A Handmade Seismograph System and its Seismograms

-Make Your Own Seismograph!-

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1. Preface

The seismograph is a fundamental instrument in geoscience. However, the seismometers that can record natural earthquakes are developed very few (e.g. Waker, 1979) for the use in school as a teaching tool. This is quite different from the other field of science such as astronomy or meteorology, where instruments for school use are common. In this regards, since the first prototype of our seismograph system in 1989, we have developed and improved the system for easy operation and more precise seismic observation at school or home (Okamoto, 1991). Now, our system can detect local earthquakes of M>2 within 50km and foreign earthquakes of M>7 elsewhere (M: magnitude). In this paper, we describe the details of our seismograph system, example of seismograms, and summary of our new simplified sensor which is easy to make at low-cost.

2. Seismometer and related devices

Our system consists of three parts (Fig.1):
i) Seismometer (sensor), ii) Amplifier + A/D converter + I/O interface circuit, and iii) Personal computer (data logger). A software for auto logging is also required. Three seismometers were made, one is a vertical type, and others are horizontal type.

<Seismometer (Fig.2)>

[Electro-magnetic sensor + pendulum] Steel body and pendulum with brass mass is used for both vertical and horizontal seismometers. But the pendulum design is quite different between two types. The vertical pendulum is designed for the modified "Ewing type" using a steel coil spring, which has 3sec free period, on the other hand the horizontal type is designed for the "Paschwitz type" which has 5sec free period. Both types employ a magnet removed from a speaker and a wounded coil on a acrylic pipe as a electro-magnetic sensor. To avoid friction, a thin bronze sheet is used instead of a pivot of the pendulum.

<***Built in amplifier***>

Two types of IC based amplifier are also built in the seismometer. One is a broad band amplifier for local earthquakes, and the other is a low-pass amplifier having cut off of 20 sec for the detection of foreign earthquakes (after Daniel, 1979).

3. PC based auto logging system

Automatic logging (recording) system is

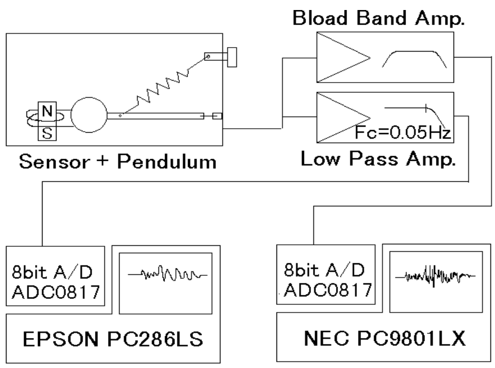

Fig.1 Block diagram of our system.

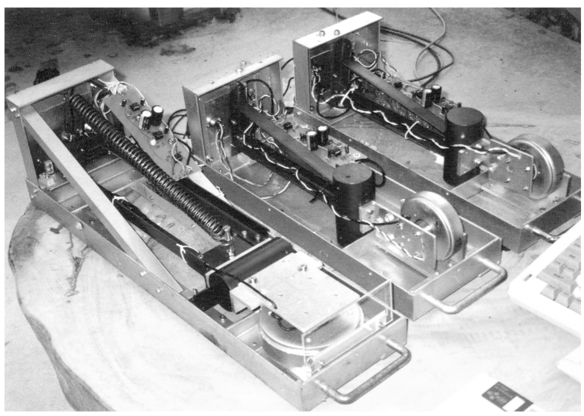

Fig.2 Three component seismometers

desirable for the daily observation of earthquakes. Many logging systems are considered up to now. The old-fashioned seismometer employs a smoked paper on a clock-driving drum. Nowadays, the digital computer changes the recording system dramatically. So our system employs the personal computer (PC) for both control of A/D circuit and auto logging.

<A/D converter>

16-ch 8-bit A/D converter ADC0817 is employed (only 3-ch are now using).

<I/O interface>

Parallel interface IC 8255 is employed. Both A/D converter and I/O interface are built in an extensional board for NEC-PC with a programmable timer IC 8253.

<Software>

The driving software is written in BASIC language for the NEC-PC (Japanese domestic PC). The main function is as follows,

i) 1-ch signal display on CRT at real time.
ii) Auto detection of events with arbitrary trigger level.
iii) Auto save of the signal in the hard disk.

