July 1956

Volume 1 Number 9

audiocraft

THE HOW-TO-DO-IT MAGAZINE OF HOME SOUND REPRODUCTION

Authors new in this issue, in order as they appear at the right:

Louis F. B. Carini is an audiophile, author, and electronic engineer; he has achieved particular recognition for his design and development of FM antennas. Now associated with Apparatus Development Company, he finds time among his many other tasks to answer letters from FM listeners who write him for advice on reception problems. Perhaps his article beginning on page 20 will spare him some correspondence, because it covers those subjects about which he is most often asked. Still, he says that he will be pleased to answer any further questions. His address: 246 Wolcott Hill Road, Wethersfield 9, Conn.

Rufus P. Turner, whose office is in Los Angeles, is a consulting electronic engineer and a California-registered Professional Engineer. One of the most widely read authors on audio subjects, he began to specialize in transistor applications almost as soon as these components became available. As AUDIOCRAFT readers know, transistors have reached the stage in their development at which they must be considered seriously for high-quality home audio. We shall give increasingly more space to construction articles on transistor equipments, so Mr. Turner can be expected to appear in these pages again.

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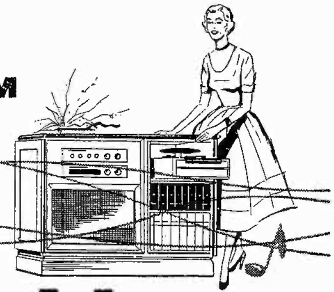

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MODEL WA-P2 **$19.75**

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This amplifier employs the famous Acrosound TO-300 "Ultra Linear" output transformer, and has a frequency response within ±1 db from 6 cps to 150 Kc at 1 watt. Harmonic distortion only 1% at 21 watts. IM distortion at 20 watts only 1.3%. Power output 20 watts. 4, 8, or 16 ohms output. Hum and noise, 88 db below 20 watts. Uses 2-6SN7's, 2-5881's and 5V4G. Kit combinations:

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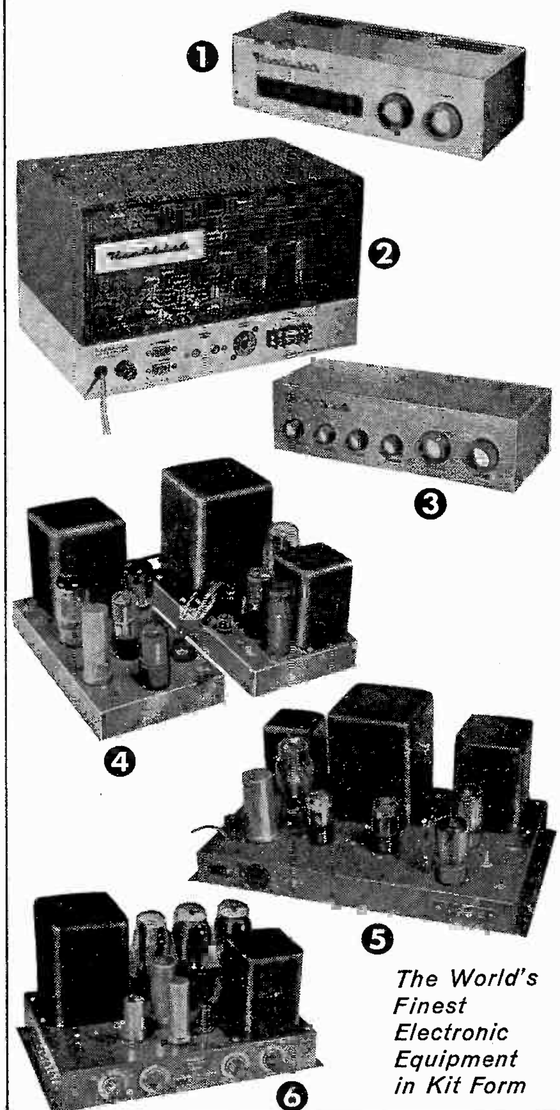
MODEL A-9B **$35.50**



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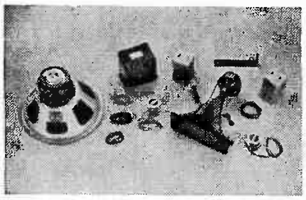
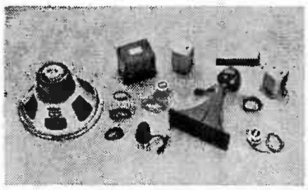
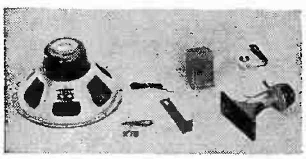


KT-31 IMPERIAL KIT
3-way system. The ultimate in performance. Specially designed 15" "woofer", compression type mid-range and "supertweeter" units. 600- and 4000-cycle cross-over networks, intrarange equalizer, special controls, brackets, cables. Recommended enclosure 25 cu. ft. in back-loading folded-horn. 16 ohms. 35 watts. $184.50

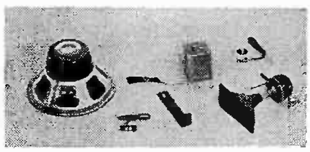
KT-32 TRI-PLEX KIT
3-way system. Superlative performance in moderate space; approx. 10 cu. ft. suggested. 15" "woofer", compression type mid-range and "supertweeter" units. 600- and 4000-cycle cross-over networks intrarange equalizer, controls, brackets, cables. 16 ohms. 35 watts..........$169.50

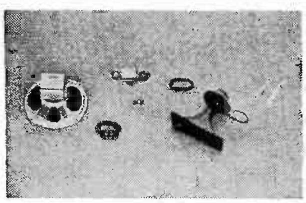




KT-21 CONCERTO-15 KIT
2-way system. An outstanding system with 15" "woofer" and compression type "tweeter", 2000-cycle crossover network and balance control, bracket and cables. 10 cu. ft. enclosure suggested. 16 ohms. 30 watts $99.50

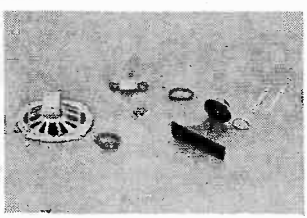
KT-22 CONCERTO-12 KIT
2-way system. Excellent performance in scaled-down size (recommended enclosure as small as 6 cu. ft.). Like KT-21 except 12" "woofer". 16 ohms. 25 watts..........$73.00

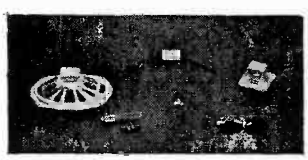




KDU-10 TREASURE CHEST DUETTE KIT
2-way system. Special 8" "woofer", compression driver "tweeter" and frequency division for compact reproducer (1½ cu. ft. Duette enclosure or 2½ cu. ft. Bass-Ultraflex type.) Includes wiring materials. 8 ohms. 20 watts..........$24.75

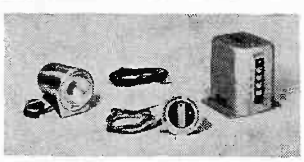
KDU-11 TABLE DUETTE KIT
2-way system. Specially designed for chair side or table TV use. May also be used in 1½ cu. ft. Duette enclosure. Heavy duty 6" x 9" "woofer", compression driver "tweeter", frequency division unit and wiring materials. 3-4 ohms. 20 watts..........$23.75





KDU-12 BUDGET DUETTE KIT
2-way system. For maximum results at lowest cost. May be installed in table or 1½ cu. ft. regular Duette or in 2½ cu. ft. Bass-Ultraflex enclosures. 6" x 9" "woofer" direct radiator "tweeter" frequency dividing unit plus wiring materials. 3-4 ohms. 15 watts..........$10.50

KTX-1 RANGE EXTENDER SUPERTWEETER KIT
Adds smooth, clean highs from 4000-cycles to limits of audibility to any single unit, coaxial or 2-way system. Complete with crossover network, balance control and cable. For systems rated up to 35 watts..........$43.75



Cabinart (G & H Wood Products) utility enclosures are available for all except KT-31 and KTX-1 Kits.

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Complete instructions for building self-contained or built-in single speaker and 2-way and 3-way speaker systems: "Duette", Bass-Ultraflex and Back-loading Folded Horn cabinets. Includes parts lists and speaker data for all types of enclosures.

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If you want a hi-fi system with the stand-out performance for which Jensen speakers are famous . . . plus the fun and saving of "do it yourself" . . . and the advantage of being able to adapt each basic design to your exact needs for a built-in or free standing speaker enclosure, then be sure to get your copy of Jensen's big new 36 page Manual 1060 now!

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The Grounded Ear

by Joseph Marshall

The Slot Radiator

One of the most interesting of recent developments in the loudspeaker field has been the increased use of the slot radiator. The radiation pattern of a slot is rather surprising. Take, for example, a slot in a cabinet or wall whose long dimension is vertical. The directivity in the vertical or up-and-down plane may be rather sharp; but the radiation angle in the horizontal plane — at right angles to the long dimension of the slot — is extremely wide. In fact, if the slot were in a thin cylinder in the middle of the room, the radiation pattern could be 360°, or circular; if the slot were in the wall or a cabinet against a wall, it might be 180° wide. Moreover, this appears to hold true for the highly directional high frequencies (depending on the slot dimensions) as well as the low frequencies.

One of the big problems in high fidelity is the "hole-in-the-wall effect" which results from narrow-angle radiation. The ability of the slot to widen the radiation angle is, therefore, extremely promising from the standpoint of producing a more natural sound distribution.

The application of the idea is still so recent that relatively little is known about it. Slotted baffles are comparatively uncritical, as loudspeaker baffles go, and accordingly the amateur experimenter can play a part in their development and have some fun as well. For that reason, I present here what little I know about the work that has been done with slot radiators.

Like so many other "brand-new" ideas, the slot radiator has been used in the past, though not always with a clear understanding of what is involved. Intense development work with slot radiators is being done by Tony Doschek of Pittsburgh, H. A. Hartley (of Hartley speaker fame), and Frazier-May (International Electronics) of Texas. Mr. Hartley has recently reported that if a plywood square or rectangle with a vertical slot is mounted in front of two speakers (spaced about 1 in. from the cone) the dispersion of highs especially is greatly improved.

Frazier-May has a series of speaker systems employing radial-slot loading of one side of the cone at low and middle frequencies, with very gratifying effect. They do it this way: a ¾- or 1-inch plywood board, spaced 1 in. from the speaker cone, is installed in front of the speaker cabinet. To smooth out the transmission characteristics, apparently, they use a plug with a profile similar to that of the cone, and mounted in front of it, as indicated roughly in Fig. 1. The cone thus works into a radial slot about 1 in. wide. The back of the cone is loaded by a horn working into a corner. Performance of this system was very pleasing to my ear, with an extraordinary dispersion of the bass and middle.

As soon as I can find the time I intend to try using the Hartley and Frazier-May idea on my own wall-mounted speakers.

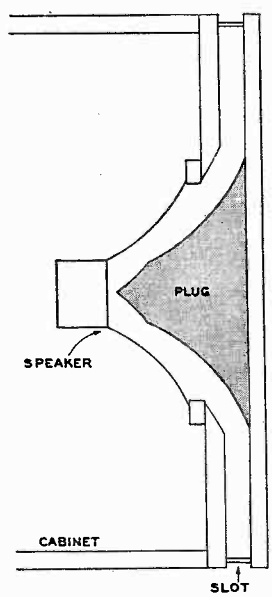


Fig. 1. Radial-slot baffle.

I will use a ¾-inch plywood board about 6 ft. high and 18 in. wide, and cut a vertical slot about 2 or 3 inches wide through the middle of it. I will then mount this in front of my array and see what happens. This is so simple an experiment that readers may profitably try similar arrangements with present bass-reflex, infinite baffle, or other enclosures.

The most impressive, perhaps, of the radial-slot systems is the tremendous theater and auditorium "radial-exponential transducer" developed by Tony Doschek for Pro-Plane Sound Systems. This is either 8 or 12 ft. in diameter and weighs about a ton. It is meant for mounting either up against the ceiling or on the floor. In either case, it has a circular radial slot that is from 12 to 18 in. wide, with a circumference of between 20 and 35 ft., depending on the model. The speaker works into this slot from the middle in a channel which is tapered exponentially. Doschek has also used slot porting in the Primastic line of bass-reflex enclosures Pro-Plane is producing, which achieve a notable dispersion of the sound source.

In any event, it is apparent that slot radiation is going to be widely investigated in speaker systems in the next year or so.

How Much Power?

A couple of months ago, you may recall, I reported that in my own home we required less than 500 mw peak output for normal listening and less than 3 watts for high-level listening of the demonstration type. I asked readers to undertake similar measurements and report them to me. A number have now done so and the most interesting thing about these reports is their close correspondence to my own and to each other. Apparently my figures hit a pretty good mean, for all the reports fall within plus or minus 50% of them. Allowing for differences in personal taste, hearing, speakers and amplifiers, and methods of measurement, this is a really extraordinary uniformity. The maximum reported figure was 4.8 watts; this was accompanied with the comment, "Too loud." It would appear that for this group of listeners, when listening to music rather than demonstrating high fidelity, a peak output of less than 1 watt is sufficient most of the time.

I implied when reporting my own experience that I was not sure what it proved. Nor am I sure what this greater sampling proves. On its face it would appear to indicate that those of us conducting this series of tests are content with levels of loudness considerably lower than advocates of "concert-hall level" would believe possible. I think there is some support for this from common-sense analysis. In the first place, it seems to me that the only acceptable definition of "concert-hall level" is not the loudness of the orchestra as it might be heard or measured close-up in an empty hall; but, rather, the loudness the *listener experiences* in a preferred seat in a filled auditorium. This is by no means as loud subjectively as the tables of sound output of orchestras might indicate. In a filled auditorium there is tremendous absorption of sound; also, the sound diminishes in intensity with distance exponentially, so that by the time it reaches the ear in a seat 40 ft. or so from the orchestra it is only a small fraction of its original intensity.

On one hand, then, the 75-watt peak of a big orchestra may actually be less than 10 watts at the ear of a listener in a preferred seat; on the other hand, 10 electrical watts in a small living room may actually seem very much louder because of reflections and the better signal-to-noise ratio. Therefore, it may well be that as little as 3 to 5 amplifier watts is sufficient in a living room to give "concert-hall realism".

Yet, I hesitate to accept either my own figures or those of my co-operating readers at face value. I recall the series of fatal experiments of the same sort before the war which appeared to prove that most people preferred a restricted frequency range to wide-frequency "high fidelity". I use the adjective *fatal* deliberately because those experiments were cited time and time again as evidence that high fidelity was neither necessary nor desirable, and did more than anything else to retard the commercial development of high fidelity. We know today that it was not the wide frequency range that was objectionable but the distortion which accompanied it; given a lot of distortion, the ear preferred a narrow band width.

