Atom Bomb Tests Leave Infamous Legacy

Damaging information on the Atomic Energy Commission has been dredged up by a high-level employee of the Pentagon

In an extraordinary opinion, federal judge A. Sherman Christensen recently ruled that the government of the United States practiced fraud upon his court in a 1956 trial on the deaths of thousands of Nevada and Utah sheep. It appears by clear and convincing evidence, the judge said, that agents of the government made false or misleading representations, that witnesses were improperly pressured, that crucial information was intentionally withheld or misrepresented, and that "by these convoluted actions and in related ways the processes of the court were manipulated" to the government's advantage.

The purpose of the government's deception was apparently to avoid linking the sheep deaths with radiation caused by atmospheric testing of nuclear weapons, which was then in full swing at a site in southern Nevada. When the government won its case, officials at the Atomic Energy Commission (AEC) presumably thought that they had permanently laid this possibility to rest.

What they failed to foresee was that—30 years later—a high-level employee of the Defense Department would come along and blow the whistle on their efforts, based on a careful review of the public record and some expert scientific calculations, performed entirely on his own time. The latter day nemesis of the AEC is Harold Knapp, who once worked there and is currently recognized as a national expert on the effects of nuclear weapons. As a technical adviser at the Defense Communications Agency, Knapp is at present concerned with the design, development, and testing of military communications systems that can survive a nuclear assault.

His work involving the sheep has placed him in a highly awkward situation, because as a Defense Department employee he has agreed that he will not bring the government into disrepute. Information he has developed tends not only to discredit the AEC's position in the sheep case but also to threaten the government's contentions in a dispute over cancer that may have been caused by the tests. Both are the subjects of litigation, some of it going on now in Salt Lake City. Knapp appeared there under subpoena last week, testifying at length about the AEC's activities during the weapons tests and his estimates of the exposure of infants and children to radiation then. The government has not yet presented its defense in court.

Knapp's efforts have won him the praise of Utah citizens and politicians, including the governor, Scott Matheson, but also the enmity of some former AEC employees who would prefer that the events be forgotten. The circumstances surrounding this controversy are detailed in voluminous documents that Knapp and others have placed in the public record, which were used in the preparation of this article.

There are enormous risks to the government in both of these trials. An affirmation of Knapp's contention that the government was negligent and scientifically irresponsible could prove humiliating for certain Energy Department employees, who firmly support the position of their predecessors at the AEC. The trials may also have wide-ranging economic impact. A federal task force on compensation for radiation-related illness warned in 1980 that the litigation carries "a risk of establishing judicial precedents which could be harmful to the government in other radiation and toxic substances litigation." A victory by the victims of cancer would cost about $2 billion. But there would surely be additional payments for thousands of soldiers who claim testing-related injuries, and possibly for others exposed to radiation by federal activities.

Unsurprisingly, a vigorous attempt has been made to rebut the plaintiffs' claims. In brief, the government's defense is that the evidence linking fallout and adverse health effects is not scientifically "competent." Federal attorneys contend, for example, that the sheep who died suddenly after exposure to radiation in 1953 were the victims of harsh weather, malnutrition, poisoning by toxic plants, or a virus. They contend that clusters of leukemia detected in the 1960's in southern Utah and northern Arizona by Clark Heath, Jr., a federal scientist, are merely statistical artifacts. They argue that more research is needed to determine if there are excess cancers in Utah, despite the publication of a study with this claim by Joseph Lyon, an epidemiologist at the University of Utah. The government's line today is essentially the same as it was during the 1950's—that radiation exposure from fallout was below the federal standard of 5 rads for workers in the nuclear industry, and therefore safe. The same assurances offered then by nuclear scientists Edward Teller, Ernest Lawrence, and Merrill Eisenbud are being offered now by federal attorneys, the Veterans Administration, and some scientists at the national weapons labs (Lawrence and Los Alamos).

