Sennheiser’s Astonishing
Binaural Recording System


Comment: We were intrigued when Sennheiser announced its binaural system (see “News and Views,” November 1973), but oh when we started to listen! It’s capabilities, as outlined below and in our separate report on using the MKE-2002 with the Uher CR-134, are among the most astonishing phenomena we have experienced in high fidelity in years.

But first let’s make sure we all understand the difference between “stereo” and “binaural.” Both are multi-channel sound reproduction systems. Stereo engineers its two (or more) channels for reproduction via loudspeakers and may employ a wide variety of mixing techniques to this end. Binaural recordings use two channels only (because we have only two ears—the expression applies here, which it does not to stereo) capturing the sounds as nearly as possible the way they would be by the two ears of an actual listener at an actual event; these sounds are then reproduced via headphones to reinsert the sounds into the hearing chain, so to speak, at a close approximation of the point from which they were extracted.

Traditionally, mikes for binaural work have been mounted inside a dummy head (having approximately the shape and acoustic properties of the average human head) with the mike membranes mounted at ear-drum position. Sennheiser uses a stethoscopic mounting to hold the condenser elements just outside the ear canal—either a live wearer’s or that of the supplied plastic dummy head. The power supply for the condenser elements is built into a box about the size of a pack of cigarettes that is permanently attached to the mike cord at an appropriate distance from the stethoscope to allow stowage in a jacket breast pocket or shirt pocket. It is powered by a 3-volt transistor battery (not supplied) and has an on/off switch and a momentary-on battery-check switch that lights a small green pilot if the voltage is sufficient for use. The mike cable on our sample was terminated in a DIN plug that would require an adapter for the mike inputs for most recorders on the American market. Sennheiser will supply appropriate connectors on special order.

Sennheiser also supplied us with a small demo disc that purports to show how good the company’s “Open-Air” headphones are, but it was of interest to us primarily because it was made with the binaural system. Now binaural recordings should make acceptable stereo listening, of course, so before trying headphones we played the record via speakers. It was not particularly impressive. The sound quality is not exceptionally clear (whether due to some wear or to occasional overload in the original tape, we couldn’t tell), and of course all attempts to reproduce the sensation of sound sources behind us—entirely possible in binaural reproduction—were sketchy to say the least. But the effect was acceptable as stereo.

Then we tried conventional headphones with an earcup seal designed for maximum rejection of ambient room noise. The effect improved dramatically. Sound placements—right to left, front to back, near to far, even up to down—appeared more unequivocal, rather like listening to those in particularly fine quadrophonic (read, “four-channel stereo”) reproduction. This is, of course, the claim of binauralism: that every nuance of aural sensation is reproduced, not merely simulated or hinted at, as it must be when loudspeakers and standard mikes are used. But, astonishingly, the quality of the recording
seemed to have improved. Specifically, extraneous noise and distortion often were perceived as being in the headphones, rather than the sound; when we concentrated on the sound field itself, the extraneous properties could be ignored the way one ignores smudges on one’s sunglasses when looking at distant objects.

Then we switched to a headset of the open-air type that provides very little seal against ambient noise. The verisimilitude was uncanny. Some sounds seemed unequivocally to be in the room—presumably because one can hear room sounds and therefore attribute particularly realistic ones to the room, rather than the recording. Spatial ambiances and three-dimensional placements were reproduced with an exactitude that defies even the best of quadraphony. (Sennheiser has a name for this property: “triaxial” sound, meaning that all axes of three-dimensional space are reproduced.)

When we used the microphone—whether “worn” by a staff member or by the dummy head—we had no trouble creating tapes that, reproduced on low ambiance-seal headsets, delivered the same startling realism. Even in recording on non-Dolby cassettes the quality is, subjectively, superb; the hiss is entirely audible—but at the headphones rather than within the “space” of the sound reproduced. The listener “tunes it out” when the recorded content takes over.

The dummy head is held in the carrying case by a single bolt. When the head is removed it can be bolted onto the outside of the case, which will hold it at approximately normal sitting height with the case placed on a chair. The microphone and power supply assembly has its own case that fits inside the carrying case along with the head. This way you can take the whole system with you or just the microphone and power supply. Since the microphone elements are held in place in your ears by small bosses on the outside of the condenser elements, they can become uncomfortable when worn for long periods; and it is easier to get extraneous noise pickup (the mike cable rubbing against clothing, for example) when wearing the microphone yourself, though the mike is surprisingly insensitive to this sort of thing. (A cable clip, normally supplied by Sennheiser, was omitted from our test sample; it should be an additional help.) So except where it is of utmost importance that you travel light or that the recording setup remain inconspicuous, we’d suggest you plan to take the dummy head along.

Quad recording is problematical, at best, for the home recordist. It also is expensive (requiring a four-channel recorder and a minimum of four mikes—to say nothing of mixers and quad headphones for monitoring). Binaural recording has been expensive too, until now. That for a mere $330 the home recordist can make tapes that will in a sense outdo conventional quad at its own game is a fact so exciting that we expect the MKE-2002 will be sold out for some time to come. In our opinion the system is fully worth waiting for.

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HOW THE SENNHEISER AND THE UHER WORKED TOGETHER

Obviously the potential of the CR-134 and the MKE-2002, reviewed in this issue, for tandem use in capturing a candid record of sounds-as-they-exist is unique. We have used them at a live music session (Buddah Records artist Michael Wendroff at the New York High Fidelity Music Show) and can imagine endless projects through which they might gladden the hearts of avid recordists. (One word of caution: Get permission before beginning to tape any public event.)

We had planned to include recordings made at the Barrington Fair (a sort of local county fair) and the Old Rhinebeck Aerodrome (which puts on a show with real and copied First-World-War military planes) in New York State, but the short supply of MKE-2002s delayed arrival of our test sample until it was too late. Our experience with the Uher’s mono mike at those events gave us a basis for comparison, however, and further convinced us how much we had missed by not having the Sennheiser.

We recorded the Wendroff group both with and without the dummy head, and both with and without the ALC feature of the Uher. In this entire recording the sense of space and place is extremely convincing, the action of the ALC circuit being virtually undetectable. Using the dummy head prevented friction noises when the recordist moved (which weren’t severe even when the recordist “wore” the mike) and kept his own occasional mutterings from being reproduced “inside the listener’s head” on playback. The head also allowed him to go onstage to assist with a tawdry PA mike without missing a beat in his own tape.

The binaural sound allows the listener to hear “through” audience noises and concentrate on the music in a way that the mono recording at the Aerodrome, for example, prevented. Whispered comments from behind the recordist at the Wendroff session reproduce (amusingly) behind the listener; children behind the recordist at the Aerodrome (maddeningly) dominate parts of the tape. And the Uher’s ALC action is very audible at explosions in the war scenes, though the likely (and less desirable) alternative would have been severe distortion at each concussion until the recordist had determined what levels to expect and how to predict each detonation.

The want of binauralism in the horse race and mid-way recordings at the Barrington Fair was particularly frustrating. Though the Uher managed a very good account of the sounds as sounds, a good deal of their excitement is lost when they are compressed into a single channel. And in terms of pure sound, the carefully designed Sennheiser elements are audibly superior to the Uher’s mike, which is engineered for convenience, rather than acoustic perfection.

You may feel a little strange, at first, walking around with mikes in your ears; but the dummy, while easier on the recordist, is far more conspicuous. Wearing the Sennheiser and carrying the Uher, our recordist looked to the casual observer as though he were listening to a portable stereo radio. And the recordings he came back with convinced us that there are plenty of fascinating new worlds out there just waiting to be captured by a recordist with this sort of equipment and a little imagination.

Go get ‘em, tigers!
Uher’s Mighty Mini Portable Cassette Deck


Comment: Let’s say it right off the bat: Never have we seen such capabilities crammed into so small a tape unit. It is battery-portable (using either six “C” cells or Uher’s Z-215 rechargeable nickel-cadmium battery), or it can be powered from the Z-135 AC converter. (The CR-134 is delivered without power source.) The AC unit can be used in two ways. It has the same dimensions as the nicad pack and slips interchangeably into the CR-134’s battery compartment (whose door has an opening for the AC cord); if the nicad pack is in the compartment, the AC converter can be used externally with a short interconnect cable (supplied) so that it both powers the recorder and recharges the nicad. The nicad pack will go from dead to full charge in about twelve hours; when we used it to record for over two hours at a clip without recharging, it showed no sign of flagging. The AC converter can be left plugged in without damage when the nicad is fully charged.

The built-in condenser microphone—mounted on the control panel between the record/playback level control and the meter—produces surprisingly good sound. With the cassette deck slung over a shoulder we were able to record all sorts of conversations and natural sounds with convincing mono fidelity; you need an external mike or line source for stereo recording. There is a DIN plug below the level control for appropriately terminated dynamic mikes and a “radio/phono” DIN input connector at the side of the unit. Also at the side are an accessory jack for the optional F-112 remote control (start/stop and tape-travel direction) unit, a jack for an accessory monitor speaker, and a level control for that speaker. We preferred to use the built-in speaker for monitoring (or for checking the recording, if it was made live).

