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RECORDING OF ELECTROMAGNETIC RADIATION UPON FRACTURING OF ROCKS USING A DIGITAL COMPUTER-CONTROLLED MEASURING SYSTEM

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Electromagnetic radiation (EMR) upon fracturing of rocks was examined in [1–3]. In [4, 5], Kurlenya and Kulakov et al. proposed to study EMR using an S-shaped curve in time-spectral frequency coordinates. At the Institute of Hydrodynamics, Siberian Division of the Russian Academy of Sciences, EMR studies are in progress in which for, recording EMR signals, a measuring system consisting of a directional ferrite rod antenna [6], an amplifier, and a digital computer-controlled measuring system is used. The components of the latter were described in [7]. Experiments were performed on a number of granite, marble, alevrolite, and argillite specimens.

In what follows, we shall consider the result of loading for an argillite specimen as an example. In the course of the experiment, 300 cycles of measurements, with 256 points in each, were recorded. The experimental data were obtained at the first moment of loading, 0.1 sec ahead of the fracture, at the moment of formation of the main-crack region (the 220th cycle of measurements, Fig. 1), at 0.1 sec after the propagation of the main crack, and at 0.2 sec after the fracture of the loaded specimen (the 222nd cycle of measurements, Fig. 2). Figures 1 and 2 show oscillograms (a) and spectrograms (b) of the EMR signals in the cycles of measurements just indicated. On the oscillograms, the moments of time are laid off as the abscissa, and the pulse amplitude U is laid off as the ordinate; on the spectrograms, the spectral density and the amplitude are plotted on the abscissa and on the ordinate, respectively.

An analysis of the oscillograms and spectral characteristics has allowed us to reveal some specific features of the electromagnetic radiation from the material under study.

1. At the moment of microcrack accumulation, the maximum spectral amplitudes of EMR signals were recorded sequentially at frequencies of 108 and 41.4 kHz (branch I of the S-shaped curve, Fig. 3).

2. At the moment of formation of the main-crack region in the loaded specimen, the EMR was being recorded for 765 μsec, with the power of the useful signal higher by a factor of 5 as compared with the power of the preliminarily recorded noise. The pulse duration was 10–15 μsec. In this stage, the maximum spectral amplitudes of the electromagnetic radiation were recorded in succession at frequencies of 4, 10, 70, and 96 kHz (branch II of the S-curve). At the same time, there are amplitudes with higher frequencies, for instance, 120 kHz, in the spectrum of the signal (Fig. 1b).

3. At the moment of propagation of the main crack, the spectral amplitudes were maximal sequentially at frequencies of 108 and 2–4 kHz (branch III of the S-curve).

4. Only noise was recorded in the spectrum of the signal at 0.2 sec after the specimen had fractured (Fig. 2b).

5. As is seen from Fig. 1b, the noticeable (in magnitude) low-frequency component of the EMR signal is observed in the spectrogram.

A specific feature of the above experiment is stable recording of high frequencies at the initial stage of loading which corresponds to the process of microcrack nucleation and formation. Such recording was possible due to the use of high-resolution recording equipment (branch I).

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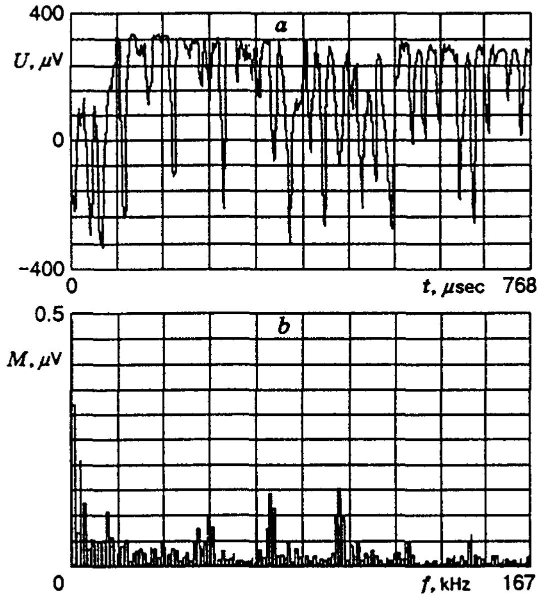

