be expected, no approach to conformity with Hooke’s law until recovery has been brought about either by prolonged rest at ordinary temperature or by exposure for a short time to some higher temperature. After recovery has taken place the elastic limit in compression is found to have been lowered; that is to say, it occurs at a lower load than in a normal piece of the same metal. But it appears from Muir’s experiments that the amount of this lowering is not at all cqual to the amount by which the elastic limit has been raised in tension. In other words, the general effect of hardening by overstrain, followed by recovery of elasticity, is to widen the range within which a practically complete proportionality between strain and stress holds good.

*Contraction of Section at Rupture.—*The extension which occurs when a bar of uniform section is pulled is at first general, and is distributed with some approach to uniformity over the length of the bar. Before the bar breaks, however, a large additional amount of local extension occurs at and near the place of rupture. The material flows in that neighbourhood much more than in other parts of the bar, and the section is much more contracted there than elsewhere. The contraction of area at fracture is frequently stated as one of the results of a test, and is a useful index to the quality of materials. If a flaw is present sufficient to determine the section at which rupture shall occur the con­traction of area will in general be distinctly diminished as com­pared with the contraction in a specimen free from flaws, although little reduction may be noted in the total extension of the piece. Local extension and contraction of area are almost absent in cast iron and hard steel; on the other hand, they arc specially prominent in wrought iron, mild steel and other metals that combine plasticity with high tensile strength. An example is shown in fig. 20, which is copied from a photograph of a broken test-piece of Whitworth mild fluid-compressed steel. The piece was of uniform diameter before the test.

Experiments with long rods show that the general extension which occurs in parts of the bar not near the break is somewhat irregular;@@1 it exhibits here and there incipient local stretching, which has stopped without leading to rupture. This is, of course, due in the first instance to want of homogeneity. It may be supposcd that when local stretching begins at any point in the earlier stages of the test it is checked by the hardening effect of the strain, until, finally, under greater load, a stage is reached in which the extension at one place goes on so fast that the hardening effect cannot keep pace with the increase in intensity of stress which results from diminution of area; the local extension is then unstable, and rupture ensues. Even at this stage a pause in the loading, and an interval of relief from stress, may harden the locally stretched part enough to make rupture occur somewhere else when the loading is continued.

*Influence of Local Stretching on Total Elongation.—*Local stretching causes the percentage of elongation which a test-piece exhibits before rupture (an important quantity in engineers’ specifications) to vary greatly with the length and section of the piece tested. It is very usual to specify the length which is to exhibit an assigned percentage of elongation. This, however, is not enough; the percentage obviously depends on the relation of the transverse dimensions to the length. A fine wire 8 in. long will stretch little more in proportion to its length than a very long wire of the same quality. An 8-in. bar, say 1 in. in diameter, will show something like twice as much the percentage of elongation as a very long rod. The experiments of Barba@@2 show that, in material of uniform quality, the percentage of

extension is constant for test-pieces of similar form, that is to say, for pieces of various size in which the transverse dimensions are varied in the same proportion as the length. It is to be regretted that in ordinary testing it is not practicable to reduce the pieces to a standard form with one proportion of transverse dimensions to length, since tests in which the relation of length to cross-section differ give results which are incapable of direct comparison with one another.

*Influence on Strength.—*The form chosen for test-pieces in tension tests affects not only the extension but also the ultimate strength. In the first place, if there is a sudden or rapid change in the area of cross-section at any part of the length under tension (as at AB, fig. 21), the stress will not be uniformly distributed there. The intensity will be greatest at the edges A and B, and the piece will, in con­sequence, pass its elastic limit at a less value of the total load than would be the case if the change from the larger to the smaller section were gradual. In a non-ductile material rupture will for the same reason take place at AB, with a less total load than would otherwise be borne. On the other hand, with a sufficiently ductile material, although the section AB is the first to be permanently deformed, rupture will preferably take place at some section not near AB, because at and near AB the contraction of sectional area which precedes rupture is partly prevented by the presence of the projecting portions C and D. Hence, too, with a ductile material samples such as those of fig. 22, in which the part of smallest section between the shoulders or enlarged ends of the piece is short, will break with a greater load than could be borne by long uniform rods of the same section. In good wrought iron and mild steel the flow of metal preceding rupture and causing local contraction of section extends over a length six or eight times the width of the piece; and, if the length throughout which the section is uniform be materially less than this, the process of flow will be rendered more difficult and the breaking load of the sample will be raised.@@3

These considerations have, of course, a wider application than to the mere interpretation of special tests. An important practical case is that of riveted joints, in which the metal left between the rivet holes is subjected to tensile stress. It is found to bear, per square inch, a greater pull than would be borne by a strip of the same plate if the strip were tested in the usual way with uniform section throughout a length great enough to allow complete freedom of local flow.@@4

*Fracture by Tension.—*In tension tests rupture may occur by direct separation over a surface which is nearly plane and normal to the line of stress. This is not uncommon in hard steel and other comparatively non-ductile materials. But in ductile materials under tension the piece generally gives way by shearing on an inclined surface. Very often the effect is a more or less perfect ring-shaped crater on one side of the break and a truncated cone on the other.

@@@1 See Kirkaldy’s *Experiments on Fagersta Steel* (London, 1873).

*@@@2 Mém. de la soc. des ing. civ.* (1880); see also a paper by W. Hackney, “ On the Adoption of Standard Forms of Test-Pieces," *Proc. Inst. Civ. Eng.* (1884).

@@@5 The greater strength of nicked or grooved specimens seems to have been first remarked by Kirkaldy *(Experiments on Wrought Iron and Steel,* p. 74, also *Experiments on Fagersta Steel,* p. 27). See also a paper by E. Richards, on tests of mild steel, *Journ. Iron and Steel Inst.* (1882).

@@@4 See Kennedy’s “ Reports on Rivetted Joints,” *Proc. Inst. Mech. Eng.* (1881-1885). In the case of mild-steel plates a drilled strip may have as much as 12% more tensile strength per square inch than an undrilled strip. With punched holes, on the other hand, the remain­ing metal is much weakened, for the reason referred to in the text.