STRONG MOTION OBSERVATION SYSTEM WITH A WIDE AMPLITUDE RANGE. PART I: CONSTRUCTION OF HEADQUARTERS STATION

by

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SYNOPSIS

A strong motion observation system with a wide amplitude range is presented. Seismic signals from 2 to 600 gals are clearly recordable on a photographic paper by use of an automatic gain changer. Recording duration is controlled in accordance with the earthquake, too. A timing clock for identifying the earthquake is attached. The maintenance of the system in case of an imergency interruption of electric power, false triggering etc, is considered. Construction of satellite stations connected to the main station by means of a wireless transmission technique, is planned.

1. Introduction

Current observation in the field of earthquake engineering is concentrated on strong motions. Weaker earthquake motions, however, must be remarked and stressed more because of their more frequent occurrence and their similarity to the strong motions. We, nevertheless, no appropriate instruments for this kind of observation. This paper presents an example of the observation system applicable to the wider range of ground motion and working as robot station. Essential parts of the system are standard moving coil type seismometers of which natural frequency is 3 cps and damping constant is around 10, T-shaped attenuators, and photographic oscillograph with critically damped 100 cps-galvanometer. Sensitivity in a range 0.3 to 30 cps is 4 mm/gal if the attenuator is kept as unity. Added to these are triggering equipment, an automatic gain changer and a timing clock. A preliminary test for construction of satellite stations was performed.

2. Triggering equipment and automatic gain changer

The triggering equipment starts to work when the ground motion reaches a certain predetermined level, and supplies electric power to the system. This is specially designed so as to control the recording duration automatically by watching the signals. The triggering level can be changed within 40 db. This is essentially composed of pre-amplifier of which input impedance is around 100 kΩ, band-pass filter, main amplifier connected to a level indicator with relay, and a time gate circuit. This time gate begins to work and to count when a moving contact of the level indicator hits the fixed target, and ceases to work when a preset duration passes after the last touch. The preset duration is changeable in a range between 3 and 120 sec.

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If our main concern is middle grade earthquakes, the triggering level must be low, so sometimes we may have false triggerings due to artificial noises. The artificial noise is several times higher in daytime than at night. Taking into consideration we designed a step-wise automatic triggering level changer by means of a CdS-photovaristor facing the window. Thus the sensitivity of the triggering equipment can be changed step-wisely in range from 0.1 to 1.0.

Dynamic range of photographic paper is within 20 db in general. An automatic gain changer is manufactured in order to widen the dynamic range up to 50 db by use of automatic control to attenuation rates, by watching the signals. This is composed of two parts, one is control circuit, the other is relayed T-shaped attenuator. The control circuit consists of an input voltage divider, three sub-circuits with signal indicators, and the sub-circuits are connected through clipping circuits. Each sub-circuit corresponds to a different level of steps in attenuation rate. The sub-circuit is similar to the circuit in the triggering equipment. Again, one touch of the moving contact of the signal indicator to the fixed target means that the motion exceeds a preset level, and drives a corresponding relay. Common type of T-shaped attenuators are used with relay circuits controlled by the before-mentioned automatic gain changer. At the instance of triggering, the attenuators are settled on step-zero, but the attenuation rate shifts up to higher steps when the ground motion increases, and finds out an appropriate step; at the same time the other steps are released. In the decreasing process of the ground motion this behaves just the reverse way. The time gate in the control circuit is designed so as to keep the same step during the preset duration (usually 5 sec) even after the signal decreases to the lower step. Here we used a socket for a pentode as a capsule of resistance network because of advantage in exchange. Attenuation rates adopted are 1/1, 1/3, 1/10, 1/30, and so on.

The applicability of the system is ascertained up to 600 gals in the condition that the damping constant of the seismometer is kept as 10, therefore if we increase the damping the system will be used as a strong motion seismometer with wider amplitude range.

3. Timing clock

Records of earthquakes at robot stations can be identified with other information only by knowing their occurrence times. The necessity of data about the time (even if not so accurate) is especially essential to the middle grade earthquakes because of their occurrence without a long pause. The clock here was specially designed to send out month, hour, minute of the occurrence and the sequential number of Eq to the recorder. A wall-clock was modified and built to have four hands good for month, day, hour, and minute. For both day and month hands additional gears were attached to regulate the speeds so as to have one rotation per 30 days, 360 days respectively. On a dial-plate two sets of metallic contacts were prepared; one is of 60 contacts, the other 12 contacts. The former relates to the times, and the latter to the sequential number. Added to these, a sweeping hand, which is controlled by the signal from the triggering equipment, was made, through which time marks are sent to the recorder. Metallic contacts fixed on the sweeping hand are different in their lengths in order of month, day, hour, minute, and also are specified by different voltages so that pulses to the recorder differ in their shape. The time needed to sweep around is selectable to fit the paper speed. The electric power for micro-motor to drive the sweeping hand is supplied at the instance of triggering, and is cut off when the hand finishes one rotation.

4. Other considerations

This observation system is generally operated as a robot station. A special attention for the maintenance must be paid. In order to get rid of an emergency interruption of electric power, we adopted a power supply by means of a floating point method. So, the system works a few weeks even if with no electric power of commercial basis. This must be very effective for the observation in aftershock region. Usual length of the photographic paper is 25 m, and standard paper speed is around 3 cm/sec, then several sequential earthquakes will be recordable in one roll of the paper. In Tokyo area it takes about half an year to record 10 felt earthquakes.

