MECHANICAL TESTS.

[Condensed from the (London) Artizan.]

We certainly possess great facilities for applying various kinds of strains to any samples we may desire to experiment upon; but experience shows that, although a sample of material may withstand a certain test once or twice, yet at some future, and perhaps not very distant, time that same sample will rupture under a strain not equal to that applied at the time of testing, but considerably below it.

Some engineers have a great objection to iron which stretches notably previous to its fracture, but for purposes where the structure, in which the iron is used, is liable to alterations of strains, producing vibration and concussion, this description of metal is decidedly preferable. Good bar iron for girders and bridgework may stretch nearly, but not more, than one inch per foot previous to fracture, and ultimately break at about 23 tuns to 25 tuns per sectional square inch. Iron which will not stretch much is usually hard, and of less ultimate strength than the softer material here alluded to. About three quarters of an inch, as the ultimate oblongation per foot, may be very fairly specified for the class of work to which we are alluding, but there should be no perceptible permanent elongation (or permanent set, as it is more commonly called), until the strain has reached at least 10 tuns per sectional square inch.

In stretching, the bars or pieces of plate necessarily become reduced in sectional area, and it may be worthy of notice that they contract chiefly in width, and scarcely at all in thickness, if they be tolerably thin, which is probably due to the position in which they are rolled in the iron mill; for the thickness of the bar or plate being determined by the distance of the rolls between which it is drawn, and its being squeezed through such rolls, it follows that the various layers or lamina of metal are pressed very close together, so as to strongly resist being brought into nearer proximity, whereas there being little or no pressure laterally upon the bars, the fibers are not in this direction so closely packed; thus the bar becomes narrower, more readily than thinner, than it was previous to being submitted to the process of testing.

In testing structures or machines of any description, especial care should be taken to guard against over testing, and no test should ever be applied much in excess of the greatest strain to which the material will be subjected in ordinary work; for if the iron be once injured, the injury will be continually augmented by even moderate loads, and at last the work will give way under a strain perhaps one half of the test load originally applied. In fact, we have no doubt that in many cases of accidents which have occurred even after years of satisfactory working, the cause of disaster is to be found in original over testing of the metal, inaugurating a slight flaw or lesion of fiber which has gradually, but surely, increased, until at last the sectional area of the material which remains is insufficient to do even its ordinary duty.

The safe working strain on iron is about one half of that load which produces the first permanent set, and this, as we have stated above, should not occur under less tension than ten tuns per sectional square inch, or say 20,000 lbs., hence the safe working load in tension of plate and bar iron may be taken at 10,000 lbs. per square inch of sectional area. In compression the permanent set should commence at about 16,000 lbs. per inch, therefore the safe working load would be taken at 8,000 lbs. per square inch of sectional area.

Now, let us see what is the proper course to pursue in testing material of which it is proposed to construct bridges or other works in iron. First, as to the terms of the specification, let us assume that the iron is not to stretch more than three quarters of an inch per foot before rupture, and not to break under 44,000 lbs. per sectional square inch. In the first place, portions taken from plates, flat bars, and angle and T irons for the purpose, should be tested, in order to ascertain their qualities; this done, the iron used in the work should be examined carefully to see that there are no visible flaws in it; and if there be large masses of metal, the fire test or the magnetic test may be applied to ascertain if there are within it any imperfect welds, or "cold shuts" as they are technically termed; and when the work is complete, it should be finally tested by loading it with the greatest load that can ever come upon it. This load should be left upon it long enough to allow the rivets, bolts, etc., to take their bearings (say twenty-four hours), after which it should be removed, the permanent set due to imperfect joints noted, and the load applied again, on removing which there should be no further permanent set notable. It may, however, in some cases happen that the joints will not all come down at the first loading; but there is a point in every structure at which it will cease increasing its permanent set with recurring loads, if it should be sufficiently strong to do its ordinary duty satisfactorily.

Thus, to take an example, to show how over testing may lead to subsequent accident. although at the time no injury is visible from the test applied; let it be determined to test some iron to 15,000 lbs. per sectional square inch, and suppose there is a flaw in the metal which loses one fourth of its area, then the actual strain per square inch on the remaining section will be 20,000 lbs.; hence on that part the point of permanent elongation is reached, and in the course of time successive loads continue to stretch the metal until at length it gives way altogether. Now, if that metal had only been tested to a little over 10,000 lbs.. the load which it was intended to sustain ordinarily, the metal would not have been injured even at the defective place, but would probably have done its work satisfactorily. On the other hand, it may be said that perhaps the load of 10,000 lbs. might start an injury on some part of the structure—and even that might be the case—but still it is useless to run unnecessary risks of depreciating the strength of the material.