At the back (or bottom, with the case slung over a shoulder) are the connector for the AC converter and one (covered by a snap-off cap) that can be used to power the unit from an automobile battery and deliver its sound to the car radio (assuming the radio has been equipped with an appropriate mating connector). Uher of America is planning to make available a bracket for automobile mounting of the CR-134.

All these features are accessible through openings in the carrying case. The main operating controls are covered by a flap that can be snapped off and reversed, allowing free access to the entire panel. Its meter is calibrated both in dB (for recording) and in volts (as a battery check during playback). It is of the type that uses a rotating drum showing through a slot as a red line with a “beveled” tip. A meter reading at the center of this bevel will give close to a 0-VU indication for DIN 0 VU; the tip of the bevel will read about ½ dB higher for the same signal level.

Next to it is a four-way switch: off/forward play (or recording)/reverse play/record. Immediately below the switch is a two-way fast-wind switch, and beside it a small meter that indicates the direction of tape travel in playback or recording. Below the meter are on/off buttons for the built-in speaker (which cuts out automatically during recording), the built-in mike, and an automatic level-control circuit, plus a recording interlock button. The interlock can be engaged only with the deck turned off (to prevent accidental recording) and is released either by turning it off once again or by switching to a fast-wind mode. With the recording interlock button in, the on/off button cannot be switched to reverse (side-2) tape travel. At the right are the tape slot (which has a spring-loaded door or flap), a three-digit counter, and an eject button.

You begin by inserting a cassette, with “side 1” up, end-first into the cassette slot. Then you push down a latch just below the cassette to lower it to operating position, where the record/play head contacts the tape opposite the pressure pad. This is a four-track head; the two elements for the reverse (side 2) direction of tape travel are used only in playback. The erase head, which fits into the small opening just beyond that for the record/play head is, of course, engineered only for the forward tape direction. The large openings at the ends of the cassette are used for pinch rollers, that on the near end of the cassette engages for the forward direction of travel, while that on the far end is used for reverse. Both capstans run continuously as long as the unit is turned on, driven by a single, electronically controlled DC motor.

When the tape comes to the end of the first side in the record mode, the pinch roller releases, but the unit otherwise remains on. If it is in the playback mode, it automatically will reverse its travel direction at either end of the tape. It does not turn off automatically when fast-wound to the end. The counter “counts” upward in the forward direction, downward in reverse. Since you can’t see the cassette window while the tape is in the unit, the counter (and the direction indicator) must be relied on for information about tape motion and use. (A suggestion: Before you go out to do any live recording, “measure” your cassettes on the counter, starting at 000. Then you will know when the tape is about to run out.)

CBS Labs made all its measurements with the AC power supply and—following Uher’s recommendation—with Maxell UD tape. The lab also checked S/N with the battery supply (some AC supplies contribute significantly to hum) but found it only marginally better. You’ll see that the measurements compare well with home cassette decks, the big difference is that most home decks today use Dolby noise reduction. Hiss is
Accuphase: A Welcome New Name in Superamps

The Equipment: Accuphase Model P-300, a basic power amplifier, in metal case. Dimensions: 17½ by 6 inches (front panel); 14 inches deep plus allowance for controls and connections. Price: $750; accessory walnut case, Model AWC-1, $45. Manufacturer: Kenison Laboratory, Inc., Japan; U.S. distributor: Teac Corp. of America, 7733 Telegraph Rd., Montebello, Calif. 90640.

Comment: Kenison Laboratories (founded by the Kasuga brothers, who also founded the Trio Electronics that makes Kenwood products) is a relatively new company that is just making its entry into this country via Teac marketing. We were anxious to test its products not only because the specs are extremely impressive and the equipment equally handsome, but because Teac guarantees the specs for five years! This means, Teac tells us, that should you find (say, via an "amplifier clinic" at a local dealer) your amp is not meeting its specs in any way within the first five years of ownership the company will undertake to see that it does. Though we've heard of guaranteed specs before, we've never had them put before us in such unequivocal and liberal terms.

Teac adds that, though the P-300 and the companion C-200 preamp can be used separately, each is so good it can be heard at its best only with the help of the other. Now this sounded to us like puffery the first time around. We have tried them together, however, and will

entirely audible in cassettes made on the CR-134, just as one would expect, though the sound is otherwise excellent when played back on a high-quality system—either directly from the CR-134 itself or via a home deck.

The Uher's strongest point, however, remains its extreme portability. It is no more bulky than a pair of field glasses, and we used it successfully (see accompanying "project" report) at outdoor events with little trouble from winoise (in the recording) or fatigue (in the recordist). We must admit that we would cheerfully have given up the monitor speaker in favor of a Dolby circuit board. (A look inside the unit will quickly convince you that something must go if anything is to be added.) Perhaps those who need monitoring would be just as happy with an accessory battery-powered headphone system or the accessory speaker for which an jack already is supplied. Be that as it may, we had a ball using the CR-134 and came away from the experience with some tapes that only it could, as a practical matter, get for us.

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comment on this in more detail when we review the C-200 next month. For the time being, suffice it to say that both are superb units and that they are well suited to each other.

The front panel of the P-300 has a pair of meters controlled by four pushbutton switches. One turns off the meters, the others adjust their 0-dB indications for full power (actual 0 dB, or 150 watts), −10 dB (15 watts), or −20 dB (1.5 watts). The speaker-selector switch nearby has positions for off (for headphone listening, for example), "main," remote 1, remote 2, main plus remote 1, and remote front—this last referring to output jacks hidden at the bottom of the front panel. The amp's output is shut off automatically when you switch to connections that have no load. Below the meter pushbuttons are level controls for each channel; below the speaker selector is a power-limiting switch with positions for 100, 50, and 25% of full power. The intent of the latter is to prevent accidental speaker damage. While the lab found the calibration to be less exact than the percentage numbers on the panel imply, greater precision would have netted no greater utility, in our opinion.

When the black strip at the bottom of the front panel is pressed it flips down to expose additional features. Of these, only the main on/off switch is accessible with the sub-panel closed. To the right of this switch is a stereo headphone jack that is live in any speaker-selector position. Next come four jacks (hot and ground for each channel) that accept banana plugs and are live only in the "remote front" position of the speaker selector.

Next is a "band-pass filter." When it is turned on, the output of the amp is sharply filtered below 17 Hz and above 24 kHz. We found it useful in controlling subsonic rumble (appreciable more as slow "pumping" in our speakers’ woofer cones than as sonic degradation) in some discs, but we also felt that it occasionally seemed to reduce slightly the perceived quantity of very deep bass—which could actually be due to "doubling" of subsonic rumble frequencies by the speakers, rather than to reduction of actual bass frequencies in the signal itself. The manual recommends that the filter be left on for normal use to protect speakers. At the right are a pair of pin jacks for input signals and a switch that selects either these inputs or the normal ones on the back panel.

The back panel itself has, in addition, an AC voltage selector, an AC input socket (accepting a removable cord, supplied), an unswitched AC convenience socket, and the speaker connections for three stereo pairs (main, remote 1, and remote 2). The speaker terminals are the type in which a pair of metal plates are pressed together by a (Philips-head) screw and accept either bared leads or spade lugs. They strike us as a good choice in a high-powered amp since they make positive, large-area connection with the leads with little or no chance for inadvertent shorting between leads or between a hot lead and the chassis. But if there's any danger of tension on the speaker leads, the connec-

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**Harmonic Distortion Curves**

<table>
<thead>
<tr>
<th>150 Watts Output</th>
<th>75 Watts Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>Left Channel: &lt;0.04% 20 Hz to 20 kHz</td>
<td>Left Channel: &lt;0.05% 20 Hz to 20 kHz</td>
</tr>
<tr>
<td>Right Channel: &lt;0.06% 20 Hz to 20 kHz</td>
<td>Right Channel: &lt;0.05% 20 Hz to 20 kHz</td>
</tr>
</tbody>
</table>

**Square-wave response**

**Power Output Data**

<table>
<thead>
<tr>
<th>Channels Individually</th>
<th>P-300 (1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Left at clipping: 190.1 watts for 0.03% THD</td>
<td>Left at clipping: 190 watts for 0.03% THD</td>
</tr>
<tr>
<td>Right at clipping: 198.0 watts for 0.07% THD</td>
<td>Right at clipping: 199 watts for 0.07% THD</td>
</tr>
</tbody>
</table>

**Power Bandwidth**

- For 0.1% THD: below 10 kHz to 58 kHz
- For 0.1% THD: below 10 kHz to 41 kHz
- For 0.1% THD: below 10 kHz to 64 kHz
- For 0.1% THD: below 10 kHz to 41 kHz

**Frequency Response**

1.5 Watts Output

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**Accuphase P-300 Amplifier Additional Data**

- **Damping factor**: 76
- **Input characteristics (for 150 watts output)**
  - Sensitivity: 1.0 V
  - S/N ratio: 102 dB
  - Rear-panel: 1.0 V
  - Front-panel: 1.0 V
- **IM distortion**
  - 8-ohm load: <0.063% to 177.2 watts
  - 4-ohm load: <0.098% to 127.6 watts
  - 16-ohm load: <0.48% to 266.4 watts
  - 16-ohm load: <0.060% to 106.9 watts

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**Frequency Response**

- +5 dB at 10 kHz
- −5 dB at 1 kHz
- -6 dB at 20 kHz

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tions should be tightened very firmly to prevent loosening and possible shorting of the stripped ends.

