News of Science

More Seismic Research Asked to Improve Atomic Test Detection

The text of a report by the Science Advisory Committee's panel on seismic improvement is published below. The report, which is expected to influence the Geneva negotiations on a nuclear test ban, was released 12 June.

The term decoupling, *as used in the report, pertains to techniques which prevent transfer to the surrounding earth of some of the energy released in the course of an underground explosion, resulting in inaccurate seismological recording of the event.*

The panel on seismic improvement, a group of distinguished American scientists under the chairmanship of Lloyd Berkner, president of Associated Universities, has recently completed a series of studies on the feasibility of improving the capability of the system recommended by the Geneva Conference of Experts last summer to detect and identify underground events.

The panel was appointed by the special assistant to the president for science and technology at the request of the State Department when it became apparent, from the analysis of new data obtained from the underground tests in Hardtack II last fall, that the capability of the Geneva System against underground tests was considerably less than had been originally estimated by the Geneva Conference of Experts.

The studies undertaken by the panel were directed at three basic problem areas: (i) the possibility of improving the Geneva System within existing technology; (ii) the possibility of further improving the Geneva System through a program of research in seismology; and (iii) the possibility that the capability of the Geneva System might be reduced by the concealment of underground tests.

The following analysis, prepared in consultation with the chairman of the panel, summarizes all of the conclusions contained in the studies by the panel on seismic improvement.

Earlier Report Cited

In order to interpret the conclusions of the panel on seismic improvement, it should be recalled that the Geneva Conference of Experts last summer concluded that, although it was not possible to identify an underground explosion by seismic means alone, it would be possible to identify a large fraction of seismic events as natural earthquakes when the direction of first motion of the seismic signal was observed at several, appropriately located stations. This procedure reduces the number of seismic events which would be unidentified and, therefore, could be suspected of being underground tests.

As was reported in the statement of the President's Science Advisory Committee on 5 January 1959, the analysis of later data from the underground tests at Hardtack last fall indicated that this method of distinguishing earthquakes from explosions was less effective than had been estimated. In addition, it developed that there were about twice as many natural earthquakes equivalent to an underground explosion of a given yield as had been earlier estimated.

These two factors meant that there would be a substantial increase in the number of earthquakes that could not be distinguished from underground nuclear explosions by seismic means alone. For example, the Geneva net of 180 stations, without modification, would have about the same capability (in terms of numbers of unidentified events) for seismic events above twenty kilotons equivalent as was originally estimated by the Geneva Conference of Experts for seismic events above five kilotons.

More Meters Needed

In considering the existing state of technology, the panel on seismic improvement concluded, with improved equipment and techniques that can be specified today, the Geneva net of 180 stations would acquire the same capability (in terms of numbers of unidentified events) for seismic events above ten kilotons equivalent as was originally estimated by the Geneva Conference of Experts for seismic events above five kilotons equivalent.

This partial recovery of the originally estimated capabilities of the Geneva System depends upon the incorporation of two improvements into the system.

The first improvement would increase the number of seismometers in the arrays at each station from 10 to 100, which would increase the ability of the system to distinguish "first motion" by reducing background "noise." On the basis of recent experiments, this improvement will increase the ability of the array to distinguish first motion by a factor of 2.5 over background noise.

The second improvement adds a new criteria for identifying natural earthquakes by means of the analysis of long period surface waves. An analysis of the Love waves (horizontally polarized surface waves) from five earthquakes similar in magnitude, direction, and distance to the Logan and Blanca nuclear shots indicated that the peak frequency in the explosions was twice that for earthquakes.

Another study of experimental data on the ratio of Love waves to Rayleigh waves (vertically polarized surface waves) and on the relative amplitude of surface waves and the *P* waves (used to determine first motion) also showed diagnostic possibilities to distinguish earthquakes from explosions. This experimental evidence led the panel to conclude that the analysis of long period surface waves can probably identify about 50 percent of earthquakes equivalent to five kilotons or more.

Data Limited

Table 1 compares the capabilities of the Geneva System, as initially estimated at Geneva last summer, with the estimates of the degradation of the system made in the light of data from the Hardtack tests and with the new estimates by the panel on seismic improvements that are now technically feasible.

In presenting these estimates, together with its other conclusions, the panel emphasized the limited nature of the data on which all estimates of seismic detection capabilities depend. There have been only a few underground nuclear shots; and all of these have been in the

same type of rock, and in a single geographical location. The type of rock, location, and shot chamber design can all have major effects on the strength of the seismic waves produced by a test of a given yield. The degree of coupling to the seismic waves achieved in the Rainier shot is the standard to which all estimates are adjusted.

