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COMPARISON OF THE SIGNALS OF DIELECTRIC AND MAGNETIC PICKUPS WHEN RECORDING SHOCK WAVES OF INTENSITY UP TO 100 kbar

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To measure the profile of a stress wave in condensed media under pulsed loading conditions, quartz [1], manganin [2], and dielectric [3] pressure pickups, capacitive [4] and electromagnetic [5] methods of measuring velocity, etc. have recently been widely used. These enable one to obtain different characteristics of elastoplastic flow and their dependence on the loading parameters.

It is of interest to compare the data obtained using the different methods under identical experimental conditions. In this paper we present the results of a comparison of the pressure profiles obtained by dielectric and manganin pickups for a plate of No. 3 steel loaded with the impact of an aluminum container of diameter 90 mm and bottom thickness 10 mm in a pneumatic-powder impact apparatus described in [6]. The rate of impact was varied from 0 to 900 m/sec. The probes were placed between two steel disks of diameter 120 mm and thickness 20 mm (Fig. 1). Terylene films 0.03 and 0.06 mm thick were used as the dielectric. The manganin pickups were made of PÉMM wire of diameter 0.12 or 0.06 mm, bent in a zigzag manner. Leads of copper foil 0.15 mm thick were soldered to the ends of the pickup. The pickups were then left in a press. The thickness at the point of contact with the lead was not greater than 0.04 mm. The resistance of the pickup together with the lead was 10-15 Ω. Some of the pickups were annealed for 4 h at 160°C.

However, as a result of the measurements we found no difference between the readings of annealed and unannealed pickups outside of the limits of error of processing the oscillograms. The signals were recorded on a bridge circuit similar to that described in [7]. The construction of the dielectric pickup and the recording circuit are shown in [3]. An estimate of the maximum transmitted frequency with respect to the growth time of the pressure in the elastic forerunner carried out as in [8] gives a value of the order of 0.5 MHz for both methods. The average piezosensitivity coefficient of the manganin probe is $\sim 2.5 \cdot 10^{-3} (\Delta R/R)$ $kbar^{-1}$. The piezosensitivity coefficient of the dielectric probe in the pressure range up to 100 kbar varied in the limits $(20-6.5) \cdot 10^{-3} (\Delta C/C)$ $kbar^{-1}$, which corresponds to a sensitivity of 2-0.65 V/kbar for a preliminary polarization voltage of 100 V. Typical oscillograms of the experiments are shown in Fig. 2 for a pressure of 23 kbar. The frequency of the calibration sinusoidal signal is 500 kHz.

To determine the pressures recorded by the dielectric pickup we used a calibration curve, shown in Fig. 3, and the dependence of the relative resistance of the manganin on the pressure taken from [9] for a manganin pickup. Both methods gave similar results when determining the times and pressures at the characteristic points of the profile of the wave in the load phase. The values of the maximum pressures and the pressures corresponding to the elastoplastic transition in the load phase found from the oscillograms agree for both pickups to within 5%. For

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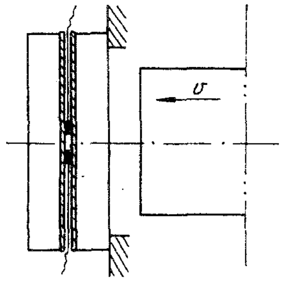

Fig. 1

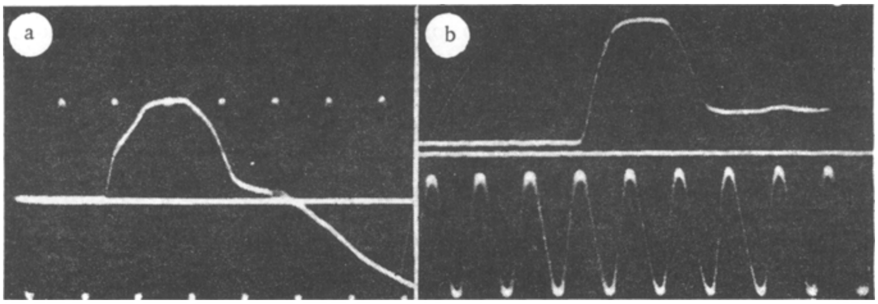

Fig. 2

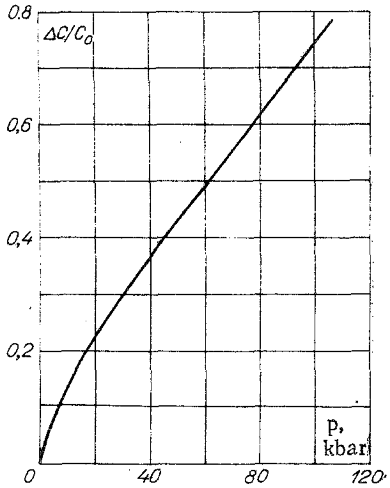

Fig. 3

loading down to zero pressures the resistance of the manganin pickup does not return to the initial value. The difference is 20-25% of the value of the maximum change in resistance of the pickup over the whole pressure range investigated (see Fig. 2b). This makes it difficult to interpret the results obtained using the manganin pickup in the unloading phase. Hence, when investigating the behavior of materials in the unloading phase, it is preferable to use a dielectric pickup.

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CONTINUOUS RECORDING OF THE SPEED OF A SHOCK WAVE IN POROUS METALS AND ITS APPLICATION TO THE MEASUREMENT OF THE SPEED OF SOUND IN VARIOUS MATERIALS

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In studying various materials the mechanical parameters of a shock wave are presently determined by recording the transit time of the wave between fixed points and determining the average speed of the shock wave between these points. In investigating the shock compressibility of porous metals a great deal more information can be obtained by a continuous recording of the position of the shock wave.

The porous sample under study, pressed from metal powder, consists of metal grains, and in the uncompressed state has a finite nonzero resistance made up of the contact resistances between grains. When a shock wave propagates through such a material the thickness of its uncompressed part is decreased and its resistance is changed. By passing a steady current in a direction perpendicular to the wave front and recording the potential drop across the sample with an oscillograph, a continuous trace in (x, t) coordinates can be obtained representing the shock-front trajectory through the sample.

Figure 1 shows a schematic diagram of the experimental arrangement. The porous sample 1 is placed on the metal screen 2 which also serves as an electrode. The shock wave is produced by the impact of the flyer plate 3. On the end surface of the porous sample there is a second electrode 4 whose edges must not protrude into the region subjected to the action of lateral relaxation.

The electric field in the sample will generally not be uniform. The current lines, shown by the open curves in Fig. 1, were determined by using an electrolytic model. The resistance of the sample is determined mainly by the resistance of its central part under electrode 4. In order not to have to correct in the experiment for that part of the field where the current lines are distorted, the sample was made in two parts: the main part, placed on the screen, in which the measurement is performed, and an auxiliary part. To separate the trace of the motion of the shock wave through the main part of the sample from that through the auxiliary part, a layer of another porous metal 5 having a smaller resistivity was deposited on their boundary, for example, nickel powder on copper, or electrical contacts 6 of 0.2-mm-diameter enameled moisture-resistant wire were placed as shown, as is usual in the electrical contact method [1]. The contacts are connected to the electrodes. In the first

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