation, the ice formed from sea water is absolutely pure and free from salt. The expenditure of heat units in producing salt (with theoretically perfect machines) by evaporation and by congelation, for equal weights, he shows to be in the ratio of 643·25 : 103·00; the latter will, therefore, be theoretically, by 6 to 1, the cheaper mode of procuring fresh water for supply of ships at sea, in place of by distillation. For the cooling of air, in tropical or other climates, M. Carré states his opinion, that it can be effected, by means of the ammonia ice machines, at a cost not exceeding double that, at which air can be warmed to an equal number of units, by means of the French *Calorifere*, i.e., by several of the forms of heating apparatus.

MM. Tellier, &c., however, say that from any given zero, equal increments or decrements of heat ought to cost alike. We are by no means as yet, assured that either are, *practically* considered, even approximately right. As a result, however, of some rather careful consideration, we have come to this conclusion at least, that on board our ships of war, stationed on the African and West Indian Coasts, and still more on board the Peninsular and Oriental Company's Mail Steamers, there would be no practical difficulty whatever, nor any serious amount of cost, in continually ventilating the whole of the sleeping and dwelling parts of the ship by air continually renewed, and kept down, even in the Red Sea, to 60° Fahrenheit, by suitable adaptations of machines of this class.—Ed.

Results of an Experimental Inquiry into the Comparative Tensile Strength, &c., of various kinds of Wrought Iron and Steel. By DAVID KIRKALDY. London: Hamilton, Adams & Co.; Simpkin, Marshall & Co., 1862.

From the London Civ. Eng. and Arch. Jour., April, 1863.

We return to the consideration of Mr. Kirkaldy's volume, the limits of a single notice not allowing the due mention of many of the important facts and data contained in its pages.

We have as yet adverted only to the experiments on rupture. These were accompanied with observations of the ultimate extension of each specimen, but as it appeared further to be very desirable to find the amount of strain required to produce a perceptible increase of length, and also to learn the rates of elongation as the strain was gradually increased from this point up to rupture, a set of experiments were conducted with great nicety for this special end, and the results are collected in a separate table. In another table a selection of these results is arranged in the order of the descriptions of metal tested, with the strains reduced to pounds per square inch, and the elongation to decimal parts of the original length. As very various qualities of iron and steel bars, iron and steel plates, and angle iron were operated on, a wide

diversity of rates of stretching was only to be expected, and it appears that—

“The rate as well as the ultimate elongation varies not only extremely in different qualities, but also considerably in specimens of the same brand. The following examples show some of these variations :—

	No.							Ultimate strength.	Ultimate elongation
Swedish, R.F. .	534	30000	0.200	40000	0.798	50000	1.6000	49122	2570
Swedish, X. .	533	“	0.200	“	0.510	“	1.670	50262	1858
Bradley, Hoop L.	527	“	0.036	“	0.350	“	0.998	56004	2300
Bradley, B. B. Scrap.	517	“	0.004	“	0.228	“	0.850	58571	2500
Low Moor, .	504	“	0.030	“	0.190	“	0.600	59726	2583
Farnley, .	502	“	0.045	“	0.210	“	0.630	64133	2647
Govan, Diamond,	511	“	0.017	“	0.160	“	0.630	59726	2717
Ulverston, .	518	“	0.028	“	0.170	“	0.630	58000	2030
Ulverston, .	535	“	0.132	“	0.604	“	“	48870	2388
Bradley, Crown S.C.	505	“	0.040	“	0.200	“	0.690	62244	2534
Govan, Star, .	508	“	“	“	0.375	“	0.405	60722	1130
Russian, C.C NO,	525	“	0.044	“	0.150	“	0.873	56477	0650
Crank-shaft, .	536	“	0.170	“	0.820	“	“	44561	1754
Crank-shaft, .	537	“	0.230	“	1.070	“	“	43120	2461

Several of the bolts were marked so that it could be seen whether they stretched uniformly throughout their length. With few exceptions this was found to be the case until very near rupture, when they more or less suddenly drew out at one part, or in some cases at two or even three; and the lateral contraction at fracture was found not only to vary extremely in amount, but also to be more abrupt in some specimens and more gradual in others. A number of the plate specimens were polished on one side, and a series of circles drawn, which were transformed more or less into ovals when the strain was applied.

