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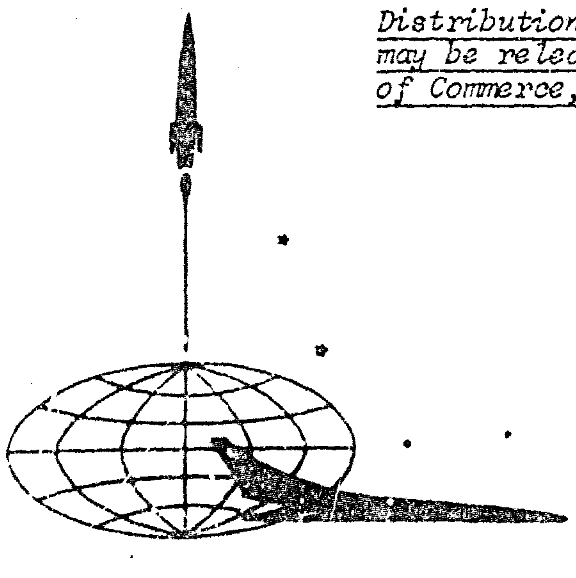
*Surveys of Foreign Scientific and Technical Literature*

# ELECTROMAGNETIC DISTURBANCES IN EXPLOSIONS







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*Translations of Foreign Scientific and Technical Literature*

# ELECTROMAGNETIC DISTURBANCES IN EXPLOSIONS

ATD Work Assignment No. 79-68-6





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# FOREWORD

This translation was prepared in response to Work Assignment 79-68-6. The article was originally published as follows:

Gorshunov, L. M., G. P. Kononenko, and Ye. I. Sirotinin. Elektromagnitnyye vozmushcheniya pri vzryvakh. Zhurnal eksperimental'noy i teoreticheskoy fiziki, v. 53, no. 3, 1967, 818-821.

# ELECTROMAGNETIC DISTURBANCES IN EXPLOSIONS

*Results of an investigation of electromagnetic disturbances produced by an explosion are presented. It is shown that the electromagnetic signal is determined mainly by the asymmetry of the scatter of the explosion products.*

A blast of high explosives, as shown experimentally [1--8], is usually accompanied by electromagnetic disturbances which can be recorded by instruments relatively far removed from the epicenter of the explosion. An investigation of the physical processes responsible for the disturbances presents a scientific problem in itself, and, on the other hand, can be of applicational value. Up to the present, however, no publications have been available on a systematic treatment of the phenomenon.

The present work discusses the results of experiments in an investigation of the electromagnetic disturbances caused by blasts of explosive charges. Investigations were made of the effect of the method of initiation, the altitude, the mass and shape of the charge, and external electric and magnetic fields on the character of the electromagnetic signal.

Aperiodic vertical flagpole antennas 2 m high were used for receiving the electromagnetic signals produced by the blast. The OK-17 M, S1-20, and S1-29 oscilloscopes served as recorders. The bandwidth of recorded frequencies, at the 0.7 level, was 30 c -- 10 Mc (OK-17 M), 30c -- 20 Mc (S1-20), and 30c - 2 Mc (S1-29).

The explosions occurred in an open area. The antennas were placed 5 to 30 m from the epicenter of the explosion. Spherical and cylindrical charges weighing from 1 to 5 kg were cast from 50/50 trinitrotoluene (TNT) and cyclonite. The oscillographic recorders were triggered either by a signal from an ionization pickup placed on an electrical detonator or by a photocell pulse.

To determine the effect of the initiation method, the charges were exploded either by an electrical detonator, or by straight ignition.

The signals recorded from the electrically exploded spherical charges display a number of characteristic features. Relatively short, irregular heteropolar spikes with a relatively low amplitude set in practically from the moment of the initiation of the charge and continued for several tens of microseconds. These irregular spikes developed into a bell-shaped pulse with negative polarity about 0.5 μsec long with a maximum about 1 μsec from the instant of initiation. Characteristically, the pulse shape and time interval $t_m$ from the instant of initiation to the maximum of the signal, with a spherical charge, persisted whether the blast was initiated from the center or from the surface. These characteristics were also independent of the height at which the charge was suspended, the direction of initiation, the distance to the antenna, and the strength and the polarity of the external electric and magnetic fields applied by special electrodes and windings. At the same time, a very definite dependence of the time interval $t_m$ on the mass of the charge was established:

$$t_m = KM^{1/3},$$

where $t_m$ is time in milliseconds and M is the mass of the fused 50/50 TNT and cyclonite in kilograms. The experimental value of $K = 0.7 \pm 0.05$. The ratio was established on the basis of pulses from many 1-, 3-, and 5-kg charges. The reproducibility of $t_m$ for each of the above mass values was good (the mean square deviation of any point did not exceed 2%).