Many Methods Promising

The panel concluded that a vigorous research program in seismology would result in important improvements in the ability to detect and identify earthquakes of small magnitude. Specifically, the panel believed that the program of research it recommended would in three years probably result in further improvements which could achieve the same capability in the Geneva net of 180 stations as was originally estimated by the Geneva Conference of Experts.

The panel submitted a very detailed technical report on the requirements for such a research program which will be published in the near future by the Department of State. Of the many ideas advanced by the panel, one of particular promise is the so-called "deep-hole" technique. There is evidence that the "background noise" which interferes with the detection of "first motion" is for the most part transmitted along the earth's surface. Therefore, seismometers located in holes thousands of feet below the earth's surface may be able to detect "first motion" with much greater sensitivity than instruments on the surface.

Another method of particular interest exists in the possibility of developing techniques to reconstruct the initial shock motion of an event from the seriously distorted and complex seismic waves observed at a distance. It may be possible to achieve this through the use of computer techniques which compensate for the passage of the seismic wave through the earth in such a way as to remove the distortions introduced.

The panel noted more generally that experience in analogous scientific fields suggests that vigorous research in the comparatively neglected field of seismology is likely to produce new ideas or approaches which will make additional large improvements possible.

Unmanned Stations Needed

The panel concluded that, in addition to the improvements discussed above, the augmentation of the Geneva net with an auxiliary network of unmanned seismic stations offers the possibility of major improvement in the capability to discriminate between earthquakes and explosions.

For example, if such unmanned stations were spaced at 170 kilometer intervals in and adjacent to the seismic areas of the world, about 98 percent of the events as small as one kiloton equivalent, located within the network, would be identified by this system. This capability would be reduced to about 75 percent for events located at the peripheries of continents. The capability of such a net would depend primarily upon the degree of reliability of equipment that could be achieved.

Some Nuclear Shots Necessary

All of the above estimates by the panel refer to nuclear explosions conducted under conditions similar to those of Rainier, Logan, and Blanca in the Nevada test sites. The panel concluded that, although the differences in seismic signals from shots conducted in different geological environments cannot be predicted with any certainty, it is entirely possible that some natural conditions will yield seismic signals much smaller for a given size shot than those from shots in the volcanic rock at the Nevada test site.

The panel recommended that, in order to resolve the uncertainty on this question, an experimental test program involving many high explosive and some nuclear shots should be undertaken as soon as feasible.

Decoupling Can Mask Shots

In considering the possibility that the capabilities, now or in the future, of the Geneva System might be reduced by the intentional concealment of underground tests, the panel concluded that decoupling techniques existed which could reduce the seismic signal by a factor of ten or more. Moreover, preliminary theoretical studies have shown that it is possible in principle to reduce the seismic signal from an explosion by a much greater factor than this.

Nevertheless, in view of the many complexities involved, it is necessary that these ideas be tested with appropriately designed experiments to determine how large a decoupling factor can actually be realized in practice.

While many of these tests can be carried out with high explosives, complete evaluation of the theory probably cannot be made without nuclear explosions. Such tests may also disclose some characteristics which might allow long-range detection of such decoupled underground tests.

Table 1. Estimated annual number of unidentified world-wide continental earthquakes.

	5 Kilotons and greater	10 Kilotons and greater	20 Kilotons and greater
Geneva Conference of Experts, Aug. 1958	20–100		
Geneva network and equipment on basis of Hardtack data Jan. 1959	20–100	400	60
Geneva network with improvements within the present state of technology on basis of Hardtack data April 1959	300	40	15

Prototype Station

The panel emphasized the need to construct a complete prototype experimental station incorporating all features of the seismic stations recommended by the Geneva Conference of Experts.

Operating this station for a period of time would serve the two immediate objectives of providing experimental evidence on the capability of such stations to detect and identify earthquakes, and of assisting in working out installation and operational problems which would be encountered in establishing a control network. Subsequently, the station should be expanded to include facilities for testing other detection methods proposed by the panel or methods which may be developed through future research programs.

Panel Members

The following scientists, representing the fields of seismology, geophysics, electronics, physics, and mathematics, were members of the panel: Lloyd Berkner, Associated Universities, Inc., chairman; Hugo Benioff, California Institute of Technology; Hans A. Bethe, Cornell University; W. Maurice Ewing, Columbia University; John Gerrard, Texas Instruments, Inc.; David T. Griggs, University of California at Los Angeles; Jack H. Hamilton, the Geotechnical Corporation; Julius P. Molnar, Sandia Corporation; Walter H. Munk, Scripps Institute of Oceanography; Jack E. Oliver, Co-

lumbia University; Frank Press, California Institute of Technology; Carl F. Romney, Department of Defense; Kenneth Street, Jr., Lawrence Radiation Laboratory, University of California; John W. Tukey, Princeton University.

