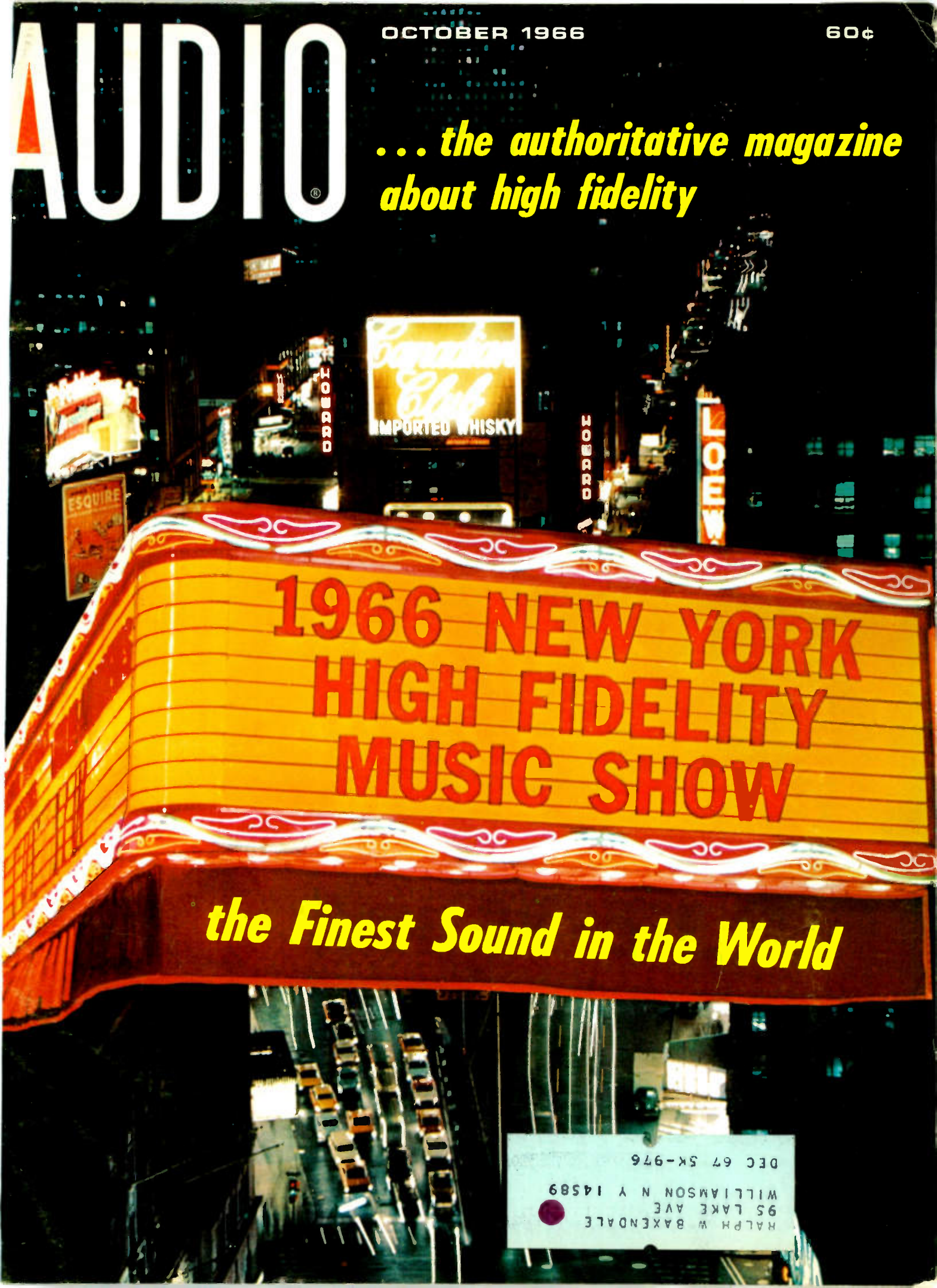
AUDIO®

OCTOBER 1966 60¢

. . . the authoritative magazine about high fidelity



SCOTT

Build two Scott solid-state kits in four afternoons

Scott's done it again, and designed two new solid-state kits that are easier to build, packed with more professional features and performance than you ever dreamed possible! The new LT-112B FET stereo tuner kit takes only one afternoon to build . . . the LK-60 120-Watt stereo amplifier takes just a little longer. Scott's full-color, life-size illustrated construction manual speeds you to a goof-proof, performance-packed finish.

LT-112B FET FM Broadcast Monitor Tuner. A cinch . . . the critical silver-plated FET front end*, the all-silicon IF strip, the patented Scott time-switching multiplex circuitry all have been assembled, wired, and tested at the factory. "Scott's LT-112 . . . is one of the finest FM stereo tuners we have tested and is easily the best kit-built tuner we have checked . . . Because of its simple construction and apparently trouble-free nature, it is a logical choice for anyone who wants the finest in FM reception at a most remarkable price." — *HiFi/Stereo Review*

". . . a kit-builder's dream: it goes together smoothly, it permits a quick and flawless final touch-up alignment without the need of professional instruments, and it performs on a level equal to higher-priced and/or factory-built tuners." — *High Fidelity*

LT-112B specifications: Usable sensitivity, 1.8 μV; Cross modulation rejection, 90 dB; Stereo separation, 40 dB; Capture ratio, 2.5 dB; Price, $189.95.

LK-60 120-Watt Stereo Complete Amplifier. Here's the kit-brother to the superb factory-wired Scott 260 solid-state amplifier, of which HiFi/Stereo Review stated that it has ". . . no sound of its own. The listener hears the music . . . not the amplifier. It will reproduce anything that is fed into it with perfect exactness without adding any sound coloration of its own . . ." The LK-60 has heavy-duty direct coupled silicon output stages for instantaneous, distortion-free power, massive military-type heat sinks for cool operation, and unconditional stability . . . even with speakers disconnected! Exclusive fail-safe test circuit warns you if you've made a wiring mistake.

LK-60 specifications: Music power (at 0.8% harmonic distortion), 120 Watts @ 4 Ohms load; Frequency response, 15-30,000 Hz ±1 dB; Power bandwidth, 20-20,000 Hz; Hum & noise, -55 dB. Price, $199.95.

Scott . . . where innovation is a tradition

SCOTT®

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Export: Scott International, Maynard, Mass.
* Patents pending

Prices slightly higher west of Rockies. Subject to change without notice. We reserve the right to make changes and improvements without notice.

For your free copy of Scott's 16-page full-color illustrated 1967 Guide to Custom Stereo, Circle Reader Service Number 100

AUDIO

October, 1966 Vol. 50, No. 10

Successor to RADIO, Est. 1917

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Coming Next Month

Articles

A High-Quality Phono Preamp with FET's, by William A. Rheinfelder. The first construction article we have been able to unearth on this subject—which is one of the hottest of the year.

Simulated "Live vs. Recorded" Speaker Testing, by Edgar Villchur. This story should clear up some otherwise unclear information we have all heard about some types of "consumer testing."

Amplifier for the Armchair Listener, by R. E. Baird. A startlingly simple amplifier for the beginning home constructor.

Profiles

Sherwood S-7800 Receiver
Stanton 581 EL Stereo Cartridge
BSR McDonald Automatic Changer

In the November Issue on the newsstands, at your favorite audio dealer's or in your own mailbox.

About the Cover

Times Square is the backdrop for Art Director George Porter's New York High Fidelity Music Show Cover. The months ahead will see even more visualizations of his fertile mind—all in full color.

AUDIO CLINIC

Joseph Giovanelli

A Stereo Channel Balance Problem

Q. I have a high-quality stereo music system. However, with the balance control set to its normal position the left channel is favored over the right. This is true for records, tuner, and also on a metronome balance test found on a test record. I need to place my balance control at past the two o'clock position in order to balance out this effect.

Does this imply that my amplifier is not operating adequately? (The amplifier has bias settings that are supposed to be adjusted. I made sure that all four positions were perfectly set to the exact same spot as designated by the manufacturer.)

My right speaker leads are 8 feet longer than the left speaker leads. Could this account for the trouble? Dr. Samuel J. Neiditch, Highland, California.

A. At this point we do not know that there is really anything basically wrong with your equipment. (That may sound strange, but stay with me and you'll see what I mean.) All that is known for sure is that the balance pot does not line up properly when aural balance is obtained. This is not necessarily the result of deficiencies in the equipment except that the balance control knob may be positioned on its shaft improperly or that the pot used in the balance circuit may not be linear. Either of these conditions would result in the knob's position falling somewhere other than the panel's prescribed "balance" position at actual aural balance.

It is possible that one speaker is more efficient than the other. This is especially likely if two different brands of speakers are used. Just to check this, interchange the two speakers.

I rather doubt that your problem lies in the lengths of the speaker leads. Of course, if you are using very thin interconnecting cable this might be your problem.

If what has already said has not enabled you to locate your problem, you will need some basic test instruments —an audio oscillator and a VTVM. This is how to proceed:

1. If your system employs separate preamplifiers and power amplifiers, disconnect the power amplifier during this portion of the check. 2. If you have an integrated system, disconnect the loudspeakers. Replace them with resistors whose values equal the impedances of the speakers. Then continue as follows. 3. Connect the audio oscillator to the tuner input of channel A and to the tuner input of Channel B simultaneously. (This can be done by using a Y connector which you can make or obtain commercially.) Turn the balance control to favor Channel A to the maximum possible extent. Feed in about 0.5 volt into this input or some other convenient signal level which will not overload the preamplifier. The front-panel controls of the preamplifier should be set for stereophonic reproduction. Connect the VTVM to the output of Channel A and read the voltage. (I should add here that the tone controls should be set to their "flat" positions and the oscillator frequency should be set to 1000 Hz.

4. Next, turn the balance control for maximum signal from Channel B. Do not change any other settings on the oscillator or preamplifier. Move the VTVM to the Channel B output and read the voltage. The reading here should be very nearly the same as that obtained from Channel A if the preamplifier is working properly. If one channel produces a lower reading, this channel is at fault. This channel should be checked out stage by stage till you have found the area in which the gain is lost.

5. Assuming that both channels measured the same, adjust the balance control so that the outputs of the two channels are equal. Does this setting correspond to the correct panel front-panel indication? If the control does line up and if we are discussing a system which has a separate preamplifier and power amplifier, it now appears certain that the reason for the unbalance lies with the right channel power amplifier. While we now do tend to suspect this right channel amplifier, some consideration should be given to the possibility that the left channel

The most satisfying volume on anybody's bookshelf... The New LEAK MINI-SANDWICH

The world's *second* distortion-free speaker is here! It's the Leak Mini-Sandwich bookshelf version of the first: the Leak Sandwich Mark II.

At the heart of both—the new Mini-Sandwich and the great Mark II—are the revolutionary SANDWICH®* cones of all speaker motors. Fantastically rigid, yet no heavier than conventional paper cones, these unique diaphragms are made of thick polystyrene foam sandwiched in skin-thin aluminum. They respond with piston-like precision to the wave form of the voice coil signals. The rigidity of the Sandwich cone eliminates "cone breakup," the erratic flexing which causes distortion in other speakers. †

Both Leak Sandwich speakers are flawlessly balanced systems. Electronic components and cabinet, materials and structural features are all functionally determined and integrated. The rich-grained Scandinavian woods and the changeable grille cloth are chosen not only with an eye to beauty but an ear to acoustical perfection.

Result: a remarkably smooth frequency response, free from violent peaks or troughs, over a frequency range of more than six octaves. Transient response is unsurpassed.

And the performance of the new shelf-size Mini-Sandwich is indistinguishable from that of the larger model except in the lowest octave.

If space permits, there is only one choice: The Leak Sandwich Mark II. But if space is a problem, satisfaction is not! Second only to the Mark II, the Mini-Sandwich will meet your most exacting requirements. Ask your Leak Authorized Sound Specialist to let you see and hear both. Look, listen and decide.

Write for literature on Leak Sandwich Speakers; Leak quality components: STEREO control centers (Pre-Amps), Amps and Tuners . . . and name of nearest dealer.

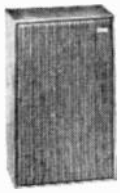
*U.S. Pat. #3,111,187

LEAK
The first name in audio since 1934

†HAVE A SLICE OF OUR SANDWICH!

Special to Audio Magazine readers: Send $1 today for a sample slice of the unique Sandwich cone. You will also receive technical data explaining this revolutionary principle of sound reproduction. After you've seen this material, you'll want to hear the Sandwich **sound!** Visit your local Leak dealer for an audition. He will redeem your Sandwich slice for $5 toward the purchase of either Leak speaker system.

LEAK MARK II
Speaker System **$199**
26"x5"x12" (49.5 lbs.)



LEAK MINI-SANDWICH
Speaker System **$135**
18½"x11"x7" (22 lbs.)

Slightly higher west of the Mississippi

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ERCONA CORPORATION

432 Park Avenue South, New York, N.Y. 10016 • (212) LE 2-6560

Circle 54 on Reader Service Card

power amplifier may have suffered a gain *increase* because of a change in its feedback loop. When checking the power amplifiers, be sure to disconnect the loudspeakers and replace them with equivalent load resistors capable of handling the power which will be applied when output levels are being measured.

In an integrated music system look for a defect in speaker wiring or a defect in the right-channel speaker itself.

When dealing with an integrated system or with a system employing separate power amplifiers, it is possible that even though the channels exhibited the same gain, correct balance does not occur when the balance control is set to its correct panel marking. Let us assume this to be the case now. When rotating the balance control from one extreme to the other, are the end stops equidistant from the markings shown on the panel? If not, reposition the balance control knob, or the pot itself, so that they are. Once this has been accomplished recheck to determine if true balance corresponds with appropriate panel indications. If it does, your problem is solved. If it does not so correspond, the balance pot is probably not linear, and should be replaced. If the pot did rotate symmetrically without reorientation, the same applies.

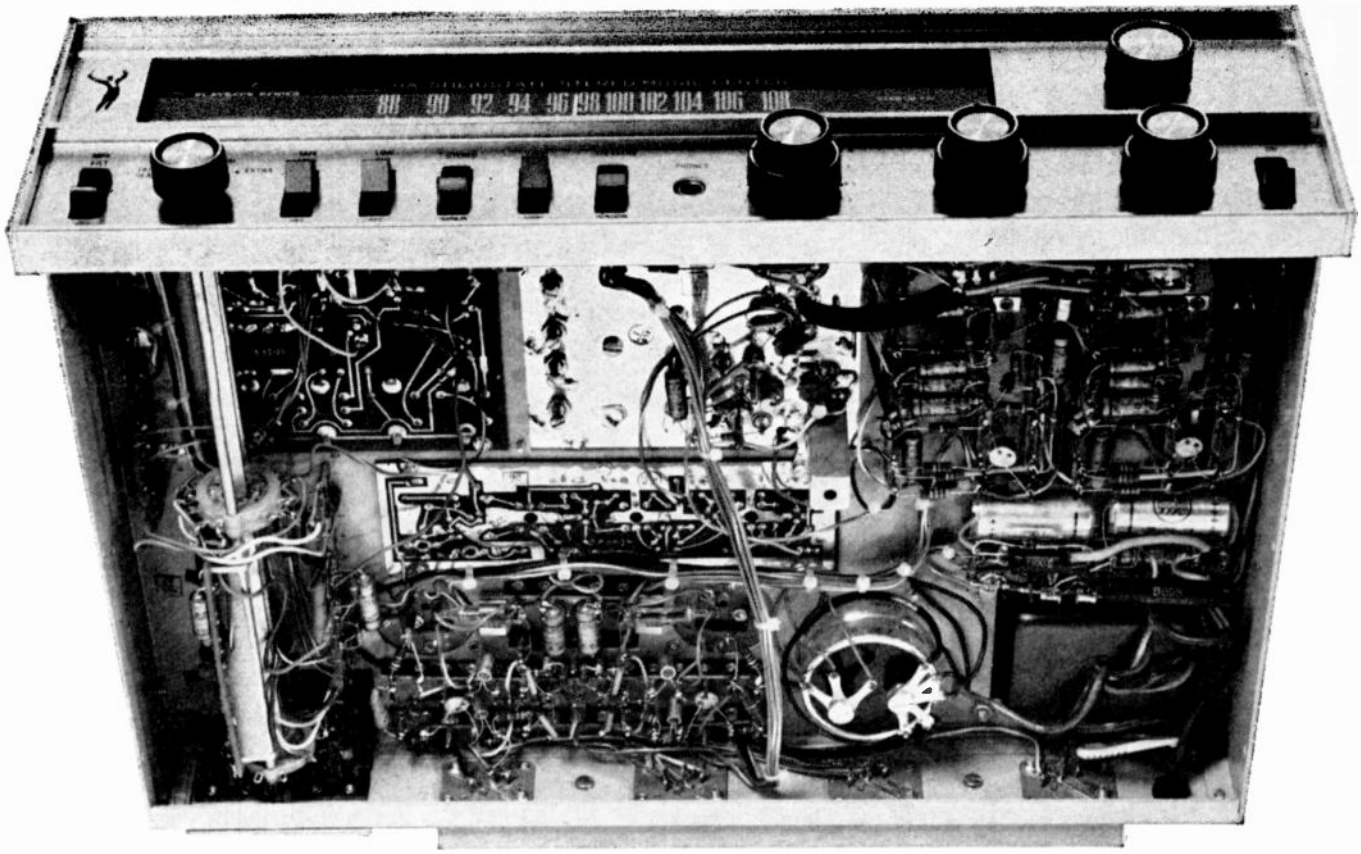
Sometimes it happens that the balance point is correct when the audio gain control is well advanced but not correct at other settings of the audio gain control. For this reason it is a good plan to check preamplifier gain at various audio gain-control settings, including fully advanced. At this setting the two channels should have nearly identical gains, regardless of any problems which might be occurring in the audio gain pot.

If the two channels measure the same gain when the volume control is fully advanced but the gain measurements do not correspond at other settings of the audio gain control, you will have a very clear indication that the audio gain control does not track and it should be replaced with a better one if you can find it.

Apparently it is a very difficult thing for potentiometer manufacturers to make pots which track correctly between their two sections and still maintain a competitive price position

Matching Preamplifiers with Amplifiers

Q. I recently finished a transistorized power amplifier. I am starting now to concentrate on the problem of the preamplifier which I might



LAST CHANCE TO SEE THE GUTS

(The Altec 711A FM Stereo Receiver is so reliable you'll never have to see it like this again)

Take a close look while you have a chance. That's what all-silicon-transistor circuitry looks like. No audio transformers to cause distortion. No heat-producing vacuum tubes. No heat-sensitive germanium transistors.

Our 711A was the first stereo receiver in the world to use silicon transistors exclusively. That way, you can enjoy years of listening, not tinkering. Silicon transistors are the most ruggedly reliable solid-state devices known to date. (If you need to be convinced, just remember that the military specifies them because they can take up to 100% more heat than germanium.)

Frankly, it's just a matter of time before all components use 100% silicon-transistor circuitry. We were first because we already knew how. (We've been building solid-state audio amplifiers for professional, commercial, and military users for nearly ten years.)

This unique Altec experience has other advantages. It not only made the 711A possible, but possible at the practical price of $378. (You don't wind up paying the cost of educating our engineers.) You do get the kind of over-all quality, reliability and performance that only tangible, state-of-the-art experience can bring. You also get some remarkable specs: 100 watts of power at .5% thd (only .25% thd at 70 watts); frequency response of ±1 db, 15-30,000 Hz; and a sensitive FM stereo tuner with a four-gang tuning condenser that provides the best possible ratio of sensitivity to selectivity to reduce cross-modulation through 80 db image rejection, 100 db IF rejection.

But that's only part of our story. To get all of it, visit your Altec dealer. While you're at it, ask him for the new 1967 Altec catalog.

Forget the guts. This is how the 711A will look to you, year after year.

ALTEC LANSING

A Division of LTV Ling Altec, Inc., Anaheim, California

Circle 56 on Reader Service Card

AUDIOCLINIC

mate with this amplifier. Can you tell me what to watch out for when matching preamplifiers, especially tube preamplifiers, to this power amplifier? Kenneth N. Kast, Indianapolis, Indiana.

A. There are two or three points which should be taken into account when matching a preamplifier and a power amplifier. This is true whether we are dealing with tubes or transistors.

1. Make sure that the preamplifier has sufficient output to drive the power amplifier to full output.

2. Make sure that the output from the preamplifier is not too much greater than required to drive the power amplifier, in order to maintain a good signal-to-noise ratio in the event that the power amplifier has no gain control.

3. Make sure that the impedance of the power amplifier is high enough to satisfy the requirements of the preamplifier's output circuitry.

Many preamplifiers are said to have rather low output impedances. However, these units do not work well when these low impedances are matched to the power amplifier having the same impedance in its input circuit. The reason for this is that the coupling capacitor in the preamplifier is of such a value that it produces a voltage-divider action at low frequencies when the power amplifier input impedance is low. This problem is not as common with solid-state preamplifiers as with tube-equipped units. *AE*

This ad is supposed to give you a reason for listening to the Fisher 700-T solid state receiver.

We decided to give you several:

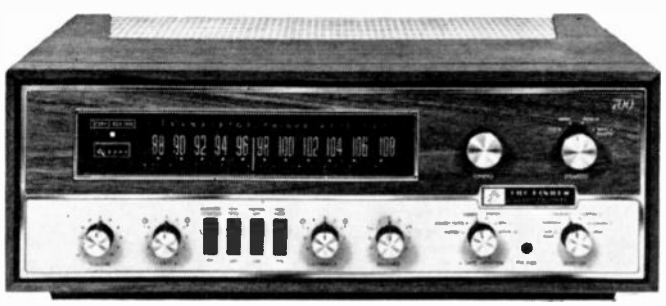
Amplifier section:

Music power (IHF)	
4 ohms	120 watts
8 ohms	90 watts
Harmonic distortion (1 kHz)	
At rated output	0.8%
3 db below rated output	0.3%
IM distortion (60:7000/4:1)	
At rated output	0.8%
3 db below rated output	0.3%
Frequency response 10-70,000 Hz	+0, −1 db
Hum and noise	
Volume control (min.)	−80 db
Phono input (6 mV ref.)	−55 db
Aux. input (400 mV ref.)	−65 db
Input sensitivities (at 1 kHz, for rated power at 4 ohms)	
Phono (low)	3.5 mV
Phono (high)	10 mV
Tape Head	2.5 mV
Auxiliary (low)	200 mV
(high)	400 mV

Tuner section:

Usable sensitivity (IHF)	1.8μV
Harmonic distortion (100% mod. and 400 Hz)	0.4%
Stereo separation (400 Hz)	40 db
Signal-to-noise ratio (100% mod.)	70 db
Selectivity (alternate channel)	50 db
Capture ratio (at 1 mV)	2.0 db
Spurious response rejection (100 M Hz)	90 db

PRICE, $499.50 (CABINET $24.95). FOR MORE INFORMATION, PLUS A FREE COPY OF THE FISHER HANDBOOK, WRITE FISHER RADIO CORPORATION, DEPT. 0310, 11-35 45th ROAD, LONG ISLAND CITY, N. Y. 11101.



The Fisher

No ad man can do it justice.

FISHER RADIO CORPORATION, INC., 11-35 45TH ROAD, LONG ISLAND CITY, N. Y. 11101. OVERSEAS AND CANADIAN RESIDENTS PLEASE WRITE TO FISHER RADIO INTERNATIONAL, INC., LONG ISLAND CITY, N.Y. 11101

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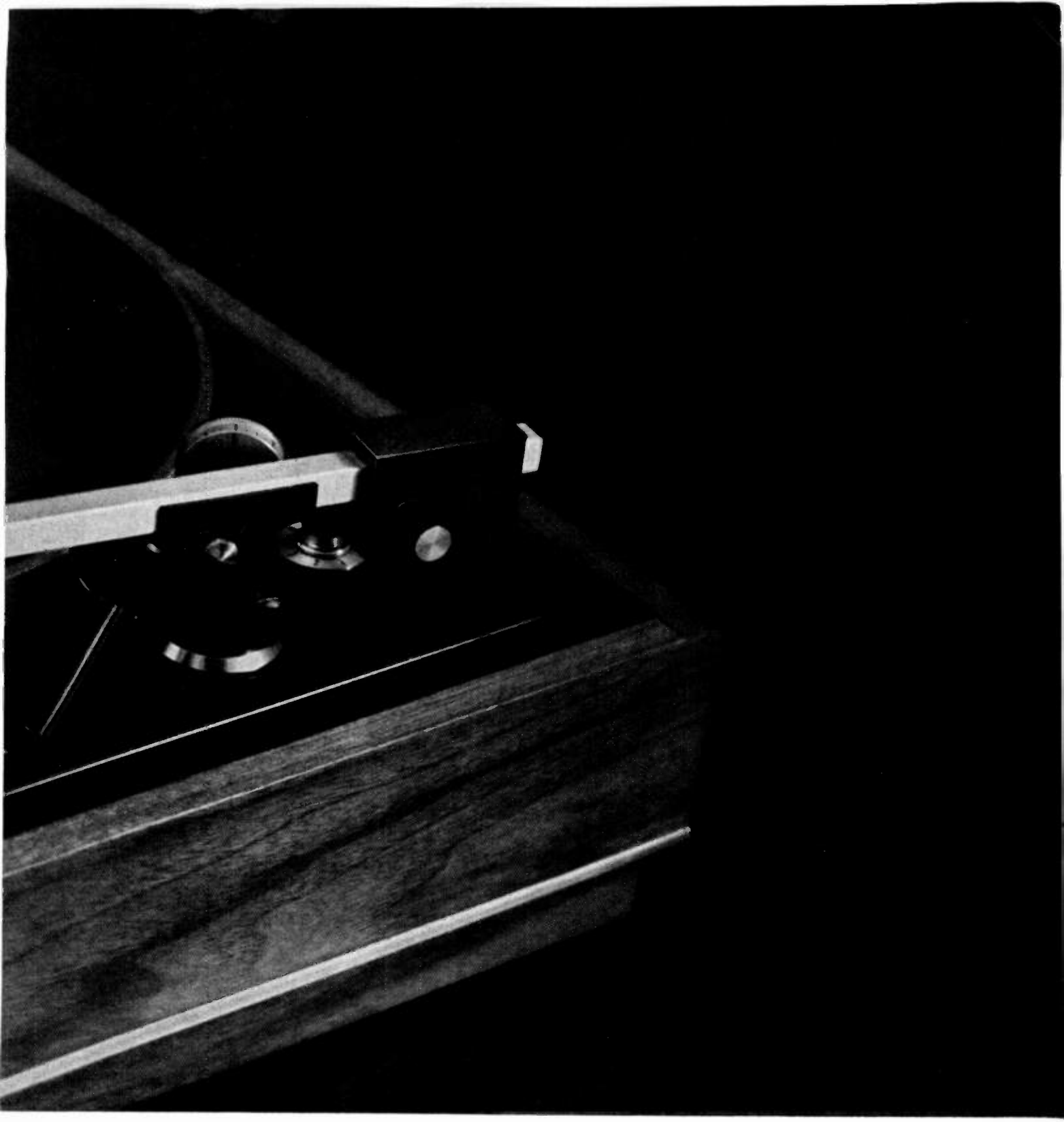
the smoothest, quietest, gentlest automatic turntable ever designed

Circle 71 on Reader Service Card



The new Miracord 50H was born of a proud tradition. The latest of a long line of great automatic turntables, it emerges as the greatest of them all.

The 50H is a totally modern instrument embodying every time-tested feature known to the art, and many exclusive innovations. Strikingly handsome, trim and uncluttered, its very appearance reveals the care and attention lavished on its design.

The 50H, achieves a playback quality beyond the capabilities of any automatic available today. And it accomplishes this with the mechanical reliability, record-handling gentleness and operating simplicity for which Miracord turntables have always been distinguished.

Who but Miracord would give you the locked-in speed accuracy of a hysteresis motor? Who else would provide the simple, gentle facilities of pushbutton operation.

And now Miracord also brings you a simple leadscrew control for precise stylus-overhang adjustment, a newly designed, dynamically balanced arm with interchangeable cartridge insert and non-slip counterweight with vernier drive, ingenious cueing facilities, gram-calibrated anti-skate compensation, all built into this great new Miracord as assurance of optimum playback performance.

The 50H plays single records manually or automatically, or stacks of up to 10 in automatic sequence, and it operates at 4 speeds. Priced at $149.50, less cartridge and base, it is probably the most expensive automatic in the field. But, this is entirely understandable when you consider that it is also the finest. See the new Miracord 50H at your high fidelity dealer soon, or write.

Benjamin Electronic Sound Corp. Farmingdale, N.Y. 11736

LETTERS

Audio Clubs

SIR:

Some months ago you published a list of active Audio Clubs. This list was the basis for the attached letter.

We thought you might publish this letter and through this medium Mr. Krupicka might obtain a "pen pal" with Audio interests.

P. S. HOWETON, PRESIDENT
The Carbide Audio Club,
P.O. Box 471,
Texas City, Texas

The Letter

DEAR MR. HOWETON:

I am a Czechoslovak fan of Audio, Hi-Fi, and stereophonic sound reproduction. I found the name of your club and the address in a copy of AUDIO magazine. I decided to write you because I want to have a friend in your country who would have the same interests that I have, or at least similar ones.

Please don't be angry with me that I decided to write you, but I really don't know how to find any "pen friends" in the U.S.A. by any other way.

Could you please be so kind as to help me find someone who would want to correspond with me about audio, records, hi-fi material, and various audio problems, and I shall be very happy to write them in return. I am 25 years old, and my branch is medicine.

PAVEL KRUPICKA,
Kafkova Street 13,
Prague-6
Czechoslovakia

(You don't have to be a member of the Carbide Audio Club to correspond with Mr. Krupicka. It is quite likely he would be pleased to hear from any AUDIO *reader.*

We continually hear "rumors" of Audio Clubs, in military installations, at schools, colleges, universities, and just about anywhere. If we had a list of, say, fifty of them, we would devote a column to their activities every month. Let the letters come in, detailing your club's activities, its officers, any anything you feel would be of interest to other audio buffs. ED.)

New Importer

SIR: (Attention Mr. Burstein)

We have read with considerable interest your article in the August issue, and this is to let you know that we have recently been appointed the exclusive United States importer for the TEAC line of Tape Recording equipment, and we are going to be actively promoting and selling this line throughout the United States.

Any questions you might receive from readers relative to our line will receive prompt attention if forwarded to us.

INTERCONTINENTAL SEAWAY
PRODUCTS CO.,
Harry Schuler, Vice-president
5400 East 96th Street, P.O. Box 4436,
Cleveland, Ohio 44125

(And that ought to answer a lot of questions in itself. ED.)

Reverberation Article

SIR:

I am somewhat amazed at the response as a result of the series on reverberation. To date no less than 42 letters have been received requesting circuit data, pictures, and even copies of the acoustical data. I will, as time permits, answer all such letters. The current of questions, however, are similar in nature and perhaps can be answered here.

1. The system is *all electronic* with no mechanical elements of any sort.

2. A solid-state version has not been designed strictly because of time and work load requirements.

3. At the time of the writing of the series no plans were made to market such a device. The response, however, has lead to the possibility of accomplishing this objective.

4. Two tube-type versions have been built. One is in operation at the recording studios of Perfectone Sound Labs. The other in my home sound installation. (NOTE: An article describing the entire sound system with pictures has been submitted to AUDIO for possible inclusion in future issues.)

5. Patent procedures prevent the release of actual circuit diagrams until the patent process has been completed.

It is gratifying to see that so great an apparent interest has been established in artificial reverberation techniques. If firm commitments are made in reference to the marketing of the system, the fact will be made known via this column along with a personal reply to all the many letters received.

GEORGE S. LEHISTEN,
22B Rolling Rudge Road,
Montvale, N. J.

If you think Gotham Audio sells only one product

You're too close to the mike

We're famous as the sole U.S distributor of the world's finest microphone.

Maybe too famous.

Sometimes our unwary friends are so dazzled by Gotham's association with Neumann, that they overlook our other products and services.

And then they're missing a good thing. More than 300 good things, in fact. Including tape recording equipment and disk recording lathes. Disk cutting systems & control room equipment.

We select these products from such outstanding European companies as EMT and Beyer and Studer. As well as Neumann, of course. And as always, the basis of our selection is this: does it contribute significantly to the technical excellence of American audio?

That's our standard. A rigorous one, because we have a reputation to protect. And to keep building. If you do, too, maybe we can help.

Gotham
Audio Corporation
2 West 46th St., New York, N.Y. 10036
In Canada: J-Mar Electronics Ltd.

Equipment Profile

FISHER TFM-1000 FM-STEREO TUNER

There is a common saying—the first guy doesn't have a chance—and it certainly applies to the hi-fi industry. One manufacturer turns out a fine piece of apparatus, the next uses this one as a target for his upcoming product, and succeeds in making a better one. The third comes along, and with both of the others to shoot at, he turns out another fine product. Well, we hope we're still around when the tenth or twentieth generation of FM tuners hits the market.

All this by way of introduction to the new Fisher TFM-1000, which we have recently had an opportunity to study, listen to, and admire. This model has a professional rack-mounting counterpart, the FMR-2, which is designed for studio, recording, and monitor applications. Except for mounting, styling, model number and appearance, they seem to be identical. Both are fully transistorized, employing 42 transistors (including 3 FET's) and 45 diodes. The specifications are fabulous, with sensitivity of 1.8μV (IHF), harmonic distortion less than 0.2 per cent; S/N of 70 dB; alternate-channel selectivity (IHF), 70 dB; separation at 1000 Hz, greater than 40 dB, and greater than 30 dB from 50 to 15,000 Hz. Most of these figures are so near the limits of measurability that only a well-equipped manufacturer's laboratory could dispute them. And with all of that, we can still find a fault with the unit—the lamp behind the tuning meter is too bright. We would be inclined to put a small resistor in series with it.

We have one other regret, too. Unlike most previous Fisher units, this one did not include a schematic in the operating instructions. We assume we could get a copy if we needed it, but we have become accustomed to finding the schematic right in the owner's manual. We feel this is always a good idea—not that the owner will actually service the unit if something *did happen*, but that he would have it available if he called in a service technician who might not have one. Otherwise the owner's manual is exceptionally complete, particularly as to the mounting on a cabinet, either horizontally or vertically, with carefully outlined precautions about ventilation.

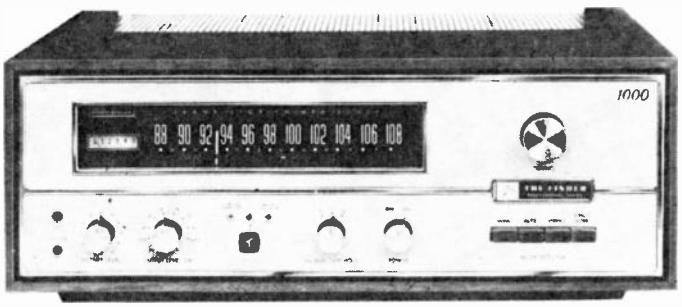


Fig. 1. The Fisher TFM-1000 FM-Stereo tuner.

Aside from all that, the circuit is apparently so unusual and advanced that the company is not yet ready to make its "innards" public. However, the description is quite complete, and we shall draw from that.

The front end consists of three FET's and one low-noise transistor in a circuit using a four-gang variable capacitor. Instead of using a sensitivity switch to reduce large signals before they reach the first transistor—a common source of cross-modulation in solid-state front ends—a PIN diode which acts like a variable resistor at FM frequencies is controlled by an AGC circuit to prevent overload on high signal strengths. It works, too. Even with the simple dipole such as is usually furnished with tuners, the overload indicator showed that the circuit was working on WFIL, which is some fifteen miles from our listening location. No audible distortion accompanied this automatic gain reduction when compared with the same signal received on 6 in. of straight wire and with no indication of "overload suppression," of which more later.

The front end is followed by an AGC-controlled amplifier stage with 60 dB of attenuation range, which, combined with the r.f. resistive attenuator, results in an input-signal range of 120 dB. Five i.f. stages follow. The limiter and detector portions of the tuner employ no tuned stages, and the three-stage limiter is claimed to have a 10-MHz bandwidth. The detector is of the counter type (we assume similar in principle to that described in the General Electric transistor manual).

The MX decoder is of the time-division type, with several advanced characteristics.

In the first place, there is a four-pushbutton switch labeled MONO, AUTO STEREO, STEREO, and STEREO FILTER. With either of the first two depressed, the tuner will respond to stereo or mono signals, switching automatically to stereo on stereo signals, but reproducing both as mono when the MONO button is depressed. With either of the STEREO buttons depressed, the tuner will respond *only* to stereo signals, remaining completely silent on mono signals, although the tuning meter still indicates their presence. All of this results from a four-diode coincidence circuit, which will switch only when it receives the correct signals from four separate sources. STEREO FILTER adds further SCA filtering.

A muting circuit, controlled by a three-position switch, eliminates interstation noise completely and effectively except when none of the four pushbuttons is depressed—an unlikely condition. The first position of the muting switch is OFF; the second and third give progressively greater muting, and in either of these positions, a small green indicator light shows that the muting is operative. A unique feature is the "Clear-Signal" indicator, operated by another pushbutton. When this is depressed, a small red light acts as a signal-strength indicator—glowing brightly on "clear" signals, and flickering when fading or multipath is present. It even permits setting a rotating antenna to the optimum position, and thus serving as a signal-strength indicator completely separate from the tuning meter, which, because of the limiting action, does not provide a true indication of signal strength. The dial, calibrated as usual in MHz, is extremely accurate, and an auxiliary tuning scale (0 to 100) is also provided. The cursor is a tiny red pinpoint of light. Operation of the overload suppression circuit is shown by a third indicator light, this one amber.

Three separate output circuits are provided—for each channel—the main output is from an emitter follower which is preceded by a stepped attenuator with losses of 6, 12, 18, 24, 30, and 40 dB, as well as an off position; the tape output is from another emitter follower fed from ahead of the attenuator, and with a maximum output of 2 V., which is also the maximum unattenuated output on the main jacks. All of this permits setting the audio output at a different level from the tape recorder feed, even allowing one to record with no monitor at all if desired. The third output signal is an ungrounded 600-ohm signal available at a pair of phono jacks, or on a Hirschmann socket, or on a pair of front-panel headphone jacks (permitting two sets of phones to be used simultaneously.

With all of these features, it is easy to miss one—the Stereo Beacon. This is a small red indicator—a short plastic rod—above the tuning meter. It lights in the presence of a stereo signal *unless* the MONO button is depressed. Thus the mono listener is never disturbed by a stereo indicator unless he wants to be—then he depresses the AUTO STEREO button.

Performance

With these specifications and the many desirable features, one would expect superb performance. And that is just what he gets—quality which makes you doubt the station or record quality if a particular number doesn't sound "right"; quiet tuning if you want it; smooth, deluxe handling, and enough flexibility for any desired application. Of course at $499.50 it should be good, but it's worth every penny of it.

CIRCLE 1

ORTOFON S-15 STEREO CARTRIDGE

We have always had a high regard for the Ortofon cartridge line. This new model is a significant step forward over that which has gone before.

The S-15 continues the Ortofon tradition of moving-magnet cartridges. And, as with the SPU/SPE series, this new one continues to have built-in transformers.

We said that performance has been stepped up. That is gross understatement. Performance is spectacular. This is as clean a cartridge, even on the fussy higher frequencies, as it has been our pleasure to hear. As is customary, we bench tested the cartridge as well as listening to music with it. Save for one significant test, the bench results are unspectacular. Frequency response and channel separation are shown in Fig. 3. This set of curves is perhaps typical of the better cartridges around. So where is the clue to superior sound?

One of the routine tests we perform is for IM distortion using the CBS STR 111 disc. This record has a series of IM distortion test grooves at increasing modulation. It has been usual for test cartridge to measure on the order of ½ per cent at the +6 dB mark, and 3-6 per cent at +9 dB. There is a +12 dB band but earlier measurements have been consistently above 5 per cent IM distortion.

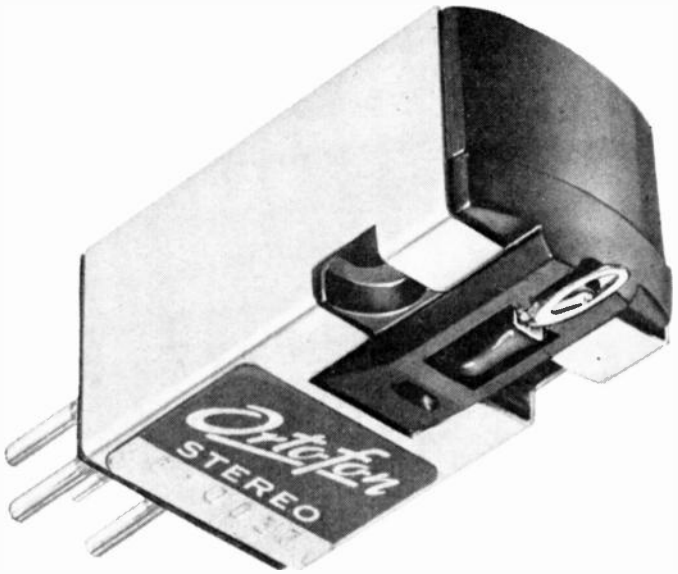


Fig. 2. The Ortofon S-15 Cartridge.

Frankly, we do not know just how good the disc itself is. Up to now it was our belief that it was not much better than the best of the ranges just quoted. But this Ortofon!

At +6 dB, IM is 0.8 per cent. At +9 dB it is 1.2 per cent. And at +12 dB it is 1.3 per cent.

This we believe is part of the reason for the window-like transparency that exists here. The S-15 plays records that we thought unplayable. And it does not play any record worse than we already knew them to be.

There is more to this quality impression than IM distortion alone, of course. The S-15 produces a highly satisfactory square wave. There is a single-cycle of oscillation on the wave front, but rise times are good.

Dynamic compliance is high. We measured 9 x 10^{-6} cm/dyne lateral and 10 x 10^{-6} cm/dyne vertical. This is in accordance with the published stylus mass of 0.9 mg.

The stylus, replaceable at the factory, is an elliptical of 0.7 by 0.3 mil radii. It was used by us at 1.5 grams, a force at which it is capable of tracking heavily modulated records.

Output of the cartridge is 6.2 mV left and 5.7 mV right from 3.54 cm/sec recorded velocity at 1 kHz. This is a good deal lower than the SPU series and, from our way of thinking, is another improvement.

Many modern transistor preamps are subject to easy overload from ultra-high-output cartridges. The S-15, however, comes in at a range that is ideal for all units, be they tube or transistor.

There isn't much more to be said. Clearly, the Ortofon is, in our opinion, at the forefront of current cartridge offerings. Cost is on the high side—$80 for the S-15T model as illustrated. There is also the S-15MT. This is the same cartridge already mounted in an Ortofon shell. (This fits the Ortofon and SME arms.) Price is $85. But what price can you place on something that is genuinely better than its predecessor. For that the S-15 is.

CIRCLE 2

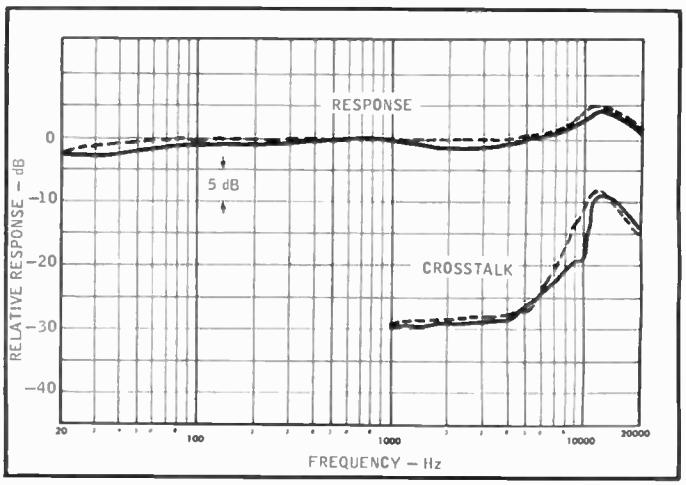
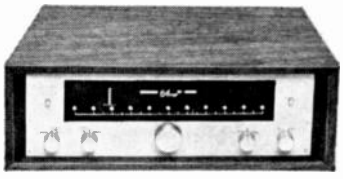


Fig. 3. Frequency response and channel separation of the S-15 with the CBS STR-100 disc.

(Continued on page 127)

Marantz components are too good for most people.



Are you one of the exceptions? For the most astonishing set of specifications you've ever read, write "Exceptions," Marantz, Inc., 37-04 57th St., Woodside, New York 11377, Department A-17.

marantz
A SUBSIDIARY OF SUPERSCOPE, INC.

The Marantz components illustrated, top to bottom: SLT-12 Straight-Line Tracking Playback System • Model 15 solid-state 120-watt Stereo Power Amplifier • Model 7T solid-state Stereo Pre-amplifier Console • Model 10B Stereo FM Tuner

Circle 62 on Reader Service Card

AUDIO ETC.

Edward Tatnall Canby

Slow-Speed Super-Fi

I HAVE A GREAT WEAKNESS for follow-ups. My curiosity is always roused by succeeding models of audio equipment that once proved interesting to me. So when Ed Straw of Metrorep, representing the Crown line of tape recorders in our region, started wooing me recently in the direction of another of those big, whopping machines he promotes—a different model this time and on a new basis of approach—I really couldn't hold out for long. Especially since I still had on hand the old and imposing tube-style Crown 800 (thanks to his indulgence), the one on which I reported at length several years ago. Since then, the company has converted entirely from tubes to transistors, and the model he wanted me to look at was not the 800 but the home hi-fi model, the 700.

Moreover—and this clinched it—he wanted me to try his machine out for quality *at the slow speed of 3¾ ips*, four-track, two-channel. This was an old love of mine, this business of slow-speed quality. And so I bit. I took on the 700 in the four-track configuration (my older 800 was two-track, pro-style) and set about "testing" it—i.e., putting it to work to see what would happen or wouldn't happen.

Before I so much as try to describe the machine, let me state quickly that the Crown sound at 3¾ ips *is* just plain *phenomenal*. Astonishingly good. And thus, in a way, I could almost stop right here. The Crown 700 does, indeed, set a standard for recording and playback, at this speed, and in four-track, which could well be a model for the industry and for all who want to know what *can* be done, so to speak, under optimum conditions. An awful lot can be done. This, we already know in theory. Miracles in tape recording are commonplace these days. But now I have had a concrete example before me in terms of an actual home recorder. Very interesting.

Supersonic

Crown gave me an individual data sheet on performance of this particular machine, both at 7½ ips and at 3¾. The oddest thing about the two record-play response runs is that the major difference is in effect in the very low bass—not the treble. Treble response has now gone supersonic. At 7½ ips this 700 records ± 1.2 dB 25 Hz to 25 kHz, a nice round figure. At 3¾ the figures are 20 to 15k, within 1.6 dB.

Looking at the actual graph you find that in the main "presence" range, from around 200 Hz up to 10 kHz (ugh—we used to call it 10,000 cps), the slow-speed plotted curve is actually the flatter of the two! That is, as of this particular run—the machine could well be micro-adjusted for minor changes. The most noticeable difference is below 100, where the 7½-ips run rises up to a full-bottomed zero dB at 50 Hz and a trace down at 30 (not bad, you'll have to admit); whereas at 3¾ ips we are down a bit at 50, down 3 dB at 30 (not bad at all!) and below that a minor hump upwards again holds until a cut-off point 'way down around 15 Hz.

Thus, purely on the basis of record-playback specs, we can infer that today the basic response range within the audible frequencies is virtually the same as between the two slower speeds—the 7½ speed gives us extra supersonic range, good for ultimate quality, and the 3¾ speed holds up a solid bass, with a full-range spread of highs to the edge of hearing. Imagine being able to state this, back as of 1950! Remember the Sound Mirror, that fabulous machine which turned out a top usable range of less-than-sibilant quality at 7½ ips?

So—now you can save tape and get hi-fi too at very slow speed! Of course, there is a minor consideration, the cost of the machine which does the recording. The Crown 700 is yours for not far from $1M, which ain't hay, Mr. Straw. Nevertheless—a lot of us souls will find the challenge darned interesting and very worth-while. Just to *experience* high-quality sound at low tape speed is a thing that will please many; and that definitely includes me. I enjoyed every minute of my work with the Crown 700—and I only bothered to use the 7½ ips speed once for a few moments. Necessary comparison.

You guessed it. Was it my imagination? The 7½-ips recording didn't sound quite as good as the 3¾. Amazing.

Big Boy

Let me give you a few of the interesting points that struck me as I put this recorder to work, including my usual reservations, constructive ones, I hope. (You don't expect me to let my enthusiasms melt into sheer gushing sentiment, do you?)

The 700 is a Big Boy among home recorders. It has many structural components visibly common to all 700 and 800 Crowns (including my tube-type 800 of several years ago) even though this model is entirely transistorized and has a thoroughly revamped quick-remove mechanical assembly as well as different controls from the 800—an important difference.

Being basically a home-type machine, the 700 is relatively much simpler than the 800 series, which is pro-oriented (though many an amateur pro has used one) and offers a dizzy maximum of adjustments and alternatives in its super-complex controls. I'm always in favor of simplicity and so I am all in favor of the 700.

Frankly, I'd rather lose out on a few super-refined biases and switchings and what-not and have a machine where I can find the right knob at the right time, instantly. After all, the recorded product is what counts and a tape on the hoof is worth two in the bush, so to speak.

The first thing I jumped to try, here, was the actual running system. For, as you may remember, my earlier 800 model was of such exasperating perfection in all its complexity of relays and interlocks that I managed to ruin some very precious tapes by pressing the wrong buttons at the wrong time. (AUDIO, April, 1963) The newest 800's, now solid-state, are inevitably much improved by experience since then and so are more foolproof to accidents. But the 700, oddly, is even more "improved" and still safer—because it is necessarily simpler, not for the pros but for advanced home-type use. Simplicity, in Crown's case, means just that—on the 700, Crown has had to skimp, curbing its well known yen towards utter perfection at the cost of ever-more-ingenious complexity. Good, very good! A healthy sort of limitation, I say. Some people are such perfectionists they *need* to skimp.

Thus the 700 has dispensed with the finger-tip sensitive relay controls of my older 800 (placed where you inevitably tripped them by accident with the edge of a finger) and has been equipped, instead, with the nicest set of prosaic pushbutton-interlocked mechanical controls I have yet used. Four buttons, and they work just like oil—but not *too* easily, for dangerous mistakes. Frankly, I gave a sigh of relief when I first saw them, though my assistant, always appreciative of ingenious complexities, still relishes the fancier relay controls. (*He* doesn't have valuable tapes to preserve.)

No room for a detailed run-down of features here, but on to my special points of interest.

Brakes

First, I was not too happy over the total lack of tape tensioners (other than the slick electric hold-back braking), or of spring-loaded arms, on both sides of the 700 tape slot. Admittedly, I ran into no concrete difficulties. But I am uneasy with any tape system where there is no "give" between reel, heads and reel, no springiness. It would seem

We didn't invent the circle.

(We just put it to music.)

Actually it was the Romans who first conceived the idea that sound projected through an urn could disperse sound in a 360 degree radius.

In 1963, Empire reasoned out that a speaker system with complete symmetry of design could provide the same effect.

We were later to make three very important discoveries: A wide angle acoustic lens assures fuller frequency and magnificent stereo separation. A mass loaded woofer facing downward, feeding through a front loaded horn will provide 360 degree sound dispersion and prevent standing waves from developing in the room. And, an imported marble top to match the flawless hand-rubbed walnut finish will bring a sigh of comfort to the decorator-conscious audiophile.

The result: superlative musical performance. When did we know we had it made? When others began copying us. Augustus Caesar, thanks a lot.

Empire Grenadier. One of the great firsts.

Great new 16 page color catalog is now available, write: Empire Scientific Corp., 845 Stewart Ave., Garden City, N.Y.

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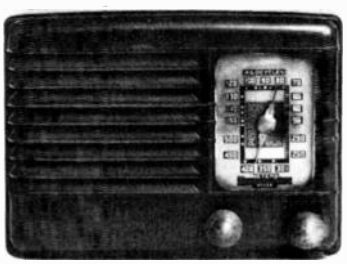
TO martel
MARTEL ELECTRONICS

If you're not impressed with these 10 exclusive features in the new Uher® 9000 tape deck,

listen to this.



Circle 39 on Reader Service Card

to ask for micro-troubles with drop-outs, flutter, and so on (though I didn't hear any . . .) and, more important, any sudden emergency, a jerk or quick take-up of loop, means a snapped tape or one that is irreparably stretched. Well, Crown must have thought a long time over this, and maybe they are right, in this particular design configuration.

But there is more to make me vaguely uneasy. Marvelously sophisticated dynamic braking here, all-electric. Obviously more subtle and flexible than mechanical braking. But what happens when the power goes off? No brakes.

Normally this isn't important. It seldom matters, except in an emergency. Then, alas, the lack of brakes can be a serious fault. I've always felt that, as on every railroad train or subway or trolley car, if something fails, *the brakes should go on automatically* and bring everything to a quick stop. That means mechanical brakes—of some sort.

My old warhorse Ampex 350, for instance is so protected. If anything goes wrong with the tape, and/or if the current fails, the whole thing comes to a swift halt. It has saved me many a disaster in its ten long years of life.

Now the Crown 700 has a peculair added feature that complicates this brake business. A micro-switch sensor in the left end of the tape slot controls, of all things, the main, over-all power switch. Even with power ON, nothing happens at all, until tape is inserted in the slot—then the electronics and the mechanical system, including the brakes, go on together. Very odd, for one unaccustomed to such refinements! (Reminds me of the "automatic" off switches on record changers that turn off the works at the end of the record, neatly deactivating themselves in the process.)

Now this is a nice way to get an automatic stop on rewind, without a movable arm. But it has peculiar side-effects. When you rewind, the end of the tape turns off the power—and your two reels run on unbraked, whzzzzzz. OK. They stop pretty soon. But when there is an accident, the same thing may apply. Suddenly—no brakes. That's conducive to trouble. You can fill a room with tape bits in a half second, that way.

Thumps

Then, too, I get uneasy at the alarming thumps which go out to the loudspeakers when the tape is moved into the slot and power is suddenly turned into the amps, slamming the two meters against their pins. When you fumble a bit (and who doesn't?), so that the tape slides a bit erratically over the sensor, there is a horrendous series of thumps and meter-pinnings.

Well, Crown wins again. *Nothing* has gone wrong, even so. My speakers are intact and so are the meters. And the amps. So maybe I'm just a nervous Nellie.

But there are more things to relate. Push the fast-rewind button, reel off the tape and let it come to a stop. Unless you think twice at this point, you are in for a mild surprise. The power goes off. The pushbutton is still in rewind position. When you start putting the next tape into the slot, power comes on again. So does the fast rewind. Quite a jerk.

Then if you rewind, push the stop button and then the *play* button—too soon, before a full stop—there is chaos. Most recorders are similarly guilty (you're supposed to have sense enough to wait for a full stop, after all) but this one does a real job! Tape spills out on the right, is rapidly reeled up by the take-up reel and neatly snaps as it comes tight. (No give, remember.) But the feed reel goes merrily on, playing tape out onto the floor. It doesn't even know anything has happened.