A series of curves of elongation are given among the plates at the end of the volume, showing at a glance the very varied character of the results obtained, and clearly illustrating the greater or less abruptness with which the rate of stretching increases just before rupture.

The number of specimens tested, and the discrimination with which the experiments were conducted and the results classified, gives much value to the information Mr. Kirkaldy has thus supplied as to rates of stretching under the higher strains. The pieces (ranging from 20 to 30 inches) were, as our author remarks, too short to observe the minute variations under strains less than from 26,000 to 30,000 lbs. per square inch. For these we must still depend upon the conclusions of previous investigators, which, however ably formed, are very deficient in the two respects in which the inquiry before us is strongest—namely, breadth of induction, and precision in distinguishing the peculiar qualities of the several specimens.

The greatest elongation (in parts of the original length) had been stated by a high authority to be greater in shorter than in longer bars. Our author points out the reason of this hitherto unexplained fact, which becomes readily understood on looking at his elongation curves. The ultimate elongation is made up partly of a pretty uniform stretching of the entire length of the bolt, and partly, as we have seen, of a sudden drawing out just before rupture, near the place

of fracture. The former would give the same rate of increase in a long bolt as in a short one; the latter, being of equal amount in the two cases, would make the total elongation of the shorter bolt greater in proportion to its length than that of the longer one; but this difference must vary with the quality, temper, and shape of the metal, and the sudden or gradual putting on of the breaking strain.

It was also found that with rolled iron bars of the same brand, the smaller the diameter the less was the ultimate elongation; and this, notwithstanding that the breaking strain per square inch for the smaller bars was decidedly greater than for the larger. The rates of elongation for equal rates of strain were reduced in a marked manner as the bars were rolled down from their original to smaller diameters.

In trying how various treatment affects the strength of steel, Mr. Kirkaldy brought out a very unexpected and striking result, namely, that the strength of steel is prodigiously increased by heating it, and then plunging it in oil.

“For the first trial, six pieces were taken from one bar of ‘chisel cast steel,’ and forged into shape. 1006, Table N, was heated and allowed to cool slowly; 1002, heated and plunged into cold water; 1003, same as the last, but tempered to yellow shade by slightly heating; 1005, same as before, but tempered to blue shade; 1004, also heated, cooled as before, and brought to ‘spring temper’ with tallow; 1001, heated and plunged into oil, instead of water. Now, observe the varied results:—1006, soft, bore 121,716 lbs. per square inch; 1002, cooled in water, extremely hard, only 90,049 lbs.; 1001, cooled in oil, and hard, actually bore 215,400 lbs., or $96\frac{1}{2}$ tons per square inch, showing a gain in strength of 77 per cent.; whilst 1002 shows a loss of 26 per cent., 1001 being $2\frac{3}{4}$ ths stronger than 1002. The other bolts, 1003, 1004, 1005, also show a loss in strength, respectively, of 17·0, 13·8, and 8 per cent. This singular effect of hardening in oil was fully corroborated by subsequent tests, shown in the Table. Various qualities of steel were taken, and the degree to which they were heated before immersion was varied, to observe the difference. The following is the percentage of increase in strength, beginning with the hard steels highly heated, and ending with the soft steels slightly heated:—7·90, 77·6, 71·4, 70·9, 65·1, 64·1, 58·5, 57·0, 55·2, 53·2, 44·8, 40·7, 29·5, 24·2, 15·6, 11·8. In a few instances coal-tar was tried, and in some tallow; but the results, although good, were inferior to those with oil, which was of the coarsest and cheapest description. Rivet steel heated, and cooled in water, shows a loss in 1035 of 24·4, and in 1042 a loss of 18·5 per cent. confirming the accuracy of the former experiment. Of course the writer was fully aware that oil had previously been used for hardening sundry thin articles; it was not, however, to increase their strength, but because they were distorted by immersion in water.”