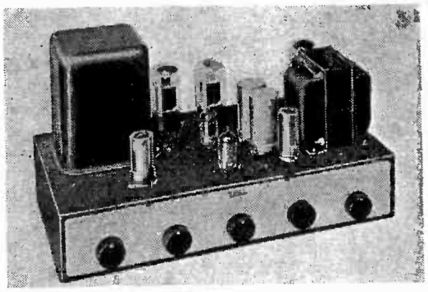
Before accepting completely the conclusion which seems to follow from our experiments, I want to be sure that no such invisible correlation exists in this instance. In other words, I ask myself: "Is it possible that we listen at these low levels not because we find them truly satisfying, but because subconsciously we cannot tolerate the distortion which accompanies a louder level?" In my own instance I am fairly confident the answer to this is negative. The amplifier used in my own tests is capable of 60 watts sine-wave output; moreover, it will deliver 30 watts complex (60 and 7,000 cps, 4:1) wave with less than 1% intermodulation distortion. No deformation is discernible to the eye when the wave is examined on an oscilloscope, even a very large one. Nor do I note any significant difference in wave form of very complex musical sounds when viewed on a 'scope, at any output less than 25 watts. Furthermore, my multiple speakers are individually excellent

Continued on page 37

Audionews

EICO 20-WATT AMPLIFIER

A new 20-watt, ultra-linear, Williamson-type amplifier is now in production by Electronic Instrument Company, Inc. The *HF20*, as the unit is called, includes a preamplifier with 5 positions of feedback equalization, variable turnover



Amplifier is available wired or as a kit.

feedback tone controls, Centralab Compentrol, and separate panel level control. The amplifier is supplied with speaker-connection taps for speakers of 4, 8, and 16 ohms.

Frequency response of the HF20, according to the manufacturer, is ±0.5 db from 13 to 35,000 cps, and ±1.5 db from 7 to 50,000 cps. IM distortion (60 and 6,000 cps/4:1, at full rated output) is said to be 1.3%. Maximum harmonic distortion (between 20 and 20,000 cps at 1 db below 20 watts) is rated at 1%.

The EICO HF20 is available both in kit and factory-wired form. Complete details will be furnished on request.

CABINART '56 CATALOGUE

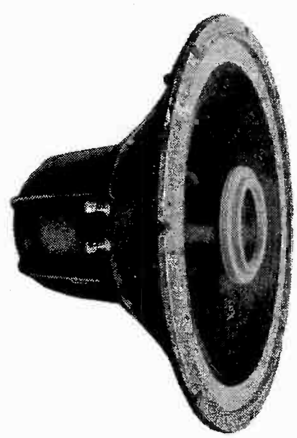
A 34-page catalogue containing a complete listing of Cabinart's 1956 line is now available. The booklet lists all of that company's hi-fi equipment cabinets, cabinet kits, speaker enclosures and enclosure kits, multiple-unit speaker systems, and furniture hardware and accessories for the sound enthusiast. New lines for 1956 include *Accessories by Cabinart*, 21 assorted record-changer bases, turntable bases, leveling hardware, mounting boards, and assorted furniture hardware.

The Cabinart '56 catalogue is fully illustrated. Copies are offered free on request.

PNEUMATIC-DAMPING SPEAKER

The Racon Electric Co. has announced introduction to the high-fidelity field of a line of high-compliance loudspeakers. The Racon *Hi-C* loudspeaker employs a new principle in cone suspension which is said to give it extremely large motion and to lower the resonant frequency (24 cps). It is claimed that Hi-C suspension, on which patent applications have been made, results in practically a free-edge cone, having great flexibility without encountering mechanical restraints or magnetic non-linearity.

A special cellular formulation of plastic is used between the cone edge and the supporting basket. This material is composed of millions of microscopic cells randomly interconnected so that the amount of pneumatic damping, due to stiffening of the air in these cells,



Racon Hi-C has new cone suspension.

depends upon the amplitude of cone motion. At large amplitudes, such as at resonance, damping is at maximum.

> FOR MORE INFORMATION
>
> *For more information about any of the products mentioned in Audionews, we suggest that you make use of the Product Information Cards bound in at the back of the magazine. Simply fill out the card, giving the name of the product in which you're interested, the manufacturer's name, and the page reference. Be sure to put down your name and address too. Send the cards to us and we'll send them along to the manufacturers. Use this service; save postage and the trouble of making individual inquiries to a number of different addresses.*

The Hi-C line is, at present, available in three 15-inch models: a woofer, a wide-range dualcone, and a triaxial. Eight- and twelve-inch models are under development.

ELECTRO-VOICE MICROPHONE CATALOGUE

An illustrated catalogue on professional microphones has just been issued by Electro-Voice, Inc. This 32-page catalogue gives detailed application information, features, and specifications on each Electro-Voice microphone used in telecasting and broadcasting. It shows how these microphones work and includes polar patterns, frequency response curves, and wiring diagrams. Electro-Voice accessories are also illustrated and described.

For a copy of Catalogue No. 120, write to Electro-Voice, Inc., Buchanan, Mich.

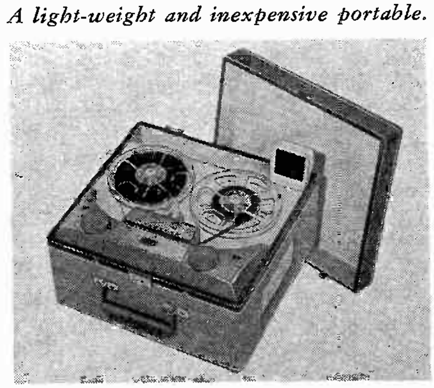
TELECTRO PORTABLE TAPE RECORDER

A new low-cost, light-weight portable tape recorder, *Model 556*, has been announced by the Telectrosonic Corporation.

The new model provides simple operation with dual-track recording at 3¾ ips; fast forward and rewind; recording level indicator; and easy threading.

Reels can be kept permanently in place, eliminating the need for threading every time recordings are made. Accessories provided include a crystal microphone with stand; a cord for recording connection with radio or phonograph; a 5-inch reel with tape, and pick-up reel; and an AC line cord. The unit measures 7 in. by 10 in. by 11½ in. and weighs slightly less than 16 pounds. It operates from 110-120-volt AC lines.

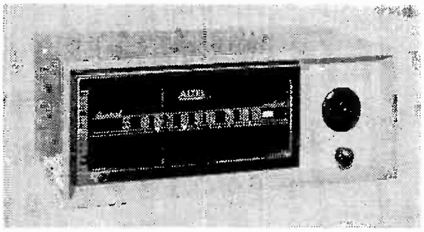
A light-weight and inexpensive portable.



NEW ALTEC AM AND AM-FM TUNERS

Altec Lansing Corporation has just announced two new tuners as part of an expanded line of high-fidelity components.

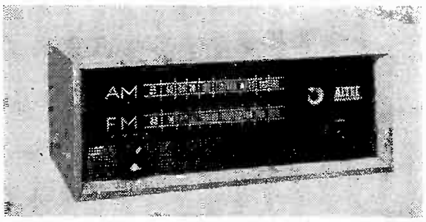
The *Model 305A* is an AM tuner designed to meet demands for a high-



Altec Lansing AM-only tuner, the 305A.

quality tuner in areas where FM broadcasting is not available. The unit is priced at $99.00.

The other new tuner is the *Model 304A* AM-FM tuner. According to the manufacturer, the 304A has exceptional



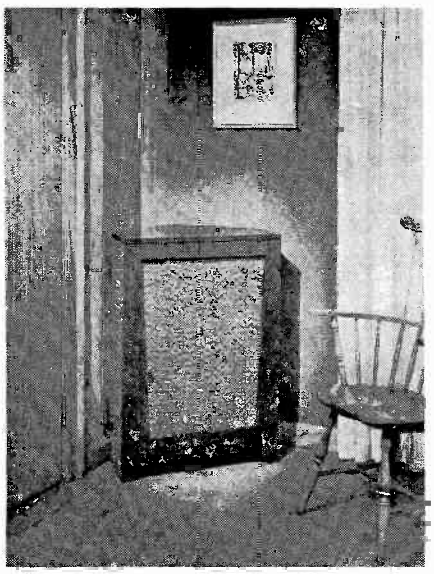
Model 304A, Altec's new FM-AM tuner.

selectivity, stability, and freedom from drift. The price is $186.00.

KLIPSCH SHORTHORN

The Klipsch *Shorthorn* loudspeaker system, formerly available only in kit form, is now offered in an assembled, finished model. Exposed wooden parts are made of either dark mahogany or light primavera. The unit may be purchased with the Klipsch ortho-15, three-way system

Shorthorn can now be obtained finished.



which includes a 15-inch bass driver, a Klipsch ortho-12, three-way system with 12-inch bass driver, or it may be purchased without drive system. An unfinished utility model is also available with the same choice of drive systems.

For further information write to Klipsch and Associates, Hope, Ark.

HARMAN-KARDON AMPLIFIER CHANGES

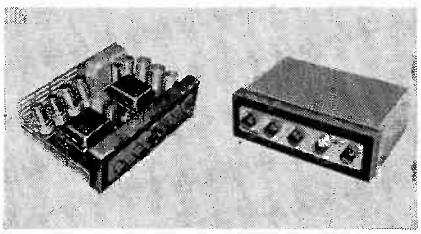
Harman-Kardon, Inc., have announced important changes in the latest version of their *Trend* 30-watt amplifier.

Three tape-equalization positions are now included for tape speeds of 15, 7.5, and 3.75 ips. Tape recorders with built-in preamplifiers may be connected to one of two auxiliary inputs.

A separate rumble-filter switch has also been added which progressively attenuates all frequencies below 50 cps.

Rated at 30 watts with 0.5% IM distortion, the Trend features variable damping from 0.1 to 20 in six steps, as well as a six-position Dynamic Loudness Contour Control.

The Trend is now available in two versions: Model C-300, complete with



New Trend amplifier has added features.

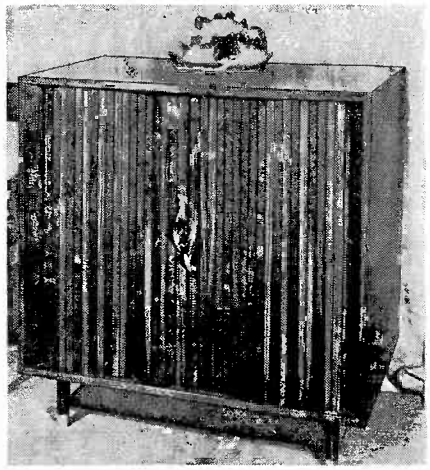
cage, at $129.95; and Model CL-30, without cage, at $119.95. Prices on the West Coast are slightly higher.

RIVER EDGE SPEAKER ENCLOSURES

The *Model 1636*, a speaker-enclosure version of the River Edge tambour-door equipment cabinet, has recently been introduced by River Edge Sales Corporation.

The new enclosure is a bass-reflex design and will accommodate any 12- or 15-inch loudspeaker, according to the manufacturer. It is claimed that the tambour doors are arranged to be free of the slightest vibration. Enclosure 1636 is identical in appearance and measurements with the tambour-door component cabinet and, like the component cabinet, the new model is made of fine hardwoods and is available in nine hand-rubbed finishes to the customer's order.

Another River Edge enclosure, the *Model 900*, is a kit version of a corner enclosure. The Model 900 kit is a horn-loaded corner enclosure designed to handle a variety of loudspeakers, including, according to the manufacturer, tweeters of any size and shape.



The 1636 bass-reflex speaker enclosure.

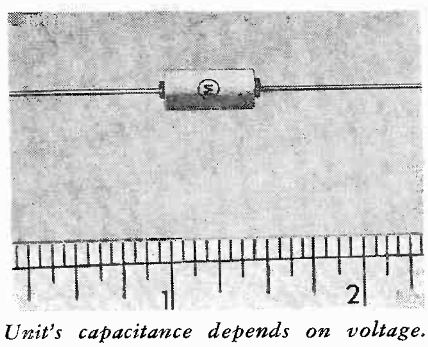
River Edge customized cabinets and kits are products of the British Industries group. Illustrated literature about this equipment is available on request.

PRINTED-CIRCUIT APPLICATIONS FOR ELECTRONIC ORGANS

Electronic Organ Arts has announced the release of printed (etched) circuit applications for its line of build-it-yourself electronic organs. The first is a tone-generator chassis consisting of a double-sided, etched panel which eliminates all wiring. Assembly is said to be reduced to mounting the oscillator components and soldering the connections. Wiring time has been reduced to a quarter that of the conventional design, it is stated. Each solder point and note is labeled to simplify construction.

VOLTAGE-SENSITIVE CAPACITORS

A new series of voltage-sensitive ceramic capacitors with capacitance values ranging from 300 down to 100 $\mu\mu$fd has been announced by Mucon Corporation. Known as types *LVSR* and *LVSE*, the capacitance of these units may be decreased as much as 60% by the application of DC potential up to 200 v. The units are temperature sensitive, type LVSR having maximum sensitivity at room temperature, and type LVSE at 70° C. Both types are housed in a steatite



Unit's capacitance depends on voltage.

tube approximately 7/32 in. in diameter and ½ in. long. Leads are No. 26 gauge.

TIPS FOR THE WOODCRAFTER

by George Bowe

Basic Power Tools, Part 2

Band saw or jig saw? That is a question many a man has pondered as he made ready to expand his workshop. There is a similarity in appearance, and there are many tasks that both machines can perform. Both saws can cut straight lines but are used more frequently for sawing curves or irregular shapes. Since the average home craftsman must purchase his power tools one at a time, he should be very careful to select the machine that best suits his needs.

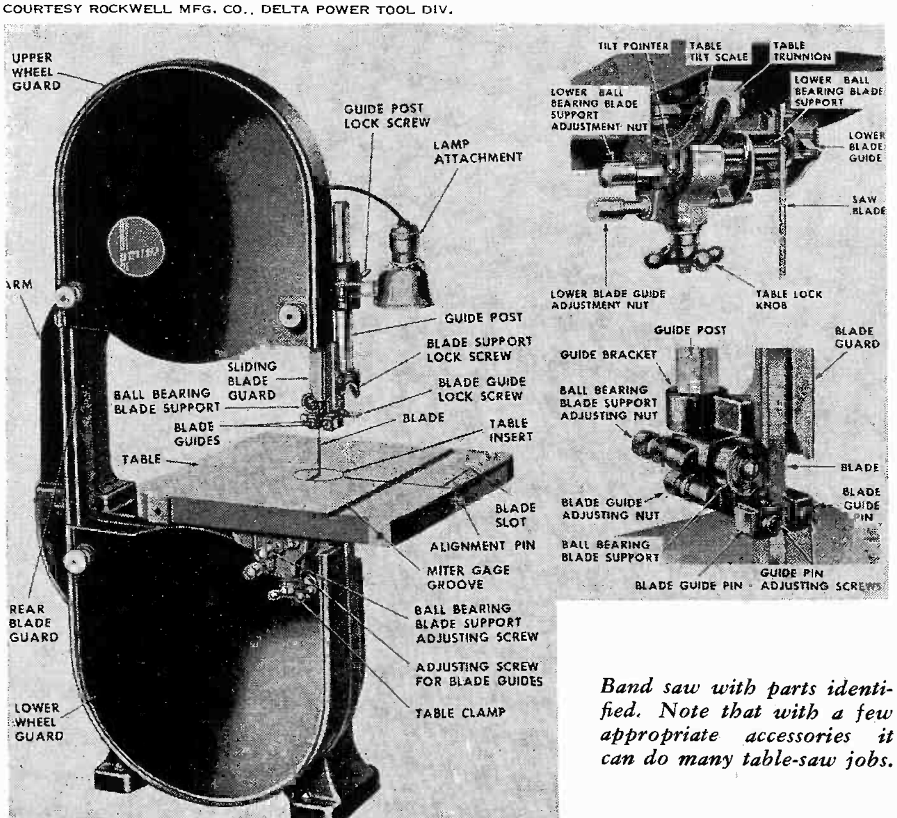
The type of work a man intends to turn out will determine his choice. For intricate scrollwork, inlay, and metal piercing, the jig saw is indispensable. It will handle wood thicknesses up to about 2 in. maximum. For heavier work such as pad-sawing, which is cutting through several layers of wood to produce many identical pieces in one operation, or resawing to reduce the thickness of boards, the band saw has no equal in home workshop equipment. It will slice through 6-inch wood with no apparent effort. In quality brands both machines are rugged tools, designed to serve you long and well in their respective capacities.