The data used to support these statements were recorded by a corps of people dispatched by the AEC after each of the Nevada blasts to monitor the local fallout and suppress any public alarm. Detection devices were set up at various locations and radiation film badges were distributed to determine individual exposure. The result was a thick file on gamma radiation distributed by the fallout. According to the government, the file shows that only a handful of people—19 to be exact—were exposed to more than 5 rads, while 160,000 people were exposed to less than 1 rad, and 11,000 people had exposures somewhere in between. An interagency group established by President Jimmy Carter and chaired by a Justice Department attorney estimated that the exposure was enough to cause between 19 and 96 cancers, and between 6 and 32 fatalities. "Thus, from an overall public health perspective, the added risk to the downwind population from fallout was very small," the group concluded. The lawsuit against the government was filed on behalf of 460 victims of leukemia, Hodgkin's disease, and other forms of cancer.

The case against the government consists primarily of evidence indicating that exposure to radiation was much greater than the government admits. It is here that Knapp is an important witness. His involvement stems in part from work he performed at the Atomic Energy Commission (AEC) in 1962 and 1963. As a young mathematician from MIT, Knapp had initially joined the AEC's Office of Operations Analysis, where he worked on studies of nuclear weapons, as well as

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annual estimates of the fallout and biological effects resulting from a nuclear war. When the AEC opened a fallout studies branch Knapp moved there.

He was assigned, on his first day in the division, to prepare a rebuttal of a letter written by an AEC critic, Ralph Lapp, to the congressional committee responsible for nuclear matters. Lapp alleged that the AEC had underestimated human exposure to radiation dispersed by the tests. In the course of his work, Knapp came across information suggesting that infants were indeed exposed to radiation that exceeded federal guidelines. The route of exposure was through cattle, which consumed forage covered with fallout and produced milk contaminated by radioiodine. Radioiodine concentrates in the human thyroid, and Knapp estimated from 1958 milk samples in St. Louis that infants there received a dose of 2 to 2½ rads to the thyroid, four to five times the amount that had just been established as a safe limit by the Federal Radiation Council. Knapp's report was forwarded to Capitol Hill with a cover letter from the AEC chairman stressing how conservative that limit was.

Dawn at the Nevada test site, 19 May 1953

The Harry blast, pictured above, would eventually be remembered as "Dirty Harry," because it generated an unusually high amount of fallout in the vicinity of the test site.

Knapp was surprised that such high exposures could occur at such great distance from the tests, and he began to inquire about the doses in Nevada and Utah. He immediately discovered that the possibility of thyroid exposure resulting from milk contamination was largely ignored by the AEC during the early 1950's. Samples had not been collected, and the public was never warned against milk consumption. On one occasion when samples were taken, in the vicinity of St. George, Utah, after the Harry blast in 1953, they proved unreliable because critical details had not been recorded. As indicated by a report at the time from the Los Alamos Scientific Laboratory, which coordinated the effort, no information was gathered "on time of milking, milking techniques, individual producers, et cetera. Off-site personnel in the St. George area decided that extensive inquiry into such details would indicate the concern of the test program's rad-safe group with the possibility of milk contamination and alarm an already worried community."

In addition, the method of chemical analysis applied to the milk resulted in the boiling off of radioiodine. It was possible to produce estimates based on back-calculations from the remaining fission products, but the AEC was apparently loath to see this done. According to a transcript of a meeting sponsored by the Energy Department in 1980, Morgan Seal, who was then in the Public Health Service and assigned to milk analysis, said that he gave some back-calculations to a top AEC official, who "got mad, red in the face, took it and threw it on the floor and stomped on it, [saying] 'Don't you do that.' "

Knapp's troubles at the AEC arose when he found a way around the lack of data that required only modest effort. The question, as he stated recently in court documents, was "how much might the levels of iodine in milk have been at a time when no measurements were made, but when one had external gamma measurements." Knapp said that it was a relatively straightforward matter to look at the gamma readings and determine the amount of fallout deposited on the ground. The next step was to determine the quantity retained by forage and consumed by dairy cattle. And the final step was to estimate the amount that would turn up in milk.