While speaking of the inutility of severe tests, we may refer to an accident which occurred some time since to a large chain, of the description known as short-linked. The chain in question was tested to a load of over sixteen tuns gross weight, and a few weeks after snapped under a load which did not exceed eight tuns. The fractured link exhibited a cold cut, showing that half the area of the metal in the link was lost. A portion of the same chain tested to fracture showed an ultimate strength of over twenty-five tuns gross load.

In our opinion, in respect to the question of chains, a portion of any given chain should be cut off and tested to its breaking strain, and the remainder, or that part which is intended to be practically applied, should be tested to a load but slightly exceeding that to which it will be habitually exposed; and subsequently it should be submitted to the fire test, which is conducted as follows: The chain is gradually passed through a smith's fire, and every link carefully examined when at a clear red heat, water being poured on each link, when any defective shut is sure to show itself, and all defective links must be then cut off and replaced by sound ones. With chains thus examined we have never had an accident in use, but have sometimes found two or three bad links in one length which had passed the ordeal of a licensed testing house, thus showing that the ordinary chain test (unfortunately too much relied upon) is, in a practical sense, no guarantee at all of the safety of the chains tested; which, by the way, might be further instanced had we space to multiply examples.

The remarks made above on the over testing of iron girders will of course equally apply to wrought iron boilers, and, indeed, it seems absurd to test a boiler up to a pressure of eighty or ninety pounds per square inch, which in actual working will never contain more than thirty lbs. per inch, and this is another instance of trying to be too sure.

We will now pass on to the question of testing cast iron girders. Here it may very easily be shown how important it is that the metal should be sufficiently elastic to allow of a notable amount of deflection before fracture, and more especially if the case of a sudden concussion be taken for example. If a body fall a certain distance, it acquires a corresponding amount of accumulated work, supposing there has been no resistance to its motion while falling, and this work is represented by its weight multiplied into the distance through which it has fallen. Let the weight equal 10,000 lbs., and suppose that the hight of its fall is forty inches, then the amount of accumulated work acquired by the mass during its fall will be—

$$10{,}000 \text{ lbs.} \times 40 \text{ in.} = 400{,}000 \text{ inch lbs.},$$

that is to say, work equal to 400,000 lbs. raised one inch high.

Let us now assume that there are two cast iron girders of equal ultimate strength; that is to say, that they will both break with the same weight laid upon them gradually, but that one deflects two inches and the other three inches previous to rupture; that is to say, the latter deflects under a given load fifty per cent more than the former; we shall find the one that deflects most suffers least from the blow of the falling weight. The amount of accumulated work in a body being known, and the distance through which it has to pass in expending such work, the force or pressure is ascertained by dividing the accumulated work by such distance. Now, the distance through which the weight has to pass is represented by the deflection of the girder, consequently in the two cases we have the following means, loads, or pressures on the girders: First girder.—Mean load due to concussion $= \frac{400{,}000}{2} = 200{,}000$ lbs. Second girder.—Mean load due to concussion $= \frac{400{,}000}{3} = 133{,}333$ lbs.

Hence the girder which deflects most suffers least mean load from the fall of a weight upon it, and what is true of a concussion thus produced must be true of all concussions.

TOOLS FOR CUTTING METALS.

[Condensed from the Mechanic's Magazine.]

Tools made of inadequate material, improperly fashioned, and wielded by unskilful hands, will inevitably cut a channel through which an employer will readily glide into the Court of Bankruptcy. It is seldom perhaps that such an unfortunate combination of evils is found to exist in any single manufactory, but one or other of them is generally present. Experience has undoubtedly furnished many valuable lessons as to the best kinds of steel for cutting tools, and the proper way to treat and form them, but the teachings of the monitor are not always understood, and are variously interpreted by different learners. Uniformity of practice is perhaps too much to hope for, but it is strange that what is pronounced to be excellent in some instances is denounced as very bad in others, and that neither masters or workmen are agreed as to a specific method of dealing with the questions involved. Much contrariety of opinion obtains, for example, as to the advantage or otherwise of using tools which have been forged entirely from the solid bar, as compared with those which are retained by, and therefore detachable from, holders. Some assert that small portable cutters of the latter description, and especially if they be made—as they usually are—from round bar steel, are the reverse of being serviceable or economical. They are said to wear very fast on the clearance side, whilst the top edge sustains comparatively little deterioration. If this be so, it is a fatal barrier to any system of machine grinding, and necessitates that this kind of reparation be performed by hand. Here if the statement be true is a manifest disadvantage, involving the expenditure of extra time and money. *Per contra,* it is asserted that separate cutters may be worked with more economy than solid forged tools, since the former can be worked down to a much shorter length than the latter, before being laid aside. This indeed is incontestable, but, say the "solid" men, general and heavy work cannot be effected by such appliances, although light and special tasks may be accomplished by their agency.

