Most parts of machines and mechanisms operate at loading rates which appreciably exceed those used in the usual mechanical tests. Many works have been devoted to an investigation of the effect of the rate of loading on the characteristics of the strength of metals, plastics, and certain other materials.

The effect of the loading rate on the strength of cermets has not been investigated in a wide range of rates. This problem is of considerable interest in connection with the characteristics of the fabrication of such materials and their composition.

In this article a method is developed for investigating the effect of the loading rate on the strength characteristics of brittle materials in a wide range of rates, and results are given which were obtained on investigation of a number of cermets.

Material of the investigation. We investigated three types of metal powder materials:

1. Heat-resistant cermets on a base of chromium carbide $\text{Cr}_2\text{C}_3$ (73%) and Ni (28%). The specimens for the investigations were fabricated, as is usual in powder metallurgy, by pressing the mixture, consisting of powders of chromium carbide and nickel, in special dies with subsequent sintering of the compacts.

   The chromium carbide was obtained by the direct reduction of chromium oxide by carbon black. Its chemical composition was as follows: 85.5-86.8% chromium, 13.0-13.6% carbon; not more than 0.3% free carbon. The purity of the nickel powder was not less than 98%. The grain size of the chromium carbide and nickel was less than 40 $\mu$m. The compacts were sintered in furnaces with a graphite heater under a hydrogen protective medium.

   By using this method we can fabricate a range of materials differing in the content of the refractory carbide and ductile nickel. With increasing carbide content, the heat-resistance of the material increases and the ductility decreases, and vice versa.

2. A heat-resistant cermet on a silicon carbide base similar in content to silits which, as is known, are used as heating elements in furnaces. Specimens of this material were fabricated by impregnation of the graphite compacts with molten silicon in furnaces with a graphite heater in a dried-hydrogen medium. The chemical composition of the material after fabrication was: 65.83% SiC; 25.13% $C_{\text{free}}$; 9.04% Si$_{\text{free}}$.

3. Iron base cermets with a porosity of 15 and 84%. The specimens were fabricated by lathe-machining compacts of sintered iron powder.

   The compacts were pressed under different pressures so as to obtain the above-mentioned final porosities, and sintered at 1300° for 2 h in hydrogen. After machining, the specimens were annealed at 1100° in hydrogen to eliminate cold working and for oxidation.

Procedure. The main difficulties we encountered in the investigation were the following:

a) It was necessary to provide a sufficiently large range of loading rates (5-6 orders) which would permit us to clearly reveal the investigated pattern. In addition, the scheme of loading at all loading rates had to be the same;

b) It was necessary to measure the stresses at the instant of fracture directly on the specimen at high loading rates to obtain sufficiently reliable results. The use of indirect methods can lead to substantial errors.

* Printed in the form of a discussion.
These problems were solved in the following manner. The tests were carried out on two devices, the diagrams of which are shown in Fig. 1a, b. The first device (Fig. 1a) was used in tests with low loading rates, $10^{-3}$ to $10$ kg/mm$^2$·sec. This is an ordinary lever machine with a gear ratio of 1:15.

Loading was carried out by means of water flowing at different rates into a vessel suspended on a lever in place of a load (Fig. 1a). The stresses in the specimen at the instant of fracture were calculated by the known formulas of material resistance by the weight of the water in the vessel. When the specimen was subjected to bend testing instead of tensile testing, a special attachment was used in the device (Fig. 1a) which enabled us to bend the test piece; the loading scheme remained the same.

When testing at a high loading rate ($10^{-10^3}$ kg/mm$^2$·sec) we used the scheme shown in Fig. 1b. In this device the specimen was loaded by a spring which was stretched by an eccentric rotated through an electric motor. By changing the rpm of the eccentric and the rigidity of the spring, we could change the loading rate over a wide range. In this investigation the rpm of the eccentric was about 1500 and the rigidity of the spring was 100 kg/mm.

The maximum stresses in the test piece at the instant of fracture were determined in this case by wire sensors glued in the zone of supposed fracture (in the middle of the length of the specimen on the stretched fibers). The signal from the sensors as the test piece was loaded was recorded on film by an MPO-2 loop oscillograph and appropriate apparatus. Before testing each specimen the oscillograph was calibrated and thus the scale for recording the deformations of the film was determined. Knowing the recording scale of the deformations, the maximum deviation of the beam on the film, and by introducing a correction when needed for nonlinearity of the "o-ε" dependence, we could determine with sufficient accuracy the stresses in the test piece at the instant of fracture. The rate of loading was calculated from the oscillograms by the travel speed of the film.

Results. Chromium and silicon carbide base materials were subjected to bend testing by a concentrated force at rates of $10^{-3}$ to $10^3$ kg/mm$^2$·sec on straight rectangular specimens with sizes of $5 \times 7 \times 85$ and $12 \times 15 \times 100$ mm respectively. Iron base materials were tensile tested at rates of $10^{-3}$ to $10$ kg/mm$^2$·sec on specimens $5$ mm in diameter.

The first two investigated materials were not ductile and their strain diagrams were almost straight lines. Figure 2a, b (Cr$_2$C$_3$ and SiC base materials) shows such diagrams obtained on bending with a concentrated force by means of wire sensors glued onto the sides of the specimens subjected to tension. The stresses in this case were determined for a middle cross section of the specimen by the known formulas for material resistance, and the strains by two wire pickups. One of them was glued to the specimen and the other onto the calibration arm, whose strain served as the standard.

Fig. 1. Diagrams of the devices used in tests: a) Lever device: 1) specimen; 2) hinges; 3) screw; 4) lever; 5) counterweight; 6) eccentric; 7) load. b) Eccentric device: 1) specimen; 2) spring; 3) eccentric; 4) electric motor; 5) loading screw.