Just to be sure, I tried this same nasty trick on the old Ampex 350. Yep—it fouled up the tape, all right, but it didn't break it. Ampex's swing arm lets go, instantly turning off the power and applying the brakes. And its second smaller spring-loaded arm, off to the left, helps cushion the shock.

Now granted that few home machines can afford such emergency controls as these on a strictly professional machine. And so maybe Crown is right again. I *should* have sense enough not to go into reverse when my car is moving forward, if you see what I mean.

'Nuff said. Altogether, this is a very interesting and challenging drive system and if I say nothing much about the other and more favorable interlocks, and so on, it is merely because they work like a charm, including the one which won't let you go into fast motion when the machine is in the record mode. No accidental erase on *this* baby. And so, onward, to my "tests." That is, my in-use experiments, on location. I made three, to see how the Crown 700 would work out in practice.

On Location

First, I spend a whole evening—on *one* 7-inch reel of 1-mil tape—recording an amateur folk fest, two channels at 3¼ ips, both directions. Then a week later I played back some of the superb results on a good solid system, to some of the very same people. A good show, indeed.

In addition, I turned the machine over to a pro sound man to record an entire public concert of the Canby Singers (I was conducting), before a large audience. Results: terrific!

The idea was to make the 3¾ element the only "bottleneck"—all the rest was to be top quality. And so I used a pair of the new Vega 20 condenser mikes, which were loaned to me conveniently at this very moment, to feed super-stereo sound into the 700 system. No space to go into those lovely little mikes right now—but they decidedly served my purpose. And, as already stated, the 3¾ ips sound was just plain fabulous when it played back. Need I say more?

Aside from some minor mike trouble in one channel (a nuvistor, I think), nothing, but *nothing* went wrong, and I came home from these two events, one under my own operating-power, with five or six hours of superb stereo sound, good enough to fool anybody into thinking it might be 15-ips two-track stuff, strictly pro. On two 7-inch reels.

Just to double check, I did the inevitable A-B experiment, and so did my sharper-eared assistant, independently. I fed broadcast and recorded sound into the machine and did A-B listening between the original and the tape playback; and so did he. His comment confirmed my own: the 3¾ ips sound seemed even better than 7½ ips.

With a bit of electronic adjustment I am quite certain that the two speeds could be made to sound virtually indistinguishable, even to a well-trained ear. In any case, there was NO discernible difference between the original and playback sound at the slower speed. Impossible to tell them apart. That's my story.

* * *

I'll add a P.S. to say that Crown has managed to leave a slot at the bottom of the 700 which accommodates a pancake-style stereo power amplifier, a physically separate unit even to a separate power cord. It is entitled the SA 20-20 and is all solid-state, of course, with direct-coupled outputs and a low-external-field power transformer—good precaution at such close range. This is a real "basic" amplifier, just inputs, outputs and a single clutch-ganged level control. I tried it and all I need say is that it works—it made loud, clear music via my speakers.

I'll have to add, in a still, small voice, that we did have a bit of trouble with it on a first try, when, alas, the outputs were attached to my speakers via unmentionable connectors—naked alligator clips. Just guess what happened. They touched. We didn't notice. Fuse went. Power supply went.

After Crown had obligingly and rapidly fixed things up, I put on my regular-style speaker connectors, which are very unlikely to short, and all was well.

I mention this merely because I do feel that the well-known fragility of transistors under such dangerous loads is one of our major problems in home equipment today, and that those solid-state circuits which manage to get a maximum of protection against accidental — and inevitable — shorts and surges and what-not are the ones which will deservedly win out, in competition, under rigorous home conditions.

We should *assume* that speakers *will* be shorted, sooner or later, that inputs *will* be connected minus ground at full volume, that outputs *will* be fed maximum wattages without any speakers attached. Anybody can forget to hook up his speakers—I ran a KLH 16 amplifier just yesterday for a half hour with one speaker missing. A mono record, it was. I didn't even notice that I had left it sitting in the back seat of my car! (The other one made plenty of noise for two.)

In tube days, these home *faux-pas* didn't usually cause any damage of serious proportions. People expect the same to be true today. Æ

EDITOR'S REVIEW

SO WHAT'S NEW? Those of you who have perused the August issue thoroughly and digested the contents of the charts thoroughly already know the answer to the opening question. Those who are about to attend the forthcoming New York High Fidelity Music Show will get to see, hear, and handle the new items. And you may be sure that there will be a few new items which were not yet ready for the blazing light of our PRODUCT PREVIEW at the time the August issue went to press, which was early in July. Those items which were not yet ready will find their way into the new products columns in the next month or so—actually there were not many.

HI-FI SYMPOSIA

The IHF has announced a series of symposiums which are to be held during the New York Show, and designed for the novice and semi-technical enthusiasts. The first, scheduled for opening day—Sept. 28—from 7:30 to 8:30 will present the salient features of all types of tape recorders, and will be conducted by Wybo Semmelink, of Norelco. A similar meeting is to cover phono equipment on the evening of the 29th, under the capable leadership of James H. Kogen, of Shure Brothers, and Allen Say, of Garrard Engineering, Ltd., London. On Friday evening, the subject is raw tape, with a discussion of the properties of the various available types. This meeting will be under the chairmanship of Joe Kempler, of Audio Devices, and Ivan Berger, audio columnist for the *Saturday Review*.

Victor Brociner of H. H. Scott and Abe Cohen of University Loudspeakers will conduct a two-part symposium on "Stereo and the Listener" on Saturday evening. In addition, two novice sessions will be held on Saturday and Sunday afternoons under the direction of Leonard Feldman of Crestmark Electronics. The $2.00 show admission entitles the holder to attend any of these sessions.

GRANT IN AMERICAN MUSIC

We take this occasion to congratulate Electro-Voice, Inc. for its establishment of an American Research Music Grant, believed to be the first ever set up by an electro-acoustic firm. According to Lawrence LeKashman, vice president of sales at E-V, there is "a tremendous heritage of American Music lying dormant in libraries across America." He continued, "This legacy of fine music, adaptable to the organ, should be ferreted out, compiled, edited, and made available for the listening enjoyment and use of all Americans."

Elbert Head, assistant sales manager of the E-V organ division, announced that the first grant has been made to Jon Spong, formerly a member of the faculty at Drake University's College of Fine Arts. He has already conducted considerable research in many U.S. libraries, and has found a wealth of virtually unknown American music, and is himself a noted organist who has been heard on recordings and in recitals and organ workshops.

This recognition by E-V again points out the importance of music as the "sixth component" of the home music system—the other five being the tuner, amplifier, record player, loudspeaker, and tape recorder. Without a source, what good is a hi-fi system? Music is, of course, the prime reason for good reproduction in the home, and without music, most of us would have no interest in the whole idea of high fidelity.

MORE ORGAN INTEREST

One of the gratifying elements of the organ world is the continuing activity of the American Association of Theatre Organ Enthusiasts. Every few months we get an announcement of a concert arranged by the New York Chapter of the AATOE in some theatre in the area which still has a "mighty Wurlitzer" in top-flight operating condition. Unfortunately for our living habits, these concerts occur on Sunday mornings, which is understandable, since the theatre naturally wants to operate normally as a movie house on the profitable Sunday afternoon, with paying customers, no less (the morning organ concerts are usually free to AATOE members and guests). One advantage of membership is that you can have an opportunity to play the organ in question. The most recent such concert was held on September 11 at the Brook Theatre in Bound Brook, N. J., and tape recorders and cameras were permitted.

WANTED FOR HISTORICAL COLLECTION

One of our early contributors whose work has been seen on these pages occasionally over the past nineteen years is assembling a collection of "the best electro-acoustic and audio equipment made from about 1900 to 1941," and enlists the co-operation of audio buffs who have some of the early material but who may not be interested in making a similar collection. Curtiss R. Schafer, RFD 1, Newtown, Conn. 06470, wants to hear from anyone who has any old W. E. and RCA broadcast and theatre sound equipment—microphones, loudspeakers, amplifiers, phono pickups, monitor receivers, tubes and sockets, and headphones. He wants practically anything in this line, in good, excellent, or "as new" condition, and is desirous of purchasing it. He requests that anyone with such equipment communicate with him, stating price and condition in the first letter.—And to think, this observer has had, at one time or another, most of the items he wants, such as Leutz, Kolster, RCA ribbon headphones, and early Jensen speakers, and never figured they would some day achive antique value! Æ

The total performance cartridge.

New Pickering V-15/3 Micro-Magnetic™ cartridge featuring Dustamatic™ stylus and Dynamic Coupling.

Now, Pickering offers you total performance from all your records with the newly designed V-15/3 cartridge.

The exclusive Pickering V-15 Micro-Magnetic cartridge assures you of the finest in natural sound, while the famous patented V-Guard Floating Stylus provides the ultimate in record protection.

And now, there's a new dimension in the V-15 line. The extremely functional Dustamatic brush assembly for cleaning records *as* you play them, and an entirely new moving system with Dynamic Coupling of stylus to record groove for positive tracking.

There's a Pickering for every installation, from conventional record changers to the most advanced turntable/tone arm systems.

That's *total* performance. Clean records for clean sound.

For free literature on the Pickering V-15/3, plus information on how to choose the correct "application engineered" cartridge for your system, write to Pickering & Co., Plainview, L. I., New York.

For those who can hear the difference. **Pickering**

Circle 63 on Reader Service Card

Compare these new Sherwood S-8800 features and specs! *ALL-SILICON* reliability. Noise-threshold-gated automatic FM Stereo/mono switching, FM stereo light, zero-center tuning meter, FM interchannel hush adjustment, Front-panel mono/stereo switch and stereo headphone jack, Rocker-action switches for tape monitor, noise filter, main and remote speakers disconnect. Music power 140 watts (4 ohms) @ 0.6% harm distortion. IM distortion 0.1% @ 10 watts or less. Power bandwidth 12-35,000 cps. Phono sens. 1.8 mv. Hum and noise (phono) —70 db. FM sens. (IHF) 1.6 μv for 30 db quieting. FM signal-to-noise: 70 db. Capture ratio: 2.2 db. Drift ±.01%. 42 Silicon transistors plus 14 Silicon diodes and rectifiers. Size: 16½ x 4½ x14 in. deep.

Now, look at the *new* Sherwood specs!

Model	V-Vacuum Tube S-*ALL-SILICON* T-Germanium Transistor	Power (IHF) 2 channels 4 ohms Watts	FM Sensitivity Microvolts	Price	Dollars Per Watt
Sherwood S-8800	S	140	1.6	$ 359.50	$ 2.57
Altec 711A	S	100	2.2	378.00	3.78
Bogen RT8000	T	70	2.3	319.95	4.57
Dyna FM-3, PAS-3 & S-70	V	90	4.0	404.85	4.49
Fisher 700T	T	120	1.8	499.50	4.16
Fisher 440T	T	70	2.0	329.50	4.70
Harman-Kardon SR-900B	T	100	1.85	449.00	4.49
McIntosh 1500	V&T	85	2.5	499.00	5.87
Marantz 8B, 7T, & 10B	V&T	75*	2.0	1340.00	17.87
Scott 348	V&T	120	1.9	479.95	4.00
Scott 342	T	65	2.5	299.95	4.61

References "T" or "V&T" (above) may include some silicon transistors.
Figures above are manufacturers' published specifications except (*) which are published test findings.

SHERWOOD 1st IN ALL-SILICON TUNERS AND AMPLIFIERS

3-YEAR WARRANTY

S-8800 140-watt FM *ALL-SILICON* Receiver
$359.50 for custom mounting
$368.50 in walnut leatherette case
$387.50 in hand-rubbed walnut cabinet

Sherwood

Sherwood Electronics Laboratories, Inc., 4300 North California Avenue, Chicago, Illinois 60618. Write Dept. A10

Circle 64 on Reader Service Card

King-Size Quarter Horse Power Stereo Amplifier

ROBERT M. VOSS and ROBERT ELLIS

Photographs by Edwin F. Meers

In this age of solid-state devices, it is unusual to find a constructor who still resorts to high-quality commercial practice to produce a high-power amplifier. This unit seemed to have sufficient merit to warrant the full treatment, and all seasoned audio buffs know that superb performance can still be obtained from vacuum tubes.

TRANSISTORS MAY BE HERE TO STAY, but tubes are not yet ready to be written off and placed in museums. The amplifier described here was designed and constructed to see just how far vacuum-tube design has progressed; it is a state-of-the-art device.

Before you read further, a word of caution: if you are interested in compact or miniaturized equipment, this is not for you. The amplifier and power supply are each built on 13- by 17-in. chassis, whose combined weight is over 80 lbs. The construction of the power supply (about 55 lbs.) required installation of a small hydraulic jack underneath the workbench to avoid sag and ultimate collapse of the bench. Those who look upon the amplifier marvel greatly; their awe is brought upon by the overall massiveness and, particularly, by the size of the power transformer which, by normal home standards is immense, although it would not hold a candle to some units in professional installations.

The basic amplifier circuit is, up to the output stages, an adaptation of a Genalex design, and a number of its features are deserving of further comment. First of all, the RC networks between C_3 and C_4 and R_{15} and R_{16} are there for the purpose of rolling off response at both frequency extremes to avoid any tendency toward motorboating or high-frequency oscillation at the resonant frequency of the output transformer and associated circuitry. Incorporation of a driver stage between the phase-splitter and power-amplifier stages, in addition to supplying some needed gain, isolates the output stage from the shaping circuits and allows both output tubes to be driven by sources of the same impedance. Circuits which drive the output stage directly from the paraphase inverter may overload assymetrically, because, although in schematic form this type of inverter tends to look completely symmetrical, such is not at all the case. The top half of the inverter is a simple voltage amplifier with no voltage feedback, while the bottom (the half which is actually the inverter) is a voltage amplifier with sufficient feedback to reduce its gain to unity and its output impedance to a comparatively much lower value. Because of the large amount of drive needed for the output stage, the plates of the drivers are fed from the same 650-volt source as is the output stage. Very large coupling capacitors are used to the output stage to hold roll-off and consequent phase shift to a point well below the frequency determined by the earlier shaping networks.

The Power Supply

Aside from these few refinements the circuit is very straightforward, and this leads to ease of adjustment and a large stability margin, in addition to generally superior performance. One possible source of difficulty, however, was the large swing in plate current drawn by each output tube from 50 mA at zero signal to 150 mA at 100 watts output per channel. To accommodate this variation (equivalent to a total amplifier drain of about 250 mA idling and 650 mA at 200 watts out) we have used a silicon rectifier feeding a choke-input filter. The rectifier (Sarkes-Tarzian S5162) is meant as a tube replacement, and was the most economical way of meeting the current and peak-inverse-voltage requirements. (Strings of lower voltage diodes, with voltage equalizing rc networks would have cost about the same, and are a makeshift solution at best.) Those with a real aversion to solid-state components can use push-pull 5R4GY's in place of the silicon rectifier: this will reduce power output somewhat because of both larger initial voltage drop and poorer regulation. In addition, it will require redesign of the physical layout of the power supply since 5R4GY's cannot be expected to live very long underneath a chassis.

The power transformer and chokes are rated at 400 mA continuous output, which means that the power supply runs at a comfortably low temperature, even after many hours of operation. If you are testing the amplifier for maximum output, or running it at high power for any other purpose, replace the half-amp B-plus fuse with 1 amp for the duration of the test, and avoid driving it at sustained full power for more than 10 minutes or so. This does not mean that the power supply has an inadequate safety margin: quite the contrary, the amplifier is quite suited to fill your living room (or major league baseball park) with large amounts of sound for indefinite periods for a long time. When initially wiring the power supply, test the filament windings to make sure they are in phase rather than bucking by momentarily touching the red leads (*thick* ones, not the thin red high voltage leads) to the green; if you get a fat spark (only 6 volts here, no shock hazard) they are out of phase; reverse one set of leads and solder.

Since the power transformer has no bias winding, a separate transformer is used for the bias supply. Any isolation transformer will do as long as

Continued on page 24

it can deliver about 15 mA; the exact output voltage is not critical since it is adjustable at each tube. If you can't locate a packaged bridge rectifier, just about any four silicon or selenium diodes will work just as well.

Figure 1 is the top view of the amplifier; each channel is on one side of the chassis, with the common components (meter and switch) in the center. Hidden behind the output transformers are the output terminal strips. The male octal power connecter is on the far side of the chassis, the hum balance control on the near side. The two other capped potentiometers (between the 6SN7's and pairs of KT88's are the a.c. balance controls. *Figure* 2 shows what the amplifier looks like underneath. There are plenty of components used in the input stages, but the large chassis leaves plenty of room. Just make sure nothing is touching that isn't supposed to touch. The locations of the meter and switch are obvious. The four large capacitors are the coupling to the output stage; the balance controls are between them. The four bias pots are on the other side of the output tube sockets. Two buss bars are used, to which all grounds are connected; they are tied together and grounded to *one* of the input sockets; this is the only chassis ground.

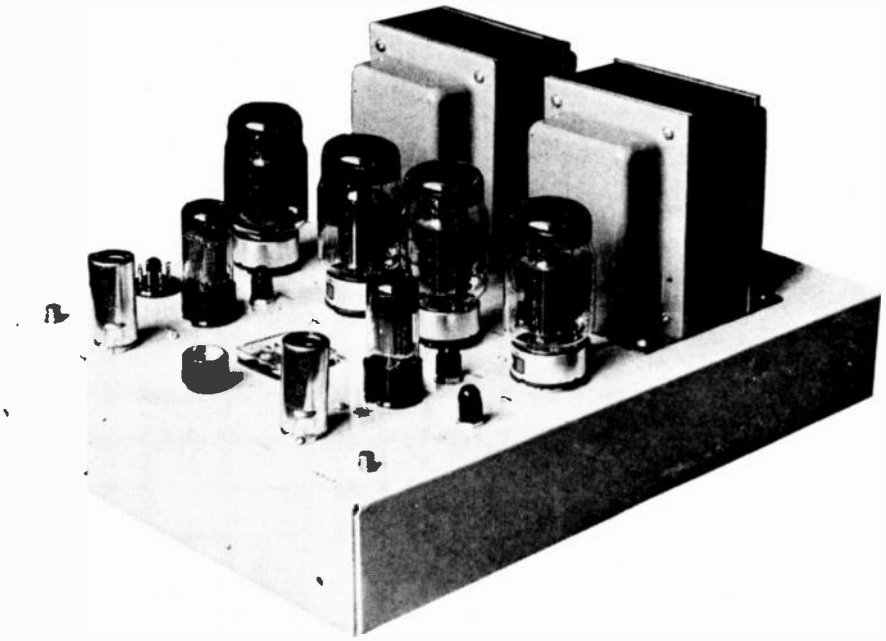


Fig. 1. Top view of the amplifier.

The top of the power supply is shown in *Fig.* 3; the only components here are the power transformer and chokes, the octal power connecter, and the line cord. More is to be seen underneath (*Fig.* 4). On the lower right are the components of the bias supply: transformer and (partly hidden) R_8, R_9, C_7, and C_8. The B-plus rectifier is mounted on an angle; there is no need to put it on top of the chassis since its life is indefinite. Underneath the rectifier is the high-voltage fuse, underneath the fuse are all of the resistors and capacitors in the high-voltage circuit.

The output of the power supply is fed to an octal socket; a matching cable is used to deliver power to the amplifier. Hook-up is by means of a 6-conductor cable. Since the total filament drain is over 8 amperes, the two wires carrying filament current should be at least #18; the others can be #22. We used Belden 8446, whose #22 conductors are rated at only 200 volts, but as in other applications, we have had no difficulty with insulation breakdown at many times this rating. Perhaps lacing six single, well insulated wires might be a more elegant solution; in any case keep the length to no more than is necessary.

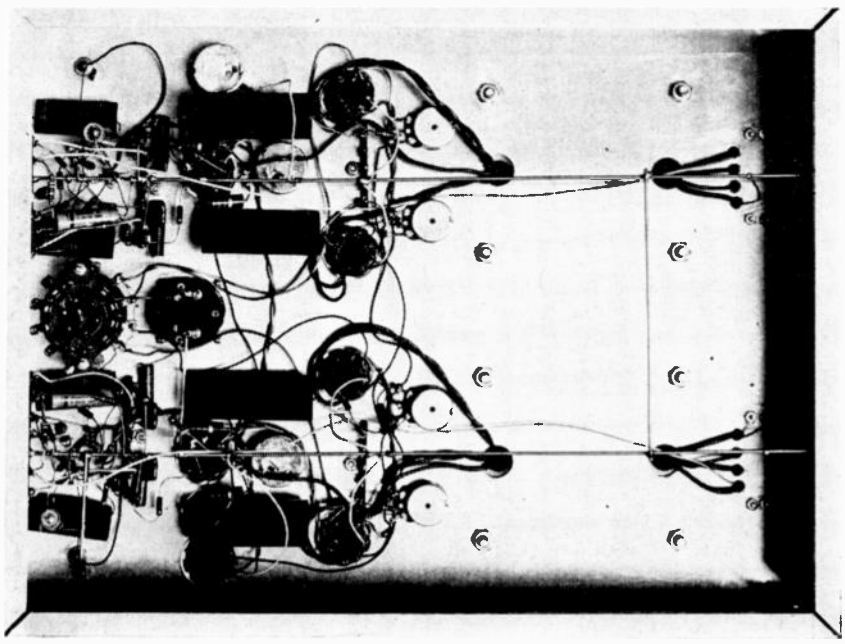
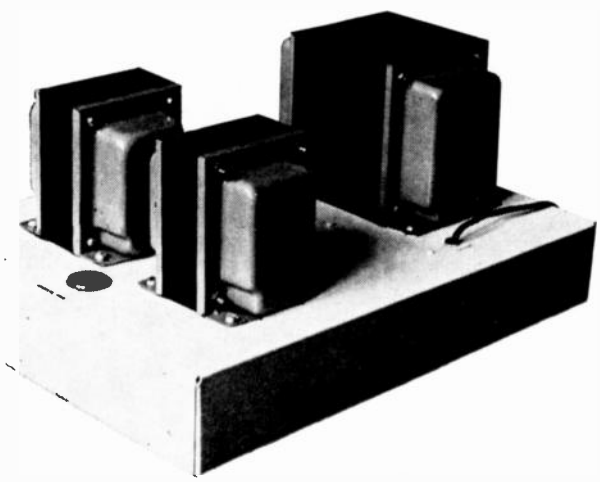


Fig. 2. Under-chassis view of the amplifier shows relatively neat construction.

Testing and Operation

Before connecting the amplifier to the power supply, make a preliminary resistance check from pins 2, 3, 5, 6, and 8 of the male octal power connector on the *amplifier* to ground. Pins 2 and 3 should be wide open



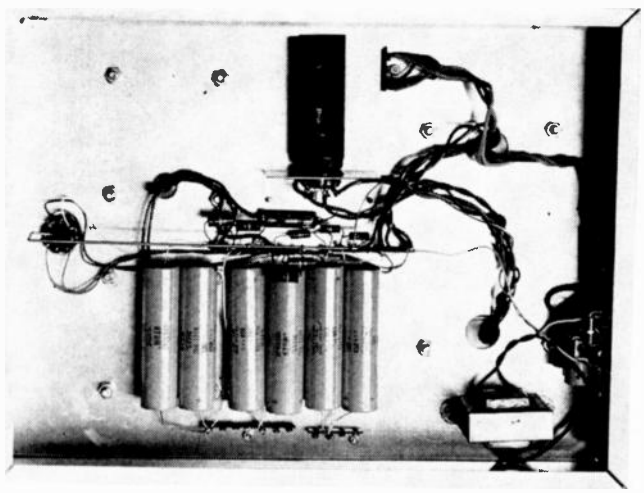


Fig. 3 (left). Top view of the massive power supply, which weighs in at about 55 lbs. Fig. 4 (right). Underside of the power supply chasis is similarly neat and uncluttered.

(infinite resistance), pin 5 about 10K and pins 6 and 8 varying from 100 ohms to zero as the hum balance control is rotated. When measuring from pin 5, turn all four bias controls from one end of rotation to the other and make sure this has no effect on the resistance to ground at pin 5. Failure to make this check cost us a KT88: a sliver of wire caught under one of the bias pots removed all bias from that tube, and before we could get to the power cord, completely stripped the cathode of the tube. Any such short would show up as a resistance variation in the above check.

Assuming that the amplifier checks out, plug in the power supply with the amplifier not yet connected (the dimming of lights is normal) and measure the output voltages (B-plus should be about 700 volts with no load). If everything is normal, unplug the power supply and connect it to the amplifier. With the 12AX7's and 6SN7's in their sockets (no output tubes yet) plug the power supply in again and make sure the tubes light up. If you want to make plate voltage checks here, keep in mind that they will be a bit higher than normal. Connect a signal generator to one of the inputs (about 1 kHz) and adjust it for about 20 volts at pin 5 of either of the output tubes of that amplifier. Now adjust R_{21} so that the signal will be the same at pin 5 for both output tubes. Repeat the adjustment for the other amplifier; we used caps on the balance controls since this is a semi-permanent adjustment which cannot be checked on the meter.

Now connect each side of the amplifier to a dummy load (or a common load to the paralleled outputs), turn each bias control fully *negative* (CCW in our amplifier) and plug in the output tubes. To check output tube current, we used a 100 mA meter with a switch which inserts the meter into any one cathode circuit or cuts it out of the circuit. If you see no purpose in building into the amplifier a meter which will be used rarely, make some other provision for measuring cathode current (such as closed-circuit phone jacks). In any case, with the controls supplying full bias, the tubes should draw little or no current. After they have warmed up, slowly adjust each bias pot for 50 mA cathode current. Since they interact, go back and adjust each pot a couple of times until all of the tubes are drawing the same 50mA. After about 10 hours of operation, repeat the adjustments to compensate for initial aging.

Before connecting the amplifier to your speaker system check each side with a voltmeter (dummy load attached) to make sure it is not oscillating; should you have made a wiring error causing the feedback phase to be reversed, the amplifier would be producing about 160 watts of oscillation which you will want to correct before it sends your speaker up in smoke.

Adjustment of the amplifier is now completed. If you have the test equipment, you might want to trim balance controls R_{21} for minimum IM distortion; adjustment for equal output is sufficient for anything less than laboratory measurement uses.

Performance

Frequency response, power output, and other data are given in *Figs.* 7 and 8. No distortion measurements are given since these have been shown (by transistor research, to a great extent) to have little to do with sound quality. Suffice to say that square waves at 1 kHz and 10 kHz are closer to the original than those coming out of any other amplifier we have seen. 20 Hz square waves show a great deal of tilt because of subsonic rolloff and high-frequency square waves are rounded because of the high-frequency rolloff. Note the large difference between maximum output before clipping and absolute maximum output in

(Continued on page 26)

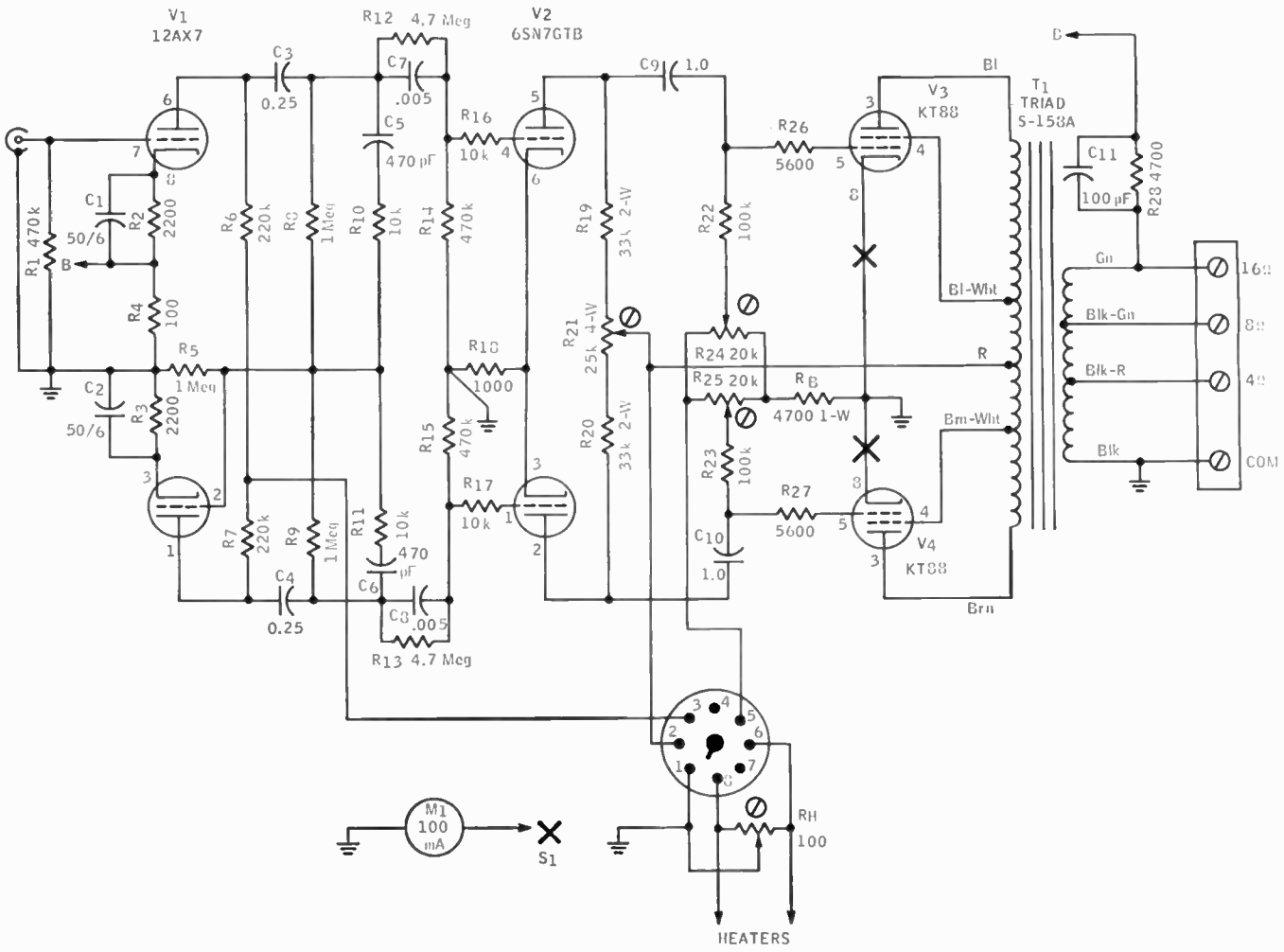


Fig. 5. Over-all schematic of the amplifier section.

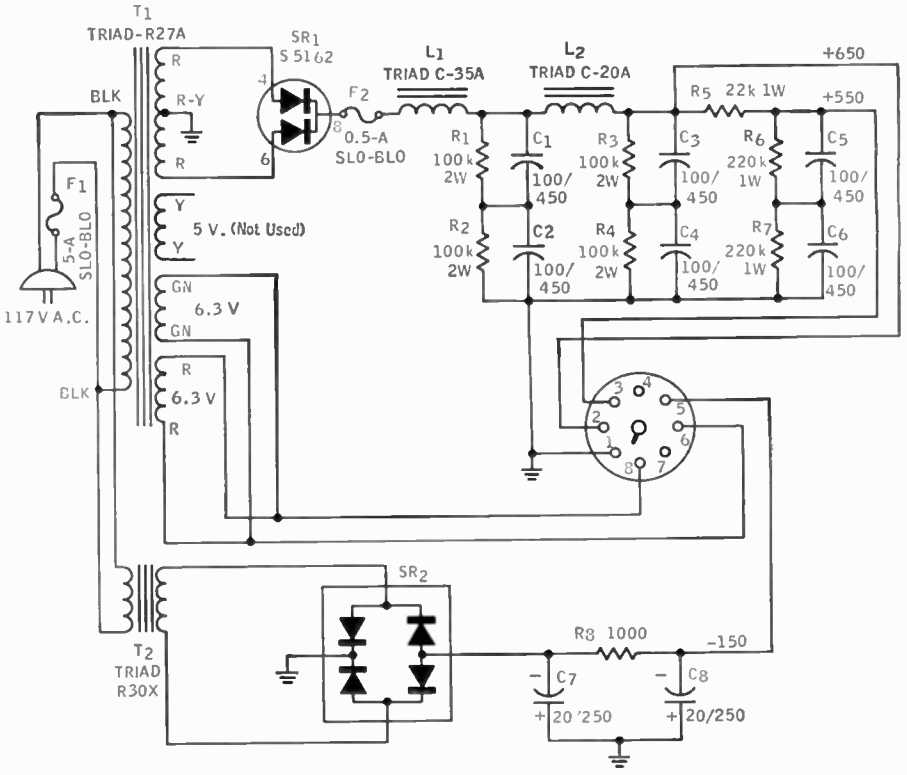


Fig. 6. Schematic of the power supply section

both the single channel and combined measurements. This is indicative of the symmetrical, gradual clipping which turns sine waves almost into square waves before sides are deformed. Maximum power without audible distortion is about 100 watts, music power about 115 watts (each channel) and total peaks in the half-kilowatt region. Frequency response is dead flat throughout the spectrum, another 15 dB of feedback will produce neither oscillation nor detectable sound improvement, the noise is inaudible, the gain very high (input gain controls may be needed in some applications), and the damping factor (remember that?) good for most speakers. The amplifier has been tested into a capacitive load approximating an electrostatic speaker and shows no signs of instability or sound degradation.

A word of caution: if you have never experimented with anything this big, be very careful about plugging and unplugging leads. An open ground could easily mean 160 watts at 60 Hz fed to your speaker. Also,

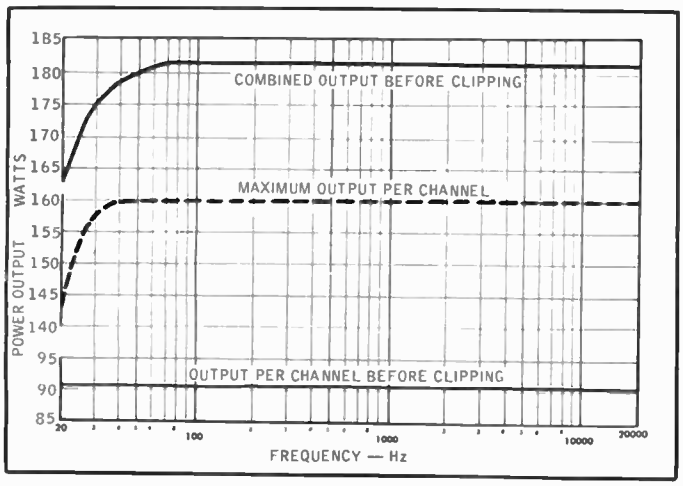


Fig. 7. Curves of output of each individual section before clipping, and of both sections together, along with maximum output per channel, all vs. frequency.

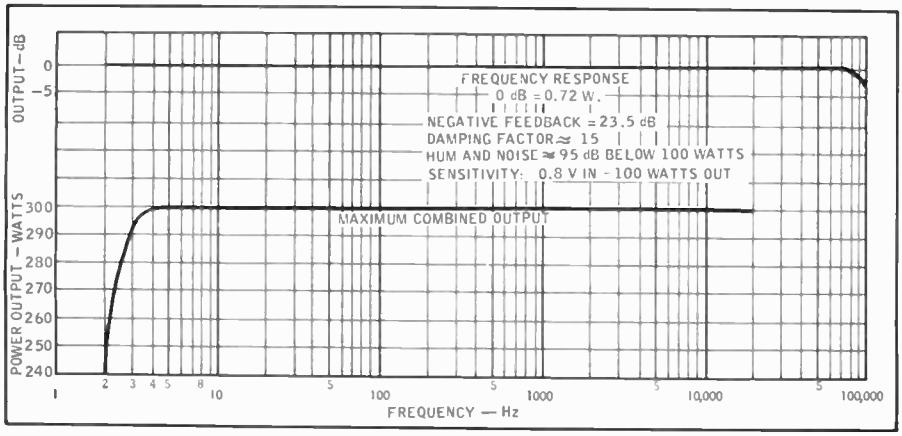


Fig. 8. Frequency response curves for 0.72 watts per channel, and for maximum combined output of both channels.

switching clicks may contain so much energy that they may cause your house lights to flicker. This does not mean oscillation, it simply means that the amplifier can reproduce a sharp thump fed into it at the equivalent of many watts of power. If you have chronically noisy switches on your preamp, you might consider a subsonic filter.

Rationale

Why, to sum things up, does one go out of one's way to listen to an amplifier whose only claim to fame seems to be the great gobs of power it can produce, an amplifier whose flat frequency response, low noise, and high gain can be duplicated by most of the commercial units on the market today, an amplifier which is hardly easy on the back muscles and which, if mistreated, may vent its rage by destroying any speaker made in a fraction of a second?

The reason is sound. For pure sound quality, this amplifier sounds noticeably better than anything we have ever heard. Using it in place of a respected 70-watter elicited immediate comments from listeners. Not only is it exceptionally clean at normal levels, but the feeling of completely unlimited power handling capacity is a new experience. We invariably listen to the amplifier at considerably higher levels than before, but it is a new type of loudness, absolutely free of listener fatigue and truly approaching live sound. This is an amplifier which can be relied upon never to call attention to itself (sonically, at least) no matter what it is called upon to do; it will always be a strong link in the chain or sound reproduction.

We would like to thank Calvert Electronics, Inc., Sarkes Tarzian, Inc., the Triad Distributor Division, and Mr. Frederic Feingold for their invaluable assistance in this project. *AE*

Parts List

Amplifier—2 of each component unless otherwise specified

C_1, C_2	50 μF, 6V, electrolitic, Sprague TE 1100
C_3, C_4	0.25 μF, 600 V, paper, Sprague 6TM-P25
C_5, C_6	470 pF, Sprague 47192
C_7, C_8	.005 μF, paper, Sprague 6TM-D50
C_9, C_{10}	1.0 μF, paper, Sprague 6TM-M1
C_{11}	100 pF, ceramic, Sprague 10TCC-T10
M_1	100 mA meter, 1 only, optional
R_1, R_{15}, R_{15}	470 k ohms, ½ watt (All resistors 5%)
R_2, R_3	2200 ohms, 1 watt
R_4	100 ohms, ½ watt
R_5, R_8, R_9	1 megohm, ½ watt
R_6, R_7	220 k ohms, ½ watt
R_{10}, R_{11}	10,000 ohms, ½ watt
R_{16}, R_{17}	
R_{12}, R_{13}	4.7 megohms, ½ watt
R_{18}	1000 ohms, ½ watt
R_{19}, R_{20}	33,000 ohms, ½ watt
R_{21}	25,000-hm, 4-watt potentiometer
R_{22}, R_{23}	100 k orms, ½ watt
R_{24}, R_{25}	20,000-ohm potentiometer
R_{26}, R_{27}	5600 ohms, ½ watt
R_{28}	4700 ohms, ½ watt
R_b	4700 ohms, 1 watt (1 only, common to both channels)
R_h	100-ohm potentiometer (1 only)
S_1	Meter switch, Mallory 1400L (1 only, optional)
T_1	100-W, tapped screen, 4500-ohm output transformer, Triad S-158-A)
V_1	12AX7
V_2	6SN7GTB
V_3, V_4	KT88
	Chassis, jacks, sockets, hardware, etc.
	Power supply
C_1, C_2, C_3, C_5, C_6	100 μF, 450-V electrolite, Sprague 1718
C_7, C_8	20 μF, 250-V, electrolytic, Sprague 1508
F_1	5-A, Slo-Blo fuse
F_2	0.5-A, Slo-Blo fuse
L_1	Triad C-35A swinging choke, 20-4 Hy, 40-400 mA.
L_2	Triad C-20A choke, 6 Hy, 400 mA.
R_1, R_2, R_3, R_4	100 k ohms, 2-watts (All 10%
R_5	22,000 ohms, 1 watt
R_6, R_7	220 k ohms, ½ watt
R_8	1000 ohms, ½ watt
SR_1	tube-replacement type silicon rectifier, Sarkes Tarzian S5162
SR_2	Bridge-type silicon rectifier
T_1	Triad R-27A
T_2	Triad R-30X
	Chassis, line cord, fuse mountings, power cable, hardware, etc.

An FM-Stereo Antenna Primer

PART 4

WALTER G. WOHLEKING

After the signal is effectively picked up by the antenna proper, there is still the problem of getting it from the antenna down to the tuner or receiver without picking up unwanted noise and without excessive losses.

Practical Transmission Lines

THE ANTENNA RECEIVES the FM signal, the transmission line delivers it to the tuner. There are various ways in which transmission lines can be classified: Shielded and unshielded, balanced or unbalanced, and so on. Our interest lies with three types and for purposes of this discussion we'll place them each in their own class despite the fact that they each have characteristics which relate with one of the others.

At one end of the transmission line spectrum is the balanced, unshielded transmission line known more commonly as "twin lead." The line is not by nature balanced, and for this reason the above nomenclature might well be misleading. What is meant by this is that the line is designed to be used with each conductor varying about ground by the same potential. When properly installed, each wire of the twin lead carries an r.f. current which varies 180 deg. out of phase with that in the other wire of the twin lead.

This situation results in minimal radiation of fields that would primarily be radiated by a single wire carrying this current. It is extremely important to minimize such radiation from a transmission line. If the line radiates, it is, in effect, an antenna whch responds to r.f. energy just as does the antenna to which the line is connected. As such, the line is susceptible to pick-up of near-to-ground interference, ignition noise, and so on, and is capable of degrading the pattern and cross-polarization level of the antenna itself. When the balanced condition is in effect and current in each side of the line is varying at equal and opposite levels with respect to ground, almost all of the electric field generated by these varying currents is located between the two wires, and radiation (and therefore, because of reciprocity, reception) of energy by the transmission line itself is quite small.

If the line becomes unbalanced, the radiated field no longer is restricted to the space between the conductors and pickup of extraneous fields and noise increases. The line is thus no longer maintaining the integrity of the signal it's supposed to transfer from antenna to tuner, but is adding other information to it and is also radiating the signal it carries into the surrounding medium. Needless to say, this particular occurrence is wasteful of the signal we are trying to get into our receiver.

Comment on line unbalance seems unnecessary, and is indeed unnecessary, if we merely eliminate the causes of unbalance. In antenna system installations, however, unbalance in twin lead is caused by any factor which places one or the other of the twin lead conductors at a different potential with respect to ground than is the other. If, for example, a transmission line is routed near a downspout and one side of the twin lead passes closer to this effective ground than the other, the line will become unbalanced because of the different impedance to ground this side of the line sees relative to the unaffected side. This type of unbalance can be minimized by frequent twisting of the twin lead to insure that what one wire of the line sees the other—at least in the space of one twist—will also see.

Twin-Lead Installation Precautions

To prevent an unbalanced condition in installations utilizing 300-ohm twin lead, careful routing procedures are required. The transmission line should be held only in appropriate standoffs designed for the specific purpose of carrying and supporting this type of line. The line should be twisted frequently to minimize unbalance and resulting radiation losses. Fortunately, such standoffs are widely available from parts jobbers and should be used rather than staples, nails, or other fastenings to hold twin lead in place.

If such care is required to install twin lead properly, why is it used by anyone and why is it in fact the most widely employed transmission line in FM and TV installations? One reason is that it is suffers the least loss of all the commonly available lines. Table *I* gives the characteristics of transmission lines of the three types we will consider. At 100 MHz, the unshielded twin lead exhibits line attenuation of 1.1 dB per 100 feet, as compared to 2.8 dB for shielded twin lead and 3.75 dB for coaxial cable.

Coaxial Cable

Coaxial cable, at the other end of the transmission line spectrum, is con-

(Continued on page 31)

Table I

TRANSMISSION LINE TYPE	NOMINAL O.D. (in.)	NOMINAL PROPOGATION VELOCITY	NOMINAL CAPACITANCE pF / ft.	NOMINAL ATTENUATION AT 100 MHz (dB)	TYPICAL COST 100-ft. length
300-Ω Twin Lead (Belden 8225)	.058 x .400	80%	4.4	1.1	$1.65
300-Ω Shielded Twin Lead (Belden 8290)	.300 x .510	70%	8.4	2.8*	9.75
RG-59/U 72Ω Coaxial Cable (Belden 8241)	.242	66%	21.0	3.75**	5.10

* Interpolated

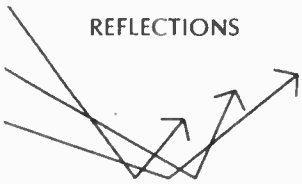
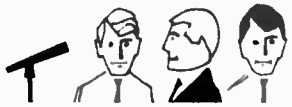
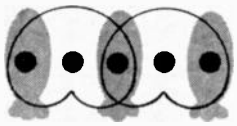
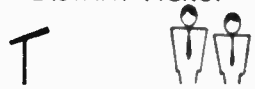
** Does not include losses in any necessary matching transformers

not all cardioid microphones are alike . . .

the SHURE UNIDYNE® III

TRUE CARDIOID UNIDIRECTIONAL DYNAMIC MICROPHONE SOLVES ALL THESE COMMON MICROPHONE PROBLEMS!

PROBLEMS CAUSED BY INEFFICIENT REJECTION OF UNWANTED SOUNDS BY THE MICROPHONE

SITUATION	PROBLEM	CAUSES	SOLUTION
REFLECTIONS 	Feedback occurs where a so-called "cardioid" microphone is used and the speakers are placed to the rear of the microphone. A common occurrence in churches, auditoriums, and meeting rooms.	Sound bounces off hard surfaces on the walls, floor and ceiling, in and around the audience area and the microphone used is not effective in rejecting these sounds at all frequencies, and in all planes about its axis.	The Unidyne III rejects sound at the rear with uniformity at all frequencies. Sounds bouncing off floor or other surfaces are uniformly rejected.
 COLUMN LOUDSPEAKERS	Unexplained feedback. Column loudspeakers are used to distribute sound more evenly to the audience in churches and auditoriums.	Feedback occurs when rear and side sound lobes of column speakers coincide with rear and side lobes of so-called "cardioid" microphones.	The Unidyne III solves this problem because it has no rear or side lobes. Thus it rejects the side and rear lobes of the sound column speakers.
REVERBERANT BOOM!	A disturbing, echoing effect of low frequency sound often found in churches, large auditoriums, and arenas.	Low frequency reverberation and boominess occuring when microphone fails to retain unidirectional characteristics at low frequencies.	The Unidyne III maintains a uniform pattern of sound rejection at all frequencies, even as low as 70 cps. The response has a controlled roll-off of the low end—low frequency reverberation diminishes effect of boomy hall.
PROBLEMS CAUSED BY THE MICROPHONE'S INEFFECTIVENESS IN PICKING UP THE DESIRED SOUND			
GROUP COVERAGE WITH ONE MICROPHONE 	A single microphone does not provide uniform coverage of a group. This is commonly experienced with choral groups, quartettes, instrumental combos, and speaker panels.	The particular "cardioid" microphone used lacks a uniform pickup pattern, so that persons in different positions within the general pickup area of the microphone are heard with varying tonal quality and volume.	The Unidyne III affords uniform pickup of the group with a resulting consistency in volume and sound quality among the members of the group.
USING MULTIPLE MICROPHONES 	Variation in the pickup level and tonal quality exists throughout the broad area to be covered. This may occur in stage pickup of musical and dramatic productions, panels and audience participation events.	The pickup pattern of the microphones used is too narrow, causing "holes" and "hot spots." The off-axis frequency response of the microphones also varies.	The Unidyne III permits smoothness in pickup as true cardioid pattern gives broad coverage with uniformity throughout coverage area. Eliminates "holes," "hot spots," and variations in sound quality, simplifies blending many microphones.
DISTANT PICKUP 	Too much background noise or feedback results when working with microphone at desired distance from sound source.	Long-range microphones are less directional with lower frequencies. Lobes or hot spots allow background noise or feedback.	Use the Unidyne III to gain relatively long range with effective rejection of sound at all frequencies at the rear of the microphone.

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STEREO LOG PERIODIC ANTENNA

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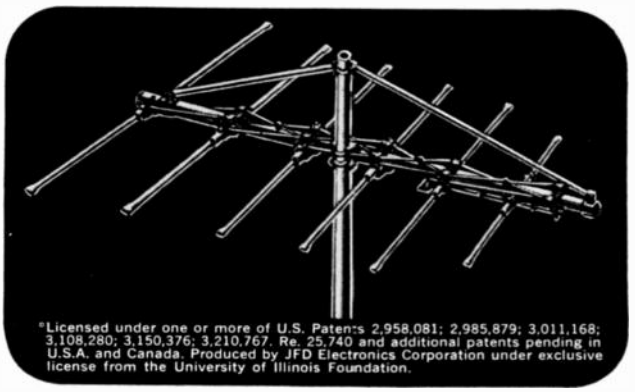

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to 175 miles	to 150 miles	to 125 miles	to 75 miles
List $49.95	List $39.95	List $29.95	List $19.95

"With it we get the effective signal into the receiver which we formerly had using a yagi beam and transistor preamplifier. In addition to better limiting in the pickup receiver, we believe that we now enjoy a better noise figure in the overall system. We would recommend the use of this antenna to other broadcast stations."
Philip Whitney, Manager
FM STATION WRFL WINCHESTER, VA.

"My experience with this antenna will make me confident to recommend it to anyone who consults us from a difficult reception area."
Lawrence Gahagan, Chief Engineer
FM STATION WPRB PRINCETON, N.J.

"One particularly difficult pick-up is KTHO across 46 miles of rugged mountain range. Your antenna solved all of the difficulties."
Jerry Cobb
FM STATION KNEV RENO, NEV.

"We receive a perfect signal with the LPL-FM antenna, where it was impossible to use the signal heretofore for rebroadcast without a great amount of fading or atmospheric noise."
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Circle 66 on Reader Service Card

(Continued from page 28)

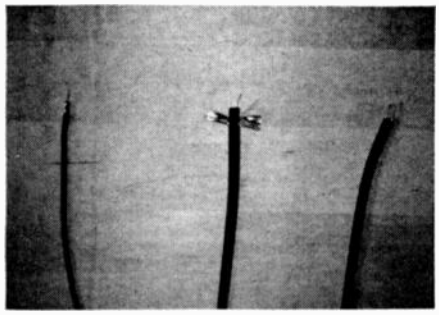


Fig. 22. Three major types of transmission lines—left, 300-ohm twin lead with a foam, weather resistant jacket; center, the same cable with an aluminum plastic outer jacket for shielding; and right, RG59/U coaxial cable, 72-ohm impedance.

siderably less susceptible to interference from extraneous fields than is twin lead. This is so because one of the two transmission line elements completely surrounds the other, containing the field within it. This shield rejects outside interference simply because it more effectively contains the field than do the two wires of the twin lead. But as a result of the fact that the shield appears as a single conductor, any currents which appear on the outside of the shield itself will not be cancelled and the shield will radiate as does an antenna and the unbalanced line discussed earlier.

To prevent such radiation the shield of the coaxial cable is grounded and currents from the antenna are prevented from traveling on the shield. The center conductor then varies about ground potential and the field is formed between the center conductor and inside of the shield. In addition to the isolation from unwanted radiation that the coaxial cable provides, the shield also allows this type of transmission line to be routed wherever you please. It can be stapled or held in place without special precautions. Coaxial cable is also much less susceptible to weathering than twin lead, although several types of weather resistant twin lead have been developed during recent years.

Fig. 23. Wall brackets and heavy-duty mast supporting a rotator and 10-element Yagi-Uda array. Shielded twin lead and rotator cable taped to mast and then together can be seen passing through a standoff at the bottom of the picture.

Table II

TRANSMISSION LINE	IMPEDANCE	ADVANTAGES	DISADVANTAGES
Unshielded Twin Lead	High – 300Ω	Inexpensive Low Low, low attenuation Light weight Easy to work with Connects direct to antenna and to receivers with balanced input	Requires special hardware for routing Sensitive to nearby conductive surfaces Characteristics change with age and exposure to weather Highest noise pick-up susceptibility
Shielded Twin Lead	High – 300Ω	Lowest noise pick-up susceptibility Impervious to weather Can be routed anywhere regardless of nearby conductive surfaces Any clamps suitable for mounting Connects direct to antennas and to receivers with balanced input	Relatively expensive (highest) Attenuation greater than unshielded twin lead
Coaxial Cable	Low – 72 to 75Ω most common	Low noise pick-up susceptibility Impervious to weather Can be routed anywhere regardless of nearby conductive surfaces Any clamps suitable for mounting	Relatively expensive Highest attenuation Requires matching transformers at antenna end and possibly at receiver end

Well, if coaxial is superior to twin lead in noise rejection and resistance to weather and aging, why isn't it more widely used? Table *I* gives one reason: It introduces more attenuation than twin lead for cable of comparative size. Coaxial cable with losses no greater than twin lead is available, but at a considerable increase in size and weight over twin lead. In addition, the cost of coax is considerably more than that of twin lead. The use of coax in a system usually requires transformers at each end of the line. These transformers have losses which must be added to the losses of the cable when comparing one system with another. While the losses inherent in a system should be a decisive factor in the selection of the components that make up the system, the major reasons for the lack of universal use of coax are really cost and the generally good results on mono reception available with twin lead. Coaxial cable is utilized in most professional antenna system installations.