The Band Saw

Like the circular saw, the band saw is one of the oldest and most necessary implements in the woodworking field, deriving its name from the continuous band of metal which forms its blade. In the lumber mill, and in industry, heavy-duty band saws turn logs into planks and planks into boards. But our concern is the band saw for the home workshop, a machine comparatively simple to operate.

Size of the band saw is determined by the diameter of the wheel. A 12-inch band saw has a 12-inch wheel—actually, *two* wheels of that size which propel the blade. Thus, the distance from the blade to the throat of the saw is approximately 12 in. The thickness of stock that can be cut is determined by the maximum distance from the upper blade guide to the surface of the table. While the adjustments on most band saws are similar, it is wise to follow the instructions in the pamphlet issued with the machine you purchase.

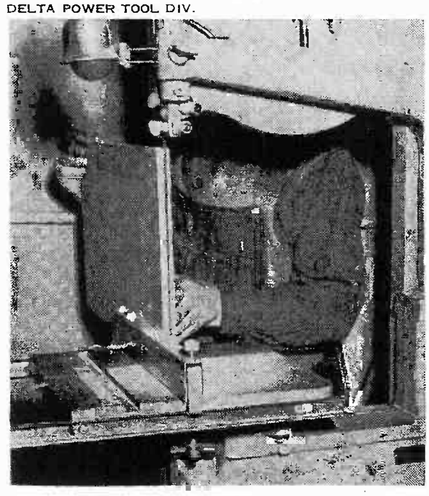
COURTESY ROCKWELL MFG. CO., DELTA POWER TOOL DIV.



Band saw with parts identified. Note that with a few appropriate accessories it can do many table-saw jobs.

The band saw is one of the safest and most dependable tools to operate,

COURTESY ROCKWELL MFG. CO., DELTA POWER TOOL DIV.



Resawing boards is a band-saw specialty.

provided certain basic rules are followed:

1) Learn to determine the correct blade to be used. Always select the widest blade that will saw the sharpest curve in your pattern. Generally speaking, the following table will apply:

Curve Diameter	*Blade*
1/2 in.	1/8 in.
1 in.	3/16 in.
2 in.	1/4 in.
3 in.	3/8 in.

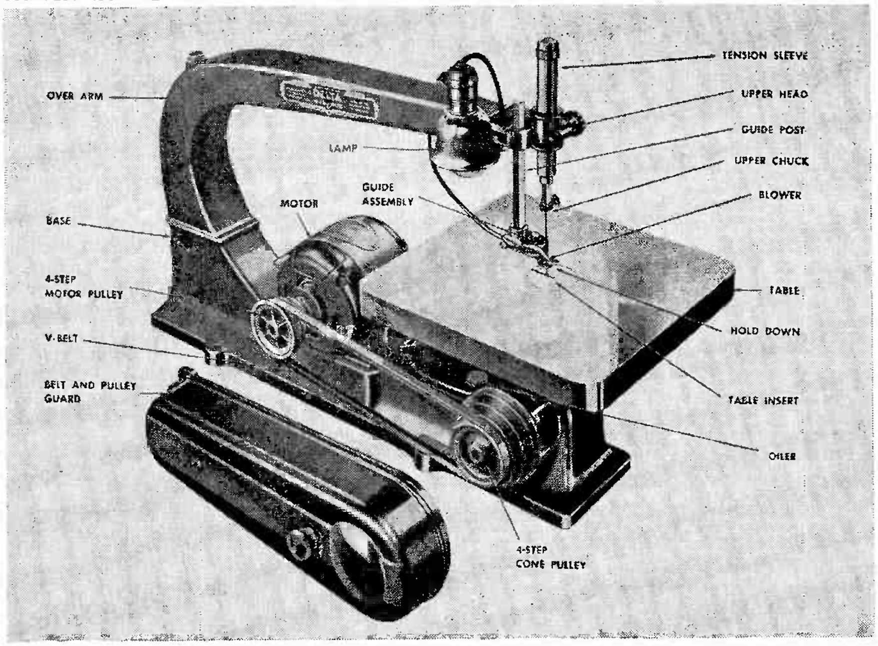
For most straight cutting, a ¼- or ⅜-inch blade is satisfactory.

2) Always check the blade to see that it is square with the top of the table. This can be done by raising the upper blade guide and placing a square against the table top and the blade. If it is not a true 90°, adjust the table until it is.

3) Lower the blade guide until it just clears the surface of the stock to be cut. This protects the operator in the event of blade breakage, and keeps his fingers away from the blade. It also provides a more accurate cut of the stock.

4) Check the layout of your work before cutting. Try to picture how the work will pass through the saw. If it will hit the throat of the saw as it is being cut, reverse the work and start the cut at the opposite end, or turn the

COURTESY ROCKWELL MFG. CO., DELTA POWER TOOL DIV.



Jig saw is slower on heavy stock, better suited to intricate work than band saw.

stock over and draw the cutting line on the opposite side.

5) Try to guide the stock with the left hand and at the same time apply forward pressure with the right hand. In most cases the operator stands facing the edge of the blade and slightly to the left of it.

6) Feed the stock slowly and with even pressure to prevent twisting or jamming the blade.

7) Avoid "backing out". Wherever possible cut through the waste stock when you can no longer continue a cut. If you must back out, draw the work

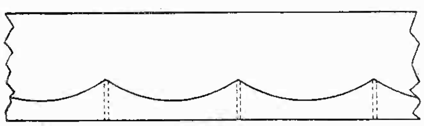


Fig. 1. Cuts to the curve intersections.

very slowly, with the blade following the saw cut. Otherwise, there's danger of the blade being forced off the wheel.

8) Before beginning to cut a pattern of curves, make a number of short, straight cuts through the waste stock (Fig. 1) to the points along the line where the blade would not be able to negotiate a turn. When the curves are finally cut, the waste stock will fall

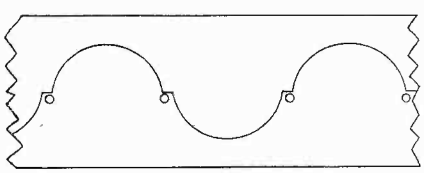


Fig. 2. Holes drilled at sharp corners.

away at these points, and the work can be repositioned for a new start without backing out.

9) Another method is to break up complicated curves by drilling clearance holes in the waste stock at points where the blade could not make a sharp turn, Fig. 2. When the blade reaches the clearance hole, the work can be turned freely to position it for a new start.

10) If the blade pulls to one side, making it necessary to feed the work through at an angle, this is a condition called leading. It can be caused by a slight burr on one side of the blade or a greater set to the teeth on one side of the blade, or the blade guides may be too loose or out of line. The first two conditions can often be corrected by holding a fine abrasive stone lightly against the leading side of the revolving blade. If the lead is too great to be corrected this way, it is necessary to remove the blade and have the teeth reset and resharpened. The last condition can be corrected by adjustment of the guides.

Band-saw tables tilt, permitting bevel cuts up to 45°. Most tables are slotted to permit the use of a miter gauge for greater accuracy. Some saws may even have a ripping fence that is similar to the fence on a circular saw. If one is not available, however, a piece of scrap wood with a straight edge can be clamped to the table and will serve very adequately if it is exactly parallel to the blade. When reducing the thickness of stock (resawing) the ripping fence is used as a guide. If the stock is too wide, the blade may have a tendency to lead. To eliminate this difficulty, first run the stock over the circular saw, putting kerfs on each edge of the wood which will act as a starter course when it is fed through the band saw. Of course, the circular saw makes a wider kerf, Fig. 3. When feeding the stock, hold it firmly against the fence. Avoid

Continued on page 35

SOUND SERVICING

by Irving M. Fried

Loudspeakers, Part 2

Last month I discussed some techniques for improving your present tweeter, so that you can live with it until you can afford a better one. This month the subject will be methods of improving the performance of your present woofer, without consuming unreasonable amounts of time and material.

Just as in the case of the tweeter, that woofer is best which is smoothest. Whatever produces a smoother laboratory response curve will produce easier (if not more impressive) listening for you. It can be shown analytically that speaker irregularities correspond to all sorts of distortions.

This will not be a series of instructions on rebuilding a speaker cone. I don't believe that slitting the surround, or coating it with goo, or putting in a felt, or shaving the spider, actually improves a diaphragm unless you are *very* lucky. Of course, you may want the exercise in cutting and coating, but don't expect that you will improve the driver. I have always found that these tricks result in *higher* over-all distortion, for most speakers are not designed to have a long cone travel; and when you change a speaker's elasticity to lower its resonance, you upset a delicate balance of engineering factors. Indeed, most of the schemes below are intended to *limit* cone travel, by changing the "acoustic environment" of the driver, simply and effectively. If these don't work to your satisfaction, your only hope is a different woofer system that will.

First step, and this is necessary for any commercially manufactured enclosure, is to coat every surface more liberally with sound-absorbent material. For reasons of economy no commercial enclosure ever has enough. In addition, some of the enclosures on the market are deliberately intended to produce the "barrelly" effect of an improperly damped cabinet — an impressive sales device, but a rather irritating kind of bass performance over the long run in the home.

Extra sound-absorbent material on every exposed surface (some authorities recommend that you coat every surface, then put in wood spacers, and then tack on another layer, leaving a dead air space between) tends to kill the middle higher frequencies which come from the back of the cone, thus minimizing the serious phase distortions which result when these frequencies bounce back at the cone or out the apertures. You reduce cancellation effects from front to back, and help to smooth out response peaks and dips in the lower middle range. Try it. At first the sound may be dead by comparison, but then you will realize that individual detail is much more pleasant to listen to. You can, in fact, control the "tone" of the bass, varying it from dead to live, in any degree you prefer, by controlling the amount of padding inserted.

Next step is to stiffen the cabinet walls, in case the above treatment doesn't suffice. Stiffening the walls will improve the bass response by reducing the amount of acoustic energy dissipated in moving the panels, and will smooth the response by minimizing spurious resonances. I have found that a 2 by 4, fitted front to back somewhere near the middle of the front panel so that it is wedged tightly against front and back (then, of course, screwed into place), is effective in reducing panel ring on most cabinets. Similar stiffeners can be used between any two more-or-less parallel surfaces.

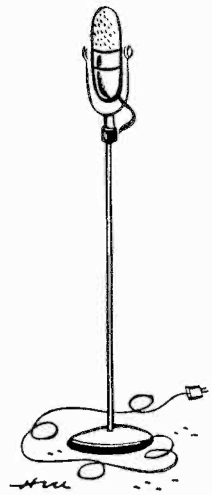
You can also run diagonal braces across vibrating panels, using heavy stock and securely screwing the brace every few inches. You may be amazed at how much extra clean bass you will get by stiffening and bracing. Of course, the ideal method would be Mr. Briggs's famous sand-filled enclosure, but that is another story.

The next series of methods should be used only after you have tried the conventional techniques of stiffening and panel coating. These next methods are more or less empirical, in that you try and adopt whichever one is most convenient, or whichever one does the job properly for you. It may be that a combination of them will work. In every case, the job to be done is to control the Q of the resonance of the entire acoustical system, to keep it from taking off at any frequency. Incidentally, for purposes of this discussion, several speaker systems which ordinarily are not considered resonant can be included. Among these are "horn-type" enclosures which resonate a back air mass, feed through a slit and into a horn; all slit propagators, including those that taper; infinite-baffle boxes and drivers (it can be shown that any direct-radiator system, even the classical speaker in the wall, tends to be resonant — and an "infinite baffle" box is definitely a resonant device). To control the Q of the resonance, you must use some method of introducing acoustic resistance in the system, or of breaking up the system into smaller parts, so that resonances can't build up so easily. Suggested methods are:

1) The Hartley Boffle method — introducing stages of acoustic resistance across the back of the cone.

2) The hanging curtain method — hang a curtain of sound-absorbent material from the top to the bottom of the enclosure, or suspend a layer of felt horizontally across the middle of the enclosure.

3) The resistive port method — hang progressively more dense fabrics across



the port or slit opening, until the bass cleans up to the desired degree.

4) The method developed in the Underwater Sound Laboratories, Harvard University — cut a circular hole in a piece of sound absorbent material, of such size that it will fit over your speaker "pot". Push the piece over the back of the speaker, and staple the edges to the baffle board. Then, cut up absorbent material into 3-inch triangles and throw these pieces into the cabinet until it is fairly full.

The latter method produces rather interesting effects. It stifles the bass resonance of the system, providing greater clarity of bass instruments and response to lower fundamentals (when a resonance is damped, the rate of cutoff below is reduced). Audio enthusiasts will be happy to know that this is a method of achieving the critical damping on a loudspeaker which has been talked about so freely in recent months. They will be more happy to know that, in smoothing out the major bass resonance, they have reduced the attack and decay times of their woofers — which adds up to more natural listening and better music.

$5.00 FOR AUDIO AIDS

We'll pay $5.00 for Audio Aids sent to us by readers and used in the Magazine. See page 29 for details.

TAPE NEWS & VIEWS

by J. Gordon Holt

Preventive Maintenance

I must confess that occasionally I find myself sighing over days gone by, when sound was of such poor quality that a golden ear had no place in the order of things. A listener was always aware that the sounds emitted by his Supreme 18-tube Symphony phonograph (with the Chromium Glottis) bore but a superficial resemblance to those of the New York Philharmonic. But his phonograph was so unashamedly bad that he simply didn't care. Live music and reproduced music were two unrelated audible phenomena, and the idea that one *should* sound like the other was never entertained seriously.

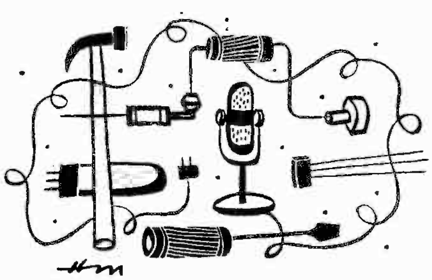
The classic low-fi phonograph of pre-tape-recorder days had one or two outstanding merits, though — not the least of which was that, being so bad to begin with, it concealed from the listener all but the most obvious malfunctions until it finally gave up the ghost and refused to work at all. From the day that one of these beautifully finished, mellow-toned contrivances was brought home from the department store, it could be set in a corner and simply *used*, like a lamp or a doorbell, for anything up to 10 or 20 years before it called attention to itself by failing to work one day.

But then came the quality craze. Fi got higher and higher, frequency range got wider and wider, and distortion got progressively lower so that the extended high end wouldn't tarnish the golden ears. And reproducing equipment was compared with "the real thing".

Along with the quest for perfection there came another parallel demand upon equipment. People who owned perfectionist-type equipment demanded that it work perfectly, and that's where the trouble started. The better the performance a reproducer was *capable* of, the more critical its user was of its performance.

A low-quality tape recorder that hums, flutters, hisses, and distorts slightly when new can limp along for years with a few unstable resistors, noisy tubes, and leaky capacitors. Because the owner doesn't expect much from it anyway he will tolerate these deviations and maybe not even notice them. But someone who pays $1,700 for a professional, two-case, portable recording studio pays for high-quality performance, and he expects to get it or know the reason why! He isn't going to sit back and smile through frying noises and cyclic speed variations with the attitude that, after all, nothing's perfect. His recorder can produce professional results, and is supplied with a half-dozen or so screw-driver adjustments so that it can be trimmed to the *n*th degree, even to matching perfectly the brand of tape being used. As long as those adjustments are there, they should be used by a critical recordist.