A typical oscillogram obtained from a 1-kg spherical charge explosion suspended 6 m high is given in Fig. 1. The ignition occurred by electric initiation from the center. The antenna was 20 m from the epicenter of the explosion.

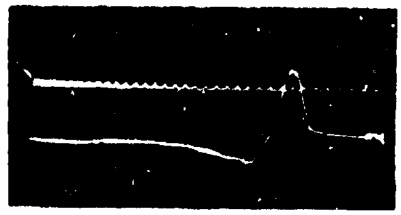

Fig. 1. Oscillogram of signals recorded by a vertical rod antenna on priming from the center of a 1-kg spherical charge (50/50 TNT and cyclonite) by means of an electrical detonator. The suspension height of the charge was 6 m. The distance from the epicenter of the explosion to the antenna was 20 m. The amplitude of the initial part of the signal was ~5 v; time scale $\Delta t = 0.1$ μsec.

In the case of straight ignition of spherical charges, the character of the signal differs sharply from the one obtained by electrical initiation. Fig. 2 shows oscillograms of signals recorded for the case of spherical charges initiated by straight ignition. When initiation of the sphere occurred from the surface, the direction of initiation determined the polarity of the signal. In the case of a spherically symmetric blast (initiation from the center), the signal was practically absent at the same sensitivity of the instruments. It should be noted that, in this case, any grounded conductor placed under the charge changes the picture: the signal takes the same shape as in the case of electrical initiation.

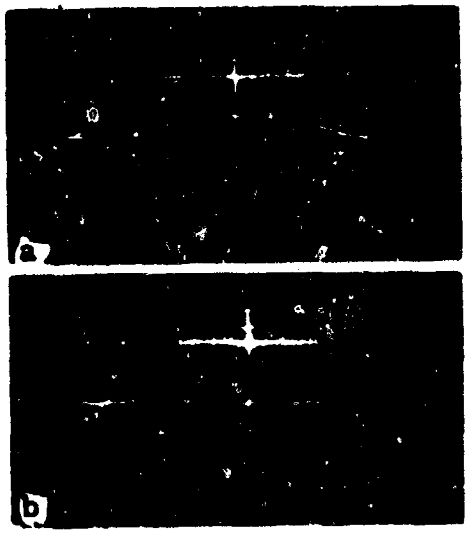

Fig. 2. Oscillograms of signals from an explosion of spherical charges initiated by straight ignition from the surface of the sphere: a - up vertically, b - down vertically. Charge mass - 2 kg, blast height - 2 m, distance to antenna — 10 m $\Delta t$ = 1.0 μsec.

In the case of cylindrical charges with vertical axes and initiation by straight ignition from the lower end, the parameters of the electromagnetic pulse depend on the form of the cylinder. The relationship was established by 1.3-kg charges with a height-diameter ratio H/d = 4.6; 2.0; 1.0, and 0.5. The blasts occurred 2 m above the ground. Oscillograms of the signals are presented in Figs. 3 and 4. For these charges, the dependence of the signal amplitude on the distance to the antenna was obtained. The dependence can be expressed as $1/R^3$, which is typical of a dipole emitter at short range.

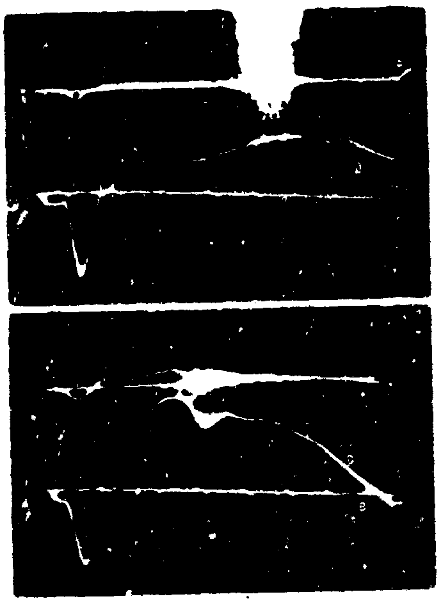

Fig. 3. Oscillograms of signals from an explosion of cylindrical charges initiated by straight ignition from the lower end:
a - charge with H/d = 4.6;
b - charge with H/d = 2.0.
Charge mass -- 1.3 kg, height of blast -- 2 m. Distance to antenna -- 12 m (upper beam) and 8 m (lower beam);
$\Delta t$ = 1.0 μsec.