All this is superb in both sound and operation. Even the meter calibration is extremely accurate—within 1/2 dB of marked values in the right channel and within 1 dB at the left. The meter lights flash, incidentally, if the protective circuitry is activated (for instance, by a short at the output) to warn the condition. Harmonic distortion is extremely low. At 150 watts it runs about one-tenth that of a typical receiver at its (generally far lower) rated power. Since the S/N ratio measures 102 dB the amplifier can be run even at background-music levels without worry about audible noise. The front-panel input and output connections add materially to the unit's convenience when it is used to check out other equipment in your system.

Structural and cosmetic design both strike us as excellently thought-out, and the finish and operation of the parts are exemplary. In short, the P-300 looks (and sounds) to us like a winner.

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HOW MANY CHANNELS ARE DRIVEN?

As regular readers know, we like to stick with any test procedure we have been using so that our report on Product X will be as closely comparable as possible to that on competing Product Y. And one feature of our amplifier reports has remained constant for years: All measurements, except where specifically indicated to the contrary, have been made with one channel driven. They might have to do otherwise, all things being equal. When you listen to stereo you obviously use both channels of amplification. But until recently not all manufacturers have written specs on this basis, and advertised power ratings generally have been based on single-channel specs. Where advertising was based on "music power" ratings, a spec for continuous power usually was available, but not necessarily one that also was made with both channels driven and for a full-frequency distortion rating. Hence, in order to allow the reader some way of relating the data as measured at CBS Labs with that offered by the manufacturer, we felt we had to stick with the one-channel-driven scheme—though we always have given clipping characteristics for amplifiers with all channels driven as well.

The advent of quadraphonic equipment added to interpretive problems, of course, in particular because we generally found bigger discrepancies between one-channel measurements and four-channel measurements than between their two-channel counterparts. But the recent Federal Trade Commission ruling on how power and distortion may be specified (see "News and Views," October 1974) has changed the picture materially. Now all manufacturers must specify with all channels driven and relate distortion ratings directly to power ratings.

This gives us new freedom to measure more characteristics with all channels driven, without risking reader confusion over differences between our lab data and the manufacturers' specs. Beginning with this issue, we will show harmonic distortion as measured with all (both, for stereo) channels driven, and we will base "rated power" references on manufacturers' specs for continuous output into 8 ohms with all channels driven or below rated harmonic distortion over the full frequency band (normally 20 Hz to 20 kHz). Should the manufacturer specify in other terms (and often in the past the lab has had to assume its own reference power output because the amplifier under test was not specified in quite the "standard" way), we will use an output figure that seems reasonably to approximate the standard—though we expect the FTC rule will make this increasingly rare.

Basic output readings will be given as they always have been: with individual channels driven to clipping, with individual channels driven to rated distortion, and with all channels driven simultaneously to the clipping point in the tested channel. These measurements all are made at 1 kHz with an 8-ohm resistive load. They can, of course, be compared directly to similar measurements in past issues. Intermodulation measurements, too, will continue to be made with one channel driven.

And power-bandwidth measurements will remain the same—allowing comparison in terms of power, distortion, and frequency between current reports and those prepared before the present change. We will continue to show power bandwidth at both rated distortion and 0.1% THD (when the amp is not already rated at this figure) and carry curves down to the -3-dB points, when they occur within the plotted range of 10 Hz to 100 kHz. The FTC, unlike the old IHF power-amp spec that defined power bandwidth, does not recognize the -3-dB (half-power) points; to approximate the FTC power bandwidth from our data, look for the points at which the rated-distortion curve crosses the 0-dB (full rated power) line. The power-bandwidth curve, therefore, represents the best-case maximum power capability of the amp with respect to frequency and without exceeding rated distortion.

The harmonic-distortion curves no longer show this maximum capability but show what might be called the worst-case distortion since in normal program material the demands seldom are at maximum in all channels simultaneously. The present curves cannot be compared directly to those published in the past, of course. A given amplifier, if it were tested both ways, presumably would have similar-looking curves with both systems, but the reference power levels at which the data are taken would be slightly smaller for the all-channels curves than for the one-channel curves. That is, when measuring with only one channel driven we generally were working from a somewhat less conservatively derived power spec than we are now that the FTC rule has gone into effect.

This change in the way power is specified also influences our sensitivity and S/N ratio measurements. Say an amplifier that used to be rated at 50 watts per channel (driven individually) now is rated under FTC rules at 40 watts per channel (driven simultaneously)—a fairly large spread. Our former reference level would have been 50 watts; our present one is 40 watts, though of course the amplifier is unchanged in either gain or noise. Since the rating has dropped by 1 dB, the S/N ratio (the difference in dB between rated power and measured noise) will too. And the sensitivity rating will change commensurately because less input will be needed to drive the amp at 40 watts than to drive it at 50. Thus, if the S/N were 60 dB and the sensitivity 200 mV for the 50-watt rating, they would be 59 dB and about 175 mV for the 40-watt rating. These differences are not great, to be sure; but for intelligent comparison of current reports with older ones you should be aware of the differences.
ESS Improves a Fascinating Speaker System

The Equipment: ESS Model AMT-3, a floor-standing loudspeaker system with "air-motion transformer" tweeter, in wood case. Dimensions: 15¼ by 39¼ inches (front); 15¼ inches deep. Price: $435. Warranty: lifetime, for original owner, on air-motion transformer, five years parts and labor on remainder. Manufacturer: ESS, Inc., 9613 Oates Dr., Sacramento, Calif. 95827.

Comment: The Heil air-motion transformer is among the most interesting new ideas in high fidelity in many years. By now its operating principles have been so widely discussed that we will only sketch them in here.

A pleated diaphragm is suspended in a strong magnetic field. A conductor running along the flat surfaces of the pleats serves as the equivalent of a voice coil in a conventional dynamic driver; but instead of moving the diaphragm forward and back, as in a cone speaker, the audio current running through the conductor alternately squeezes the pleats together and forces them apart. This design, among other things, dispenses with those elements in conventional dynamic drivers that require the most precision for good speaker design. It may be partly for this reason that an unusual clarity and transparency often is noted in the sound the AMT tweeter produces.

The bass in this model, as in the AMT-1 (HF test reports, June 1973), is provided by conventional drivers. The AMT-1 had a single woofer in a port-loaded enclosure, and we found the bass distinctly less impressive than the remainder of the frequency range—handled by the Heil driver. The AMT-3 has beefed up the bass dramatically. It uses a pair of 10-inch woofers (again in a port-loaded enclosure, but of much larger size), a 6-inch midrange driver (actually handling upper bass and lower midrange), and the Heil tweeter. ESS calls the design the "Rock Monitor" not because it is better suited to rock than to other music (we found it equally good for any music we fed to it), but because its enhanced dynamic range makes it better suited to the levels associated with rock than earlier models in the AMT series were. In big symphonic music we find the added capabilities of the AMT-3 a welcome improvement. And even in chamber music the cleaner, cleaner bass adds materially to reproduction quality.

In listening tests we found that its range reaches down to about 30 Hz with very little doubling, with an oscillator source set at lower frequencies there is very little audible output (most speakers will continue to deliver audible, spurious harmonics even when the input frequency is so low that the fundamental no longer can be heard). Response is unusually flat all the way up to the limit of normal hearing. Since the air-motion transformer is a bipolar radiator (it produces equal but opposite wave fronts at front and back) it essentially delivers sound in a figure-eight pattern: at most frequencies, and in normal listening rooms, the "null" spots at the side cannot be heard at all (due partially to room reverberation), though they can be spotted in careful listening with input signals above 10 kHz. Essentially, however, the system may be considered as a quasi-omnidirectional radiator. (Note the close match of the three curves in the response graph.)

The air-motion transformer is mounted at the top of the unit in a compartment that is open toward the sides, through large "ports" cut in the enclosure wall, and to front, top, and back through the grille strip that runs up the front surface, over the top, and part way down the back. The midrange drivers and woofers are mounted to sock than to other music (we found it equally good for any music we fed to it), but because its enhanced dynamic range makes it better suited to the levels associated with rock than earlier models in the AMT series were. In big symphonic music we find the added capabilities of the AMT-3 a welcome improvement. And even in chamber music the cleaner, cleaner bass adds materially to reproduction quality.

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lower on the front surface. On the back are the terminal posts (accepting bared wires or large spade lugs, and color-coded for polarity) and a three-way balance control: "bright/normal/soft." This control alters output above 1 kHz, having maximum effect (about 2 dB of attenuation between steps) uniformly across the range from 2 kHz up. The lab measured the unit at "normal," and we preferred it at this setting in most rooms and with most program material. The difference is, in any case, fairly subtle.