On the other hand, as long as they are there, a really critical recordist is likely to spend about a third of his leisure time *checking* his recorder to make sure that none of the screws needs adjusting. This sort of performance quality check is necessary from time to time, and is a good thing as long as it



doesn't become a sort of compulsion like carefully stepping over the seams in the sidewalk.

The point is that every tape recorder needs constant maintenance if it is to work at its best, and the better the recorder, the more care has to be taken to keep it that way. This isn't to say that the best recorders are the least dependable. . . far from it. But they are so good that the slightest deviation from normal operation will show up as diminished quality, so the price of perfection must be eternal vigilance. Professional recording studios check out their tape recorders at least once a week (sometimes once a day in the more critical organizations), and overhaul them at least once a month. Such a servicing schedule would keep the home recordist in a constant frenzy of maintenance campaigns, and would be pointless anyway, since he doesn't use his recorder eight hours a day, seven days a week.

The average home recordist is likely to use his recorder a total of 12 hours a week. A reasonable servicing schedule might be every month or so for a quality recorder and every six months for one of lesser pretensions.

This, by the way, refers to the kind of servicing that might be considered as preventive maintenance, as distinguished from the emergency measures that are called for when a coupling capacitor pops an hour before a Metropolitan Opera broadcast. Emergencies are unavoidable from time to time even in the best-regulated recording studios, but preventive maintenance can help to reduce the number of such unanticipated tragedies.

Apart from tube and component failures (which are about as foreseeable as light-bulb failures), there are a number of periodic checks that will indicate whether a recorder is operating properly and will continue to do so for a while. Besides these performance tests, there are a few simple procedures that should be observed regularly no matter how well the recorder is running.

By far the most important of the routine service procedures is head and transport-mechanism cleaning. Even the best recording tape will tend to leave some of its oxide or its surface lubricant on the recorder heads, tape guides, pinch wheel (if any), and capstan.

If allowed to accumulate unchecked, it will cause poor tape contact with the heads (resulting in loss of high-frequency response and diminishing record level); slippage of the tape on the capstan, with accompanying speed variation; and, perhaps, squealing noises as the tape crosses the heads. In recorders using felt pressure pads to hold the tape against the heads, fouling of these pads is a common cause of an annoying high-pitched squeal.

Accumulations on the tape guides will probably not have any direct effect on quality, but there is always the possibility that a large piece will come loose and get jammed between one of the heads and the tape passing across it.

So, step number one: clean all tape contact surfaces, and clean them fairly often. With certain kinds of tape, particularly the "bargain" tapes sold at very low prices, coating spillage is a really serious problem and occurs fast enough to foul one of the heads within the duration of a half-hour recording. Heads, then, might be cleaned after every four hours of use, at least until the tape being used has proved itself to be better than average in this respect.

Carbon tetrachloride is sometimes recommended as an ideal head and tape-transport cleaner, probably because it does about as quick a cleaning job as any solvent. It should be used with extreme caution, however, partly because it is injurious to certain types of capstan, pinch-wheel, and head-mounting materials, and partly because it is very poisonous. I don't know whether this is fact or fallacy, but I have been told that the effects of repeated doses of inhaled carbon tet are cumulative over a period of time, and will cause headaches, nausea, and general malaise. I haven't tried to prove this myself, but I find that pure alcohol does just as good a cleaning job and has no reputation for inducing illness (not when inhaled, anyway).

Alcohol takes a little more time than carbon tet to remove the glaze that accumulates on a pinch wheel, but it apparently has no ill effect on rubber or resilient plastics. I prefer it despite its higher cost. Pure grain or wood alcohol may (subject to certain state drug or liquor laws) be purchased in a small bottle for about 60 cents at a drug store, and a very small amount will last for dozens of cleaning jobs.

Pinch wheels and tape guides may be wiped clean with a small wad of clean linen or cleansing tissue. But the heads in most recorders are a little less accessible, and will probably require the use of a cotton-tipped "Q-Tip" stick or something similar. Recorders having hopelessly concealed head assemblies may be cleaned with a narrow, foot-long strip of linen dipped in alcohol. This can be dropped into the head slot as if it were a length of tape, and pulled back and forth past the heads a few times. In recorders that have moving heads or pressure pads it may be necessary to move the function switch toward the FORWARD drive position (with the recorder's AC unplugged) to force the strip up against the heads. Then, as the strip is pulled through, it will clean the pressure pads and heads simultaneously.

The second item on the service agenda will depend largely on the quality of the recorder itself. If it is a professional-quality unit with potentially low noise level, the record and playback heads should be demagnetized at least once a month, and preferably once a week. The best means of doing this is with a device designed specifically for this purpose, such as is made by Ampex Corporation, Audio Devices, and Omega. Certain hand-held bulk tape erasers may be used, if the heads are first stripped of their mu-metal shields and the eraser is kept away from db meters with degaussable magnets in them.

If the recorder has a fairly high inherent hiss level, however, head demagnetization assumes less importance; it probably need be done only every three to six months.

Transport cleaning and head demagnetization are maintenance procedures; the rest of the attention devoted at intervals to a recorder involves performance checks to determine whether the unit is performing at its best.

A good recorder should have its head alignment, frequency response, and output level checked at least every six months, preferably every three months. For these tests the recordist should avail himself of a good standard test tape, of a type that matches his recorder's playback characteristic. There seem to be two "standard" playback curves that are used in high-quality tape recorders, one using bass turnover at 3,000 cps (the Ampex curve) and the other using an 1,800-cps turnover (the so-called Dubbings curve). Both the Dubbings Company and Ampex Corporation produce test tapes conforming to their particular playback curves, and each tape is useful only on a recorder whose characteristic it matches. Generally, most home recorders use something fairly close to the Dubbings curve. If in doubt, the Dubbings tape will probably be found to work satisfactorily.

Both these tapes have high-frequency signals recorded on them for checking and adjusting head azimuth alignment, and this should be the first step when checking out a recorder.

Next, a blank tape should be substituted for the test reel and used to run off a frequency test throughout the recorder's rated range, making sure to record this at 15 to 20 db below normal record level.*

If a recorder shows up poorly on its own tapes but comes up to specifications when playing the test tape, the record section is probably at fault. On the other hand, some recorders will never meet their own specifications; for this reason it is a good idea to run a check on a new inexpensive recorder in order to determine just what its characteristics should be.

At this time, the 400-cps standard "zero-db" level on the test tape should also be run through the recorder and a note made somewhere (maybe on the recorder's amplifier chassis) of the volume-control setting which produces a certain output reading on an AC voltmeter connected across the recorder's

Continued on page 39

*Holt, J. Gordon, "Tape News and Views", AUDIOCRAFT, March 1956.

Readers' Forum

Gentlemen:

I should like to add a few comments to those of Joseph Marshall on "Modern Design" (AUDIOCRAFT, March 1956). I have been trying to find an AM-FM tuner to replace an inexpensive communications receiver bought in 1940 and an FM tuner which, while a good one in its day, is 6 or 7 years old and must be considered obsolete.

I looked over the tuners on the dealers' shelves and rejected most of them without a trial, solely on the basis of the modernized frequency scale which has been reduced by designers to useless decoration. An AM tuner without an accurate frequency scale is valueless to me even if it has the most advanced electronic interior. I have to be able to find my station before the electronics can perform. Apparently the designers intend the tuners for use in the few large cities where there is no necessity for listening to out-of-city stations. Under these conditions an accurate frequency scale is not essential. The sensitivity and selectivity of the few tuners tried so far are poor and suitable mostly for local listening. The FM sections were not up to my old tuner.

A surprising number of tuners, even expensive ones, lack any kind of tuning indicator. But they all had the "modern" pancake shape. I have three more tuners to try, one AM with short wave and two AM-FM; and that is all without trying radios made in Europe.

Mr. Marshall urges "manufacturers to keep durability, serviceability, and high performance in mind — indeed, to give them priority. . . ." The servicing of my old AM radio, which consisted of one complete set of tubes in 15 years, indicates that the manufacturers know how to make durable equipment. When the new tuners are less sensitive than the old ones, then the manufacturers

Continued on page 40

ERRATUM

In a letter about his article on a home-built pickup arm (AUDIOCRAFT, May 1956, page 26), J. E. Richardson called our attention to a dimension error given in the mounting instructions (page 40). The stylus should overhang the spindle by 0.48 in., *not* .048 in. This dimension is critical in determining the performance of the arm, and it should be corrected. Sorry!

EDITORIAL

WANT a sun-powered portable radio? You can buy one for $234.95, according to a news release from Admiral Corporation.

This cost breaks down to $59.95 for the radio itself, which is built around six transistors, and $175.00 for the 32-cell sun-operated power supply. The power pack converts sunshine to electrical energy directly. It is quite sensitive, being able to operate well on overcast days; even a high-wattage electric lamp or an infra-red lamp will activate the power supply.

The reason it costs so much is that the principal cell constituent is pure silicon, which sells for about $300 a pound. Silicon in its combined states is among the most plentiful of elements, but it is difficult and costly to refine. We won't even bother to list some of the many applications that inexpensive sun-operated power supplies would have, since they are obvious as well as exciting to contemplate. But they aren't possible without cheap pure silicon or an inexpensive substitute for it. Metallurgists, here's your chance to become wealthy while serving mankind.

Oh, yes. If you don't want to buy the Sun Power Pak you can operate the transistor radio for 800 hours or so with a half-dozen flashlight batteries, at something less than a dollar.

THIS month we inaugurate a new department: *Sound-Fanciers' Guide*, by R. D. Darrell. It will contain reviews of new disc and tape recordings of standard works that are particularly outstanding in technical quality; comments on recordings that are off the beaten path in subject matter; complete information on "sampler" selections; and evaluations of test and demonstration discs and tapes. Mr. Darrell's approach will differ from that of conventional reviewers in at least three ways:

1) *Emphasis*. Most reviewers either ignore technical quality altogether or, at best, give it brief mention. In a surprising number of cases the few comments that are given are unreliable, because the reviewer has a hopelessly inadequate or second-rate sound system. Mr. Darrell's playing equipment is among the finest available; moreover, he has the experience and technical knowledge necessary for dependable evaluations of recording quality. And, as one of the first record reviewers to achieve prominence in this country, his opinions on performance — musical interpretations and technique — are also authoritative. They will be given when they are appropriate to the review, of course; but they will not make up the entire review.

2) *Selectivity*. There will be no attempt to review all recorded discs and tapes, or even most of them. The main criterion is to be exceptional sound or unusual subject; that which might excite the interest of the sound fancier, whether or not this interest is subservient to a love of good music. Test records and show-off pieces will be reviewed — great performances, not necessarily.

3) *Informality*. In keeping with the subject matter, the style will be informal and light. Among other advantages this will permit grouping of reviews that logically belong together, rather than the alphabetical listing by composer that is necessary to preserve order in more ambitious review sections.

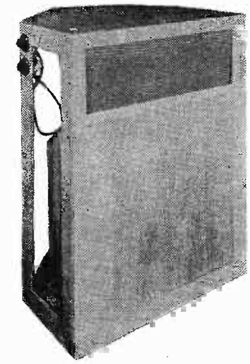
Mr. Darrell was unable to set up a stereo tape playback system in time for this month's column, but has assured us that he will begin stereo reviews in the next issue. Readers' comments will be welcome, favorable or not. "Sound-Fanciers' Guide" is intended to be of maximum utility to readers by offering an approach not found anywhere else. If it is useful to you, or if not, please let us know.

NOT long ago we received a courteous but severe letter chiding us for confusing electron flow with current. Our correspondent admitted that electrons, in circuits external to primary voltage sources, travel toward the more positive potential — from cathode to plate of a vacuum tube, for instance. But he insisted that current was in the opposite direction.

During the early days of electrical studies it was assumed that current issued from the positive terminal of a source and returned to the negative terminal. Textbooks were written that way, and college students were taught that way. When it was demonstrated that electricity conducted in external circuits was electron flow, and that electrons are negatively charged and *must* be attracted toward a positive potential, there was a surprising degree of resistance to changing the original concept. There still is.

We were taught to regard electron flow and current as the same thing, however, and upon inquiry find that most schools now follow this more sensible practice. So, with apologies to the old-timers, AUDIOCRAFT will continue to assume that current direction is the same as electron flow. — R. A.

Electro-Voice Centurion Kit



An AUDIOCRAFT *kit report*

MANUFACTURERS of hi-fi component cabinets have, for several years, offered unfinished versions of loudspeaker enclosures; some have marketed kits for home construction and finishing. These have been the simplest types of enclosure. If something more elaborate was desired, it was necessary either to pay full price for the commercial version or to build it from plans, which required a great amount of woodworking experience and a well-equipped home workshop.

With the growing "kit" boom, though, it was inevitable that speaker system kits would be made available by the major manufacturers. Electro-Voice, for instance, now sells knock-down enclosure kits for just about everything in its commercial line, from the diminutive Baronet to the awesome Patrician. Complete step-by-step instructions are furnished, together with all necessary parts, at a price very much less than that of the finished enclosure. Packages of driver components identical to those used in the ready-built versions are available; or, if the builder has some of these or equivalent drivers already on hand, he can buy the rest individually. With a good screw driver and some spare time, then, even a novice can have the speaker system of his choice at a substantial saving.

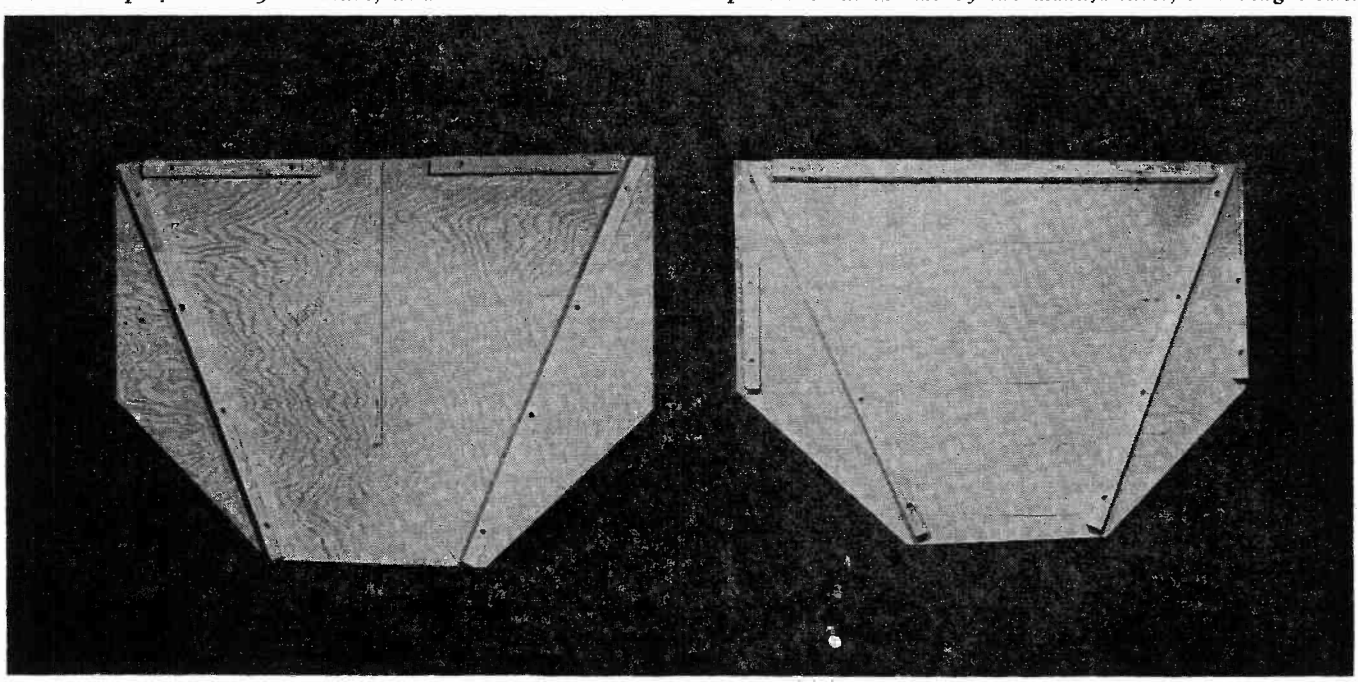
To determine if that last statement were true in practice as well as in theory, we assigned the job of building a Centurion kit (KD3) to a staff member who was inexplicably proud of the fact that he didn't know a Phillips head from a dado head. He did very well, to his surprise. The notes in the next section are his; they indicate steps in the construction where he could have gone wrong (or did go wrong!). His comments may be helpful to anyone else with a similar lack of woodworking experience.

