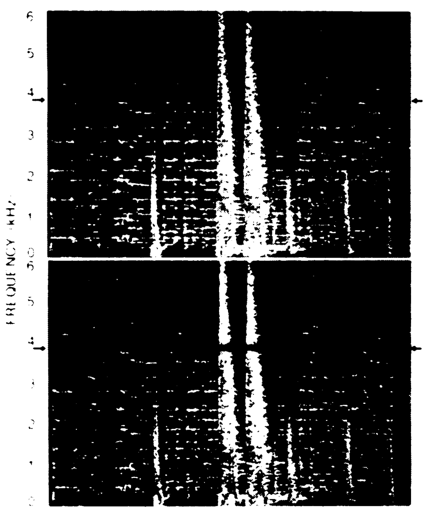
Putting a notch into digital sound

Digital audio tape offers the possibility of making crystal-clear copies of recordings, with none of the background hiss typically heard on tape. However, that possibility alarms the recording industry, which has been championing an electronic system designed to prevent people from freely copying recorded music. After five months of tests done at the request of three congressional subcommittees trying to resolve conflicting claims, the National Bureau of Standards (NBS) in Gaithersburg, Md., last week concluded that the proposed copy-prevention scheme "does not achieve its stated purpose." Moreover, some listeners can hear a difference in sound quality.

The copy-prevention system, developed by CBS Records in Milford, Conn., and known as Copy-code, involves electronically filtering out a narrow band of frequencies from any recorded music. This "notch" in the recording is centered at 3,840 hertz, a frequency that lies between the highest B-flat and B notes on an 88-key piano. Circuitry in the tape recorder would scan incoming signals and stop the machine from recording if the notch were detected.

NBS researchers found that such a copy-prevention system is not foolproof. Sometimes the system allows notched music to be recorded, and sometimes it fails to record music that is not notched. Moreover, NBS engineers designed and constructed five different circuits that could be attached to a tape recorder to defeat the copy-prevention system. According to NBS, a competent electronics technician could build any of these circuits for about $100 in parts.


NBS

This pair of spectrographs demonstrates the effect of a proposed copy-prevention system on a 70-second segment of Copland's composition "Fanfare for the Common Man." The system functions by filtering out a narrow range of frequencies, as indicated by the thin, black band across the lower spectrograph.

Because the system requires the deletion of certain frequencies from a recording, another key question was whether a listener can readily hear the difference. A series of listening tests showed that for some listeners and for some musical selections the inclusion of the notch has a discernible effect.

The effects of the notch are "extremely subtle," says Irwin Pollack of the University of Michigan in Ann Arbor, who conducted the listening tests. "I reject the extreme position that the [system's] action is so evident and pervasive that it will be immediately recognized by unsophisticated listeners. I also reject the extreme position that the [system's] action is so benevolent that it cannot be detected." However, there is enough of a difference to warrant caution about allowing such electronic tampering.

"The record industry and the electronics industry have strived for the last 20 or 30 years to get towards perfect reproduction of sound," says Gary Shapiro of the Home Recording Rights Coalition in Washington, D.C. The proposed copy-prevention system represents a step backward, he says.

The Recording Industry Association of America, also based in Washington, D.C., says it accepts the NBS results. But the association plans to continue pressing Congress for some form of copy-protection or compensation. *— I. Peterson*

FDA warns aspirin makers

Stressing the preliminary nature of a recent study showing aspirin's prevention of first heart attacks, Food and Drug Administration (FDA) Commissioner Frank E. Young told aspirin manufacturers last week that advertisements making such claims would be considered "mislabeling" and could lead to federal regulatory action. Young met with manufacturers at FDA's headquarters in Rockville, Md., to discuss industry's response to two studies released in January. The U.S. study found a marked decrease in the incidence of first heart attacks among men taking aspirin every other day (SN: 1/30/88, p.68). A smaller study by British scientists, however, failed to find any benefits (SN: 2/6/88, p.84). Young warned the industry representatives that the FDA will not make a final decision on the appropriate guidelines to physicians until further studies are done and questions answered about an increase in strokes among test subjects taking aspirin. In a prepared statement, Young said the manufacturers "agreed to exercise voluntary restraint and refrain from further promotion of the study results" pending the final results. □

U.S. education: Failing in science?