Because the saved data are not only of earthquakes but also of traffic noises etc., the selection of natural earthquake data is need. This process is suitable for the routine work in school. Fig.3 shows an example of signal on CRT.

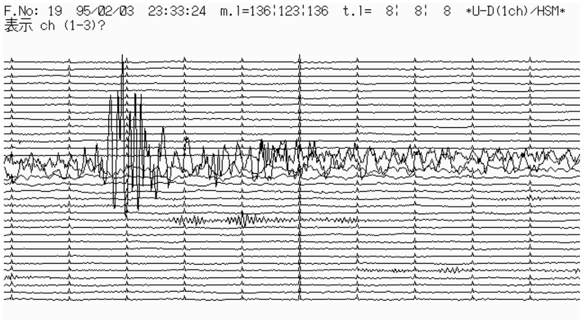

Fig.3 An aftershock of 1995 Kobe earthquake displayed on CRT (time mark interval is 1 [sec] , traffic noises are seen at later)

4. Seismograms of local earthquakes

Since the first trial in 1989, more than 5000 earthquakes are recorded with previous system at our house in Hashimoto city, Wakayama prefecture (Western Japan). Especially, aftershocks of the 1995 Kobe earthquake has been recorded throughout day and night, because the distance between our observation site and the focus region is only about 60km. Fig.4 shows some examples of local earthquake seismograms.

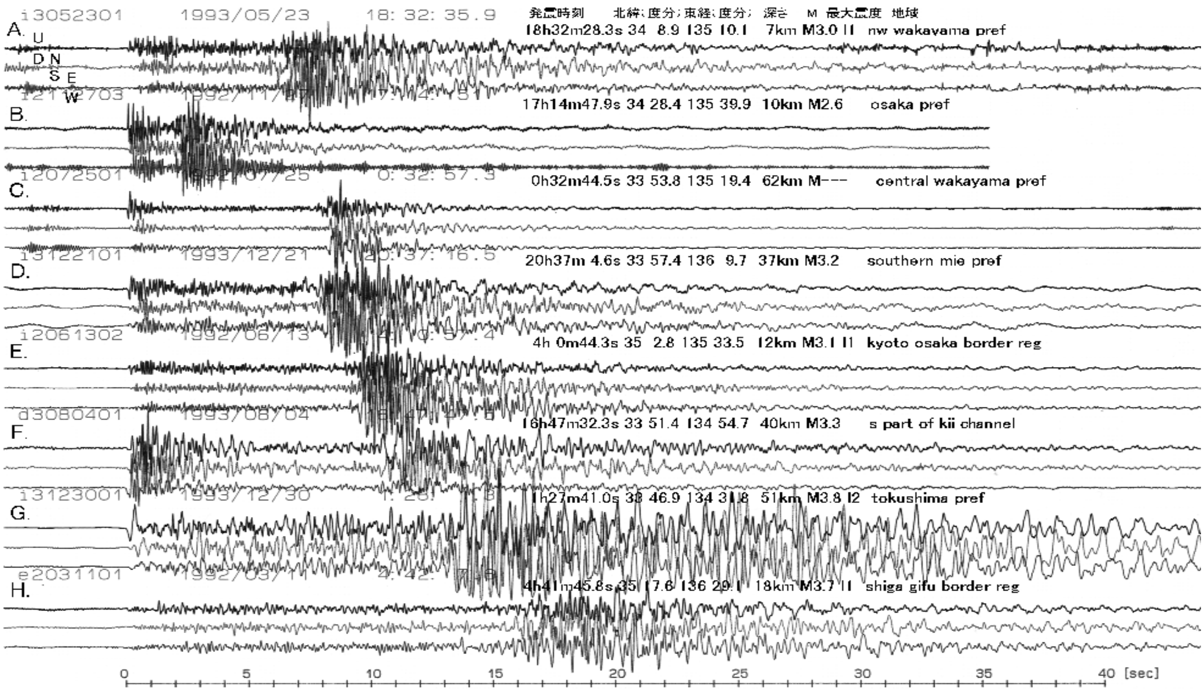

Fig .4 Seismograms of local earthquakes. (P and S phases are clearly seen.)