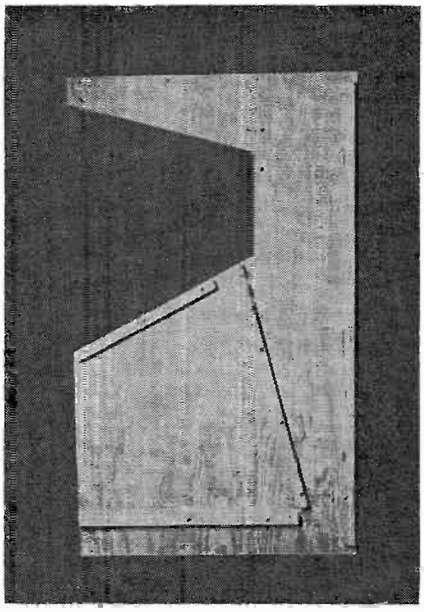
The bass section of the Centurion utilizes a 15-inch Klipsch-type driver. This is sealed in a relatively small cavity that produces, on the back of the cone, a stiffness to cancel the reactance at very low frequencies of the horn which loads the front of the cone. Mounted facing downward in the cavity, the speaker drives a single-path horn that begins in the bottom of the enclosure, expands upward between the front panel of the enclosure and the front wall of the cavity, then toward the back and out into the corner. The room corner completes the horn flare. This is a simpler structure by far than the twin-path horn used in the Georgian and Patrician systems; the compromise in performance because of the simplification is surprisingly slight.

Taking over above 300 cps is one of Electro-Voice's CDP middle-range coaxial driver and horn assemblies. This is positioned behind the grille cloth in the top of the enclosure. The range above 3,500 cps is handled by a Super-Sonax very-high-frequency driver and horn, which is mounted beside the middle-range system. Since the CDP voice coil drives two individual horns — one short straight one for higher middle frequencies, and another larger folded one for lower middle frequencies — the Centurion can be considered a four-way system. Individual level controls are furnished for the middle-range and high-frequency drivers.

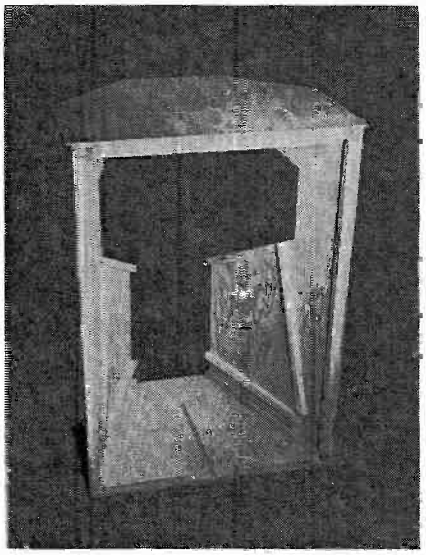
Price of the basic KD3 enclosure kit is $87.00. The decorative trim kit (AK4) is $9.00; a finishing kit (Walnut, Cordovan Mahogany, Fruitwood, Cherry, Golden Oak, or Ebony) is available at $5.00. In Mahogany finish the ready-built enclosure alone costs $168.00; in Limed Oak, $178.00. The

Base and top of the KD3 enclosure, with cleats attached. All wood parts are cut to size by the manufacturer, including cleats.

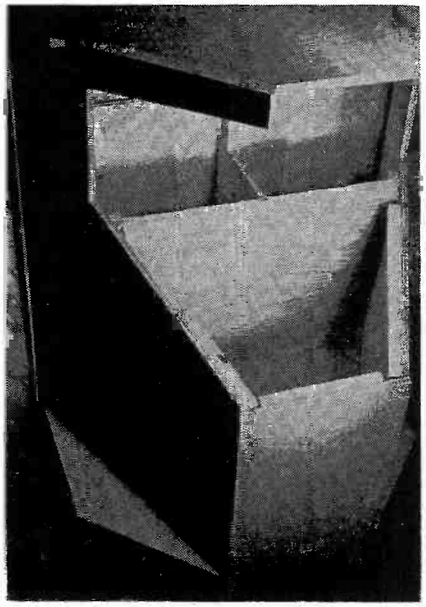




One of the two side-pieces of bass horn.



The first step in assembling major parts.



Speaker faces downward inside the trapezoidal cavity, which has sealed cover.

maximum saving you can make building the Centurion kit is, accordingly, $91.00, and the minimum saving is $67.00. Neither figure is negligible, by any means — particularly when you consider that it takes less than a week of spare time to do it. And there is no small reward in being able thereafter to admit to having made it yourself.

Electro-Voice has a de luxe line of drivers and a second or "B" line that is much less expensive. It is claimed that frequency responses of the two types are identical. The B line has somewhat lighter magnets and is, therefore, about 3 db less efficient. Its power handling ability is not as great, and its damping less efficacious. B drivers for the Centurion, with three-way crossover network, level controls, and cabling (the model 117 driver component package) costs $145.00. The model 105 package, incorporating the de luxe drivers, costs $217.00. It is obviously possible to assemble a complete Centurion for as little as $232.00, or $304.00 with the finest drivers.

Construction Notes

Although you can get along without one, it is suggested that you equip yourself with a good long-handled spiral-ratchet screw driver (such as the Yankee 130A). Be sure to get Phillips-head bits, too. In lieu of this it is absolutely necessary that you have a good long-handled Phillips screw driver. And, though it isn't mentioned until later in the instructions, you will also need a small amount of flat black paint and a brush. It would be well to check the kit parts against the white-on-black plans to be sure that all are present in the indicated quantity (ours were).

The following comments apply to assembly steps listed in the instruction book. We have been informed by Electro-Voice that many of these points are now covered in a mimeographed addendum to the instruction book.

Step 1. Don't waste time looking for long screws to affix the legs to piece 1. The screw holes in the legs are sufficiently countersunk so that you can use the 1-inch screws that are provided in great quantity. Be sure to save all the brass screws until the end; they will be used where they are visible externally.

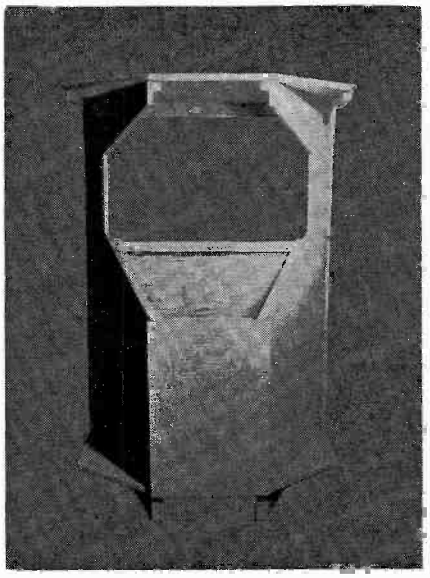
Step 2. On pieces number 4 be sure that the countersunk ends of the diagonal holes are positioned inside. There should be two cleats (pieces 7) on the bottom of piece 1. They are not shown in any of the instruction-book illustrations, but are mentioned in the text under Step 3. . . . This is as good a time as any to suggest that you straighten out all the warps in the cleats as you go along. It's too late after you glue them.

Step 3. Ignore the details of construction as shown in the photo accompanying step 3 in the instruction book. Here, as in other photos, there have been changes in the kit since the pictures were taken. On top of piece 5 mount battens number 7 flush to the rabbeted edges.

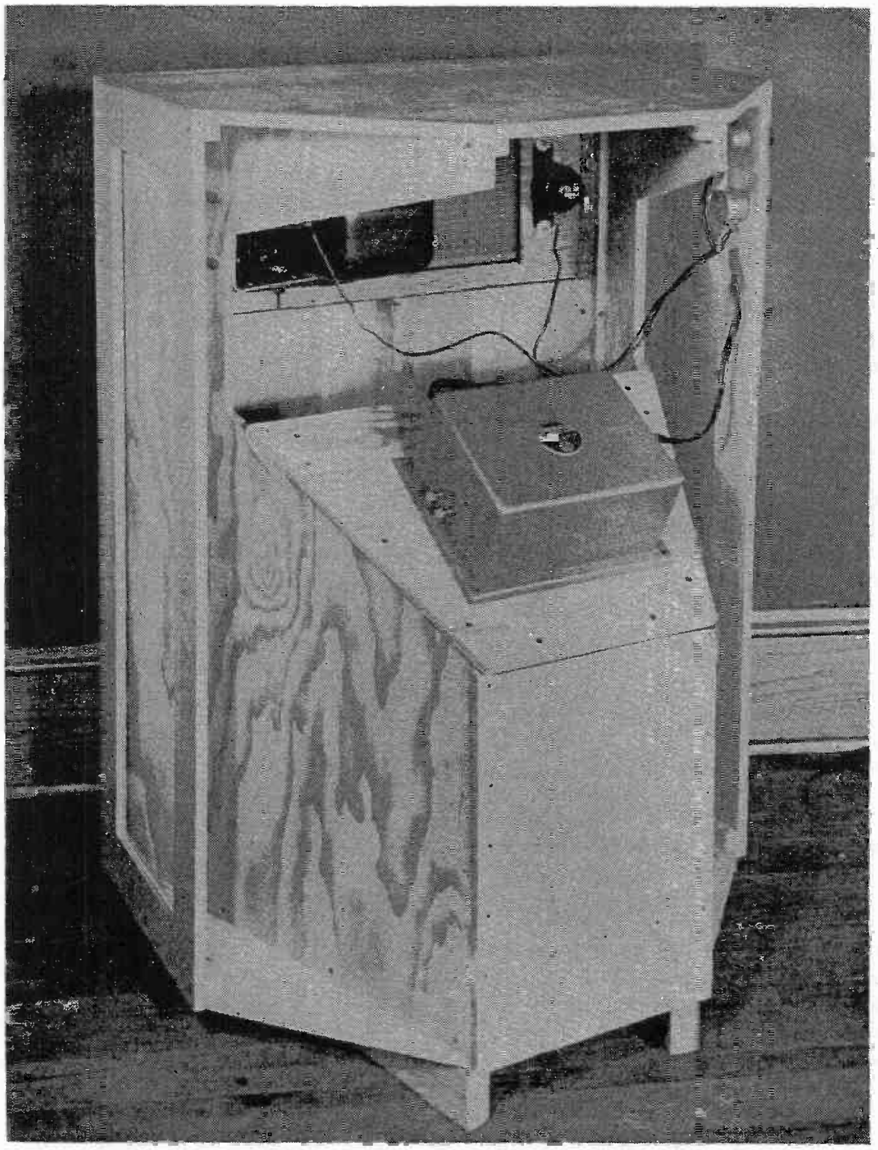
View is down into the cavity; the woofer drives horn through this throat opening.

Step 4. Position battens number 10 one inch down from the tops on pieces 32 and 9, with their angled sides down and narrow edges toward the rear. Screws are driven into these battens through panels 9 and 32, from the outside.

Step 7. To drive difficult screws through battens number 10 into framing pieces number 15, lay the assembly face downward on the floor. Be sure to pad the floor first to avoid scratching the frame pieces, which are to be finished later. Glue the top frame piece (14) first. *Do not glue* the side frame members (pieces 15) and bottom member (another piece 14) until the whole front frame has been screwed into place for a trial fitting. The alignment is a bit tricky, and plays an important part in the final appearance of this enclosure. While you are doing this trial fitting, hold the two grille panels (pieces 27) in place to check further the frame-piece orientations. . . . When you begin pulling frame pieces 15 into place with their screws, you will probably appreciate the ratchet screw driver suggestion. Temporary removal of the still-loose batten 13 will make the job easier.



Horn path is complete except for front.



Kit completed except for grille cloth on wings. Note tweeter on front grille panel.

Step 9. It is strongly suggested that you *not* glue cleats number 19 in place before you install speaker mounting board 18. Simply screw them in place; glue them later when you install panel 20. When piece 18 is pulled all the way to the rear, just before you glue and screw it into place, be sure that it projects an equal amount at each end. This will guarantee a good fit when back piece 25 is finally glued and nailed into position. Again, follow the instructions — not the instruction book's illustrations. You can waste a lot of time trying to make your work come out looking like some of those pictures. Design changes and improvements are obviously the reasons for the differences.

Step 10. The installation of panel 20 was the source of greatest difficulty. If the advice given above (don't glue cleats 19 in place) had been available, this job would have been easier. (Incidentally, the screw holes on panel 20 were countersunk on the wrong side. Be on the lookout for this possibility.) After you're sure panel 20 fits to your satisfaction, mark plainly on piece 18 the optimum positions for cleats 19. Then remove panel 20, and rescrew and glue the two cleats to the places you have marked. The final position of panel 20 should be no farther down than necessary to make a tight fit with the front edge of piece 18. Ideally, you should end up with the top edge of panel 20 at exactly the same level as the edges of panels 32 and 9. This makes for a tighter joint when you come to attach cover piece 26. Quite a few important joints (the more airtight, the better) come together when you fasten down panel 20 permanently and finally. *Be sure* you have smeared glue on all edges of panel 20 that join other pieces of wood, before you start working with your screw driver. Don't worry about the excess dripping inside the cabinet. It can be removed easily later with a damp rag. A product known as "Miracle Tub Caulk" was used afterward to make a good airtight seal around the inner edges of panel 20 where it contacted cleats and sides. It worked very well indeed, and insured tight joints where they were acoustic necessities. Another point: if you put in spacer panel 22 while you are affixing panel 20, it will help hold things more or less in place.

Step 11. When spacer 22 is permanently installed it sits firmly on piece 17. Tap spacer 22 into place with a hammer, if necessary. Use plenty of glue all around.

