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# TIMING EQUIPMENT FOR EXPLOSION SEISMOLOGY

by

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As a part of the IGY program of the Seismological Station, University of Helsinki, an explosion seismology operation was carried out in the Gulf of Bothnia in July 1958, in cooperation with the Finnish Navy and the Oceanographic Institute. The purpose of the filed work of 1958 was to obtain preliminary results on the elastic constants of the Earth's crust in Finland, and to develop equipment for explosion seismology.

A description is given of the communication system between ship and coastal seismographic station which was used to synchronize the recorders with the mine firings at sea. A direct detonating pulse transmission was used to produce corresponding firing marks on the recording paper, and the system delay was experimentally measured.

In order to furnish the seismograms with zero moment marks of reasonable accuracy, the trigger and the time marker on the recorder had to be synchronized. Here the timing was effected by letting the detonating current pulse directly operate the transmission system.

To reduce the inaccuracy arising from the different working times of the trigger and the relay, a very short detonating pulse was used. The signal was transmitted over a radio channel to the receiving equipment which operated the time mark devices. A different radio channel was used for purposes of communication.

Fig. 1 shows the block diagram of the system. A relay was connected to the detonator and to the mine cable which worked off the detonation

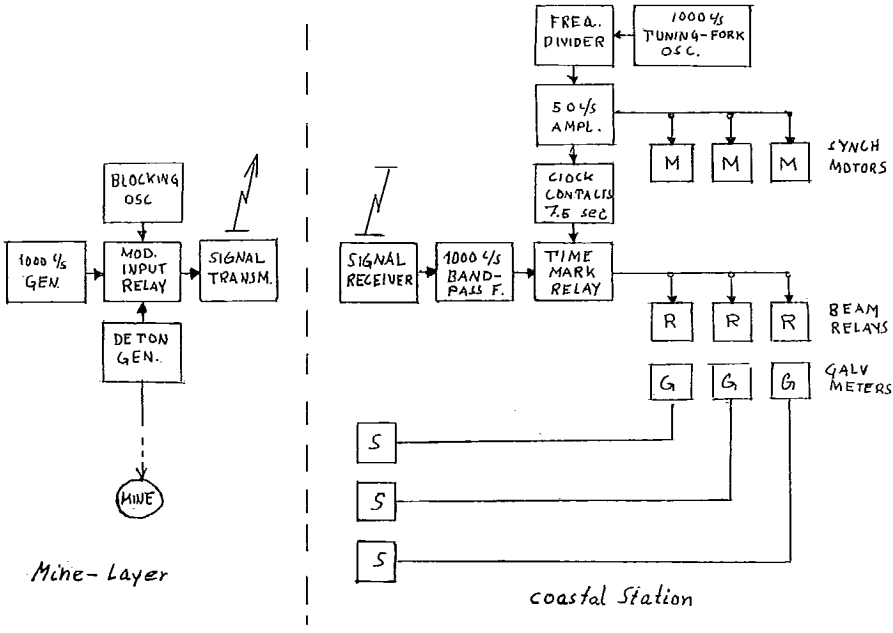


Fig. 1. The block diagram of the signal transmission system.

pulse and drove another switching relay to operate the radio channel. Any direct keying of the transmitter was found impractical; however, a 1000 c/s modulating pulse was used instead, since it made it easier to overcome the background interferences at the receiving end.

To make the receiving safer, some extra drop-out delay was incorporated into the switching relay. During the firing, the impulse was held back about 0.5 sec.

A blocking oscillator producing slow pulses was used prior to the firings to aid the final checking of the receiving equipment. In order to distinguish them from the firing pulse, their duration was made somewhat shorter. The two impulses were set so as not to overlap.

At the receiving end of the system, a 1000 c/s band-pass filter was coupled to the output of a communication receiver. After passing through the filter, the 1000 c/s pulse was properly amplified to operate the time mark relay by raising the cut-off bias of a driving tube.

