

Digital Tuners: Threading FM Through a Needle's Eye

by Ivan Berger

FM tuners are beginning to resemble calculators, with numbers that light up to indicate what station is tuned in. But more significantly, they're beginning to work like calculators, too, with digital-logic circuits taking the place of conventional circuits that have been used, in the same basic form, since long before FM itself was invented.

The most visible application of digital technology is the numerical station readout, which makes it easier to tell whether you're tuned to 98.3 or 98.5 megahertz, even from across the room. But, easy as it is to tell just what station you've tuned in, digital readouts don't tell how well you've tuned it. Depending on the tuner's other circuits, you could be tuned to the edge of the station's signal, hearing it with noise, distortion, limited-frequency response, and little stereo separation. You could even be well into the gap between the indicated station and the next one.

A tuner's problems only start with finding one station in the jumbled haystack of signals coming through the air. Once the tuner finds the station, it must encircle that signal as snugly as a needle does its thread, passing all of the desired signal while not admitting the signals of other stations. If the station (whose channel is 200 kilohertz wide—0.2 megahertz on the FM tuning dial) is tuned in off-center, noise and distortion increase. A tuning error of just 0.1 percent of the station's frequency would add distortion of about 1 percent or more to the sound; a 1 percent tuning error would put you nearly five channels away from your target station.

Tuning accuracy can be increased through the use of automatic-frequency-control (AFC) circuits, which nudge the tuner toward the center of the channel, and meters, which measure how well centered the station is. But the ideal would be a tuner that, instead of scanning all the frequencies in the FM band, jumps from one precise station frequency to the next.

Digital circuitry moves in just such discrete jumps; and with its aid, just

such tuners are now with us: the Heathkit AJ-1510, H. H. Scott T33F, and Revox A720 (which have digital readout as well), and the new Kenwood 700-T (which has a conventional tuning dial).

But to understand how to make a tuner jump, you must first know how it tunes. Early radio-input circuits had to be tuned through the radio bands, trying to find a station they could pick up, a technique akin to corralling a stationary thread with a moving needle's eye—harder, in fact, because the electronic "eye" would be less sensitive at some points on the dial than at others.

Modern tuners shift the station frequency, instead, until it matches the sensitive opening into the tuner's later circuits—moving, in other words, the thread into the needle's eye. (Ask anyone who sews if that's not easier.) That "eye," in modern FM sets, is fixed at 10.7 megahertz, far below the actual station frequencies. But the tuner generates another signal whose frequency changes as you turn the dial but is always 10.7 MHz above some point within the FM band.

The tuner constantly compares the frequencies of its received and internally generated signals, subtracting the higher frequency from the lower. When the internal tuning signal's frequency is 10.7 MHz higher than that of a station within listening range, the resulting difference signal slips neatly through the tuner's 10.7 MHz "eye" and on to the tuner's other circuits. But if the tuning signal should be 10.71 MHz above the station, it will be mistuned and, accordingly, sound harsh.

So the trick is to jump the tuning signal 200 kHz at a time, between only those frequencies that are exactly 10.70 MHz above the frequencies where stations can be found. In true digital tuners this is done by "frequency synthesis": A quartz-controlled reference oscillator (like that in an electronic watch) puts out a precisely regulated, fixed-frequency signal whose output can be divided digitally down to 100 kHz. Then another digital circuit can compare this frequency with the tuning signal's. If the tuning signal is a precise, odd multiple of 100 kHz (or an even multiple for European FM stations), then the tuner is ready to receive a station. If the tuning signal is not the correct multiple of the reference frequency (as it won't be, if

the tuner is off-station), the comparator sends a corrective control signal to the tuning oscillator.

Now, as you turn the tuning knob, the oscillator tries to shift frequency but can't, because the comparator won't let it—until you've tuned closer to the next channel on the dial than to the previously locked-in one. Then, the comparator takes the easy way out and kicks the tuning oscillator directly up or down 200 kHz to the next channel.

Some digital tuners, like the Scott and Heathkit, have no knobs at all. Instead, they tune by sweeping automatically from one station to the next, by reading station cards inserted in a slot, or—in the Heathkit—by having you punch in the station number as you would a number on a push-button phone. Surprisingly, though, the simple knob-tuning system used on the Revox and the Kenwood digitals is at least as convenient to use, especially when you only know a station's approximate location on the dial.

Advanced design is rarely cheap: The Kenwood 700-T is \$750, the H. H. Scott T-33F is \$1,000, and the Revox A720 (which includes a preamp) is \$1,300.95. The Heathkit AJ-1510 costs \$560—plus about 30 to 60 hours of your time to build it; if you like kit-building, you can consider that recreational time—if not, you may consider the real cost higher than the dollar price tag.