U.S. science and math education at the primary and secondary levels is foundering, according to two new surveys released last week by the National Science Foundation. Preliminary results from one survey comparing students' science and math achievement in 17 countries ranked U.S. students fair to poor. A second, U.S.-only study identified worrisome trends in both the nation's teaching practices and its science-teacher education.

The multi-nation study, conducted by the International Association for the Evaluation of Educational Achievement, an association of research centers, compared students' performance on special standardized tests at the roughly fifth-, ninth- and twelfth-grade levels. The study looked at approximately 150 students at each of these levels in each country. While U.S. fifth-graders ranked eighth among 15 responding nations, U.S. ninth-graders tied with those in Thailand and Singapore for fourteenth place in a field of 17 responding nations.

But these are grade levels at which all students are taking the same courses. What about the high-achieving science "specialists" — high school seniors taking an optional second year of advanced biology, chemistry or physics? Among the 13 countries responding — Australia, English-speaking Canada, England, Finland, Hong Kong, Hungary, Italy, Japan, Norway, Poland, Singapore, Sweden and the United States — U.S. students placed last in biology, eleventh in chemistry and ninth in physics.

What should concern U.S. education policymakers, says Richard N. Wolf of Teachers College at Columbia University in New York City, who was one of the survey's two U.S. coordinators, is "this apparent progressive decline" in science achievement: from the middle-ranking younger grades — which include even below-average students — to older science specialists.

Bill C. Aldridge, executive director of the Washington, D.C.-based National Science Teachers Association, describes the low rankings given the best U.S. science students as "pretty distressing." Nevertheless, he says, their international standing "is very easy to understand if you look at the other [nations'] curricula." Topping the survey's list for twelfth-grade science specialists were Hong Kong, England and Singapore — nations where these students take only science and math courses. Such curricula are in sharp contrast to a more varied training given U.S. students. (Wolf, who studied this "two-cultures phenomenon" in British Commonwealth countries, says he found that by offering only literature or science in upper grades, "you often had scientists who were illiterate or humanists who were innumerate.")

But most science-education analysts don't think course offerings explain the whole disparity in scores. Many point to other potential cofactors described in the U.S. study involving 6,156 teachers, authored by Iris Weiss, formerly with Research Triangle Institute in Research Triangle Park, N.C. (and now the head of Horizon Research Inc., a consulting firm in Chapel Hill, N.C.). Looking at how teacher training and science/math teaching have changed over the past 10 years, Weiss found several disturbing trends.

Chief among them, she believes, is that teachers are spending more time lecturing their classes and less time on hands-on projects. "This is exactly contrary to what scientists and science educators recommend," she told SCIENCE NEWS. In 1977, she points out, on any given day roughly 60 percent of classes would involve laboratory work and about 70 percent would include lectures. Now only about 40 percent are doing hands-on work on any given day, while some 80 percent include lectures. She found that elementary grades are more likely to include hands-on training and less likely to involve lectures than either junior high or high school classes.

Even more important, Weiss believes, is the actual amount of time spent on hands-on work. In kindergarten through sixth grade, a science class spends just about as much time (28 percent) on hands-on activity as on lectures (25 percent). But by junior high, an average of 11 percent more classroom time is devoted to lecture than to hands-on activities. By high school, lecturing accounts for 43 percent of the class time – more than twice the time devoted to laboratory studies.

Weiss was also "astonished" at the low classroom use of computers. While virtually every school in the study had computers, she says, only 8 to 15 percent of science classes and 19 to 23 percent of math classes studied had used them in the week prior to the survey. Moreover, of the classes that had used them, most had logged in a total of only 15 minutes or less during that week.