ESS rates the impedance as "4 ohms minimum." CBS Labs measured it at 6 ohms nominal—which, as it turns out, also is the minimum impedance measured at any frequency in our test sample. The bass rise (at about 70 Hz) does not exceed 8 ohms; above the rating point the impedance value creeps gradually upward, rising somewhat above 8 ohms beyond 1 kHz. Over-all, it is one of the flattest impedance curves we have ever seen.

The AMT-3 proved to be slightly more efficient than the AMT-1. The earlier model required 6 watts to produce the standard 94 dB (at 1 meter on axis); the newer one needed only 4.68 watts. This translates to about 1 1/2 dB less input—or roughly 25% less power—to produce the same sonic level with the AMT-3. At the same time the newer model displayed its excellent dynamic range by accepting up to 100 watts (at 300 Hz) of steady-state signals and 300 watts average (or 600 watts peak, the limit of the test amplifier) without excessive distortion. In this last test, an output level of almost 116 dB (at 1 meter) was reached. Amplifier power would not appear to be critical; anything from, say, 15 to 100 watts per channel should be appropriate, depending on the maximum sound levels you want, as long as the signal is of high enough quality to do justice to the AMT-3.

All in all, then, this is an extremely fine speaker—and an exciting one. Since testing the AMT-1 we have had plenty of opportunity to "live with" the Heil tweeter, and we continue to be impressed by its unique clarity and impidtity of sound. Not that it makes its presence felt in any positive way. On the contrary, the index of its quality is that one so seldom is conscious of it; one hears the music rather than the speaker. The sound of the AMT-3 is effortless, well balanced, and very neutral.

Since the tweeter is bipolar, the precise qualities of its sound and the stereo imaging that a pair of them creates are somewhat more sensitive to placement in the listening room than with typical bookshelf systems, which radiate much less high-frequency energy toward the back. Generally speaking we have found that the AMT-3's ability to create a sense of depth and "air" in the sound image can be inhibited by placing them too close to a wall. But unless you experiment with placement it may not occur to you that an improvement could be made. These are excellent speakers in any case; with careful placement and fine program material they are exceptional.

A Truly "Professional" Recorder from Revox

The Equipment: Revox Model A-700, a three-speed (15, 7 1/2, 3 1/4 ips) half-track or quarter-track stereo open-reel tape deck accepting reels to 10 1/2 inches, in metal case. Dimensions: 19 (wide) by 18 inches; 6 1/2 inches deep plus allowance for feet and connecting cables (back), controls, etc. (top); 7-inch reels overhang at top, 10 1/2-inch reels at both top and side. Price: $1,800. Warranty: minimum one year parts and labor on everything except lamps and fuses; five years on all other parts except heads and capstan roller. Manufacturer: Willi Studer, Switzerland; U.S. distributor: Revox Corp., 155 Michael Dr., Syosset, N.Y. 11791.

Comment: If you're into the NAB-reel machines that long have epitomized glamor in high fidelity and in the last few years have grown even more popular, there are two features that probably will strike you as soon as you thread up a tape on the A-700: the lack of a reel-size switch and the unusual design of the idlers and tension arms. In themselves these are not particularly important features, but their handling in the A-700 is indicative of the very special qualities of the design as a whole.

The reel-size switch is not used (though the deck will handle everything from NAB reels down to those with 1 1/2-inch hubs), because the motional and tape-tension logic system in the unit adjusts itself automatically, partly by way of the double tension arms and oversize rubber-surfaced idlers. This system, together with the three motors (a servocontrolled capstan motor with a crystal speed reference, plus separate reel motors) it controls, allows ad-lib intermixing of reel sizes within the design range.

The controls also allow an unusual range of mechanical functions, input modes, and mixing functions. The main transport functions are selected by means of illuminated pushbuttons just below (or in front of, with the deck horizontal) the transport itself. In the first group on the left there are the main AC power switch, a momentary "repeat" button, an "auto" switch, recording selectors for left and right channels, and a momentary "pause." The repeat will switch the transport to rewind as long as you keep it pressed in; when you release it the transport automatically switches into play. We found the feature extremely useful in picking up cues or in checking particular spots (say, a splice of dubious quality) on the tape. The automatic function works only in conjunction with clear transparent leader, spliced
into the tape. During recording or playback, the unit will run normally until a photocell system in the head assembly encounters the clear leader. If the automatic function is turned off, the transport stops at this point; in the automatic mode the transport begins rewind and reverts to recording or playback when it encounters clear leader earlier in the tape. Though this is an interesting idea, we judged it considerably less useful for the purposes to which our readers generally put a recorder. The pause is not like that on typical home machines; it produces the same effect as pressing the stop button, except that playback (or recording) will recommence as soon as pressure is removed from the pause button.

In the next group of controls are buttons for rewind, fast wind, play (actually play/record), stop, and recording interlock. The interlock button, like those for selecting the channels to record on, glows red in use. The remaining buttons (except for AC, repeat, pause, and counter-reset) all glow white when they’re pressed in. In the last group are a button for resetting the counter and three for tape speeds: 3⅞, 7⅛, and 15 ips. The counter reads directly in minutes and seconds (at 7½ ips; at other speeds the readings must be doubled or halved) and is driven by the right-hand tape idler. This is the first true-reading counter on any deck we have tested (except for 8-track cartridge equipment), and we found the “real” numbers a big help by contrast to the arbitrary (and non-time-related) indications of conventional counters. The speed buttons are particularly fascinating. They allow you to change speed without stopping the transport (actual speed change and equalization switching are managed electronically), and their pilot lamps will not come on until the transport has reached the correct speed. Similar memory and self-evaluating logic circuits govern other functions so that, for example, you can press “play” while the deck is in a fast-wind mode; the stop button will light up, and as soon as the tape has actually stopped, the transport will switch itself into play.

The metering is via a single, double-needled, double-scaled vertical meter. This arrangement, in our opinion, has a big advantage over separate meters in the two channels because levels are easier to follow in both channels at once. Two red pilot lights in the meter face indicate instantaneous overload conditions for the two channels.

To the left of the meter system is a master recording-level slider. At the center of the same panel are two left-and-right pairs of input-level sliders, flanked by an input selector for each pair. That for the left (“input 1”) pair has positions for low-impedance mikes, high-impedance mikes, phono, “radio,” and “aux” (line 1). That for the right (“input 2) pair has the same two mike positions plus others for echo/multiply, “aux” (line 2), and off. Below each selector is a pair of phone jacks for mike inputs; impedance matching of these inputs is selected at the switch. The phono input is for a magnetic cartridge and includes an RIAA-compensated preamp. The multiply/echo position is used like the sound-on-sound and tape-echo switches on home equipment.

**Revox A-700 Additional Data**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Speed accuracy</td>
<td>15 ips: 0.46% slow at 105, 120, &amp; 127 VAC&lt;br&gt;7⅞ ips: 0.50% slow at 105, 120, &amp; 127 VAC&lt;br&gt;3¾ ips: 0.57% slow at 105, 120, &amp; 127 VAC</td>
</tr>
<tr>
<td>Wow and flutter (ANSI weighted)</td>
<td>15 ips: playback: 0.02%&lt;br&gt;7⅞ ips: playback: 0.02%&lt;br&gt;3¾ ips: playback: 0.03%</td>
</tr>
<tr>
<td>Rewind time, 7-in. 1,800-ft. reel</td>
<td>87 sec</td>
</tr>
<tr>
<td>Fast-forward time, same reel</td>
<td>87 sec</td>
</tr>
<tr>
<td>S/N ratio (re NAB 0 VU)</td>
<td>playback: L ch: 60 dB&lt;br&gt;record/play: L ch: 53 dB</td>
</tr>
<tr>
<td>Erasure (400 Hz at normal level)</td>
<td>74 dB</td>
</tr>
<tr>
<td>Crosstalk (at 400 Hz)</td>
<td>record left, play right: 51 dB&lt;br&gt;record right, play left: 50% dB</td>
</tr>
<tr>
<td>Sensitivity (re NAB 0 VU)</td>
<td>line inputs: L ch: 13 mV&lt;br&gt;mike Inputs (hi-Z): L ch: 0.62 mV&lt;br&gt;mike Inputs (lo-Z): L ch: 0.05 mV&lt;br&gt;phono Input: L ch: 0.7 mV</td>
</tr>
<tr>
<td>Meter action (re NAB 0 VU)</td>
<td>L ch: 3% dB low&lt;br&gt;ch: 3% dB low</td>
</tr>
<tr>
<td>Total harmonic distortion (at 10 VU)</td>
<td>15 ips: &lt;1.0%, 50 Hz to 10 kHz&lt;br&gt;7⅞ ips: &lt;1.0%, 50 Hz to 10 kHz&lt;br&gt;3¾ ips: &lt;1.6%, 50 Hz to 10 kHz</td>
</tr>
<tr>
<td>IM distortion (record/play, -10 VU)</td>
<td>15 ips: L ch: 1.1%&lt;br&gt;7⅞ ips: L ch: 1.5%&lt;br&gt;3¾ ips: L ch: 2.5%</td>
</tr>
<tr>
<td>Maximum output (line, 0 VU)</td>
<td>L ch: 0.53 V&lt;br&gt;ch: 0.57 V</td>
</tr>
</tbody>
</table>
The four-in/two-out mixing system therefore has a spectacular range of capabilities.

