

universities, medical schools and Government. At the present time in the United States some hundred students are training at postgraduate-level in seven centres offering biomedical engineering facilities. There is no doubt that this type of training will expand and extend. At Glasgow, post-graduate research facilities exist in this field at the Royal College of Science and Technology, and at present three full-time research students work on bio-engineering projects.

The future in research, one would surmise, lies with collaborative medical engineering teams rather than with biologically trained engineers. Yet it is essential to keep an open mind on these matters, and there is one thing certain—there is no shortage of problems or of opportunities to participate in a deeply interesting activity with an enormous potential of contributions of basic value to come.

THE ALASKA EARTHQUAKE OF MARCH 28–30, 1964

JUST after 5.36 p.m. on Friday, local time, when many of the people of Anchorage, Alaska, were homeward bound, thinking no doubt of getting indoors again out of the snow and freezing temperatures, suddenly and without warning the first seismic shock occurred. Immediately, buildings in the city centre collapsed, ground fissures appeared, down which cars slumped (one fissure was almost 100 ft. long with a drop of 10 ft.), and the control tower at the airport came toppling down. Immediately also, more than 1,000 houses were destroyed, water pipes, electric power lines and gas mains were severed, and communications disrupted. Many people were killed and injured. When the impact of the first shock was past, the city's services with all possible assistance drove into action. Residents were asked not to use the sewers, people queued for typhoid inoculations and hospital services were overworked. The State of Alaska was a disaster area. On the Gulf of Alaska, the village of Valdez was evacuated, apart from the necessary officials, owing to lack of water, sanitation and other services, and an emergency evacuation camp was set up at Gulkana, about 110 miles away. Seward, also on the Gulf of Alaska, was half destroyed and there were numerous fires since the earthquake had scattered the house fires as it passed. The village of Tuguyak on Kodiak Island was almost completely destroyed. The ripples from this earthquake focus sped through the solid earth to be recorded at seismological observatories throughout the world. The tsunami warning system began its calculations.

At the moment of disaster the tsunami or seismic sea wave set out from near the epicentre and, shortly after, the tsunami warning system went into action and messages were flashed to all parts of the Pacific. The sea waves were about 30 ft. high at Kodiak and Cordova in Alaska, and 8 ft. high when they arrived at Oahu, Hawaii. At Vancouver Island the sea-level rose as the waves passed, and at Crescent City in northern California five oil tanks were destroyed by the 12-ft.-high waves. The waves caused a break in the Commonwealth telephone cable connecting Canada with Australia and New Zealand, at a point about $7\frac{1}{2}$ miles off the Canadian Pacific coast near Port Alberni in British Columbia. The waves were significant on tide gauges in Japan.

Preliminary determinations of the epicentre of the shock place this at 61.1° N., 147.8° W. The depth of focus is considered shallow, and the Richter logarithmic magnitude between 8.2 and 8.6, making this one of the world's greatest earthquakes. The epicentre is east of Anchorage, Alaska, and the origin time was 1964 March 28d 03h 36m 10s G.M.T. The complete death-roll and damage are not yet known. In Alaska, 65 are known dead as the result of the earthquake, and damage is estimated at more than 250 million dollars. In Crescent City, California, due to the tsunami, 12 people are known dead and there was major damage to property. Aftershocks are still continuing. Eight above magnitude 6 were experienced on the first day, March 28, and there were many smaller ones. On March 30, at 02h 18m 05s G.M.T. from the Kodiak Island region, came a shock of magnitude 6.7.

The Aleutian Islands arc from Komandorski Islands to Alaska, and Alaska itself must be considered a major seismic and volcanic zone of the Earth. For example, in the year 1959 there were some 40 earthquakes felt and recorded in Alaska. Shocks greater than magnitude 6 and of shallow depth of focus near to the present epicentre also occurred at the following times and places: 1932 September 14d 08h 43m 23s G.M.T., 61° N., 148° W. ($6\frac{1}{4}$); 1933 January 04d 03h 59m 28s G.M.T., 61° N., 148° W. ($6\frac{1}{4}$); 1934 August 02d 07h 13m 08s G.M.T., $61\frac{1}{2}^\circ$ N., $147\frac{1}{2}^\circ$ W. (6); 1934 June 02d 16h 45m 29s G.M.T., $61\frac{1}{4}^\circ$ N., 147° W. ($6\frac{1}{4}$): and earthquakes with intermediate depth of focus (about 80 km) occurred at: 1912 January 31d 20h 11m 08s G.M.T., 61° N., $147\frac{1}{2}^\circ$ W. ($7\frac{1}{4}$); 1934 May 04d 04h 36m 07s G.M.T., $61\frac{1}{4}^\circ$ N., $147\frac{1}{2}^\circ$ W. (7.2).

Perhaps the greatest of the previous Alaskan earthquakes were on September 3 and 10, 1899, at Yakutat Bay, the latter being the greater, though from seismograms both had magnitude between $8\frac{1}{2}$ and $8\frac{3}{4}$. The area was visited shortly before the earthquake by the Harriman glacier exploration expedition, who took photographs, and about 6 years after the earthquake by a party of the U.S. Geological Survey. The shocks were accompanied by block faulting, and the largest known displacement by a single group of earthquakes then occurred. At maximum there was a permanent uplift of 47.5 ft.

At the time of the shock a small party of prospectors was camped near by on a glacier. Above them an ice dam holding a glacier lake broke, landslides happened all around, and a great wave 30 ft. high in the bay swept away their boat. Fortunately, they recovered the boat and escaped by sea, since the adjacent land was so cut up as to be almost impassable. The region was otherwise uninhabited. Outside the bay the sea wave was extremely small. Large seismic sea waves, or tsunamis, have been sent right across the Pacific Ocean from earthquake epicentres at various times, for example, from the Arica earthquake of 1868 and from the Iquique earthquake of 1877. A great wave destructive at Hilo came from the small Aleutian Islands shock of April 1, 1946, although a very small wave had resulted from the strong earthquake in the same Aleutian Islands region of November 10, 1938. Large tsunamis came from the earthquakes in Chile in May 1960 and from the present Alaskan shock.

In the Aleutian Islands arc shallow-focus seismicity follows the northern concave side of the Aleutian trench, being less intense near the Komandorski Islands. At the eastern end of the arc activity is higher near the Kenai Peninsula. This seismic activity is only exceeded by that of Mexico, Japan and the Solomon Islands. Shallow-focus earthquakes with depths from 50 to 70 km are frequent, and intermediate-focus earthquakes with depths from 100 to 170 km occur along the northern side of the Aleutian Islands arc and on the Alaska Peninsula from 176° to 160° W. The shallow shocks in the interior of Alaska indicate an interior structure related to the Pacific coastal arc, in the same way as the Rocky Mountains are related to the Pacific coastal ranges farther south in America.

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