Shielded Twin Lead

By combining the features of twin lead (balanced line) with coaxial cable (concentric shield) a transmission line results which has rejection characteristics superior to both twin lead and coax and has attenuation characteristics somewhere between the two. The reason for the superior noise characteristics should be obvious from

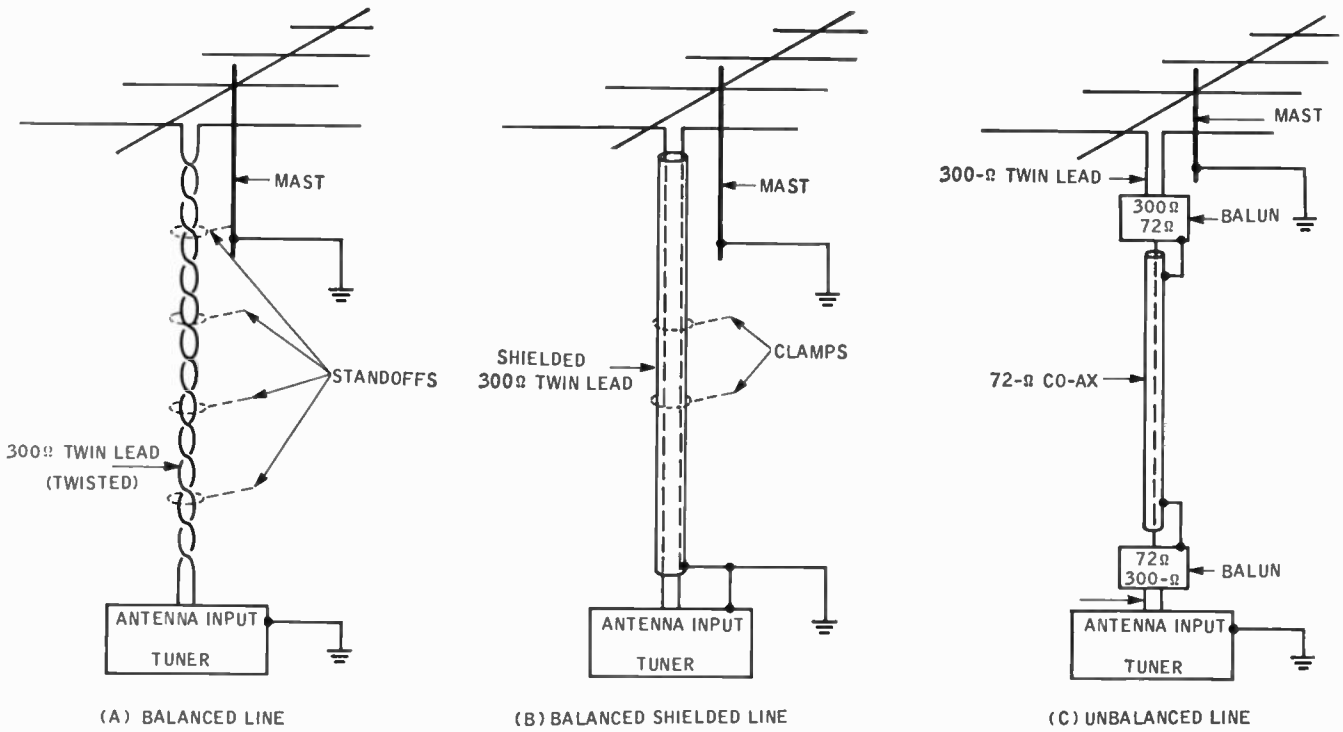


Fig. 24. Antenna system installations for three primary transmission line types.

our discussion of the other two transmission lines. The shielded, balanced, two wire transmission line uses what might be termed a brute force approach, the combination of the balanced line capability to concentrate field along with the even greater effectiveness of the shield in reducing noise pickup. It is weather and age resistant and can be run near conductive surfaces without danger of degrading balance. Characteristics of shielded twin lead are given in Table I, and all three types of cable are shown in *Fig.* 22.

Selecting the Transmission Line

Just as we're faced with antenna selection for a specific situation, we are faced also with a decision as to the transmission line which will do the best job of coupling antenna to receiver or tuner. A summary of transmission line attributes which should help considerably in making such a decision is given in Table II. The choice of transmission line is nowhere near as clear cut as the choice of antenna (providing of course that this choice is in fact clear cut). The following is a summary of the guidelines that can be used to facilitate this mind-numbing decision.

1. As a general rule of thumb, the best transmission line for the majority of installations is shielded twin-lead. True, it is relatively expensive and on a cold day, when the plastic becomes less flexible, it is a bear to install. But it guarantees for all intents and purposes that extraneous effects on the signal travelling the line will be slight, and special routing or handling is not necessary to achieve this end.

2. If signal level at the receiver is marginal for stereo reception, unshielded 300-ohm twin-lead is the best choice. Pick a good grade that is designed to provide high resistance to weathering and use standoffs to carry the line, even in the house, where possible. Tests have indicated that misinstallation of 300-ohm twin lead, using Romex cable staples, can increase the effective loss of the line by over 1.25dB per 100 ft. at 108 MHz.[3] Whatever you do, don't route the unshielded line through metal conduit or gutters or other similar surrounding metal tubes. The same test showed high line-loss factors when twin lead was allowed to lie on the ground or become soaked with water. While careful routing can prevent the former from happening, Providence alone can keep rain off the line.

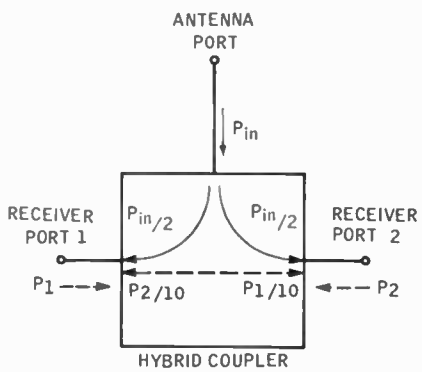


Fig. 25. Block diagram of hybrid operation where P_{in} = received power from antenna P_1 and P represent radiated powers from receiver front ends.

3. Although priced between shielded and unshielded twin leads, the losses incurred when RG-59/U coax is used along with the necessary matching transformer baluns takes this cable out of the same league as the other two. It is somewhat easier to handle than the shielded twin lead and of course possesses all its interference and age rejection properties. Cable losses are functions of length, and in short runs actual differences in attenuation between various cables may be negligible. The same may not be said for transformers. Their losses in an antenna system are fixed values which have no regard for line length. So, what we are faced with when coax line is employed for long cable runs is a much greater line attenuation than with a similar length of either shielded or unshielded twin-lead. As the length

[3]Mark L. Nelson, "Loss figures for 300-ohm twin lead." *Electronics World*, January, 1965.

is shortened, the line differences become less, but now the fixed loss of the transformer rears its head and becomes a greater percentage of the total system loss than it was when the line length was great.

Before we stop beating this topic with a stick to make sure it has died, some smart aleck probably wants to know how he can tell in advance if he must use a transmission line that is unshielded for maximum signal transfer or if he should gamble and go out and sink the big money into the shielded stuff. There is an easy way to check that costs very little. Purchase enough of a very inexpensive unshielded twin lead to run from antenna to receiver and connect it between these two marvels of the electronic age. Route the wire properly, making sure it is not near any conductive surfaces, or the like as previously discussed. If, when the receiver is turned on and a stereo broadcast tuned in, noise is present, chances are that the increased losses of the twin lead will only make the noise worse.

If noise does not make its objective presence known, then place 10-ohm, ½-watt resistors in series with each of the wires of the twin lead at the point where they connect to the tuner or receiver. This is a fair approximation of the attenuation that will result if shielded twin lead is employed. If noise does not turn up when this is done, shielded twin lead can be installed and the listening will be good. If noise does turn up on a stereo station, then a good grade of unshielded twin lead should be used to replace the cheap stuff that was used to make the test.

When making the test described above, two things are important to bear in mind. First, use only stereo broadcasts on which to base the selection of line. Second, make sure that the unshielded test line is installed properly or else the losses resulting from this misinstallation will obscure the real test results.

In summation, and recognizing the usual risk of dangerous generalization that opinionating carries with it, the following may be said about that other half of an antenna installation, the transmission line. Just as high gain is the word or should be the word of antenna disciples, shielded twin lead is the king of FM antenna system transmission lines. The advantage in attenuation offered by unshielded wire will eventually be compromised by environmental conditions, and that bit of ignition noise that *doesn't* slip in during a crucial FM stereo taping session will make the extra cost worthwhile.

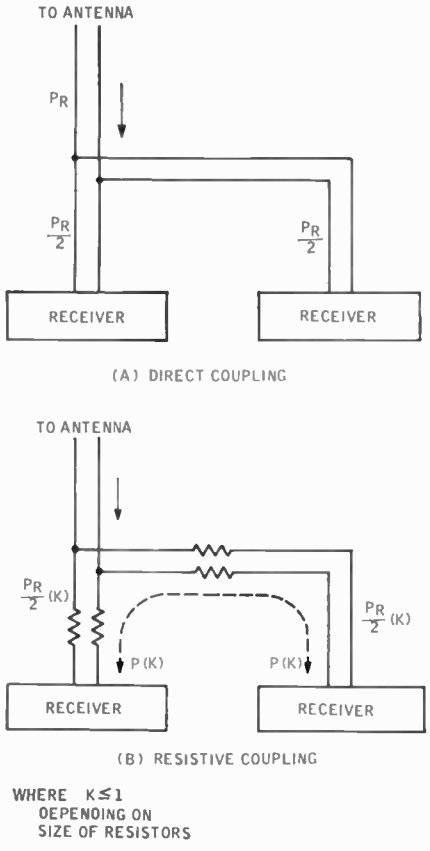


Fig. 26. Less-desirable methods of coupling multiple receivers to a common line.

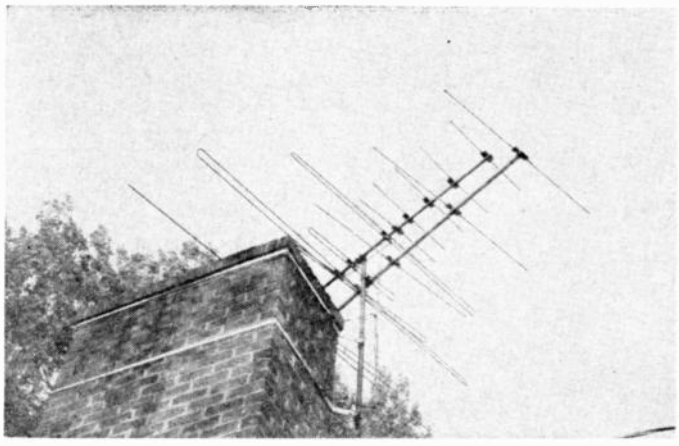


Fig. 27. Separate antenna systems mounted too closely on the same mast. Lower of the two is a 6-element FM Yagi. Transmission lines are routed through the same standoffs, resulting in high cross coupling. Close spacing of antennas as shown here deteriorates pattern and impedence of each antenna.

Practical Antenna Systems

We've covered much ground and have really defined quite well an optimum antenna system for FM stereo: High gain yagi or log periodic dipole array (lpda), on a rotator if necessary, and shielded twin lead transmission line. What we will talk about in the space and time that remains is the mechanics of putting this system or any antenna system up where it belongs, and the results that can be expected if we use other than this so-called ideal. For instance, suppose connection is made to the TV antenna system. Suppose we wish to connect more than one receiver to the line. What are all the line splitters and couplers about that appear in every parts catalogue from Honolulu to Huntington? In short, we are going to put our tremendous backlog of brilliant and thought-provoking antenna knowledge to work.

Let's first talk about installing the high-gain array mentioned earlier. About the only thing important about the physical location of the antenna itself is that it not be too close to a flat roof, such as those found on dormers for instance. While certain substances are relatively transparent to r.f. energy impinging upon the surface perpendicularly, when the grazing angle becomes small the substance becomes a very good reflector and will affect the radiation pattern of an antenna mounted directly above it. Keeping the antenna high above any such surface increases the grazing angle, substantially reducing reflection from the surface. This problem is obviously not as severe with sharply sloping roofs.

A multitude of devices is available to support the mast which in turn supports the antenna. Which is best is really a matter of what for a particular installation is most convenient. A very good mast support bracket which is strong and readily installs on any wall is shown in *Fig.* 23. This figure also shows the wall thickness you should look for when choosing a mast.

(Continued on page 51)

this is your Comparator Guide to Garrard's great new line of Automatic Turntables

COMPARATOR

Garrard®

WORLD'S FINEST
AUTOMATIC TURNTABLES

Retain for reference

In Automatic Turntables today Garrard is the innovator and has been for over 50 years!

It is remarkable how a stereo record captures the sound of the live performance.

It is equally remarkable how a Garrard automatic turntable reproduces that record without a hint of distortion or unwanted noise.

Modern records contain a miraculous spectrum of simple and complex waveforms, covering a wide dynamic range, from very soft to very loud.

The recognized ability of Garrard units to reproduce this material with more consistent perfection than any other home record playing equipment, has brought this line to its pre-eminent position.

Musically – the results have been so impressive that more owners of component stereo systems enjoy their records on Garrard automatics than on all other record playing equipment combined.

Technically – these results stem from this thoughtfully formulated policy, followed by Garrard for more than 50 years:

To incorporate meaningful new features as soon as available.

But, to retain tested mechanisms which have not been surpassed.

Advancements inspired by the state of the art are eagerly pursued.

But, changes for the sake of change are sternly rejected.

This demanding creed guides the everyday activities of the phenomenal organization known as the Garrard Laboratories . . . whose key personnel have devoted their entire careers to this one company and this one product.

The engineering background, teamwork, sheer know-how of this established corps of experts are simply not matched by others producing record playing equipment anywhere in the world.

This is the Garrard tradition. What has it accomplished in actual practice? The impressive answer is the long list of advancements introduced by the Garrard Laboratories. These Garrard developments established most of the significant trends which have literally upgraded this entire class of equipment over the years. Proof of this is self-evident in the degree to which Garrard automatics have been, and continue to be imitated by others.

Consider with us the various parts of an automatic record playing unit. Note how Garrard equipment has evolved since the beginning of high fidelity.

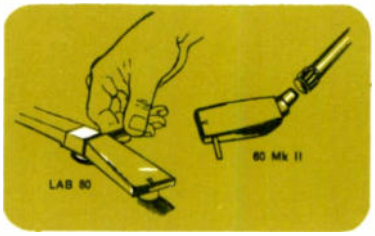
Tone arm

This is probably the most prominent part of any record playing unit – and a tremendous amount of attention has been paid to it by all manufacturers. The key to the metamorphosis of the tone arm is the cartridge. The basic purpose of the tone arm is to hold the cartridge in a shell and to track it with the correct force, obtaining the best reproduction possible, and imposing no impediments on the free action of the stylus. This sets up a complex geometrical problem in arm design. It has also required continued improvement in pivoting, permitting the arm to move more freely, since inertia and friction are detrimental to the performance of the cartridge. Poor tracking, of course, may also result in damage to the stylus and the record. In each of these basic aspects of tone arm design, Garrard has led the way, as the following will indicate.

The shell

First, the accommodation for the cartridge. The physical size of the cartridge, its mass and weight, its shape and related mounting problems . . . have all changed. Furthermore, each brand of cartridge has its own loyal group of followers – all of them interested in using the cartridge of their choice. Simple as this may sound, it was nevertheless true that few record players, automatic or manual, were ever able to accommodate more than a fraction of even the popular cartridges on the market at the time.

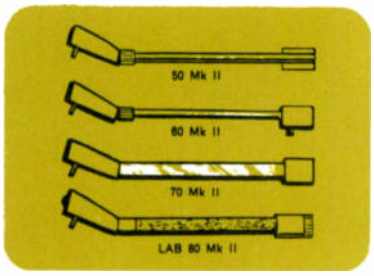
It was Garrard who introduced the plug-in universal shell . . . taking all cartridges . . . in models built as far back as the 1940's. This feature has remained in virtually all Garrard equipment to the present time.



But today's plug-in shell is vastly improved over its earlier counterparts. It is now a lightweight, low mass structure compatible with the smallest, lightest cartridge on the market. You will notice this most prominently on the Garrard Lab 80 Mk II (pages 4-5) and the 70 Mk II (pages 6-7), but all Garrard models have cut-away plug-in shells which accommodate any cartridge, and are furnished with mounting hardware for the simplest installation and finest performance.

Arm material

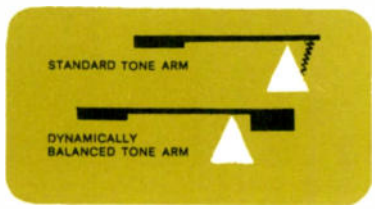
Even at the time when Garrard's classic RC80 was introduced, there was a noticeable trend toward lighter tone arms. Most manufacturers met this problem by building the arm of plastic. But this material was not sufficiently rigid and it tended to create resonance. The RC80 and subsequent Garrards, therefore, featured an aluminum tone arm. This material still serves excellently on most of the models. The most popular separate professional arms have been built of tubular aluminum. Garrard introduced this construction feature in its automatic AT6 five years ago. Today, you will find it on the 60 Mk II, the 50 Mk II and, in a flat silhouette version which imparts extreme rigidity, on the 70 Mk II.



The epitome of low mass tone arm construction is the exceptional arm of the Lab 80. It is made of Afrormosia – the least resonant of woods . . . therefore, ideal for this special application. The wooden shaft is rigidly held by a "T" of aluminum . . . an ingenious combination of materials promoting flawless tracking performance.

Tone arm weight and balance

In order to bring out the best in modern cartridges, it is essential that the arm be balanced perfectly and capable of tracking the stylus at the correct force against the record groove. At one time, this was a relatively simple matter. Tracking force was established by a simple spring, which pulled the arm from the rear to partially offset the dead weight of the shell, the cartridge, and the shaft of the arm. Essentially, this reduced the weight forward of the pivot, leaving the remainder of the weight for tracking. Today, with the very light cartridges and the feather light pressures prescribed for them, this method is not adequate. Professional tone arms are balanced in much the same manner as a doctor's scale – by the positioning, inward or outward, of a counterbalance weight.



Garrard introduced this type of dynamically balanced tone arm, for the first time in an automatic unit, with the revolutionary Type A – the first automatic turntable – six years ago. The Type A series (now the 70 Mk II) and then the AT6 series (now the 60 Mk II) still use this type of sliding weight very success-

fully. The Lab 80 has a more precise variation of it, the counterweight being mounted on a vernier adjustment for really fine, precision balancing.

Even on the lower priced Garrard units, you will now find a counterweight at the rear of the tone arm – placed there to reduce the amount of spring action needed to balance the arm, resulting in a dramatic improvement in performance.

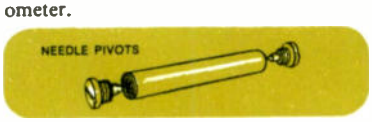
Every modern cartridge is designed to track properly within a specific range of pressure. The tone arm must be capable of being set to this pressure, and maintaining it. Garrard has pioneered in this direction by simplifying the stylus pressure adjustment, conveniently locating a knurled knob at the back of the tone arm on early models such as the RC88 and more recently, under the arm of the 40 Mk II.

However, as stylus pressures became more critical, with cartridges tracking down to fractions of a gram, it was necessary to depend upon accessory stylus pressure gauges, not always available or convenient to use. Therefore, Garrard introduced the concept of the built-in stylus pressure gauge, first on the Type A . . . then on the AT6. Now, this development has been carried through to its logical fulfillment with the precision pressure gauges built into the arms of the Lab 80 Mk II, 70 Mk II and 60 Mk II.

In the Lab 80 Mk II and the 70 Mk II, accurate settings to fractions of a gram are easily made by click settings calibrated at quarter gram intervals. The adjustments are both audible and visible. In the 60 Mk II (pages 8-9) the pressure is dialed in by turning an optical type knob. If the knob is turned beyond 5 grams, it simply clicks back to starting position, making the mechanism foolproof. There is also an interesting variation of the stylus pressure adjustment in a new type of gauge just introduced by Garrard – on the tone arm of the 50 Mk II (pages 10-11). This useful adjustment is a model of simplicity to read. The markings vary in size. Larger means heavier, and smaller means lighter pressure.

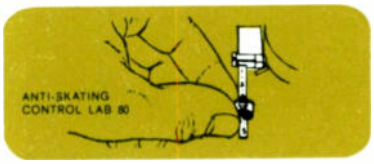
Pivots

One of the most obvious problems in tone arm design is to eliminate resistance to motion, vertically and laterally. Only with an effective pivoting system can the arm track freely enough at the very light pressures now required. Garrard engineers have been working on this problem for many years, utilizing Garrard's special capabilities for maintaining precision tolerances in minature fabricated parts. The results can be visualized by examining the tiny needle pivots used in the Lab 80 Mk II, 70 Mk II, and 60 Mk II, where a jewel-like point just touches into a miniaturized ball bearing race, resulting in vertical pivoting which would do credit to the finest chronometer.



Anti-skating control

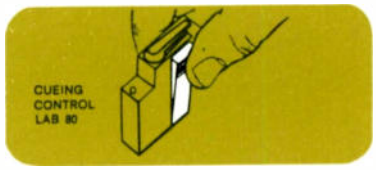
One development has logically led to another. Ultra-sensitive cartridges have resulted in low mass tone arms with virtually frictionless motion. Stylus assemblies have become more delicate. The dynamic range of records has become wider. Now . . . tracking must be very light, but it must not impair in the slightest the freedom of motion of the stylus. Side pressure acting on the stylus would result in distortion of one side of the stereo groove or the other. It might also cause undue record wear – particularly affecting the all-important clarity of the highs. Some years ago, Garrard laboratory tests confirmed that the natural side pressure created in all tone arms by the angle of the cartridge head was creating an increasingly noticeable problem, with the growing sophistication of stereo equipment. It was clear that compensation for this side pressure was essential to permit the stylus to function unimpeded. This very genuine need resulted in the design of the patented anti-skating device introduced by Garrard in the Lab 80 and Type A70 for the first time in automatics, and now refined in the Lab 80 Mk II and 70 Mk II.



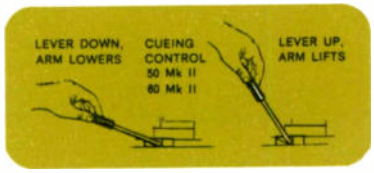
This small, simple arm, calibrated in grams, is adjusted by sliding a weight to match the stylus pressure setting on the tone arm. There are no springs or delicate mechanisms to get out of order. In a few minutes, using a grooveless record, any Garrard dealer can make a most convincing demonstration proving how this little weighted arm neutralizes the side pressure on the stylus, and results in perfect tracking. Garrard has incorporated another version of anti-skating control in the 60 Mk II, where it performs a similar service with a weight that is preset. Until Garrard's presentation of the anti-skating compensator on the Lab 80, this principle was found only in a few professional tone arms. Now, of course, the feature has been imitated on other units, but the patented method of utilizing a simple sliding weight to accomplish the purpose cannot be duplicated.

Cueing

When one considers the modern tone arms which Garrard has evolved for its automatics – it becomes clear that such an arm is not an arm – it is a system by itself – a group of components of advanced design whose purposes are to transport a modern cartridge, track it perfectly, and protect it as well. The matter of protection for the stylus and the increasingly delicate record grooves, has become more important as tracking forces have become lighter. For today, it is no simple matter for the user to set a tone arm down on a record by hand, or to pick it up off the record manually. Sooner or later, there is damage to the record or stylus. Furthermore, a large number of records have multiple selections on one side of the disc. Finding these bands ("cueing" the stylus into them) is also a frequent cause of damage to nearby grooves. Cueing devices have existed for some years on professional equipment used in broadcasting studios – but it remained for Garrard to be the first to apply the principle to automatics.



When they did – with the integral cueing control on the Lab 80, it was again with a highly advanced, yet simple mechanism. The Lab 80 cueing control is a squeeze device, cleverly located in the tone arm rest, where it is easily reached regardless of where the record player is installed. It is hydraulically operated. A touch of the finger on the manual tab starts the record player, activates the cueing device . . . smoothly raising the tone arm a safe half inch over the record. Then, move the tone arm over any groove desired and press the cueing control. The arm gently lowers to the groove. It is that simple, and that useful . . . now the most wanted feature in any record playing equipment. But follow the rest of the story for a typical example of Garrard's developmental leadership in the field. Naturally, the cueing feature, per se, was soon imitated on other automatic turntables . . . all of them higher in price than the Lab 80. Then, recognizing this interest, Garrard developed a lever type cueing control similar in use to those which appear in the highest priced competitive automatics. You will find it in the 60 Mk II (pages 8-9) and in the new 50 Mk II (pages 10-11) which is priced not at $130.00 or $150.00, but at $54.50!



One of the reasons why the cueing device is very appealing is the pause feature. Should the record player be operating when the phone rings – for example – the music may be interrupted, simply by touching the cueing control – and it may then be resumed at the very same groove when the interruption is over. Thus, a feature which was originally developed for professional applications in radio stations – has found its widest use in the home – safeguarding records and styli, and making the record player a greater pleasure to use than ever before.

The turntable

Garrard believes in a carefully balanced turntable, capable of imparting flywheel action – to smooth out any variations in the turning speed of the motor. No one familiar with record players will ever forget the beautifully manufactured turntable of the old RC80, revolving on a ball bearing main spindle race, and covered by a felt top. For subsequent models, Garrard carried on a continuous design project, culminating with the precision cast "sandwich" turntable introduced on the Type A – the first time such a turntable was seen on an automatic record player. Now, there is an entire group of oversized Garrard turntables . . . on the Lab 80 Mk II, 70 Mk II, and 60 Mk II . . . each of them somewhat different in construction . . . but all cast of non-magnetic metal, and dynamically balanced on special Garrard equipment. The record is well supported, and rumble, uneven speed, or hum caused by

Continued on **inside back cover**

LAB 80 Mk II

AUTOMATIC TRANSCRIPTION TURNTABLE

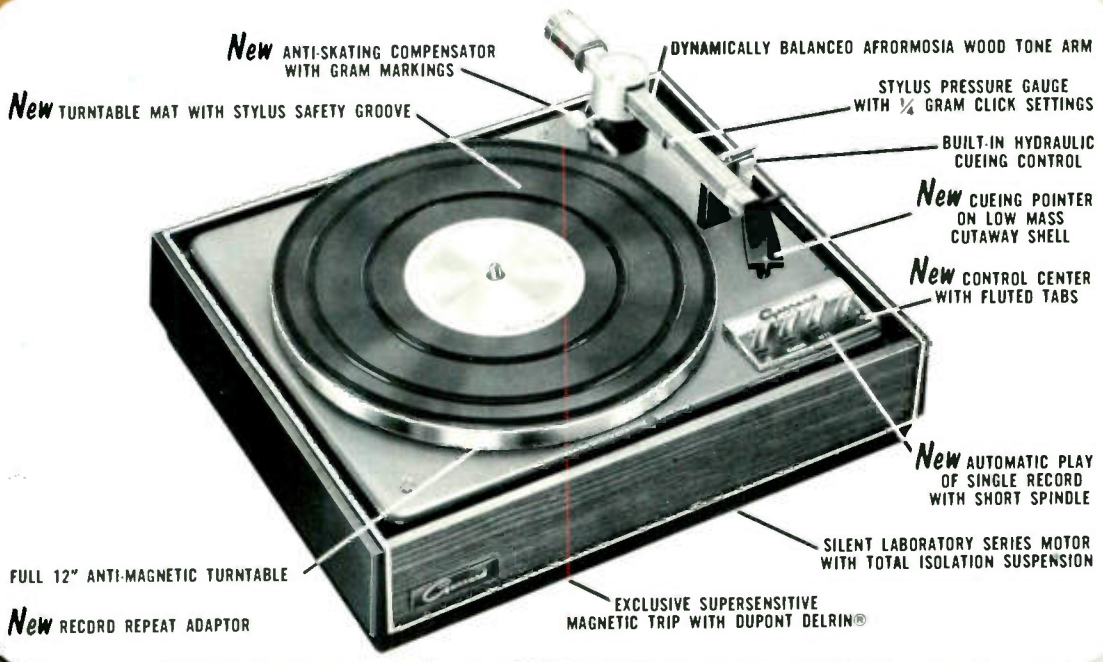
$99.50

less base and cartridge

Just two years ago, with the introduction of the Lab 80, Garrard set a spectacular precedent in record playing equipment – by combining precision, performance, and convenience to a degree not previously available in either single play or automatic units. Due to this extraordinary product, the entire industry has witnessed a revolutionary upgrading in fine record playing equipment.

Now, consistent with the Garrard leadership tradition, the Lab 80 Mk II is introduced. It is the Lab 80 brought to perfection . . . subtly but magnificently refined in appearance and engineering. All the Lab 80 developments remain, but in addition, there are useful new operating features. One of them is provision for automatic play of a single record. The Lab 80, which was the first automatic player to have an integrated cueing device, retains this outstanding feature, which differs from all other types since it is hydraulically operated. The anti-skating control introduced to the automatic field by the Lab 80, has been refined, with the compensator now calibrated at half gram increment markings, and employing a counterweight with a window to facilitate accurate settings. Refinements in the Lab 80 Mk II have been carried even to the turntable mat. It is now designed with safety rings which protect the stylus should the arm be lowered accidentally, without a record on the turntable.

The Lab 80 Mk II is also an outstanding example of ingenuity and good taste in contemporary product design, with its distinctive tone arm assembly, turntable and mat, and a newly styled, raised control center, with fluted tab operating levers.



Dynamically balanced, counterweight-adjusted tone arm, built of Afrormosia wood for light weight, low resonance.

New anti-skating control with patented sliding weight design. Does not use springs. Compensator is calibrated in ½ gram markings. Counterweight has window to facilitate accurate setting. With this control, the natural side pressure on the stylus which frequently causes distortion and rapid record wear, is eliminated.

Exclusive super-sensitive magnetic trip, with Dupont Delrin® to offset friction . . . performs perfectly with highest compliance pickups at correct minimal tracking force.

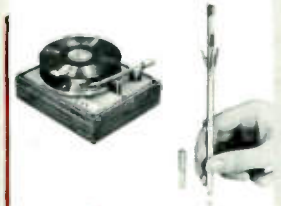
Newly styled control center with fluted tab operating levers.

Calibrated stylus pressure gauge with precision ¼ gram click adjustments for accurate audible/visible settings.

Built-in hydraulic cueing control eliminates all danger of accidental damage to records or stylus through manual handling. A great operating feature and tremendous convenience which permits selecting any band of the record with complete safety.

Low mass, cutaway shell with new cueing pointer and extended finger lift. Compatible with the most advanced cartridge designs.

New automatic playing of single records. Press AUTO tab. . . tone arm comes over and plays the record. At the end of the music it returns to rest and unit shuts off.



Two spindles – one for manual play, the other for automatic operation. Convenient short spindle interchanges with revolutionary center drop spindle, which handles 8 records fully automatically when desired.

New repeat adaptor fits over automatic spindle, repeats records as often as desired. Doubles as 45 rpm single spindle.

Full 12" anti-magnetic turntable – dynamically balanced for perfect speed.

New anti-static mat, featuring deep rings at 12", 10", and 7" positions, to protect the stylus against accidental damage.

Silent Laboratory Series® 4-pole shaded motor with vibration-proof total isolation suspension.

Specifications:
2 speeds: 33⅓ and 45 rpm. 100-130 volts, 60 cycles AC (50 cycle pulley available).

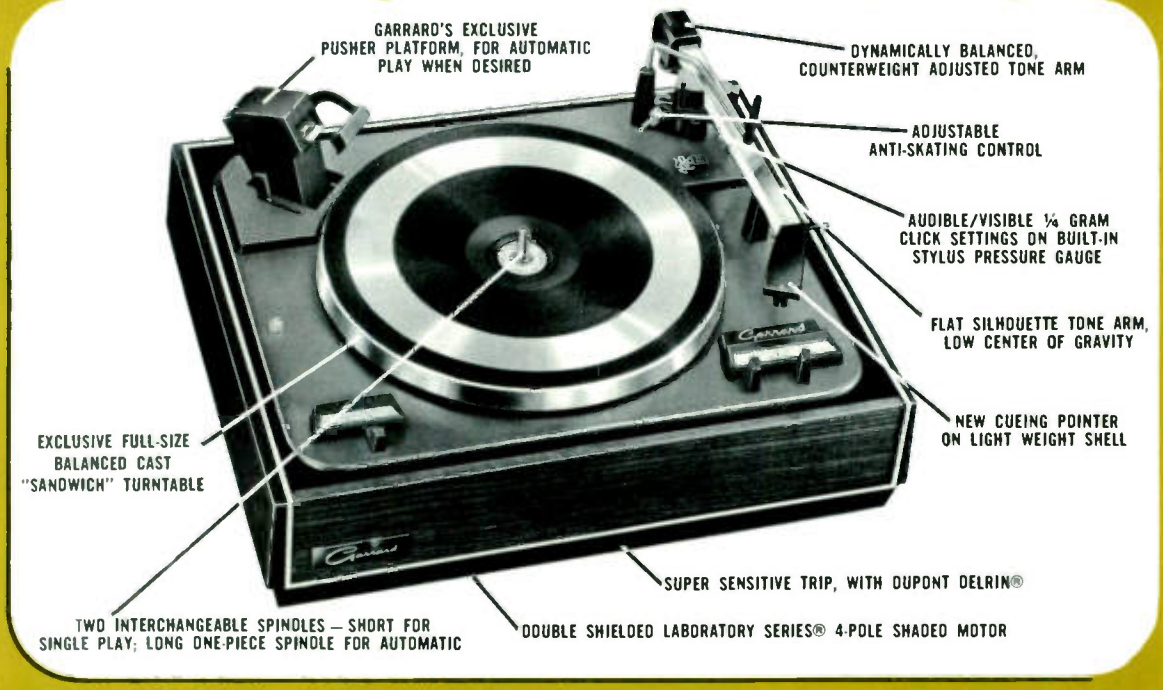
Minimum cabinet dimensions:
17" left to right; 14¾" front to rear; 5½" above and 3½" below motor board.

70
Mk II

AUTOMATIC
TURNTABLE

$84.50
less base and
cartridge

This is the aristocrat of record playing units . . . the ultimate expression of the automatic turntable concept which Garrard launched with the original Type A. It has been, and remains the most successful and satisfactory series of record playing instruments the high fidelity field has ever known . . . a perfect expression of the Garrard philosophy. Dealers throughout the industry, who for many years have been featuring the outstanding record changers which established the Garrard reputation for unassailable integrity, will recognize in the 70 Mk II certain familiar and proven features which have become indivisible from the Garrard name. As in previous models of this notable series, the 70 Mk II retains the exclusive Garrard pusher platform record changing principle . . . a classic mechanism which has never been equalled, much less surpassed, for gentleness or reliability. This feature is retained, and combined with other, new advancements, including an adjustable anti-skating control and a precision counterbalanced tone arm, designed to an exceptionally high standard. Because of its low mass and flat geometry, this tone arm provides the 70 Mk II with impressive advantages in tracking capability, and achieves outstandingly clean reproduction with modern cartridges. Thus, for reasons of quality, Garrard dealers everywhere not only carry the 70 Mk II — they are proud to feature it and recommend it.



The Garrard pusher platform record changing principle for automatic play when desired. Over 2 million of the Garrard units sold in this country alone, have featured this exclusive device. It is a smooth, silent, totally reliable mechanism which accommodates 10 records, dropping each one gently over a polished removable spindle containing no levers or moving parts.

Dynamically balanced, counterweight-adjusted tone arm. Low counterweight geometry establishes optimum center of gravity, assures accurate tracking, and enables arm to resist external jarring and vibrations.

Low mass cutaway slide-in shell with cueing pointer . . . locks positively into position; takes any cartridge, including very light, high compliance professional types. Extended finger lift.

Needle pivots set into miniaturized ball bearings, make vertical motion of tone arm virtually frictionless.

Calibrated stylus pressure gauge with precision ¼ gram click adjustments for accurate audible/visible settings.

Adjustable anti-skating control — "sliding weight" design. The natural side pressure on the stylus, which frequently causes distortion or rapid record wear, is eliminated.

Two-piece full size turntable . . . cast and balanced . . . . Unique sandwich design . . . actually two turntables balanced together, separated by a resilient foam barrier which damps out noise and vibration. Non-ferrous . . . will not attract magnetic pickups or affect tracking pressure.

Garrard Laboratory Series® shaded 4-pole motor, shielded completely, top and bottom, with accurately oriented plates which prevent any interference or hum, even with ultra-sensitive magnetic cartridges.

Super-sensitive trip with Dupont Delrin® to offset friction. Operates perfectly with highest compliance pickups at correct minimal tracking force.

Specifications:
4 speeds: 16⅔, 33⅓, 45 and 78 rpm. 100-130 volts, 60 cycles AC (50 cycle pulley available)

Minimum cabinet dimensions:
16¾" left to right 14⅛" front to rear, 6" above and 2⅞" below motor board.

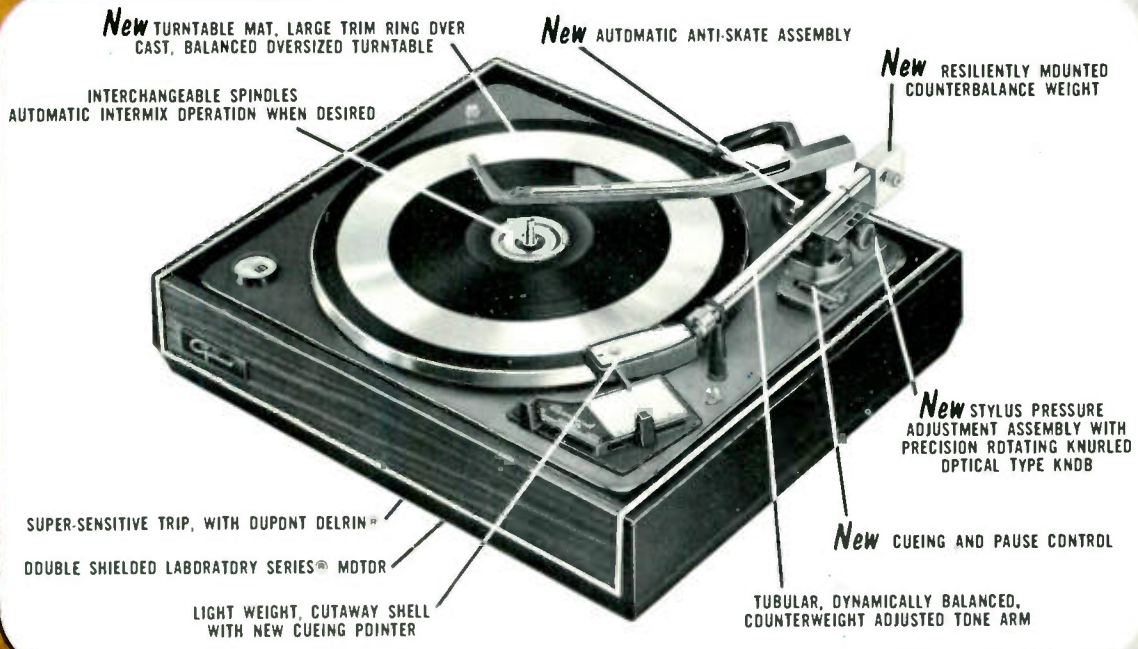
60
Mk II

AUTOMATIC
TURNTABLE

$74.50
less base and
cartridge

The basic design of this unit was developed from the AT60, recognized as a "best buy" among all automatic turntables. Now, the enhanced styling of the 60 Mk II includes a new turntable mat and the large trim ring, similar to that of the 70 Mk II. But appearance – handsome as it is – is only a minor virtue of the 60 Mk II. The selling appeal of this dramatic unit lies basically in superior performance, and it is richly endowed with engineering features, refined to assure excellent reproduction with the latest ultra-sensitive cartridges. The true dynamically balanced tone arm is of the most advanced construction. Rumble and resonance, already minimal in the AT60, have now been even further eliminated by a new resilient counterweight mounting. The arm system of the 60 Mk II will track flawlessly at ½ gram. Stylus pressure adjustments have been made more precise, and more convenient, by a new stylus pressure control assembly which incorporates the type of dial arrangement found in fine cameras and other precision optical instruments. Another key feature of the 60 Mk II is a new manual cueing and pause device. The tone arm may be placed safely on the record at any groove, or raised safely from the record at any time, by this simple, positive lever device.

Add to the impressive appearance of this model, and its impressive list of features, automatic intermix operation versatility, compact size, and modest price . . . and it becomes clear why the 60 Mk II will continue to be the ideal automatic turntable to satisfy the growing major market for high fidelity components.



Tubular, dynamically balanced counterweight-adjusted tone arm. Counterweight on new resilient mounting for absolutely minimal rumble or resonance. Same type arm and construction as on the highest priced automatic turntables and popular separate arms.

Built-in stylus force adjustment and pressure gauge. Precision knurled "optical instrument" type dial for easy, smooth, highly accurate setting of tracking force. Oversized indicia for very precise settings.

Automatic anti-skating control eliminates the natural side pressure on the stylus which often causes distortion and rapid record wear with ordinary tone arm.

New manual cueing and pause control permits placing the tone arm on the record in any position by use of cueing lever. Also acts as a pause device, since it can be activated at any point while playing a stack of records. Simply lift cueing lever and arm stays above the record as long as desired. When lowered, it resumes, and entire playing cycle continues.

Lightweight, cutaway shell with cueing pointer and finger lift. Positive, bayonet fitting.

Two spindles – a convenient short spindle for playing single records manually; an interchangeable center drop spindle for automatic play when desired. Spindles remove for safety and convenience when taking records off the turntable.

Cast, balanced, oversized turntable with new, decorative mat and large trim ring.

Ultra-compact – fits easily into any record changer space.

Super-sensitive trip, with Dupont Delrin® to offset friction, operates with any high compliance pickup at correct minimal tracking force.

Double-shielded Laboratory Series® 4-pole shaded motor designed exclusively for the 60 Mk II.

Specifications:
4 speeds: 16⅔, 33⅓, 45 and 78 rpm. 100-130 volts, 60 cycles AC (50 cycle pulley available).

Minimum cabinet dimensions:
15¾" left to right, 13⅛" front to rear, 4⅞" above and 2⅞" below motor board.

50
Mk II

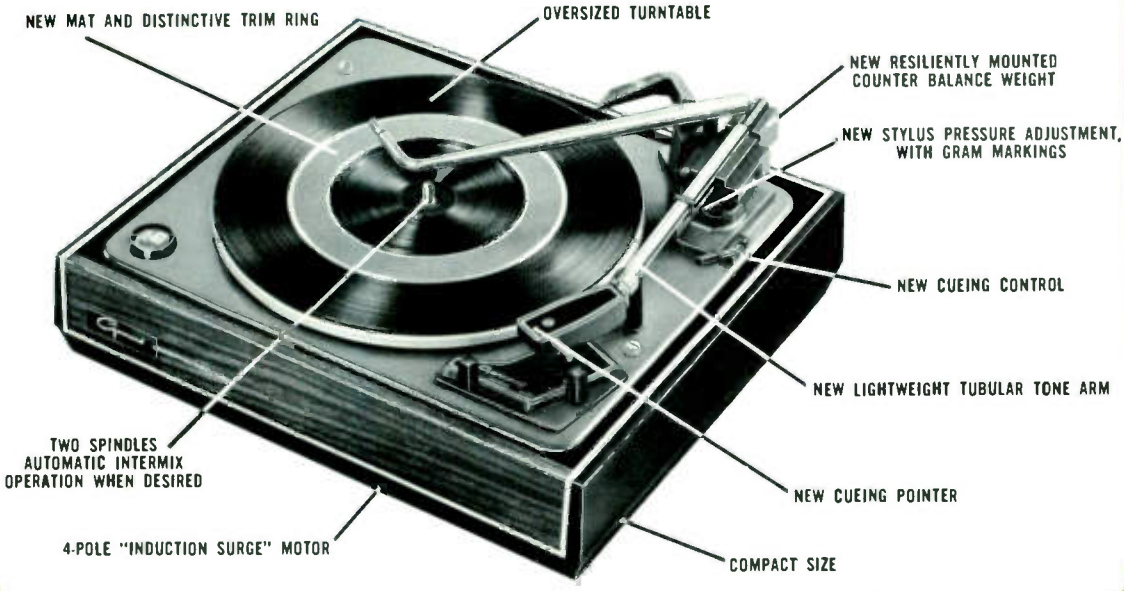
AUTOMATIC
TURNTABLE

$54.50
less base and
cartridge

Far from being keyed to the level of budget or even medium-priced music systems, the 50 Mk II deserves comparison with the most expensive automatic turntables. It will then become clear how much the Garrard organization has accomplished in this excellent new compact model. The dramatic impact of the 50 Mk II begins with the styling. It is chaste, functional and handsome . . . beautifully coordinated . . . with a quality appearance which is a tribute to the designers and engineers alike. The features are equally impressive. The tone arm is the excellent performing light weight tubular type, with a resiliently-mounted, fixed position counter-weight. The low mass shell will accommodate all cartridges, and the stylus pressure is set by moving a pointer along a gauge conveniently located on the side of the arm, which indicates heavier or lighter pressure by markings of varying lengths at 1 gram intervals.

Perhaps the most dramatic feature of the 50 Mk II is a manual cueing and pause device, operated by a control lever carefully located for utmost convenience. Simply lift the cueing lever and the arm stays above the record as long as desired. Lower it, and the arm gently lowers to the record groove. This control provides complete safety to records and stylus, and can be used at any time . . . to begin a single record, or to pause whether the unit is playing manually or automatically. Built-in cueing of the same type is now considered the single most desirable operating feature of the most expensive automatic turntables.

As with all Garrard automatic turntables, the 50 Mk II is a manual player, but it may also be used automatically – with intermix operation.



Ultra-compact – fits easily into any record changer space.

New manual cueing and pause control permits placing the tone arm on record in any position by use of cueing lever. Also acts as pause device, since it can be activated at any point, while playing a stack of records. Simply lift cueing lever and arm stays above the record as long as desired. When lowered, it resumes, and entire playing cycle continues.

Super-sensitive trip, with Dupont Delrin® to offset friction; operates with any high compliance pickup at correct minimal tracking force.

New light weight tubular tone arm, with fixed position counter balance resiliently mounted to eliminate rumble and resonance.

Newly designed lightweight plug-in shell with cueing pointer . . . Tone-arm safety catch for easy portability. Accommodates all cartridges.

New stylus pressure adjustment. Pressure is set by moving pointer on side of tone arm. Once pressure is established (with any stylus pressure gauge) markings on tone arm serve as a guide to continued accuracy and facilitate any readjustments desired. Markings are at approximate 1 gram intervals, with longer markings indicating increased pressure.

Oversized turntable with distinctive mat and trim ring.

Garrard 4-pole shaded "Induction Surge" motor, with dynamically balanced rotor, shielded from hum. Constant speed assured, free from vibration.

Two spindles – a convenient short spindle for playing single records manually; an interchangeable center drop spindle for automatic play when desired. Spindles remove for safety and convenience when taking records off the turntable.

In automatic position, 50 Mk II intermixes records of any size or sequence.

Specifications:
4 speeds: 16⅔, 33⅓ 45 and 78 rpm. 100-130 volts, 60 cycles AC (50 cycle pulley available).

Minimum cabinet dimensions:
14⅞" left to right, 12½" front to rear, 4⅝" above and 2⅞" below motor board.

40
Mk II

AUTOMATIC
TURNTABLE

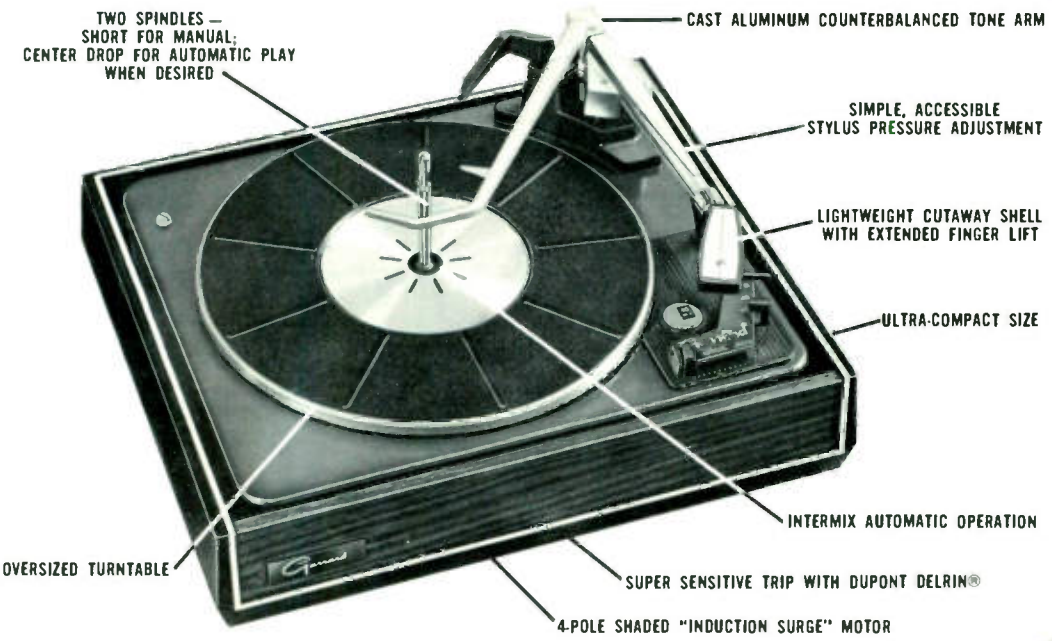
$44.50

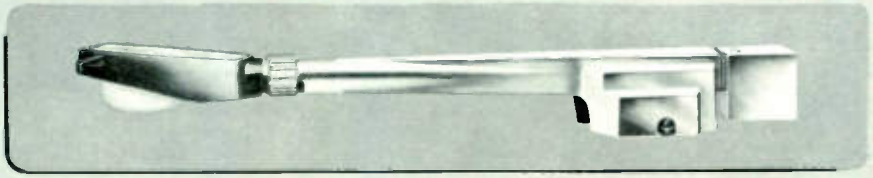
less base and
cartridge

Built to Garrard's highest standards, this handsomely designed 4-speed unit is actually an exceptionally compact automatic turntable at the price of an ordinary record changer!

It was designed to introduce a new concept of performance and versatility to systems where space must be considered. Despite its modest price, dealers large and small, in all parts of the country, have included its predecessor in the overwhelming majority of advertised music systems which they preselect. These dealers are aware that they can combine the 40 Mk II with the finest amplifiers, receivers and speakers, and offer them to their most discriminating customers assured that it will be compatible and an enduring credit to their judgement.

The widespread dealer confidence which this Garrard model type has earned, is as significant as the impressive list of features which the 40 Mk II offers. This is the lowest priced Garrard automatic turntable, but all Garrards must meet the same high standards of quality. The 40 Mk II may be purchased with complete assurance that it will serve its purpose admirably, operating with utmost reliability from the beginning, and for years to come.





Shell is lightweight cut away type with extended finger lift for safety in handling. It plugs in . . . accommodates widest personal choice of cartridges . . . can be removed from the arm instantly to change cartridge or service stylus.

Super sensitive trip, with Dupont Delrin® to offset friction, operates with any high compliance pick up at correct minimal tracking force.

Stylus pressure adjusted with simple, accessible finger touch device, for correct tracking force, according to the cartridge manufacturers' specifications.

Garrard 4-pole shaded "Induction Surge" motor, with dynamically balanced rotor, shielded from hum. Constant speed assured, free from vibration.

Graceful cast aluminum tone arm is counterbalanced — first time this type of arm has been available in a popular priced unit. This feature alone gives the 40 Mk II particular significance — an automatic in the economy field which can track high quality cartridges for finer sound reproduction.

Oversized turntable with handsome mat is reminiscent of previous Garrard models in a considerably higher price echelon.

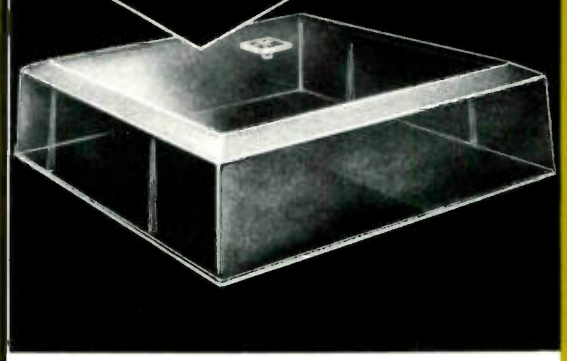
Two spindles — a convenient short spindle for playing single records manually; an interchangeable center drop spindle for automatic play when desired. Spindles remove for safety and convenience when taking records off the turntable.

In automatic position, 40 Mk II intermixes records of any size or sequence.

Specifications:
4 speeds: 16⅔, 33⅓, 45 and 78 rpm. 100-130 volts, 60 cycles AC (50 cycle pulley available)

Minimum cabinet dimensions:
14⅞" left to right, 12½" front to rear, 4⅜" above and 2⅞" below motor board.

COORDINATED
DUST COVERS and BASES



A new "playing" dust cover for use with all Garrard models, and coordinated with the official Garrard base, is designed so that it can be used when playing a stack of records.

The dust cover is made from a clear styrene for durability and crystal-like clarity.

An emblem at the top center of the cover has been attractively designed to be used as a handle for easy placement and removal.

You can now lift or grip the cover with one hand and eliminate any fingermarks on the clear plastic.

DC89 — Lab 80 series, 70 and Type A series. (Also the 88 series.)	$5.50
DC10 — For 60, 50, 40 and 20 series. (Also for AT6 and Autoslim.)	$4.50

Beautifully styled and executed base, with a model coordinated to each Garrard player.

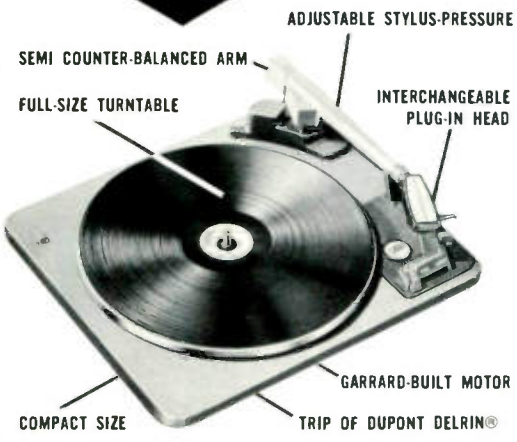
Made of simulated ebony and walnut and highlighted with silver trim and the Garrard escutcheon.

It is lightweight, strong and durable, an attractive companion accessory which enhances the appearance of each Garrard model.

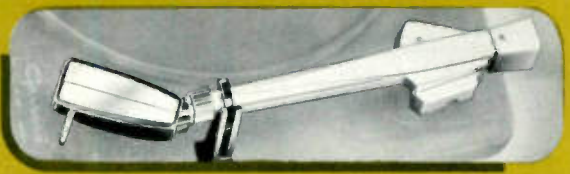
It can be used on top of furniture or housed in cabinetry. Provisions for easy mounting of draw slides have been built into the underside of the base.

CB 8 — For 70 series and Type A series. (Also the 88 series.)	$5.50
CB 9 — For Lab 80 series.	$5.50
CB10 — For 60, 50, 40, and 20 series. (Also for AT6 and Autoslim.)	$4.50

SP20
4-SPEED MANUAL RECORD PLAYING UNIT
$37.50



It is a compact, efficient, 4-speed manual player, particularly recommended for basic stereo music systems and quality audio-visual applications.



- Interchangeable plug-in head, for any cartridge
- Semi-counterbalanced arm with adjustable stylus pressure
- Trip of Dupont Delrin® . . . track as light as 2 grams
- Motor designed and built entirely by Garrard
- Full size turntable
- Size — Compact 14⅜" left to right, 12½" front to rear, 3½" above and 2⅛" below motor board.
- Automatic return of arm to rest and shut-off after play

Prices and specifications subject to change without notice.

continued from page 3

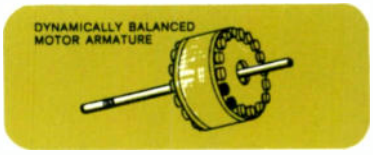
electrical interaction with the cartridge . . . are all things of the past. If you wish to see an example of fine metal craftsmanship, lift a Garrard Lab 80 turntable and inspect the bottom. Note the ribbed, rigid structure and the copper weights which balance it, as on an automobile wheel.

However, the turntable itself is not the entire story – for the mat receives a full share of attention. A Garrard mat is an object of beauty. It is also a challenge to engineering ingenuity. Perfect example of this is the exclusive material Garrard formulated for the Lab 80 mat. It protects the record, but is also anti-static – tending to discharge the electrical force which attracts dust to the record. This feature is more than a flourish, since it helps to protect records from their greatest enemy . . . dust. Also note the deep safety grooves at the 7", 10", and 12" positions, incorporated by Garrard to protect the stylus, should the automatic tab be pressed accidentally. The stylus would then ride in these special grooves without damage.