Step 12. Be sure to install the rubber-like gasket (cutting all pieces to exact size; no extra is furnished) before

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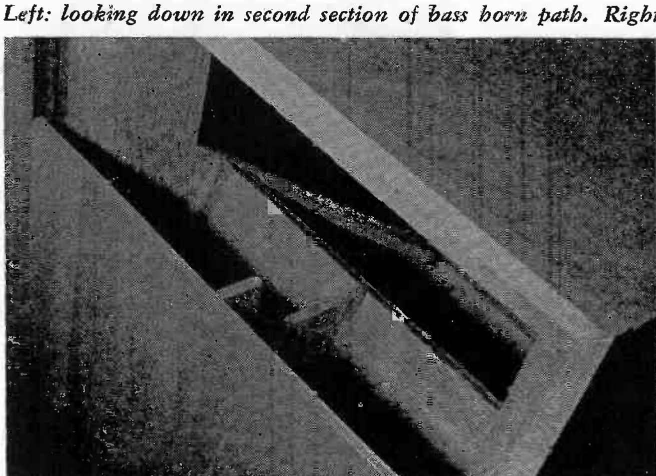
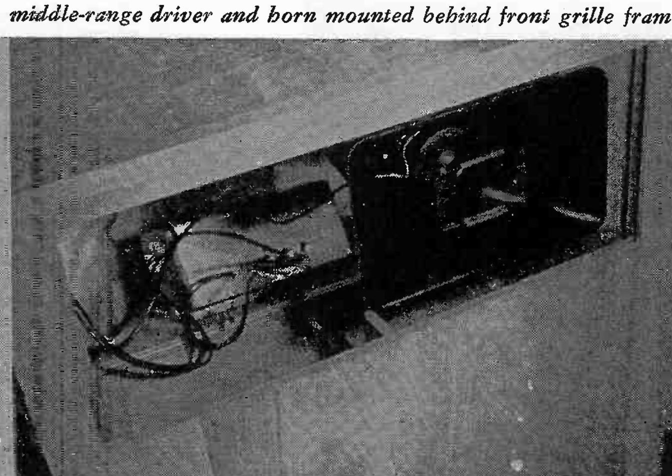
Left: looking down in second section of bass horn path. Right: middle-range driver and horn mounted behind front grille frame.





Designing Your Own Amplifier

by Norman H. Crowhurst

Part IVa: Push-Pull Power Stages

THE reasons for using tubes in push-pull for the output stage of an amplifier are two: 1) to reduce distortion, and 2) to increase the available power output for a given tube. Push-

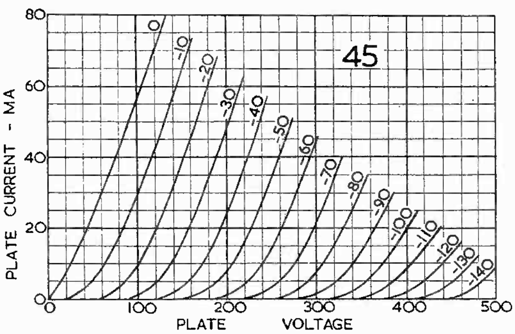


Fig. 1. Characteristic curves for a 45 tube, which are used as a basis for the discussion of push-pull output stages.

pull operation was first adopted to get more output from triode tubes. Then, since greater improvement could be achieved with pentodes — they have a higher efficiency to start with — it was applied to them and, still later, to beam tetrode tubes. To this day, however, there are good reasons why some designers prefer triode tubes.

Fig. 1 shows the published tube characteristics for a type 45 triode as a single tube. Using its maximum operating plate voltage of 275, we can just get 2 watts output in Class-A operation. If two such tubes were operated under the same conditions, but in push-pull, we should obviously get twice as much output (4 watts), but with considerably less distortion, because the second-harmonic components would cancel. By changing the operating conditions we can push the 4 watts up to about 5.5 watts. Further, by working the tube into the positive-grid region, the same arrangement is capable of giving as much as 18 watts output, still using only a plate supply voltage of 275. But, when the grids are driven positive, a power drive stage is needed, and we shall come to that later. Let's take a look at the available data and see how this comes about. Fig. 2 shows the same curves drawn twice, with one set inverted so that 275 volts comes on the same vertical line, right through the combined graphs. First we must justify and explain this construction.

As the tubes are operating in push-pull, the coupling provided by the output transformer (see Fig. 3) acts in such a way that, when the plate voltage on tube No. 1 swings down by, say, 75 volts, so as to be 200 on this tube, it will swing up on the other tube, represented by the lower half of Fig. 2, so

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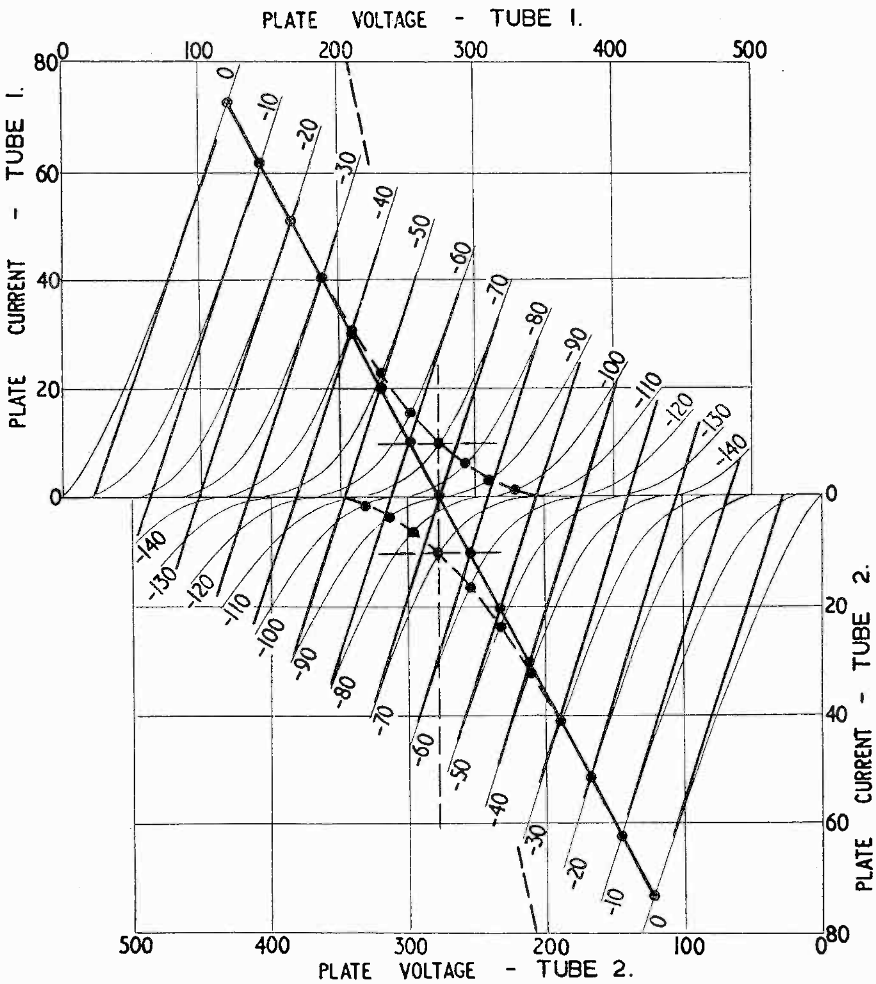

Fig. 2. How two copies of the curves in Fig. 1 are put together to make composite characteristics. Dashed lines near the center indicate the operating points for the two tubes, with 70 volts grid bias. Light curves are those of individual tubes, and straight lines joining them are the composite characteristics. Solid line crossing these composites is the composite load line, while the dashed curves show the component of this load presented to each tube. Short pieces of dashed line at the top and bottom indicate the optimum load (not drawn in full, to avoid confusion).

FM *antenna systems*

by L. F. B. CARINI

THE FM tuner of today has a high degree of sensitivity. Under normal conditions, quite satisfactory reception is obtained with a simple folded dipole antenna, Fig. 1. This antenna may be a flexible length of flat ribbon wire (as supplied with a tuner) or, for outdoor use, it may be built of rigid tubing not

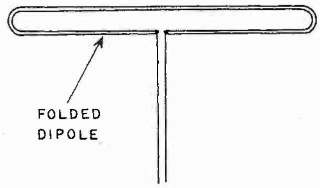

Fig. 1.

unlike some TV antennas. Of the two, the roof-top antenna usually affords the best reception. Since it is generally erected at a high elevation for unobstructed clearance, it is at a considerable distance from the tuner, and a suitable connection to the tuner is important. The antenna, interconnecting wire or transmission line, and all incidental accessories related to such an installation, are collectively known as the *antenna system*. This plays an important role in the over-all performance of the FM tuner.

Balanced or Unbalanced?

Antenna systems can be grouped in two distinct classifications, determined by their basic electrical operating characteristics. Most common is the balanced system in which neither side of the line is grounded. The characteristic impedance is usually 300 ohms; this corresponds to the nominal value of most antennas and is the standard input impedance of practically all FM tuners. The balanced antenna system is the least expensive to employ, from the standpoints of both antenna installation and tuner manufacture.

The alternate, or unbalanced system, has an impedance of 72 ohms. It utilizes a coaxial cable for interconnection between the antenna and tuner. Some tuners are equipped with separate inputs for the selective use of either 72- or 300-ohm systems. The distinguishing characteristic of the two systems is the electrical operation of the antenna and its closely-associated transmission line. Also, the physical appearances of these lines differ materially. In the balanced system, there is a pair of parallel wires equidistantly spaced and contained within an insulating ribbon of polyethylene. Each wire is terminated in equal load circuits, being the electrical pathways from the antenna output to the tuner input. Fig. 2 shows the common types of lines.

In the unbalanced system, the transmission line is a coaxial (concentric) cable consisting of a center wire at the core that is insulated from a metallic sheath woven around it. The center wire and the inside surface of the metal sheath comprise the two conductive circuits of this line. By grounding the sheath, the inside wire may be electrically isolated from all exterior electrical fields, thereby preventing pickup of noise and interference. Because of the close proximity of the wire to the shield, a coaxial cable, such as type RG-59/U, has a comparatively high insertion loss or signal attenuation (3.8 db per 100 ft.) which is caused by the high inherent capacity between the two conductors. This loss is an important factor that must be reckoned with whenever coaxial

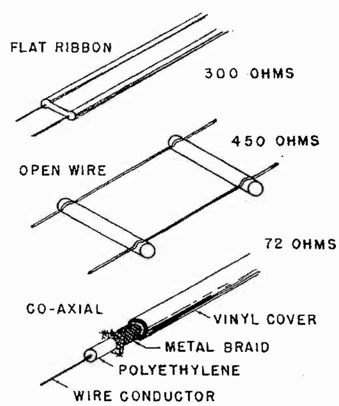

Fig. 2. Appearance of transmission lines.

lines are contemplated. It also explains why the system operates best with lines whose length is not in excess of 100 ft. It is well to note here that the cable loss in 100 ft. is about equal to the gain of a conical-type antenna. For that reason a much higher-gain antenna should be used, in order that the signal to the tuner may be considerably more than that otherwise obtained with just a folded dipole.

Impedance Matching

Just as a speaker and audio amplifier must be properly matched for corresponding impedances at 4, 8, or 16 ohms, the antenna system likewise requires the same careful attention if the maximum signal strength is to be delivered to the FM tuner. A system is said to be matched when there are no reflections of RF energy at either end of the line; that is, when no "standing waves" are set up on the line. Any disparity in impedance between the antenna and transmission line, or the tuner and the line, will create a mismatch which prevents delivery of maximum signal energy from the antenna to the tuner. In fringe areas, this may mean the difference between a good signal for enjoyable listening or no signal at all.

In order to preserve or establish proper impedance relationships among the various constituents of the system, one of two practices should always be observed to be certain that optimum results will be obtained:

1) Use an antenna, line, and tuner all having the same impedance.

2) Employ low-loss matching transformers wherever required to effect the proper impedance coupling.

The former procedure is, of course, the simplest to follow: one merely makes sure that all constituents have the same 300- or 72-ohm values. When any 300-ohm component is to be used with a 72-ohm unit, a proper match must be established between the two since they are fundamentally incompatible. A matching transformer, known as a *balun*, should always be employed to effect the proper electrical coupling between components with different impedances.

Use of the Balun

The word balun is coined from BALanced and UNbalanced; the purpose of such a device is to interconnect, with maximum efficiency, these two types of lines. Essentially, the action of the balun may be accomplished in many

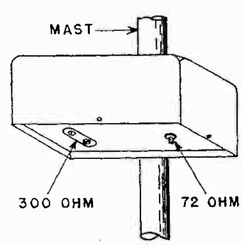

Fig. 3. Balun to match line impedances.

ways, and the device may be composed of inductance coils, parallel metal tubes, tapered lines, or an electrical network composed of capacitors, inductances, and resistors. An efficient balun is that shown in Fig. 3.

Since most FM antennas are designed for a standard 300-ohm impedance, the accompanying illustrations depict how the balun may be used in order to obtain correct matching of impedances in various types of tuner installations. Fig. 4 is the straightforward 300-ohm system throughout. Next, in Fig. 5, a balun is employed to effect a step-down transformation from the 300-ohm antenna to the 72-ohm coaxial line. Note that here the tuner has a 72-ohm input circuit and accepts the coaxial cable by direct coupling to a suitable chassis fitting. In Fig. 6 both antenna and tuner are of standard 300-ohm impedance; however, a 72-ohm line is used with the aid of two baluns.

Baluns afford an easy and efficient means of converting from standard 300-ohm circuits to 72-ohm systems (or vice versa) where conditions of reception indicate that some improvement might be obtained by using a shielded transmission line.

FM Sensitivity Ratings

Most high-fidelity enthusiasts are interested in the manufacturer's specifications for a particular tuner; sensitivity is, indeed, an important factor in a tuner's ability to furnish good reception. The usual rating for sensitivity is so many microvolts for so many db of quieting. It follows, then, that the lower the microvolt value, and the higher the db of quieting obtained for that input, the better is the tuner's ability to make use of weak signals likely to be. This is particularly important for fringe-area listeners.

It is common, though, to misinterpret these specifications for tuners having both 72-and 300-ohm input circuits. The 72-ohm input always has a 2-to-1 advantage over the 300-ohm input; if the former requires 5 μv, the latter will require 10 μv for the same amount of quieting. But this is misleading. Recalling what has already been said about the unbalanced system, and assuming that proper impedance matching is maintained throughout, *a 72-ohm system will deliver only half as much signal voltage to the tuner* as the 300-ohm circuit, for the same type of antenna. Accordingly, because of inherent electrical limitations, there is actually very little difference (as far as usable sensitivity is concerned) in the relative signal strength obtained, whether the tuner receives its signal

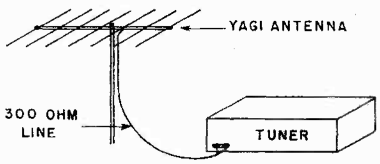

Fig. 4. A normal FM line installation.

from a 72- or 300-ohm antenna system. Despite these reservations, however, the 72-ohm system has decided advantages.

72 vs. 300 Ohms

The principle merits of the 300-ohm balanced antenna system include negligible insertion loss, ease of installation, and low cost. When properly installed, this system will satisfy the requirements of most listeners for normal FM reception.

The important factors of a good installation are the proper choice of antenna and transmission line, and the manner of transporting it from antenna to tuner. Since 300-ohm line is not shielded, it is susceptible to noise pickup in any length of line having a horizontal traverse. Noise induction is kept at a minimum only if the transmission line is run vertically, with little horizontal traverse. To preserve its low insertion loss, it should *not* be run in close proximity to, or parallel with, any metal gutter, beam, pipe, or electrical conduit.

