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AUTOMATIC "ZERO-TIME" MARK FOR MICROBAROGRAPH RECORDS

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ABSTRACT

A simple system is described whereby the electrical transient accompanying a nuclear detonation is employed to place automatically a zero-time signal (time of detonation of a nuclear weapon) on microbarograph records. Feasibility of this system was proven during Operation TEAPOT at stations up to 134 miles distant from the Nevada Test Site.

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Foreword

The microbarograph program performs two important functions during the Nevada Test Operations. The first of these is to record, at a number of distant populated points, blast pressures from HE charges detonated before shot time near the bomb tower. This information is then used to predict where and with what intensity blast will strike, thereby making possible a last minute "shoot" or "don't shoot" recommendation. The second function is to operate during the nuclear shot and record the actual pressures that struck these localities (useful for scientific reasons as well as being a valuable aid in adjusting claims for window breakage and popped plaster).

In add tion to the microbarograph pressure record, it would be desirable to obtain accurately the 'travel time' of the shock wave. Shock wave travel time can sometimes be used to obtain an indication of the yield of the weapon and is also valuable for subsequent meteorological studies. This travel time could be very conveniently obtained if an accurate zero-time mark were placed on the microbarograph trace.

With the present (old) recording system, the operator places a zero-time mark on the record manually by pushing a button when, according to scheduled shot time, he counts down to zero on his pocket watch which has been set as accurately as possible from WWV. Or, he may more accurately mark the record if he sees the flash from the bomb. However, since many of the microbarograph stations are windowless, plus the fact that some shots are detonated during daylight hours, the operator frequently can not see the flash. Either way, pocket watch or bomb flash, the human element involved in placing the zero-time mark often results in an error of possibly a second or more. Thus, some automatic method of marking the record at the instant of detonation would be highly desirable.

Ideally, this zero-time "marker" signal should be generated by the actual detonation, that is, not simply by the count down time zero signal. Besides being more accurate from standpoints of true zero time and automatic marking, a system such as this would provide the additional advantage of indicating to the microbarograph operator whether or not the shot was detonated, a fact which now often must be relayed to him. The proposed method fulfills these requirements.

Proposed Zero-Time Signal Source

The detonation of an atomic device (above ground) is always accompanied by an extremely powerful electromagnetic transient. This transient, the object of much scientific scrutiny and measurement, is a composite pulse

resulting in a damped wave of several cycles in the Very Low Frequency (RF) spectrum.*

During past operations, the transient has been naught but a nuisance, obstructing instrumentation records and often burning out gauges. During Operation TEAPOT (February to May 1955), an attempt was made to employ this transient for a practical purpose: to place automatically a zero-time signal on the microbarograph record.

Signal Pickup and Record Marking Method

The experimental automatic zero-time indicator consisted of a loop antenna feeding into a final stage of the regular microbarograph amplifier through a 1N34A crystal and filter. This is shown in the block diagram of Fig. 1.

The antenna consisted of seventy turns of No. 18 hookup wire wound on a square plywood form, 2 feet on a side. The result was a low Q loop, broadly resonant between 10 and 70 kc. In general, zero-time transients consist of several cycles, of say 20 μsec/cycle (50 kc). These damped wave trains were rectified by the crystal and then filtered, resulting in a single positive pulse of long enough duration for the recorder to follow.

Results

At the beginning of the TEAPOT series, two stations were equipped with the automatic zero-time indicator. One was at the CP, approximately 10 to 15 miles from the various shot towers. The other was at Lund, Nevada, 134 miles from the shot site. Both stations operated successfully throughout the series, receiving and recording the zero-time transient on all but the underground shot. (The Lund station did not receive the signal from the Zucchini shot, but there is a question of whether the antenna was connected.)

Figures 2 and 3 are examples of microbarograph records at the CP and at Lund. These were the most accurate manually placed zero-time signals of the whole series (on records equipped with the automatic zero-time indicator, where a comparison could thus be made). As is customary, each record is composed of two traces. Both are produced by the same pressure

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* Eklund, M. H., and Sander, H. H., Electromagnetic Signals from Operation CASTLE Recorded in Albuquerque, Sandia Corporation report SC-3592(TR), December 7, 1954.