Motor

Under the turntable are the motor and drive assembly. Garrard has traditionally used the shaded induction motor, recognizing that the key consideration in power plants is not type but quality. The differences in viewpoint over induction vs. hysteresis principles were resolved many years ago when Garrard introduced the smooth, completely reliable 4-pole type, to replace the 2-pole motors which were then in general use.

The present precision-made Laboratory Series motors used in the Lab 80 Mk II, 70 Mk II, and 60 Mk II, were developed entirely by Garrard, which designs and builds its own motors completely.



Armatures are dynamically balanced on exclusive machines . . . built for Garrard specifically for this purpose. Regardless of which Garrard model you own, you are assured that the motor will be exactly the right size and power to turn silently and smoothly, at perfect speed, without any service whatsoever for years. The Laboratory Series motor will maintain its speed within NAB standards, even through the unlikely line voltage variation of 95 to 135 volts. The construction is exemplary, with refinements such as oilite bearings used to make the unit flawless and ageless. Garrard also takes pains to insure that even the slightest vibration of the motor cannot be imparted to the record via the unit plate or turntable. Rubber mountings are incorporated in all Garrard units. In the Lab 80, there is something additional . . . a coordinated suspension system of rubber anti-vibration mountings and damping pad devices which isolate the motor completely from the unit plate. You can move the entire motor structure freely by hand. Try it at your Garrard dealer. You will be impressed. Incidentally, speaking of motors and drive assemblies, we should also mention that one reason why Garrard equipment lasts so long is that every lever is adjustable – with bronze bushings wherever needed. This construction, used 18 years ago in the RC80, made it the phenomenal success it was, and is – since the majority of these machines are probably still in use, almost two decades after they were purchased. Garrard automatics are built of a greater number of adjustable small scale components – rather than fewer, unadjustable large scale stampings and castings, which although simplified, may be subject to warping and misalignment. Therefore – Garrards take more hours to assemble than mass produced record players, but in the long run, it pays . . . because any Garrard is virtually indestructible.

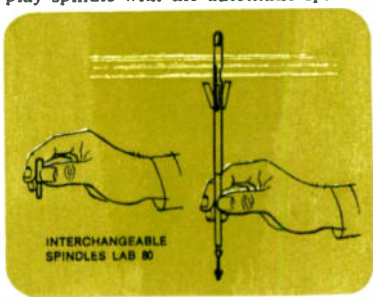
While on this subject, consider some of the refinements which Garrard has brought into automatic record players (all record playing units for that matter) over the years. For example, the muting switch, which keeps the unit perfectly quiet except while a record is playing (first incorporated by Garrard in the RC88 more than 10 years ago); the resistor/condensor networks incorporated by Garrard 12 years ago, eliminating the annoying electrical discharge "plop" which used to startle record listeners in the early days of high fidelity. Then – there is the question of wiring and installation. Ever since the RC80, all Garrard automatics have come fully equipped with UL approved wiring. Garrard introduced it. Before this, you would have had to solder the various cables to the record player before you could incorporate it into the music system. Now, due to Garrard, the changer is simply plugged in. Not only are the AC wires installed, but the twin stereo cables and plugs are already attached, with a 4-pin 5-wire system – separate ground connections – ideal wiring because it eliminates the problem of hum. And, this is done with Amplok connectors for AC and twin female phono sockets on the unit plate – so that a Garrard can be connected or disconnected instantly from the music system. Today, these conveniences may seem elementary, but they simply were not provided until Garrard research paid them the attention they deserved.

Automatic and Manual operation

As far back as the 1930's, Garrard had already developed and incorporated an automatic record handling device known as the pusher platform. Those were the days of gates, scissors, and other changer mechanisms equally murderous to records. The Garrard pusher platform revolutionized all automatic record changers, and established Garrard, even at that early date, as the outstanding . . . indeed (many will say) . . . the only really reliable record changer in the market. When the LP era and high fidelity began, this same pusher platform, refined in action and appearance, was built into the RC80 . . . and Garrard has kept it to this day.

On pages 6-7, you will see the latest version of this fine completely reliable mechanism, on the 70 Mk II. Today – we have the benefit of a tremendous number of these mechanisms built, most of which are still in operation. It is a classic example of how Garrard will retain an unsurpassed principle while incorporating legitimate improvements.

But recent developments, emphasizing the need for clearing the top of the automatic to add convenience – called for a new type of automatic arrangement, and resulted in the revolutionary single spindle introduced in the Lab 80. Here, no adjustments are made in converting from single play to automatic. It is done by simply replacing a short single play spindle with the automatic spindle.



Place a stack of eight records on top of the spindle, and this transcription turntable instantly becomes a fully automatic changer. Compare the Garrard spindle with others that, at first sight, may resemble it. Note the wide record support which only the Garrard spindle affords. Cup your hands at the sides of the turntable. Let a record drop and feel the cushion of air which explains why the record falls so gently . . . and suddenly the words "Garrard engineering ingenuity" will hold new meaning for you.

The other three Garrard automatics have the more usual spindle and overarm arrangement, which makes them more compact and provides the intermix feature. Here again, the automatic spindle is removable and a short single play spindle can be substituted. There is never any reason to take a record off a Garrard unit by pulling it awkwardly over a locked-in spindle.

Now, play the record. Note that however light the tracking force, the Garrard will shut itself off at the end of the record (or stack). Also note how reliably and silently it will trip – go into automatic cycle – at that same minimal pressure. This is due to the material which Garrard has applied for the first time to this use . . . Dupont's remarkable Delrin® . . . often called the "slippery plastic." The quietness of Garrard automatic tripping is due to the ingenious use of silent materials and the elimination of friction, but the Lab 80 goes even further. There, Garrard engineers have replaced the mechanical contact which begins the tripping process in every other automatic, with the principle of magnetic repulsion. Because of this, it can be said that the Lab 80 will trip at virtually zero stylus pressure. Ingenious it is . . . but more important, it permits the Lab 80 tone arm to operate at the lightest tracking forces in the industry, with the most sensitive and advanced cartridges. As with all other Garrard innovations, this one was developed and is used for only two purposes – better musical performance – longer satisfaction.

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STEREO ANTENNA

Continued from page 33

Thick wall masts from an inch and a half to two and a half inches in diameter are available at suppliers and cost about eight or ten dollars. One cable running up the mast in *Fig.* 23 is a shielded 300-ohm twin lead and the other is the control cable for the rotator which is visible at the top of the picture. Because the transmission line is shielded, it can be taped to the mast. A standoff is used to hold both cables after they leave the mast, but any other type of clamp would have been suitable.

If unshielded twin lead were used in an installation such as this, special mast standoffs would have been needed to keep the cable away from this conductive surface, and away from the rotor wire.

A block diagram of this antenna installation with the three transmission line types available for use is illustrated in *Fig.* 24. Note that the cable shields are not used to ground the antenna mast, which should definitely be grounded. Grounding the mast ensures that the current maximum on each antenna element will occur at the center of the element, yielding the desired radiation pattern from the yagi or log periodic dipole array.

To connect more than one receiver to the same antenna system (something not advised if signal levels on stereo broadcasts are marginal) a hybrid is called for. The hybrid T is a device which provides a power split with isolation between the two devices accepting the power. Refering to *Fig.* 25 if the antenna delivers signal into arm A of the hybrid, the T will split the energy equally and half the power will appear at arm 1 and half will appear at arm 2 (neglecting losses in the T, of course). But any energy appearing at arm 1 from the device connected to this arm will appear at arm 2 at a much lower level, typically about 10 dB down. Thus if the receiver connected to arm 1 were to radiate energy from its local oscillator, the hybrid T would attenuate this local oscillator energy 10 dB before it reached and interfered with reception in the tuner connected to arm 2. Local oscillator radiation, incidentally, is the interference that is often seen on TV screens when two receivers are connected to a single antenna, and the method of coupling the two to the common line is inadequate with regard to cross-coupling reduction. A good hybrid T would correct interference such as this. Make no mistake. The hybrid does not magically eliminate the 3-dB signal loss that goes with any equal power split. But it

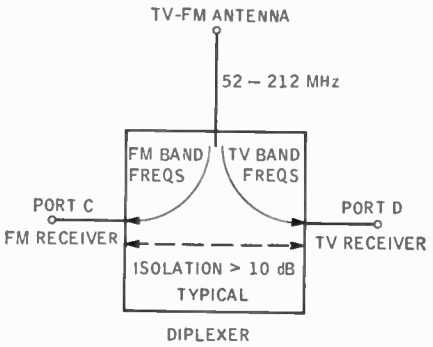

Fig. 28. Block diagram of diplexer operation.

does prevent the devices that accept the energy division from interfering with each other. Hybrid connections in a system are evident from *Fig.* 25.

Just in passing it might be well to mention the other methods of coupling receivers to the same antenna system. There is of course the direct connection which provides no isolation between receivers at all. It is made by connecting a piece of transmission line in parallel with the existing line. The second receiver is connected to the other end of the line. It suffers from the interference problems just mentioned.

Some T's couple using resistive elements to reduce interference, as illustrated along with direct coupling in *Fig.* 26. This is undesirable because power is wasted in the resistive elements.

Two Antenna Systems on One Mast

If two tuners capable of simultaneous operation are a requirement of a

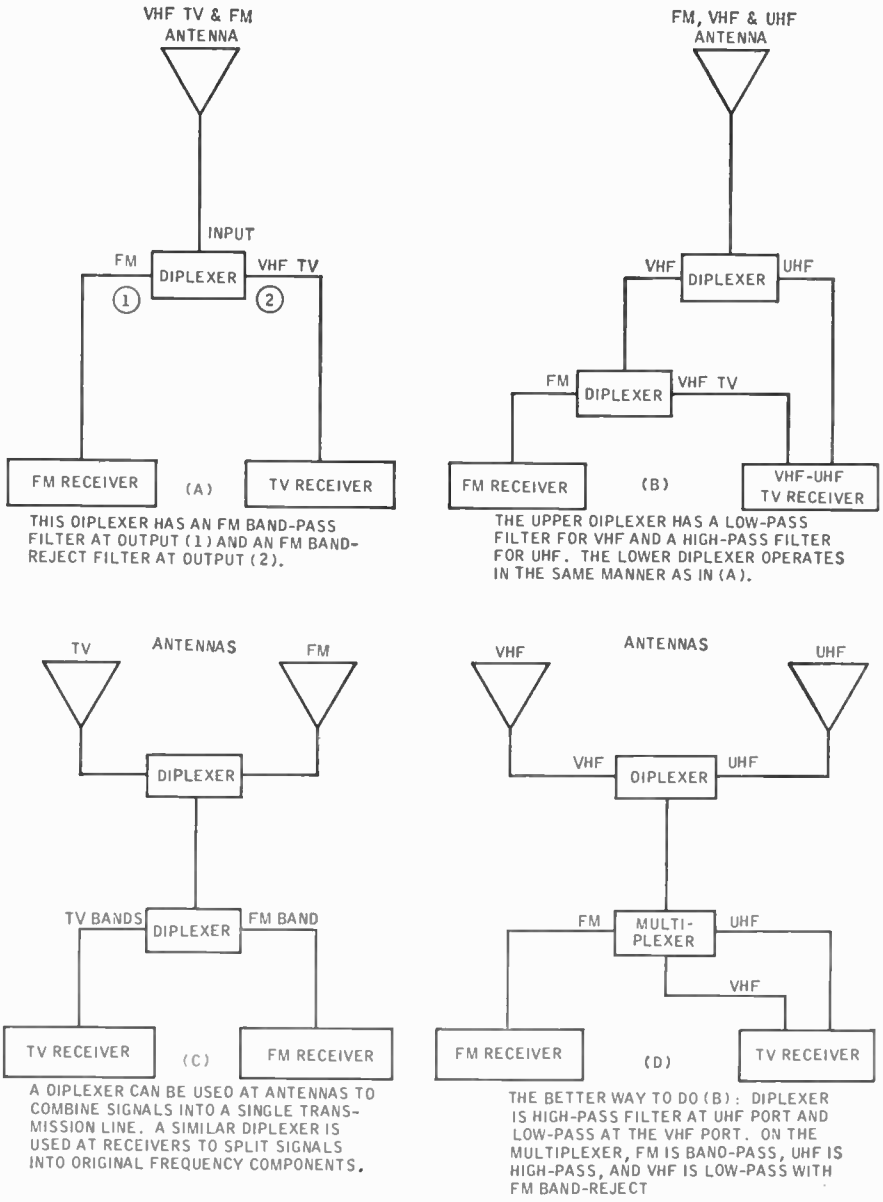

Fig. 29. Typical uses of diplexers and multiplexers.

particular audio installation, an antenna system for each is best for optimum signal transfer to each receiver. Both antennas in the system can be mounted on the same mast if they are spaced an adequate distance apart, or aligned at right angles to one another. The same is true of a single receiver which for some reason must use two separate antenna systems selectable by a switch, or for a single mast carrying both TV and FM receiver antennas.

As long as two antennas on the same mast are spaced greater than a half-wavelength apart at the lowest frequency of operation, the effect on the impedance of one by the presence of the other will not be great and the two can be used satisfactorily in this manner. If unshielded twin lead is used to feed the dual antenna installation, one twin lead should be placed on the opposite side of the mast from the other. No installations such as that pictured in *Fig.* 27, if you please. Here, both antennas are situated in close proximity, and the unshielded twin-lead transmission lines are run together in the same standoffs. Both the pattern and impedance of the antennas are degraded and a high level of cross coupling between the transmission lines exists.

Utilizing Existing TV Antennas

Although not by any means an optimum antenna system for FM, the TV antenna possesses one main advantage to the person who requires an antenna for an FM receiver. It's available and already installed. In addition the arrival on the scene of log periodic, frequency independent (relatively speaking, of course) antennas recently has given rise to the hope of an all-purpose VHF TV, FM, UHF TV Antenna for home use.

Connection to this antenna system can be made by the direct and resistive methods touched on earlier, if the disadvantages of these types of connections can be tolerated. The best way of combining both FM and TV on the same antenna system, however, is through the use of a diplexer. The diplexer is similar in operation to the hybrid, except that it operates on two different frequencies of frequency bands. As such, the hybrid shown in block form in *Fig.* 28 delivers all the FM-band signal at the input to output port C and all the TV-band signal to output port D. In addition it provides isolation similar to that of the hybrid between ports C and D.

The diplexer is a specific form of a general device termed a multiplexer. The multiplexer works in the same manner as does the diplexer except that more than two different frequency bands are involved. Almost any number of bands can be covered by a multiplexer, and there are units available for home antenna system installations that split into Low VHF TV, FM, High VHF TV, and UHF TV. Often these units will recombine the High and Low VHF in a diplexer that is included within the multiplexer package! Hybrids connected in various installations are shown in *Fig.* 29. Where the hybrid is placed in the line depends on the losses of the line at a particular frequency. For example, if a VHF, UHF, FM Multiplexer were used and minimum line loss were desired at UHF (where losses tend to be greatest) it might be wise to connect the multiplexer near the antenna and use the line configurations shown in *Fig.* 30. Most diplexers will be located after a fairly long run of transmission line from the antenna. In this case, this run of line from the antenna down to the diplexer is the determinant factor in total system loss.

Baluns

Almost all the antennas available for FM reception require balanced feed voltage. As was the case with a balanced transmission line, the antenna signal at one input terminal varies about ground at equal potential to, but 180 deg. out of phase with, the signal at the other input terminal. This is satisfactory for use with any balanced line of proper impedance, but as stated earlier, causes currents to flow on unbalanced lines of the coaxial type. To prevent currents on the outside of the coax shield and also to effect the impedance transfer from antenna (300 ohms) to coaxial cable (72 ohms) a balun is required. Balun is, quite literally, short for "balanced to unbalanced." The balun is in most cases installed at the antenna between a short piece of 300-ohm twin lead to the antenna terminals and the coax to the receiver. The antenna system illustrated in *Fig.* 31 utilizes a balun to transform from 72 ohms unbalanced to 300 ohms balanced at the antenna. There are a great number of ways to construct a balun, but most of the large number that are available from electronic suppliers are the bifilar type. A bifilar-wound balun is a broadband device suitable for use over both TV and FM bands.

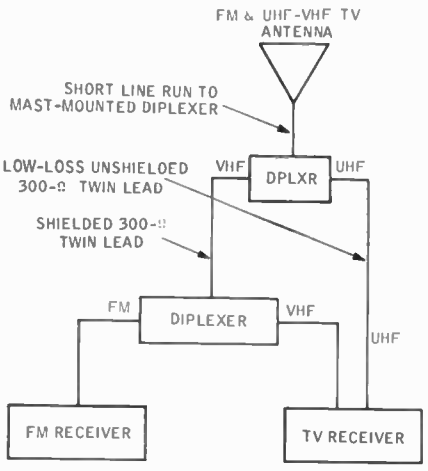

Fig. 30. Installing one diplexer on the mast permits the use of optimum transmission lines for each frequency band. Unshielded line must be carefully routed to prevent signal degradation due to impedance mismatch.

When selecting a balun for use in a coax system, three basic things are important. First, the balun must be made to withstand environmental conditions just as does the transmission line and antenna. Second, it must cover the frequency band of interest. And third, it must have minimum insertion loss over this frequency band.

Distributing the Signal

Certain antenna system installations use tapoffs throughout the house to allow mobility for the receiving system. While this is not a recommended way to install an antenna system, there are many among us who will find a distribution system like this a necessity. When purchasing outlet boxes or tapoffs for a system such as this, anti-stub effect boxes are often recommended. An open transmission line paralleled with the main feed line does not necessarily look like an open at the point where it connects to the feedline. Depending on the length of this parallel line, which is known as a stub, the impedance at the connection can vary from an open to a short and can be either capacitive or inductive in reactance. Anti-stub effect outlet boxes are tapoffs of extremely short length to minimize any added reactance and keep the connection point appearing as an open circuit. The major trouble with this type of distribution system is that when a connection is made to any point other than the end of the line, the remaining transmission line looks like a very long stub. The way to get around this is to use hybrids for all tapoffs. A number of outlet boxes available commercially are in fact hybrids packaged for installation in distribution systems, and they are recommended strongly

(Continued on page 114)

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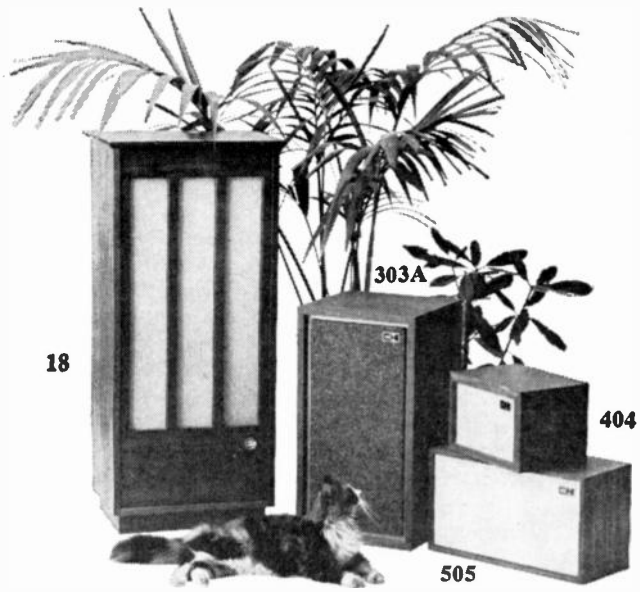

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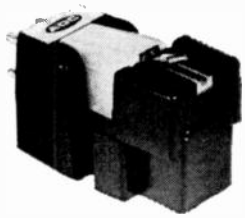

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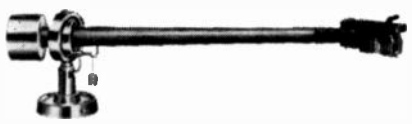

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Can We Hear Phase? | Yes! No!

The age-old question of whether or not we can hear phase differences of the harmonics which make up a complex tone is again attacked by a competent observer. But is the question finally answered so we may accept the conclusions as final proof? At least the test methods appear to be reliable.

R. A. GREINER
Professor, College of Engineering,
Department of Electrical Engineering
University of Wisconsin, Madison, Wisconsin 53706

OVER THE PAST SEVERAL YEARS, there have been many comments published which refer to the audibility of phase shifts in the harmonic structure of acoustical signals. Some authors have claimed to be able to hear even small phase shifts near the ends of the acoustical frequency spectrum. Others claim that the ear is completely insensitive to phase. Much of what has been written is not well founded on actual controlled experiments and is in fact hearsay or opinion based on casual experiments. Casual listening seems to indicate that one cannot hear phase shifts as changes in sound quality while more careful listening experiments show that there is something "going on" when one modifies the phase response of a system substantially. It is not clear, however, exactly what is "going on" since the acoustic and psychoacoustic phenomenon are complicated and closely tied together.

What follows is a brief review of the present beliefs held by most physiologists regarding the audibility of phase in acoustic signals followed by a more detailed description of some experiments in listening done by the author over the last several years. These experiments and the conclusions drawn from them are not, of course, the final word on this complex subject but they are interesting. They show that it is reasonable to say that we both can and cannot hear phase depending on the precise details of the acoustic situation. They show that any experiments in listening are complex and must be interpreted with great care. They show that most of the statements on the audibility of phase are not really wrong but just oversimplified or overgeneralized by the authors. They show that what we know we hear must be attributed to a cause with caution.

A review of what is known about the audibility of phase immediately reveals that much attention has been given to this original statement by Helmholtz in his *Sensations of Tone* . . . "the quality of the musical portion of a compound tone depends solely on the number and relative strength of its partial simple tones, and in no respect on their differences of phase." In this passage Helmholtz is clearly referring to experiments involving the generation of complex tones having several randomly phased components and the fact that phase does not in any way change the timbre or quality of the tone. Experiments have been performed by many investigators and have shown agreement with Helmholtz on this point. In the experiments described below this result is again verified. More precisely, we should state Helmholtz's pronouncement with the following qualifications. *The quality of a compound tone consisting of harmonically related components when perceived at a low sound pressure level and in an acoustically dead environment depends solely on the number and relative strength of its partial simple tones and in no respect whatsoever on their differences in phase.*

However, this statement does not mean that we are in fact absolutely phase deaf. Helmholtz himself gives a clue to the type of signal in which phase may be audible in the same reference. The essence of his remarks is as follows. We were not able to perform experiments with essentially non-musical tones in which the upper partials are close together in frequency, controlled in phase, and not

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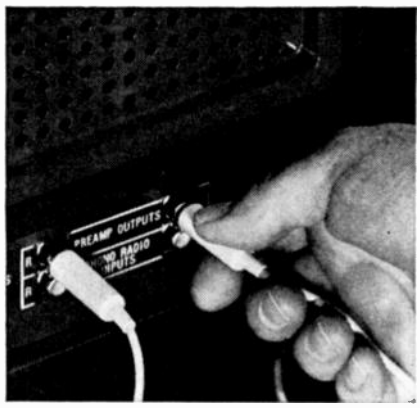
Takes two to swing. If you already have a second tape recorder on hand, you're ready to get started. If not, find a good friend that will lend you his. But do be particular about your friend. Because that old cliché about the weakest link applies in spades as far as dubbing equipment goes. Also be particular about the tape you use . . . but as they say on radio, more on this later.



Read the instructions. First off—and though it may seem obvious—make sure your two tape systems are in the best possible condition. Look at it this way—the dubbed recording will be at best a second generation recording . . . it's going to combine all the deficiencies present in your original tape recording, in the playback recorder, and in the recording equipment. So read both instruction books . . . then clean the heads with one of the commercial preparations available for that purpose . . . and demagnetize the heads if you can lay your hands on a degausser.

Next, connect your two tape machines—the "master" and the "slave." If you have a choice, take your output from the master at the pre-amp stage rather than at the amplifier. No reason to add its distortion to your dubbing. For the input to the slave, you usually have a choice—one marked "mike" or "high-impedance" (usually in the 50,000-200,000 ohms range), the other marked either "radio," "phono," "tuner," "tape" or "low-impedance" (in the 500-ohm range). You want the latter one.

Choose your tape. Signal-to-noise is the touchiest area in dubbing. Picking a tape that will give you the lowest noise level on the duplicate without lowered output makes a lot of sense. We've got just the tape for you: KODAK Sound Recording Tape, Type 34A. It packs five or more additional decibels of undistorted output than the usual low-noise tapes. When dubbing on KODAK Sound Recording Tape, Type 34A, set the recording level on your slave unit at 4 decibels over your normal level—that's just slightly higher than normal if you set your level by a VU meter. Because you can put a lot of signal on this tape, you can play it back at lower gain . . . and, Eureka, there's your low noise!

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necessarily harmonically related and "hence we must leave it for the present doubtful whether in such dissonating tones difference of phase is an element of importance. Subsequent theoretic considerations will probably lead us to suppose that it is." Thus not only did Helmholtz realize the limited scope of his experiments but he pointed out the very type of tone which has proven to demonstrate that we are not phase deaf in some circumstances. Twenty years ago Mathes and Miller generated signals electronically which consisted of three tones. The signal frequency, f, and two sidebands, $f - f_1$, and $f + f_1$. By adjusting the phases of these signals one can generate essentially an amplitude-modulated signal or a frequency-modulated signal similar to those shown in *Fig.* 1. The phase difference alone accounts for a substantially different sound between these two signals. The first (AM) sounds rough while the second (FM) sounds smoother and of more correct pitch. Several other waveforms can be contrived which show that subjective differences in sound can be attributed to phase differences alone. Thus Helmholtz's suggestion seems to be correct. Three conditions are required for these contrived tones to show subjective quality changes with phase. They are (1) the important components must be close together in frequency, (2) the phase changes must make a clear cut change in the envelope of the signal, and (3) there must not be too many frequency components present in the compound signal. These three requirements are rather severe and establish a situation for detecting subjective phase differences which is essentially non-musical and probably not likely to occur in normal musical reproduction. The existence of the latter results cause enough complication in our theories of hearing however to allow open conjecture about the audibility of phase differences in both periodic and non-periodic transients. It is so immensely difficult to perform transient listening tests and interpret the results with any certainty that they have been largely ignored by most experimenters. We must await entirely new and different techniques before receiving the benefit of such tests. The tests carried out and discussed below are steady-state tests for this reason. Still, the results add much to pinpointing the source of the various effects which have been reported in the literature so they are of interest.

Description of the Listening Tests

Basically, a complex tone in which both the amplitude and phase of the harmonics can be adjusted was generated and listened to via a series of different headphones and loudspeakers and in listening rooms with widely different acoustic characteristics. There are so many possible variables to adjust that only a few can be reported on at this time. Those selected are the ones which best pinpoint the causes for differences or apparent differences in the subjective quality of the test tones. Many experiments were tried which did not help clarify the nature of the acoustic phenomena taking place.

The basic signal or tone consisted of a fundamental sinusoidal waveform to which the 2nd, 3rd, 4th, 5th, and 7th harmonics could be added in any arbitrary but steady-state amplitude and phase relationship. Suitable power amplifiers, oscilloscopes, wave analyzers, meters, and so on were used as required. All equipment had wideband, low-distortion characteristics and was accurately calibrated. Calibrated capacitor microphones and associated equipment were used to check the acoustical waveforms generated by the loudspeakers and headphones and to establish the absolute sound-pressure levels used in the tests. Several high-quality headphones were used and at least four separate speaker systems ranging from a single cone radiator to a large multispeaker system, and including an acoustic suspension system, were used in the tests. Two rooms were used which are categorized as live and moderately dead. The live room was about 1500 cubic feet in volume and very live. All surfaces were tile, glass, and terrazo with no soft furniture at all. The moderately dead room was about 3500 cubic feet with acoustical tile, carpets, and soft furniture. The latter would be similar to any typical, good listening room.

Several listeners were used to get a concensus on the quality changes being evaluated in these experiments. "No change" indicates unanimity of opinion as does "substantial change." "Possible change" means some difference of opinion but if any very slight. In addition to listening with headphones and loud-speakers, several modes of listening including monaural and binaural were tried. Also a so-called close listening test was performed by listening at a distance of six to eight inches from the loudspeaker. This scheme effectively reduced the relative importance of room

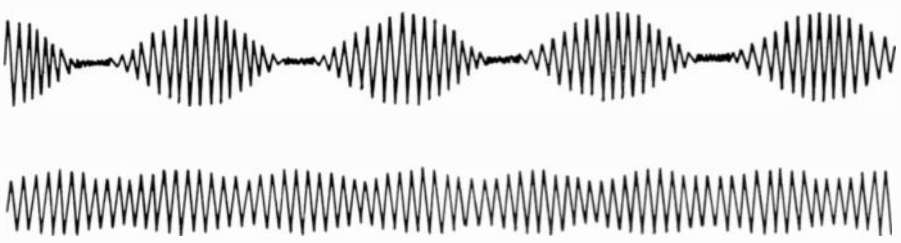

Fig. 1. A special waveform consisting of a signal of frequency, f, $f + f_1$ and $f - f_1$. The phase of the two sidebands can be adjusted to give an amplitude-modulated signal above or a smoother frequency-modulated signal below.

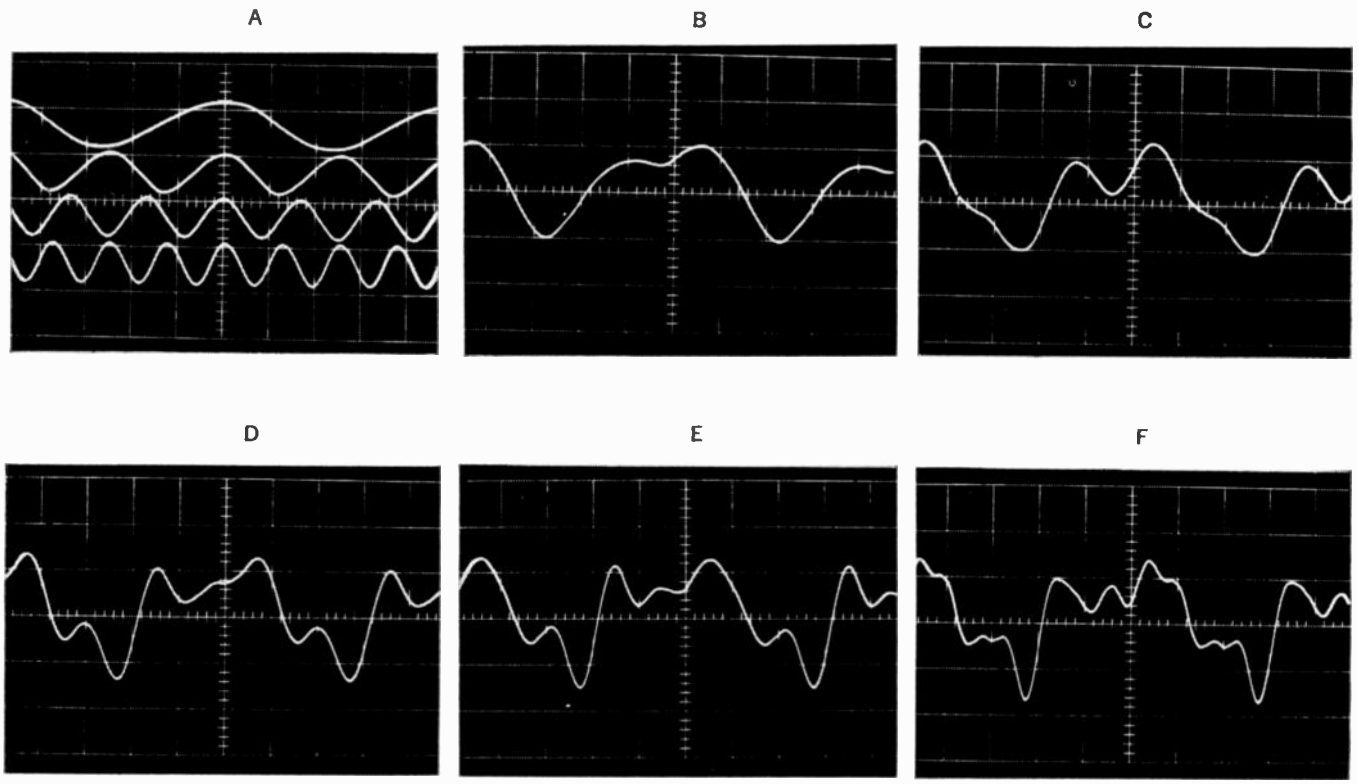

Fig. 2. The six waveforms shown demonstrate the variety which can be synthesized from a fundamental and five harmonics. See text for details.

acoustics and tended to verify the headphone results.

The Test Signals

A closer look at the test signals used is informative. We find a substantial variety of waveforms, as observed on an oscilloscope, can be generated with the fundamental and five overtones available. The six waveforms shown in *Fig.* 2 demonstrate this variety. In (A) we see the fundamental and the 2nd, 3rd, and 4th harmonics all in phase as cosine waves. (B) shows the fundamental and second harmonic of equal amplitude but arbitrary phase. In (C) the 3rd harmonic has been added in equal amplitude but again in arbitrary phase. There are clear cut differences in these waveforms and equally obvious differences in quality of sound under any listening conditions. In (D), the 4th harmonic, and in (E), the 5th harmonic have been added. These figures do not look greatly different surprisingly enough. However, they very clearly sound different. Finally in (F), the 7th harmonic is added, again clearly changing the waveform as well as the sound. Any number of nice, pleasant musical tones can be generated by varying the amplitude of the various harmonics. A tone with equal-amplitude harmonics sounds very rich and complex but in fact is not at all realistic or subtle. A second type of tone was used in the tests as well. This waveform is shown in *Fig.* 3. It consists of 100 units of fundamental, 50 of 2nd harmonic, 25 of 3rd, 15 of 4th, 10 of 5th and 10 of 7th. The sound is pleasant, musical, and ordinary. We will call the first type of tone "harmonic rich" and the second "musical."

The harmonic-rich tone was generated in three forms as shown in *Fig.* 4. Harmonic-rich tone (A) consists of cosine waves in phase at zero to give as large a peak as possible compared to the average amplitude of the waveform. Harmonic-rich tone (B) was adjusted, by changing phases alone in signal (A), to give a peaked but more symmetric looking wave. Finally more phase adjustments were used to give a smoother looking wave with a lower peak-to-average waveform shown as harmonic-rich tone (C). Note that the amplitudes of the harmonics in these three tones are identical but the phases are different. This fact is important in understanding the tests which follow.

A final pair of waveforms was generated to establish an even more startling and clear cut line of demarcation between the difference in the "look" of a waveform and the difference in the "sound" of a waveform. In *Fig.* 5 we see at (A) a more or less square

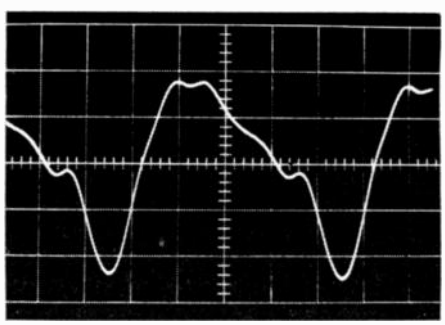

Fig. 3. The smoother "musical" waveform shown here contains 100 units of fundamental, 50 units of 2nd harmonic, 25 of 3rd, 15 of 4th, 10 of 5th, and 10 of 7th.

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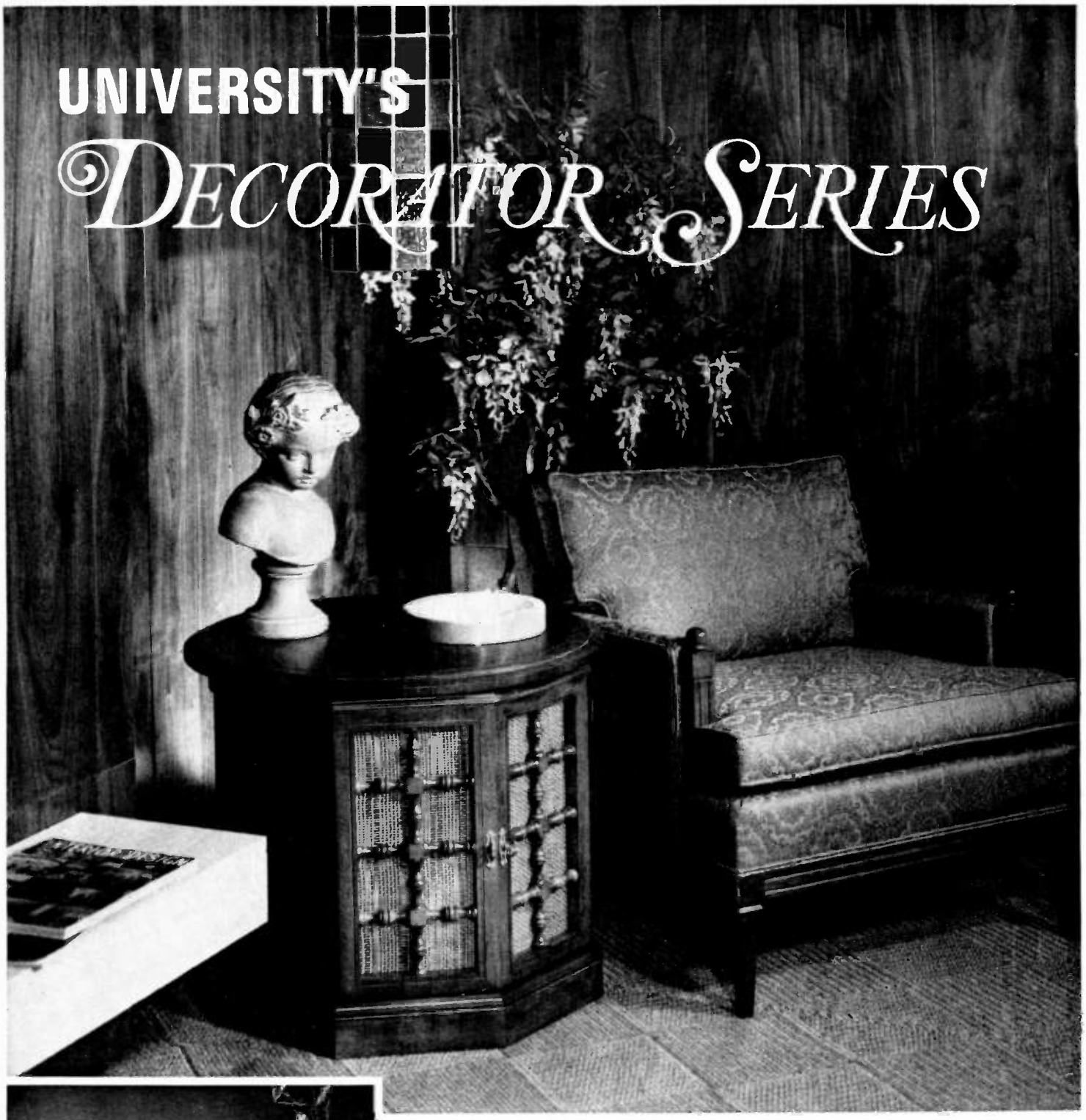

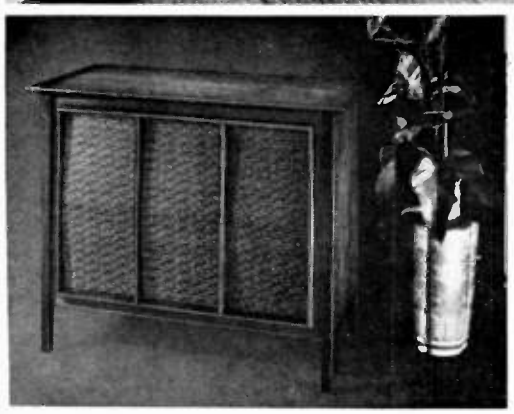

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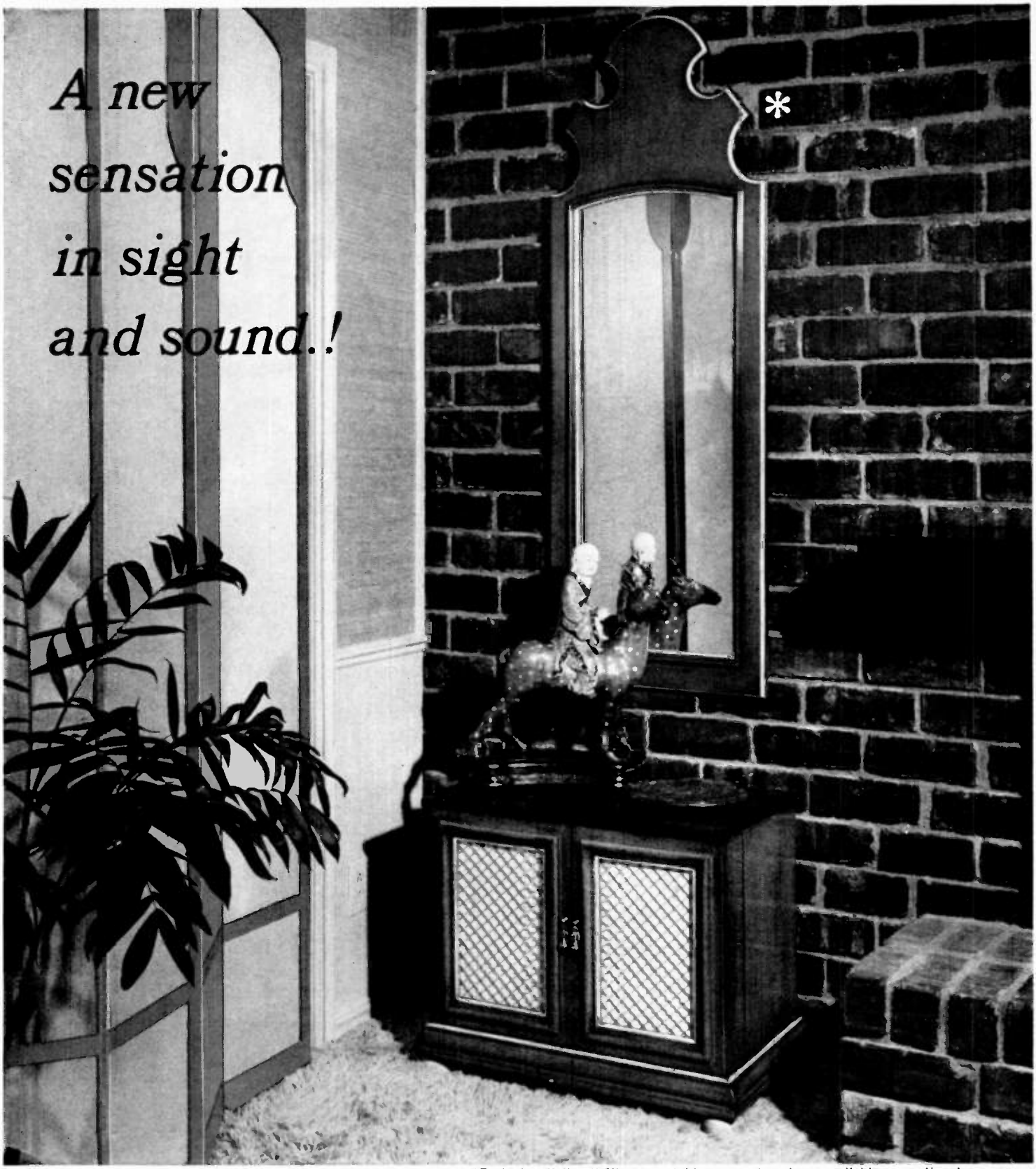

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wave formed from the fundamental and first three overtones. It is a fairly good square wave considering the limited number of overtones present. Now by simply shifting the phases of the overtones we can generate the much smoother looking waveform shown in (B). Clearly these two signals look very different. The first we call the odd harmonic "square" tone, the second the odd harmonic "smooth" tone. We are now ready to use these signals to test some acoustic and psychoacoustic phenomena.

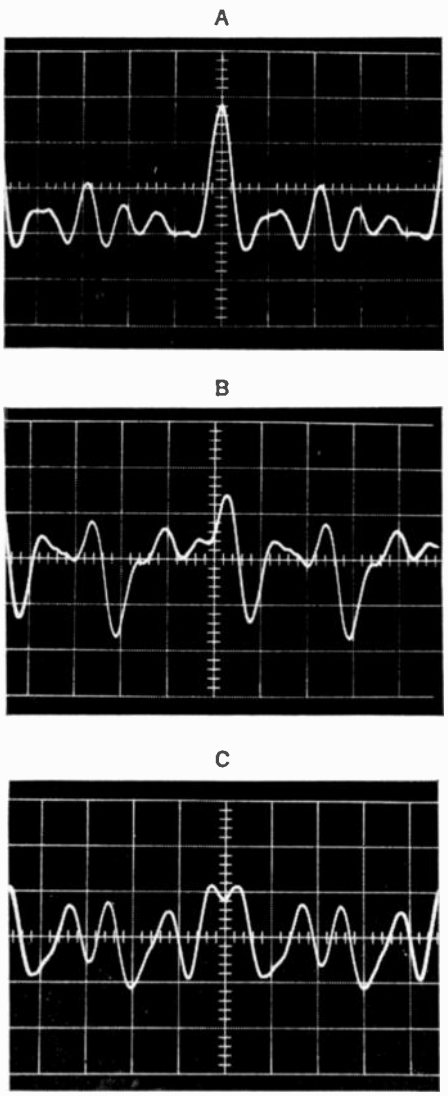

Fig. 4. Changes in phase alone can give a substantial difference in the "looks" of these three harmonic-rich waveforms.

Listening with Earphones

It seems appropriate to perform first some tests using earphones at low levels. This situation is most similar to the original Helmholtz conditions. It eliminates acoustics of rooms and, because of the low levels, nonlinearities in the transducers and ears.

Low-level earphone tests were carried out at a sound pressure level (SPL) of 60 to 65 dB. Absolute agreement was found with the earlier statement of Helmholtz (as modified). The harmonic-rich waveforms shown in *Fig.* 4 are completely indistinguishable. Phase has no effect whatsoever on the subjective quality of the tone. Even more amazing we find the odd-harmonic square tone and odd-harmonic smooth tone are also indistinguishable. While it seems amazing that such different looking waveforms should sound identical it is even as surprising that the waveforms in (D) and (E) of *Fig.* 2, which are very similar in looks, are quite different in sound. Fortunately this result is in complete agreement with other researchers, including Helmholtz.

As we raise the sound level to 80-90 dB SPL, we find that some small differences in quality appear between the several harmonic-rich tones and that these differences get greater as the level is raised. It is hard to determine what causes these differences but they seem to be related to distortion and are probably generated partly in the ear of the listener and partly in the headset at these relatively high sound-pressure levels.

At levels of 100 dB SPL there are definite differences in the acoustic waveforms generated due to distortion in the transducers. New harmonics are generated due to the distortion and since the peak-to-average waveforms are different, so are, of course, the amounts of distortion. This can be verified with a capacitor microphone and wave-analyzer. The tones thus sound different because they are different.

One might conclude that if tones of the type described sound different there is probably distortion in the system or the listening level is too high for the observer. Binaural and monaural results were essentially identical. The ear is very sensitive to test differences of the sort described above.

Listening Tests With Loudspeakers

The very first series of tests were made in a moderately dead room and in a relatively nonchalant manner. It was expected that immediate verification of man's "phase deafness" would be obtained and that not much else would be observed. However, one finds that under these listening conditions, tones like the three harmonic-rich tones sound quite different from each other and that is that. In fact, the musical tone with much reduced harmonic content also changes its quality as the phases of the harmonics are shifted. Even at very low levels the various test signals sound different. Relatively small motion on the part of the listener also seemed to change the quality of the tones. It is certainly not reasonable to find complete "phase deafness" with earphones

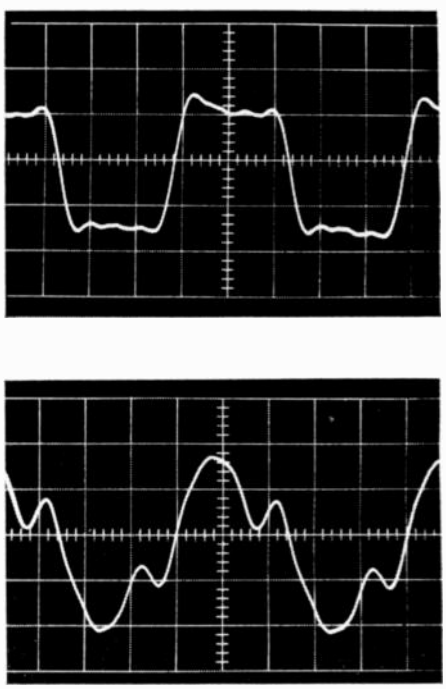

Fig. 5. At the top, a square wave synthesized by adding harmonics to the fundamental in appropriate strength and phase. Below, the same harmonic content and strength but phase shifted to give a smooth waveform.

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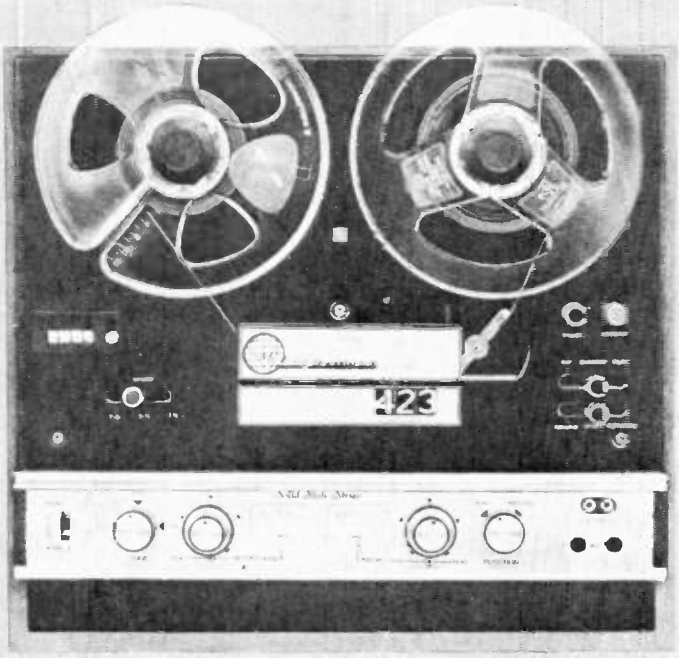

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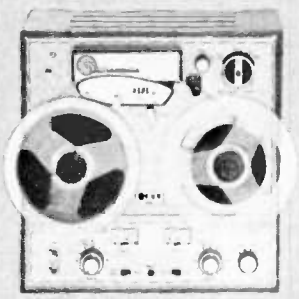

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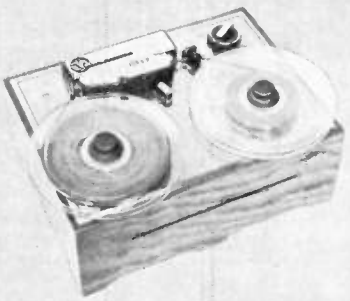

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and then suddenly find complete ability to perceive phase in an acoustical environment. There was something going on which must account for this sudden "apparent ability" to hear phase and it must be an acoustic or environmental phenomenon.

In order to check out the loudspeaker systems and establish some common ground on which to start the investigation, a series of close listening tests was performed. In these tests, the listener rests his head on a stationary support so that his ear or ears are 6 to 8 inches from the speaker. One or both ears can be used. Effectively, this technique greatly reduces the effects of room acoustics on the sound the listener hears. This is particularly true if the room is relatively dead and no reflecting walls are nearby as was the case in these experiments. In near listening tests one gets immediate and complete agreement with the headphone results described above. There is no difference between monaural and binaural tests and small changes in head position are not important. Thus it appears that we are both monaurally and binaurally phase deaf under these acoustic conditions.

The casual listening tests still remain correct and undeniable, however, so we must proceed to decipher the acoustic effects which are causing the tone-quality changes observed. It was established that not only room acoustics but the position of the listener and loudspeaker in the acoustic environment were very critical. The tones could certainly be made to sound different by moving about the room. But, even motions of a few inches by the listener could cause differences in the quality of the tone which were as large or larger than the differences between the several tones themselves. It is surprising how great this sensitivity is. The differences in quality are not due to a sudden ability of the ear to hear phase or due to a binaural effect because either or both ears give the same results. Instead, it appears to be small changes in the *strengths* of the harmonics which are being heard as a change in quality of the tone. The great sensitivity of the ear to changes in strength of harmonics was verified in separate tests. Changes as small as 2 to 4 per cent in any one of the 3 to 5 harmonics which made up the complex tone could be detected as a change in quality.

It is of course due to standing wave patterns set up in any acoustical environment that variations in the intensity of the individual harmonics takes place as a function of position. With a perfectly stationary listener we find that small changes in loudspeaker position cause similar changes in tone quality of the test tones. When both listener and loudspeaker are perfectly stationary, small changes in tone quality with changes in phase of harmonics are still perceptible due to slight changes in the standing-wave patterns in the room with a different excitation waveform from the loudspeaker. In the latter case, binaural listening is more sensitive than monaural.

Amplitude variations which agree with the above observations can be made using a calibrated microphone and wave analyzer but it is difficult to make accurate measurements. The ear is sensitive to much smaller changes than can be measured easily.

As the loudness level is raised there are more apparent quality differences between the various test tones. However, at levels of 100 dB SPL it is difficult to attribute these differences to any one source. Undoubtedly the loudspeakers, the ear, and the reflecting surfaces of the room all behave in a sufficiently non-linear way to cause waveshape, or envelope, differences to appear in the perceived tone.

Tests in a Live Room

Tests in a very live room where standing waves and reflected sound dominates show great emphasis of the effects described above. Speaker and listener motion are very critical. Sensitivity to electrical phase shifts is emphasized as well. It should be noted that phase shifts of 10 to 20 deg. are not readily audible even in a live room but larger shifts of 60 to 200 deg. or more are usually perceptible as changes in quality of the test tone. The effects of higher sound pressure levels and distortion are also more evident in the live room.

Preliminary tests in an anechoic room indicate a return to the results obtained for headphone listening as expected.

General Conclusions

We may conclude that the phase shifts normally encountered in the electronic part of sound reproduction equipment are entirely insignificant. Substantial phase shifts in the harmonics of a tone are audible in a normal acoustic environment and even more so in a very live environment.

However, random changes in tone quality due to listener motion far overwhelms these equipment-produced effects. Loudspeaker placement and listener position strongly affect the quality of test tones and the effects observed are entirely due to room acoustics. These effects can be heard because of the great sensitivity of the ear to changes in the strength of the harmonics in a tone and not because of phase sensitivity of the ear. A large and relatively dead room minimizes the speaker placement and listener position affects and gives a smoother and more consistent tonal response to the listening environment.

We may also conclude that many authors who report hearing phase shift are really hearing something else and that it probably is caused by the acoustics of the room. We appear to be, as Helmholtz found, essentially "phase deaf" except for certain very unusual and contrived, non-musical, tone signals mentioned in the introduction. The above generalizations do not improve sound system reproduction or make its many interesting problems go away but they do help us to understand the acoustic problem a little better and to appreciate its complexity.