The clock time marks were brought independently to the same relay by clock contacts shorting the cut-off bias of another tube parallel to the first. The slight inconvenience in handling the equipment, because

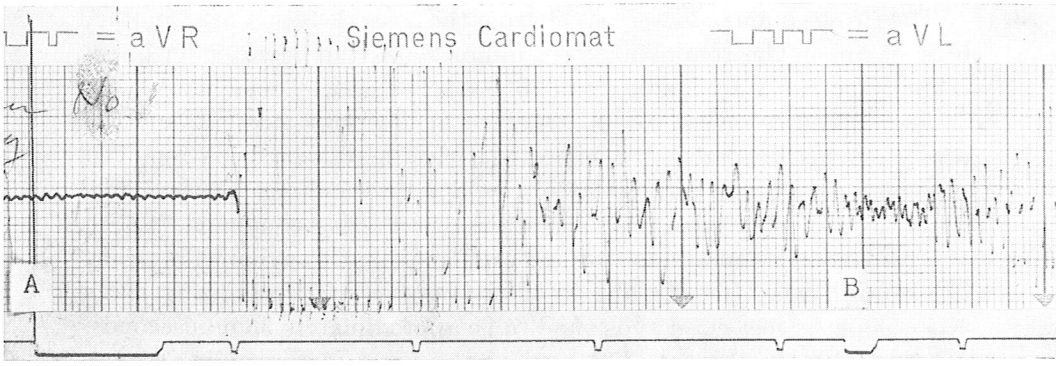


Fig. 2. The timing signals are recorded on the lower edge of the recording paper. The time mark for the mine firing is denoted by A, the shot pulses represent the time marks of the used ECG apparatus und the deviation B represents time marks (7.5 sec intervals) given by the clock.

of bringing the time signals and firing signals together, was compensated for by the simplicity of the system in field operation.

The clock contacts were operated by a synchronous motor to produce time marks at 7.5 second intervals. The motor was run by a 50 c/s generator, which consisted of a 1000 c/s tuning fork oscillator, scaling units and a power amplifier, and when also supplied the 50 c/s current for the motors revolving the drums of the galvanometer recording units.

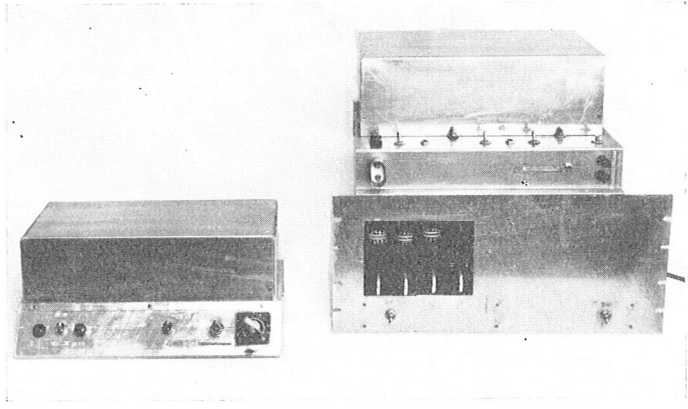

Fig. 3. The equipment at the coastal station.

The firing commands were given from the coastal station over another radio channel. The commands were indirect, i.e., the operator on board delayed the firing by a number of time marks fixed by schedule so that the high speed recorders could be started at the right moment, and the local time mark nearest the expected firing mark could be removed manually to prevent any possible overlap. This indirect method was found to be more reliable in use than the direct firing command.

This transmission system worked satisfactorily throughout the trials. The overall delay (mostly due to the successive relay energizings) was experimentally measured and found to be approximately 35 milliseconds. At a recorder chart speed of 30 mm/sec there is a corresponding correction of 1 mm.

Fig. 2 shows a typical recording. The leading edge of pulse A denotes the mine firing, while pulses B represent time marks at 7.5 second intervals.

The equipment at the coastal station is shown in Fig. 3.

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