The latter view is the one which has been widely held, and the endurance limit has been regarded as coincident with the "true" elastic limit of a material. In favor of this view may be cited the fact that the number of repetitions of stress necessary to cause failure increases very rapidly as the fiber stress is lowered; that a number of tests have been made in which test specimens withstood tens of millions of repetitions of stress without failure; and that at low stresses, even with delicate measuring apparatus, there can be detected no signs of structural damage. Various methods have been used for determining the value of the endurance limit for a material; these different methods yield widely varying results.

In favor of the view that damage is done to materials under low stress and that there is a probability of their eventual failure under repeated low stress, the following considerations may be cited:

1. The occurrence of "slip lines" in metal under repeated stress seems to be the result of cumulative damage within a crystal of metal. No sharply defined lower limit has been found, either for the appearance of these slip lines or for their tendency to spread and develop into cracks.

2. The gradual development of permanent set, under repeated stress so low that preliminary static tests had shown no measurable set, seems to the writers to be an indication of damage at low stresses. This development is shown especially by the tests of Bairstow for cycles of stress not involving complete reversal. He found that the set for any stress gradually increased, though for a single cycle of stress no mechanical hysteresis could be detected; and that after several thousand repetitions the set did not further increase during the test. Whether this set would have shown further increase with an increase in the number of repetitions, or whether increase would have been shown by more delicate instruments, is an undecided question. In the opinion of the writers the significant fact is the cumulative development of permanent set under repeated low stress.

3. The sudden sharp breakages which occur in repeated stress tests, even of ductile materials, would seem to indicate that structural damage may be done to material without any undue deformation of the member as a whole. The fact that no undue deformation can be detected is no sure sign that a material is free from danger of failure under repeated stress.

4. Data of tests involving more than a million repetitions of stress are very few, yet frequently machine parts must be designed to endure several hundred millions of repetitions. The repeated stress problems of the time of Wöhler and Bauschinger were mainly problems of railroad bridge members and other structures and machines which would be called on to withstand only a few million repetitions of stress. From the viewpoint of these earlier investigators experiments under a few million repetitions covered the ground; for machines of to-day reliance on the results of such experiments involves enormous extrapolation of test results. The data seem hardly sufficient for establishing an endurance limit for infinite repetition, or even for repetitions numbering hundreds of millions. Moreover, the results of some tests, if taken alone, seem to indicate that some exponential law of endurance holds up to the limit of experimentation. These unusual tests are discussed later.

5. As instruments of increased delicacy are used in measuring deformation, evidences of mechanical hysteresis are found at lower and lower stresses in static tests. In actual material these evidences have been found at stresses not much above ordinary working stresses. When the cumulative action of repeated stress is considered, the indefiniteness of the elastic limit becomes apparent. While the statically determined elastic limit has some significance for static loading, it apparently has no significance as a criterion of endurance strength.

6. If elastic vibrations are set up in metal test specimens such vibrations soon die out. This dying out would seem to indicate loss of energy in heat, with accompanying internal friction, wear, and structural damage.

To the writers it seems that a negative argument against the use of a definite endurance limit is furnished by the indefiniteness of its determination. A common method of locating this limit is to plot from test a curve with stresses as ordinates and number of repetitions to cause failure as abscissas. The curve becomes nearly horizontal at a few millions of repetitions and the horizontal line to which the curve is asymptotic is judged by the eye. The ordinate of this horizontal line is taken as the endurance limit, and in this case gave a value of 18,000 lb. per sq. in.

Another method is to plot stresses (N) as ordinates and values of $1/N$ as abscissas. The endurance limit is taken as the ordinate of the intersection of this curve (extended) with the zero axis. This method, for the same test data as the first method, gives a value for the endurance limit of 17,500 lb. per sq. in.

A third method is to plot stresses as ordinates and some root of $1/N$ as abscissas. Using the fourth root of $1/N$ in the given test data, the endurance limit is found to be 15,000 lb. per sq. in. The eighth root of $1/N$ as abscissas gives the endurance limit as 7,000 lb. per sq. in. This series of tests involved one test at 19 million repetitions and one at 132 millions. If these various methods were applied to tests covering no more than one million repetitions of stress the results would show still greater variation.

Effect of Rapidity of Repetition of Stress.—A certain amount of time is required for any member of a machine or structure to assume the deformation corresponding to any given load, and if repetitions of load follow each other at intervals shorter than this time, the deformation in the member, the stress set up, and the number of repetitions it will withstand may be appreciably affected. A few recent British tests of material under repeated stress seem to indicate that for small members there is no appreciable effect produced by varying the rapidity of repetition of stress below about 2,000 repetitions per minute. Above that speed very little test data are available.

Effect of Rest on Resistance to Repeated Stress.—If metal is stressed beyond the yield point so that plastic action is set up, its strength and its elastic action are improved under subsequent stress, if the material is allowed to rest. Recent experiments by British investigators seem to indicate that, for steel and iron at least, the effect of rest on the resistance to repeated stress is negligible for unit stresses below the yield point of the material.

Effect of Sudden Change of Outline of Member.—Every sharp corner in a piece subjected to repeated stress facilitates the formation of micro-flaws in the piece. From results of repeated stress tests made by Stanton and Bairstow, at the British National Physical Laboratory, on test specimens of different shape, the superiority of the test specimens in which sharp corners are avoided is obvious. The relative values for strength under repeated stress for the shapes tested seems to be about as follows: Rounded fillet, 100; standard screw thread, 70; sharp corner, 50.