ment many of the recommendations of the Panel on Seismic Improvement, of which Lloyd Berkner was chairman. Last year that panel concluded that this country's seismological research should be greatly expanded immediately and proposed a number of important programs, yet the executive branch has not asked for funds to support such work.

Other Aspects Examined

Senator Humphrey put forward still another aspect of the problem in his analysis of the test-ban issues when he urged that the principle of deterrence, the concept underlying other United States defense policies, be applied to the nuclear test control problem. He commented:

"We must accept the fact that we cannot cover every little unidentified event in the Soviet Union to see whether it is an earthquake or a nuclear test. We can, however, demand the right to inspect a certain number of cases on the assumption that such inspections will constitute a spot check system of random sampling which will have a high probability of accuracy and which will deter a nation from thinking a few sneak tests can be held without being caught."

Humphrey emphasized that new scientific data do not preclude the realization of a workable agreement. He pointed out that the scientific problems that have developed during the course of the negotiations in Geneva are not substantially different from those the negotiators faced when the meetings began. He said:

"We knew then that although our techniques of detecting and identifying tests would improve with increased research and knowledge, we would also discover a larger number of natural phenomena with this newer and more sensitive equipment.

"Nothing has changed since last October that justifies our giving up."

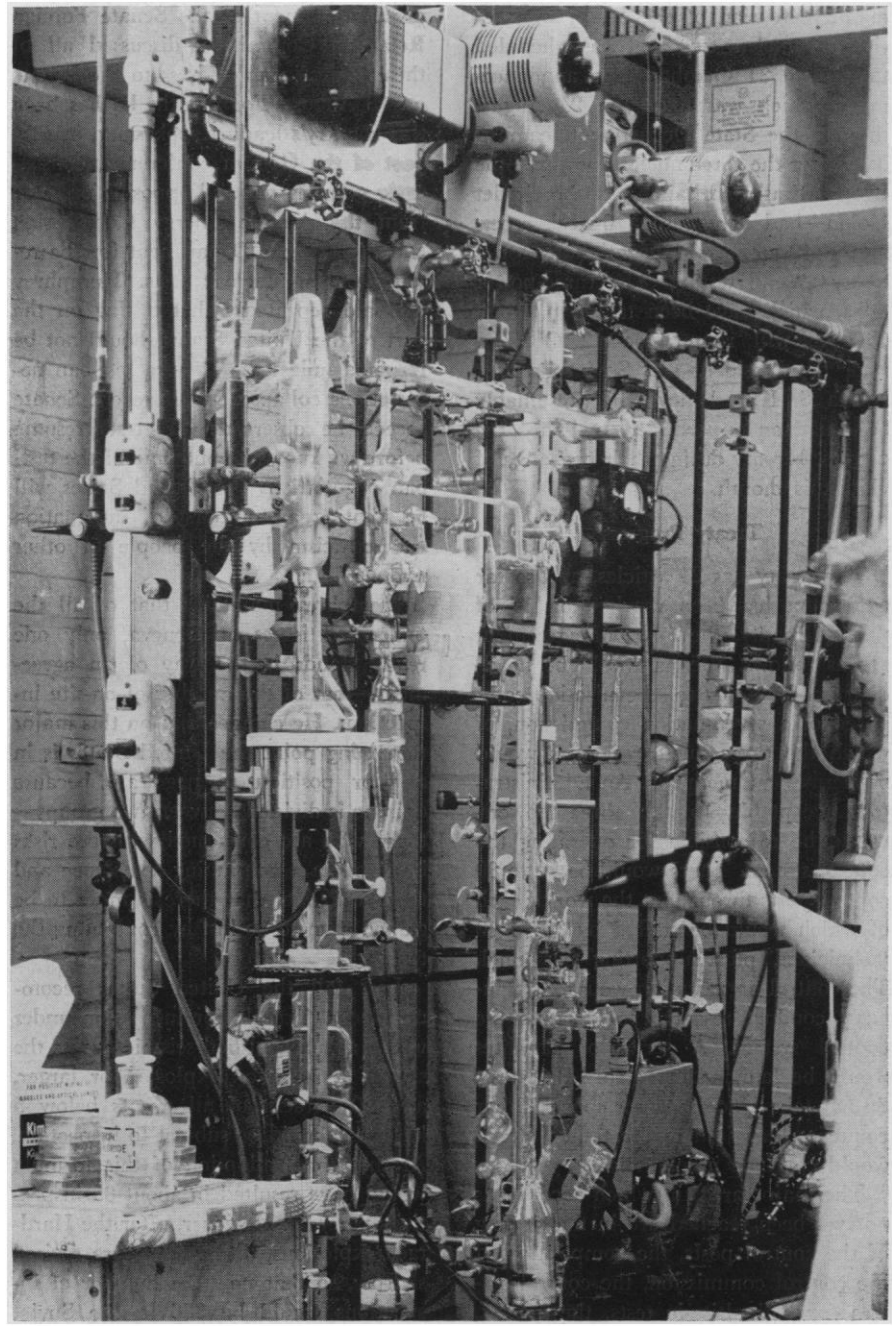
Hydrogen Isotope Studies Applied to Geology