After careful study, Knapp determined that infant thyroids could be exposed to radiation at levels from 96 to 840 times the dose of external gamma radiation, which generally ranged between 1 and 5 rads in Nevada and Utah. "I was astonished because it came out that the levels around St. George, for example, could have led to doses of several hundred rads to the thyroid," Knapp has testified in a deposition. "Mind you, people were excited already when it was two rads in St. Louis." The effect of Knapp's work was to demonstrate that the government was grossly underestimating human doses of radiation.

Knapp told his superiors that the results were "disturbing." And indeed they were. Charles Dunham, the director of the biology and medicine divison where Knapp worked, said in a memo that he found the work "amateurish. . . . Its inadequacies, i.e. almost total absence of any thoughtful basis for many sweeping assumptions, uncritical use of analogy and models, are such as to make me reluctant to waste any more people's time on this draft. In fact what has been thrown together here can be looked on as an invitation to others to write the document for the author."

Knapp said that he could have interpreted that as "an invitation to stop doing that work, perhaps an invitation to resign from the AEC. . . . But I hadn't enough experience in the government then to know what I was supposed to do, so I said well, they say I have to do more careful work, so I will do more careful work." Knapp went to Nevada, talked to the people who monitored fallout, and

learned more about cattle forage. When he resubmitted the report with his conclusions unchanged, the AEC decided that the best recourse was a review committee. One of those appointed to the committee was John Gofman, who was then the director of a radiation health program at Lawrence Radiation Laboratory. "Charles Dunham called us in and said, 'we have a very serious problem,' " Gofman remembers. "Dunham said if this is published it will make us look like liars." Gofman told *Science*, "that review committee was called for the purpose of suppressing Knapp's report."

The committee decided that Knapp's formula for estimating thyroid doses from records of external gamma radiation should be tested against data from a recent atomic test. It was, and the results supported Knapp's conclusions. Gordon Dunning, then deputy director of the AEC's division of radiological safety, opposed the report's release as an AEC document, but suggested that Knapp might get it published on his own. "We may expect letters and inquiries," he said in a memo to others at the AEC. "We can then treat these in the same professional and unemotional way that we have many others in the past."

Ultimately, the AEC published it after Knapp excised applications of his formula to fallout from single high-yield weapons, and cast doubt on its general applicability. But the doubts proved unwarranted. Arthur Tamplin, a biophysicist at Lawrence, published a study of fallout and thyroid doses several years later that generally affirmed Knapp's estimates. And monitoring data from other atomic tests also supported Knapp. At a recent reunion of federal monitors, Harold Mueller, a fallout specialist with the National Oceanic and Atmospheric Administration, said that "I think we have looked at the Knapp relationship for quite a number of blasts. . . . I think we found that all of those you looked at, the iodine levels, did fall within the range that he predicted."

Knapp testified last week in Salt Lake City that, on the basis of his formula, fallout resulting from the Harry blast in 1953 resulted in a dose of 120 to 440 rads to the thyroids of children in St. George, a level that he considers significant. The government's official response to Knapp is likely to be that the doses were much lower, and that the medical evidence linking such low-level exposures to the onset of hypothyroidism, thyroid nodules, or thyroid cancer is highly questionable. Studies that demonstrate cause and effect at low levels generally involve

Harold Knapp

external, not internal, exposure to radiation, such as that caused by treatments for hyperthyroidism. According to Jon Wolff, an endocrinologist at the National Institutes of Health, even these data are poor. Still, he says, some increase in the number of nodules may be expected from exposure in the range that Knapp estimates. Seymour Jablon, an epidemiologist at the National Academy of Sciences who has studied the Utah dosimetry, also says that excess thyroid cancer will result from doses in the range of 100 rads.

Knapp was so distressed by the AEC's treatment of his research in 1963 that he left for a job as a research analyst at the Institute for Defense Analyses (IDA), a Pentagon weapons think-tank. A condensed version of his AEC report was published in *Nature* in 1964, with the extrapolation to an individual bomb blast added back in.

