3. In contrast to highly urbanized centers, the hospital service areas of Vermont tend to be relatively discrete and seldom overlap. Over 85 percent of all hospitalizations of Vermont residents in 1969 took place in the service area of residence. Maternity patients, patients requiring general surgery, and most patients with medical conditions that comprise the majority of admissions are usually hospitalized in their own area. Patients with conditions requiring specialized services were more often referred to other areas. In the community hospital areas, about two-thirds of the admissions for neoplasms were treated locally and one-third treated in referral hospitals. Neoplasm was the major diagnosis in 5 percent of hospital admissions.
4. The major effect of the allocation procedure on estimated bed supply was to distribute one-third of the 587 beds of the referral hospital to the other hospital service areas in and outside of the state. In four areas, the number of allocated beds was lower than the number of resident beds, reflecting overlap at service boundaries. In none of the community hospital service areas did the allocated number of beds differ from the resident beds by more than 20 percent.
5. Significance level for simple regression coefficient with 11 degrees of freedom: r: .55 = 5 percent; .68 = 1 percent.
6. Unpublished report prepared by the Northern New England Regional Medical Program for the Connecticut Valley Health Compact, Springfield, Vermont, 1971.
7. Blendon's classification of level of difficulty of surgical procedures was used [R. J. Blendon, thesis, Johns Hopkins University (1969)].
8. Cochrane has recently summarized technical and organizational problems encountered in appraising the effectiveness and efficiency of health services. Failure to subject particular medical actions to randomized, controlled trials is, in his opinion, the major reason for uncertainty about the value of many common preventive, therapeutic, and diagnostic activities [A. L. Cochrane, *Effectiveness and Efficiency* (Nuffield Provencial Hospital Trust, London, 1972)].
9. Modified from *Vermont State Plan for Construction and Modernization of Hospital and Medical Facilities* (Vermont State Health Department, Burlington, 1971).
10. Partially supported by Public Health Service grant PHS-RM0303. We gratefully acknowledge the help of W. Gifford, R. Gillim, P. Hickcox, K. Provost, and J. Senning in the work leading to the development of this article.

NEWS AND COMMENT

Watergate: Verification of Tapes May Be Electronic Standoff

The long legal skirmish over possession of the White House's Watergate tapes is over, but a new battle of wits between opposing experts is about to begin, this time with scientists instead of lawyers as the adversaries.

Last month Judge Sirica, in consultation with the White House and the Special Prosecutor's Office, appointed a panel of six experts to advise on the authenticity of the surrendered tapes. If the tapes have been altered, and altered by amateurs, the panel will probably have little difficulty proving it. But if the tapes have been edited by the most sophisticated means available, the result may be a technical impasse between the counterfeiters and the verifiers from which no clear conclusion is possible.

A second technical issue raised by the tapes is whether the panel can succeed in resurrecting the conversation on the 18-minute portion of tape, part of which the President's secretary says she may have erased by accident. The erasing procedure on tape recorders reduces sound to an inaudible level but often leaves a residual signal from which, by suitable computer enhancement, the original conversation can be reconstructed. The reconstruction process is so well recognized in the intelligence community that the Department of Defense requires tapes containing classified material to be specially demagnetized. According to George O'Toole, a former CIA computer specialist with experience in signal processing, restoration of the 18-minute gap in the 20 July tape would certainly be difficult, but he says, "I don't know of anyone in the field who would say it is impossible if it were important enough to do."

Sirica's panel of experts* has been chosen to represent the best available level of competence outside of the federal government. Selection of the panel was coordinated by Carl Feldbaum, a member of the Special Prosecutor's Office, who spent 2 weeks in ascertaining what disciplines were pertinent to the verification of the tapes and who were the best people to represent them. Panel members have been instructed by the court not to comment on the procedures they will follow, but they will probably be guided by an outline of possible approaches prepared for Feldbaum at an early stage of the selection process. The author of the outline is Barry Blesser, an assistant professor at MIT whose research field includes both electrical engineering and acoustics. Three features that should be studied for evidence of tampering, Blesser told *Science*, are the various electronic fingerprints left by the tape recorder, the environment in which the microphone was operated, and certain speech factors including what are known as coarticulation features.