It is possible that transient experiments and tests with extreme phase shifts or delays will eventually shed light onto the hearing process. But these results are difficult to obtain and will probably not aid sound-system and listening-room design in any case. We can be satisfied for the present that we hear quite well, in fact, often too well. We can clearly hear that two loudspeakers of great perfection are quite different and that those very big, very expensive, speakers sound much better than those little, not quite so expensive ones. And we can hear that one auditorium or room is better than another and that there always seems to be room for improvement. Æ

Sound & Sight

HAROLD D. WEILER

Previous articles in SOUND AND SIGHT —March, May, and July, 1966, discussed the vidicon tube and its operation with particular reference to the scanning of the optical image focused on its faceplate by the lens system. As explained, scanning is the process by which optical information is converted into electronic information which may then be recorded or transmitted.

We also indicated that the U. S. Television Standard established in 1941, through the combined efforts of the Federal Communications Commission and the National Television Systems Committee limited the horizontal scan rate to 525 lines. Once this scanning rate was established, the resolution of commercial television was limited. Most scenes, in addition to the brightness gradations in a horizontal direction also have brightness gradations in a vertical direction. The ability of a scanning beam to allow reproduction of electronic signals corresponding to these vertical brightness gradations is dependent upon the number of scanning lines.

In closed circuit television systems employed by science, business and industry there are no restrictions on the horizontal line rate, in consequence the vertical resolution can be greatly increased and images providing much finer detail can be obtained. With a horizontal scanning rate of 525 lines, the maximum vertical resolution is approximately 350 lines. Horizontal scanning rates as high as 1023 lines are being employed in modern CCTV systems. These are capable of a vertical resolution of over double the broadcast resolution, or 715 lines, and provide a considerably more detailed picture.

Until recently, video cameras employing the higher horizontal scan rates were usually custom made and designed for specific applications and requirements. Bio-medical research often employs cameras having horizontal scan rates of

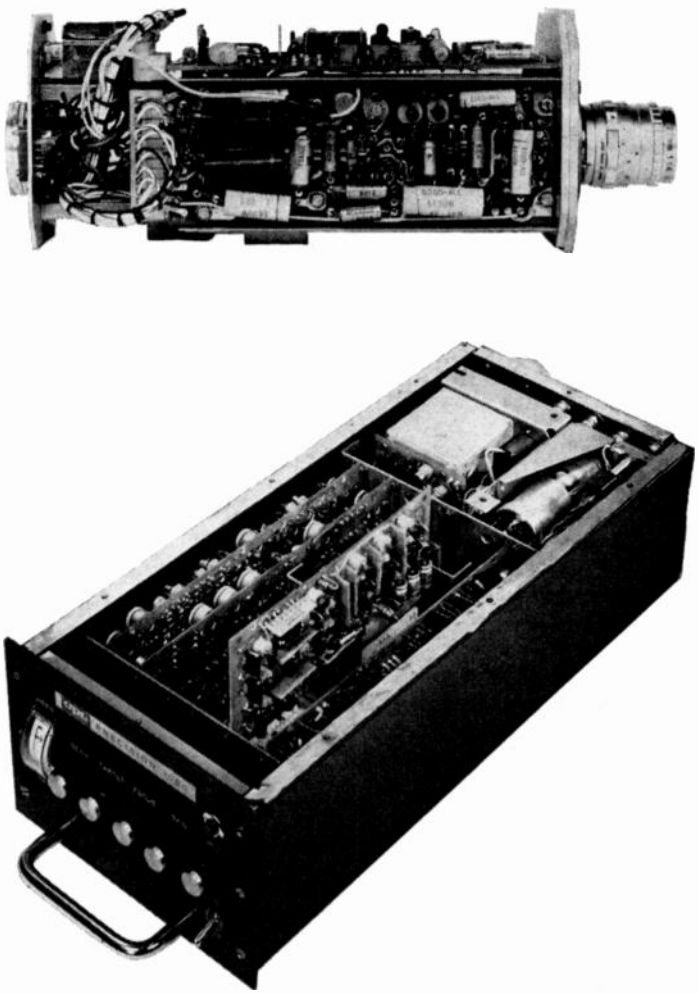

Fig. 1, showing the printed circuit modules of the GPL two-piece camera configuration. The modules in both the camera head, top, and the camera unit, bottom, are of the plug-in type and instantly replaceable.

(Continued on page 129)

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You can record selected TV programs for playback anytime—presidential speeches, news events, space launches, sporting events, etc. Even record them while away, or while watching another program, and play them back at your convenience.

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See back page for video camera and accessories.

*diagonal measurement.


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TV Adapter CVA-3—Plugs into most standard TV sets and adapts them for use with any Sony Videocorder (deck or complete unit). TV set can be used as program source for taping off-the-air and as playback screen for off-the-air or "live" recordings. Set can also be used as a monitor in conjunction with the Sony video camera for taping "live" action.

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SPECIFICATIONS

VIDEOCORDERS	TCV-2010	TCV-2020	CV-2000D	CV-2000
Built-in Receiver/Monitor Channel Coverage:	2-13 VHF, 14-83 UHF	2-13 VHF, 14-83 UHF	None	None
Picture Tube:	8*-inch 90° deflection, aluminized screen	8*-inch 90° deflection aluminized screen	None	None
Power Requirements:	117 VAC, 60 c/s, 103W	117 VAC, 60 c/s, 103W	117 VAC, 60 c/s, 80W	117 VAC, 60 c/s, 80W
Dimensions:	27 1/2x16 1/4x11"	28 3/8x16 3/4x11 1/4"	19 3/4x9 7/8x 15 1/4"	18 1/8x11 7/8 x15 3/4"
Weight:	66 lbs.	70 lbs.	42 1/4 lbs.	46 lbs.
Standard Equipment:	Tape, reel, earphone, external antenna connectors, head cleaner set	Tape, reel, earphone, external antenna connectors, head cleaner set	Tape, reel, connectors, head cleaner set	Tape, reel, connectors, head cleaner set

*diagonal measurement

CAMERA ENSEMBLE

CVC-2000 Camera: Lens: f/1.9, 25mm, "C" mount. Control Range: 100 lux to near infinity (f/1.9 lens). Power requirements: 117 VAC, 60 c/s, 10W. Dimen.: 3 1/8x5 1/4x9 7/8". Weight: Approx. 6 lbs.

F-87LM Microphone Directivity: uni-directional (cardioid) Output Impedance: low impedance (600 ohms) Output level: —57db.

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MUSIC AND RECORD REVIEW

Record Review • Edward Tatnall Canby

Hysteresis

P.D.Q. Bach—An Hysteric Return. Royal PDQ Bach Festival Orch., Okay Chorale, etcetc. With Prof. Peter Schickele. (Rec. at a Carnegie Hall perf.)

Vanguard VSD 79223 stereo

Much to-do and argument recently, as between rival discs from Elektra and Vanguard, the *Baroque Beatles Book* (Joshua Rifkin) and this series on the mythical P.D.Q. Bach (1807-1742), proferred—and composed—by Peter Schickele. Both feature pseudo-Baroque music, though Schickele goes far afield into other areas in this second extravaganza. But there the similarity ends.

They have different, and—this album makes clear—both have their utterly different values. I enjoyed this one a lot, even if its music is hardly stuff for the ages. I'll have to admit that the brash Mr. Schickele has a way with his audiences—and even more of a way in his vocal introductions. Lovely dead-pan comedianship.

Very simply, the "Baroque Beatles" is a high-level musical parody on Beatles' tunes, astonishingly good music on its own, the work of a near-genius (he will be, if he pans out in later life). As actual Baroque music, it is excellent. And those who know the Beatle tunes can attest to its incredible ingenuity.

Schickele aims at a simpler effect. His is the best ham imaginable, without the slightest pretense at profundity. Corny gags to beat the Hoffnung Festival at its gaggiest. Outrageously amusing tune-combinations — often funnier because they don't "fit" but simply swear at each other. Happenings, like the final chord of one piece, played by a soaring ballon through a set of pitch-pipes! Also bicycles, automats, weird non-instruments and so on. Hilarious.

Here we have a somewhat labored cantata on Side One, "The Seasonings" (S. ½ tsp.), full of elaborate musical and literary puns. Tarragon of Virtue is Full. Bide thy Thyme. By the Leeks of Babylon, There we Sat Down, yea, and Wept. (Ugh!) Also Sumer is a cumin seed. *(Get it?)* Or, to Curry Favor is to Favor Curry. So it goes.

Side 2 is the highly amusing "Unbegun Symphony" in which the most outlandish combinations of familiar tunes pile up on each other with bewildering largesse. (The album notes list them for your help, but I think they left out a few.) Then the Pervertimento for Bagpipes, Bicycle, and Balloons. A bit more labored, this, but reasonably hysteric, too.

Book-and-Record Spectaculars

Wagner: Lohengrin (complete). Konya, Amara, Dooley, Goor, Hines et al., Boston Chorus Pro Musica (augmented), Boston Symphony, Leinsdorf.

RCA Victor LSC 6710 (5) stereo

This is the first complete Wagner opera recorded in the U.S. for a long time and the manner of its production is highly significant. There are, to be sure, the expected "Metropolitan Opera stars"; but the Met itself is oh-so-definitely absent. So is the opera house in any form. This is Boston-Symphony-Tanglewood stuff, a production first put on in concert form at the summer festival and then recorded, in the Boston Symphony's home hall, immediately afterwards—the now-standard method of recording big works. (Even the hall itself was revamped for recording, with the orchestra on the floor, the soloists on a sort of runway at the front of the stage and the huge chorus in back of them.)

The prime listening factor here, then, is the orchestra itself, not an opera orchestra but a first-class symphony ensemble. The whole production is built around this factor, which is vital in Wagnerian music, and thus the predominant sound of the 10 LP sides, voices or no,

(Continued on page 116)

LIGHT LISTENING

Chester Santon

Ethel Merman: Annie Get Your Gun
RCA Victor LSO 1124

Perhaps the easiest way to revive a show is to persuade Ethel Merman to take up once more a role she originally created on Broadway. The present revival of Irving Berlin's "Annie Get Your Gun" is one of the brightest in the series of productions being mounted at the Music Theatre of Lincoln Center. Other shows already revived there under the skilled eye of director Richard Rodgers have been "Carousel," "Kismet," "King and I," and "The Merry Widow," with RCA Victor doing the recording honors. A combination of modern miking and passage of time has smoothed off some of the sharper edges of the famous Merman theatre-filling voice. And the songs Berlin wrote for this show! As with other revivals in this series, you'll hear more hit songs in the first third of the production than you did in the past Broadway season. A most welcome revival in an otherwise lackluster season.

Andre Previn With Voices
RCA Victor LSP 3551

Funny thing about Previn's piano playing. For many years I've been told by people whose judgement I should trust that Andre Previn can do no wrong once he is seated at the piano. In either jazz or popular music, he has been held in high esteem by experts who insist his style is supposed to be "good" for one. I admit he deserves credit for commendable avoidance of cliches wherever possible but his keyboard approach has always seemed too cold and impersonal for my taste. The fact that I've relented and decided to consider this particular Previn release doesn't mean that he's turned over an entirely new leaf. The news here is that RCA has figured out a way to make his piano stylings more palatable to listeners who have entertained thoughts similar to mine. Producer Joe Reisman has selected a wonderful collection of songs and then hired an excellent mixed chorus to sing them while Previn entertained at the piano. Although the chorus is important, this is still very much Previn's album. Virtually the entire left channel is given over to his instrument. I would have preferred a miking with the chorus spread across both channels but then "Voices with Andre Previn" is not the title of the album. The vocal arrangements by Wayne Robinson immediately explain why he's considered by Previn to be the best pop arranger in the business where the use of voice is involved.

Luiz Bonfa: The Brazilian Scene
Philips 600-208

The Philips label has logic on its side when it assumes that guitarist Luiz Bonfa is going to occupy an important place in their catalog. It wouldn't be stretching a point to say that he is capable of fulfilling several functions on any record company's roster. He's a great guitarist in his own right. His arrangements of American tunes have a novel "foreign" touch and the music he composes so freely is indicative of the best work being done these days on the Brazilian scene. A clear and mercifully uncomplicated recording process on the part of Philips' engineers makes his releases a greater attraction than they otherwise would be. This process, although it's almost too simple to be called that, is the ideal medium for an instrumentalist of his caliber. Here one can follow with ease the intricate finger work when Bonfa plays the melody line and creates the bass line at the same time without benefit of overdubbing. This is a Brazilian style of playing wherein the movement of the thumb is separate and different from the movement of the other fingers. Assisting Bonfa in this attractive collection of Brazilian and U. S. fare are drummer Helcio Milito, flutist Jerome Richardson and Donald Payne, bass. The accompanying ensemble is as relaxed as Bonfa himself and the result is an album of high appeal for the layman as well as the guitar afficionado.

Ray Conniff: Somewhere My Love
Columbia CS 9319

One phenomenon in popular music that shows no signs of diminishing with the passing months is the carload of happiness the Conniff Singers deliver in each new recording. This zest of theirs was evident in their first stereo recordings with an impact that mono simply could not match. As improvements in recording came along this very skilled mixed chorus has kept its place at the head of groups stressing lilt above all else. With the sonic presence Columbia is delivering in its current stereo discs, the effect can be quite overwhelming on a large system if the listener is encountering the group for the first time. The usual solid beat distinguishes the instrumental accompaniment as Conniff leads his charges with machine-tool precision in "Red Roses For a Blue Lady," "Charade," a sprightly Australian novelty "Tie Me Kangaroo Down, Sport," and a generous sampling of Broadway show scores.

JAZZ and all that

Bertram Stanleigh

Blind Willie McTell: 1940
Melodeon Mono MLP 7323

These recordings were made in 1940 by John Lomax during one of his Library of Congress field recording trips. A skillful performer on the twelve-string guitar, and a crisp and articulate singer with the kind of clear enunciation that many of the young urban singers could profitably use as a model, McTell sings some unusual versions of a number of traditional folksongs. Many of his songs are introduced by brief comments, and three bands of interview with Lomax do a great deal to heighten the insight into the rich background and personality of this exceptional blind singer. The inclusion of a popular song from the 30's, *Baby, It Must Be Love*, may have little interest to the collector of folk rarities, but it serves to further round out the portrait of McTell as a performer. As might be expected, neither the recording nor the record surfaces are up to present day standards. However, considering the conditions under which these sides were originally cut, things are generally quite acceptable. In the few instances where the sound breaks up badly, the exceptional merit of the musical material more than justifies the inclusion of the poor recordings.

Oliver Nelson Plays Michelle
Impulse Mono A-9113

Here is a delightful parcel of swinging versions of pop tunes performed by an all-star, 12-piece band led by Oliver Nelson on tenor and alto. In addition to *Michelle* and *Yesterdays* by Beatles Lennon and McCartney, such recent hits as *These Boots are Made for Walkin'*, *Beautiful Music*, *Fantastic, That's You*, and *Flowers on the Wall* are coupled with Ellington's *Island Virgin*, Johnny Hodges' *Once Upon a Time*, two Nelson originals—*Jazz Bug* and *Do You See What I See?*—and that Russian standard *Meadowland*. Outstanding solo work by Nelson, Clark Terry, fluegelhorn and trumpet, Hank Jones, piano, and Phil Woods, alto, make this a worthwhile collection for both dancing and serious listening.

Raymond Fol Band: Vivaldi's Four Seasons in Jazz
Philips Stereo PHS 600-198

Since its phenomenal success with swinging versions of baroque music performed by the Swingle Singers, Philips has been straining to discover another hit that would appeal to the same market. First they tried *Bach Humbug* by a German group called the George Gruntz Quintet; now they make another attempt with a French big band that features solos by three Americans: Johnny Griffin, tenor, Jimmy Woode, bass, and Arthur Taylor, drums, and the superb Belgian vibraphonist, Fats Sadi. The main difference between the present platter and previous swinging-the-classics experiments is that this new try is devoted, not to a brief miniature or a fragment of a longer composition, but to an entire large-scale work. Such an approach presents special problems, and it is only fair to state that Monsieur Fol has been only partially successful in solving them. His version offers many clever touches and sensitive bits of instrumentation that show deep insight into his source material, but these fine moments are often laced together by trite, obvious clichés right out of a 1940's big band arranger's handbook. There is much to admire in this bright, clean recording, but the old red monk of Venice was a bit more of a swinger than Raymond Fol and his boys, and I'd prefer to take this one straight. The swing approach to a full-scale classical work does, however, raise the question of future repertory. Is it possible that Philips is at work right now on hotted up versions of the B Minor Mass, Bruckner's Seventh, or the Berlioz Requiem?

Clifton Chenier: Louisiana Blues and Zydeco
Arhoolie Mono F 1024

"Zydeco" is the name for the popular dance-hall music of a less refined variety Coast, and Clifford Chenier, who sings in a Cajun patois and plays accordion and harmonica, is reported to be its finest performer. It is rough, vigorous dance hall music of a less refined variety than is heard in the New Orleans dance halls, and its performers have a robust style with abundant blues color but very little subtlety. The group, in addition to accordion and harmonica, includes piano, guitar, and bass. They have been recorded in a Houston, Texas sound studio; the sound is bright, close-up, and just a bit edgy. But these musicians perform with all of the joy, spirit, and freshness of a live performance. The liner notes indicate that another album of Zydeco can be expected from Arhoolie later this year. It will be just as welcome as the present disc.

Barbara Dane and the Chambers Brothers
Folkways Mono FA 2468

For her latest recording, Barbara Dane is joined by four gospel singers in a group of civil rights protest songs. The Chambers Brothers, who hail from Carthage, Mississippi and a background of religious music and rhythm and blues, seem to be about to break into a new career in the pop-rock category. But on this platter their function is largely that of choral accompaniment as Miss Dane sings out with feeling the songs of protest that she has collected while participating in the Freedom Schools and registration demonstrations in the South. A dedicated, rather than polished, performer, Barbara Dane has a message to get across; she does so with unabashed sincerity.

Hampton Hawes Trio: Here and Now
Contemporary Stereo S7616

Working with two new partners, Chuck Israels, bass, and Donald Bailey, drums, Hawes offers his very creative, highly unorothdox variations on a handful of pop tunes that includes *Fly Me to the Moon*, *What Kind of Fool Am I?*, *The Girl From Ipanema*, *People*, *Chim Chim Cher-ee*, and *Days of Wine and Roses*. As is usual in Hawes case, one starts out wondering why a musician of his talents wastes his efforts on such flimsy tunes. However, it soon becomes clear that these melodies serve as a mere point of departure as he builds his solid improvisations. Both Israels and Bailey have ample opportunity to indulge in free-time improvisation of their own, and the group is well recorded in rather widely spread stereo.

Willie Bobo: Uno, Dos, Tres
Vogue Stereo V6-8648

Latin accented jazz by a ten-man group with fifty per cent of its manpower devoted to light, airy, colorful percussion. Typically, Bobo offers a mixed bag that includes pop tunes, Latin numbers, chestnuts like *Old Man River* and *The Breeze and I*, as well as Benny Golson's *I Remember Clifford* and Willie's own *Fried Neck Bones and Some Home Fries*. Everything fits together neatly in a well balanced package with an easy, swinging pace and exceptionally crisp, transparent stereo that shows this ensemble off in fine fashion. Æ

ABOUT MUSIC

Harold Lawrence

The scene is a recording studio. The orchestra sits in noisy expectation—then at a signal settles down . . .

The Recording Musician— Is He A Man Or Machine?

THE RED LIGHT went on in the hall. Over the loudspeaker system sounded the announcement of the next take: an insert of the final sixteen bars of the score. The conductor lifted his arms, waited for silence, but no downbeat followed. A gray-haired cellist suddenly rose from his seat, began rolling down his shirt sleeves, and said: "I'm going home." The astonished conductor could think of nothing to say, except "Why?" Buttoning his shirt collar, the cellist replied, "Because I am *not* a machine." He then grasped his cello and bow in one hand and his jacket in the other and stalked from the recording hall, drawing a chorus of boos and hisses from his colleagues.

A heated argument ensued in the Car Park outside the hall between the orchestral manager and the wildcat cellist, but the latter refused to return. It was an open secret that the player, a valued member of the self-governed English orchestra, had walked out three times before during the current season because of reasons entirely unrelated to working conditions. Today was no exception. The recording was proceeding smoothly and the players seemed to be enjoying the work. But though the orchestra disapproved of the cellist's irrational conduct, some may have sympathized with him in his protest against the routine of modern recording. Surely the recording director can't really appreciate what it means to play those notes over and over. One indeed can feel like a machine after a half dozen takes of the same passage.

Usually, the man in the control room is fully aware of the implications of his requests for re-takes because he is a musician himself. If he is a competent producer, he already will have recorded his "basic take"—a performance that is both technically and musically excellent. Now he must fix the accidents, correct slight imbalances, replace any glaring blemishes. The slight *accelerando* near the end is not quite together, the low brass suddnly dominates the orchestral texture where it should only provide accompanying sonority, or someone accidentally kicks over a music stand in the middle of an otherwise perfect take.

Veteran recording musicians take it all in their stride. They understand and may even appreciate what the producer and maestro are trying to achieve. Besides, they don't relish the idea of repeating the same musical fragment many times. The prevailing spirit is "Let's get on with it." But if the recording crew and the conductor are interested in something more than musical cosmetics, they hope to arouse another kind of spirit in the players.

It is a difficult task. For the atmosphere inside a recording hall is basically impersonal. No audience to hear your performances, cables and microphone booms to trip over, a battery of bug-like mikes mutely staring at you from above. And don't forget to hold your breath at the end of each movement. Total gloom can be achieved by the producer who will never address the players directly over the loudspeaker but prefers to deal with the orchestra through an intermediary, the conductor. A typical scene: the last smashing chords of the symphony resound in the hall. While the reverberation dies away, everyone freezes as if waiting for an invisible photographer to release his camera shutter. The telephone's nasal buzz breaks the silence, and the conductor picks up the receiver. He nods, frowns, says "Oh?", and hangs up. "Gentlemen. Once again, please!" Unless the reason for the re-take is obvious, only two people know why the take was called.

Some producers feel that the best artistic results are possible only when the orchestral players are deeply involved in the making of a record. But first there must be mutual respect and trust between conductor and producer, so that both serve a common musical purpose. Once this has been achieved, the conductor can concentrate on the "music," relying on the producer to inform him about details of balance, articulation, and other musical details which show up more clearly in the control room than from his vantage point in the hall. One conductor was only half-joking when he said "I'm too busy conducting to listen."

Considerable time is saved by announcing the reason for re-takes over the loudspeaker. Everyone in the orchestra knows why the passage or movement is being repeated. The telephone is there only for comments and discussions of a more discreet nature, such as "Mr. X's intonation is off. Should we call for a sectional tuning, or would you like to tell him yourself, Maestro?". Ideally, the producer must act as musical watchdog, diplomat, and fellow musician. Under these conditions, few orchestral players will feel like machines or assembly-line workers, but rather like participants in what sometimes can be an exciting musical experience. Æ

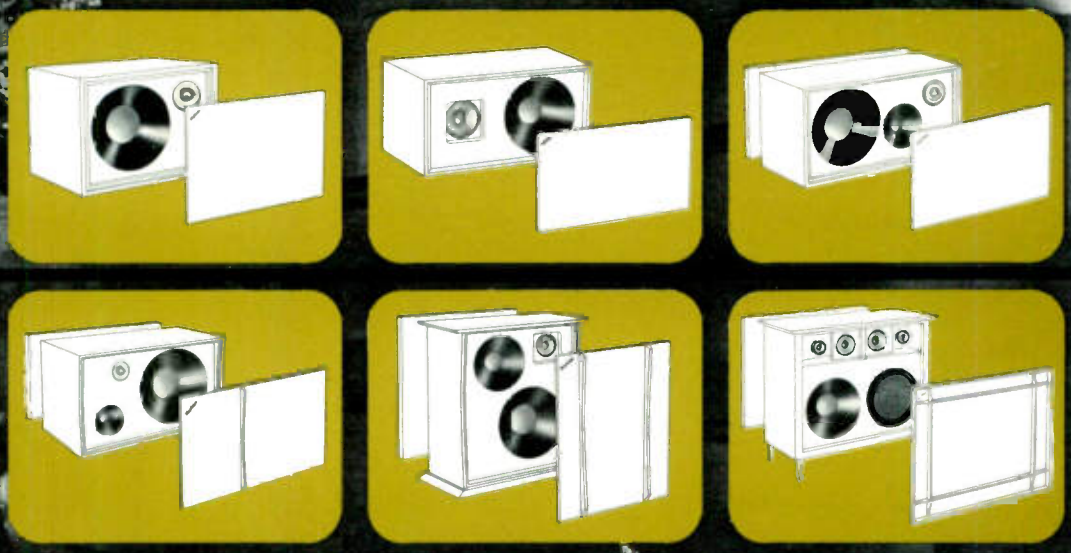
COMPARATOR

We cordially invite you to review the new series of

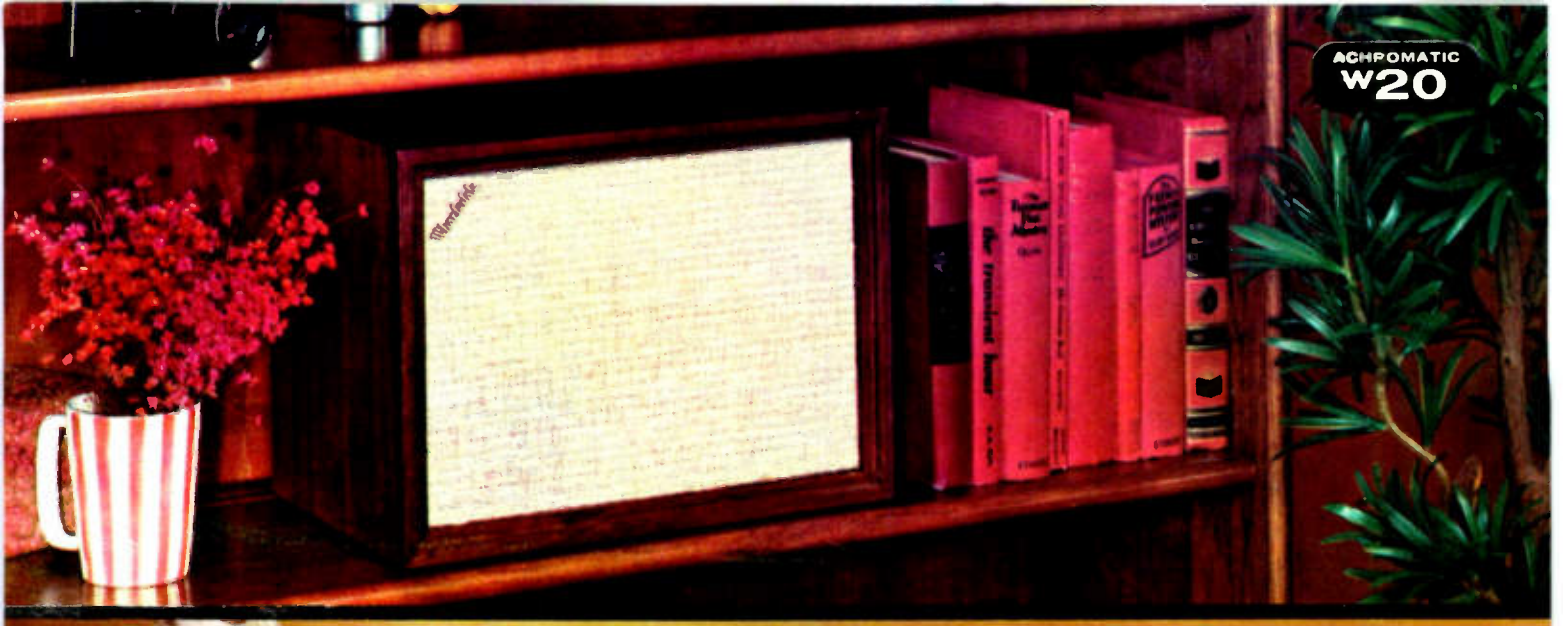
Wharfedale

Achromatic Systems

consisting of six magnificent loudspeakers



plus three unique Expandules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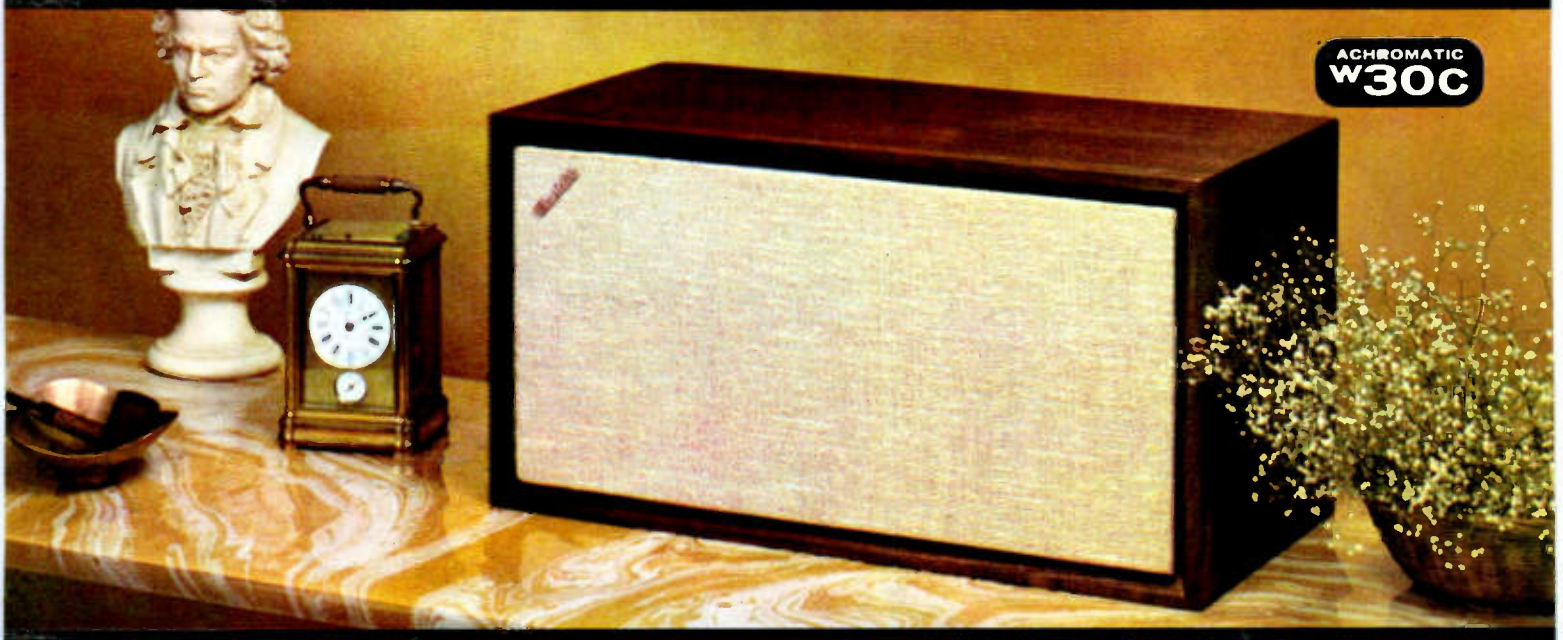
W20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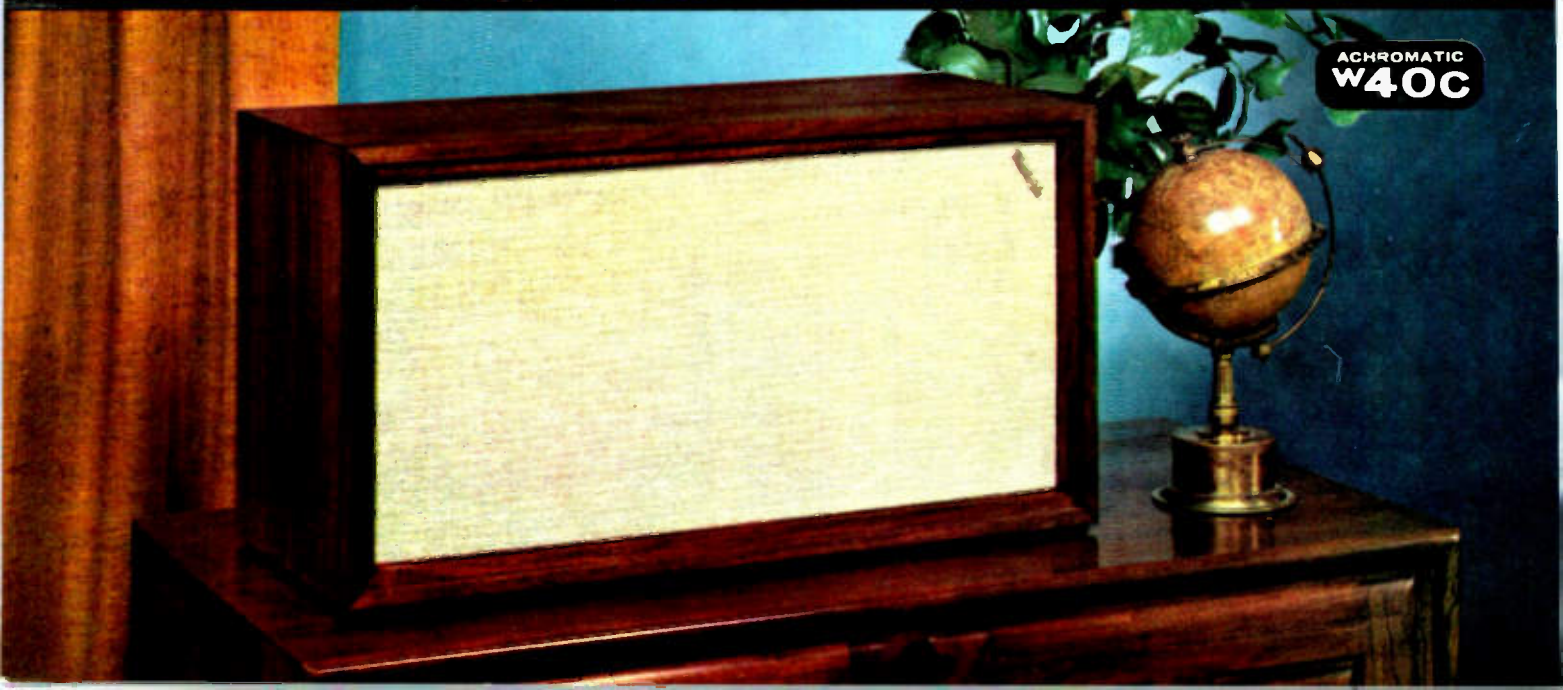
ACHROMATIC
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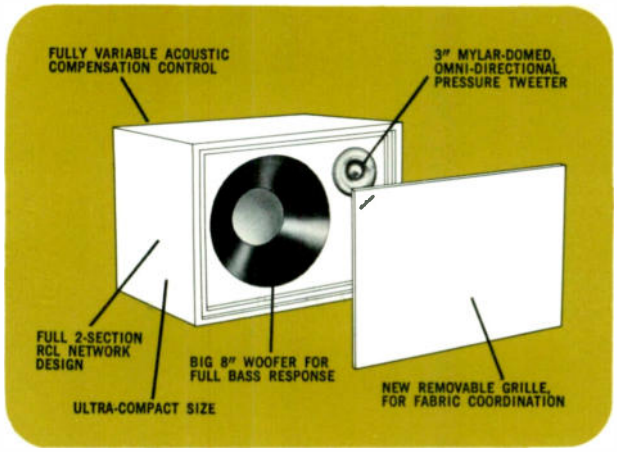


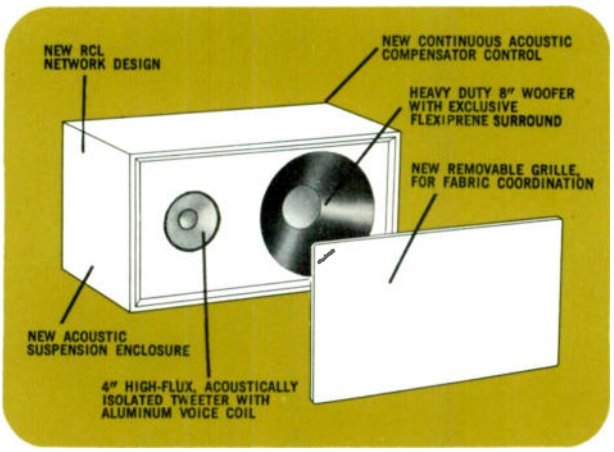
SPECIFICATIONS — Speakers: (Two-way) Woofer, 8" acoustic suspension; Tweeter, 3" omni-directional pressure dome. **Control:** Wire wound, continuous. **Minimum Power Required:** 10 watts (per channel) IHF. **System Impedance:** 4 to 8 ohms. **Dimensions:** 9¾" x 14" x 8½" deep. **Finish/Price:** (Genuine wood veneer) Oiled walnut, $49.95.

ACHROMATIC W20 — 2-WAY MINORETTE SPEAKER SYSTEM

The new Wharfedale .W20 Minorette set its sights on *sound* above all . . . with dimensions and cost a secondary consideration. This is why the W20 does not use a 4", 5" or even a 6" woofer . . . but a high compliance, low resonance full 8" woofer with exclusive Flexiprene cone suspension. And, this is topped off with a new, advance-design mylar-domed pressure tweeter with excellent omni-directional dispersion characteristics. Both speaker components have heavy magnet assemblies for controlled transient response. Network and voice coil values have been carefully designed for optimum performance with either vacuum tube or transistor amplifiers and receivers. A continuously variable acoustic compensation control is included.

The sturdily constructed, handsomely appointed cabinet (acoustic suspension principle) is finished with genuine walnut for greater decorating versatility; even has an easily removed front grille to make changing the cloth simple. The small overall dimensions make the W20 suitable for either stand-up or horizontal positioning; ideal too for placement inside of stereo "consoles."

Listen to the W20 with your eyes closed, and forget that it's so small and costs so little. What you hear will make it easy!



SPECIFICATIONS — Speakers: (Two-way) Woofer, 8" acoustic suspension; Tweeter, 4" acoustically isolated. **Control:** Wire wound, continuous. **Minimum Power Required:** 8 watts (per channel) IHF. **System Impedance:** 4 to 8 ohms. **Dimensions:** 10" x 19" x 9¼" deep. **Finishes/Prices:** (Genuine wood veneers) Oiled walnut, $69.95; Utility model, sanded birch hardwood with flat molding, $63.95.

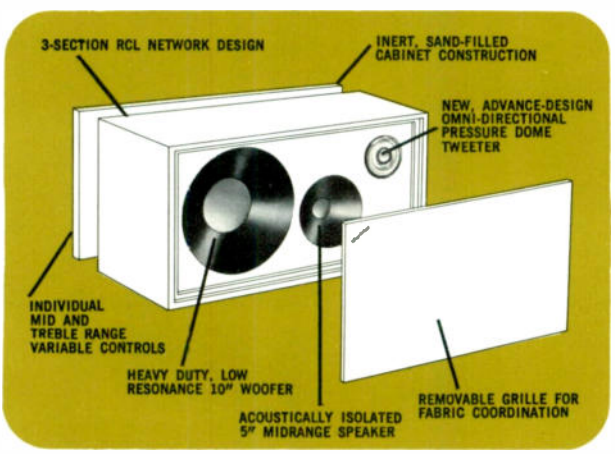
ACHROMATIC W30C — 2-WAY COMPACT SPEAKER SYSTEM

The new Model W30C embodies an enlightened technical approach to the problems and virtues encountered by modern speaker systems intended for use with either tube type or transistor amplifiers and receivers. The all-new network configuration used in this latest edition of the W30, and the impedances employed in the woofer and tweeter components, make the W30C suitable for any amplifier having an output of 4 to 8 ohms.

Heavy (2 lb.) woofer magnet assembly provides proper damping, eliminates hangover, insures excellent transient response . . . all desirable when a bass speaker employs a high compliance, low resonance suspension, such as Wharfedale's exclusive new Flexiprene cone surround.

The acoustically-isolated, full-sized 4" tweeter with large 1¼ lb. magnet assembly performs easily and smoothly throughout its assigned range, adding clarity without harshness, musical definition without stridency.

The new W30C is indeed a speaker that may be used, despite its modest size and price, as the main system where space is at a premium, or as a highly gratifying "second" system in secondary listening areas.



SPECIFICATIONS — Speakers: (Full three-way) Wooter, 10" high compliance, low resonance; Midrange, 5" acoustically isolated; Treble: 3" omni-directional pressure dome. **Controls:** Wire wound, continuous treble and midrange controls. **Minimum Power Required:** 8 watts (per channel) IHF. **System Impedance:** 4 to 8 ohms. **Dimensions:** 12½" x 23½" x 10⅛" deep. **Finishes/Prices:** (Genuine wood veneers) Choice of oiled walnut or polished walnut, $89.95; Utility model, sanded birch hardwood with flat molding, $78.95.

ACHROMATIC W40C — 3-WAY BOOKSHELF SPEAKER SYSTEM In exclusive "sand-filled" enclosure

With the new W40C, Wharfedale has established a new technical standard applying to all systems above the size of a "compact." The W40C, and all larger systems in the Wharfedale line, are full three-way multiple speaker assemblies, yielding a carefully tailored, ultra linear response that can best be accomplished with individual speakers designed for and operated over a restricted frequency range.

In the W40C, a heavy duty 10" high compliance, low resonance woofer is mated with an acoustically isolated 5" midrange speaker and an advance-design omni-directional pressure dome tweeter. Cone and chassis designs of the individual speakers have been developed to minimize reliance on the crossover network for channel separation. Separate mid and treble range, continuously variable acoustic compensation controls are provided.

The W40C brings a new dimension in sound realism to the world of "bookshelf" speakers, at a very reasonable cost. An optional set of legs adapt the speaker for free standing floor use where desired. Here indeed is exceptional value!

ACHROMATIC W60C

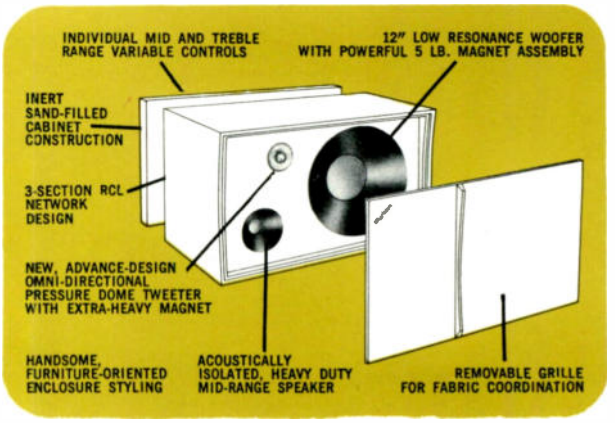
BOOKSHELF AND FLOOR-STANDING 3-WAY SPEAKER SYSTEM In exclusive sand-filled enclosure

The W60C enjoys important benefits derived from its new 3-way speaker configuration.

A 12″ woofer with extra-heavy (5 lb.) magnet assembly, 2″ voice coil and one-piece cone molded of English long-fibred wool and soft pulp contribute, among other factors, to the remarkably undistorted, extended bass response of this system. The newly developed 5″ acoustically isolated mid-range speaker, in this instance, incorporates a generous 1¾ lb. magnet assembly, for well-controlled, wonderfully clean reproduction of this very important part of the audio spectrum. Add to this an all-new omni-directional mylar-domed pressure tweeter, also equipped with extra-heavy magnet for insuring a comparable output level.

Individual continuously variable mid and treble range compensation controls are provided to adjust for acoustic environment.

The W60C may be used with equal satisfaction as a bookshelf or floor-standing system. An optional base is offered for floor use, as a further decorative refinement. The cabinet is more than just an acoustic enclosure; it is fine furniture, tastefully styled to suit any room. The removable front grille facilitates decorative changes.



SPECIFICATIONS — Speakers: (Full three-way) Woofer, 12″ high compliance, low resonance; Midrange, 5″ acoustically isolated, heavy duty; Tweeter, 3″ heavy duty omni-directional pressure dome. **Controls:** Wire wound, continuous treble and mid-range controls. **Minimum Power Required:** 8 watts (per channel) IHF. **System Impedance:** 4 to 8 ohms. **Dimensions:** 14¼″ x 24″ x 13″ deep. **Finishes/Prices:** (Genuine wood veneers) Choice of oiled walnut or polished walnut, $129.95; Sanded birch hardwood with flat molding, $113.95. **Option:** Model B67 floor standing base (adds 4¼″ to height of system). $10.50 oiled or polished Walnut; $9.50 unfinished.

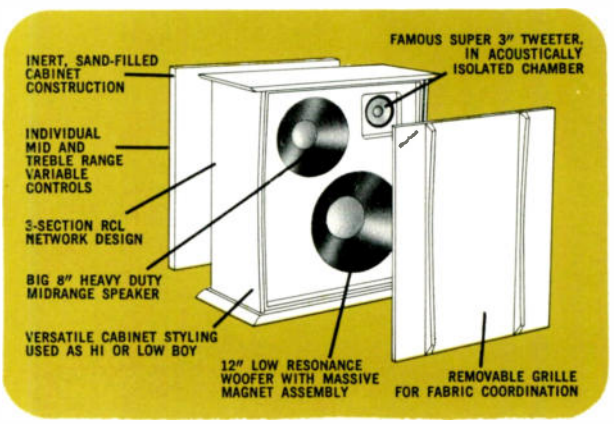
ACHROMATIC W70C

3-WAY HI AND LOW BOY DELUXE SPEAKER SYSTEM In exclusive sand-filled enclosure

The new W70C incorporates the finest components available for multiple speaker systems. The 12″ woofer employs a massive (9½ lb.) magnet assembly on a heavy cast aluminum chassis. The 2″ pole piece and magnet keeper plates are made of the finest grain-oriented, high permeability Sheffield steel, insuring maximum gap flux density with minimum heat loss, as well as exceptional power and transient handling ability. Low natural resonance, high but well controlled compliance, and long axial excursion add to the bass response capabilities of this acoustic suspension system . . . right down to the thrilling depths of audible range.

As a natural and necessary complement, a full 8″ speaker with heavy duty magnet assembly is used for midrange, while Wharfedale's famous 3″ Super tweeter, with big 3¼ lb. magnet assembly provides the cleanest, most natural treble reproduction achievable.

The versatile cabinet may be used standing on end ("Hi Boy") or on its side ("Low Boy"), yet occupies surprisingly little floor space in either instance. The W70C is often used, because of its attractive table top, as an end table alongside sofas, chairs, etc.; and it is ideal for positioning on either side of a bay window. The front grille assembly is easily removed for decorative changes if desired.



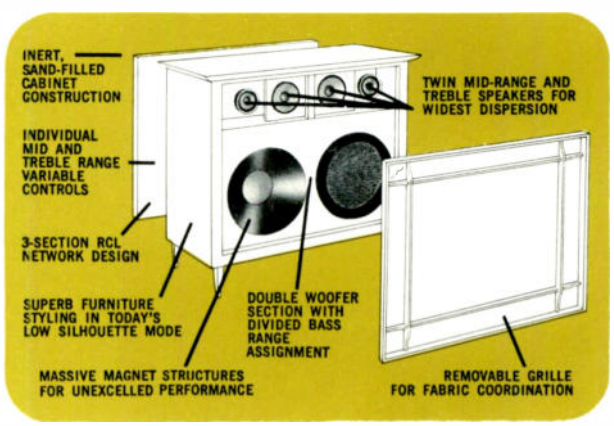
SPECIFICATIONS — Speakers: (Full three-way) Woofer, 12″ high compliance, low resonance; Midrange, 8″ heavy duty; Treble, 3″ Super tweeter. **Controls:** Wire wound, continuous treble and mid-range controls. **Minimum Power Required:** 8 watts (per channel) IHF. **System Impedance:** 4 to 8 ohms. **Dimensions:** Finished model, 24″ x 23¼″ x 14″ deep; Utility model, 24″ x 20⅞″ x 12⅜″ deep. **Finishes/Prices:** (Genuine wood veneers) Choice of oiled or polished walnut, $179.95; Utility model, sanded birch hardwood with flat molding, no table top, $160.95. **Option:** Model B67 set of legs (not essential for floor standing use).

ACHROMATIC W90C

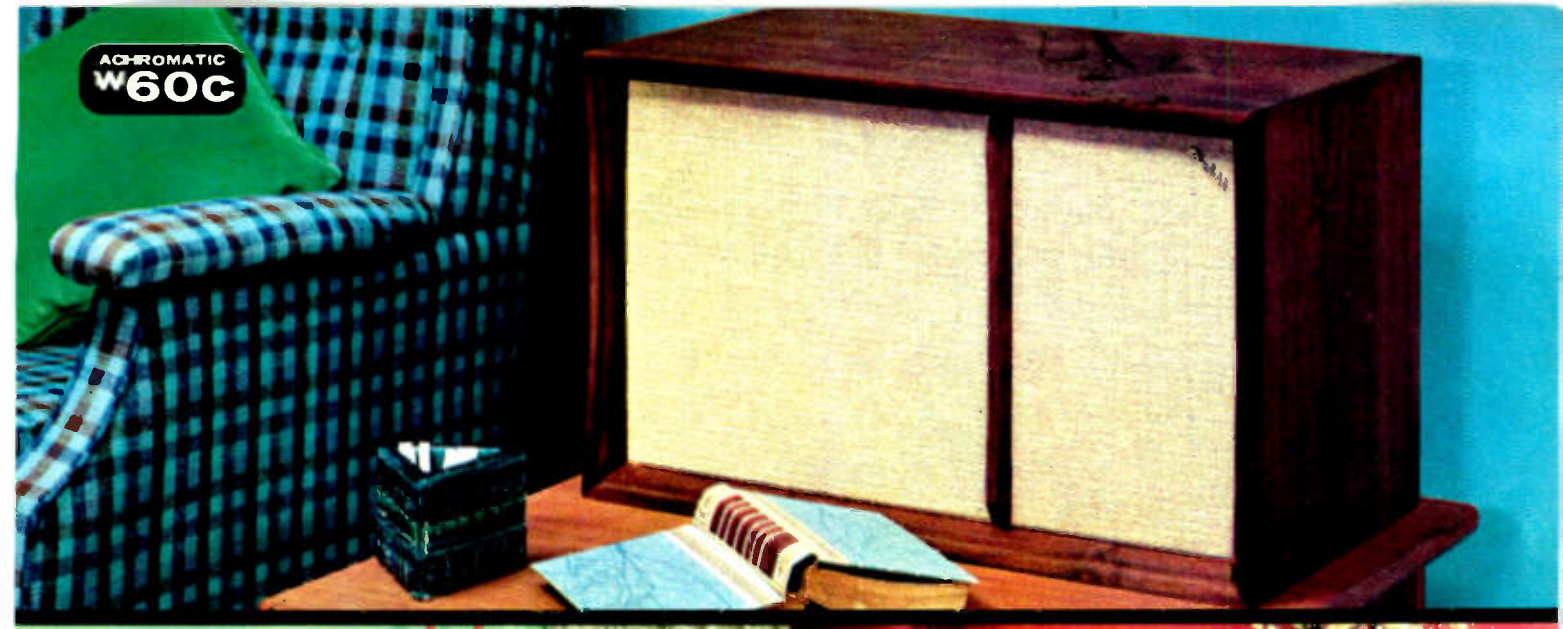
6-SPEAKER CONSOLETTE, 2 BASS, 2 MID-RANGE, 2 TREBLE superbly matched and integrated with a magnificent sand-filled enclosure

The truly remarkable sound of the W90C — so exciting because it is so lifelike no matter where one listens from in a room — is due both to the particularly high quality of its components and to the design used in putting them to best use. The bass range is divided between two 12″ woofers, each with massive (9½ lb.) magnet assembly, on cast aluminum speaker chassis. One, with a flat 70 sq. in. polystyrene radiator, provides free piston action efficiently, coupling the low bass range energy into the room. The other woofer, with conically shaped diaphragm, excels in reproducing the *upper* bass range. Both speakers operate in an acoustic suspension type enclosure. In this manner the bass spectrum is uniformly reproduced, with surprising output level down to the very depths of audible bass tones.

A pair of special 5″ heavy duty mid-range speakers and a pair of the famous Wharfedale Super 3″ tweeters handle the balance of the musical spectrum. All these speakers are, of course, acoustically isolated from the bass compartment, and the cabinet employs the exclusive sand-filled panel construction principle to eliminate enclosure coloration. The wide angle dispersion resulting from the array of mid and treble speakers insures correct musical timbre and definition anywhere in the listening area.



SPECIFICATIONS — Speakers: (Full three-way) Woofers, one 12″ with polystyrene 70 sq. in. piston, one 12″ with conical diaphragm; Two 5″ Midrange speakers; Two Super 3″ tweeters. **Controls:** Wire wound, continuous treble and mid-range controls. **Minimum Power Required:** 8 watts (per channel) IHF. **System Impedance:** 4 to 8 ohms. **Dimensions:** Finished model, 23¾″ x 30¼″ x 13⅞″ deep; Utility Model, 23¼″ x 27⅜″ x 12¾″ deep. **Finishes/Prices:** (Genuine wood veneers) Choice of oiled walnut or polished walnut, $279.95; Utility model, sanded birch hardwood, flat molding, no table top, $263.95. **Option:** Model B67 set of legs (adds 4¼″ to height of system).


ACHROMATIC
W60C


ACHROMATIC
W70C


ACHROMATIC
W90C

E-X-P-A-N-D-U-L-E-S

Wharfedale's exclusive Expandules convert bookshelf speakers into magnificent-sounding floor models, preserving your investment when you are ready to improve upon the original speakers in your music system. Each Expandule contains a high-compliance, low-resonance woofer of appropriate size, plus the correct matching network to extend bass response and improve sound projection into the room . . . complementing the performance of the original bookshelf speaker. Expandule enclosures are table-top (30") height, and of slim-line design. Finished in oiled or polished walnut, they blend perfectly with present home-decorating trends. The handsome appointments and tasteful styling completely conceal the fact that the Expandule also contains the bookshelf speaker. Matching legs are optional.

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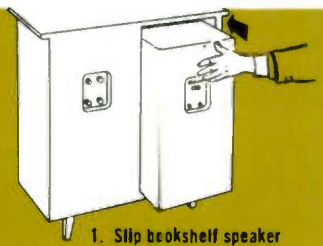
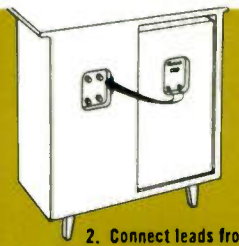
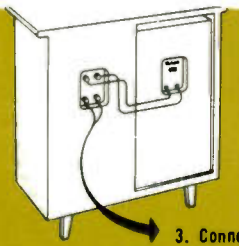
How a bookshelf speaker can be converted to a full-size system in three simple steps.