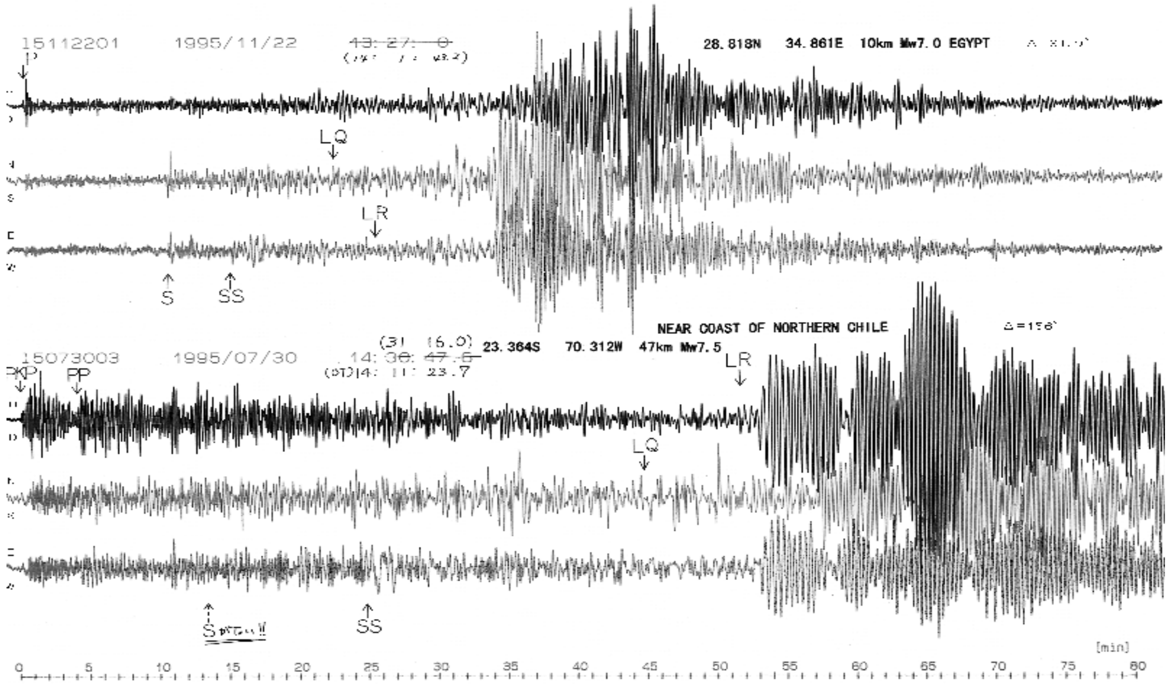

Fig.5 Seismograms of foreign earthquakes (Upper: Egypt Mw7.0 Lower: Chile Mw7.5).

5. Seismograms of foreign earthquakes

Detected waves from foreign earthquake have longer period, especially in the surface wave. In order to record these waves, the low-pass amplifier is employed. These seismograms are shown in Fig.5. Many phases relate to the earth's inner structure are clearly seen.

6. "Film case seismometer" (Make your own seismometer!)

Our seismograph system has high potential for seismic observation though it is fully handmade. However, production of these system requires precise skill through the making process concerned with metal devices, electronics and PC software. In this regard, now we propose a new easy making sensor worked as a seismometer and a new recording circuit, using only three IC, which is connectable through the PC's parallel port (Ito, 1991 and Okamoto, 1997) .

<"Film case" sensor (Fig.6) >

The vertical pendulum consists of serial connected rubber bands and a alnico bar magnet. The hanging bar magnet is placed in a film case wounding urethane coated coil as a sensor. To damp the fluctuation of bar magnet, salad oil is half filled in the film case.

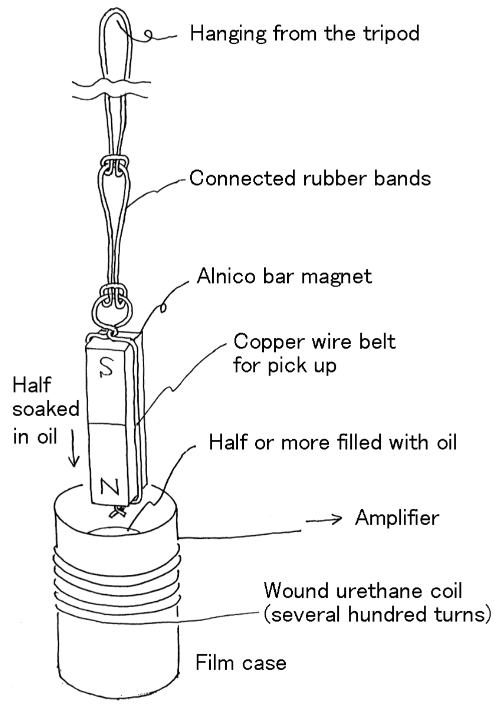

Fig 6. Film case sensor

<Signal processing unit (Fig.7) >

OP07 and TL072 amplify the input signal as a integrator. MB4052 is a serial 8-bit A/D converter. Digitized signals are led into the PC through a parallel port (printer port).