Potentially the most useful kind of fingerprint is the high frequency added to the tape at the same time as the sound frequencies in order to smooth out the nonlinear character of the magnetic tape. The bias frequency, as it is known, varies from one production line model to another and is a special, though not necessarily unique characteristic of each machine. Most sound engineers assume that the bias frequency cannot be picked up from a tape. It seems to be a little known fact that the bias can be usually recovered with sufficiently fine recording heads. Study of bias frequency should tell first of all whether one or more machines were used in making the tapes given to the court.

The bias frequency should also indicate the presence of any spliced-in segments of tape that may have been recorded on the same recorder. Because of its periodic nature, the bias frequency of a spliced-in segment will be out of phase with that of the original recording, unless special precautions have been taken. Mismatching of the two phases can be detected by a device known as a phase-lock loop.

A third application of the bias frequency is to determine if the original tape has been either rerecorded or overdubbed. The system used by the White House is said to have been voice activated, which means that the tape spools begin to turn each time the microphone starts picking up voices. The acceleration of the tapes from rest to their normal speed can be measured by the change in pitch of the recorded bias

* Panel members are as follows: Richard H. Bolt, chairman of Bolt, Beranek and Newman; a former professor of acoustics at MIT, Bolt has available to him the expertise of some 40 specialists in his own company. Franklin Cooper, adjunct professor of linguistics at the University of Connecticut and one of the pioneers of speech analysis. James L. Flanagan, Bell Laboratories, a specialist in the digital coding of speech. John G. McKnight, consultant to the Dictaphone Corporation, formerly at Ampex and involved in specifying standards for audio tape recorders. Thomas G. Stockham, professor of computer science, University of Utah, specialist in the processing of sound and pictures with digital methods. Mark R. Weiss, vice-president for acoustics research, Federal Scientific Corporation, New York; Weiss has developed techniques for reducing background noise and other interference on speech recordings in order to increase the detectability and intelligibility of speech.

frequency, a feature known as the start transient. The start transients will be present on the original tape but not on any rerecording, because the bias frequency is too high to be reproduced by conventional playback heads.

The White House tape recorder—a Sony 800B—may have left other distinguishing marks on the tape besides the bias frequency. One is the angle of the recording head to the tape; any shift from the vertical can be measured by a reduction in the efficiency of the recording. Another measurable feature is the degree of wear on the recording head (or, more precisely, the difference in wear between the top and bottom halves of the head). The wow and flutter, caused by imperfections in the capstan, are also a characteristic of each machine. Though none of these features by itself is definitive, together they should serve to fingerprint the White House machine beyond any reasonable doubt.

Unfortunately the particular speed at which the White House recorder was played may put the bias frequency studies suggested by Blesser at or even beyond the limits of present technology. To pick up the bias requires a playback head with a gap between its magnetic poles which is no wider than the frequency wavelength. The Sony 800B has a bias frequency of 55,000 cycles per second and was played at a speed of 15/16ths of an inch per second, giving a wavelength of 17 microinches. The smallest gap available in commercially produced heads is 60 microinches. Even with a custom-built head, the minute separation caused simply by the surface finishes on the recording head and the tape might have prevented the bias frequency from being recorded in a recoverable way.

If the bias frequency cannot be recovered, it may be possible to use other periodicities on the tape instead, such as the 60-cycle-per-second hum of alternating current.

Another approach outlined by Blesser is to look at the acoustics in which the recording was made. According to the White House, some of the microphones were concealed in desk drawers. A desk drawer will act like a sound box, with a particular dominant resonance that can be identified from the tape recording. If any rerecording had been made with the mike outside the drawer or even in a different position in the drawer, there would probably be a noticeable discontinuity in the energy pattern of sounds recorded on the tape. The expert placed on the panel to study this possibility is Thomas Stockham of the University of Utah. Stockham has developed a computer program for improving old Caruso recordings by subtracting the undesirable acoustic qualities of the horn Caruso sang into. The same method should be capable of pinpointing Nixon's drawer.