Fig. 1

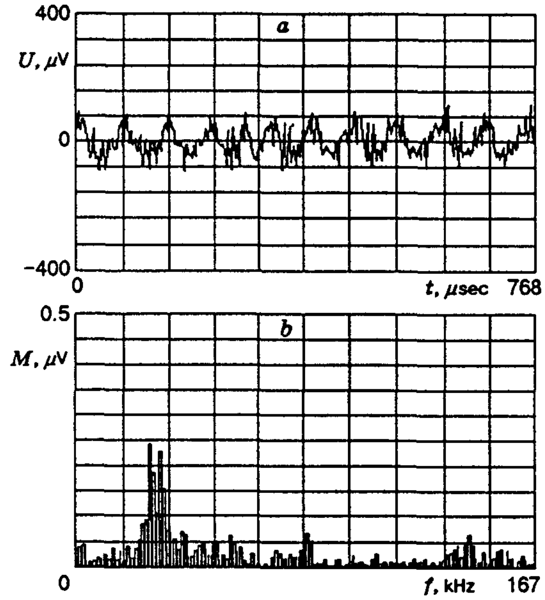

Fig. 2

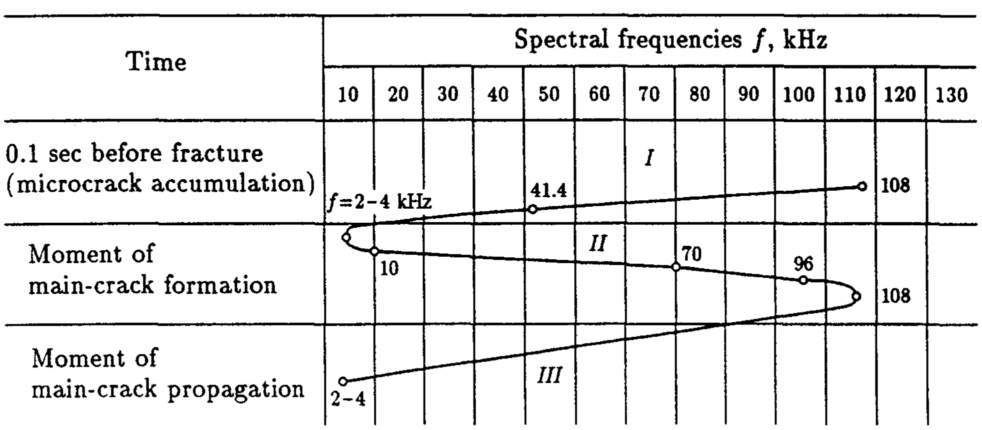

Fig. 3

In concluding, we shall note the following:

(1) A digital computer-controlled system for registration of the electromagnetic radiation generated upon loading and fracture of rock specimens was developed, assembled, and tested in EMR experiments;

(2) An experimental procedure using this system was devised and illustrated by loading a concrete rock specimen (argillite);

(3) An S-curve for the specimen of sedimentary rock (argillite) was constructed, which contains stably recorded points in the high-frequency region of branch I and, hence, indicates the formation of microcracks in the specimen under load;

(4) In an analysis of the spectrograms, an appreciable increase in the low-frequency component of the EMR signals was observed.

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REFERENCES

1. M. B. Gokhberg (ed.) *Inquiry into Electromagnetic Precursors to Earthquakes* [in Russian], Nauka, Moscow (1982).
2. P. V. Egorov, V. V. Ivanov, L. A. Kolpakova, and A. G. Pimonov, "Crack dynamics and electromagnetic emission of loaded rocks," *Fiz. Tekh. Probl. Razrab. Polezn. Iskop.*, No. 5, 20–27 (1988).
3. D. V. Alekseev and P. V. Egorov, "On the shape of an electromagnetic-emission pulse generated by a moving crack," *Fiz. Tekh. Probl. Razrab. Polezn. Iskop.*, No. 6 (1993).
4. M. V. Kurlenya, G. E. Yakovitsakaya, and G. I. Kulakov, "Stage character of the fracture process based on a study of electromagnetic emission," *Fiz. Tekh. Probl. Razrab. Polezn. Iskop.*, No. 1, 44–49 (1991).
5. G. I. Kulakov and G. E. Yakovitskaya, "Features of the change in the frequency spectrum of electromagnetic emission upon fracture of rock specimens," *Prikl. Mekh. Tekh. Fiz.*, **35**, No. 5, 160–165 (1994).
6. V. A. Markov, "Study of electromagnetic emission from rock specimens using a magnetic screened antenna," *Fiz. Tekh. Probl. Razrab. Polezn. Iskop.*, No. 2, 102–104 (1991).
7. P. S. Akimov, P. A. Bakut, V. A. Bogdanovich, et al., *Theory of Signal Detection* [in Russian], Radio i Svyaz, Moscow (1984).