In addition, Warren Heckrotte, Lawrence Radiation Laboratory, Montgomery Johnson, Aeronutronic Systems, Inc., and Albert Latter, Rand Corporation, participated as special consultants to the panel.

Strauss Rejected as Commerce Secretary by Senate

Voting half an hour after midnight, 19 June, the United States Senate rejected by three votes the nomination of Lewis L. Strauss as Secretary of Commerce. The Senate action, which climaxed three months of growing controversy over the issue, represents the first rejection of a Cabinet appointee since 1925. Strauss, who was defeated by a 49 to 46 vote, is the eighth such nominee to be refused confirmation in the history of the country. He had been Acting Secretary of Commerce since his appointment by President Eisenhower last fall. Under the Constitution, the President's appointments must be made with the advice and consent of the Senate. After committee hearings on the nomination, which produced 1100 pages of testimony, Strauss' name went to the full Senate after approval by a narrow margin. Floor debate produced little new information, and the issue was pushed to a conclusion by Senate majority leader Lyndon Johnson (D-Tex.).

The course of events in the Strauss controversy represented a steady downward progression of the nominee's prospects. When the first confirmation hearings before the Interstate and Foreign Commerce Committee convened, 17 March, an informal poll showed the committee members to be 14 to 3 in favor of confirmation. As the sessions continued, the positions of many of the members changed, with the result that the final committee vote was a close 9 to 8 for confirmation. When the nomination came up for consideration by the full Senate, the general opinion in Washington was that Strauss would make it. However, very effective opposition, led by Senator Clinton Anderson (D-N.M.), and the negative position taken by the Senate majority leader, among other factors, resulted in Strauss' rejection.

Number of Foreign Scholars in U.S. Increases

The number of foreign students studying in the United States has increased by 38 percent in the last five years, the Institute of International Education has reported. The 47,245 students from 131 countries registered in U.S. colleges and universities this year represent a 9-percent increase over the number last year and an 86-percent increase over that of the academic year 1948–49. According to all available statistics the current figure represents the largest foreign-student population in any country of the world.

The postwar period has also produced a great increase in the exchange of university teachers and scholars, the institute reported in its 1959 edition of *Open Doors,* an annual statistical report on educational exchange. In 5 years, the number of foreign professors teaching in our schools has tripled. American colleges and universities reported 1937 foreign faculty members this year, in comparison to 635 in 1954–55. This was the first year on record that the United States, with 1842 American faculty members abroad, "imported" more professors than it "exported."

The sharp increase in both the "export" and "import" figures reflected the United States' growing concern with education in the physical sciences. Nine hundred and seven, or 47 percent, of the foreign professors brought to American schools this year were in this field. This was double the number of foreign science professors brought here last year. The number of American science professors who went abroad to teach and to do research was 389—43 percent more than last year.

"The increasing percentage of foreign students attracted by our science courses seems to show that the United States is achieving new status in science education," said IIE president Kenneth Holland in commenting on the survey.

The rapidly developing Middle East sent a record number of students here this year, according to *Open Doors.* This was the first year that more students came from the Middle East than from Europe to study in the United States. The largest number of foreign students (15,823) continued to come from the Far East, and the second largest number (10,249), from Latin America. The Middle East was third, with 6619, and Europe fourth, with 6601. Engineering, which claimed 23 percent of the students, continued to be the most popular field of study. The humanities, with 20 percent, was again second. Students from the Far East, the Middle East, and Latin America, concerned with the industrialization of their respective countries, again concentrated on engineering courses. Many of the new students in the physical sciences were also from the Far and Middle East.

Statistics on sources of financial support showed that, again this year, students who made up the largest single group (42 percent) supplied their own funds. Those in the next largest group (28 percent) were aided by scholarships from private organizations. There was a slight increase this year in the number of students supported by foreign governments; a particularly large number of African students received help from their own governments. The United States government gave scholarship aid to 4.8 percent of all students and joined with private organizations in supporting another 2 percent. These statistics again point up the vital role of private foundations and fraternal and civic organizations in bringing foreign students to our shores and also seem to indicate that the prestige of our schools is as much a factor in attracting students as the availability of scholarships.

Another reason for the influx of foreign students to this country was indicated by the large number who said they would welcome employment with the overseas branch of an American firm after graduation. Forty-one percent of the students answering the pertinent question in the survey expressed such an interest. More than half of these were engineering students, a third of them from the Far East.

The University of California was again the institution with the largest number of foreign students. Massachusetts Institute of Technology, however, had the highest percentage of foreign students—12 percent of its total enrollment. Massachusetts Institute of Technology also had more foreign faculty members (198) than any other United States college or university.

Archeological Work in Guatemala

An expedition from the University of Pennsylvania Museum has completed its fourth season of work at the ancient Maya site of Tikal, located near the center of the tropical rain forests of the Yucatan Peninsula's El Peten region in