A third kind of test for editing, according to Blesser, is analysis of various speech factors. One such factor is the intonation pattern that rises and falls continuously throughout a sentence. Excision or insertion of a phrase will produce an evident discontinuity in the pattern. Another anomaly caused by trying to edit the continuous stream of human speech can be detected by making sound spectrograms, or voiceprints. Most speech sounds are com-

SIPI Appeals for Aid to Vietnam

The Scientists' Institute for Public Information (SIPI) has started a drive to mobilize the resources of the American scientific community to aid in the recovery of war-damaged Indochina. Scientific Aid to Indochina (SAI), a task force established by SIPI, plans to determine what scientific and technological help is needed by the peoples of Indochina to restore their agricultural lands and to help supply it through voluntary contributions of time, equipment, and money by scientists.

Arthur W. Galston, professor of biology at Yale University and SAI's chairman, said that the first project of the task force will be to establish a small Research Institute of Agricultural Botany in North Vietnam in response to a direct request from the North Vietnamese government. The institute is expected to be staffed by 25 to 30 scientists and a number of technicians. The government of South Vietnam has made no such request, but in the event that they do, Barry Commoner, chairman of the board of directors of SIPI, says that SAI would make every effort to provide similar help there.

The Research Institute of Agricultural Botany is of first priority because of the dependence of the Vietnamese people on agriculture. The destruction of agricultural lands by U.S. earthmovers, bombs, herbicides, and other weapons calls for advanced techniques in repairing the land and making it productive again. Existing agricultural research laboratories were destroyed during the war, according to the SAI.

Senator Gaylord Nelson (D–Wis.), who has introduced an Ecological Damage Assessment bill to determine the long-term ecological effects of the war, is fully in support of the task force and its first project.

The SAI was established last spring to inform American citizens of the extent of human and ecological damage in Indochina and what can be done to repair it. Its first project was developed after two of its members, E. W. Pfeiffer, professor of zoology at the University of Montana, and Arthur H. Westing, professor of botany at Windham College, returned from a tour of North Vietnam last summer. They told of massive bomb craters and large areas of devastated farm land. After Pfeiffer and Westing had discussed the situation with the State Committee for Science and Technique of North Vietnam and the Society for the Dissemination of Science and Technique, SIPI's counterpart in North Vietnam, SAI adopted the research institute as its first project.

The letter of appeal from SIPI, signed by Commoner and Galston, has been sent to more than 10,000 scientists. According to Galston, the project will have no connection with any government-related effort. Galston likens the voluntary participation of U.S. scientists in this venture to "an act of personal restitution for war damage." The immediate goal is to raise $100,000 by early 1974 so that Galston can travel to North Vietnam in the spring to establish the institute. Books, journals, and equipment are also needed, as well as scientists to train the institute personnel. Prospective contributors may contact SAI at 38 East 68 Street, New York 10021.—S.B.M.

posed of three principal frequencies called formants. The precise shape of the formants in each sound is influenced by those of the preceding sound. Thus if the word "not" were excised from the phrase "He was not involved," the formants of the "i" sound of "involved" would still indicate that the "i" had actually been preceded by a "t", not an "s."

Could a counterfeiter evade all these methods of detection? "In overview it looks rather impossible," Blesser says. "But given enough time and equipment and expertise you could make your editing undetectable." There are probably no more than a hundred people in the country who are even aware of all the technical issues. Only if the White House had access to the National Security Agency or the CIA could they get a perfect editing job done, Blesser believes. Other experts feel that detection of a well-edited tape is far from certain. "You can't guarantee that you can detect very professionally done alterations," says Amar G. Bose, professor of electrical engineering at MIT and chairman of Bose Electronics.