Next, to the right, is a group of four rotary switches. That at the upper left selects playback mode (stereo, left only, right only, and left-plus-right mono). Below it is an input/tape monitor switch. At the upper right is a stepped treble control (affecting headphone and power-amp outputs only), and below it is a similar bass control. And below the four knobs are two stereo headphone jacks. One automatically switches off the power-amp output on the back panel; the other does not. At the extreme right are a pair of sliders that control the output to headphone and power-amp connections only.

The back panel has pin-jack pairs for aux (line) 1 and 2 inputs, magnetic phone input, and line A and B outputs. The A output bypasses the front-panel mode switch; B does not. In addition, there are two DIN-type sockets. One is the usual ‘‘radio’’ record/play socket; the other is designed for direct output to the Revox A-722 power amplifier (not supplied)—the ‘‘power amp’’ output specified earlier. There are on the back panel other features that relate to accessories not supplied (and not tested by us) but that can make the A-700 materially more welcome to users interested in special applications: a socket for an external capstan speed control (with a range of 2% to 21% ips, according to Revox), one for remote control of a slide projector (using a special sync head not included in our test sample), and a remote-control unit for tape-drive functions themselves.

It goes almost without saying that the A-700’s many functions and modes work magnificently. The logic is superbly worked out; it never wastes a second, yet it never threatens damage to the tape nor results in illogical function sequencing even in the hands of the most insouciant of operators. Though we tried to find flaws in the way Revox had worked out which of its controls would override which of their fellows, we were unable to do so. (We did have one minor misadventure, however, when we didn’t lock down one reel securely; as a result one reel motor was turning though the reel was not; ‘‘misforming’’ the logic about tape motion. But no damage was done, and in horizontal operation gravity will prevent even this from happening by keeping the reel firmly in place.)

Generally speaking, the performance is equally superb. Note the particularly fine record/play response curves and the extremely low distortion. Also exceptional are the wow-and-flutter figures, which (unlike those for almost every other recorder we’ve tested) are as low in record/play as in playback only—and extremely low by any standards.

In some measurements—all made with Scotch 207 tape, the type for which the A-700s delivered in this country are optimized—the fine measurements may be attributed in part to the half-track head configuration of our test sample. Rule-of-thumb guidelines would indicate that S/N figures might be as much as 3 dB poorer with quarter-track heads, for example. But in practice the S/N ratios achieved should be better than those (53 to 60 dB) shown under ‘‘Additional Data,’’ because we always measure ‘‘worst case’’ conditions, with the inputs at maximum. In using the A-700 we never found it necessary to advance them more than about half way with typical ancillary equipment.

One measurement did take us somewhat aback, though in the normal run of equipment it would not be counted a fault: the speed accuracy, which is not within Revox’s ±0.1% spec. At approximately 0.5% slow the speed accuracy is well within normal consumer requirements. Had we been testing the unit for broadcast use, however, we would have asked Revox to supply us with another sample, or to adjust the one we had for more accurate performance, since an hour program recorded on it would be about 20 seconds off when played on a studio machine adjusted for absolute accuracy—critical, perhaps, when you’re on the air but hardly a real problem in the home.

The sound produced by the A-700 is excellent. At 3½ ips it is just short of the widest possible range and just tinged with hiss. At 1½ ips the sound is totally free and open. To the ear the difference between 7½ and 15 can be established only by A/B comparisons, using superb input signals and first-rate ancillary equipment. And when this sort of sound quality is coupled with the utterly unsurpassed tape-handling qualities and multipurpose input mixing of the A-700, we are talking about equipment that, for all its interest to home recordists, is truly in the professional class.

CIRCLE 150 ON READER-SERVICE CARD

The Sequerra 1: Quite Probably the World’s Greatest Tuner

The Equipment: Sequerra Model 1, a digital-readout FM tuner with multipurpose oscilloscope and built-in Dolby noise reduction. In metal case. Dimensions: 16 by 6% inches (front panel); 12% inches deep, plus allowance for controls and connections. Price: $2,500 (without ‘‘panoramic’’ RF tuning-band display, $2,000); wood case, $125 in walnut, $150 in Brazilian rosewood. Warranty: five years parts and labor (scope and inductance lamps, 1 year), shipping paid one way. Manufacturer: The Sequerra Co., Inc., 71-07 Woodside Ave., Woodside, N.Y. 11377.

Comment: By now we assume that everyone knows about the Sequerra 1, often characterized as ‘‘the world’s most expensive FM tuner.’’ It also is an extremely fine one. Though there are some available functions (punched-card or pushbutton tuning, for example) that the Model 1 does not include and no occasional performance measurement (ultimate signal-to-noise is one) that we may have seen bettered in past lab measurements, the functional design is so encompassing and the over-all performance so superlative that the Sequerra can, with justice, be called ‘‘best.’’ It certainly is a superb achievement.

First, a word about the kind of digital tuning that is involved. The tuning circuits themselves are conventional; it is the read-out of the tuned frequency that is digital. Unlike ‘‘true digital’’ tuners (those that will tune only to synthesized, discrete frequencies), the Sequerra can be mistuned. The advantage of the digital
readout is that it shows frequency unequivocally and accurately to 0.1 megahertz and is to that extent far more accurate than the normal dial-and-pointer arrangement in distinguishing, say, between a station at 101.5 MHz and one on the adjacent channel at 101.7 (it also will read the in-between point at 101.6), but it can be tuned to 101.53, for example, slightly off the 101.5 frequency. The Sequerra relies on its oscilloscope for more precise centering; a "true digital" design relies on its frequency synthesis.

The scope dominates the front panel. Beside it are the frequency readout, a lighting "stereo pilot" indicator, and the tuning knob. At the sides are two banks of pushbuttons and indicator lamps. The first four at the upper left are interlocked and control the scope display: "panoramic," "tuning," "tuner vector," and "ext[ernal] vector." Then comes a push-push switch for separation: maximum/hi-blend. At the bottom is a Dolby on/off switch. On the right are three interlocked muting buttons: off, interstation, interstereo. (The latter, of course, mutes the output except when a stereo pilot is sensed.) The bottom three are again of the push-push type: mode (automatic/mono), panel illumination (normal/dim), and AC power (on/off).

Of the oscilloscope modes, the "vector" display should be the most familiar. Amplitudes of output signals are represented by the distance toward the outer edges of the display panel from the center of the scope; mono signals appear as a vertical line running straight up from the center, while stereo signals fill the top quadrant of the scope—the left and right 45-degree lines that define this quadrant represent left-only and right-only signals respectively. When outputs from a quad system are connected to four pin jacks provided at the back, these 45-degree lines represent the two front channels, while those running downward from the center represent those at the back. The vector display thus can be used to check relative amplitudes and placements in any signal source: quad, stereo, or mono.

The "tuning" display also should be familiar. A perfectly tuned station shows as a horizontal line centered in the scope, which displays three lighted vertical graticules (calibration marks). The center one represents the frequency to which the Model 1 is tuned, and the display should be symmetrical about it. Those to the right and left indicate maximum modulation, and the display should not go beyond them if both the station's transmitter and the tuner are being used correctly. Horizontal cross hairs along the center graticule calibrate it for signal strength. Where multipath distortion interferes with the tuned signal, the display will be wiggly, rather than a straight horizontal line. Thus this one display mode gives you much more detailed information about tuning and the quality of the RF signal to which it is tuned than you can get from the familiar meter pair.

The "panorama" display does still more. It is calibrated vertically in terms of signal strength, but its graticule has vertical lines that represent alternate-channel spacing, and the display itself embraces more than 1.6 MHz of the RF spectrum (showing five alternate channels or nine adjacent ones) centered on the tuned frequency. Each receivable station within this range appears as a "peak"—"purple mountain majesties," so to speak, rising above the "fruited plain" of noise at the bottom of the scope. The shape of the peaks can be used to tell which stations are broadcasting a stereo subcarrier and which have an SCA subcarrier. Where adjacent channels interfere with each other, the display can be used as a gauge of antenna positioning to minimize the interference. (And if you've never before seen this sort of display, we guarantee you'll be fascinated by it.)