Construction of a satellite station is easer than that of headquarters station. The robot satellite station is of the automatic gain changer coupled with a recorder. All the satellite stations are to be under the command of the headquarters station by means of a wireless transmission technique. The transmitted contents are commands for operation, time mark, and sequential number of the earthquakes and so on. Among them the time mark transmission to keep " common time " covering the net work is specially important because of understanding the phase characteristics of propagating seismic waves.

A preliminary test for finding an appropriate wireless system was carried out. A 1/2 watt transmitter with 27 Mc (citizen frequency band in Japan) was employed for sending signals, and found that the maximum distances available were 5 km in the urban area and 20 km along the coast line. This tells us to use a more powerful transmitter and to introduce a career frequency other than the citizen bands. Now we are building a 5 watts transmitter system with the higher frequency. This will be very moderate for handling and also economically. We hope to keep at least 10 satellite stations with intervals 1-2 km in a limited region.

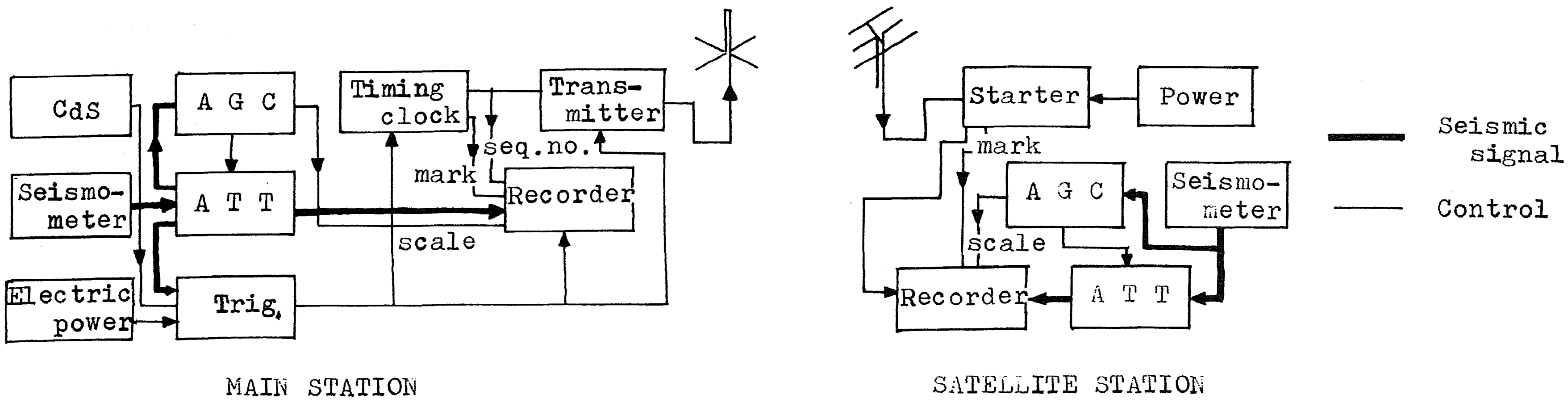

Fig. 1 Block diagram of the system

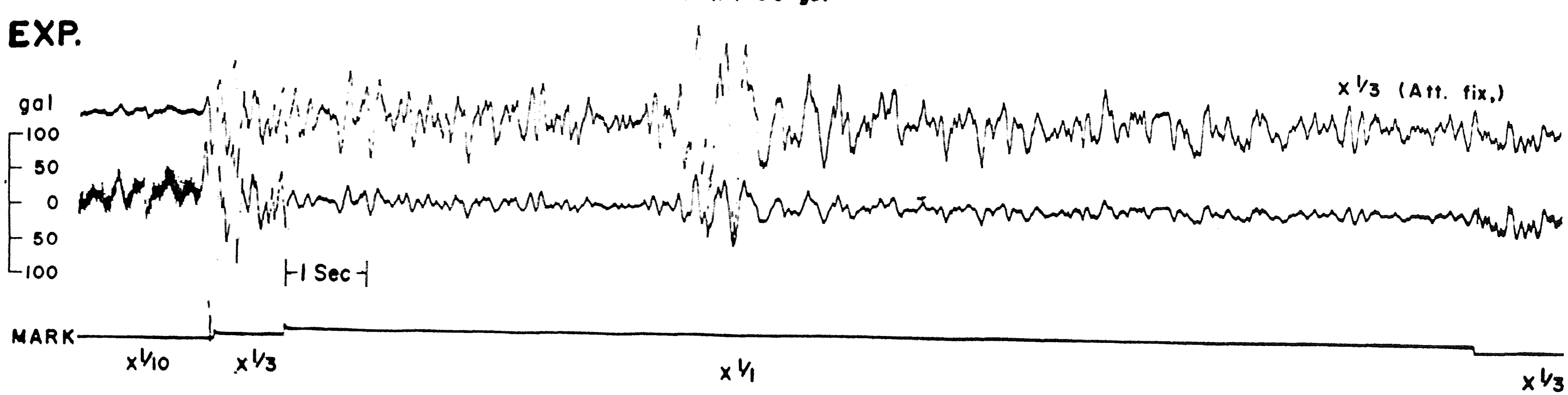

Fig. 2 Example of records with and without automatic gain control. Test was carried out by use of shaking table.