Besides testing the authenticity of the tapes, Sirica's panel will also try to restore the conversation in the erased 18 minutes and in any other gaps that may come to light. The 20 July tape is already undergoing tests in the laboratories of the Federal Scientific Corporation in New York. A member of the Sirica panel, Mark R. Weiss, is the corporation's vice-president for acoustic research. At this stage, it seems that, in order to resurrect the erased portions of the 20 July tape, it will be necessary to subtract the hums apparently made by the electric typewriter and tensor lamp in the office of the President's secretary. With the hum removed, the hiss that remains can undergo signal enhancement analogous to that used to process the video pictures sent back by spacecraft. This kind of processing is apparently a standard technique in the intelligence community; without it, the low-grade recordings obtained from the bugging of embassies and the like would be virtually useless. Certain of the panel members have access to the intelligence agencies or their contractors who have the necessary expertise.

A simpler way of restoring the lost portion may be available if the heads of Miss Woods's tape recorder, as is often the case with amateur's machines, were not absolutely clean. Pieces of gunk accumulating on the erase head can sometimes lift the tape away from the erasing signal and leave a thin strip of unerased material on the tape. The strip can be visualized simply by painting the tape with a solution of carbonyl iron particles, which settle only on the strip of tape that has remained magnetized. Also, tape recordings grow stronger with age as the magnetic pattern recruits new particles that are more resistant to erasure. The tape of 20 July, 1972, erased on 1 October 1973, may be just old enough to show this effect. Third, if the erase head were misaligned, it may have left an unerased fringe.

Many of the tests for tampering described by Blesser and other experts are statistical in nature, which means that, unless some particularly crude forgery has been perpetrated, the panel may only be able to give probabilistic conclusions. And exhaustive tests of all seven reels of tape could take a long time—5 man-years according to one estimate. One way or another, Sirica's court will be lucky if it receives any quick or definitive answers from its panel.—NICHOLAS WADE

Cancer: Select Committee Calls Virus Program a Closed Shop

The last few weeks have not been all that one might hope for the nation's premier biomedical research enterprise —the war to conquer cancer. First, assistant secretary for health Charles C. Edwards declared the whole operation an "administrative mistake." Then, a special committee of the National Cancer Advisory Board turned in a review of the multimillion dollar Virus Cancer Program (VCP) that was not exactly complimentary.

Edwards's remark won him as many friends as it did adversaries. Right from the start, many, many scientists opposed the administrative scheme that set the National Cancer Institute (NCI), which is running the war, apart from the rest of the National Institutes of Health. But the National Cancer Act of 1971 was passed just the same, and the question of whether that ever should have happened became submerged as controversies arose over details about how the cancer crusade should be staged. So, a lot of people, including some members of the cancer board itself, were happy to see Edwards resurrect what they consider still to be the basic issue.

The catch is that, were Edwards to have his way by withdrawing the NCI's special status within NIH and cutting it down to size, it does not necessarily follow that future decisions about the level and style of support of cancer research would revert to the scientific community. Nor does it logically follow that less money for cancer would mean more for anyone else. What does follow is that scientific decision-making would become even more centralized within the Administration than it is now (*Science*, 2 November).

The strongest exception to Edwards's charge that the cancer program is an administrative mistake has come from investment banker Benno C. Schmidt, who is President Nixon's principal adviser on the cancer crusade. "Despite expressions to the contrary by the assistant secretary for health, it is my opinion that the National Cancer Act of 1971 is a sound piece of legislation that has worked extremely well," he told a crowd of physicians attending the National Conference on Virology and Immunology in Human Cancer, held recently in New York. The mistakes that have been made, in his opinion, should be blamed on the Administration, not the cancer legislation. Schmidt thinks it was a mistake for the Administration to cut research training grants and to reduce funds for other areas of research at a time when progress in cancer depends upon progress in other areas as well. "At the time we were urging on Congress and the Administration a greater effort in cancer, we were very explicit in the position that the increased cancer effort should not be at the expense of other biomedical research. I must confess that I, for one, did not believe that