At IDA, Knapp produced reports on weapons targeting, weapons design, nuclear effects, civil defense, and the vulnerability of military communications systems. In 1979, a congressional committee asked him to testify about his activities at the AEC, and it was at these hearings that he first learned about the dead sheep.

Shortly after the AEC tested Nancy and Harry, two high-yield bombs, in the spring of 1953, ranchers noticed what appeared to be radiation burns on sheep grazing just to the north and east of the detonation site. Some of the sheeps' wool sloughed off in clumps, and within a short period of time, 2000 ewes and 2200 lambs died. The AEC immediately launched an investigation, and concluded 6 months later that "on the basis of the information now available, it is evident that radioactivity from atomic tests was not responsible." The sheep did not die from gamma or beta radiation, because the doses were too low, the AEC said. And they did not die from excessive doses to the thyroid, because that is a slower cause of death. No alternative explanation was offered, but the suggestion was made that malnutrition and diseases related to pregnancy may have been at fault.

Knapp was present during the testimony of some sheepmen, and took home records on the AEC investigation. Almost immediately, he noticed that no one had considered the possibility that the sheep died from the effects of fresh fallout in their stomachs. He wound up visiting three federal libraries and using virtually all of his spare time to produce—15 months later—a 620-page analysis of how the sheep might have died. His conclusion was that sheep exposed to only 4 rads of external gamma radiation might have gotten a dose of 1500 to 6000 rads in their gastrointestinal tracts. He estimated that fetal lambs may have received a thyroid dose of 20,000 to 40,000 rads.

Knapp concluded that such doses are high enough to cause the deaths. But he also discovered evidence that the doses may have been much higher. An AEC staff report at the time of the deaths indicated that radiation readings from the wool of sheep in the vicinity of Cedar City, Utah, were consistent with a dose of only 2 to 4 millirems above background. But the report failed to note that the measurements were recorded 25 or 26 days after Harry, the second of the two blasts. Taking into account fission decay characteristics, Knapp calculated that the real external gamma dose would have been between 38 and 169 rads, not 4 rads, a reading that could be explained by the uneven distribution of fallout.

Kenneth Nagler, a former fallout specialist with the National Weather Service, confirms the existence of such hot spots. There are, he says, all kinds of local effects—such as wind—"that would louse up the last part of the fallout process." There was a good chance of missing such phenomena, because monitoring was poor in remote grazing areas. But there was also a tendency to ignore unusually high readings. Frank Butrico, a monitor at St. George, Utah, admits that he failed to record some readings after the second blast that "didn't reinforce my natural prejudices."

Once Knapp's conclusions became known they quickly became a source of controversy. The sheepman subpoenaed him to testify at a hearing last spring on behalf of their efforts to win a new trial. By that time, Knapp had resigned from IDA and become a director of the Pentagon's Joint Program Office, which is charged with coordination of efforts to build a survivable military communications system. Acquaintances say that Knapp was uneasy at the prospect of testifying, but the Pentagon's general

counsel ruled that he had to comply with the subpoena. The government mounted a vigorous assault on his conclusions at the hearing. Lynn Anspaugh, a scientist at Los Alamos, testified that he thought the sheep received a dose of only 1.4 rads to their intestinal tracts, and only 100 to 400 rads to their thyroids, a factor of 100 lower than Knapp's estimates.

The topic on which the calculations diverge, and on which the sheepmen's claims may ultimately depend, is the quantity of soil that a sheep ingests while eating. Knapp says that sheep foraging on a dry range, such as the one in Utah in 1953, ingest a good amount of soil, and so ingest a good amount of radiation. Anspaugh says they don't. Neither side can really prove its case, given the paucity of reliable research data, and the lack of any measurements at the time.