1. Slip bookshelf speaker into back of Expandule.

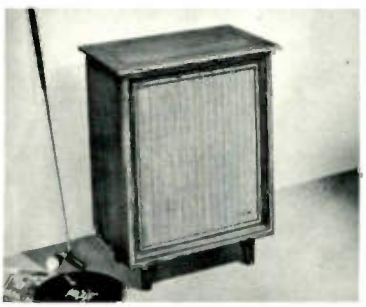


2. Connect leads from bookshelf speaker to Expandule.



3. Connect leads from Expandule to amplifier.

EXPANDULES ARE OFFERED IN THREE MODELS



Model E35 is 29¾" high, 23⅜" wide, 13⅝" deep; (dimensions include table top overhang and optional legs); uses a special extended bass 10" woofer; has a 19⅝" x 10⅜" x 11" compartment. $99.75.

Model E45 is 30" high, 30⅜" wide, 13⅝" deep; uses a 12" woofer; has a 24⅛" x 12¾" x 11" compartment. $149.50.

Model E65 is 30" high, 36⅛" wide, 16¼" deep; uses a 15" woofer; has a 24⅛" x 14½" x 13½" compartment. $199.95.

All are offered in either oiled or polished walnut. A set of 4 optional legs (Model B70) 4⅜" high is offered for all Expandules $7.50.

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Wharfedale Div. British Industries Corporation, Westbury, N. Y. 11590

An Integrated Complex-Tone Generator for Electronic Music

ROBERT C. EHLE*

The author, in addition to his laboratory work in electronic music, is also a composer in this art. Here he describes some of the "hardware" which the Electronic Music composer uses to create the unusual sounds—to the uneducated-in-electronic-music ear. He also describes a generator which can do the work of a whole labful of more-conventional equipment.

MANY ARTICLES have been written describing the various oscillators, generators, modulators, gates, filters, and so forth, which may be employed in the composition of electronic music or in the generation of a variety of sounds for research in psycho-acoustics and other experimental areas.

It would seem, then, that the best procedure in establishing a studio or installation of equipment for such purposes would be to purchase one or more of the several types of equipment available in each of the various categories, such as oscillators, generators, gates, modulators, filters, recorders, mixers, and so on, and then to assemble them in a cabinet or relay rack in convenient proximity to each other.

Although this procedure will work to a degree, there are many ways in which one slightly more elaborate piece of equipment may serve two or more functions (as in the case of the gate-modulator, or an oscillator which is capable of generating several different waveforms.) By investigating these possibilities it is possible to reduce the amount of required equipment and, often, to increase its flexibility and utility.

In purchasing equipment, one must also keep in mind the necessity of matching the inputs and outputs of the different pieces (for example: impedance matching, signal level matching, and so on), and the fact that some equipment can generate hum and other interference in equipment when mounted nearby.

When an installation of reasonable proportions has been properly completed, it will be found that many operations to be performed will require several duplicate pieces of equipment. In other words, one or two oscillators are not enough for a complete studio, and for some of the more complex operations, half a dozen may not be sufficient. There is no limit to the number of filters needed for some applications; some studios have used a unit which contains at least fifty separate band-pass filters with independent frequencies and controls.

One of each kind of equipment will allow only the most basic sound generation and may be unsatisfactory in most situations, but cost rises rapidly when we attempt to obtain several duplicates of the various units. One approach to this problem is to reduce the flexibility and range of the individual generators, oscillators, and filters, and to install special amplified units (which are much less expensive and require less power and weight) in one special chassis and in the quantity desired for the particular experiment.

Such an installation may sacrifice some of the flexibility and accuracy obtainable from the largest studio installations, but it will provide a convenient and portable source for a wide variety of electronic sounds within a limited budget allowance.

In order to fill the need for such a functional source for complex tones, we at North Texas State University have designed a generator which contains the following: five sine-wave oscillators, one multivibrator, one pulse generator, one balanced modulator, one sweep-frequency oscillator, six formant filters, and an assortment of envelope control attachments to the modulator, including a rectifier and integrating network on the modulation input, an expansion-compression switch between the main and the modulation inputs of the modulator, and inputs for external d.c. and a.c. modulation.

The oscillators are limited in the range which they can produce; in the design, it was planned to include simple oscillator circuits which would not consume much space or power. And the oscillators do not produce a continuous pitch selection, but employ capacitors in an additive fashion to determine the pitch, all oscillators drawing from the common capacitor bank. This arrangement conserves space and provides only as much flex-

*Research Assistant in Electronic Music, North Texas State University.

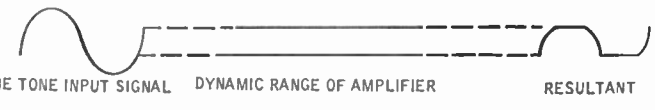

Fig. 1. Overdriving an amplifier produces a squared output.

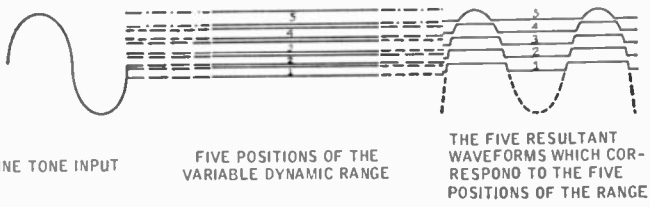

Fig. 2. How variable bias produces various outputs.

ibility as is considered necessary in the light of the intended application.

The unit has proved capable of producing a wide variety of continuous, clangorous sounds and, through the envelope-control features provided, a range of bell, chime, and other percussive sounds. These sounds, generally beyond the reach of a standard studio installation of moderate size, have been accomplished by sacrificing some flexibility in the individual oscillators, in the interest of increased variety and range in numbers and types of oscillators. The complete unit is a moderate-sized table-top unit, which is portable and contains all of the components necessary for its operation.

The heart of the unit is the modulator and its various envelope shaping controls. With this unit any oscillators could have been used to accomplish the results with an increase in cost over the present unit, as well as an added requirement in size and weight.

When the unit is used in conjunction with several other input devices, such as the Cembalet (a sort of electronic harpsichord manufactured in Germany), a Theremin, the Wurlitzer electronic piano, or another generator with a convenient method of control, an extremely wide range of sound variety may easily be obtained. In each case, the performer plays the input instrument and the complex-tone generator is used to modify the output or to generate new signals with some relationship to the input.

The unit functions as a signal-modifying device, taking its input from any electronic musical instrument and providing certain basic manipulations upon this signal. It is capable of performing several manipulations simultaneously, and also of generating new sounds controlled in several different ways by the input signal. Finally, it is capable of generating certain types of continuous or percussive signals independently, with only a switch as the input signal device.

As such, the instrument may be used as a performing instrument, either alone, or when attached to some electronic input device. A keyboard-controlled input device has been found to be most satisfactory because it allows the average musician to relate the new sounds to something with which he is already familiar. It also offers a convenient method of notation.

Future plans call for a completely transistorized unit which will be somewhat easier to operate but will provide the same variety of complex-tone manipulation possible with the present model. In the same fashion, the simplest effects will be eliminated and laboratory accuracy sacrificed in order to provide the performer with a portable "electronic music lab in a hat-

box." In terms of generating complex tones, this unit will be the equivalent of several racks of expensive test equipment.

The purpose of the present article is to describe some of the various ways that the complex-tone generator may be set up and used, and the various types of sounds and their compositional usefulness as they are obtained from the generator in conjunction with various input devices. In the event that such a unit could be developed and distributed to any extent, composers would be able to write for it with the expectation that it could be obtained for performances, no matter where or when the performance was to take place. This device could put the range of significant new electronic sounds at the disposal of orchestral and chamber music composers without forcing them to rely on tape-recorded sounds.

Although the descriptions which follow are written in a general sense and may be performed in any complete laboratory, they have all been done with the complex-tone generator described.

Overdriving and Clipping

One of the simpler techniques which may be performed is the distortion of the input signal by clipping it so that only a portion of the wave is reproduced. If we overdrive any amplifier we can clip the peaks off the wave.

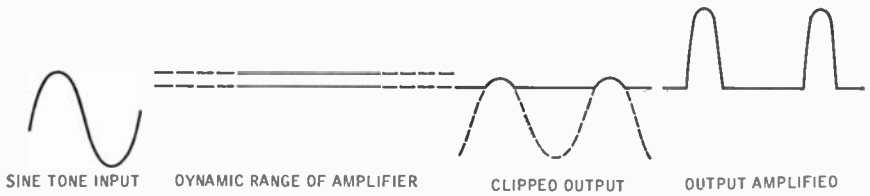

Fig. 3. Clipping and amplifying produces pulses from a sine-wave tone.

The simple overdriven amplifier will generate odd harmonics from a sine tone. (It produces an oscilloscope presentation which approaches that of a square wave.) If several tones are fed into the amplifier, the resultants will include sum and difference tones as well as the harmonics mentioned above.

If we should drive such an amplifier but add one feature, a variable bias, we can accomplish much more. By varying the bias we can change the location of the dynamic range of a vacuum tube or a transistor.

By varying the dynamic range of an amplifier we can change the output in several ways. We may change the lengths of the mark and space portions of the squared waveform. We may also reduce one of them almost to the point of disappearing. Thus we may convert a sine tone into a series of widely spaced pulses.

Such a clipped tone as has just been described will have a quality in which the overtones predominate and the fundamental is very weak. It will sound somewhat like a bassoon and may be very "buzzy." It is derived from a sine-tone input by use of a simple amplifier and a variable bias control.

If two or more tones are fed into a clipping amplifier the result is extremely complicated. Interestingly, the consonant intervals generate only integral partials, while the greater the dissonance of the interval, the greater is the number of foreign components. This gives a heightened effect of consonance and dissonance, and even

simple two-part counterpoint has a very strong contrast when treated through such a system of electronic manipulation.

Filtering Complex Tones

In any situation where more than one frequency is present, we may apply our filters. The filters have the greatest effect on complex waves such as those which we obtain by overdriving an amplifier, as just described.

If we desire to generate a particular frequency or set of frequencies within a certain range, but find that we get others which we do not want in the process, we may suppress the unwanted frequencies, at least partially, with a filter. This device will often save a desperate situation by pulling the desired signal out of the noise.

A further attractive application of filters is the use of formant filters. These filters may be applied to the output of any generator, usually with improved results.

The theory of formant filters has already been described elsewhere.[1] but the effect is to add a certain musical sound to an otherwise coarse and rough tone.

The filters are applicable to any of the various types of complex tones to be described later in this article.

Techniques of Modulation

If two or more tones are amplified by a non-linear amplifier, as has been described under "overdriving and clipping," the difference and sum tones which result are products of intermodulation. These products are present along with the harmonics of each of the tones generated as the tones are clipped.

With a true modulator we will be a little more sophisticated and separate the harmonic from the intermodulation products.

[1]Robert C. Ehle, "Techniques for the Synthesis of Electronic Music," North Texas State University, Electronic Music Laboratory Manual (Syllabus).

A modulator is an amplifier which is basically linear but which is made non-linear by means of the modulation input signal. The modulation signal changes the bias point on the amplifier and therefore varies the dynamic range of the amplifier in direct relation to itself. When the dynamic range changes, the input signal is modified accordingly.

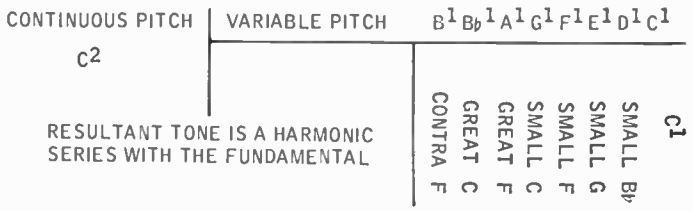

Fig. 4. Resultants from modulation of the diatonic scale by a single tone.

Our modulator should be balanced so that the modulation signal can be balanced out of the output. This allows us to modulate an input signal by a continuous tone and not hear the continuous tone when the input signal is not present.

So we will use a balanced modulator with a variable bias control, and can accomplish many results by means of such an instrument.

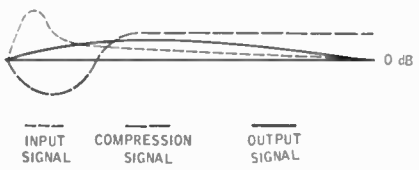

Fig. 5. Volume compression as applied to a transient and decay.

Modulation of Input Signal by a Continuous Wave

We will modulate the output of any electrical musical instrument by a continuous wave which is balanced out in the balanced modulator. The result is that each pitch of the input instrument will generate difference- and sum-tone spectra which are the resultants of the input and the continuous wave. If the continuous wave is a simple sine-tone and the input is an equally tempered scale, the resultant scale will be a series of difference tones resembling an inverted series of intervals from those obtainable from a simple pipe or string. The reason for this is that each pair of pitches generates the overtone series containing that pair of pitches. The row of fundamentals becomes the apparent new scale.

This technique may be applied to any type of input signal, whether from a traditional instrument played into a microphone or from some all-electronic instrument. When the Theremin is used, several secondary glissandos result, one of which moves in the inverse direction to the input.

A further extension is to use a more complex continuous tone such as that which is generated by five sine-wave oscillators pitched in random relationships. The results in this case, when an input signal is present, are complex tones with a brittle, metallic quality. Often the input pitch can be discerned but usually it is only an apparent change heard when the input signal is changed. The effect is percussive and, like tuned cymbals or wood blocks, is only vaguely pitched, with non-integral tones predominating. These sounds are very musical and practical for electronic music.

Volume Compression and Expansion

We may use a modulator to provide further modifications to an input signal by feeding the input signal into both the signal and modulation inputs on the modulator.

In series with the modulation input we will have a rectifier and a set of filters which we may change in various ways. If the rectifier is set to pass positive pulses and we have a capacitor which is charged by the positive pulses, we will have a volume-expansion control. If the capacitor passes negative pulses the result will be volume compression.

When we adjust the threshold of the bias with the bias-adjust control, we may have a unit which

1. Suppresses loud sections more than soft ones (volume compression),
2. Amplifies loud portions more than the weaker ones (volume expansion),
3. Passes loud portions only (expansion & clipping),
4. Passes soft portions only (compression and clipping).

By adjusting the capacitors in the

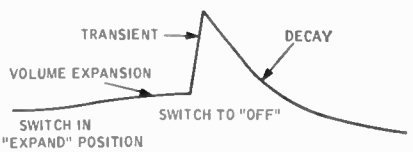

Fig. 6. Envelope generated by bell synthesizer.

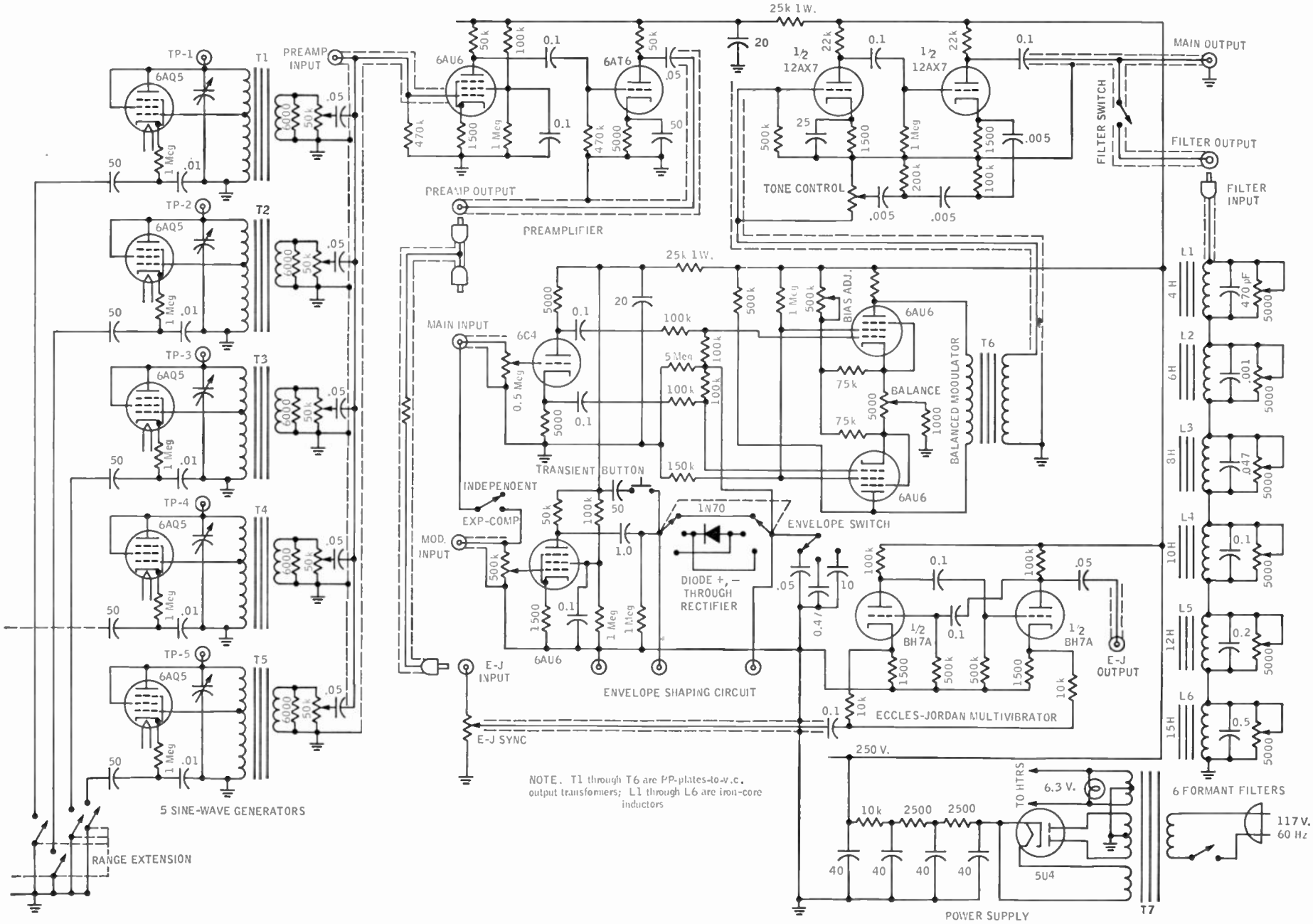

Fig. 7. Over-all schematic of the complex-tone generator described by the author.

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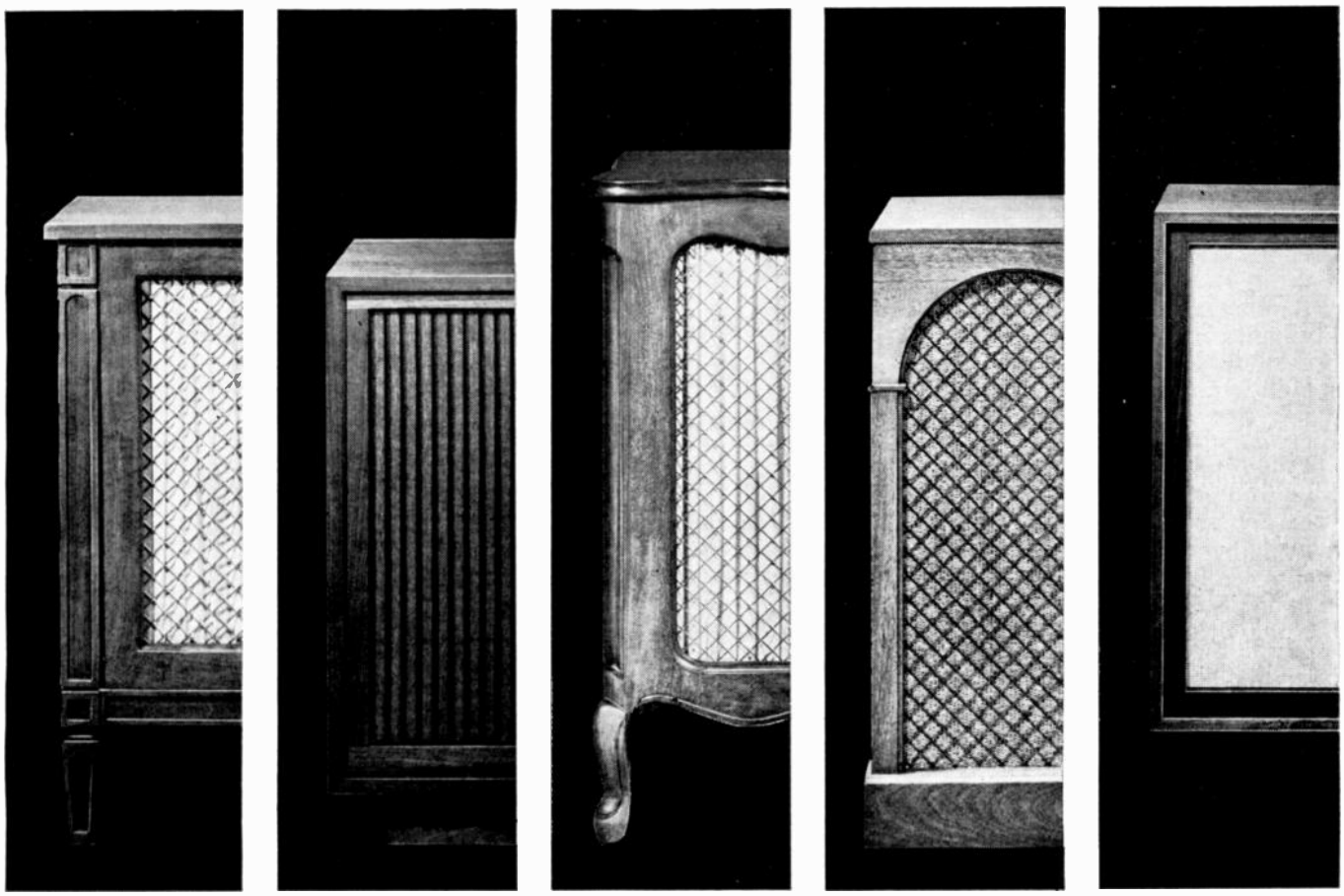

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filter we may vary the response time so that we may

1. Suppress the transients on "percussive tones."
2. Reproduce only the transients on "percussive tones."
3. Vary the volume in relation to the number of tones played in a period to time.

These techniques may be used either for long, slow variations in volume or for fast clipping of loud or soft portions. Thus the device may remove the attack from a piano tone and extend the apparent length of the tone by increasing the volume as the tone dies away.

It must be considered, however, that when the bias is set so that any portion of the tone is clipped completely, the amplifier will of necessity be operating in a non-linear section of its dynamic range and a certain amount of distortion will result. In order for this distortion to be removed, it is necessary to use the modulator in the middle of the range and to use a large filter on the modulation input so that no modulation takes place at an audible frequency. Often, of course, the particular distortion which results in such cases is the goal of the composer and is actually the desired output.

Generation of Synthetic Bells and other Percussive Tones

In the specific instrument on which these techniques were worked out, a switch was installed between the main signal input and the modulation input.

This switch was originally intended for going from an independent modulation mode to an expansion-compression mode of operation in which the input signal also fed the modulation input.

This switch, it was soon discovered, served another very useful function, the generation of single percussive tones.

Originally it was planned to use the five continuous-wave oscillators as the basis for a complex bell tone and then to gate them on suddenly and reduce their volume gradually by means of the modulator. The modulation input would be switched to a source of constant d.c. voltage, such as a battery, and, through a capacitor, this voltage would increase the bias on the modulator. As the capacitor charged up, the bias would be reduced gradually.

Although this method worked, a simpler, more dramatic method was subsequently discovered.

When the switch is thrown to the expansion-compression position, the continuous input from the five oscillators provides its own expansion voltage on the modulation input and through the rectifier and filter, mentioned earlier, the volume is expanded Then when the switch is thrown to the opposite position, the signal is suddenly removed from the modulation input. This sudden drop in voltage is inverted across a single stage of amplification and then becomes a sudden, positive-going voltage which passes through the rectifier in the "positive" position and generates a fast transient in the modulator when applied to it.

Any type of input may be used in this fashion, and a wide variety of percussive sounds may thus be generated.

Further Applications of the Modulator

Of course, the list of techniques related so far is not at all complete. Many more combinations of instruments are possible. For example, one input instrument may modulate another. One player may play a Theremin into the modulation input while another plays a Cembalet into the main input. The controls may be set so that the Cembalet tone is modified by the Theremin or so that the Cembalet is not heard until the Theremin player plays also. Each may interact with the other in a variety of ways, depending on how the controls are adjusted.

Modulated white noise is another possibility. When modulated by a pitch, white noise seems to take on the characteristics of that pitch although it is still "noise." It becomes a sort of tuned noise and is useful in electronic music, where it is sometimes called "pink" noise. Still remaining, and not to be covered in the present article, are the radio frequency modulation techniques useful in spectrum inverters and other devices.

(Continued on page 112)

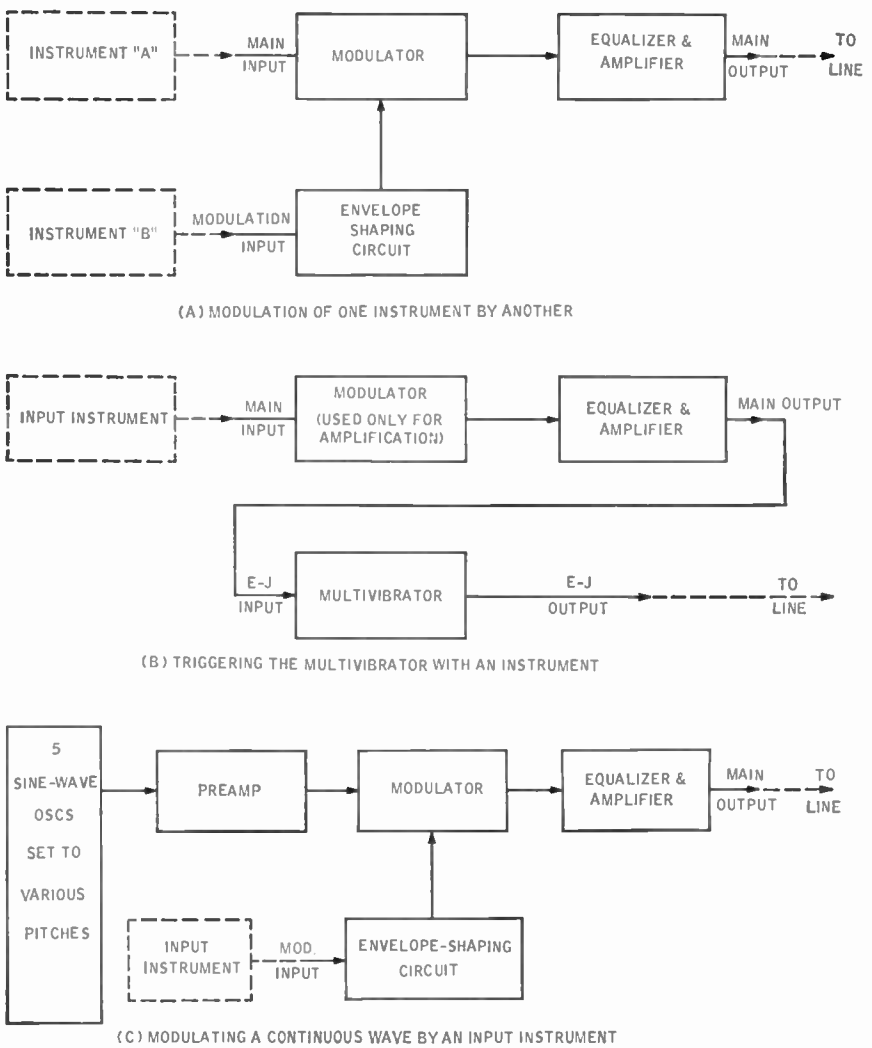

Fig. 8. Block schematics of typical applications of the complex-tone generator.

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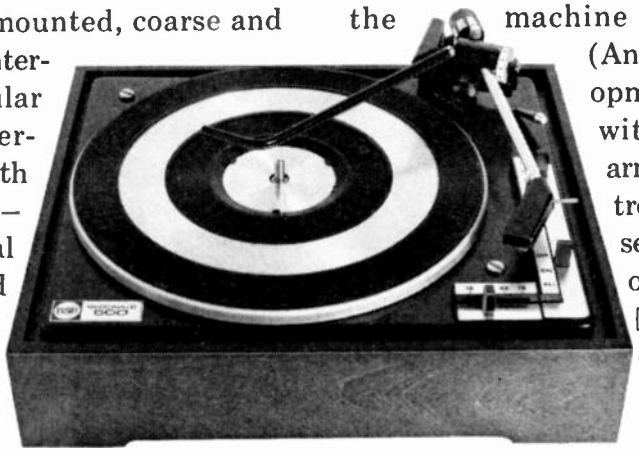

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Audio Measurements Course

PART 9

NORMAN H. CROWHURST

Complete measurements on an audio system will usually entail consideration of phono-pickup performance. In this installment, the author tells you what to measure, how to measure it, and how to interpret your findings.

MEASUREMENTS connected with phonograph operation involve all the same considerations discussed for amplifiers, plus a few that don't occur there. Frequency response, distortion, and dynamic range each have their counterparts, and for stereo, separation needs measuring. Then the mechanical character of the device adds another source of "noise"—rumble, caused by the pickup transducing mechanical vibrations in the turntable. Flutter and wow, which are forms of frequency modulation of the signal due to variations in turntable speed as it rotates, must also be measured.

With all aspects of phonograph performance, complication ambiguities occur that don't arise with simple electronic circuits. In amplifier circuits, terminating impedances are important, and variation can change frequency response, distortion, and so on. When dealing with phonograph records, the electrical terminating impedance—provided by the cutterhead in recording and the pickup on playback—produces effects similar to those discussed in earlier installments. Additionally, the transducers have a mechanical impedance termination in the form of the disc material.

The recording cutter head has to cut into the master material, which loads it. The usual practice is to provide a high degree of negative feedback, so the resistance offered by the disc material to cutting does not materially affect the stylus movement. In any event, the result can be checked both visually and by playback with a high-quality pickup, so necessary measures can be taken to linearize the cutting operation.

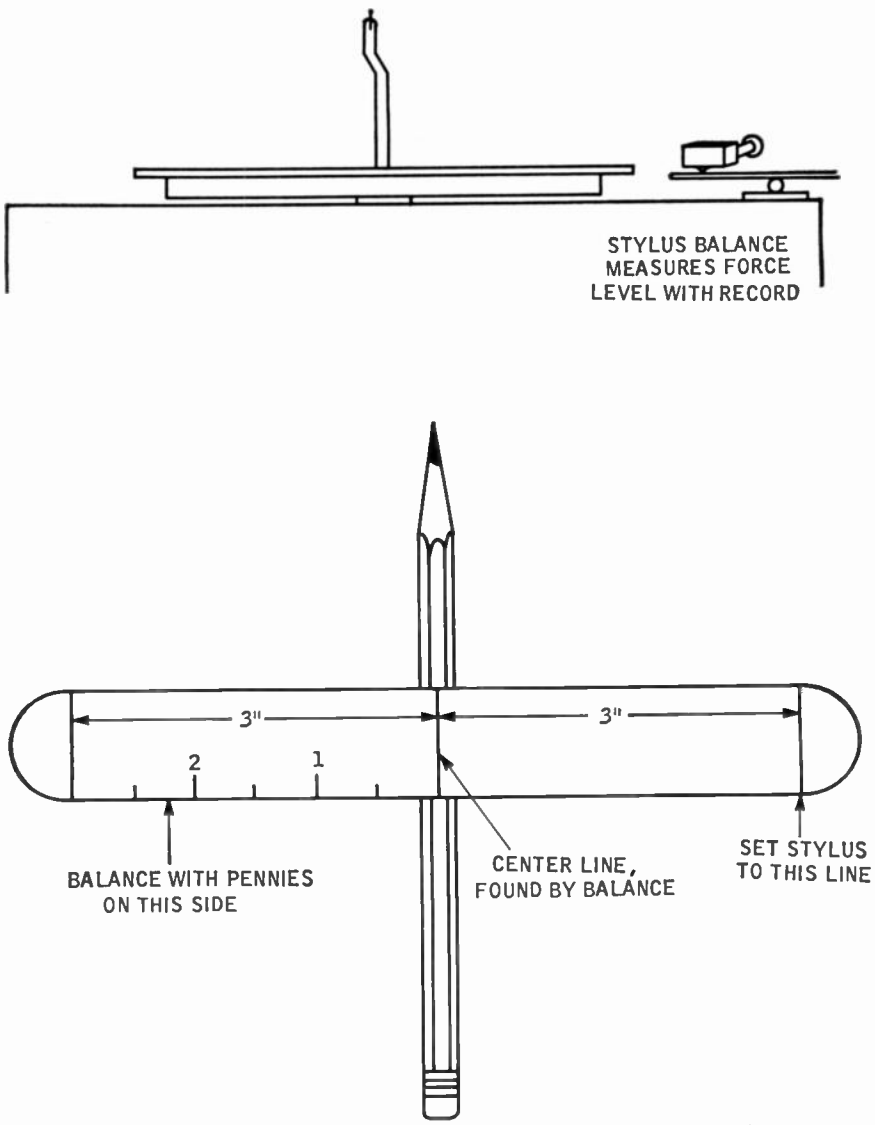

Fig. 9-1. Improvizing a stylus force balance: top, the force should be measured (balanced) with the stylus at the same level it occupies when playing the record; bottom, using a tongue depressor to make a balance that uses pennies.

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Our sole concern is sonic perfection. We don't follow the herd in engineering, styling or promotion. Fads, status and "revolutionary new sounds" never enter our planning. We avoid regular model changes and the planned obsolescence they engender. We take the extra time to do things right the first time. That probably explains why our limited product line has become increasingly popular each year. It's why our kits are so easy to build; why maintenance is so easy; and service problems so few. We constantly strive to improve our products though, and when we do, these changes are available to our customers to update existing equipment at low cost.

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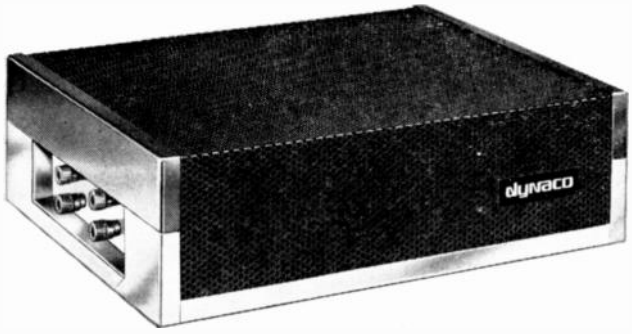

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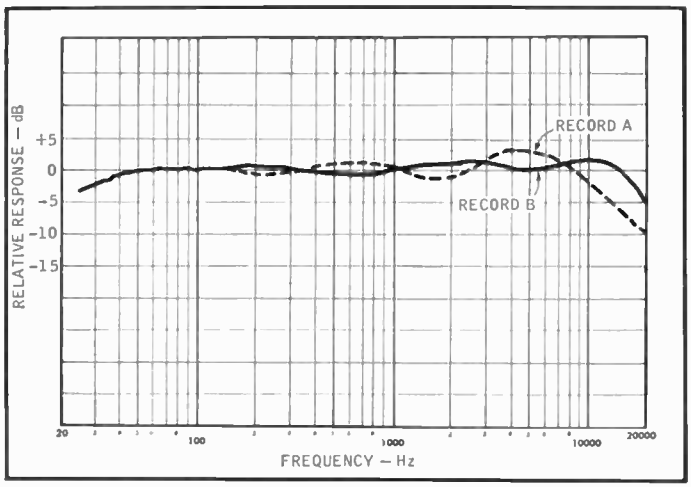


Fig. 9-2. Response (after correction for level deviations) of the same pickup taken with test records using different compositions for the disc of which they are pressed.

On playback, linearizing is not so simple. Feedback is not possible. And the movement transmitted to the pickup stylus is a function, not only of the shape of the groove and the mechanical way in which the stylus can follow it, but also of the resilience and other properties of the groove walls, when they attempt to drive the stylus.

These properties will vary from record to record, and with the different materials and fillers that are used. The effect the differences make will vary from pickup to pickup, because they too will have different mechanical characteristics, as well as different inherent transducer responses. So the deceptively simple expression "pickup response" is not so easy to "tie down."

Any record of tests made should quite completely specify the test conditions, the record used, the tracking force applied, and so on to have any meaning at all.

Tracking Force

The force required to keep the pickup stylus in the groove at various recording velocities and frequencies is an important quantity. Excessive force over that needed to keep the stylus from riding up the walls will produce unnecessary wear. So will too-little force, because then the stylus will tear into the walls, instead of riding the groove properly. Too-little force also causes excessive distortion in the reproduced sound.

Tonearms invariably provide some kind of adjustment to vary the tracking force, and many of them are calibrated in grams. But the only sure way to measure force is with a stylus balance, and with the stylus at the same level it occupies when playing a record (*Fig.* 9-1). If a balance designed for the purpose isn't available, it is easy to improvize one with a tongue depressor and pennies.

A one-cent piece weighs almost exactly 3 grams. Mark off the tongue depressor with a center mark (found by balancing it across a pencil). Then mark off points an equal distance from the center, say 3 inches. These points should be as near the ends as reasonably possible, but it is more important for these dimensions to be exactly equal than for them to be really close to the ends.

Now, with the center line over a pencil as fulcrum, and the stylus resting on one of the end marks, balance will occur if one penny is centered over the other end mark when the tracking force is 3 grams. Two pennies will show 6 grams, or three pennies 9 grams.

To measure fractional amounts of 3 grams, intermediate marks can be used. If the end marks are each 3 inches from center, when a penny is placed on a mark 1 inch from center (or one-third whatever the dimension is) it will balance a 1-gram force at the stylus end. Placed on a mark at half an inch, a penny will provide a balance point for one half gram (at which some of the best pickups will track). A mark at 1½ inches will cause a penny centered there to balance 1½ grams, one at 2 inches will balance 2 grams, one at 2½ inches 2½ grams. It's a linear scale.

For forces between 3 and 6 grams, one penny can be placed at the inch mark for 3 grams and the other moved to find the fractional part.

Frequency Response

This must be measured with some kind of test disc. Suggestions have been put forward, periodically, of setting up a purely mechanical test, such as coupling a pickup stylus directly to a cutter drive mechanism. This may produce some test results, but they are not valid, because they "short-circuit" that very important element, the record material. It's like measuring the response of an amplifier with zero source resistance, instead of with the proper value inserted between generator and amplifier.

Any test record with calibrated frequency bands, or a gliding tone with identifying marks (the tone momentarily interrupted) to indicate when specified frequencies are passed, or with the frequency scale designed to work with a recorder using a synchronous motor and log paper driven at specified speed, can be used to check pickup response, within broad tolerance: such a test will indicate roughly "how good" a pickup is. But no one test record should be used to compare one pickup of a given quality with another of the same approximate quality.

Assuming we have a reliable test disc or, more hopefully, several different ones, frequency runs are made, either by spot readings, or by a recording meter with the glide-tone test band.

If several good records are used, an indication of the consistency of the pickup, in playing different records (with varying resilience or other composition qualities) can be obtained from comparison of the results of the tests (*Fig.* 9-2).

Different test records use different levels, and different ways of varying level with frequency, which may or may not follow a standard equalization characteristic. In any event, the records come with data that will correlate the results so corrections can be made for these differences. That is a matter of simple arithmetic (working on dB) so we will not take up time here to explain such conversions, but will assume that a corrected frequency response, inclusive of standard characteristics, has been derived.

Now comes the puzzle. When you

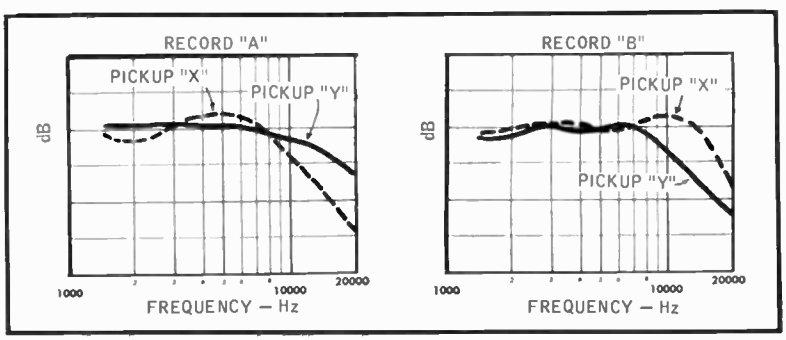
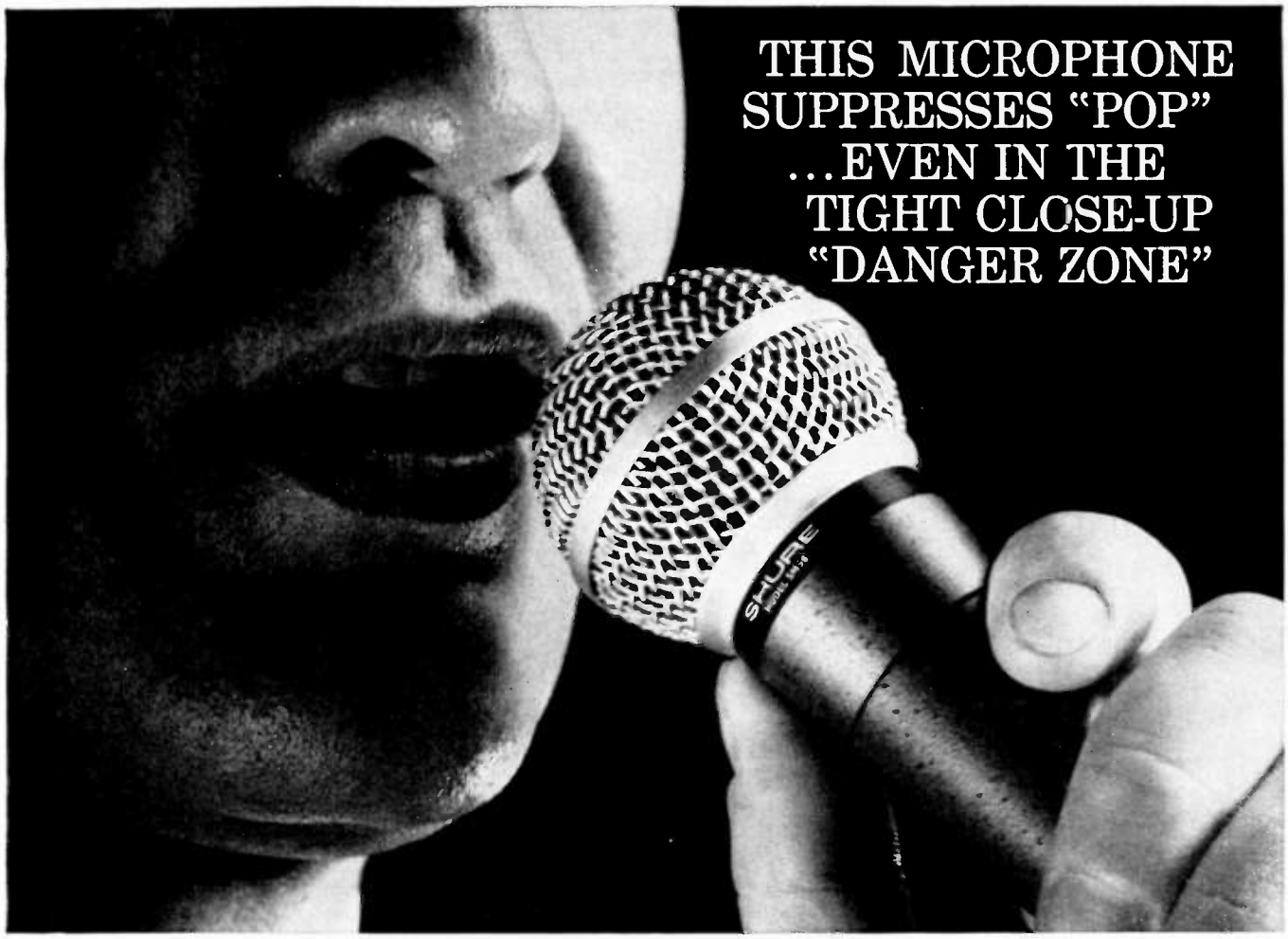


Fig. 9-3. Two comparisons between the same two pickups (X and Y) made with different test records (A and B).



The Shure SM58 *self-windscreened* unidirectional microphone is ideal for broadcast uses such as remote news, sports, interview and vocal recordings because it eliminates or minimizes the irritating "pop" caused by explosive breath sounds. With the SM58 you will have the peace-of-mind assurance that you're delivering the quality audio that goes with pop-free pickup. It's great for studio announcing, too—or wherever the announcer or vocalist has the audio-degrading habit of "mouthing" the microphone. Of course, the same filters that eliminate pop also do away with the necessity for an add-on windscreen in outdoor uses.

On the other hand, the unusually effective unidirectional cardioid pickup pattern (uniform at *all* frequencies, in *all* planes) means that it is a real problem-solver where background noise is high or where the microphone must be operated at some distance from the performer. Incidentally, but very important, the SM58 tends to control the low frequency "boominess" that is usually accented by close-up microphones.

All in all, close up or at a distance, the Shure SM58 solves the kind of ever-present perplexing problems the audio engineer may have felt were necessary evils. The SM58 might well be the finest all-purpose hand-held microphone in manufacture today. And, all things considered, it is moderate in cost.

Other features: the complete pop-proof filter assembly is instantly replaceable in the field, without tools. Filters can be easily cleaned, too. Stand or hand operation. Detachable cable. Rubber-mounted cartridge minimizes handling noise. Special TV-tested non-glare finish.

For additional information, write directly to Mr. Robert Carr, Manager of Professional Products Division, Shure Brothers, Inc., 222 Hartrey Ave., Evanston, Illinois 60204.

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make comparisons between results obtained on different records, you are apt to find that the difference between pickups is not consistent. Using one test record, after applying corrections, the difference between responses is not the same as the results of using another record (*Fig.* 9-3).

The basic response recorded on the test disc can be checked by light pattern reflections (*Fig.* 9-4). Recording at constant velocity (as frequency is varied) results in a band of reflected light of constant width. For the most accurate pattern the light should come over your shoulder and strike the record at 45 deg. (*Fig.* 9-5). The light can be masked to a vertical slit for clear-cut patterns.

Reflected light from stereo test discs, where left and right channels are recorded separately (with unused channel unrecorded) can similarly be checked by careful angling of the record to the light, so reflection from the recorded wall of the disc is viewed. The left channel will be seen on the side nearest you, the right channel on the far side (*Fig.* 9-6).

Observation of the light patterns will most likely confirm the calibrated levels supplied with the disc. Looking at them will confirm whether or not any eccentricity observed in the test results (response measured), particularly at the high-frequency end, are due to erratic record-cutter performance, not stated in the calibration, or due to something occurring in the playback.

Most modern test records have such deviations carefully corrected or removed, but looking at the light patterns is a good way to check. While on this point, it should be mentioned that light patterns can also indicate distortion in the recording, of asymmetrical kind (even-order harmonics). When this is present, the light pattern is not symmetrical (*Fig.* 9-7).

Distortion

Distortion can occur in record reproduction due to a variety of causes that do not occur in other audio equipment items. The groove may be perfectly recorded (free from distortion of any kind) and yet, for various reasons, the pickup may be unable to trace the groove accurately. Causes of these distortions have been discussed extensively in the literature, but their effects may be lumped for test purposes.

In monophonic recording (lateral only) some of the distortions can be avoided by designing the pickup so it is not sensitive to vertical stylus movement. In stereophonic recording, using the 45/45 standard, a vertical component of movement is part of the recording, so the pickup must follow it accurately. Failure to do so will result in loss of separation and, what is more noticeable, heavy distortion components in the "leakage" (crosstalk) signal.

Any high-quality recorded signal can be checked for harmonic content by an analysis method. The bridge method cannot be applied here, because the input signal used for the record is not available. Standard tests for distortion on disc may also include a low/high recorded signal (SMPTE-type) or a difference-frequency intermodulation test.

The latter uses two higher frequencies, spaced by a difference of, say 1000 Hz. One of the high frequencies is recorded continuously. The other is alternated with a 1000-Hz tone in A-N code, at a level to represent the result of a specified amount of distortion, say 2 per cent. The recorded 1000-Hz signal uses the A code (*Fig.* 9-8). If distortion is less than the specified amount (2 per cent), the 1000-Hz tone is louder than the intermodulation product and the A-signal is heard. But if asymmetrical distortion exceeds the specified amount, the beat produced by the distortion will be louder than the recorded 1000-Hz signal, so that the N code will be heard instead.

In testing stereo reproducing pickups for distortion, separation tests should be analyzed. Not only should the quantity of left leaking into right (crosstalk) — and vice versa — be checked, but the nature of the breakthrough should be analyzed. If it is pure tone breaking through, check the pickup mounting for its orientation.

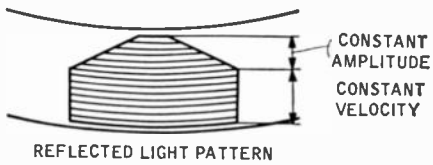

Fig. 9-4. Using the light-pattern method of checking the recorded response of a test disc.

Incorrect alignment of the 45/45 axes will cause simple crosstalk of this nature, which can be corrected by improving the alignment (*Fig.* 9-9). A good separation curve, plotted automatically with glide-tone record (CBS-STR-100) is shown at *Fig.* 9-10.

But if the crosstalk contains distortion components from second harmonics on up, then it is more serious. It may be due to a poor vertical tracking angle (*Fig.* 9-11). In a theoretical analysis of this method of recording, the stylus should move in a plane vertical to the record, in directions mutually at 45 deg. to the vertical axis for each channel.

In such a theoretical ideal, departure from the vertical plane in this complex movement would result in distortion components due to movement that *should* be vertical introducing a component of back and forth *along* the groove, as the record rotates.

But the record cutter does not cut according to this ideal, because there is no feasible way of mounting it so that such a vertical planer movement can be achieved. This being the case, minimum distortion due to vertical/longitudinal modulation will occur when the off-vertical plane (vertical tracking angle) used for both cutting and playing back is the same.

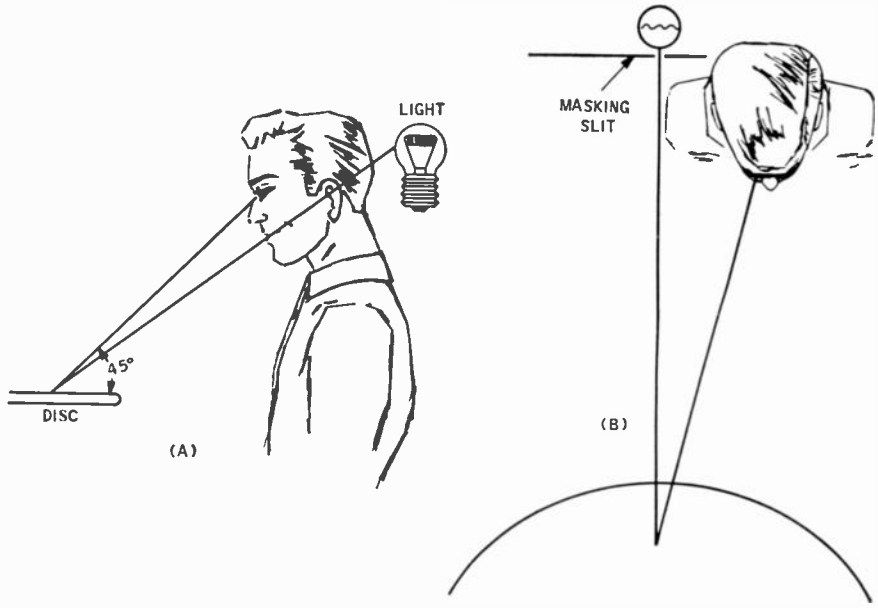

Fig. 9-5. (A) Viewing angle for observing light patterns, and (B) masking the light source to get a sharp pattern.

We got rid of rumble

(what's left is virtually unmeasurable)

Our engineers wanted to design a turntable that was so free of rumble, that it was unmeasurable and certainly inaudible. They started by directing their attention to the motor, where most of the rumble-producing vibration is born. While the motion of the motor cannot be eliminated, it can be reduced by reducing its speed and so reducing vibration at its very source. The motor employed in the Servomatic is designed to provide optimum torque at 300 rpm, *about 1/6 the speed of conventional turntable motors.* This accounts for a sharp reduction in rumble-producing vibrations.

Whatever little vibration that still might be left was isolated and contained by the use of a belt-drive coupling between the motor and turntable to absorb all residual mechanical vibrations. The problem of rumble caused by the motion of the turntable itself was dealt with by maintaining extremely close tolerances in the main bearing.

Sony designers then tackled the problem of precise speed regulation. Their approach: a precision servo-controlled motor, first ever used in a turntable. It is designed to operate at low voltages which are provided by a solid-state amplifier, an integral part of the turntable system. To assure precise speed accuracy, the motor shaft is coupled to an alternator or frequency generator. The output of this generator is fed to the control circuit of the servo amplifier. This control circuit is highly frequency sensitive. The slightest change in frequency output from the generator or even the slightest change in turntable speed, results in an instantaneous compensating change in the operating voltage provided by the amplifier to the motor. Model TTS-3000, $149.50.

The Servomatic, a most unusual turntable, is designed for use with today's finest tonearms and cartridges. The Sony VC-8E, the first moving coil cartridge with high enough output to eliminate the need for transformer coupling, makes an ideal mate. $65. Add the Sony PUA-237, 12" professional arm (or the PUA-286, 16" transcription arm) a remarkably sensitive and stable arm, and you've got the finest playback system available today. PUA-237, $85; PUA-286, $99.50. See these new components at your Sony high-fidelity dealer, or write for complete catalog: Sony Corporation of America, Dept. H, 47-47 Van Dam St., Long Island City, N.Y. 11101

SONY

High-quality cutters and pickups have narrowed this angle's variation to between 15 and 45 deg. As cutters are not standard, not all recordings will yield the same low distortion. A record cut at 15 deg. and played at 45 deg. (or vice versa) will show many times the distortion produced by a record cut and played back at, say 30 deg. Probably the trend will be to narrow down the angle variation to the middle of this range, so deviations cause minimum distortion, and the best cutter and pickups result in close to zero distortion, at least due to this cause.

Dynamic Range

Dynamic range on records is a function of the noise level, due to surface irregularity, as well as spurious vibration picked up from the turntable, for the low-level end, and the maximum velocity that can be recorded and/or played back for the high-level end. Most pickups will require greater tracking force with higher-velocity recording. Measurements should be made on this, as well as on distortion as the tracking force is reduced at various values of recording velocity (where the test record includes a variety).

A higher velocity can be used, at a higher frequency also, by increasing turntable speed. A test record for playing at 33⅓ will raise in frequency and velocity a factor of 1.33 when played at 45, or by 2.33 when played at 78 rpm.

It should be mentioned that phonograph hum has often been traced to a mechanical cause: the motor of some other electrical part generates a 60-Hz vibration that is transmitted to the pickup stylus. This will readily be proved by the hum disappearing the moment the stylus is lifted from the groove. On earlier recordings, this could also be due to hum recorded in the groove of that particular record, but modern records are, with few exceptions, recorded remarkably hum-free.

Hum can also be induced into the pickup by either electric or magnetic field. All magnetic types of pickups, which includes moving coil, moving iron, and moving magnet, some of which are sometimes called dynamic, can prove susceptible to magnetic hum pick-up of the type radiated by electric motors or power transformers. Piezo pickups are susceptible to electric field pick-up, radiated by power wiring.