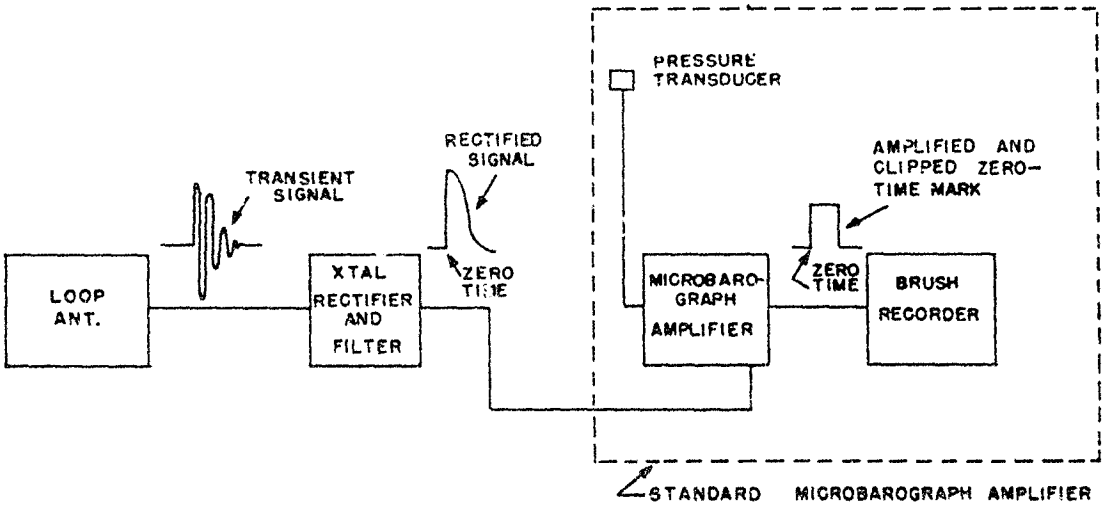

Fig. 1 Block Diagram of Experimental Automatic Zero-Time Indicator

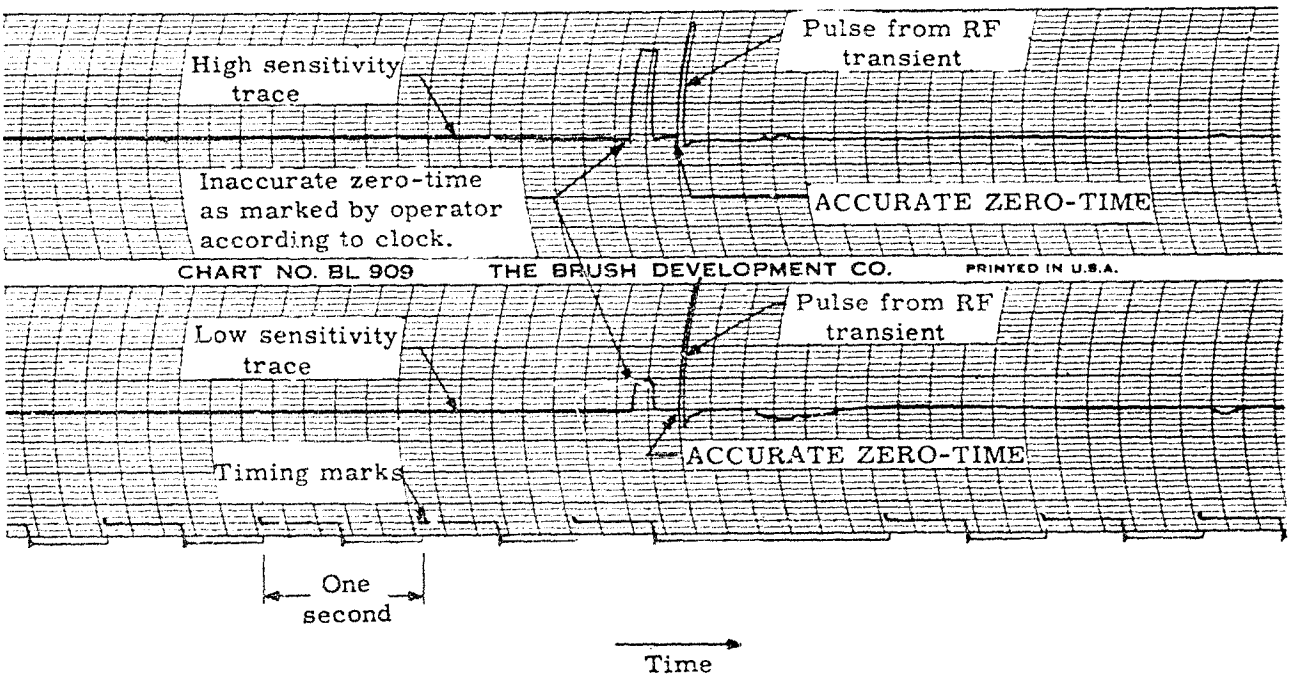

Fig. 2 Microbarograph Record from MET Shot, Recorded at CP Station, 12 Miles from the Shot Tower, with Zero-Time Transient Pickup Loop Installed