Finally, her data showed that unexpectedly large proportions of high school science and math teachers have an actual degree in science or math (76 and 52 percent respectively) – not just science or math education. However, a third of the chemistry classes and half of the physics classes were taught by individuals who had studied a different field – usually biology. Weiss considers this quite troubling. "Teachers are being trained as if they're only going to teach one subject," she says. Perhaps, she suggests, they should sacrifice some depth of training for some background in a second scientific field.

While conceding that most analysts recommend focusing initial corrective action on the youngest students in the U.S. educational system, F. James Rutherford, chief education officer for the Washington, D.C.-based American Association for the Advancement of Science, believes this is not the way to address such a systemic problem. "I won't be happy," he says, "until we're attacking the problem on all fronts." – *J. Raloff*

Transistor sensitive to one electron

In this day of transistors doing prodigious things, who remembers vacuum tubes? Electronic circuit elements are getting finer and finer and more and more precise. Now there is a transistor so precise that it will respond to a voltage change equivalent to a single electron.

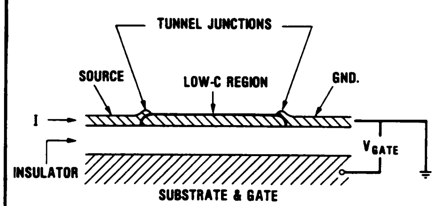
According to a statement by AT&T Bell Labs in Murray Hill, N.J., where Ted Fulton and Gerry Dolan developed the device, the best previous miniaturized field-effect transistors (FETs) require thousands of electrons to elicit the same response. The one-electron transistors, in Bell Labs' estimation, "show potential to change the way we think about a future generation of integrated circuits, because they use infinitesimal amounts of power and space; have an intrinsic speed of less than a picosecond; . . . and use the smallest possible amount of charge transfer."

Illustrations: AT&T Bell Labs

An electron micrograph magnifies the new "one-electron" transistor 100,000 times. Electrodes run upward from either end, and a probe for test measurements comes down the middle.

Transistors most often work as switches. An input current either comes out through the output terminal or not, depending on the state of a part of the transistor called the gate. These new transistors work best when made of superconducting metals – the old-fashioned, very low-temperature kind, not the modern high-temperature ones. The devices consist of two tunnel junctions separated by an "island" of metal only a few hundred atoms across. In a tunnel junction, two superconducting electrodes are separated by an insulating barrier only a few atoms thick, and current passes through the junction by the phenomenon known as quantum mechanical tunneling. The junctions and the island between them lie on an insulator, above a conducting substrate. A voltage – that is, an electric field – applied across this insulator forms the gate and controls whether or not current flows between the two junctions.

In the new devices, an electric field equivalent to a single electron will turn the current on or off. "If you charge the gate capacitance up to the equivalent of a single electron, 10^{-16} of a farad," says Fulton, "the device goes through its entire cycle." That is, it goes from full current to no current. "It's really cyclic in one electron." Furthermore, the cycle can be subdivided, so that the transistor is sensitive to changes as small as the equivalent of 1 percent of an electron. This leads to the suggestion of an early possible application as electrometers for measuring extremely minute electric fields.



Schematic drawing of the "one-electron" transistor shows current – designated by I – entering at "source." It will exit at "GND" if the voltage (V) across the gate lets it.

New fabrication techniques developed by Dolan allow the microscopic transistors to be made less than one-twentieth of a micron across. The researchers use electron-beam lithography to make a pattern on an organic film layer. Then they deposit the electrodes and the barrier. Fulton and Greg Blonder, who heads the Bell Labs department where the work was done, stress that only the old-fashioned metal superconductors, which require refrigeration by liquid helium, can be used. Nobody has yet succeeded in making tunnel junctions with the new high-temperature superconductors, they say, and furthermore, the new materials do not have the stability and uniformity of properties required for this application.

At the moment the new devices are experimental, although there is a potential for applying them in computer circuitry. However, says Blonder, "You will be a lot older before you see it."

– *D.E. Thomsen*