Either kind can be checked by moving the pickup back and forth to see whether the hum varies. No electric or magnetic field is uniform over the range of positions through which a pickup can move in playing a record. It may not disappear at any point, but it will increase and decrease, showing that the pick-up is of this nature. If it stays constant, look somewhere else for the source of injection.

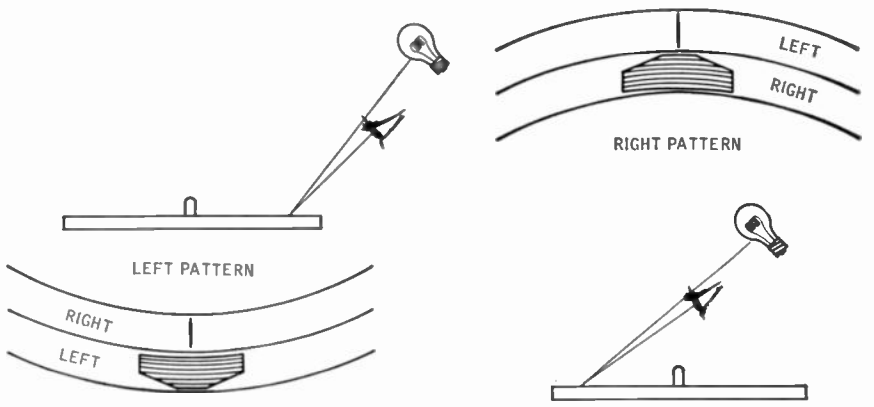

Fig. 9-6. Using the light-pattern method for stereo discs: each track may be viewed separately.

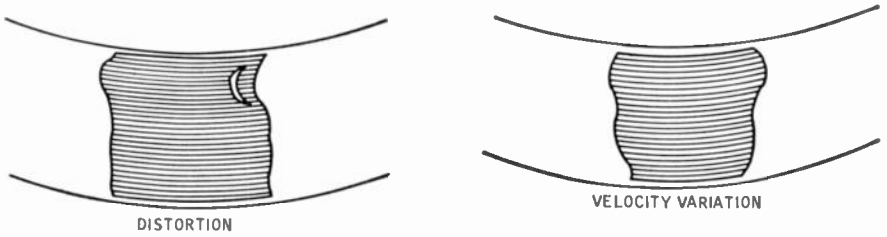

Fig. 9-7. The difference in irregularity of light pattern caused by distortion (A) or deviation in frequency response (B).

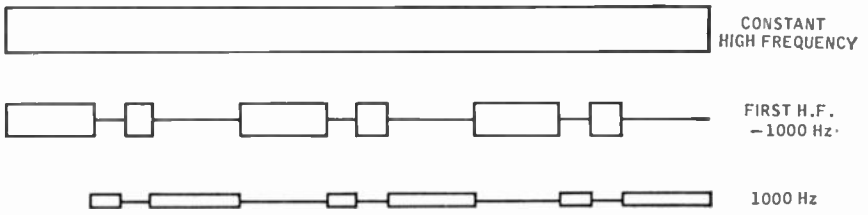

Fig. 9-8. The frequency of synthesis of a test signal recorded to give A-N indication of difference-frequency intermodulation effect.

As well as distortion due to failure to track, or tracing distortion, both of which are mechanical failures of the stylus in transcribing what is in the groove, pickups can cause distortion due to non-linear properties of the transducer itself, just like an amplifier can. When this is the case, changing tracking force, or varying tracking angle, will not reduce the distortion below an irreducible minimum for the level at which the measurement is taken.

Flutter and Wow

Before modern pickups reduced record drag to such a low order, and before such precision workmanship was put into phonograph turntable drives, flutter and wow were the bane of phonograph reproduction. Wow may be caused by friction of the turntable bearing varying at different points during rotation, so the pitch of reproduced music warbles up and down as the platter turns.

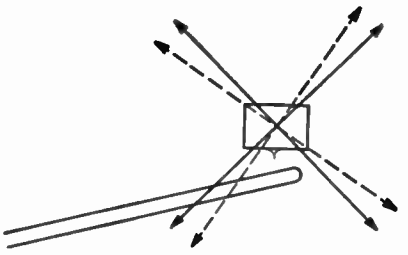

Fig. 9-9. Incorrect orientation (exaggerated here for clarity) will produce simple (relatively undistorted) crosstalk.

It can also be caused by eccentricity of the hole in the center of the record, so that the grooves are not concentric, and the pickup waggles slightly from side to side as the disc rotates. A warped disc can also cause wow.

Flutter is a similar fluctuation in speed, but where wow occurs at some

(Continued on page 118)

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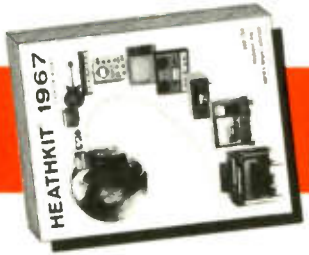

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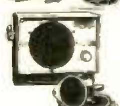

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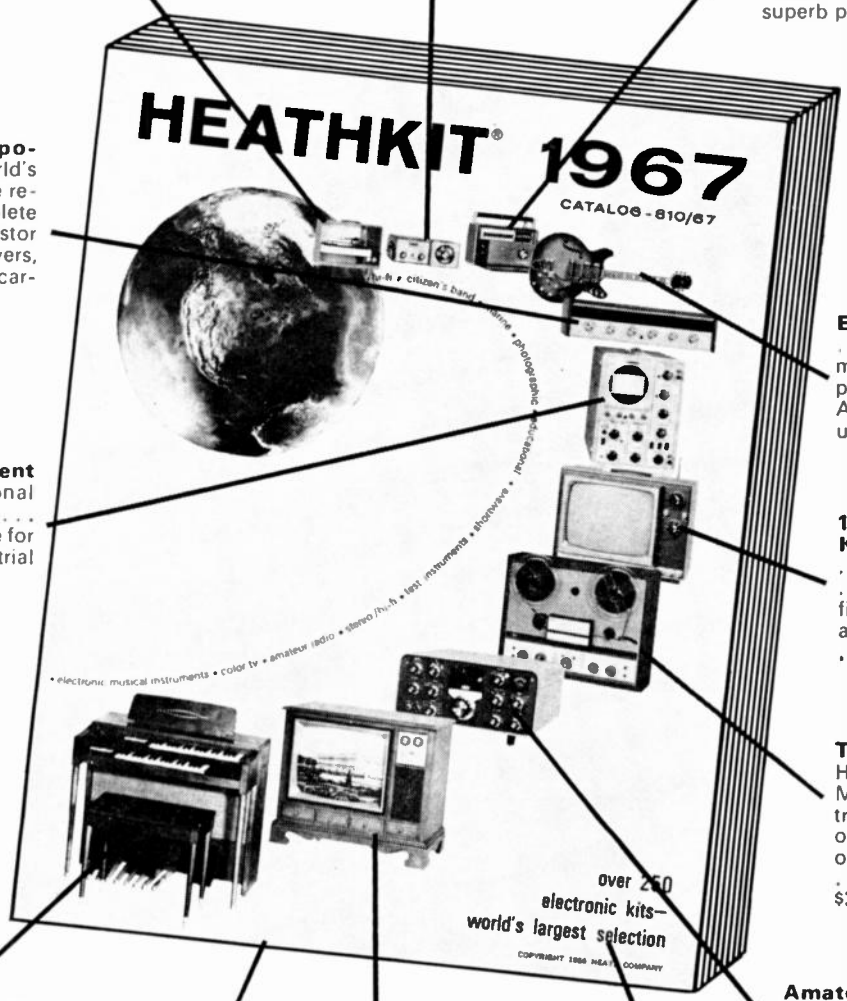

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THE NEW YORK HIGH FIDELITY MUSIC SHOW

A Statement by Walter Stanton
President
Institute of High Fidelity

IN THE FIRST TWO DECADES of its existence, component high fidelity has already participated to an exciting extent in the life and time sof an ever-urbanizing America. But the outlook is even more exciting. Automation, the social desires of the U. S. people, and the steady trend toward shorter working hours on the part of the nation's labor movement, clearly indicate that America of the 1970's will offer its populace much more leisure time than does the America of the 1960's.

To the component high fidelity industry, this increase in leisure time for all Americans represents both a challenging social obligation and admittedly a marketing opportunity. As we at the Institute of High-Fidelity, Inc. see it, the prospect of five to six or more hours a week of additional at-home recreational time clearly spells a broadened opportunity for our industry to bring more and more of "music at its best" to the people.

And it is at shows such as the 1967 New York High-Fidelity Music Show opening September 28th that the public will see what the top audio engineering talent in the country is doing to enhance the nation's opportunity to enjoy the finest in musical sound through component equipment.

You can see for yourself that component high fidelity means more than better sound at the New York Trade Show Building. Variety, diversity, and even an expression of your personality are built into your home through a component system. The use of components in the ever-expanding world of entertainment is a great stimulus behind Component High Fidelity's new products for 1967.

Home video tape recording equipment will be exhibited by several manufacturers. Video recording systems not only enable you to make instant home movies, but also to set a timer and record your favorite television show while out playing bridge. You will be able to replay the show when you return home, or even on a rainy Saturday afternoon six months later.

Another exciting and very popular exhibit will be the automobile stereo recorders. Reports indicate that automobile manufacturers are installing more than 750,000 tape music units in cars this year. Airplanes and yacht manufacturers are also adding component high fidelity systems as optional equipment on their new models.

Not all the components at the show are as unusual as the video tape recorders or even the underwater speakers for swimming pools, which will also be exhibited. This year, the aesthetics of component high fidelity equipment and its decorative blending with the rest of the consumer's home are being given additional attention.

Dispelling the concept of wires, circuit breakers, and tubes, this year an emphasis on the part of manufacturers has been placed on decoration with component equipment.

Most components sold today are enclosed in walnut, oak—or in many cases—teak and mahogany casings. The simple and beautiful exterior design of today's equipment will harmonize and complement any decoration theme from Early American to Chinese Modern. To illustrate this trend, the Institute of High Fidelity with the cooperation of the Association of Interior Decorators has created eight distinctively different decorator-designed rooms which will be exhibited at the New York High Fidelity Show. As you move through what we sincerely trust will be an exciting visit to our show, be sure to listen to all the component equipment and audio specialists available to you. The exhibitors and dealers at the show are experts and can answer any questions you might have about your present component system or one you plan to have in the future. WALTER O. STANTON

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LIST OF EXHIBITORS

Manufacturer	Room Numbers
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Acoustic Research Inc.	620, 622, 624, 625, 627, 628
Altec Lansing	534
Audio Dynamics	333, 335
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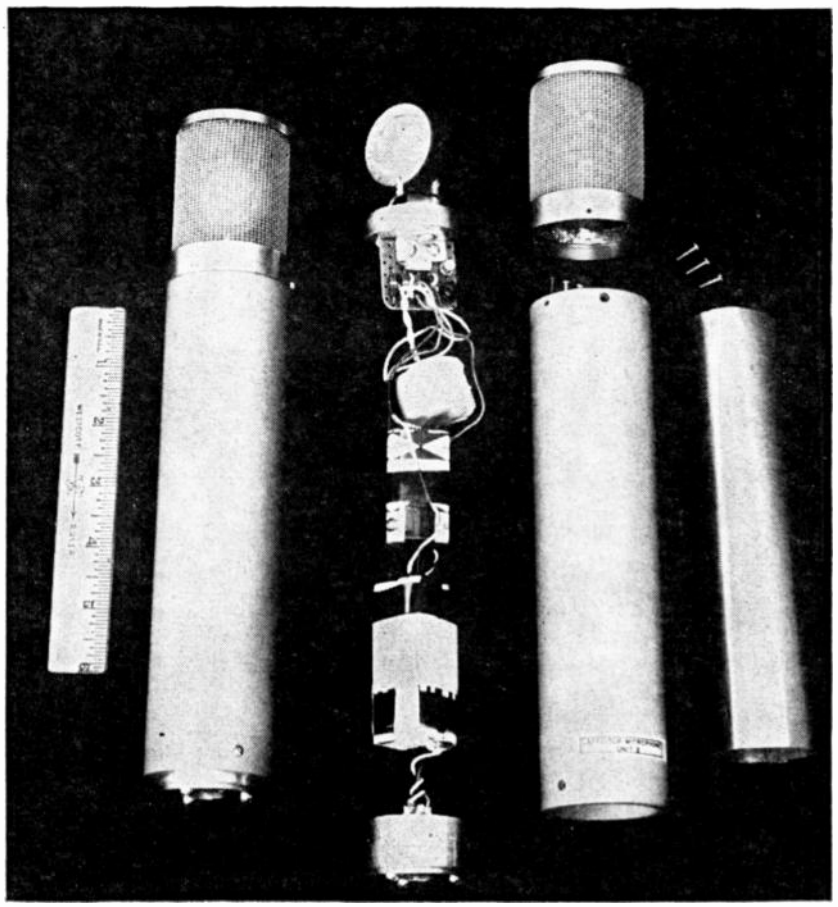
A CAPACITOR MICROPHONE SYSTEM

USING SEMI-CONDUCTOR DEVICES

Elimination of the vacuum tube in capacitor-microphone construction offers some advantages and simplifies the work. The unit described should be sufficiently simple for any advanced experimenter to undertake as an interesting and rewarding project.

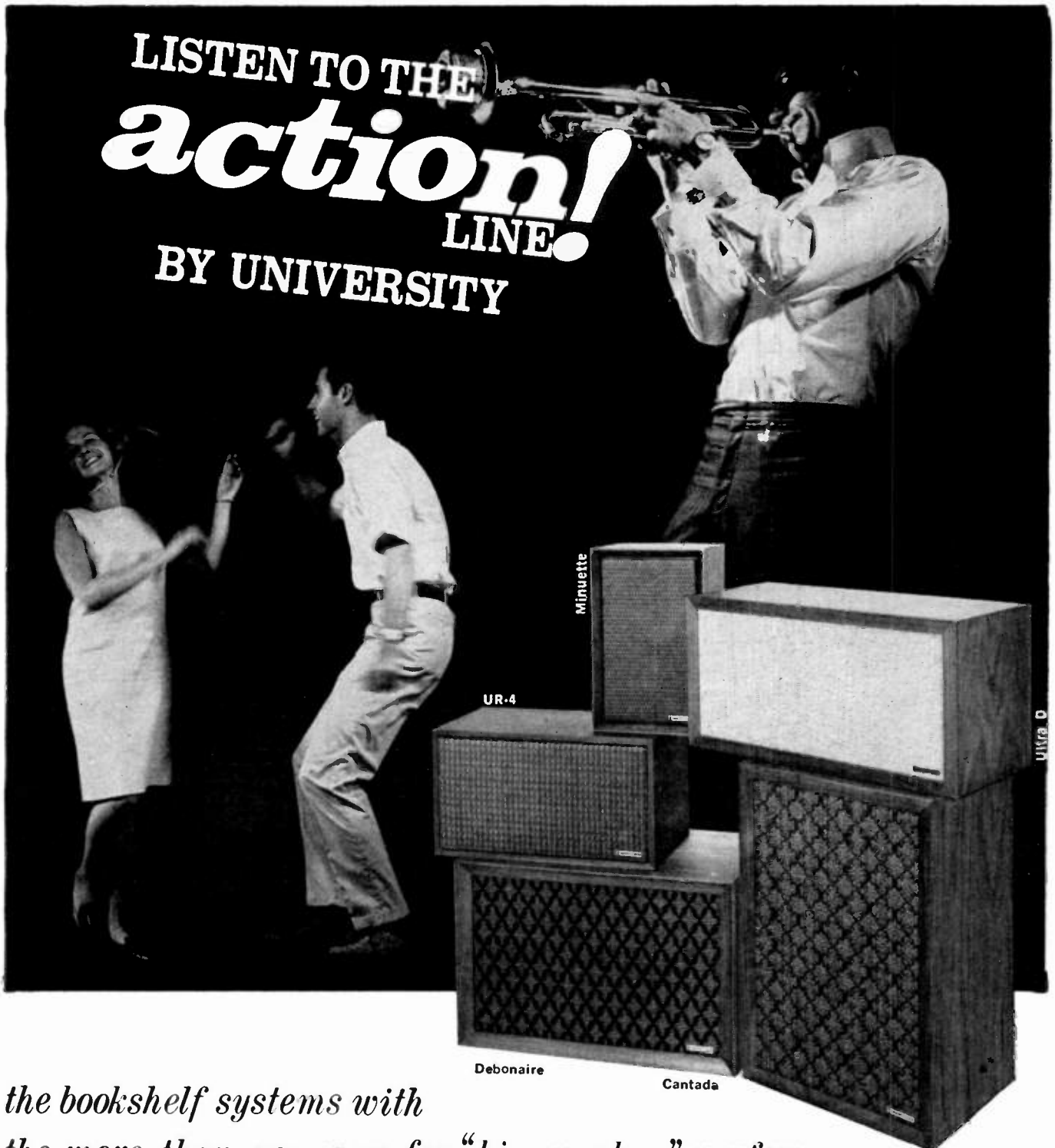
ROBERT B. SCHULEIN*



Two of the author's microphones, one of which is partially disassembled to show its internal layout.

As a result of R. Williamson's article "A Professional Condenser Microphone" in the July, 1963, edition of AUDIO, this Audio experimenter developed an interest in the construction of quality capacitor microphone systems. Since that time, several microphone systems have been constructed and tested, including that designed by Mr. Williamson. Within the past year, however, favorable results have been obtained using a field-effect transistor in the microphone impedance-matching circuit, and a complete microphone system has been developed and tested. Generally, the system consists of a capacitor pickup, similar in construction to that of Mr. Williamson, a single FET impedance-matching stage, and a low-impedance emitter-follower transistor output stage. The system developed offers several practical advantages over the conventional tube type, transformer-output, d-c polarized microphone scheme. As a result of the use of semiconductor devices, self-contained battery operation is practical, and by virtue of an unbalanced low-impedance output stage, conventional 2-conductor shielded cable can be employed using one conductor and

*2438 Electrical Engineering, Dept. of Elec. Engrg., University of Wisconsin, Madison, Wis. 53706.



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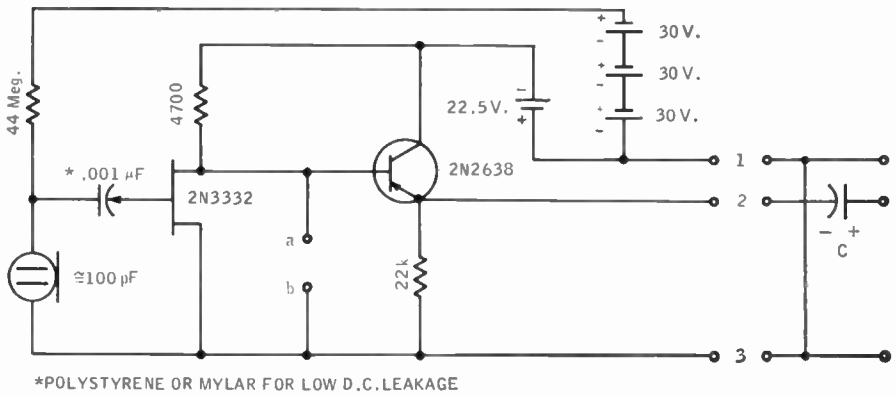


Fig. 1. The complete schematic for the author's microphone. The .001-μF capacitor marked with * should be polystyrene or Mylar® for low d.c. leakage.

ground in conjunction with cable connectors as an on-off switch.

Semiconductor Capacitor Microphone Systems

When considering the use of semiconductor devices in capacitor microphone circuits, one generally encounters three approaches to the problem. The first and oldest is a d.c. bias scheme which relies on the relation between voltage (V) and charge (Q) on a capacitor i.e. $Q = CV$. If the capacitor transducer is polarized through a resistor (R), the voltage across the capacitor will obey the previous equation for capacitance variation above the frequency $f = 1/2\pi RC$ at which point it is 3 dB down from its high-frequency limit. If 30 Hz is considered a practical low-frequency cutoff point, and a typical C of 100pF is used, the necessary R is about 50 megohms. If this voltage is to be amplified, severe restrictions are placed on the low-frequency input impedance of the amplifying device. This is the primary reason that vacuum tubes, as opposed to bipolar transistors have been used with such schemes until the recent availability of field-effect devices.

A second possible approach is to use the capacitor pickup in a radio-frequency scheme, whereby an AM, FM, or phase modulated signal is generated and detected. One such system constructed and tested by the author was that proposed by P. J. Baxandall.[1] This system consisted of a 1-MHz oscillator, which was amplitude modulated by the capacitor pickup in a balanced-bridge configuration, the output of which was detected by a phase-sensitive detector and filter. Even though Mr. Baxandall's experimental results indicated his system to be of professional quality, the author's experimental system suffered from a slight signal-to-noise-ratio problem. As a result of this experimental problem, I would not advise construction of such systems except to individuals skilled in the techniques of r.f. circuitry and having extreme patience in regard to small problems affecting signal-to-noise ratio. For the interested experimenter, however, additional references are given in regard to r.f. schemes at the end of this article.[2, 3]

The third approach is that of a permanently polarized capacitor, in which a Mylar diaphragm, serving as the variable capacitor plate, is polarized by heating and cooling in a high electric field. Such a system has been developed by G. M. Sessler and J. E. West of The Bell Telephone Laboratories[4, 5], and offers certain advantages over the other schemes described. Due to the fact that the transducer is permanently polarized, a much smaller electrode spacing can be used than conventional d.c. bias or r.f. schemes, and hence high sensitivity and high source capacitance result. By virtue of the increased source capacitance, conventional transistors can be employed in an amplifying circuit. Even though such systems were not pursued by the author, due to the complexity of pickup construction and diaphragm polarization, they are certainly worthy of consideration by the interested experimenter.

A Capacitor Microphone System Using a FET

As previously pointed out, the field-effect transistor, by virtue of its high

[1]P. J. Baxandall. "New low-noise transistor circuit for electrostatic microphones." *Wireless World*, November and December, 1963.

[2]Edmond DeNiet. "Parametric amplifiers used in electrical acoustics and Condenser microphone amplifier with semi-conductor elements." *J.A.E.S.*, July, 1964, Vol. 12, No. 3.

[3]Hans Joachim Griese. "Circuits of transistorized r.f. condenser microphones." *J.A.E.S.*, January, 1965, Vol. 13, No. 1.

[4]G. M. Sessler. "Electrostatic microphones with electret foil." *J. Acous. Soc. Am.*, September, 1963, Vol. 33, No. 9.

[5]G. M. Sessler and J. E. West. "Condenser microphones with electret foil." *J.A.E.S.*, April, 1964, Vol. 12, No. 2.

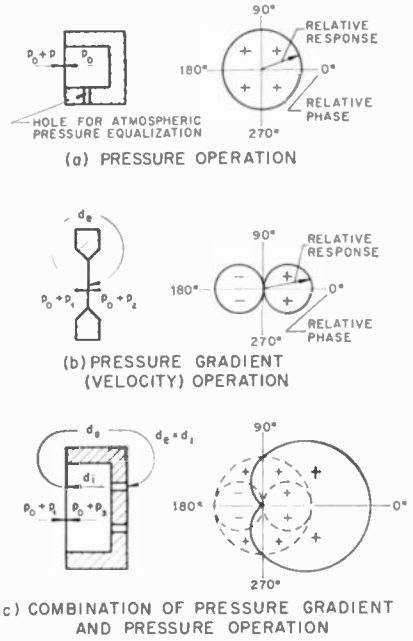


Fig. 2. Transducer directivity patterns: (A) in pressure operation; (B) in pressure-gradient (velocity) operation; and (C) in a combination of pressure-gradient and pressure operation.

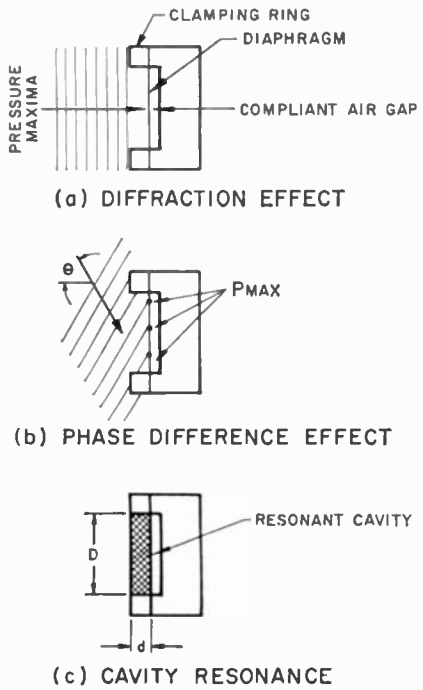


Fig. 3. Transducer dimensional effects: (A) diffraction effect; (B) Phase-difference effect; and (C), cavity resonance.

input impedance, is worthy of consideration in d.c. biased capacitor-microphone systems. One of the most important problems in any capacitor-microphone scheme is the signal-to-noise ratio of the circuitry, and this proved to be a genuine problem at the beginning of the author's experimentation. Part of the problem involved picking a low-noise device from published manufacturer specifications which are generally not in a form meaningful for this type of circuitry. After purchasing and trying numerous devices, two particular units (2N3332 or 2N2500 P-channel FET) were found most suitable for the final circuit. For those interested in considering other devices or future devices, the parameters shown in Table 1 may be of some help.

Using either of the suggested devices, the final microphone circuit is as shown in *Fig.* 1. In the circuit, the capacitor is polarized by the 90-V supply through 44 megohms, which corresponds to a low-frequency 3-dB cutoff of about 35 Hz. Separate battery supplies are used for polarizing and for biasing, since the current demands for polarizing are almost negligible in comparison to the drain for biasing. (i.e. Approx. 30 nA leakage through the polarized pickup and approx. 3 mA biasing.) Of particular importance for low-noise operation is the need to couple the output of the transducer to the FET with a low d.c.-leakage capacitor of the Mylar or polystyrene variety. As far as the rest of the circuit is concerned, the transistor used in the emitter follower should have a beta of about 200 at a collector current of 500 μa in order to produce an output impedance of about 150 ohms. Since the circuit has this low an output impedance, long unbalanced cables can be used without inducing objectionable hum or capacitive high-frequency loss. If the tape recorder or amplifier used with the microphone is not a.c. coupled, a coupling capacitor should be used as indicated at the amplifier end of the cable so as not to alter the biasing condition of the microphone circuit or possibly damage the output transistor by shorting the output to ground. For a given amplifier input impedance, the value of this capacitor can be determined from the expression $C \cong 1/49R_i$ where C is the coupling capacitance in farads and R_i the amplifier input impedance in ohms.

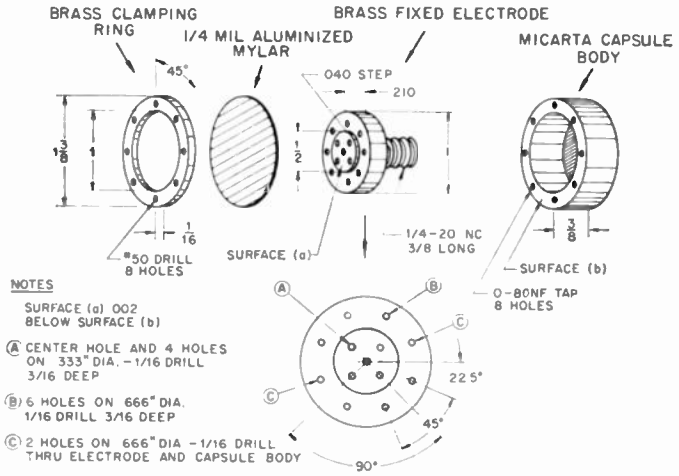
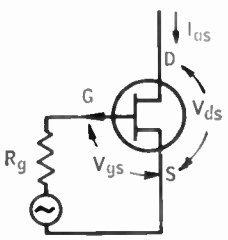


Fig. 4. Details of the author's capacitor microphone capsule.

TABLE 1

PARAMETER	TEST CONDITIONS	DESIRABLE VALUE
g_m	$V_{ds} = -10$ $V_{gs} = 0$ $f = 1000$ Hz	$\geq$ 2200 μmhos
I^*_{ds}	$V_{ds} = -10$ $V_{gs} = 0$	$\leq$ 2.5 mA
SPOT NOISE FIGURE (NF)	$V_{ds} = -5$ $f = 1000$ Hz $I_{ds} = -1$ mA $R_g = 1$ Meg	$\leq$ 1 dB

* OF PRACTICAL IMPORTANCE FOR BATTERY OPERATION



The Capacitor Pickup

Once the impedance-matching circuitry had been developed, specific attention was given the capacitor pickup. During the initial experimentation, the pickup used was modeled after that designed by Mr. Williamson, however, the present pickup design is somewhat different. In redesigning the capacitor pickup, three basic problems were considered, viz. directionality, frequency response, and sensitivity.

Directionality: The important factors which affect the directionality of a capacitor pickup, or for that matter, any microphone, can be seen in *Fig.* 2. Here it is demonstrated how pressure and pressure-gradient (velocity) diaphragm operation can be combined to achieve various directionality patterns from an ideal* single-diaphragm transducer. *Figure* 2a depicts a pickup which has only one side of its diaphragm exposed to the sound field and consequently its response is independent of the direction of incident sound waves. In *Fig.* 2b, a pressure-gradient or velocity-operated diaphragm is shown where it is noted that both sides of the diaphragm are exposed to the incident sound field, resulting in a figure-eight directionality pattern. This directionality pattern can be inferred by noting that a wave front incident at right angles to the diaphragm will cause the diaphragm to experience a net pressure p_1-p_2 due to the phase shift in p_2 referred to p_1 as the wave front traverses the distance d_s, whereas a wave front incident parallel to the diaphragm will result in zero net pressure since p_1 will equal p_2. Finally, in *Fig.* 2c, pressure-gradient may be combined with pressure operation by creating small sound passages in the back of the pressure-operated diaphragm of *Fig.* 2a. The accompanying directivity plot indicates graphically how a proper mixture can result in a cardioid directivity pattern.

Frequency Response: In general, most capacitor microphones (including the one constructed by the author) rely on the fundamental diaphragm resonance being above the audio-frequency band. Under such conditions,

*By this I mean a pickup whose largest dimension is small compared with the shortest wavelength considered.

the diaphragm is said to be compliance controlled, in that the mechanical impedance of the pickup is primarily that of a compliant element within the audio-frequency band. Thus:

$$Z_m = \frac{F}{U} = \frac{PA}{U} \cong \frac{1}{C_d s}$$

Where:
Z_m = Mechanical impedance
F = Force on diaphragm
U = Velocity of diaphragm
P = Pressure
A = Diaphragm area
C_d = Effective diaphragm compliance
For a constant applied pressure independent of frequency we can then write:

$$\frac{PA}{X_s} = \frac{1}{C_d s}, \text{ or } X = C_d PA$$

This is a desirable result indicating the diaphragm displacement — and hence capacitance variation—to be independent of frequency. Generally, this is not the case except for diaphragms of infinitesimal size and consequently the dimensions of the transducer must be considered. *Figure* 3 demonstrates three of the basic effects which tend to cause the pressure on any finite size diaphragm to deviate from that of the unperturbed sound field at the point of the microphone. The first effect, known as diffraction, results when the reflected component of the sound wave front incident upon the diaphragm causes a sufficient standing wave to produce pressure doubling or tripling. This effect generally occurs for wavelengths comparable to the diaphragm diameter. A second form of difficulty is known as the phase-difference effect and again becomes important for wave lengths comparable to the diameter of the diaphragm. This effect occurs when the incident wave front strikes the diaphragm at an angle ϕ causing the pressure to vary considerably over the face of the diaphragm and hence not accurately represent the true sound pressure at the point of the microphone. As a final point of consideration, attention must be given to the cavity created by the clamping ring used to maintain the stretched diaphragm. This cavity will become resonant at a wave length comparable to its inside circumference and will cause an increase in sound pressure in proportion to the ratio of d/D. In summary of these effects, it is generally felt that for audio entertainment applications the effect of diffraction can be adequately minimized by a diaphragm diameter less than 2 in., the effect of phase difference by a diameter of 1 in. or less, and cavity res-

onance minimized by a ratio of d/D less than $1/10$.[6]

Sensitivity: For the case of the circular-parallel-plate capacitor transducer, the open-circuit output voltage is approximately $V\Delta C/C$ where V is the applied d.c. bias and ΔC is the change in the unexcited capacitance C. In an attempt to increase the sensitivity of a given pickup, one might try to increase the polarizing voltage, but would soon learn that the diaphragm would collapse or be biased into a position of unstable equilibrium due to the electrostatic attraction of the capacitor plates. For such diaphragms having a diameter of about 1 in., bias voltages much over 100 volts are impractical for this reason. A similar argument also applies when one decreases the capacitor spacing in an attempt to increase the ratio $\Delta C/C$ for a specific polarizing voltage. One method commonly used to increase sensitivity is based on the fact that most of the ΔC results from the displacement of the center of the diaphragm and not its edges since a clamped diaphragm does not move as a piston. By making the fixed-back electrode smaller than the vibrating diaphragm, this effect may be taken advantage of to improve sensitivity. This method of optimization, as well as that of varying the magnitude of the bias voltage across the surface of the back electrode, is considered by K. Teer.[7]

[6]A. E. Robertson. "*Microphones*." Hayden Book Co., New York, 1963.

[7]K. Teer. "On the optimization for a condenser microphone." *Acustica*, Vol. 15, 1965.

The Author's Pickup

As previously mentioned, the author's initial work was done with a pickup modeled after that of R. Williamson. Serious diaphragm mounting problems were, however, encountered using his recommended 1-mil air gap, 90-volt bias, and ¼-mil. aluminized Mylar. The problem experienced was that of diaphragm collapse and is believed by the author to be a result of an unstable bias voltage for the indicated spacing. Much more reliable results were achieved using a 2-mil air gap. Also, the sensitivity was improved by reducing the diameter of the back electrode as indicated in *Fig. 4*, where the final pickup is shown. For those interested in constructing such a pickup, the machining techniques and diaphragm mounting procedures discussed in Mr. Williamson's paper have proven to be quite satisfactory.

Performance

Of the quantities commonly specified for high-quality condenser microphones, the following were measured

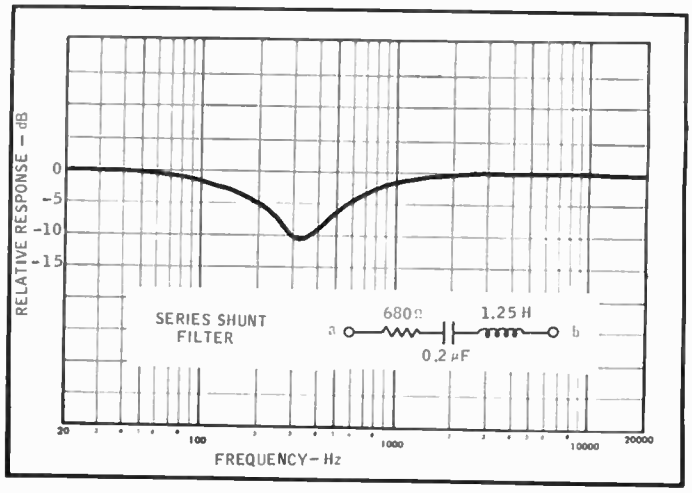


Fig. 5. Octave-band response of completed condenser microphone to pink noise.

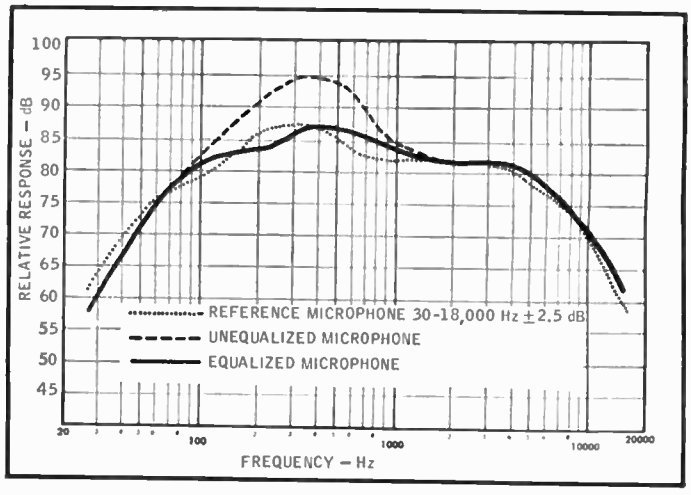


Fig. 6. Shunt-applied series RLC filter, and its insertion characteristic.

by the author:

Sensitivity: Using a pink-noise generator (constant power per octave), and a calibrated General Radio condenser microphone, the two microphones constructed had measured sensitivities of approx. —49 dB re 1 volt/μbar.

Noise: The unweighted noise-open-circuit voltage as measured over an 80-/ to 10,000-Hz bandwidth in a quiet room was $\cong$ 6 μV.

Output Impedance: Using a 2 μF output coupling capacitor, the output impedance at 1000 Hz was 150 ohms.

Frequency Response: Frequency response was inferred from a pink-noise source and an octave band analyzer and compared to that of a high-quality commercially available capacitor microphone whose calibrated response was known. The results of these measurements are shown in *Fig.* 5 where a 6-dB peak is indicated at about 300 Hz. As a result of this peak, listening test gave the impression of a lack of high-frequency response. The problem was, however, conveniently corrected by the insertion of a series RLC filter within the microphone between points a and b in *Fig.* 1. This filter and its insertion characteristics are shown in *Fig.* 6, and the resulting microphone response characteristics in *Fig.* 5. The basis for this problem is felt to lie in the diameter and length of the two phase-delay tubes coupling the back side of the diaphragm with the sound field, with respect to the acoustic compliance of the air mass behind the diaphragm. While it would be desirable to correct this problem in the pickup itself, the fact that the desired net results can be easily obtained through filtering is worthy of merit. It must also be realized that the proper modification of the capsule to correct the problem will most likely result in a loss in sensitivity which may be intolerable with the marginal noise characteristics of reasonably priced FET's currently available. The author is, however, considering the problem, but is presently limited by the lack of accurate measuring instruments and a good mechanical analog of the present pickup. Two microphones constructed by the author are shown in the illustration at the beginning of this article, one of which has been disassembled to show the component layout. As a final note, I would like to make it quite clear that the design of capacitor microphone systems is not as straightforward as some portions of this article might imply, but requires a detailed knowledge of accoustical and electrostatic effects, accurate testing equipment, and much time and patience.

TONE GENERATOR

(Continued from page 88)

Some Unusual Applications of Multivibrators

The multivibrator, as the reader probably knows, is a type of oscillator which generates square waves, sawtooth waves, and pulses of various sorts. It operates on the "relaxation" principle, by which two amplifier stages are fed back to each other with a pair of time constants in the feedback circuits. By adjusting the time constants, the frequency of the multivibrator may be changed. If the time constants are large enough, the multivibrator will oscillate at a subsonic frequency or may stall completely.

The slow, free-running multivibrator described may be triggered by an input signal of sufficient amplitude, and will follow the input signal in its own oscillations over a range of more than four octaves. As the amplitude of the input signal is reduced, the multivibrator syncs first on every two cycles and then on every three or four, thereby creating a harmonic relationship with the input.

This apparatus has been employed in various experiments, for the generation of a variety of unique aural phenomena.

One simple device is to sync the Eccles-Jordan multivibrator to a high-frequency sine-tone oscillator through a level control. As the amplitude of the sync from the sine oscillator is increased, the frequency of the multivibrator is increased; however, the frequency does not change linearly but in steps, as it forms small, whole-number ratios in hertz with the sine oscillator. An unusual scale results, with a very satisfying aural effect. Probably, the oscillator triggers the multivibrator by syncing with its overtones in the order that they occur naturally . The greater the amplitude of the oscillator sync, the closer the multivibrator approaches a unison with it.

Some more elaborate types of results may be had by synchronizing the multivibrator with some input instrument, such as the Theremin or Cembalet, or the like.

When the amplitude of the input is not constant, the pitch of the multivibrator will depend both on the input pitch and the input amplitude.

With a percussive input such as a piano, a plucked-string type sound, and so on, the multivibrator will synchronize at first with the input pitch,

and as the input level drops off the multivibrator drops to sub-frequencies in which its overtones match the input. Therefore each input pitch generates a series of falling output pitches matching the decay of the input.

If the control which varies the synchronization input voltage is turned to reduce the sync input, it is possible to get outputs over a small range of inputs which will be in a certain harmonic relation to the input signal. The result is a sort of electronic organum in which the device of parallel fifths, fourths, or octaves result.

Conclusion

Each of the previously described techniques has been generated with a single experimental unit. The filters are included; however, some other equipment which is not included, and can increase the flexibility, includes reverberation devices, stereophonic reproduction and recording equipment, and some others. However, with some auxiliary input source, it is a relatively complete electronic music unit which can be used in performance as well as in the laboratory.

Figure 7 shows a circuit and *Fig.* 8 a block diagram of the experimental, complex-tone generator. Of particular interest is the oscillator circuit, which is the Hubbard oscillator.[2] This oscillator is particularly stable, and produces a particularly pure waveform as a result of the fact that its power source is the space charge between the cathode and the control grid of the tube. There is no connection to the high voltage, but only to the filament voltage.

The equalizer, a bass-boost type, utilizes a phase-shift feedback loop. It is needed in the present model to compensate for bass loss in the output transformer of the modulator.

The rest of the circuitry is standard and needs no comment here. Needless to say, it is the particular musical results which are of primary importance, not the circuits employed, and these results could have been achieved with many other types of apparatus performing the same functions as those employed. Æ

[2]Harold C. Hubbard, "A Most Unusual Oscillator," *Radio and Television News*, May, 1955.

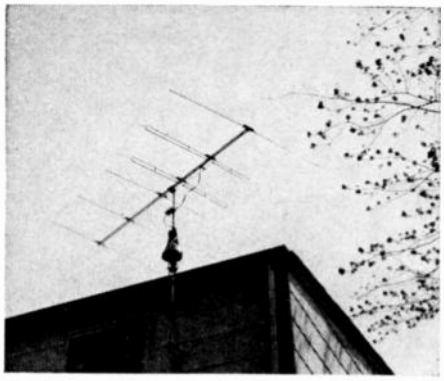


Fig. 31. Typical 6-element, twin-fed, Yagi-Uda array installed on a rotator. Transmission line is 72-ohm coax, RG59/U, and the small box mounted to the mast between the rotator and antenna is a balun. Transmission line between balun and antenna is well-twisted, 300-ohm twin lead.

because of their isolation characteristics between the used and unused channels.

Amplifiers

Mast-mounted and indoor amplifiers have been hailed recently as the solution to most reception problems. We'll say little about them here, except to review some basic facts about their relation to the tuner we're using.

When a tuner is limiting fully, the signal-to-noise ratio of the tuner sets the dynamic range or minimum usable signal the receiver will accept. The main area of the receiver exerting the most control on noise is the front end. The r.f. amplifier in this part of a tuner is usually a cascoded nuvistor, frame-grid tube, or transistor circuit utilizing amplifiers with extremely high transconductance. The preamplifiers offered for use ahead of the receiver input utilize the same tubes as do most modern receivers, and therefore, have the same noise figures as do the tuners. For this reason the amplifier can do nothing to improve signal-to-noise while the receiver is limiting. But the amplifier, of course, is not obtained for use with a signal strong enough to limit the receiver. In Part 2, we discussed a typical receiver limiting and noise curve. Refering again to this curve will help make evident what the amplifier will do for us. With signals that would ordinarily appear at the bottom of the curve the increase in input voltage that the amplifier provides drives the operating point farther up this curve and increases therefore, the quieting of the receiver. The price that must be paid for this is the fixed signal-to-noise ratio of the preamplifier. The best way to utilize an r.f. preamplifier is to have a method of removing it from the antenna system when there is sufficient signal to limit the receiver without the preamp. The noise will then be caused by the receiver front end only.

On older receivers that do not use frame grid or high transconductance tubes, a preamp can be a real help at all times because its noise figure is probably better than that of the older receiver. The only thing to be aware of is that the increase in signal available at the receiver input from the preamp might well overload the receiver front end and cause cross-modulation distortion. In this instance an attenuator is warranted between the preamp and receiver.

Words to the Wise

Everyone develops prejudices for certain things as they are exposed to them, either by direct contact or through advertising or written material in other forms. Such prejudices impair seriously our ability to evaluate something objectively, with the result that a good technical decision is often due to luck alone. An awful lot of luck can be removed and replaced with fuel for a good decision if you contact the various manufacturers of FM antennas and request technical data from them on the particular antennas that interest you.

There is no reason an antenna house should not supply anyone with the gain, beamwidth, and minor-lobe characteristics for an antenna in which a potential user is interested. The manufacturer had to obtain this data in the course of his development program on an antenna and it should be as readily available as frequency response, power output, and distortion figures for an amplifier. I dare say that none of us would venture forth to purchase an amplifier without that data, at least. So, no sympathy can be had for the company that will not upon request supply this technical information. A letter will be necessary, though, for completion of the usual fill-in cards will more than likely just bring advertising data. Most of the manufacturers contacted in the course of accumulating information for this article were extremely helpful in supplying pertinent technical information about their products.

One more word about advertising-developed prejudices. Just because you view an ad that pronounces an antenna to be of a particular design, or extremely broadband, or high gain, don't automatically assume that the antenna retains these characteristics over the entire range of frequencies for which you want to use it. While log periodic antennas properly designed are truly broadband radiators, a poorly designed one will exhibit characteristics that could be entirely unsatisfactory for even narrow band operation. Yagis are high-gain antennas, but again, if a yagi is not carefully designed, it can have an awful impedance mismatch and gain variation in the frequency spectrum of interest. All antenna design involves a great deal of the old "cut and try" technique. This in turn costs money, and in the development of an antenna it's entirely possible that the cutting and trying begins to eat up a considerable amount of the green stuff, causing that last quarter of the band, which had not been matched very well, *never* to get matched very well. What all this is saying, really, is "go out and *ask* for information."

This last gasp of the article is also the place for miscellaneous suggestions that were either forgotten or had no place earlier. For example, when purchasing a rotator, the fully automatic ones are really only about 5 or 6 dollars more than the semi-automatic despite the tremendous disparity in their list prices. The automatics are usually more accurate than the semiautomatics, too, making them

Table III

	TYPE	GAIN	PATTERN
ANTENNA	Yagi-Uda Array Log-Periodic Dipole Array Bi-Directional Omnidirectional TV - FM Antenna	6 dB - 13 dB 6 dB - 13 dB 4 dB - 7 dB 0 dB - 3 dB ?	Unidirectional Unidirectional Bi-directional Omnidirectional Depends on Antenna
	TYPE	Z RATIO	LOSS
BALUN	Multifilar	300 Ω to 72 Ω	About 0.7 dB
	TYPE	ISOLATION	LOSS
DIPLEXER	UHF-VHF	15 dB Typical	About 0.7 dB
	TYPE	IMPEDANCE	LOSS
TRANSMISSION LINE	300-Ω Twin Lead 300-Ω Shielded Twin Lead RG-59/U Coaxial Cable	300 Ω 300 Ω 72 Ω	1.1 dB per 100 ft. 2.8 dB per 100 ft. 3.8 dB per 100 ft.
	TYPE	ISOLATION	LOSS
MULTIPLEXER	UHF-VHF TV - FM	15 dB Typical	About 0.7 dB
	TYPE	ISOLATION	LOSS
TAPOFFS	Hybrid	15 dB Typical	About 1.5 dB per Tap

a better buy. As far as pertinent information on the rotating unit itself, look for one with the greatest torque capability.

Most TV antennas will not provide satisfactory FM reception, since in many cases they are cut to reject the FM band and in most other cases are not designed with any view toward receiving this band. Notable exceptions are some of the new log periodics. But you should request information from the manufacturer of these as to their performance in the FM band. Certain of the log periodic dipole arrays are harmonically related designs that have gain fall-off in the area between the high and low VHF TV bands, and it is in this area that the FM band lies.

Lastly, while on the subject of prejudices, just how much has been injected into this article? Probably a lot, hopefully a little. Installation experience with all three types of previously discussed transmission lines has led to the belief in these quarters that shielded twin lead is the best for FM use. This is a prejudice of a sort. Practically, because the shield is actually integrated with the vinyl outer cover, it is hard to flex and therefore rather hard to install relative to the other types. Then, after you've installed it and you're listening to a broadcast and some ignition noise makes its presence known, you'll probably wonder what all the effort and money spent was worth, if the line doesn't do its job. Well, in many cases the antenna itself will pick up ignition noise and there is no way current technical knowledge shows us how to shield an antenna and still have it work. Anyway, the transmission line prejudice is one based on experience rather than the written word only.

Conclusion

To sum up this great pile of words, another pile would probably be necessary. In place of this is Table III, a compilation of various antenna system facts and typical installation guides that will aid in the selection and installation of components for a good FM antenna system. Select the parts of your system carefully, for they will be with you a considerable time. When the choice has been made, install them carefully and remember the one great, basic tenet of all those hardy antenna installers who joust with peril atop a ladder:

"Don't look down!" Æ

[4]Robert Leitner, "Antenna method minimizes co-channel interference." *Electrical Design News*, June, 1963.

(Continued from page 71)

is that of the superb BSO under Leinsdorf. That in itself is enough to "sell" the production to many of us—for nothing can match the sound of the Wagner orchestra, rightly directed.

The solo voices are plenty good enough, if oddly assorted in background (an old American opera tradition). Lohengrin is Hungarian, his lady friend, Elsa, is Armenian-American; from there we move onwards to a Belgian and three Americans, two from California. Lohengrin is just fine; so are the other more massive males who back him up. The modest Elsa, shy maiden ever-so-determined, is not quite so good for my ears but her deficiencies are not dramatically serious in the whole—just a rather unsteady production, more wobbly than the ear can easily follow.

As for the all-important chorus—superb! Instead of the usual motley collection of elderly professionals (and youngerly would-be professionals) this one is an augmented standard amateur chorus, a very knowledgeable one, which represents the mass of the people in the opera with wonderfully musical effect—nicely contrasted with the all-male pro group of Brabantian nobles, who sing together as a second chorus. With all this enormous vocal population, the big ensemble scenes are no less than stunning.

But maybe the biggest virtue of this set is RCA's commendable restraint in miking the solo voices, which are kept well back and in proportion, never zooming out super-close-up (as used to be the fashion), often actually drowned out in luscious orchestra sound—exactly as was intended. Those who distrust Wagnerian vocalizing need not worry a bit here. All is properly in perspective.

It's a documentary too, this album. A huge, fat booklet with all the text, word for word in German and English, plus quite a bit of useful info along with the usual decorative plugs for the various performers.

The Story of Great Music. Vol. 2, The Romantic Era. With book.

Time-Life Records STL 140 (4) mono

(by subscription)

The publicity on this is dated May, 1966, but the album arrived by special messenger just as I was "going to press" for this month (i.e., to the local P.O. with my copy).

Those who know the Time-Life and similar big documentary picture books will recognize the standard approach used here ("The Editors of TIME and LIFE invite you to share their delight in music . . .") and in many another project concerning the arts. Now—it's records. And a new kind of record club, I suppose. (". . . for less money than you may be spending now on haphazard record buying.")

While I vigorously dislike the implications of the "haphazard buying" phrase, which suggests, as usual, that none of us has the common sense we were born with and we'd better let TIME-LIFE take over for us, I'll gladly admit that you get what you pay for here ($11 approximately per volume, 4 LP's and a big book) in the every-other-month releases. That is, if you haven't bought these works already, in these or other recordings. They are fairly standard fare, as might be expected.

Except for some grand opera excerpts, they do also have the virtue—once rare in "music appreciation" projects — of completeness. The whole *Fantastic Symphony* of Berlioz, all of the familiar Liszt and Mendelssohn concerti, a solid set (a whole side) of Chopin on the piano. No faded-out excerpts, no commentary. Just music, complete. Good, in this situation. (Excerpts plus commentary can be good too, if I do say so, being somewhat of an expert in that area.)

The recordings are from Angel, out of British E.M.I. Not all the items are in the U.S. Angel catalogue, but all feature familiar Angel artists, of first-grade celebrity calibre. They are needed in Romantic music.

The lavishly illustrated text, with the familiar Time-Life style of authority (it *sounds* right even if it isn't) is a characteristic team-product—by a Fortune man, Max Ways, plus "the Editors of Time-Life Records." That is, scads of busy researchers, rewriters, checkers, and recheck-writers. No doubt a computer or two had its say before the final words were sent down to the printer. It's a team world.

Odd paradox: Whereas, starting from the record business, Columbia's documentaries often feature enormous eye-books and rather skimpy ear-music (1 LP and maybe 70 pages of book), Time-Life, coming from the other side of the publisher's fence, offers 4 LP's of music for a slightly less impressive book. More than a meeting of minds here! They passed each other in mid-stream.

Big Stuff, Old and New

Master Works for Organ, Vols. 1, 2, 3. Jorgen Ernst Hansen, organist.

Nonesuch H 71100, 71105, 71110 stereo

Three volumes of excellent organ playing, mainly centered on the famed Baroque North German school of the late 17th and early 18th century, the organist a sensitive musician of a very slightly Romantic tinge (just enough to ensure that these works are definitely not played with the dogmatic approach of some Baroque specialists), on a lovely oldish organ which is also somewhat Romantic in its sound, but in a way that does no harm at all to the music.

Though some specialists in the Baroque may feel both organ and organist to be a bit "off," I am sure that the sheer musicality of both, the fine ear of the player and the lovely sounds of the organ, will please just about everybody else. A fine acoustic space for the recorded sound is an additional asset.

See catalogues for the many individual works performed on each of the three records, which are separately available.

Beethoven: Trios (complete). Jean Pougnet, Frederick Riddle, Anthony Pini.

Westminster WMS 1017 (3) stereo

An interesting venture here from Westminster, and typical of today—Westminster Multiples, economical folding albums of updated older material in multiple discs, rechanneled for stereo as well as re-cut. There are many more already listed, and a lot will be old friends, so to speak, for those who have bought Westminster in the past.

The Beethoven Trios are beautifully played by this trio (violin, viola and cello) of English performers—I don't remember hearing a more precise, more carefully thought out and tailored version, nor a more fully dramatic. For these are, of course, big pieces in content, within the small instrumental framework, like those of Haydn and Mozart in a similar vein and out of the same school of thought. The synthetic stereo seems effective enough, mainly spreading out the sound and adding a sense of immediacy and presence, without too noticeable a degradation in the sound. I found it musically helpful.

Beethoven: Pastoral Symphony (No. 6 in F); Fidelio Overture. Philharmonic Promenade Orch. of London, Boult.

Vanguard SRV 193 SD stereo

It seems as if these Beethoven symphony recordings by Sir Adrian Boult, with their distinctive Michelangelo sculpture covers (the Medici chapel) have been coming out for years on end. But this one now carries an SRV designation instead of VRS (Vanguard Recording Society)—which means that the Price is Right. Very right—about the lowest on the stereo market! SRV now brands the Everyman Series, capitalizing on the company's unusually high-quality tape masters from earlier years on up.