Not all of that high price comes from digital tuning alone: Such tuners incorporate other design advances, yielding more performance gains than merely easier, more precise tuning. But then, at those prices, they'd better. □

WIT TWISTER NO. 38

Edited by Arthur Swan

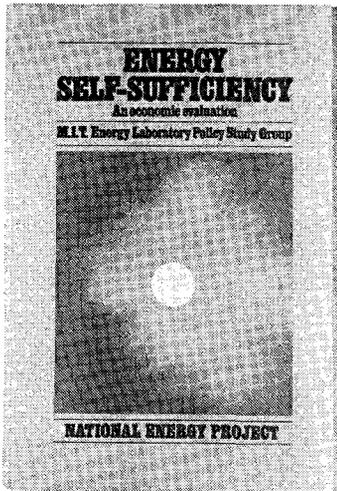
The object of the game is to complete the poem by thinking of one word whose letters, when rearranged, will yield the appropriate word for each series of blanks. Each dash within a blank corresponds to a letter of the word. Answers on page 55.

Quite — — — — — with his
superficial life,
Ashamed of — — — — — kept
secret from his wife,
He joins no more in dalliance or
play—
But in his — — — — — dis-
patches his valet.

A. S.

Ivan Berger, a longtime contributor to SR, is also electronics editor of Popular Mechanics.

FROM AEI



ENERGY SELF-SUFFICIENCY: An Economic Evaluation

by the M.I.T. Energy Laboratory
Policy Study Group

An examination of the consequences of achieving U.S. energy self-sufficiency by the 1980s, the book concludes that gaining domestic independence would lead to much higher prices for American consumers than would policies—such as oil stockpiling—using imported oil.

89 pages Paperback, \$3.00



American Enterprise Institute
for Public Policy Research

Please send me _____ copies of *Energy Self-Sufficiency*
@ \$3.00 per copy

Quantity discount information available
Payment must accompany orders of under \$10.00

NAME _____
ADDRESS _____
CITY _____ STATE _____ ZIP _____

Make checks payable to:
American Enterprise Institute
1150 Seventeenth Street, N.W.
Washington, D.C. 20036

The Crime of Dispassion

by Henry Hewes

In this remarkable season when the majority of new theatrical attractions on Broadway have been imported from abroad, the most strikingly successful entry appears to be Peter Shaffer's *Equus*.

Equus locks together the ordeals of two very different protagonists. One, Martin Dysart, is a quietly unhappy psychiatrist, who has a longing for a Greek civilization where myths and rituals were based on instinctively experienced truths, but who has accepted a frigid marriage and package tours to Greece as a safe substitute for a more passionate and more fully realized existence. Martin's way of non-life is suddenly challenged when he is asked to treat the play's second protagonist, Alan Strang. Alan is a teenage psychopath, who has committed the incredibly horrible act of blinding all of the horses in a stable with a spike.

With insistent theatricality *Equus* follows the psychiatrist, as by means of various tricks and devices he uncovers the pertinent factors that have caused his young patient to go berserk. It is revealed that an incompatibility between Alan's mother and father has led Alan to acquire a religious fixation, which, when blocked, is transferred to a fixation on horses. Thus his ultimately unsuccessful attempt at lovemaking with a girl in a stable brings Alan a double wave of shame. Not only has he failed as a man among men, but also he has desecrated his temple of horses, whose staring eyes become unbearable. Quite superbly the action builds to a violent and naked climax in which Alan relives for us the terrible moment. This reliving is, we are told, the healthy process of abreaction that will cure Alan of his obsession with horses. However, we are also told that Alan had found, in the fierceness and nobility of the horse, an object worthy of worship in a world where true worship had become most difficult. And Martin concludes with a final lament that his cure will reconcile Alan to a smaller, worshipless living-out of his years.

Some American critics have found in

Martin's situation a disguised statement of the plight of the timid homosexual, who lacks the courage to pursue the dangerous consummation of his desires. However, Shaffer has strongly denied any such intention, and the play works quite well if Martin is taken to represent the apparently ingrained tendency of many modern Britons to accept, without passion or anger, a well-ordered but watered-down existence. Yet the play's statement is less impressive than is Shaffer's skillful theatrical fabrication, which deftly finds layers of comic relief as he inexorably drills deeper into the hard rock of tragedy. Indeed, *Equus* emerges as a surprisingly painless modern tragedy, which accounts for both its popularity and the reservations some serious critics have expressed about its significance.

CERTAINLY A GREAT PART of the play's success comes from its boldly inventive staging, by John Dexter, and the dedication its performers bring to their nightly ritual. Using a stage arrangement similar to the one Ingmar Bergman developed for his Stockholm production of *Wozzeck*, Dexter creates all the play's action in an empty space between two opposing groups of theatergoers. Everything is simple and exact, with no scenery and all actors and props always onstage. When horses are required, some of the actors simply put on horses' heads, made of sculpted wire, and elevated iron hooves. Similarly, when a character must participate in a scene, the performers just rise from their onstage benches and beautifully manage their instant transformations into the characters they must play. Most spectacular is Peter Firth, who makes the furtive and insolent Alan into an ultimately sympathetic victim. And, as the troubled psychiatrist, Anthony Hopkins is frequently electrifying in quick flashes of deeply felt anger. And Marian Seldes, Roberta Maxwell, Michael Higgins, and Frances Sternhagen all suggest hidden depths in characters whose functions are primarily supportive.

All in all, one suspects *Equus* is at its truest when it is reflecting its author's anger at his own civilization. □