< *Software for signal display and auto logging* >

The software which drives this seismometer is introduced with some modification of the previous system.

<*Improved sensor (Fig.8)*>

A modified sensor using a sample bottle and a copper pipe damper instead of a film case and oil is developed for more precise measurement. Comparison of seismograms of this sensor and that of film case sensor is shown in Fig.9.

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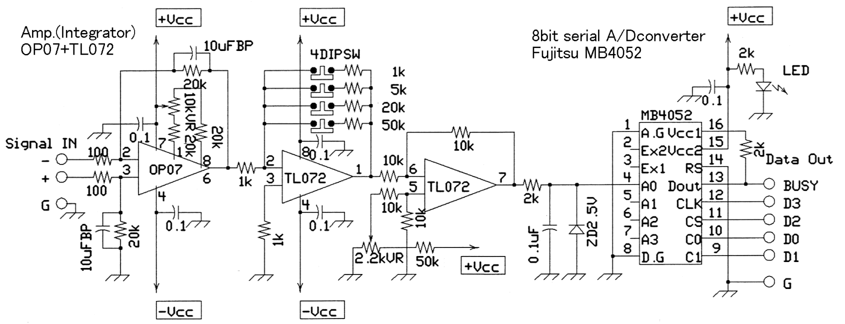

Fig.7 Signal processing circuit

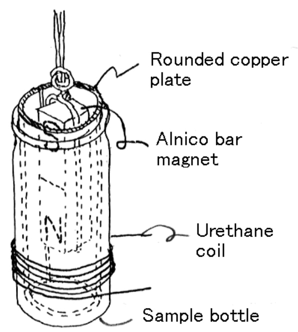

Fig.8 Improved sensor

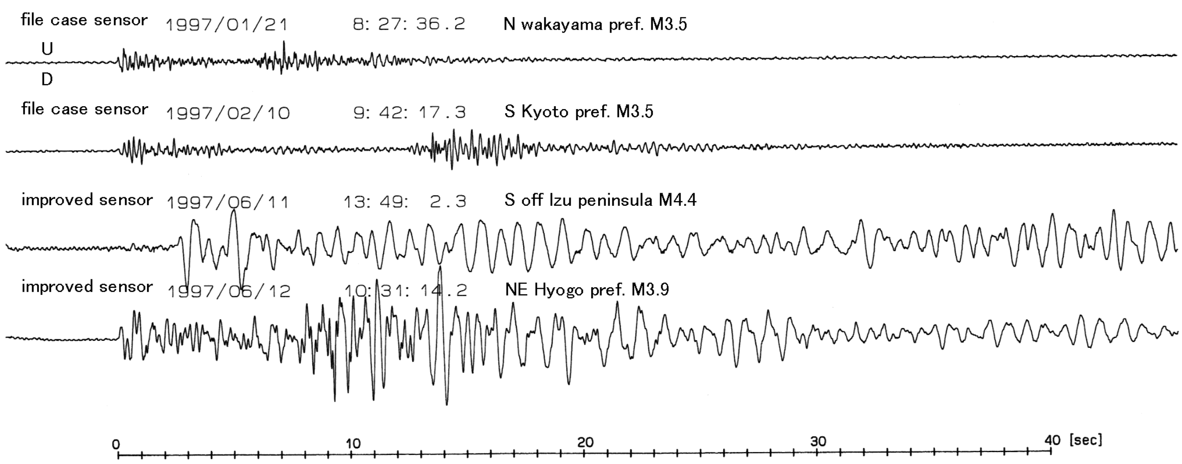

Fig.9 Seismograms recorded by film case sensor and improved sensor.
(Upper two records: film case sensor Lower two records: sample bottle sensor)