The movement of water in cosmic scale processes and its geochemistry are current projects of the Geochemistry and Petrology Branch of the U.S. Geological Survey. By mass spectrometry, researchers in the nucleonics group are determining the ratios of light to heavy hydrogen in clouds, surface waters, glaciers, rain and snow, and the rocks of the earth's crust in an attempt to learn the earth's past and present water circulation and migration.

Water sometimes takes thousands, even millions, of years to complete the hydrologic cycle from ocean to cloud, to land, to ground water, to surface water, and back to the sea. And in the sea itself there are also known to be large time factors involved in the mixing of the various layers of ocean water and for exchanges with the atmosphere.

Congressional Report Says Current Fallout Not Hazardous but Warns against Test Resumption

On 24 August the Joint Committee on Atomic Energy released a "Summary-Analysis" *of hearings on weapon-test fallout that were held in May before the Special Subcommittee on Radiation. The 42-page report is reassuring about the fallout hazard from past nuclear tests but warns against resuming testing at the level of intensity of the last 5 years. The committee's analysis also points out that*



A U.S. Geological Survey geologist preparing a sample of atmospheric water for hydrogen isotope analysis.

while research efforts have been accelerated in the past 2 years, the fallout program as a whole has not received the high administrative support it needs. It emphasizes that better coordination of fallout information is essential, together with the development and application of adequate radiation standards. The analysis points to the need for better coordination among government agencies in determining, controlling, and evaluating environmental hazards.

A panel of technical advisers that was composed of scientists from both inside and outside the government assisted the subcommittee in preparing for the 3-day hearings. With the help of the panel, a detailed technical outline for the hearings was developed and some 30 expert witnesses were invited to testify. Members of the advisory panel were as follows:

S. D. Cornell, executive officer, National Academy of Sciences.

L. S. Taylor, chief, Atomic and Radiation Physics Division, National Bureau of Standards.

F. J. Weber, chief, Division of Radiological Health, U.S. Public Health Service.

John H. Harley, assistant director, Health and Safety Laboratory, Atomic Energy Commission.

L. Machta, U.S. Weather Bureau.

C. L. Dunham, director, Division of Biology and Medicine, Atomic Energy Commission.

Bentley Glass, Johns Hopkins University.

Hal Hollister, Division of Biology and Medicine, Atomic Energy Commission.

Paul C. Tompkins, Joint Committee on Atomic Energy consultant.

W. Selove, University of Pennsylvania.

William F. Neuman, University of Rochester.

Russell Morgan, Johns Hopkins University (invited but could not attend).

Origin of Fallout

Information developed at the hearings shows that if the test programs of all countries are considered together, the total nuclear yield resulting from these tests has increased markedly since 1954. Of the total 90–92 megatons fission yield equivalent released to date, 40 megatons was produced in 1957–58. The bulk of this was detonated during 1958 in the U.S. Hardtack series and the U.S.S.R. October series. Large portions of the radioactive products produced in this latest series have gone into worldwide fallout due to detonations of large-yield weapons at high altitudes.