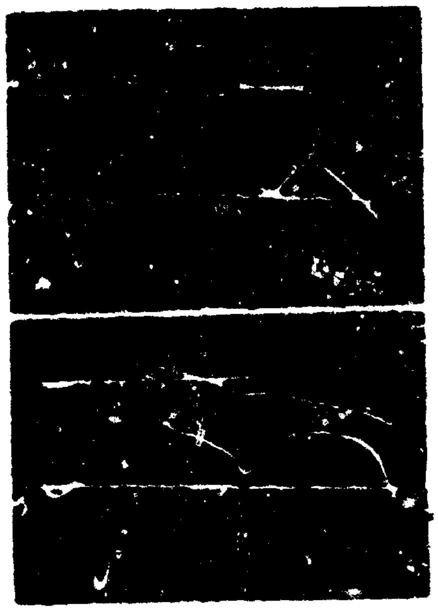

Fig. 4. Oscillograms of signals from an explosion of cylindrical charges initiated by straight ignition from the lower end:
a - charge with H/d = 1.0;
b - charge with H/d = 0.5.
Charge mass -- 1.3 kg, height of blast -- 2 m. Distance to antenna -- 12 m (upper beam) and 8 m (lower beam);
$\Delta t$ = 1.0 μsec.

Signals from cylindrical charges with horizontal axes picked up by antennas positioned in opposite directions from the plane perpendicular to the axis of the cylinder and crossing that axis in its center, have opposite polarity. A signal is practically absent in the case of an antenna position in that plane. A change of the direction of initiation reverses the polarity of both signals.

Fig. 5 presents oscillograms of signals recorded by vertical antennas inclined at 45 and 180° to the direction of initiation of a cylindrical charge with a horizontal axis.

Fig. 5. Oscillograms of signals from an explosion of a cylindrical charge with horizontal axis initiated from the end by straight ignition. Upper beam is the signal from antenna inclined $180^{\circ}$ to the direction of initiation (R = 10 m); lower beam - antenna inclined $45^{\circ}$ (R = 8 m). Charge mass - 1.3 kg, H/d = 4.6, height of blast - 3 m, $\Delta t$ = 1.0 μsec.

No effect of an electric field on the signal characteristics was observed in the case of straight ignition of the charge. Screening of the electric field above the ground level or the application of fields up to $10^3$ v/m of opposite polarity in the blast region did not change the characteristics of the recorded signal. Magnetic fields of up to ~ 5 oe also failed to affect the characteristics.

From the experimental material presented, it can be assumed that the governing factor in the formation of electromagnetic disturbances is the asymmetry of the blast. In the case of electrical initiation the asymmetry is apparently caused by the cables, which may introduce the asymmetry in the distribution of the charges. The geometry of the charge is the cause of asymmetry in the case of straight ignition.

On the basis of the experimental data, it can also be assumed that the electrification of the scattering products of the blast is responsible for the development of electric charges (or currents) and the creation of electromagnetic disturbances. This assumption is supported by the fact that the onset of the signal occurs after a delay of hundreds of microseconds following the emergence of the detonation wave on the surface of the charge. The fact that the onset of the signal is independent of the height of the blast, and that the signal characteristics are independent of both the strength and polarity of the external electric field, argue against the mechamism of signal production suggested by Cook [5].

In conclusion, the authors thank Professor B. M. Stepanov for assigning the subject and for his attention to, and interest in, the work, Professors F. I. Dubovitskiy, L. N. Stesik, M. I. Vorotovov, N. I. Mochalov, and coworkers at the A. N. Dremin laboratory for their help in the experiments, and A. A. Yemel'yanov and M. N. Nechayev for useful discussions.

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## References

1. A. G. Ivanov. Izvestiya AN SSSR. Seriya geograf. i geofiz., 5, 1940.
2. T. Takakura. Pub. Astronom. Soc. Japan, 7, 210, 1955.
3. H. Kolsky. Nature, 173, 77, 1954.
4. V. I. Zinin, V. N. Mits. Vzryvnoye delo, sb. 52/9, Gosgortekhizdat, 1963, str. 115.
5. M. A. Cook. The Science of High Explosives, New York, 1958, str. 159.
6. B. Koch. Academie Sci. comp. rend., 248, 2173, 1959.
7. C. D. Curtis, Proc. IRE. 50, 2298, 1962.
8. W. H. Anderson, C. L. Long. J. Appl. Phys., 36, 1494, 1965.