In the portable tool, the section need not be so large as in the case of the solid forging, and thus where great quantities are used, the stock of steel held in reserve may be smaller. The economy here of course is obvious, but the "separatists" further advance that, as the solid tool must be cut from a square or rectangular bar, it must also be forged into shape before use, and the operation will have to be repeated again and again ere it is used up. Separate tools do not require forging at all, since whatever section of steel be employed, it is only necessary to select a bar that is uniform, cut it into proper lengths, and then harden and grind the ready made cutters. These and similar practical considerations are, beyond doubt, worthy of attention. Probably it may be discovered eventually that the advocates of solidity and separation are like the travellers with the chameleon, all right and all wrong. Much depends upon the class of work which has to be produced. The happy medium consists in selecting the right tool for the right work, just as we wish to see, in a wider field of action, "the right man in the right place."

There are, however, other phases of diversity in regard to metal cutting tools. Separate cutters made from round bar steel have their advocates, whilst the tools of triangular form are not without supporters. The latter assert that such instruments as the last named, may be made to produce work of a finish superior to that obtained by the use of tools made from round bars. Tools presenting large cutting areas, on the contrary, it is urged, cannot be made to yield the evenness of surface which results from the application of angular and smaller cutting edges. This test of character, however, will greatly depend on the amount of feed or traverse given to the tool, as a coarse or fine pitch with either kind of tool may be made to produce surfaces uneven or smooth; at least one of the largest firms in England manufacturing agricultural engineering work, celebrated for the excellent quality of its machine work, and whose aim has been to minimise the duties of its fitting shop, has adopted the separate cutter plan, the tools being made almost uniformly from round sections.

With regard to the cutting angles of tools, there is less divergence of opinion than exists upon the points above indicated. As a rule, an angle of 50 deg. for wrought iron, and of 60 deg. for cast iron and brass, are the standards adopted, and this arrangement is no doubt the growth of successful and general experiment. Careful grinding is a question perhaps not sufficiently heeded in some establishments, yet it is one of moment to all concerned in the economical performance of the operations of turning, planing, and shaping metal. The cutting edge of a tool is in appearance, as it is in action, the counterpart of a wedge, and when that edge is well and properly maintained, the resulting work will be far better finished than if the reverse be the case. Sir Joseph Whitworth long since introduced a plan of grinding tools by mechanical means, and which has answered well. The stones in this arrangement are fitted on movable seats, whilst the tool is held in the proper diagonal position for giving it its right cutting angle. Some firms have gone so far as to make the grinding of tools a distinct branch of their works, and to appoint a general grinder for the whole of each establishment. This is for several reasons, as it seems to us, a questionable course of action, but its advisability or otherwise must of course be determined by those who are most interested in the results of such experimentation.

In due time the best form of tools, the best material of which to make them, the best way to keep them in repair, and the best way of using them, will possibly determined and adopted by universal consent; meanwhile more light upon all these points is needed.

Circular Saws for Stone Work.

A most important addition to the means for working stone, which art has hitherto advanced very little since the creation, has been proposed by Mr. J. E. Emerson, now residing at Pittsburgh, Pa, the inventor of the movable toothed saw. Mr. Emerson's inventions have been described in our columns, and numerous contributions, of a highly practical and valuable nature, have appeared in this journal, and are familiar to our readers.

With the sagacity of a practical man, Mr. Emerson saw that to avoid the difficulties which have arisen in cutting stone, either by steel or carbon points, the saw teeth should be of the pattern of a mason's chisel, and capable of being varied in position, that new faces of the tool may be applied as the work progresses, and the tooth becomes partially worn. The saw has to be run very slowly, and the teeth must cut away chips of regular size. The effectiveness of the invention is increased by the simplicity with which the teeth can be changed, a new set being inserted in less than three minutes. Mr. Emerson has taken out a patent which covers the use of adjustable, revereible, and interchangeable chisels or cutters, for sawing stone, also the nse of adjustable diamond or carbon holders, the use of diamonds or carbons alternated with the chisels, and the manner of fastening them in the saw plate.

THE average length of passage of the steamers in the East India jute trade, plying between Calcutta and Dundee, Scotland, is $56\frac{1}{2}$ days, being several days less than one half that of the sailing vessels.