As in 1957, testimony at the 1959 hearings indicated that strontium 90 and cesium 137 are still considered to present the greatest hazard in worldwide fallout (fallout away from the testing sites). But shortlived isotopes, such as strontium 89, iodine 131, barium 140, zirconium 95, and others, were described by several witnesses as worthy of more consideration or even potentially equal in hazard to strontium 90 and cesium 137. Similarly, long-lived carbon 14 was described as a potential long-term hazard from nuclear weapons tests.

Distribution of Fallout

The nonuniform distribution of fallout material in the stratosphere and on the ground, which was indicated in the 1957 hearings, has been confirmed. About two-thirds of the stratospheric material has been found in the Northern Hemisphere and about one-third in the Southern Hemisphere.

The estimated mean residence time of material in the stratosphere is now taken as from 1 to 5 years, compared to the 5 to 10 years estimated in 1957. The shortest residence time (about a year) can be expected for debris from the 1958 U.S.S.R. tests in the Arctic.

The rate of deposition of strontium 90 showed an increase in the spring of 1959 in the northern latitudes. Testimony indicated that such an increase may be the result of seasonal fluctuations and/or southward movement of polar air masses, coinciding with the 1958 U.S.S.R. tests in the Arctic. The existence of localized hotspot areas was recognized, resulting among other things from uneven distribution of radioactive debris removed from the troposphere by local rainfall. But the relationship of these hotspot areas to worldwide fallout, if any, remains unclear.

Uptake of Radioactive Isotopes from Fallout

The content of strontium 90 and cesium 137 in food has risen since 1957, even more rapidly than the total fallout. Temporarily high levels have been found in various parts of the country suggesting that under certain conditions strontium 90 may be taken up directly without going through the soil. Therefore, a consistent degree of discrimination (i.e., the selective reduction of strontium 90 in relation to calcium) from the ground to man cannot be expected.

Biological Effects of Radiation

Evidence was presented at the hearings suggesting that the magnitude of genetic effects (i.e., effects on future generations) resulting from a given dose of radiation may, contrary to the general belief in 1957, have a definite relationship to the *rate* at which the dose is delivered. The implication of this evidence is that the effectiveness of a given dose of radiation is less at low dose rates than at high dose rates, even for genetic consequences.

The biological significance of low levels of radioactivity is still largely unknown. No resolution was reached on whether or not a threshold level of radiation exposure exists below which effects such as cancer and leukemia do not result.

Hotspots and Their Significance

The term "hotspot" is used to refer to local areas, geographically speaking, where environmental contamination levels are considered to be higher than average levels in other areas of the country with which comparisons are being made. That such hotspot areas exist was not disputed; yet one of the ambiguities in the hearings testimony was the fact that no completely satisfactory definition was presented of what a hotspot is, how the limits of such an area are defined, and what the problems involved really are.

Some testimony suggested that higher radiation levels in limited areas do not, any more than other nonuniformities, increase the overall hazard of fallout to the world's population. This contention is based on the argument that the total hazard is related to the total dose of radiation received by an entire population, and is not related to geographic distribution. It is evident, however, that more data and greater consideration of how to evaluate the data are needed before a satisfactory answer to this problem can be worked out.

Significance of Short-lived Isotopes

According to the testimony, recent fallout samples have concentrations of short-lived isotopes which are equal to and in many cases higher than those of the longer-lived isotopes such as strontium 90 and cesium 137. Due to their relatively rapid decay, the total radiation dose they deliver is ordinarily only a small fraction of that delivered

by the longer lived isotopes. However, the short-lived isotopes may be acquiring more significance than previously thought in view of the fact that fallout from the stratosphere has proven to be faster than estimated earlier, together with the possibility of selective concentration in some particular organ of the body (i.e., radioactive iodine in the thyroid). The question apparently merits greater attention than it has received in the past, particularly in forecasting the effects of future tests.

Significance of Carbon 14

Information provided for the hearings suggests that radioactive carbon 14 from past weapons tests could constitute a genetic hazard to the world's population. The magnitude of this hazard has been estimated to be comparable to, and in some estimates in excess of, the genetic hazard from other fallout isotopes. One of the principal problems in making these estimates is how to assess the hazard of a dose which may be comparable in magnitude to that from cesium 137 and other genetically hazardous fallout isotopes but which occurs over a much longer time period (the equivalent of 8,000 years compared with 40 years or so). Here again, a problem was presented for which available information appears to be inadequate. Greater emphasis should be given to means by which this problem may be properly evaluated.