In congressional documents, Knapp admits that he did not rigorously prove that "fallout was the sole cause of death, or the primary cause of death . . . only that fallout is the simplest explanation of the primary cause of death." It is up to the government, he said, "to show that certain things did not happen. This is especially true if there is good reason to suspect that the government was deliberately deceptive or incompetent, or both, in presenting the facts of the case."

Shortly after giving his testimony, Knapp left the Joint Program Office and moved to his new position at the Defense Communications Agency. When the latest subpoena came around, Knapp was mindful of the Pentagon code on conduct, which says that employees will avoid any action that affects "adversely the confidence of the public in the integrity of the government." This time, he turned the subpoena down, with support from the Pentagon legal counsel. Subsequently, the judge told the Justice Department to arrange for his participation anyway.

America's nuclear weapons establishment has not been kind to those who dissent from its official positions. Gofman and Tamplin, whose work supported Knapp's initial study of radiation in milk, were eventually drummed out of weapons-related work, according to their own accounts. But Knapp's situation is different. He has on his side the passage of time: his allegations have been carefully confined to events of 20 to 30 years ago. His intention is obviously not to generate ferment, but to correct history.—R. JEFFREY SMITH

Next week: Did federal scientists deliberately conceal information that might have forced a halt to the testing?

New Slant on Engineer Training

A quartet of senior electrical engineering professors at MIT argue in a new report that an effective way to deal with the much-publicized crisis in engineering education is to pay more attention to working engineers now prey to "creeping obsolescence."

The authors shift the discussion from its usual focus on overcrowded undergraduate programs and a shortage of engineering and computer science faculty by advocating education for postgraduate engineers through a new structure linking universities, industry, and professional organizations.

Under its rubric of "Lifelong Cooperative Education," the report calls for a "new pattern of engineering education intended to meet the needs of a world characterized by rapid technological change and by engineering systems of growing complexity. In such a world, creative, responsible, and broadly knowledgeable engineers are a most precious resource whose quality cannot be replaced by quantity."

The report was prepared as part of the celebration of the 100th anniversary of the MIT electrical engineering department and was released on 2 October at a symposium marking the centenary. Members of the centennial study committee are professors Robert S. Fano (chairman), Louis D. Smullin, William M. Siebert, and James D. Bruce.

Created because the centennial seemed an appropriate occasion for a critical look at electrical engineering education, the committee decided in its early discussions that the rapid pace of innovation in the field made postgraduate education and professional development a problem area needing attention.

The subject was discussed in workshops in January and April attended by people from industry, MIT, and other universities. The committee completed its drafting work this summer. The report's major conclusion is that the demand for electrical engineers "cannot be met by replacing 'obsolescent' engineers with new graduates (and the human costs of such a replacement policy would be unacceptable even if it were feasible).

"The only apparent alternative is better utilization of the presently available engineering workforce through continuing education at the workplace with the active encouragement and support of employers."

Engineering schools and neighboring industries are urged to collaborate in making off-campus graduate programs available to working engineers. The report recommends that MIT and other engineering schools establish special master's degree programs for working engineers but not limit enrollment to degree candidates.

As a model for course instruction the report urges adoption of a method of "tutored video instruction" developed at Stanford over more than a decade. Television recordings of regular Stanford classes are used in off-campus sessions in small classes guided by tutors. The technique stresses frequent playback and discussion of material during the session; questions can be referred to a lecturer at Stanford by phone for discussion at the next meeting of the class.

While recognizing that continuing education programs in engineering already exist, the report argues that a much more widespread and effective system is required. The approach should strike a responsive note with critics who complain that industry prefers to pay lower wages to successive crops of recent graduates trained here and abroad, while shedding older, more highly paid engineers whose professional training is in many cases outmoded.

The report's authors concede that the major obstacle to implementation of their proposal is the current shortage of engineering faculty. As one answer, they say, "The help of industry is urgently needed in the form of sabbatical leaves for senior engineers so that they may join us as visiting faculty."

The report is addressed specifically to the MIT electrical engineering department, but the hope is that its proposals will attract broader interest at MIT and at other institutions.—JOHN WALSH

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