Seismic Technology Evolves into the 21st Century

By Heidi Koontz

USGS scientist emeritus Waverly Person remembers the days when a rotary phone, a pen, a globe and a keen sense of geography were the required ingredients for locating earthquakes around the world.

Things have changed dramatically since he was a newly minted seismologist.

"We really had to scramble," he says, referring to earthquake response in the '50s and '60s, when he and his fellow scientists did calculations on globes with tape measures and compasses. "It might take a day or a day-and-a-half to get information from remote locations."

That struggle makes Waverly all the more appreciative of the real-time data and global-monitoring systems available now. "It's great to be a part of the change and to have had a hand in getting there," said Person, who recently retired after a 51-year career as a premier earthquake scientist. [See page 13.]

Today, the USGS has the most extensive seismic monitoring and response system in the nation and works with numerous universities to advance understanding of the cause and effects of earthquakes and with emergency response agencies in the interest of public safety and hazards mitigation.

Throughout history, a variety of instruments has been developed to measure movement of the earth.

By definition, seismographs, seismometers and seismoscopes are instruments used to detect and measure the intensity, direction and duration of movements of the ground (as caused by an earthquake).

The earliest account of such technology is a seismoscope invented by the Chinese philosopher Chang Heng in A.D. 132. The instrument consisted of eight dragonheads, facing the eight principal directions of the compass. Below each of the dragonheads was a toad with its mouth opened toward the dragon. The mouth of each dragon held a ball, and when an earthquake occurred, one of the dragon mouths would release a ball into the open mouth of the toad situated below. The direction of the shaking determined which of the dragons released its ball.

The ancestry of today's USGS seismic instrumentation can be traced back to the late 1800s. And while the dragonheads had been replaced by more advanced creations, the equipment of that era was still a long way from the sophistication of today's machinery.

"At the time of the 1906 earthquake there were less than 100 seismographs operating around the world. Today there are thousands," said USGS scientist Gray Jensen, who has been tracking earthquakes for the USGS for more than 30 years.

John Milne, an English seismologist and geologist, invented the first modern seismograph and promoted the building of seismological stations. In 1880, Sir James Alfred Ewing, Thomas Gray and Milne, all British scientists working in Japan, began to study earthquakes. They founded the Seismological Society of Japan, and the society funded the invention of seismographs to detect and measure earthquakes. Milne invented the horizontal pendulum seismograph in 1880.

The horizontal pendulum seismograph was improved after World War II with the Press-Ewing seismograph, developed in the United States for recording long-period waves. With the advent of modern electronics, conventional magnet-and-coil seismometers and geophones became the typical sensors. Electronic amplifiers were then used to produce highly sensitive seismographs. Electronic feedback was added to these devices to create sensors with the maximum in dynamic range, frequency range and sensitivity. Ultimately, arrays of these sensors were connected to computers to produce today's fully automated seismic networks.

Although USGS scientists are currently unable to predict earthquakes, the advances in technology since 1906 allow them to provide much needed information for saving lives and pinpointing risk.

Compiled with assistance from Gray Jensen, Steve Walter, Jack Van Schaack and David Hebert.

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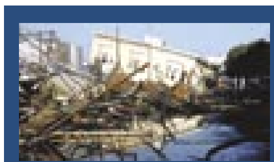
>
> **— Gray Jensen**

This seismoscope, invented in A.D. 132, represents the earliest account of technology used to record information about earthquake shaking. During an earthquake, the direction of the shaking determines which dragon releases its ball.

Geotech Helicorder model drum recorder used widely since the mid 1900s to record and display seismic records. Now used mainly for visitor and press displays. Whole-day records like this can be produced on computer but requests still come in for the drums.

A room full of Develocorders. These were devices with a roll of 16mm photographic film in them. They also had 16 galvanometers with very tiny lights attached. The row of lights was focused on the film as it was drawn past. This caused a line to be drawn on the film for each light. The galvanometers would cause the light to move from side-to-side in response to the seismic signal which was then recorded on the film. The film was then developed internally over the next ten minutes. Finally the developed portion of the film was projected on a glass screen for viewing. The film was changed each day and the removed film could then be viewed on a larger projector for analysis of the records.

Loma Prieta, California



This section of San Francisco's Marina District is destroyed following the earthquake on Oct. 17, 1989. (Photo: C.E. Meyer)

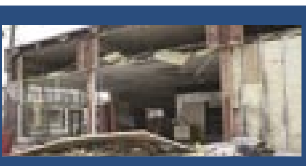
Date: Oct. 17, 1989

Magnitude: 6.9

Damage: The most severe damage occurred in Oakland and San Francisco, where many buildings and elevated-freeway and bridge spans collapsed. Pipelines, port facilities, airport runways and levees were also damaged, and more than 1,000 landslides occurred near the epicenter in the Santa Cruz Mountains. Damage was estimated at $6 billion (1989 dollars), and more than 3,500 people were injured.

Number of deaths: 63

Nisqually, Washington



This business in Seattle has sustained heavy damage following the Nisqually, Wash., earthquake on Feb. 28, 2001. (Photo: Kevin Galvin, FEMA)

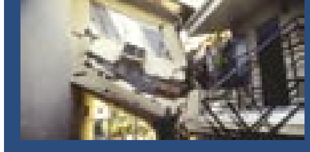
Date: Feb. 28, 2001

Magnitude: 6.8

Damage: This earthquake, including its resulting landslides, caused $4 billion in damages to buildings, highways and other structures in the cities of Olympia, Seattle and Tacoma. Approximately 400 people were injured.

Number of deaths: 1

Northridge, California



This section of a Los Angeles-area apartment complex is broken in half following the Northridge, Calif., earthquake on Jan. 17, 1994. (Photo: FEMA)

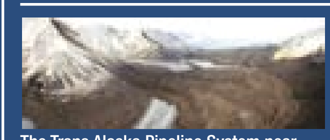
Date: Jan. 17, 1994

Magnitude: 6.7

Damage: In the Los Angeles area, an estimated $20 billion in losses were sustained through damage to more than 40,000 buildings, collapses of freeway overpasses and subsequent fires. More than 5,000 people were injured, and more than 20,000 lost their homes.

Number of deaths: 33

Denali, Alaska



The Trans Alaska Pipeline System near the Denali Fault has shifted but remains intact following the earthquake on Nov. 3, 2002, thanks to its slider bar supports. (Photo: Rod Combellick, Alaska Division of Geological and Geophysical Surveys)

Date: Nov. 3, 2002

Magnitude: 7.9

Damage: Despite being the largest onshore earthquake in nearly a century, the Denali quake was significant for what it did not do: rupture the Trans Alaska Pipeline System. In anticipation of just such an event, the pipeline was engineered to shift on Teflon-coated slider bars where it crossed the fault. Despite nearly 20 feet of displacement, the pipeline did not spill a drop and was quickly back in service.

Number of deaths: 0