In cities and other locations where the listener experiences considerable annoyance from electrical interference and noise, the 72-ohm system is recom-

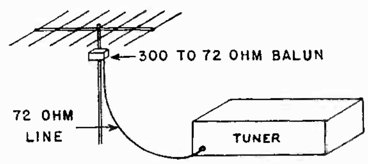

Fig. 5. Coaxial line with 72-ohm tuner.

mended. Its effectiveness in this matter depends upon several factors, including the location and type of antenna, and the extent of shielding in the tuner. Obviously, an FM tuner that is inadequately shielded cannot be expected to exclude interference; while the shielded line cannot pick up any noise, it is still possible for a vulnerable chassis to absorb noise by inductive infiltration.

A well-designed tuner with complete shielding will, therefore, benefit most from use of a 72-ohm system. Only the antenna itself will then act in signal interception. If it is well located and of good design, having a sharp forward-response pattern and confined vertical pickup, maximum suppression of noise should be realized since most noise originates at or near ground level. In apartments, the shielded line effectively excludes interference radiated by motors and other apparatus known to create such disturbances. Sometimes, though, noise must be attacked at its origin, such as that radiated by utility power lines. All these matters must be weighed in estimating the effectiveness and wisdom of installing the 72-ohm system in difficult locations.

Other Impedances

For many listeners dependent on long-distance reception of FM stations, it is essential that every microvolt of the intercepted signal be conserved for low-loss delivery to the tuner. Here, more than anywhere else, a good high-gain antenna, frequently in the form of a

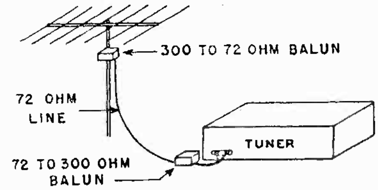

Fig. 6. Balun used at each end of line.

stacked array, together with a carefully installed antenna system, may make the difference between usable signals or a weak signal with so much background noise that it is distracting.

Open-wire transmission line has the least insertion loss of all systems in use. Consequently it is recommended for use in extreme fringe-area installations, and whenever very long transmission lines must be used.

Of the several common types of open-wire lines, the 450-ohm version with spacing of approximately 1 in. is most widely employed. Its alternate, the 600-ohm line, is similar except that it has wires spaced 2 in. apart, and is usually preferred where it is necessary to run a line for as much as a mile.

Open-wire line finds its greatest application in hilly or mountainous terrain where the antenna must be erected at a substantially higher elevation than the tuner, which may be located several thousand feet away in the valley below. Tapering the line at its terminal points, or the use of special matching transformers, is necessary to maintain proper impedance matches between the line and the remote constituents of the system. It should be noted that open-wire line is available also with standard 300-ohm spacing (approximately 5/16 in.), and it is recommended highly for FM installations requiring from 100 to 750 ft. of transmission line. It is also unexcelled for very low-loss signal conduction in fringe areas and coastal locations subject to saline deposits. Further, it requires no balun for proper matching. Special all-plastic retainers are utilized for supporting the line while in suspension.

Comparative Tests

I have made laboratory tests for the purpose of studying the relative performance results obtained with a standard make of FM tuner using both the 72- and 300-ohm antenna systems. Conditions for the test included the following:

1) FM tuner: standard production type having separate inputs for 72 and 300 ohms, with sensitivity ratings of 1.5 μv and 3.0 μv respectively. Totally shielded chassis. AFC disabled.

2) FM antenna: standard multi-element double-driven broadband Yagi,

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MINIATURE SIGNAL INJECTOR by RUFUS P. TURNER

TROUBLE shooting by means of signal injection is a useful technique that is well known to audio experimenters and servicemen. An audio oscillator usually is employed for this job, but in some instances it proves large and cumbersome or inconvenient. Since only one frequency actually is needed for signal-injection testing, the use of a variable-frequency oscillator or generator also seems wasteful. There would seem to be many applications for a miniature single-frequency oscillator that might be held in the hand, and which would need no connection to the power line.

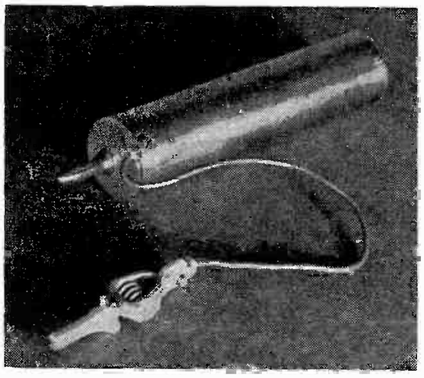


Fig. 1. External appearance of injector.

The instrument described in this article has been designed to meet that need. It is as small as a flashlight and as simple to use. Basically, it is a transistorized 1,000-cps oscillator built into a probe, and powered by a single 1½-volt self-contained penlight cell. A push-button switch at the back end of the probe enables the user to start and stop the oscillator at will.

The injector is housed in a metal can 1¼ in. in diameter and 5 in. long. Fig. 1 shows the completed instrument. A prod is attached to one of the insulated end-discs of the can. The prod shown in Fig. 1 is a standard banana plug, but other types, such as pointed metal tips, may be used. Touching this prod to an appropriate point in a circuit under test transmits the injector signal into the circuit. When checking very sensitive circuits, it is sufficient to *point* this prod at the circuit junction! The injector return circuit and the metal shell of the probe are connected to a crocodile clip which is fastened to the chassis or other ground point of the device under test. The probe then is free to be moved around among the various appropriate test points in the circuit.

Injector Design

Fig. 2 is the complete schematic diagram of the injector. A tickler-feedback oscillator is employed, with a miniature transistor interstage transformer, T, providing the feedback coupling. In this circuit, a Sylvania 2N34 transistor is connected in the common-base configuration. (This arrangement is known also as *grounded base.*)

The oscillation frequency is approximately 1,000 cps. This will vary slightly in one direction or the other with individual transformers, but the actual frequency value is unimportant. The wave form is basically a square wave with slightly rounded edges.

This circuit is a vigorous oscillator and a fast starter. The open-circuit signal output voltage is 1 volt peak-to-peak into an impedance of 39 K. With an external load as severe as 1,000 ohms, the signal voltage is still at least 50 millivolts peak-to-peak, enough for most amplifier testing.

DC battery drain is 8 microamperes, which means that very long life may be expected for the small penlight cell used.

Construction

The transistor, transformer, resistor, and cell are mounted on a strip of thin Bakelite or fiber, 3¼ in. long and ¾ in. wide. The transformer is attached to the strip with Duco cement and its leads passed through small holes drilled through the strip. A loop of wire passed through two similar holes secures the battery. Pigtails of the resistor and transistor are passed through additional holes. Most of the circuit connections are made by soldering the leads under the strip.

The push-button switch, S, is mounted in the rear end-disc and is connected by two leads to battery B and resistor R. Coupling capacitor C2 is connected directly from the top of resistor R (by soldering to the proper pigtail) to the prod mounted in the front end-disc. Tuning capacitor C1, mounted on the other side of the strip, is connected from the junction of the 2N34 emitter pigtail and the yellow lead of T, to the ground lug by which the alligator clip lead is anchored.

The construction is shown in Fig. 3 and drawn pictorially in Fig. 4. After the parts are mounted on the strip and wired, this assembly is wrapped with insulating tape to prevent grounding on the metal shell of the probe.

Transformer connections must be phased correctly or the circuit will not

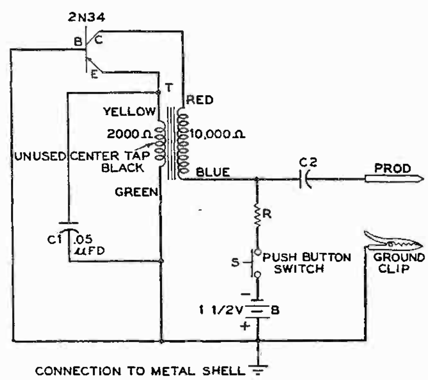
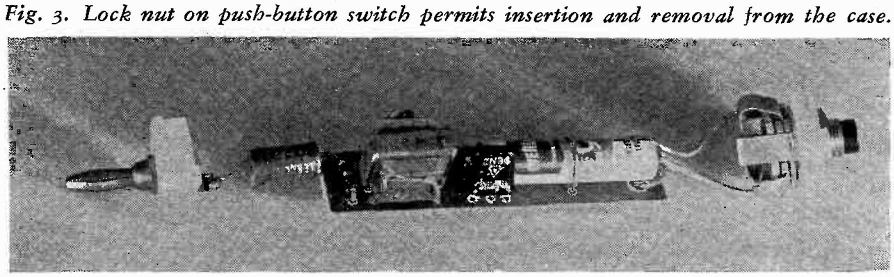


Fig. 2. Circuit arrangement is simple.

oscillate. If the transformer specified in the parts list is used, correct phasing will be obtained simply by following the color coding shown in Figs. 2 and 4. If another type of transformer (which must have the same 10-K to 2-K impedance rating) is employed and oscillation does not occur, reverse *either* the primary or secondary connections.

Care must be exercised when solder-

Fig. 3. Lock nut on push-button switch permits insertion and removal from the case.



ing the transistor pigtails to prevent heat damage to the transistor. A simple method is to grip the pigtail with pliers while soldering it, continuing to hold it afterward until there is no doubt whatever that it has cooled completely.

The metal shell was cut from nickel-plated brass stock, and the end-discs were turned from Lucite. Other more readily available materials might be used on which, perhaps, no extensive work need be done. For example, the shell might be the can of a discarded electrolytic capacitor. It also might be a flashlight barrel (whereupon one also gets a push-button or slide switch into the bargain). Some builders might be satisfied with a slender rectangular can or box.

Parts List

B — Small penlight cell (1½ v). Eveready No. 912 or equivalent.

C1 — Miniature .05-μfd 200-v metallized paper capacitor.

C2 — Miniature 0.1-μfd 200-v metallized paper capacitor.

R — 100,000-Ω ¼-w composition resistor.

S — Miniature push-button switch (single-pole, single-throw non-locking). Switchcraft 101-L or equivalent.

T — Miniature transistor interstage transformer: 10,000-Ω primary, 2,000-Ω secondary. Argonne AR-109 (Lafayette Radio, New York 13).

2N34 — PNP junction transistor. Sylvania.

AUDIOCRAFT Test Results

This is a device for which it took more time to procure and prepare parts than to assemble them and wire the circuit! We used the shell of an old electrolytic capacitor for the body of the chassis, as Mr. Turner suggested, cutting off and smoothing both ends with a file. Sheet Lucite, about 3/16 in. thick, was used both for end discs and for the rectangular parts-mounting strip. We found that it was possible to pass the mounting flanges of the transformer, bent vertically, through slits cut in the mounting strip and then twist them to secure the transformer firmly in place. Perhaps cement would have done just as good a job, but we felt more comfortable about the improvised twist-lock mounting.

A word of caution: be extremely careful when drilling Lucite, and in tapping screw holes in the end discs if you elect to do so. The material seems quite workable with tools but may be treacherous; it is surprisingly easy to break a tap, or shatter the Lucite. It is safer to make the end discs force-fit into the can. When drilling the required holes in the mounting strip take it slowly and easily — a hand drill is best.

Output voltage, frequency, and wave form are all dependent on the load impedance in greater or lesser degree. The frequency variation will be unimportant in most cases, since it isn't very large; it is shown in Fig. 5 plotted as a function of load impedance. With a 1-K load it is about 885 cps, and it rises gradually to about 985 cps as the load increases to 1.7 megohms.

There is much more variation in output voltage with load, as Fig. 5 shows also. Output with a 1-K load is 60 mv peak-to-peak; this rises to 2.05 volts at 1.7-megohm loading. Since the output with a 10-K load is nearly half a volt (ample to obtain an audible signal in just about any audio circuit), we would install a built-in load of 10 K directly across the output. This would assure a virtually constant output voltage regard-

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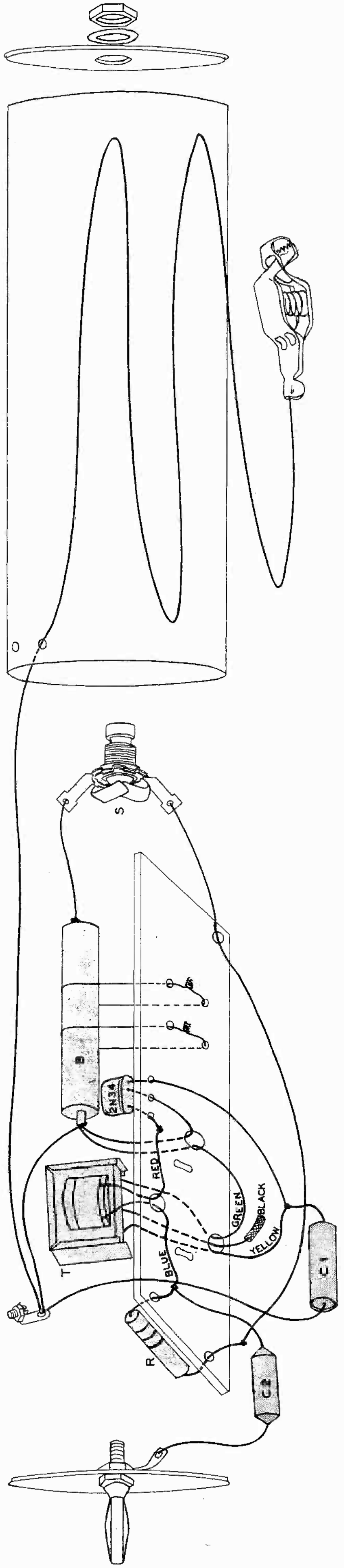

Fig. 4, left: pictorial wiring diagram.

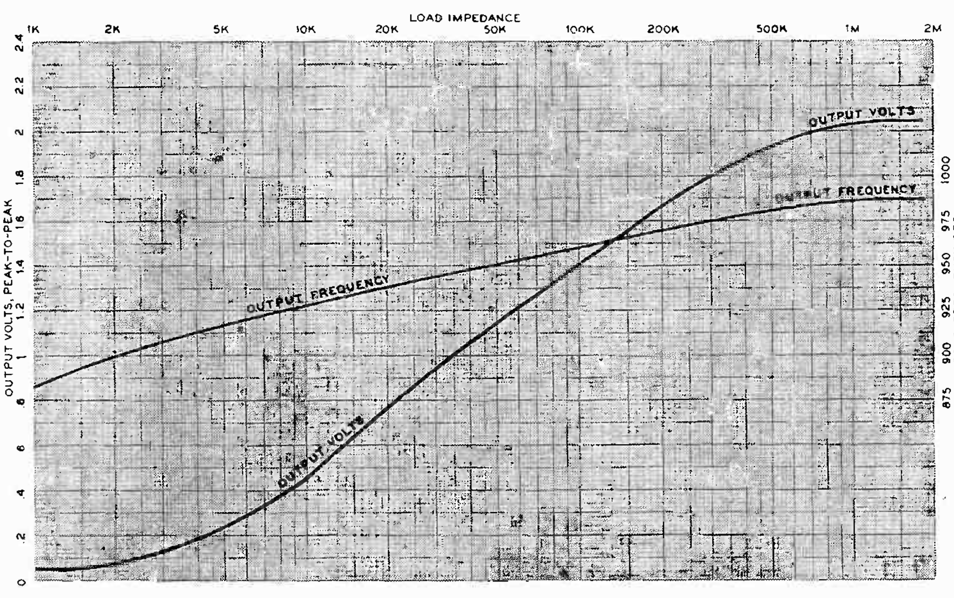

Fig. 5, below: how the output voltage and frequency vary with the load impedance. Frequency scale is on the right.

by E. B. Mullings

Using Test Instruments

Audio Signal Generators, Part II

FIFTH OF A SERIES OF ARTICLES ON TEST INSTRUMENTS AND HOW TO USE THEM.