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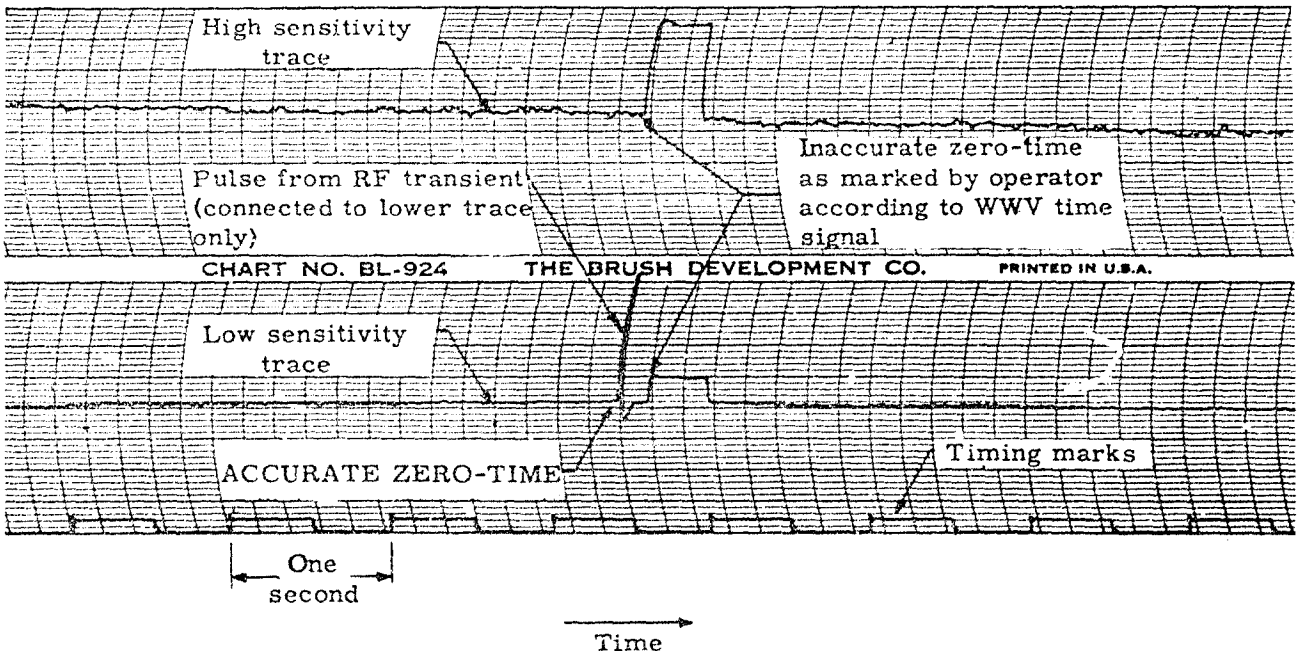

Fig. 3 Microbarograph Record from BEE Shot, Recorded at Lund, Nevada, 134 Miles from the Shot Tower, with Zero-Time Transient Pickup Loop Installed

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transducer, but one trace is given greater amplification than the other to minimize error in estimating expected signal strength. At the station in Fig. 2, the received RF transient signal was injected into both traces. In Fig. 3, it was connected to deflect only the lower trace. Both figures display the accurate zero-time signal superimposed on the record by the transient versus the manual zero-time signal superimposed by the operator pressing a button (microswitch) according to a clock set with WWV. The pressure pulse is not shown on this early portion of the records.

Conclusions and Recommendations

It is obvious that the tremendously powerful zero-time transient that accompanies an atomic detonation is an ideal signal source with which to mark microbarograph records (and other instrumentation records).

The following recommendations are made for the design and construction of automatic zero-time indicators for permanent installation in each microbarograph unit.

1. A low Q antenna should be employed, broadly resonant around 30 kc and not over 2 feet in diameter (or on a side).

2. Rather than utilize the amplifier stages of the regular microbarograph unit to amplify and shape the signal from the antenna, as was done during this experiment, a separate amplifier should be constructed having its output coupled to the recorder without going through the microbarograph amplifier. This is recommended because the microbarograph amplifier employs a phase-sensitive system, whereas all that is required with the loop is a simple AC amplifier with sufficient output to drive a Brush recorder. The amplifier should be fixed-tuned to pass from 10 to 100 kc. The output of the zero-time signal amplifier should be fed into the Brush recorder through an appropriate mixer stage so as not to shunt the normal signal from the microbarograph unit.

For convenience, especially with portable stations, a telescoping "whip" antenna might be substituted for the more cumbersome loop. This would, of course, necessitate higher gain in the 'zero-time amplifier' stages.

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