On the back panel are two pairs of stereo pin jacks that carry output signals. That for normal use has fixed
### Sequerra Model 1 Additional Data

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capture ratio</td>
<td>1 dB</td>
</tr>
<tr>
<td>Alternate-channel selectivity</td>
<td>94 dB</td>
</tr>
<tr>
<td>S/N ratio</td>
<td>67 dB</td>
</tr>
<tr>
<td>THD Mono</td>
<td>L ch 0.07%</td>
</tr>
<tr>
<td></td>
<td>R ch 0.13%</td>
</tr>
<tr>
<td></td>
<td>L ch 0.10%</td>
</tr>
<tr>
<td></td>
<td>R ch 0.11%</td>
</tr>
<tr>
<td></td>
<td>L ch 0.20%</td>
</tr>
<tr>
<td></td>
<td>R ch 0.11%</td>
</tr>
<tr>
<td>IM distortion</td>
<td>0.15%</td>
</tr>
<tr>
<td>19-kHz pilot</td>
<td>-62 dB</td>
</tr>
<tr>
<td>38-kHz subcarrier</td>
<td>-68 dB</td>
</tr>
<tr>
<td>Frequency response</td>
<td></td>
</tr>
<tr>
<td>Mono</td>
<td>+ ¼, -1 dB, 20 Hz to 15 kHz</td>
</tr>
<tr>
<td>L ch</td>
<td>+ ¼, -1 dB, 20 Hz to 15 kHz</td>
</tr>
<tr>
<td>R ch</td>
<td>+ ¼, -1½ dB, 20 Hz to 15 kHz</td>
</tr>
<tr>
<td>Channel separation</td>
<td>&gt; 42½ dB, 20 Hz to 3.3 kHz</td>
</tr>
<tr>
<td></td>
<td>&gt; 33 dB, 20 Hz to 15 kHz</td>
</tr>
</tbody>
</table>

Again, the second pair, for high-impedance inputs, has a small screwdriver level control. So do the four pin-jack inputs for the external vector display. There also is a detector output (for a discrete-quad adapter if and when a broadcast method is approved) and a jack marked "25 microsecond Dolby." In early samples, you must insert a shorting plug into this jack to convert the non-Dolby standard de-emphasis (75 microseconds) to the new Dolby standard; later samples have the change—which affects only the Dolby mode, of course—already made internally. Future production will omit the jack.

In addition the back panel has an array of screwdriver controls for adjusting calibration of the scope and its various modes and for setting muting threshold. There is a terminal strip (appropriate for bared leads or small spade lugs) for 300-ohm or 75-ohm antenna connections. And there is a multi-pin jack marked "accessory" that is designed for a remote-control unit. It should be on the market (at about $150) by the time you read this, according to Sequerra, and will have six pushbuttons similar to those on the front panel: five for preselected stations and one for manual (non-remote) tuning.

Sequerra provides a checkout sheet for each tuner. CBS Labs' data for our test sample match the checkout very closely indeed. This is particularly surprising since a tuner of this quality puts a premium on the test equipment used, it is touch and go whether the unit under test will prove better than the test setup. The lab had to double-check many of the measurements to be sure that it wasn't simply measuring the limitations of its own equipment.

In particular, the stereo quieting, separation, and distortion figures of the tuner are spectacular. Stereo performance is almost as good as mono, and the mono itself is superb. Since a tuner of this caliber defies its critics to be peevish if they can, we might note that our test sample doesn't live up to the specs that preceded (by many months) the actual equipment; but we can't really fault the performance for being merely excellent in these respects. For example, advance data suggested that alternate-channel selectivity would be in the neighborhood of 140 dB! The 94 dB that the lab actually was able to measure falls far short of this, though it is among the best we've ever encountered. And we might note that the tuning is subject to some drift during the first half-hour or so after it is turned on—though any change in tuned frequency is so dramatized by the scope (in the tuning mode, which the manual recommends for most accurate tuning) that you can see (and correct) the drift long before you can hear any signal degradation.

So, peevish though we may try to be, we must concede that the Sequerra Model 1 is not only unique, but a superb tuner.

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### A Tangent-Tracking B&O Turntable With a Mind of Its Own

**The Equipment:** Beogram 4002, a two-speed (33⅓ and 45) automated single-play turntable with radial-tracking arm and MMC-6000 pickup cartridge, in wood case with hinged dust cover. Dimensions: 19¼ by 15 inches (case); 4 inches deep with cover closed, about 17 inches of vertical clearance with cover fully open. Price: $650. Warranty: one year parts and labor, shipping paid one way. Manufacturer: Bang & Olufsen, Denmark; U.S. distributor: Bang & Olufsen of America, Inc., 2271 Devon Ave., Elk Grove Village, Ill. 60007.
Comment: In terms of sophisticated design—both cosmetic and mechanical—this is not only a unique turntable, but deserves to be considered as the most impressive we have ever tested. If you’re interested in an automatic turntable (not a changer), this is by all odds the most fascinating we have worked with.

Its basic element is a two-speed electronically controlled drive motor, belt-coupled to a heavy (4 pounds, 15 ounces) aluminum platter with radial rubber “spokes” that support the disc. The platter bearings are mounted on the same independently suspended subassembly (which is unusually insensitive to external shock) as the arm-drive system, which has its own motor. For cueing, this motor can be manually or automatically controlled; during record play, it acts as a servo system, turning the lead-screw assembly that advances the arm in response to minute (less than 1 degree, says B&O) arm displacements.

The arm itself is of the radial tracking or true tangent type and is specifically designed for the MMC-6000 cartridge (see test report, December 1974). It is a “CD-4” pickup—meaning that it will play mono, stereo, or matrixed quad discs, or CD-4 Quadradiscs. At this writing, B&O America is readying (for about $150) a plug-in CD-4 demodulator circuit board for the 4002 (which is sold in Europe with the board as the Beogram 6000).

A set screw in the assembly at the arm’s fulcrum adjusts vertical tracking force, which reads on a small dial visible through a window in the assembly; there is no antiskating adjustment, of course, because radial arms develop no skating force. A second “arm” parallel to the tone arm and about an inch ahead of it contains a photoelectric system that not only is part of the servo for arm positioning during play, but “reads” the surface beneath to determine where the edge of the record is—or, indeed, whether there’s a record on the platter.

The control panel is unique. It is fabricated out of a single piece of spring metal, slitted so that each individual control section can be pressed to activate a switch below it as it bends slightly downward. Normally you need use only the sections along the front: on, advance, cue, backup, and off. If you press “on,” the 4002 will turn itself on and the tone arm will move to the lead-in groove of the record and commence play. At the lead-out groove the arm will rise, the arm assembly will return to its rest position, and the 4002 will shut itself off. If you tire of the record before it’s over, press “off” and the 4002 will raise its arm and complete the shut off cycle. It takes about two seconds for the arm to find the lead-in groove of a 12-inch LP, about six seconds from leadout to shut off. That’s all there is to it unless you’re looking for a specific passage in the middle of the disc side.

The advance and backup sections of the control panel move the arm slowly toward or away from the spindle, and do so only as long as you continue to press them. Very accurate positioning can be accomplished by a series of quick touches. (Note that the arm cannot be moved manually—only via the controls.) If the record has been playing when you touch these sections, the arm-up cueing is automatic and the cueing section must be pressed to lower the arm and re commence play once you have located the correct spot on the disc. For faster cueing you can use the “on” section (for advance) or the “off” section (to back up), and you can go from one of these modes to another in any sequence. Once pressed, the fast-cue modes will continue to drive the arm until you press another section of the control panel or until the arm runs out of space. If it is running toward the spindle, it will reverse and move toward the off position; if it already is moving away from the spindle, it likewise will continue toward the off position; once the sensor is beyond the edge of the record the arm no longer can be lowered.

We found this the one point on which we could “fool” the logic of the system. If you put a small (less than 12-inch) disc on the platter and begin play, then raise the arm and back it off until the stylus is beyond the record groove but not off the record-support fins with the cueing switch. So it is possible to damage the stylus, but in normal practice we consider it highly unlikely.

But what about turntable speed? The automation takes care of that, too, for all normal purposes. When you press “on,” a little dial above the 33-rpm section of the control panel lights up. It is calibrated from +3% to +3% in 1% increments and has a small wheel for adjustment. It works with the servocontrol system, which according to B&O is more accurate than any strob system. The unit, therefore, has no strobe. If the advancing tone arm finds no disc until it reaches the 7-inch diameter, the 33 dial will go dark and that above the 45-rpm section will light up—indicating that turntable speed has switched automatically. If you have a 7-inch LP or an oversize 45, you can override the automatic speed selection with the manual portions of the control panel. An adapter for the large-hole 45s is provided, incidentally.

If the 4002 seems to have a mind of its own, its designers most certainly do have. The entire design is exceedingly well thought through, and of course its cosmetics are spectacular. It is astonishing to find so much—two motors, a vibration-trapping suspension system, logic circuitry, space for CD-4 circuitry, and so on—contained in such a shallow base: barely 2 inches from tabletop to control panel.

Performance also is excellent in terms of lab measurements. No measurable error could be found in the exact-speed calibrations of the unit at any line voltage used in our tests. The fast and slow settings on these dials, measured at extreme rotations (though not precisely at the 3% calibrations in each case) are +3, -3%5% for 33 rpm and +3, -4% for 45. Flutter is extremely low at 0.025% average (0.05% maximum), and so is rumble at -64 dB (ARLL). No arm friction could be measured, and since the tripping system at the end of the disc does not depend on arm motion as such it adds no drag either. Stylus-force calibrations (in half grams from 0.0 to 1.5) all measured 0.1 gram high—a negligible discrepancy.

The lab measurement of arm resonance showed a 10-dB rise at about 12.5 Hz. Apparently, the frequency is fairly optimum for avoiding both audible-range effects and warp-tracking problems, and, despite what seems to be a fairly high amplitude at that frequency, we encountered no problems—either in tracking or listening to warped discs.