Steel plates similarly treated also showed a great increase of strength; and trials by hammering under heavy strain, and by bending, showed

that the metal was not only hardened but toughened by being cooled in oil. Experiments on riveted steel plates established the further fact that the loss of strength caused by the rivet holes is more than counterbalanced by the increased strength of the hardened plate.

It is to be remarked that the tensile strength of steel established by Mr. Kirkaldy's investigation is very far below that obtained by Mr. W. H. Barlow from experiments conducted at the Royal Arsenal, Woolwich (of which a notice appeared in this *Journal*, vol. xxv. p. 39.) The reason of this is very satisfactorily traced to the different forms of the specimens tested in the two cases; Mr. Kirkaldy's being in the ordinary shape of bolts, while Mr. Barlow's were short thick blocks gradually tapered off towards the middle to a minimum section. The strength deduced from the Woolwich experiments is between 30 and 40 per cent. more than that given by the experiments now before us; and from his own trial of the effects of merely altering the shape without altering the minimum sectional area, our author shows that this difference is anything but surprising. The Woolwich test having thus been exceptionally favorable in its conditions, Mr. Kirkaldy's results must be taken as the real indication of the tensile strength of the metal under ordinary circumstances.

Experiments on the strength of welded joints, different sizes and qualities of iron being employed, all concurred to show the extreme uncertainty of such work, even in the most practised hands.

"The pieces were cut through the middle, and then scarfed and welded in the ordinary manner by the same smith who prepared the bolts for the other experiments, and a few by a chain-maker, for comparison. The result varied greatly,—fourteen, as operated on by the smith, show a loss, compared with the original whole bar, from 4.1 to 43.8 per cent., the mean loss being 20.8 per cent.; four by the chain-maker, from 2.6 to 37.4; mean, 15.1 per cent. Of the former, four broke solid, away from the weld; eight, partly through solid portion and partly at the weld; two separated at the weld. Of the latter, two broke solid, one broke partly solid and partly at the weld, and one gave way at the weld."

The following experiments on the effects of frost upon wrought iron, while they do not go as far as could have been wished, are not without interest. They would seem to show that in iron of good quality the loss of strength from this cause is less than might be thought.

"Frost being considered to act injuriously on the strength of iron, some experiments were made during the severe weather in Dec. 1860, to ascertain its effects. A bar of Glasgow B Best, $\frac{3}{4}$ -inch diameter, was converted into ten bolts in the ordinary way. Six were exposed all night to intense frost, and tested in the morning with the thermometer at 23° Fahr. The other four were kept in a warm place, and carefully protected during testing. Three were tested with gradual, and seven with sudden strains. When the strain was gradually applied there was very little difference between the specimen tested in the ordinary condition and the two that were frozen; the former bore

55,717, the later 54,385; difference, 1332 lbs., or 2·3 per cent. less. The difference under sudden strains is somewhat greater, viz: 3·6 per cent. less when frozen. The load just sufficient to cause rupture was in the one case somewhere between 50,835 and 49,948; in the other, between 49,060 and 48,109; the mean in the one instance being 50,391, in the other, 48,584; difference, 1807 lbs., or 3·6 per cent. The writer regrets that other duties prevented him carrying out his intention of repeating these experiments with bars of various qualities. It will be noticed that the bar tested happened to be of superior quality; had it been of a coarser description, the difference when frozen might have been much greater. The frozen bolts were coated with a thin layer of ice, for the purpose of better observing the effects produced. In one specimen with strain slowly applied, the ice gradually became opaque and white, and just before breaking it resembled hoar frost. In another, under sudden strain, the ice remained transparent, and the instantaneous stretching of the specimen was most beautifully exhibited by the ice cracking and forming a series of complete rings. In another specimen the strain was greater than in the last, and caused the rupture of the specimen; the heat thereby generated was apparent by the ice melting, and in the formation of vapor."

The specific gravities of upwards of 160 specimens of iron and steel are given in a table, arranged according to the brands. The means range from 7·7677 for steel bars rolled, to 7·4276 for puddled iron rolled, the specific gravity generally indicating pretty correctly the quality. One result is remarkable as contrary to the common idea that the density of iron is increased by cold-rolling. Mr. Kirkaldy finds that the reverse is actually the case.