Maximum Permissible Dose and Maximum Permissible Concentration

It was generally agreed that in considering acceptable exposure limits in the context of worldwide environmental contamination from fallout, the best assumption that can be made at present concerning the relationship of biological effect to radiation dose is to assume that any dose, however small, produces some biological effect and that this effect is harmful. The testimony made it clear that much difficulty now exists in evaluating the hazards of environmental contamination from worldwide fallout. This is because of the difficulty in attempting to apply to whole populations exposed to fallout the concepts behind "maximum permissible dose" and "maximum permissible concentration," which were developed for occupational exposures to individuals under controlled conditions.

Even if concepts developed for industrial application were clearly transferable, the testimony suggested confusion over such points as to how to apply existing maximum permissible concentrations for water to food in the fallout situation, how to handle diets (what time period to consider when "averaging"), and how to allow for the possible presence of other isotopes than the one being considered.

Further evidence of confusion concerning hazards evaluation in the testimony presented was given by the use, on the one hand, of industrially oriented exposure recommendations discussed above and by the use, on the other hand, of comparisons with natural background radiation levels. At present, it appears that each controversial situation involving fallout exposure is evaluated on an ad hoc basis, but with little understanding or agreement on how the evaluation is to be done.

Effects of Past and Future Tests

It was forecast that the average concentration of strontium 90 in human bone from past weapons tests will reach its maximum value in the period 1962–65. The predicted U.S. average value of 6 strontium units (S.U.) is slightly higher than for average Western populations (5 S.U.) and lower than the average for Eastern peoples (10 S.U.). Thus for testing already conducted, man's exposure to fallout radiation is and will be relatively small compared to the "normal background" radiation or the standard recommended by the International Commission on Radiological Protection (ICRP).

Assuming successive cycles of testing over the next two generations or less, following the same pattern as the past 5 years, the predicted average concentration in bone will be about 48 strontium units. This is close enough to the maximum permissible body burden of 67 strontium units recommended by the International Commission on Radiological Protection to suggest that a hazard to the world's population could result during this period.

Alternative Patterns of Testing

Testimony at the hearings indicated that—

Underground tests can be conducted with relatively small weapons, without contaminating the atmosphere with radioactivity. Great practical difficulties exist for testing large or megaton weapons underground.

Outer space tests can be conducted under conditions—among which are distance and yield of the device—which will reduce atmospheric contamination to an as yet unknown degree. To obtain test data, there exist practical problems of instrumentation which would require further tests in space to resolve.

Environmental testing is necessary to establish effects of nuclear weapons on military targets, equipment, radiation levels, etc.

Government Program and Organization

While the AEC has accelerated its efforts in fallout research in the past 2 years, particularly in sampling and analysis, the fallout program as a whole apparently has not received the high administrative level support it needs to give it the necessary impetus. Increased dollar outlays for facility and operating expenses have been useful but further improvements in the program, its administration and its organization, are required. These should include adequate staffing in the AEC Biology and Medicine Division to meet the broad requirements of an expanding program. Better coordination by the AEC of fallout information is essential. Adequate radiation standards must be developed in cooperation with the various Federal, State, and private agencies.

The Public Health Service, which has been conducting a survey of radioactive fallout debris in milk, operates a research laboratory in Cincinnati and has a newly created staff in Washington. However, expenditures and numbers of personnel remain small.

With regard to the fallout program, increased emphasis should be placed on the "hot spot" program, declassification and periodic publication of useful information, development and application of exposure standards, and better coordination among Government agencies in determining, controlling, and evaluating environmental hazards.

In implementing an effective program, the first job is to define clearly what the real problems are and then assign responsibilities for meeting these problems. In the process, care should be taken not to interfere with existing programs which are making major contributions to knowledge in the fallout field.

Scientists in the News

CHARLES A. ANDERSON has been named chief geologist for the U.S. Geological Survey, a position recently vacated by WILMOT H. BRADLEY, who was appointed in 1944. Anderson, whose career with the Survey began in 1942, has been heading the Mineral Deposits Branch.