the field of view, and also to calibrate the readings of the micro­meter scale. The scale allows readings to be taken to 1/50000 in., by estimating tenths of the actual divisions. The arms CP and CQ are equal, and hence the movement of Q represents twice the extension of the bar under test. In another form of the instru­ment adapted to measure the elastic compression of short blocks the arm CQ is four times the length of CP, and consequently there is a mechanical magnification of five besides the magnification afforded by the microscope.

When the behaviour of specimens of iron, steel, or other materials possessing plasticity, is watched by means of a sensitive extensometer during the progress of a tensile test, it is in general observed that a very close proportionality between the load and the extension holds during the first stages of the loading, and that during these stages there is little or no “ creeping ” or supplementary extension when any particular load is left in action for a long time. The strain is a linear function of the stress, almost exactly, and disappears when the stress is removed. In other words, the material obeys Hooke’s law. This is the stage of approximately perfect elasticity, and the elastic limit is the point rather vaguely defined by observations of the strain, at which a tendency to creep is first seen, or a want of proportionality between strain and stress. “ Creeping ” is usually the first indication that it has been reached. As the load is further augmented, there is in general a clearly marked yield-point, at which a sudden large extension ensues. In metals which have been annealed or in any way brought into a condition which is independent of the effects of earlier applications of stress, this clastic stage is well marked, and the limit of elasticity is as a rule sharply defined. But if the metal has been previously overstrained, without having had its elasticity restored by annealing or other appropriate treatment, a very different behaviour is exhibited. The yield-point may be raised, as, for instance, in wire which has been hardened by stretching, but the elasticity is much impaired, and it is only within very narrow limits, if at all, that proportionality between stress and strain is found. Subsequent prolonged rest gradually restores the elasticity, and after a sufficient number of weeks or months the metal is found to be elastic up to a point which may be much higher than the original elastic limit.@@1 It has been shown by

J. Muir@@2 that the rate at which this recovery of elasticity occurs depends on the temperature at which the piece is kept, and that complete recovery may be produced in iron or steel by exposure of the overstrained specimen for a few minutes to the tempera­ture of boiling water. Figs. 18 and 19 illustrate interesting points in Muir’s experiments. In these figures the geometrical device is adopted of shearing back the curves which show extension in relation to load by reducing each of the observed extensions by an amount proportional to the load, namely, by one unit of extension for each 4 tons per square inch of load. The effect is to contract the width of the diagrams, and to make any want of straightness in the curves more evident than it would otherwise be. To escape confusion, curves showing successive operations are drawn from separate origins. In the experiment of figs. 18 and 19 the material under test was a medium steel, containing about 0∙4% of carbon, which when tested in the usual way showed a breaking strength of 39 tons per square inch with a well-marked elastic limit at about 22 tons. In fig. 18 the line A relates to a test of this material in its primitive condition; the loading was raised to 35 tons so as to produce a condition of severe overstrain. The load was then removed, and in a few minutes it was reapplied. The fine B exhibits the effect of this application. Its curved form shows plainly that all approach to perfect elasticity has disappeared, as a consequence of the overstraining. There is now no elastic limit, no range of stress within which Hooke’s law applies. With the lapse of time the curve gradually recovers its straight­ness, and the material, if kept at ordinary atmospheric tempera­ture, would show almost complete recovery in a month or two. But in this instance the recovery was hastened by immersing the piece for four minutes in boiling water, and line C shows that this treatment restored practically perfect elasticity up to a limit as high as the load by which the previous overstraining had been effected. The loading in C was continued past a new yield-point ; this made the elasticity again disappear, but it was restored in the same way as before, namely, by a few minutes’ exposure to 100° C., and the line D shows the final test, in which the elastic limit has been raised in this manner to 45 tons. Other tests have shown that a temperature of even 50° C. has a considerable in­fluence in hastening the recovery of elasticity after overstrain.

In the non-elastic condition which follows immediately on overstrain the metal shows much hysteresis in the relation of strain to stress during any cyclic repetition of a process of load­ing. This is illustrated in fig. 19, where the arrows indicate the sequence of the operations.

When a piece of iron or steel which has been overstrained in tension is submitted to compression, it shows, as might

@@@1 See experiments by Johann Bauschinger, *Mitt, aus dem mech-tech. Lab. in München* (1886), and by the writer, *Proc. Roy. Soc.,* vol. xlviii. (1895). A summary of Bauschinger’s conclusions will be found in Martens’s book, cited above, and in Unwin’s *Testing of Materials.*

@@@2 Muir, “ On the Recovery of Iron from Overstrain,” *Phil. Trans.* A, vol. 193 (1900).