You can buy here with confidence and forget the low price. This is an unusually well-conceived "Pastoral" (one of the most difficult symphonies to project with success), brisk and modern in its rapid tempi but never either harsh or mannered, the pictorial elements—peasants, the countryside and bird calls, the big storm—depicted lovingly, with utmost grace and naturalness. Quite a feat. My only minor criticism is an occasional bit of ragged or blurred ensemble due mainly to the rather fast speeds. The sound is a great deal more than adequate, at any price.

If you like this one, try others in the series.

Mozart: Requiem, K. 626. Seefried, Pitzinger, Holm, Borg; Chorus Vienna State Opera, V. Symphony, Jochum.

Heliodor HS 25000 stereo

This is just to note another excellent ex-Deutsche-Grammophon recording, updated in very good synthetic stereo and down-priced by a half and more. A recording with such names as Seefried,

Borg and conductor Jochum on it is worth anybody's cash in any sort of "fi"! In D-G, it is worth plenty more.

Bruno Walter's Mahler (Das Lied von der Erde; Symphony No. 9). N. Y. Philharmonic; Columbia Symphony.

Columbia D3S 744 (3) stereo

Bruno Walter's Brahms (Academic, Tragic Overtures; Vars. on a Theme by Haydn. Columbia Symphony.

Columbia MS 6868 stereo

Bruno Walter Conducts Mozart & Haydn (Mozart: Symphony No. 40. Haydn: Symphony (No. 88.) Columbia Symphony.

Columbia MS 6869 stereo

Columbia is regrouping its Bruno Walter forces. Here are recent samples.

It's a cinch that none of these was recorded after Feb. 17, 1962—that was the day Bruno Walter died. But how far back these and others go is a question. (The Walter discography extends into 78's, back well before the War.) I'm wondering mainly on one purely technical point—how many of these releases came before the stereo ear and hence may have been stereo-synthesized? None is so marked here. I note (after *some* research . . .) that the Mahler *Lied von der Erde* came out late in 1960 and the Symphony No. 9 in May of 1962, as a memorial album. Both, clearly, were stereo on the master tapes. Others *might* be earlier—back at least to the early 50's? What with no fewer than four currently available Columbia discs already containing the two Brahms overtures in at least two different Bruno-Walter versions (Columbia Symphony; N. Y. Philharmonic), it's a guessing game for fair.

Well, Columbia could tell you all about it in moments. What really matters, though, is the musical quality of these performances in terms of present-day values. You'll find Bruno Walter superb—even unbeatable—in his Mahler, always a specialty. His Brahms is solidly musical, marvelously shaped in every detail though a bit heavyweight for our changing ears. His Mozart already smacks of another era; the orchestral sound is too thick for present preferences, the Romantic angles are rather too much played up (as though they had to be pointed out to us). His Haydn is similar, showing the last traces of that former "quaintness" of approach, the "Papa Haydn" attitude, which was once universal and is now gone into limbo in newer Haydn.

Bruno Walter wasn't perfect nor any sort of Last Word (except maybe in Mahler); but he was a splendidly dedicated and knowledgeable musician and an engaging, modest conductorial personality. By the way—the Mahler album includes one of the traditional Bruno Walter rehearsal recordings, where these things may be heard most convincingly.

Some slight obsolescence in some of the sound; no one who listens first to Walter and second to hi-fi will ever notice it. Even the buffs won't really mind.

Bach: Suites for Unaccompanied Cello (complete). Janos Starker.

Mercury SR3 9016 (3) stereo

Some time ago, Mercury released a single disc of Starker playing this unaccompanied cello music. Now, here are all the Suites, on three discs, and about time.

For many informed ears—and for many an uninformed ear, too—these are the finest recorded versions available and the most musically intelligible. Many young people already worship the ground on which Starker plays and love these pieces, for all their weird grunts and groans. That is simply because Starker makes the *musical sense* clear, as most other cellists do not. He plays the rhythms accurately and in time, his pitch is impeccable and so is his phrasing, the harmonies and counterpoint—mostly in a sort of sketch-like form—are nevertheless projected clearly for the ear. *He* hears them, and, so do we.

It didn't use to be that way. The most famous recording of the Suites, still very much alive on discs, is that by the grand old man, Casals. Very fine in a super-Romantic sort of way; but to enjoy them you must not only like Romanticized Bach (few do, today) but you must know the *music* cold. Casals gives a fine impression of it, with such very expressive liberty (the olden style) that newcomers hear nothing but grunts and groans. Not so with Starker! Try him.

The Roving Ear

Aaron Copland Conducts. (Music for a Great City; Statements). London Symphony.

CBS Masterworks 32 11 0002 stereo

What? A new label?

Yep. CBS Masterworks. Looks exactly like Columbia Masterworks on the outside, but sports a plain bright blue label on the disc instead of the familiar Columbia gray. No explanations.

Well, the music is worth explaining. These two big pieces for orchestra, 1934 and 1964, are a kind of before-and-after combination—coming before and after the Copland which is most familiar to us, those bland, folksy pieces of the later 1930's and '40's which began with *El Salon Mexico* and went on through such as *Billy the Kid, Rodeo,* and *Appalachian Spring. Statements* was at the tail-end of the earlier 1920's period, of snazzy, uncompromised dissonance (Copland and everyone else . . .!); whereas *Great City* is current production and out of a newly resumed dissonance, which followed the great popular period of the 30's. It is quite a remarkable synthesis, *Great City,* relating all three eras—20's, 30's and the postwar era—and especially tying together the outer periods of dissonance in many revealing ways.

First time through, you'll find both works pretty hard and noisy. Second time around, though, they go down *much* more easily. You begin to hear the superb professionalism of Copland's orchestral writing, which in hi-fi terms, of course, means "demonstration" sound. Noisy, all right, but plenty interesting and gorgeously recorded.

And, also, you hear in *Statements*—the earlier piece—many an intimation of the popular-style Copland of the later Thirties that was about to come forth, soon after this piece. In *Great City* you hear the synthesis, the best of the popular style combined with the arrid dissonance and the square, stark formality of the early and late Copland.

No doubt about it—*Great City* is a far more subtle and finished piece than *Statements.* Copland has grown, steadily.

Twentieth Century Classics for Strings. (Stravinsky: Concerto in D. Bartok: Divertimento. Hindemith: Five Pieces, op. 44 No. 4.) Bath Festival Orch., Menuhin.

Angel 36335 stereo

A curious collection of performances here—oddly uncomprehending of the music, as if the musicians and conductor (with all sorts of good will) just didn't really understand all this modren stuff.

It really isn't *that* modern—and, in fact, every one of these pieces, in other recordings, can be heard and easily enjoyed by most of us. Yehudi Menuhin, the master violinist-prodigy, is a frightfully naive conductor at times, "discovering" music with enormous enthusiasm and not always very knowledgeable execution.

It just seems as if Yehudi and his Bath Britishers are a bit behind the times. They plough through the familiar jittery syncopations of Stravinsky with figuratively furrowed brows—playing it like, say, modified Brahms. Hindemith's very easily heard harmonies are decidedly unclear to these performers—and so to us. The Bartok, most furious of these works, is merely soggy in a damp British way. Nope, definitely not up to usual Angel standards.

Vivaldi: The Four Seasons. Wurttemberg Chamber Orch., Faerber.

Turnabout TV 34040S stereo

Here's more direct evidence that price —within reasonable limits—has no longer much meaning in relation to recorded content. For my ear, this is one of the two or three very best "Seasons" since the work was first recorded many years ago. Best at any price, even though other recordings feature bigger names.

These players not only achieve a dramatic intensity and earnestness such as are rarely heard in these relatively simple little concerti, but they do it with good style, no excesses and no romantic hogwashing. The tone quality of the strings is exquisite, that thin, ethereal purity of ensemble which has been the special feature of the more famous small Italian ensembles, such as "I Musici."

There are other recordings on Turnabout in this same series (Wurttemberg Chamber Orchestra, Suzanne Lautenbacher, violin, Martin Galling, harpsichord, etc.) and if you are eagle-eyed you will dart into the nearest record store after them.

Franz Danzi: Three Woodwind Quintets. New York Windwood Quintet.

Nonesuch H-71108 stereo

Danzi is one of those minor composers of entertainment music whose productions, formerly considered beneath notice, are now being rediscovered —as entertainment music. How very right! And about time.

Nope, he's no towering genius. But then, neither does he try to compose like one. His music is of an interesting period, poised between Mozart and Beethoven, at the turn of the 19th century. It is wholly 18th-century in purpose and mood, the sort of stuff that was played before (or by) sophisticated nobility. But its harmonies and turns of melody are already close to the Romantic sound.

If you don't expect too much, you'll find that these make excellent semi-background music, and very smoothly played by the New Yorkers, too. Æ

CROWHURST *(Continued from page 96)*

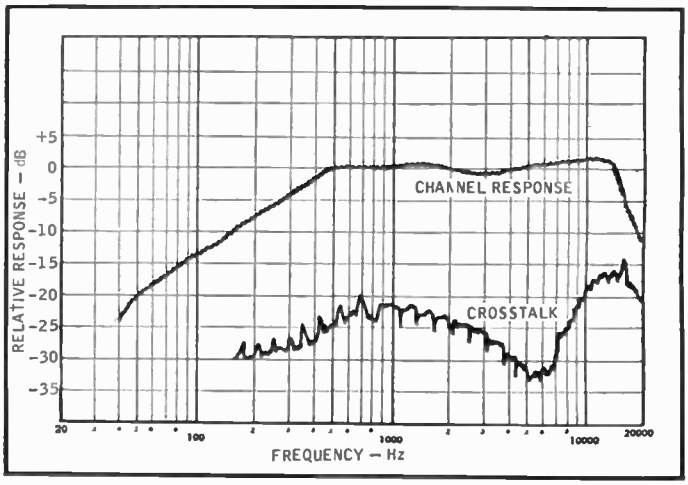


Fig. 9-10. A typical pair of responses—the upper curve is the channel response (left or right), and the lower is for crosstalk (left output in right channel or right output in left channel).

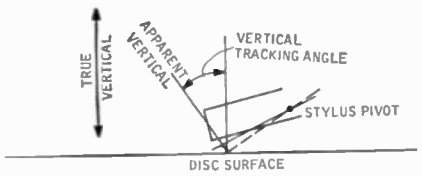


Fig. 9-11. Vertical tracking angle is illustrated.

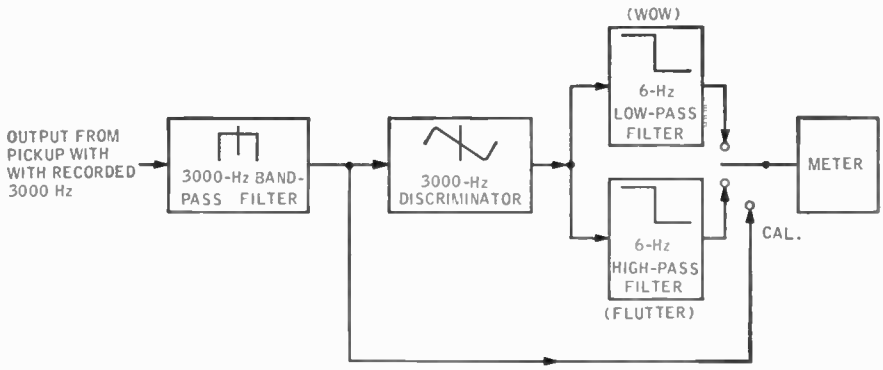


Fig. 9-12. How a flutter and wow meter works.

frequency usually below 6 Hz, and thus is usually one, two, or three times around for each revolution of the turntable (running at 33⅓), flutter occurs at some faster speed. Where a commutator motor is used as drive, vibrations from the commutator segments could create it. If a belt drive is used, and the tensioning device for the belt gets into a resonant vibration, this could cause it. Any form of abnormal friction can also cause it.

Because of its higher speed or frequency, flutter is not so noticeably a frequency effect as is wow. It sounds very like intermodulation by a low frequency, except that it may occur when no low frequency is present in the recorded program.

The method of measurement is the same for all these effects. A recording with standard 3000-Hz tone is used. This is analyzed by a flutter and wow meter, which is designed to work from this particular frequency tone. The meter uses filtering and amplitude limiting to produce a pure tone, should other effects be occurring at the same time, which is then passed through a discriminator similar to that used for demodulating an FM carrier (*Fig.* 9-12).

The output of the discriminator will represent deviation of the 3000 Hz from its nominal or average value. This is then passed through filters to determine what form it takes: wow, consisting of frequencies lower than 6 Hz, or flutter, consisting of frequencies higher than 6 Hz.

Curing such defects in the performance of a unit that is normally free of them will usually involve fitting of precision parts: replacing a worn belt or drive pulley, or perhaps even a motor in which the bearings may have deteriorated. Motors for driving phono turntables have to be virtually perfect.

So much for phonograph measurements. Tape recorder measurements have certain similarities, and we shall take up their measurement next month. Meanwhile, why not try to figure out in what ways tape recorder measurements will differ from phonograph measurements? Æ

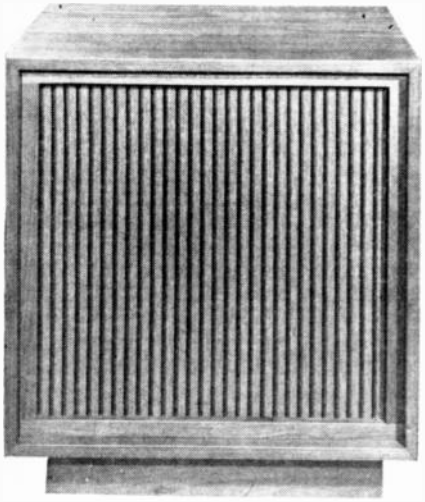
NEW PRODUCTS

Low-Power Amplifier

Lafayette Radio has released a new all-transistor amplifier of modest cost and power. 15 watts IHF per channel constitute the power claim. This is achieved with a frequency response of ± 2 dB from 30-20,000 Hz at 1 watt. THD is 1 per cent or less; hum and noise is —50 dB on magnetic phono and —65 dB on tuner and auxiliary inputs. Phono sensitivity is 3 mV. There are outputs for 4, 8, and 16-ohm speakers and tape recorder outputs. There is one switched a.c. outlet. Size of the unit is 10¼ x 3$^{9}/_{16}$ x 7$^{3}/_{16}$ in. Shipping weight of the unit, which carries the model number LA-224T and the stock number 99-0167WX, is 9 lbs. Price is $59.95.

CIRCLE 5

Accent on Decor



Bozak, long noted for fine speaker systems in equally fine cabinetry, has expanded their line of enclosures to include new period pieces. All told, there are now five broad stylings available to enclose their variety of loudspeaker systems. New to the line are the Moorish and Century (illustrated) motifs. This last design is available for the Bozak B-300, B-302A, and B-305 systems. Matching equipment cabinets are available to house amplifier, record changer, tuner and tape recorder. Surfaces of these cabinets are either true walnut with a matte finish or real cherry with a dark polish fruitwood finish. The Moorish influence cabinets use rounded arches to reflect the warmth and grandeur of ancient Spain," according to the Bozak catalog. Speaker models B-300, B-302A and B-4000 are available in the Moorish style. The surfaces are mahogany and are finished in hand-rubbed light or dark fruitwood. CIRCLE 6

A New Auto Turntable

BSR (USA) Limited has announced its entry into the retail consumer high-fidelity market with a number of products. This auto turntable is the first. This is the McDonald 500 model. It features a low-mass head that is both vertically and horizontally balanced so that the entire turntable can be turned on a bias while playing without inter-

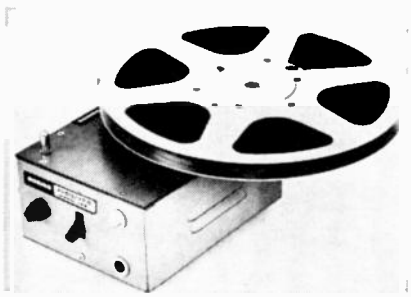
rupting the record. Stylus force is controlled by a dial setting which permits ⅓ gram adjustment from 0-6 grams. An interesting device is an automatic arm lock that is activated whenever the machine turns off. Shut off and repeat are automatic. In addition to the usual manual and automatic features there is a cuing lever that allows gentle starts and stops at any point on a record. The arm is protected from damage should the lift mechanism (automatic) be activated with the lock in place. Bearings for vertical motion are ball-bearing pivots. 7, 10, and 12-inch discs may be played on the 11-inch platter. All four speeds are available. The drive motor is a dynamically-balanced four-pole unit. List price of this new entry is $49.50.

CIRCLE 7

Mike Stand

The Atlas Sound DS-6G is a gold-finished microphone desk stand. It has been specifically designed for special decor requirements and will complement the available range of black and gold microphones. The base is designed to concentrate weight at the outer edge for maximum stability. Base pads prevent damage to table tops. Tube height is 4 inches; the base is 10 in. List price of the DS-6G is $5.75. CIRCLE 8

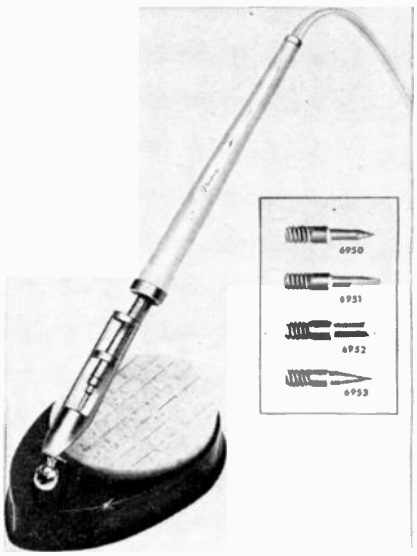
Bulk Tape Eraser



The Robins TM-100 is designed to clear both audio and video signals from tape spools up to the size of 10½ in. and 1-in. wide. Tapes up to 2-in. wide can be cleared by a double operation involving turning the tape over on the erase platform. The TM-100 reduces tape noise levels 50 to 90 dB below the saturation minimum. It has an overheat indicator and other safety features. Operation is from 115 volts, 50-60 Hz. It has a 5 minutes on, 15 minutes off, cycle. List price of the TM-100 is $85.00.

CIRCLE 9

Smaller Heater



This new Ungar soldering system has been specifically designed as the answer to hand soldering micro electronic circuits. According to the manufacturer, the Princess iron combines ultra miniaturization with a thermal efficiency and work capacity never before achieved in small soldering irons. For high-density circuits, flat or stack pack, and discrete components, the unit has a special series of sub-miniature copper or iron-clad soldering nibs, some drawn as fine as 0.005 in. Heat cartridges are available in 6, 10, 15, and 18 watts with temperatures from 450 to 1000 deg. F. All parts are interchangeable and screw together to form a custom iron for the type of project at hand. CIRCLE 10

Lower Cost Tape Deck

Viking has just announced a model to be priced in the under $250 category. This is the model 423, list priced at $249. The model number in fact, is coded to identify the configuration of the model—4 track, 2 head, 3 speed. The 423 is a three-motor machine with dynamic braking. Heads are of the hyperbolic type and have no pressure pads. A swing-away pinch roller allows easy drop-in loading. The electronics are all solid state with silicon transistors on plug-in boards. Frequency response is stated to be 50-15,000 Hz at 7½, 50-10,000 Hz at 3¾, and 60-5000 Hz at 1⅞ tape speeds. Mechanical operation is by directional control levers: pause, record-interlock, push-button counter and dual illuminated VU-type meters add convenience. The 423 accepts up to 7-inch reels and is available with a walnut enclosure and optional remote-control accessory.

CIRCLE 11

Miracord Super-Base

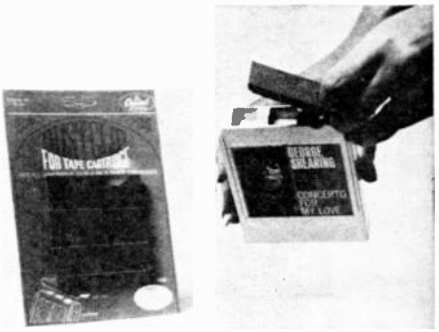
This accessory item is the Miracord Power Control Base, Model PCB-50. It is made specifically for the Miracord PW-50H changer and adds a considerable amount of versatility to the installation. The base contains wiring which will automatically turn on or shut off the entire component system. A rocker-type on/off switch on the front of the base by-passes the automatic power system. An a.c. receptacle is located conveniently on the rear of the base. Dimensions are 17¼-in. wide, 14¾-in. deep, and 4½-in. high. The PCB-50W is in oil-walnut wood and retails for $22.50. The PCB-50R is finished rosewood and sells for $29.50.

CIRCLE 12

Dust Covers

Tape is immune to the problems of dust that plagues discs—that is, until you place it into a re-entrant-type cartridge. Dust can cause difficulties in spooling. Some manufacturers are, in fact, supplying dust covers for their cartridges. Now Capitol has leapt into the breach with a bubble package of three plastic covers to fit 8-track stereo tape cartridges. The clips snap over the end of the cartridge and protect tapes from dirt or any other foreign matter. The optional list price from dealers is all of 29 cents.

CIRCLE 13



HERMAN BURSTEIN

Anent the subject of large-hub tape reels, brought up in the August issue, we have the following communication from Mr. Jay S. Rose, Audio-Visual Engineer of 7 Southgate Rd., Great Neck, N. Y.: ". . . such reels are available from regular sources (including) hi-fi stores, and two different types are listed in the Lafayette 1966 catalog. I have been using one of the Lafayette reels (99-2304, 39¢ in single quantities) for almost a year. I do much editing and production for a radio station, and have found the large-hub reels perfect for working with 10-second jingles (150 ft. long) on professional equipment. Using these reels with my home machine, I have found that the large hub allows a much more even wind than the regular reels. The reels that I use are seven inches in diameter, with a four-inch hub, and hold about 900 feet of tape (24 minutes at 7.5 ips, 48 minutes at 3.75 ips, and 96 minutes at 1.875 ips—H.B.). They're sturdily made, and I haven't had any mechanical trouble with them yet."

On the same subject, Mr. Jerry Kaplan, Sales Manager of Morhan National Sales Company, Inc., 458 Broadway, New York City, points out that IRISH makes a 5-in. large-hub reel (A-1032) and a 7-in. large-hub reel (A-1052), which can be ordered through dealers.

Mr. Frank Wood of B. F. C., Inc., 900 Tri-State Building, Cincinnati, Ohio, informs us that 7-in. plastic reels with four-inch hubs are available from Amerline Corp., 1800 West Fullerton, Chicago, Illinois 60614. He states that he buys these reels in lots of 1000 for about 14¢ each. However, I do not know whether these are available in smaller lots, and if so at what prices.

Finally, Mr. R. A. Braden of 34 Littlebrook Road, Princeton, New Jersey, states that on "page 126 in the 1966 Lafayette catalog you will find a listing of a Robins TR 74 Low Torque large-hub 7-in. reel. The Lafayette catalog number is 28R7102, and the price is 59¢. Shipping weight is not stated, but my postal scale indicates that it is about 7 oz."

Spurred by an advertisement he read in the August issue, Reader Braden comments on difficulties he has had with a series of tape recorders; perhaps there is a lesson here for other readers on what to look for when buying a machine: "I am now using my third machine, and I am still learning. While my present one is a very fine instrument, I don't think it is the one I want to use for the rest of my life. Occasionally it tangles tape for reasons I could never discover. Sometimes severe crosstalk occurs from the ½-track playback gap to the ¼-track playback circuit when playing 4-track tape. The rotating parts have to be lubricated about every 6 months to prevent a severe case of flutter at low speed. Some of the lubrication points are difficult to reach. The electrical circuit adjustments are fairly accessible, but the front panel controls are not . . . I hope that some day I will find a machine that is simple in construction, easy to service, light in weight, versatile in operation, able to operate in either ½-track or ¼-track mode, and not too expensive. In the meantime I am very happy with my present machine except when I have to open it up for service."

"The use of "synchronous" motors at other than rated speeds (for the feed and takeup reels), knowledgeably discussed by Reader W. D. Tiffany in the August issue, has drawn an irate reaction from Mr. Edward W. Logan Jr., 953 North Highand, Memphis, Tennessee: "A motor is either SYNC or NON-SYNC. The use of additional adjectives tacked on to confuse the public does not change the facts. Call the hysteresis motors that do not run sync pink motors or whooper motors or better yet, as some of the better motor makers do, TORQUE MOTORS. It is way past time to stop the careless, meaningless use of the extra adjectives . . . Semantics! What a lot of trouble we have in communicating . . . If I buy a motor called sync and it does not run sync and sync only, the seller is going to get it back so fast that it will make him dizzier than he already is."

The line of those who are dizzy on this subject may form to the right, behind me.

Spotlight on S/N Measurements

A high signal-to-noise ratio is certainly one of the hallmarks of high fidelity, a key distinction between that which is garden variety and that which is exceptional. Of all audio components, the tape recorder has the most difficulty achieving a signal-to-noise ratio sufficiently high to please the discriminating ear. Therefore the individual seeking to buy a tape recorder as an adjunct to a fine audio system is or should be especially interested in the S/N of his intended purchase. Judging by TAPE GUIDE correspondence over the years, the problem of S/N does loom large in the minds of tape enthusiasts. Quite a number of questions have been directed at means of achieving satisfactory S/N through choice of machine, choice of tape, use of better tape heads and tubes and resistors, and so on.

Accordingly one would think that equipment reviews of tape recorders would pay careful attention to the question of S/N. Distressingly, this is not the case. The majority of tape machine reviews I have encountered are not crystal-clear about the machine's S/N, permitting unambiguous comparison between one machine and another in this particular respect. At least they are unclear to me. This is not a piece of conceit in which I hold that if I can't understand something neither can anyone else. However, I have had substantial exposure to the subject of tape recorders, and I say that if an equipment review on this subject leaves me puzzled, most readers of the review probably will also be puzzled.

Manufacturers as well as equipment reviewers are remiss. Some say nothing at all about S/N. Others find a way to inflate the S/N claim. Thus one manufacturer claimed an astonishing 60 dB S/N for a machine that measured less than 40 dB. It turned out that the claim pertained only to the tape amplifier and did not include hum picked up by the playback head, noise generated by distortion in the bias-oscillator waveform, other amplifier noise, and tape noise. Other manufacturers base their S/N rating on an excessively high (distorted) recording level, which results in an exaggerated S/N specification. Some state S/N fairly and explicitly (congratulations to these few). And some understate the S/N which they could justifiably claim, because they use too low a recording level as the reference.

While the subject of S/N in tape recorders has been touched on in this column from time to time, the unsatisfactory situation that still exists in describing S/N of specific machines calls for further comment. Hopefully the following discussion may stimulate more explicit statements about tape-recorder S/N by manufacturers and reviewers; may help the reader better understand the problem of S/N where tape recorders are concerned; and may help him compare S/N of one machine with that of another when their S/N specifications are stated differently but explicitly.

It is quite accepted practice among the makers of leading high-quality home tape recorders, such as Ampex, Crown, and Tandberg, to measure S/N on the basis of a mid-frequency tone, typically 400 Hz, recorded on 1½-mil high quality, conventional (as distinguished from high-output) tape at a level producing 3 per cent harmonic distortion on the

tape. The level of the 400-Hz tone is measured in playback. The tape is again put through the recording process, including erasure, but with no input signal. The no-signal tape is played back, and the output of the machine is again measured. S/N is the ratio, in decibels, between the first and second measurmnts.

One may ask whether the output level of the 400-Hz tone recorded at 3 per cent distortion will vary according to brand of tape, with corresponding variation in measured S/N. While the answer is yes, the variation is usually slight, perhaps within 1 or 2 dB, so that the particular brand of tape employed is not very important. What is important is that it be high quality, conventional, 1½-mil tape of a recognized and reputable manufacturer, so that the tape shares the performance characteristics of competitive tapes.

By modern high-fidelity standards, 3 per cent harmonic distortion may seem unusually great to identify with a reference level. We are generally accustomed to thinking of 1 per cent distortion or even less as the maximum acceptable amount, at least when talking about power amplifiers, preamplifiers, tuners, mixers, and the like. But in the case of tape recorders, experience has shown that satisfactory results are obtainable if audio peaks are recorded at a level producing no more than about 3 per cent distortion. Most of the program material, being well below the peaks, will incur negligible distortion. Accordingly, in a high-quality tape machine using a magic eye as the record-level indicator, the eye is calibrated to close when the recording level at 400 Hz reaches 3 per cent harmonic distortion. However, if the machine uses a "VU meter," the meter is calibrated to read 0 VU at the 1 per cent distortion level rather than at 3 per cent. The reason is that the meter cannot promptly and completely follow the heights of signal peaks; in other words, it tends to understate peak recording levels. As an offset, the meter is calibrated to read 0 VU (maximum permissible recording level) at the 1 per cent distortion point. This allows about 6 to 8 dB margin for the mechanical lag of the meter, inasmuch as the recording level that produces 1 per cent distortion is about 6 to 8 dB below the recording level that produces 3 per cent distortion.

Use of 3 per cent distortion as a reference level partly derives from necessity. Using 3 per cent as a reference level, one can achieve about 55 dB S/N with a high-quality machine when recording quarter-track at 7.5 ips. In life, however, one sometimes encounters dynamic ranges greater than 55 dB; for example, the distance between the softest and loudest sounds of a symphony orchestra. If a tape machine has S/N of only 55 dB, it cannot satisfactorily record an orchestra's dynamic range of, say, 65 dB. Instead, the softest sounds of the orchestra are then submerged by tape recorder and tape noise. For reasons of this sort, compression is used in radio broadcasting and in making phonograph records; these program sources

can satisfactorily accommodate a dynamic range of about 50 dB. If one records tapes from records and off the air, and if his tape recorder has S/N of only 50 dB, he has little if any margin to spare in recording the dynamic range coming off the air or the record. But if the S/N of the machine is 55 dB, achieved by permitting the recording level to rise to the point where distortion becomes 3 per cent (instead, say, of a lower level producing 2 per cent distortion), the recordist has a greater margin for encompassing the dynamic range of the material he desires to capture on tape.

In sum, one finds a necessary and logical relationship among the material to be recorded, the state of the tape recording art, and the reference level employed in rating S/N of high-quality home tape recorders.

An equipment review of an amplifier would hardly dare omit mention of S/N or would hardly dare say something as obscure as this: "The **** amplifier S/N measured 65 dB with reference to normal output." But reviews of tape recorders sometimes do say nothing at all about S/N, or else come up with comments that are difficult to fathom. In the latter vein, the reference level for measured S/N is often given as "0 VU." This will usually mean either of two things:

1. The reference may be a tone on a test tape (such as a 700 Hz tone on an Ampex test tape) which has been recorded at a level producing 1 per cent harmonic distortion. The intention is that the VU meter of a professional tape machine should read 0 VU when recording a tone of the same level (and same distortion) as on the test tape. If an equipment review cites S/N based on 0 VU and clearly indicates that the reference level is the 0-VU tone on a standard test tape, the reader can easily translate this into S/N based on a recording level that produces 3 per cent distortion. The difference between a tone recorded at 1 per cent distortion and a tone recorded at 3 per cent distortion, as we have noted, is about 6 to 8 dB. For convenience, let us take the middle figure of 7 dB. Therefore one should add 7 dB to the S/N figure based on a test tape tone recorded at 0 VU. For example, if S/N is given as 48 dB with reference to 0 VU on a test tape, S/N with reference to 3 per cent harmonic distortion is 48 dB plus (about) 7 dB, or (about) 55 dB.

2. The 0-VU reference level may be a tone recorded at a level such that it drives the VU meter to an indicator of 0 VU. Unless the machine in question is professional, so that a reading of 0 VU means a signal of 400 Hz (or thereabouts) is being recorded at a level producing 1 per cent distortion on the tape, the equipment reviewer and his readers are at the mercy of the recorder manufacturer. In some machines, the meter may be adjusted so that it doesn't read 0 VU until distortion reaches 3 per cent or possibly even 5 per cent. Of course this increases the S/N that the manufacturer can claim. To illustrate, the VU meter of Machine A may be calibrated to read 0 VU at the 3 per cent distortion level, while the meter of Machine B may be read 0 VU at 1 per cent distortion. If the two machines are otherwise completely equal, and if a reviewer measures S/N of each machine with reference to a recording level that drives the meter to 0 VU, he may conclude that Machine A has S/N of 55 dB with reference to 0 VU, while Machine B has S/N of only 48 dB. But actually both machines have the same S/N.

Occasionally the S/N reference level is given as —10 VU. This may mean a recording level of 10 dB below that which produces 1 per cent harmonic distortion. Or it may mean 10 dB below that which drives the meter to 0 VU; the two may or may not be the same thing. The thinking behind such a reference level, it appears, is that —10 VU approximates the average recording level, so that S/N measured on this basis indicates the relationship between signal and noise that prevails most of the time. However, it is customary in audio to base S/N on maximum rather than average output. Thus it is the usual practice to measure S/N of a power amplifier with reference to its rated power output (maximum output at acceptably low distortion); to measure S/N of a preamplifier with reference to its rated voltage output (maximum output at acceptably low distortion); to measure S/N of an FM tuner with reference to full modulation and full limiting.

If the reference level of —10 VU refers to the 0-VU tone on a test tape, one would add an additional 10 dB to the specified S/N. To illustrate, if S/N is stated as 40 dB with reference to —10 VU on a test tape, the corrected S/N (referring to 3 per cent distortion) is 40 dB plus 7 dB plus 10 dB, or 57 dB (approximately). On the other hand, if the reference level of —10 VU merely denotes a level that causes the meter to read —10 VU, one cannot say for sure what the S/N is.

In some tape machines the reference level is as high as 5 per cent harmonic distortion. This level is about 6 to 8 dB—let us say 7 dB—above the recording level that produces 3 per cent distortion. Thus a manufacturer can increase his S/N specification about 7 dB by using a 5 per cent harmonic distortion as the reference level. But if the equipment reviewer is diligent and notes that the magic eye closes at 5 per cent distortion, not 3 per cent, and if he happens to measure S/N at the recording level corresponding to eye closure, he will deduct about 7 dB from his measured S/N ratio. For example, if he measures 58 dB S/N at eye closure, he will report S/N as about 51 dB relative to a tone recorded at a level producing 3 per cent tape distortion.

Once in a while S/N is reported with reference to tape saturation, namely the recording level that causes the tape to saturate, preventing further increase in output. This level is roughly the same

as (perhaps 2 dB higher than) the recording level which causes 5 per cent distortion. Therefore if the reference level is given as tape saturation, one should subtract about 7 to 9 dB—say 8 dB—to translate this S/N rating to one corresponding to a reference of 3 per cent distortion.

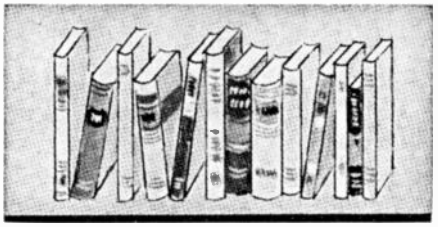
To sum up, it would be a great kindness to audio buffs if manufacturers and reviewers of tape recorders would all rate S/N with respect to the recording level that produces 3 per cent harmonic distortion on conventional 1½-mil tape at about 400 Hz; or else if they would at least clearly state the reference level on which their S/N rating is based, thereby allowing the audio buff to make a conversion, if necessary, to S/N based on 3 per cent distortion.

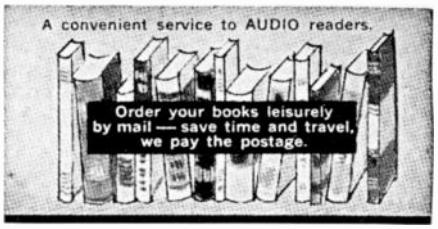
Assuming that the reader has an accurate idea of the S/N ratio for each machine in which he is interested, enabling him to make a satisfactory choice, it still remains for him to realize the potential of that machine. This means adjusting the volume control during recording to the optimum setting, so that peaks are recorded at about 3 per cent harmonic distortion. Thus he avoids recording at too high a level with an accompaniment of excessive distortion, or at too low a level with an accompaniment of poor signal-to-noise ratio. And this brings us back to the old controversy concerning the use of a magic eye versus a meter for the purpose of setting recording level.

This writer is still heavily in favor of the magic eye, because it can follow transients and indicate true recording level, whereas the VU meter may have a lag of as much as 10 or 20 dB, resulting in serious over-recording and consequent distortion. The VU meter requires considerable skill on the part of the recordist in order to judge recording level, whereas the novice can set recording level properly with a magic eye (assuming the eye is properly calibrated to close at 3 per cent distortion). The advantage of the VU meter is that it enables one to make desired numerical changes, in terms of decibels, in recording level. But this is seldom of importance to the home recordist. It must further be recognized that seldom are the meters in home machines true VU meters having the frequency response and speed characteristics of professional meters; accordingly, it becomes all the more difficult to wend that tight path between excessive distortion and excessive noise.

Q. Does contact between the pressure roller and the back of the tape produce tape transport? Or does contact between the tape and the drive capstan produce tape transport?

A. Essentially it is the capstan that drives the tape. The pressure roller gives sufficiently so that it is driven by both the capstan and the tape. Æ





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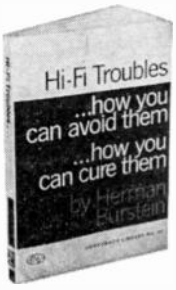

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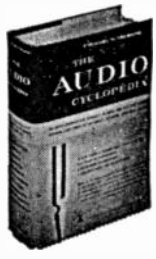

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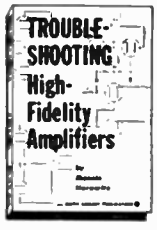

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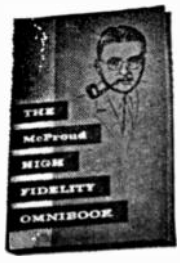

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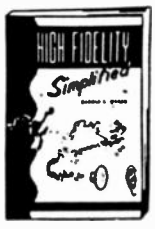

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EQUIPMENT PROFILE

(From page 14)

KLH TWENTY STEREO MODULAR SYSTEM

Like it or not, the complete stereo modular system is here to stay. While it can be argued that this is an incursion into the pre-packaged area that is better left to those specialists, that discussion is not germane to the performance of these units. And it is performance, after all, with which we are concerned.

The KLH Twenty (KLH likes to spell out its model numbers) is record player, stereo-FM tuner, amplifier, and two speaker systems. All this is in three enclosures. Two are the speaker systems; the third is everything else.

It is our belief that subjective listening plays a far larger part in the evaluation of complete systems than it does when discussing a particular component. It is common in the design of these units to add compensation to amplifiers for the inadequacies of speakers and cartridges. We are not saying that this is the case here; rather only that these are *complete* systems; they must be judged as a *whole*.

With that in mind we did a great deal of listening to this unit. We played records and we listened to FM—both mono and stereo. The KLH Twenty is easy to listen to. Our over-all impressions are of clean, bright, and wide-range sound. The speakers each measure 23⅛ by 11¾ by 9 inches. These are bookshelf dimensions. Still, there is good bass output to about 45 Hz. Music is reproduced with all but the extreme bottom octave. (And how many speakers of any size can reproduce that?)

Our suburban location demands an outdoor antenna for FM stereo reception without noise. With the KLH unit connected to this antenna, stereo programming came in well—distortion was audibly low and background hiss was no problem. A local stereo station produced equally satisfactory results from an indoor folded dipole. So, based on listening tests alone, the Twenty is a highly satisfactory metropolitan and moderate fringe performer.

The changer is a Garrard unit fitted with a Pickering V-15 cartridge. We did not specifically test this sample cartridge—its quality reputation is well deserved. The changer had rather lower rumble and flutter than we would have expected. True, we could hear rumble under soft passages of music with the level high, but no more so than on many other turntables. Flutter was 0.2 per cent, certainly low enough for the more critical ear.

This particular changer ran exactly 1 per cent fast with one record playing. This we know to be a somewhat variable factor (1 per cent is the worst we have seen—and that's not so bad). If you have perfect pitch you may have to shop some for an exact speed unit since there is no speed adjustment possible.

We performed spot checks on the unit—perhaps more to verify what we heard in the listening tests than for any other reason. After all, the buyer of such a system is stuck (as it were) with the *over-all* performance. It matters little to him that this amplifier is flat within ± 1 dB from 20-20,000 Hz—except for a 3-dB peak at 10 kHz. It also matters little that IM at listening levels is a relatively high 2 per cent. It matters little because that is the way it is and because of it, or in spite of it, the unit sounds good.

The KLH Twenty is a fine musical instrument. We feel that it is a system that the most fastidious ears can live with—even if it is not the ultimate in state-of-the-art performance. After all, here is a complete music system, in walnut cabinets, and selling for $399.95. That's hard to beat.

CIRCLE 3

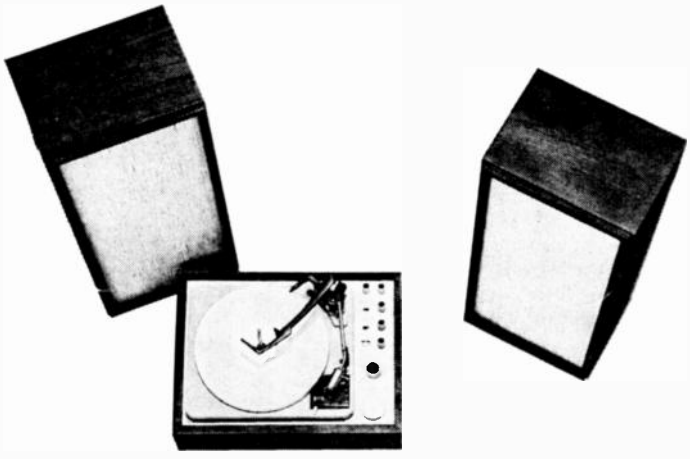

Fig. 4. The KLH Twenty modular system.

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HI-FI SPEAKERS EXPERTLY REPAIRED
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FREE! Send for money saving stereo catalog AM and lowest quotations on your individual component, tape recorder, or system requirements. Electronic Values, Inc., 200 West 20th St., New York, N. Y. 10011.

M. RETTINGER Consultant on Acoustics Analysis. Room Design. Noise Reduction, 5007 Haskell Ave., Encino, Calif. Tel: (213) 784-3985.

PROTECT YOUR LPs. Heavy poly sleeves for jackets, 5 cents. Round bottom for records, 3 cents. Minimum 100. May Assort. Poly Co., Hillburn, New York Post Office.

WRITE FOR LOW QUOTES, fast service, everything in audio. Special Dynaco kits or custom wired plus walnut cases for complete Dynaco line. Kitcraft. 738A Washington Ave., Brooklyn 11238.

WANTED: USED SCULLY LATHE. Age and condition not important. Peter J. Helffrich, 419 W. 4th St., Bethlehem, Pa. 18015.

LOWEST PRICES on new LP jackets. White-Colors. Samples, 50c. Record Supplies, Hillburn, P. O. Box 323, Hillburn, New York 10931.

RCA LC-1A, $100. Maury, 1117 Geary, San Francisco.

WANTED: 601 or 602 Ampex Recorder —full or half track in excellent condition. Richard Miles, 131 Farrington St., Wollaston, Mass. 02170.

AUDIOPHILE for over ten years would like work in Audio and Recording field. Have FCC 1st class license, and Assoc. of Science Degree. Box AO-1.

"CROWN" Professional Recorders: New and used. Reasonable prices. Wiegand Audio Labs, 221 Carton, Neptune, N. J. 07753.

DISC RECORDING EQUIPMENT: Cutterheads, Recording Amplifiers, and Lathes. New and used. From Rek-O-Kut to Scully. Send requirements. Wiegand Audio Labs, 221 Carton, Neptune, N. J. 07753.

TAPE DUPLICATING. Low prices. Any quantity. G&G Recording Service, Box 412, Peekskill, N. Y. 10566.

CONCERTONE 20/20 2 track Stereo Recorder with cases and microphone transformers $250.00. Also, Stephens Model C-2 Microphone System. Rodney Yarbrough, Celina, Texas. DU 2-2884, Area 214.

2 FISHER XP4A speaker systems $195. 2 Fisher WS-1 speaker systems, $25. Fairchild Compander, $25. Koss Pro 4 headphones, $25. Dual 1009, Empire 880 PE, Base $60. Norman Little, 32-581 Sky Blue Water, Palm Springs, Calif.

JANSZEN 1-30 Electrostatic Tweeter (4 element), good condition, $75. John McBride, 2626 Boxwood Drive, Wilmington, Del. 19803.

WANTED: Fairchild 412, Electro-Voice 18" or 30" Woofer. Donald Bisbee, 685 So. Roys Ave., Columbus, Ohio. 43204.

PROFESSIONAL quality 23" custom TV Fleetwood 1010, with solid walnut cabinet $200 or best offer. EV665C, 666 and 646 mikes and 2 stands $200. Ampex 612 $200. RCA 70C turntable and arm $100. Fisher 200C, new $180. Broadcast audio console $100. R. G. Streeter, 9 Poplar Place, Fanwood, N. J.

SELL—MARANTZ 8B Amp. Perfect, like new $170. Rev. Gordon Jones, Honey Brook, Pa. (215-273-3023).

FISHER 90-T Tuner, $65.00. Dynakit "Stereo 70" Amp (unwired) $60.00. Ampex A 122, Mono Record-2 or 4 tr. playback-luggage case built-in amp & speakers, $165.00. Telex Stereo Headset, $12.00. T. Slack, 517 E. Wildey St., Phila. 25, Pa.

SOUND AND SIGHT

(Continued from page 66)

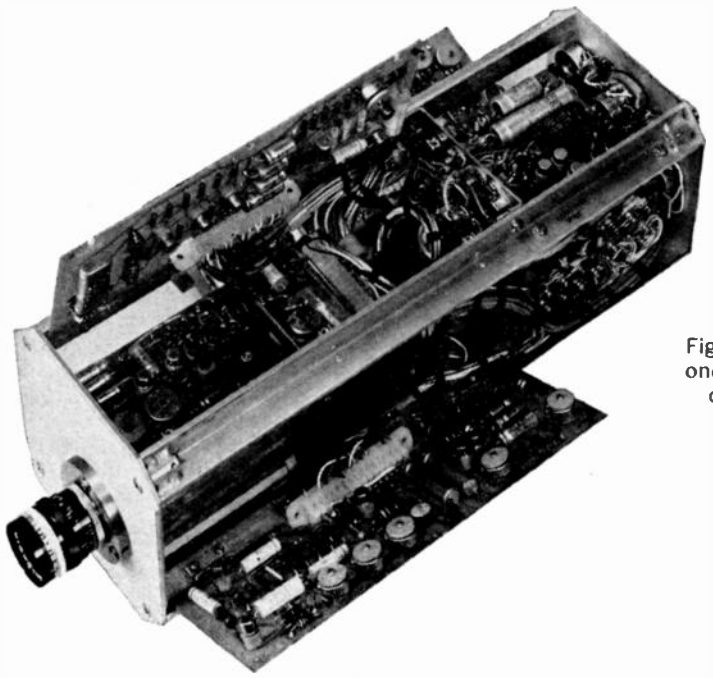

Fig. 2. The GPL one piece camera configuration.

from 672 to 837 lines, and in consequence they provide better resolution than the 525-line cameras employed for broadcasting and in most educational television systems. A scan rate of 875 lines is employed by the U. S. Navy for applications in which even greater detail is required. A 945-line rate is employed by organizations such as NASA for various scientific purposes. The U. S. Army employs line rates as high as 1023 lines.

Once the bandwidth and horizontal scan rate for a CCTV system have been established, changes are expensive and difficult to make. General Precision Inc. (GPL Division) have finally solved this problem. Their new 1000 System, illustrated in *Fig.* 1, permits the user, for the first time to choose by means of the seven solid-state plug-in modules available, scan rates from 525 to 1023 lines. The scan rate can be changed instantly, in the field, at any time by simply plugging in the correct module. All other camera sections are also made up of plug-in modules and provide the user with a number of other options. The 15-megacycle video module may be replaced at any time with a 30-megacycle module when increased horizontal resolution is required. Four plug-in sync options are also available—random interlace, 2 to 1 interlace, internal or external EIA RS 170 sync.

The complete interchangeability of all modules also simplifies service and maintenance. These are always a problem when equipment is in use twenty-four hours a day for months on end as many CCTV applications are.

The two-piece camera, illustrated in *Fig.* 1, incorporates two other features which we venture to say will soon be copied by others. First, the Video Level Indicator which enables inexperienced personnel to obtain professional results easily. A waveform monitor, heretofore considered essential in many broadcast, medical, and scientific applications, is no longer required, since the proper levels for sync, blanking, and video can be obtained easily and quickly with the meter.

The second feature is the extremely clever method of eliminating the necessity for extension tubes and close-up lenses when the camera is to be employed for close-up or micro-photography. In the past, the complete vidicon assembly was mounted on rails and moved closer to or further from the lens, for this type of application. GPL has greatly simplified the use of the camera for this purpose by employing an adjustable "C" mount to hold the lens. This permits the user to obtain exact optical focus by merely moving the lens assembly in relation to the faceplate of the vidicon tube. It eliminates the necessity for opening the camera for adjustment of the vidicon assembly.

The camera of the two piece system is a marvel of miniaturization, as may be seen in *Fig.* 1. The head measures only 3-13/16" wide x 3-13/16" high x 8-1/2" long.

The same camera system is also available in a one piece configuration which includes the control unit and the camera in one case, as illustrated in *Fig.* 2. Æ

Advertising Index

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OCTOBER 1966 ISSUE

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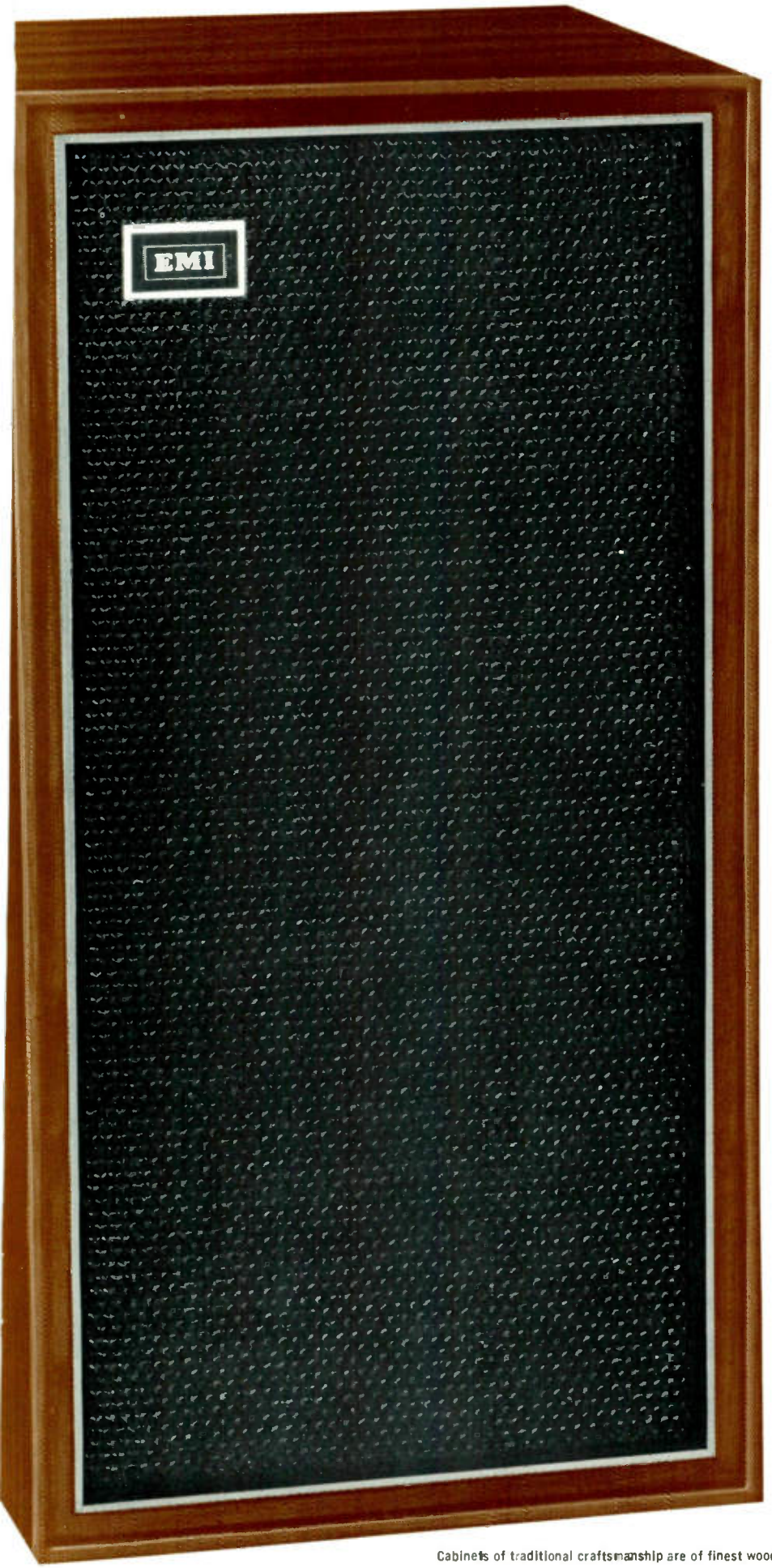

The new EMI Scope "102" bookshelf loudspeaker treads on English tradition

The quality manufacturers England is famous for (the name EMI comes as quickly to mind with audiophiles as the name Rolls-Royce with motor car enthusiasts) are not driven by the compulsion some manufacturers have for coming out with a new model every year.

When minor engineering breakthroughs are achieved, improvements are made in existing models without fanfare.

And so when a manufacturer such as EMI comes out with an entirely new series of models, it constitutes a sharp departure from tradition.

Thus with EMI's new loudspeakers. In the case of the EMI Scope "102," England's top audio engineer worked for many years in one of the world's great laboratories to perfect the ideal bookshelf-sized speaker. When he finally had just what he wanted, it was so radically different that EMI decided to rush it to market as first in a whole new series of speakers.

For their size and price, the EMI Scope series give absolutely unrivaled response over the full audio range from silken highs and controlled mid-range to a deep, deep bass. Part of the secret is a unique, rigid center cone of aluminum that cuts breakup and transient distortion as the usual paper cone could never hope to. But it's only part of the secret; there are literally dozens of innovations in these speakers.

To discover for yourself whether or not this distinctly un-British enthusiasm is warranted, ask your EMI dealer to demonstrate the ultimate EMI Scope "102" at $199.50 today. Also unsurpassed at the price are the EMI Scope "92" at $109.95 and the EMI Scope "62" at $79.95. They're all 8 ohms.

EMI / SCOPE

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When teamed with a pair of famed Electro-Voice speakers, you've achieved a matched high fidelity system of rare excellence. And the E-V approach to high fidelity design makes installation easy and operation effortless.

Oh. One other thing about the E-V 1177. The price. It's right in line with the size. Small. Just $280.00, including the walnut-paneled case. See your E-V dealer for a demonstration. Or write for our complete high fidelity catalog. *It's* big!

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