"The specific gravity of a bar in the ordinary condition was 7·6360; the mean specific gravity of four pieces cold-rolled was 7·5824; that of two pieces of boiler plate in the ordinary condition was 7·5664; and that of two other cold-rolled pieces was 7·5392. Instead of an increase we have a decrease in the specific gravity of 0·70 per cent. in the bar specimens, and 0·36 per cent. in the plate specimens, produced by the process of cold-rolling. The writer will now give proof of this fact in another form, by comparing the cubic contents of a bar previous to and after undergoing the process, thus:—

	Diameter.	Area.	Length.	Cubic Contents.
Ordinary state,	·825	·5310	35·06	18·6168
Cold-rolled,	·764	·4584	40·94	18·7669

We have here an increase in the bulk of this specimen of 0·1501 cubic inches, or 0·86 per cent."

Although these data show that it is not, as usually supposed, the case that the metal is consolidated by cold-rolling, there is no question as to its being greatly hardened and made capable of standing higher strains than in its ordinary state.

"'Blochairn Best' boiler plate; lengthways, 'cold-rolled' contracted 2·5 per cent. with 88,993 lbs. breaking strain; cold-rolled and afterwards annealed, 13·6 with 50,960; in the ordinary condition, 14·3

with 45,812; crossways, in the same order, 0·0 with 80,643, 7·2 with 48,674, and 7·7 with 43,020. These 'cold-rolled' pieces were extremely hard, as shown by the above figures, and by the strips splitting when being cut off at the shearing-machine, also by the broken pieces punched out for rivet holes.

"'Blochairn Best' bar; 7 pieces 'cold-rolled' varied from 26·8 with 78,466 to 39·3 with 68,718, mean 36·3 with 74,948; 2 pieces cold-rolled and then annealed, 45·2 with 62,285, and 47·6 with 56,477; 1 piece in usual state, 43·1 with 60,637.

"It will be noticed that the greatly increased strain borne by the pieces after being cold-rolled by Mr. Lauth's patent process, was consequent on the iron becoming very much hardened by the treatment."*

* For further remarks on this subject, See Journ. Frank. Inst., pp. 310 and 397 of Vol. xlv.

W. Clissold's Driving Belt.

From the London Mechanics' Magazine, March, 1868.

We last week alluded at some length to the interesting subject of machinery belts, and we also gave a short account of the belt patented by Mr. W. Clissold, of Dudbridge, Gloucester. The following is a description of this novel mode of constructing that class of driving belts which bind by lateral pressure on their pulleys, and thereby take so firm a hold as to remove the liability to slip, which is a disadvantage common to ordinary driving belts. This improved class of belts (which already forms the subject of letters patent granted to Mr. Clissold, and bearing date May 22d, 1860, No. 1266), may be described as an endless band beveled at its edges to fit into V-grooves formed in the periphery of the driving pulleys, such band being composed of layers of leather or other material connected together by pins, or otherwise. In practice it has been found that the beneficial thickness of which these belts may be made is limited, by reason of the unequal strain upon the outer and inner layers, or parts of the material composing the belt, and, consequently, that the strength of such belts cannot with advantage be indefinitely increased. From this cause it was deemed necessary to limit the application of belts constructed of a wedge or taper form in cross section to uses where no great strain was likely to be experienced.

The object of the present invention is to increase the strength of belts of this class, so as to render them equal to the heaviest work to which it has hitherto been or may hereafter be found desirable to apply driving belts or bands. To this end, instead of making beveled-edged belts as heretofore, with one continuous length of beveled edge, they are formed of links, which, while presenting good contact surfaces to the V-grooves of the pulleys (against which they will press laterally without touching the bottom of the grooves), will so divide the unequal strain upon the inner and outer surfaces of the belt hitherto found so destructive to the wedge form of belt as to render the strain nugatory. The friction or wedge-shaped links may be made of strips of leather or other flexible material coiled up to the ordinary