This, then, is an exciting piece of record-playing gear: elegant, silky-smooth, and thoroughly competent. And it is delivered equipped with a fine cartridge, as last month’s report documented. Old-timers, used to hooking a finger under the grip on the pickup head and deftly dropping the stylus into the first groove by hand, may find the 4002’s ultramechanized approach Orwellian at first (though they should find that their records pick up fewer gouges in the long run), but we doubt that even those who are most opposed to automation could hold out long against this turntable’s charms once they’ve tried it.

CIRCLE 149 ON READER-SERVICE CARD
Audionics' Speaker "Kit" for the Real Do-It-Yourselfer


Comment: This unit is called a "kit" for want of a better word. Unlike the more familiar kits, which generally give you either a prefinished enclosure (one now is available for the TL-90—see below) or precut parts ready to assemble, this one gives you only plans and notes on construction. You must decide on the cosmetic treatment and even enclosure configuration yourself—and supply the necessary materials for the enclosure.

Audionics offers information on two enclosure types, both of them with transmission-line loading of the woofer. The taller—and somewhat simpler to construct—was chosen by our kit-builder. Its transmission line begins at the bottom of the woofer chamber and "folds" upward to emerge at the back top. A lowboy design has a second fold in the transmission line, so that its mouth is at the bottom of the enclosure. Neither should pose severe problems to the reasonably accomplished woodworker equipped with a radial-arm or bench saw; but they should not be attempted by the hammer-and-nails duffer if an acoustically and cosmetically satisfactory system is to result. As in any speaker enclosure, joints must be solid—and therefore accurately fitted—for correct performance.

Audionics also supplies acoustic "stuffing" material,

a prewired crossover board, and the necessary parts to complete the electrical portion of the system. The crossover has been changed somewhat since our samples were shipped, and the design now has spring clips for the amplifier leads. (Ours have screw terminals that could permit shorting of the leads, so we are glad to learn of the change.)

Obviously, the way that the product tests out in the lab will to some extent depend on the skill of the constructor. We only can report, therefore, on how our samples came out, though we would not expect major differences in other competently constructed samples.

CBS Labs' measurements, plus our listening tests, show our speakers to have quite flat response, with the fairly high sensitivity and tight (rather than boomy) bass associated with transmission-line systems. It delivers the standard sensitivity (or efficiency) test level (94 dB at 1 meter) for only 2.1 watts' input. It accepts steady-state input signals up to about 35 watts without exceeding distortion limits, a 300-Hz tone at this level will blow the fusing (supplied). Pulse power to 150 watts (average, or 300 watts peak), the limit of the test amplifier, can be fed in without excessive distortion. In the steady-state test, levels of above 100 dB were reached; pulse tests ran to 112 dB. Thus good dynamic range can be achieved even with fairly modest amplifier power—say, up to 30 watts per channel.

Audionics rates the system at an impedance of 7.5 ohms. Though our samples dropped to this value at the extreme top of the audible range, the rating point (just above the bass-resonance rise), as measured at the lab, was 12 ohms at about 80 Hz. The impedance curve is fairly flat. It drops to 8 ohms at 5 kHz and then rises again before dropping at the top end. We would have no qualms about paralleling it with other speakers, working from a transistor amplifier, on the basis of the data.

Pulse tests, particularly at 3 kHz, showed some evidence of ringing, but it is not severe. (Audionics claims an improvement in this respect with the new crossover.) The sound is very good; by contrast to many American systems (the kit is based on a design by Radford of England, whose drivers and crossover are used in the system) the bass is a little reticent, though some listeners express admiration for its "lack of boominess." The design admittedly aims for tight, clean bass, rather than maximum "bass sensation." Consequently, some listeners prefer the sound with loudness compensation in the system driving the speakers while others do not. (We should point out that bass-resonance properties of the system can be tailored to some extent by the way in which the constructor installs the acoustic wattage.)

The sound is quite smooth at the top, but here too a

<table>
<thead>
<tr>
<th>Output Level (dB)</th>
<th>80 Hz % 2nd</th>
<th>80 Hz % 3rd</th>
<th>300 Hz % 2nd</th>
<th>300 Hz % 3rd</th>
</tr>
</thead>
<tbody>
<tr>
<td>70</td>
<td>0.24</td>
<td>0.24</td>
<td>0.20</td>
<td>0.45</td>
</tr>
<tr>
<td>75</td>
<td>0.33</td>
<td>0.20</td>
<td>0.20</td>
<td>0.52</td>
</tr>
<tr>
<td>80</td>
<td>0.60</td>
<td>0.25</td>
<td>0.20</td>
<td>0.65</td>
</tr>
<tr>
<td>85</td>
<td>1.2</td>
<td>0.30</td>
<td>0.20</td>
<td>0.66</td>
</tr>
<tr>
<td>90</td>
<td>2.5</td>
<td>0.25</td>
<td>0.75</td>
<td>0.55</td>
</tr>
<tr>
<td>95</td>
<td>5.5</td>
<td>1.2</td>
<td>2.3</td>
<td>0.56</td>
</tr>
<tr>
<td>100</td>
<td>4.1</td>
<td>4.1</td>
<td>4.1</td>
<td>4.1</td>
</tr>
</tbody>
</table>

*Distortion data are taken on all tested speakers until distortion exceeds the 10% level or the speaker produces the spurious output known as buzzing, whichever occurs first.
distinction must be drawn between "typical" European and American design objectives. The wide dispersion that so many American systems strive for is not universally considered a virtue in Britain. The extreme highs (above 10 kHz) are not as broadly dispersed in the Audionics system as they are in some American systems we've tested, though, as it happens, the same tweeter is used in some systems manufactured here. It does provide extended highs, a good spread even by American standards, and firm stereo image.

All told, we are pleased with the sound of the TL-90s; in addition they have the virtue of a considerable saving with respect to their finished counterparts, which cost $449 apiece. Our constructor spent about $30 on wood and grille cloth and needed five and a half hours to complete a pair of the speakers. So the total price (exclusive of time, glue, miscellaneous hardware, finishing materials, and electricity for his power tools) of the pair was some $390—as opposed to $698 for the finished units. Furthermore, he had the opportunity to tailor the styling to his own needs. The kit therefore offers both a challenge (to the home constructor) and an opportunity (to the music lover).

If you want the opportunity without the challenge (and aren't looking for a custom cabinetry job), Audionics has just added a second kit that includes prefinished cabinetry at $340 (shipping included). The standard finish is a rosewood pressure laminate. Teak and black finishes also are available on special order—at no increase in price, but requiring extra waiting time. So now you can buy the TL-90 in three stages of completeness.

**CIRCLE 148 ON READER-SERVICE CARD**

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**An Auto-Reverse Cassette Deck from Toshiba**


**Comment:** This report establishes two "firsts" in our testing program: the first auto-reverse home cassette deck we've measured, and the first product of any description from Toshiba—a company perhaps best known for its mass-market wares, but the producer of a component line as well.

There is a tilted blackout control panel at the back with lighting direction indicators at the left, Dolby and recording indicators near the center, and recording meters at the right. At the left of the main panel is the cassette well with buttons for the usual functions (plus reversing) in front of it. They allow the user to go directly from play into either fast-wind and back without pushing "stop" but not directly from one fast wind mode to the other. The stop button also controls eject; if the transport is running, a push on this button will stop it but not eject the cassette, which requires that the deck already be stopped—a nicely thought-out prevention for unintentional eject in start-stop work. The entire system returns automatically to "stop" at the end of the tape in any transport mode, unless an automatic-reverse mode is triggered, of course.

The automatic reverse is controlled by a three-position mode switch to the right of the transport buttons. The "nonreverse" position allows manual selection of transport direction (using the "reverse" button) in either recording or playback. The "reverse" position causes the deck to change automatically from forward (tape moving toward the right) to reverse (tape moving left) in either recording or playback at the end of the tape. In the "repeat" position the deck will reverse at both ends in playback, in recording it still will stop at the end of the second cassette side.

Next to the mode selector is a tape selector: "normal"/"hi-fi"/"chrome." Toshiba recommended TDK types D, SD, and KR, respectively, for these settings, and lab tests were made accordingly. At the extreme right front are switches for Dolby action and AC power. Behind them are a pair of sliders to control recording level, while behind the two three-position knobs are similar sliders to control playback level. Unlike most cassette decks, the PT-490 does not control source output during recording via the playback sliders; only the recording-level controls do that.

We found the fixed source-feed level via the PT-490 higher than input levels unless we cut recording levels back to peak at roughly -10 VU. Because of this "mismatch" we prefer the more common system using an output (not just playback) level control for the return feed to the stereo system, though the point obviously is not a major one for most users.

There is a turns counter at the back of the top plate. At the bottom right corner of the base are a stereo headphone jack and mono phone jacks for left and right mike inputs. The latter disconnect the line feed when the mikes are plugged in. The line input and output connections are on the back of the unit: both pin-jack pairs and a DIN connector. There are no user-accessible Dolby adjustments.

**CIRCLE 148 ON READER-SERVICE CARD**

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**January 1975**
The most newsworthy feature of the deck is, of course, the automatic reversing. Toshiba achieves it by using a four-track record/play head in the central (normal) position, aligned with the cassette’s pressure pad. This is flanked by two erase heads (one for forward and one for reverse) that fit into the smaller openings between the record/play head opening and those normally used for the erase head (on one side) and the pinch roller (on the other). The transport uses both of these latter openings for capstan pinch rollers, which one engages depends on the direction of tape travel.

The system works very well indeed, though truly instantaneous reverse is possible only in playback. In recording, the manual reverse button is locked; you must stop the tape before it will operate. With leaderless cassettes, the turnaround time in automatic reverse is about three seconds; leader in the tape increases the “missed” time during automatic-reverse recording, of course. So while a C-120 cassette will, for example, allow two uninterrupted hours of unattended recording on the PT-490, there will be a noticeable break at the end of the first side.

Mechanically the PT-490 is no more complex than its nonreversing counterpart except for the extra pinch roller; there are no shifting heads or flipping cassette mount. This simplicity of design strikes us as all to the good. Unlike the more complicated convenience designs (including 8-track decks with their shifting heads), the PT-490 would not appear to be particularly prone to azimuth alignment problems or to tape-to-head contact changes with reversed tape feed. Response measurements confirm, in fact, that record/play behavior in two directions is virtually identical—unlike that of some mechanically elaborate reversing decks we’ve tested in the past. And, of course, the simpler the design, the less there is to go wrong in any respect.

By checking the prices at the beginning of this report you’ll see that the reversing feature adds $100 to the price of a $250 Dolby deck. The extra costs are due largely to the extra switching and wiring, it would appear. Basically, then, this is a moderate-priced Dolby deck with a particularly efficient reversing system added and with no corners cut in the basic design.

That basic design represents good value, in our opinion, though a comparison with the measurements for the “better” (nonreversing) Dolby decks we’ve tested at, say, about $350 naturally will turn up better performance—particularly obvious in record/play response curves, where all the lab’s measurements of the PT-490 show a gradual rolloff in the treble and an ultimate top flatness below that of a typical $350 deck. The result is slightly bass-heavy but particularly hiss-free sound whose balance can, to some extent, be restored by a gentle treble touchup. It certainly is not out of line for a $250 deck.

One word about the meters. The lab’s measurements show those in our test sample to be set for a 0 VU ½ dB above DIN standard. Common practice today is to set them for a 0 VU indication at Dolby reference level (about 1 dB below DIN 0 VU) or even lower to allow greater headroom for peaks. The PT-490’s metering therefore offers little if any headroom, and we’d suggest that you set levels more conservatively with it than you would with most decks.

That leaves us with one outstanding question: Is the automatic-reverse feature worth $100? Judging from reader correspondence, we think it will be to many users, particularly when the reversing is accomplished by so sane a design. For once we can say without equivocation that we see no negative side effects to the inclusion of the reversing feature—it adds much to the convenience of the unit without discernibly subtracting anything in performance, reliability, or versatility.

Toshiba PT-490 Additional Data

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Speed accuracy</td>
<td>0.7% slow at 105, 120, and 127 VAC</td>
</tr>
<tr>
<td>Wow and flutter</td>
<td>playback: 0.09%</td>
</tr>
<tr>
<td></td>
<td>record/play: 0.12%</td>
</tr>
<tr>
<td>Rewind time (C-60 cassette)</td>
<td>128 sec.</td>
</tr>
<tr>
<td>Fast-forward time (same cassette)</td>
<td>128 sec.</td>
</tr>
<tr>
<td>S/N ratio (re 0 VU, Dolby off)</td>
<td>L ch: 55 dB, R ch: 52 dB</td>
</tr>
<tr>
<td>playback</td>
<td>L ch: 47 dB, R ch: 47 dB</td>
</tr>
<tr>
<td>record/play</td>
<td></td>
</tr>
<tr>
<td>Erasure (333 Hz at normal level)</td>
<td>65 dB</td>
</tr>
<tr>
<td>Crosstalk (at 333 Hz)</td>
<td>40 dB</td>
</tr>
<tr>
<td>record left, play right</td>
<td>42 dB</td>
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<tr>
<td>record right, play left</td>
<td></td>
</tr>
<tr>
<td>Sensitivity (re DIN 0 VU)</td>
<td>L ch: 88 mV, R ch: 88 mV</td>
</tr>
<tr>
<td>line input</td>
<td>L ch: 0.26 mV, R ch: 0.26 mV</td>
</tr>
<tr>
<td>mike input</td>
<td></td>
</tr>
<tr>
<td>Meter action (re DIN 0 VU)</td>
<td>L ch: ½ dB low, R ch: ½ dB low</td>
</tr>
<tr>
<td>Total harmonic distortion (at -10 VU)</td>
<td>L ch: &lt;2.0%, R ch: &lt;2.0%</td>
</tr>
<tr>
<td></td>
<td>50 Hz to 5 kHz</td>
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<tr>
<td>IM distortion (record/play, -10 VU)</td>
<td>L ch: 6.0%, R ch: 6.5%</td>
</tr>
<tr>
<td>Maximum output (re DIN 0 VU)</td>
<td>L ch: 1.2 V, R ch: 1.2 V</td>
</tr>
</tbody>
</table>
Onkyo’s “Totally Engineered” TX-560 Receiver

The Equipment: Onkyo Model TX-560, a stereo FM/AM receiver in wood case finished in wood-grain vinyl. Dimensions: 18 1/2 by 5 1/2 inches (front panel, including allowance for feet); 13 1/2 inches deep plus allowance for controls, connections, etc. Price: $449.95. Warranty: three years on parts, two years on labor; shipping paid one way. Manufacturer: Onkyo Corp., Japan; U.S. distributor: Onkyo Sales Section, Mitsubishi International Corp., 25-19 43rd Ave., Long Island City, N.Y. 11101.

Comment: Onkyo’s phrase “totally engineered” apparently refers to the integration within this receiver of a number of features—direct-coupled differential amplifier, phase-linear FM IF circuitry, ceramic AM filters, negative-feedback tone controls, thermal overload protection, exceptionally smooth tuning control, “transient killer” to prevent “pops” in the speakers when the unit is turned on and off, and so on—that Onkyo engineers believe important in a modern, well-designed receiver. But a stereo receiver is more than electrical engineering, of course; and this one is a handsome, sanely designed piece of music-reproduction equipment.

The faceplate is finished in a bronzy anodizing with well laid-out cream-color lettering. The wide tuning dial lights up green with a red pointer tip; only the meters in use (signal-strength for AM and for FM and center-tuning for FM) also light up green. The tuning knob to the right of the dial has a particularly attractive feel; for quick retuning, a single sharp swirl can drive the pointer all the way from one end of the dial to the other due to its silky bearings and heavy flywheel action.

The remaining front-panel features are lined up below the dial. Next to the headphone jack (which is live at all times) at the extreme left is the AC/speaker switch, with positions for AC off, speakers off, any of three stereo pairs of speakers, and the first of these pairs plus either of the other two. Next are the bass and treble controls, each with friction-clutched elements for the two channels. The volume control near the center of the panel has a flange element for balance. Then come a series of pushbuttons for high and low filters, loudness, mono/stereo mode, tape monitors 1 and 2, and FM muting.

Square-wave response
Onkyo TX-560 Receiver Additional Data

Tuner Section
- Capture ratio: 2 dB
- Alternate-channel selectivity: 74 dB
- S/N ratio: 66 dB
- THD: Mono 0.49%, L ch 0.82%, R ch 0.76%
- IM distortion: L ch 0.18%, R ch 0.22%
- Frequency response
  - Mono: +1½, -3 dB, 30 Hz to 15 kHz
  - L ch: +¾, -3 dB, 20 Hz to 13 kHz
  - R ch: +0, -3 dB, 20 Hz to 13.5 kHz
- Channel separation: >38 dB, 120 Hz to 2.6 kHz
- >28 dB, 31 Hz to 5.5 kHz

Amplifier Section
- Damping factor: 46
- Input characteristics (for 43 watts output)
  - Phono: 2.8 mV, S/N ratio 71⅔ dB
  - Aux: 3.6 mV, 68 dB
  - Tape 1: 190 mV, 89⅓ dB
  - Tape 2: 228 mV, 87⅔ dB
  - RIAA equalization accuracy: +⅓, -⅔ dB, 20 Hz to 20 kHz

RIAA equalization accuracy
- +⅓, -⅔ dB, 20 Hz to 20 kHz

Harmonic distortion curves
- 43 watts output
  - Left channel: <0.05%, 40 Hz to 20 kHz
  - Right channel: <0.05%, 40 Hz to 20 kHz
- 21.5 watts output
  - Left channel: <0.18%, 20 Hz to 20 kHz
  - Right channel: <0.16%, 20 Hz to 20 kHz
- 0.43 watts output
  - Left channel: <0.18%, 20 Hz to 20 kHz
  - Right channel: <0.15%, 20 Hz to 20 kHz

Onkyo's TX-560 Receiver is a high-quality component that offers solid performance and functions, without flamboyance. Though we generally look askance at such advertising terms as "totally engineered," the phrase does seem to have real meaning when applied to the TX-560, which consistently puts its performance and design priorities in rational order to deliver quality and flexibility while dispensing with the frills that add more to cost than to usefulness.