IN the preceding article of this series we discussed a modern audio signal generator and how it works. Such a generator can be extremely valuable for tests and observations on many types of audio equipment, for the hobbyist as well as the audio engineer. An audio signal generator can be used with a vacuum-tube voltmeter to determine the frequency-response characteristics of an audio amplifier, for example. This month's column will explain how to use two such instruments to check the frequency response of your own audio equipment.

Determination of frequency response in an amplifier is important, and can serve as a good indicator to the quality of sound that can be expected from the amplifier with program material. It should be emphasized, however, that frequency response is only one of many factors that determine high-fidelity audio performance. There are such matters as intermodulation and harmonic distortion, power limitations, and transient response that must receive consideration in evaluating an amplifier. Also, the frequency-response curve of an amplifier cannot show the quality of the signal being fed to the amplifier, nor the capabilities of the speaker connected at the amplifier output. It should be remembered that, although frequency response is important to know, other factors must also be taken into consideration before conclusions may be drawn concerning over-all system quality.

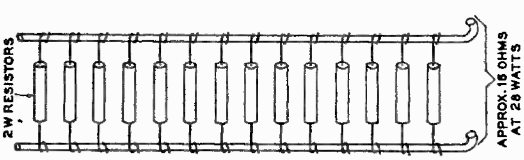

Fig. 1. A resistive load for amplifiers.

Most manufacturers specify the frequency response of their equipment. It is nevertheless interesting to run your own frequency-response curve to see how closely it follows the specified curve, and to see if your amplifier is operating properly. A manufacturer may specify the frequency response of his amplifier at a particular power level, while the user may be interested in the frequency response of the same amplifier at a different power level. There is a change in the frequency-response characteristics of amplifiers as the power level of operation is varied.

In order to plot a frequency-response curve of your power amplifier, or of your power amplifier and preamplifier in combination, a source of audio signal is required. An audio signal generator is normally employed for this source, and it should be capable of producing clean audio signals throughout the audio range, without radical changes in output level. Also, a measuring device is required at the output of the amplifier. An AC vacuum-tube voltmeter, a multifunction vacuum-tube voltmeter, or an oscilloscope can be employed for this purpose. The frequency response of the measuring device must be taken into account, so that irregularities in readings actually caused by the meter will not be attributed to the amplifier. It is important, therefore, that the frequency response of the vacuum-tube voltmeter or oscilloscope used in such a test be known in order to allow for it in the resulting frequency-response curve.

The logical procedure for plotting a frequency-response curve with an audio signal generator and, say, a vacuum-tube voltmeter, would be to feed a constant signal level into the audio system at various frequencies throughout the audio range, while measuring the output signal of the amplifier in each instance with the VTVM, to see how the output varies with frequency. Such a procedure can be employed with fairly good success. But this procedure is often modified to allow for two important considerations.

First, it is desirable to check frequency response at a particular power output level. Holding the signal-generator output at a constant level does not necessarily assure a constant power level in the amplifier. If the response curve varies up or down at particular frequencies, the amplifier will operate at higher or lower power levels, depending on curve shape. The power capabilities of the amplifier could easily be exceeded under such circumstances, and the resultant frequency-response curve would not be as meaningful as it should be. Actually, it's better to hold the output reading to a constant value on a VTVM, and plot the differences in input signal required to maintain this constant output level. In this way, the power level is kept constant, yet the frequency-response curve of the amplifier may be plotted from the amplitude of signal required to maintain this constant level over the full range of audio frequencies.

Second, it is desirable to remove the speaker load from the amplifier and substitute a load resistor. This eliminates the possibility of a speaker upsetting the amplifier's performance through changes in impedance, variations in reactance, and so on. A load resistor of the proper resistance value and power rating is normally substituted for the speaker, and the measurement with the VTVM is made across the load resistor.

Perhaps the first step in preparing to test the frequency response of your amplifier would be to make up this load resistor to connect in place of the speaker. A 16-ohm value is recommended, although any resistance value that corresponds to one of the output taps on your output transformer would be satisfactory. The load resistor used at the output of the amplifier should have a power rating that equals or exceeds the maximum power output rating of the amplifier, so that the resistors will not be overloaded. A 16-ohm resistor rated at 25 or 30 watts might be difficult to obtain, and could be rather expensive. It is recommended that fourteen 220-ohm, 2-watt resistors be connected in parallel to make up the output load resistance. The resistance

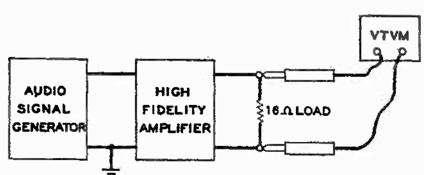

Fig. 2. Frequency response test setup.

of such a network will be in the vicinity of 15.7 ohms, and the power rating of the network will be about 28 watts. Two lengths of heavy wire can be used to mount the resistors, as shown in Fig. 1. The resistors should be of 10% tolerance if available. The total cost should not exceed 3 or 4 dollars.

Table 1 shows the approximate output power level of your amplifier in terms of output volts across 8 and 16 ohms, assuming a single sine-wave signal input. This table will allow you to set the output level without actually measuring the power in watts. For example, 2 volts AC across a 16-ohm load indicates the amplifier is operating at a level of 0.25 watt, while 12 volts AC across the same load indicates the amplifier is operating at a level of 9 watts.

The setup for running the response test is shown in block-diagram form in Fig. 2. The audio generator is connected so that its output feeds the input of your high-fidelity amplifier. A preamplifier could be included, if it were desired to check the response of the preamplifier as part of the hi-fi system. Shielded cable should be used between the audio generator output terminals and the input of the amplifier, to prevent hum pickup. The resistor network should be substituted for the speaker. Be sure to connect the network across the proper output terminals of the amplifier. The VTVM should then be connected to measure the AC voltage existing across the resistor network.

It should now be decided at what power level the frequency-response test is to be run. The best curve will result at ¼-watt or 1-watt level, while normal room listening-level peaks would be in the vicinity of 4 to 5 watts. The latter level would be recommended if the curve is to be representative of amplifier performance under ordinary listening conditions. This would mean that the VTVM should read approximately 9 volts AC across a 16-ohm load resistance, or 6 volts across an 8-ohm load, as the curve is being run. The signal-generator input should be adjusted until the specified output level is obtained at some arbitrary frequency, say about 8,000 cps.

TABLE 1

WATTS OUTPUT	VOLTS ACROSS 8 OHMS	VOLTS ACROSS 16 OHMS
0.25	1.4	2
1	2.8	4
2	4	5.6
3	4.9	6.9
4	5.7	8
5	6.3	8.9
6	6.9	9.8
7	7.5	10.6
8	8	11.3
9	8.5	12
10	8.9	12.6
13	10.2	14.4
15	11	15.5
20	12.6	17.9
25	14.1	20
30	15.5	21.9
35	16.7	23.7
40	17.9	25.3
45	19	26.8
50	20	28.3

It isn't necessary that the output be set *exactly* to the desired level, so long as the output is held constant throughout the frequency-response test. Therefore, for convenience, find a combination of settings between the continuously variable output control and the step attenuator on the signal generator that sets the meter pointer to read 0 db on the decibel scale of the audio generator meter, while the output reading on the VTVM is in the vicinity of 9 volts or whatever output level is wanted. A little experimentation will indicate that this reference level can be established at the signal generator while still keeping the output reasonably close to the power level at which the curve is to be run. Using 0 db on the signal generator meter as a reference level saves the trouble of converting the input signal

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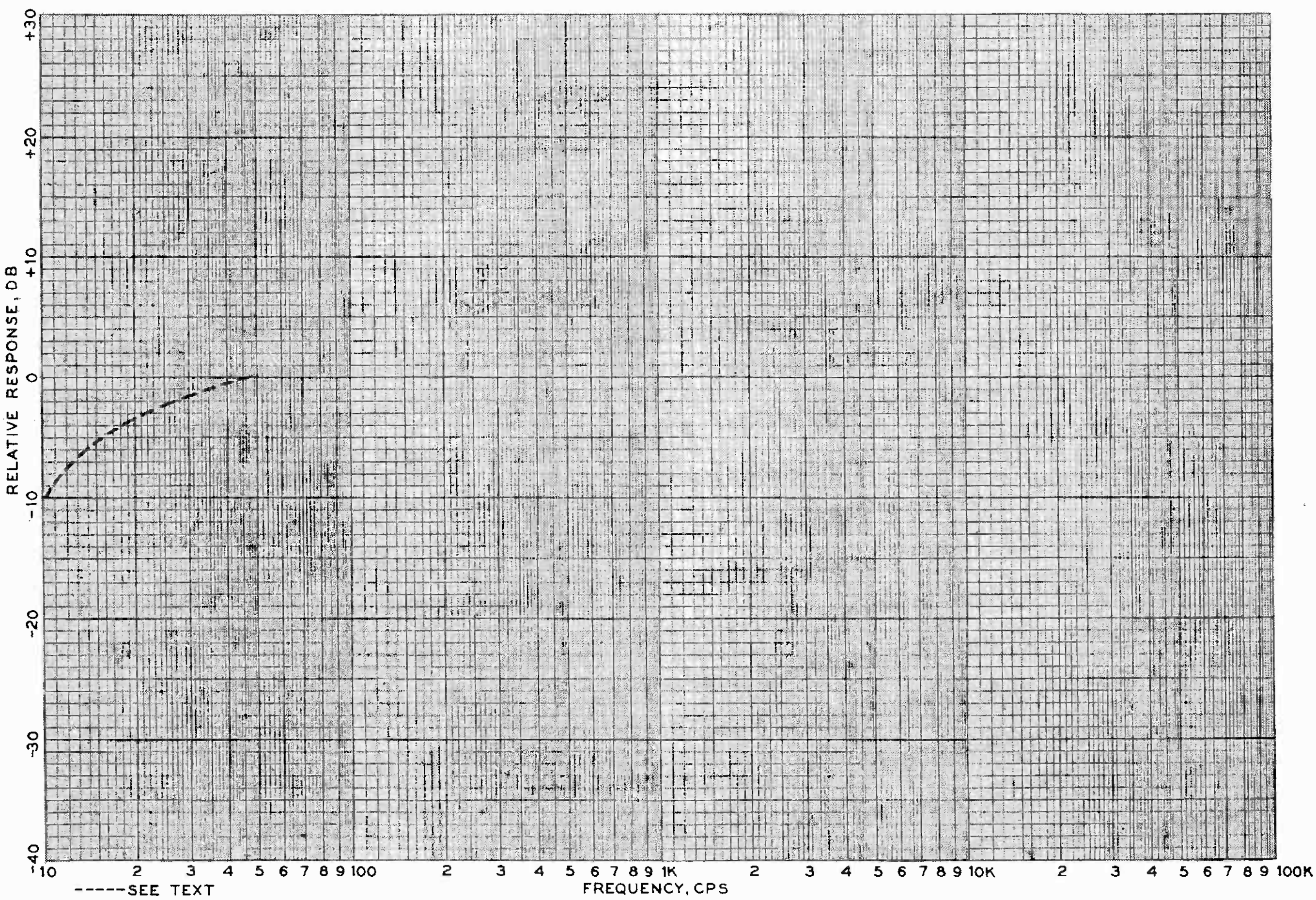
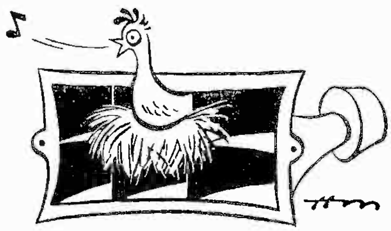
Fig. 3. Chart on which amplifier or preamp frequency response can be plotted. Several curves can be graphed in various colors.





Sound-Fanciers' Guide

by R. D. DARRELL

SO you've just wired up a new amplifier or installed a new speaker system, control unit, pickup cartridge, or tape playback head. Everything is checked and ready to go. You switch on the power, put your fingers in your ears, and brace yourself. Happily, for once, there's no explosion or sickening stench of burning insulation — only the glow of tubes, the purr of turntable or tape-transport motor spinning, and some barely audible (certainly not strong) hum or hiss. All you need now is some program material — but what should it be? Almost anything will prove that your equipment "plays". The big question is, "How does it play?"

Well, if you're smart, you'll try first something you already know extremely well, so that you can judge accurately the change in reproduced-sound qualities caused by the new equipment component. And if you're still smarter, you'll have made sure in advance that the particular disc or tape you use provides a really rigorous test of the whole system's capabilities: in frequency and dynamic range, in freedom from distortion, and above all in cleanness of transient response. If you don't already have some highly effective check materials, or if you're seeking new ones among later disc and tape releases, read further. The primary purpose of this column is that of calling to your attention both the existence of the most promising of these releases and the particular characteristics which make them unusually useful for this special purpose.

Bang! Boom! (Tinkle) Crash!

Steady-state frequencies and sweeps, paired frequencies for IM-distortion checks, and other true test recordings have an important role here (and I hope to discuss all the available ones in later columns), but for audiophiles who don't own adequate response-measuring devices, or who lack experience in their use, perhaps the best means of making significant aural checks is the reproduction of percussion recordings (played softly as well as *fortissimo*). In any case, nothing tests more severely the over-all transient response.

The most fantastic example I've come across yet is Audio Fidelity's *Bach for Percussion* (AFLP 1812), in which a New York group under Harold Glick "renders" (and I'm not kidding) John Klein's transcriptions of several Toccatas and Fugues. Unless you can recognize the music here by its rhythmic textures alone, it will sound mighty strange, but it's played with superb precision in a close-up, very dry, but also ultra-crisp and ultra-wide-range recording. Some of the coloring is highly ingenious, notably the use of cowbells (of all things) in the great C major fugue from BWV 564. This is an experiment that just had to be tried (once!) and I hope to hear it again in the promised stereo tape version, which should have greater acoustical warmth and spaciousness. Meanwhile, this is a disc which, however much a nightmare for Bachian music lovers, certainly provides a rambunctious field day for hi-fi fans.

Another release which violently exercises (without really pleasing) my ears is the Scherchen-Quadri program of Honegger, Chabrier, Mossolov, and Revueltas on Sonotape SW 1005 (previously well known on Westminster LP's, W-LAB 7004 and 7010): terrific climaxes, big but very clear sound, yet much of it — to be frank — aurally exacerbating. The tape also includes a specially recorded *Study in Percussion*, which has frantic drive and tremendous recorded

impact; but so much goes on at once that I can't get the point of it all if, indeed, it actually makes any.

A work which makes much more musical as well as just as much sonic sense is the Chavez Toccata, famous in several LP versions, of which one (Boston 209) may now also be heard on a Boston tape, BO 7-2. Livingston Tape Club members get it at a reduced price. This has more natural and warmer sound qualities, if not quite as much brilliance; I enjoy too the improvisatory Farberman *Evolution* on the same track. But I can't understand coupling — or should I say "side-tracking"? — these with such a poetic chamber work as the Britten *Serenade*, by Lloyd and Stagliano (formerly Boston LP 205).

All these are extremely useful for transient-testing, as well as for sheer ear-and-viscera titillation, but if you want to recognize and identify the various individual percussion instruments, you well may find *Spotlight on Percussion* (Vox DL 180, or Phonotapes-Sonore PM 115) even more instructive. I can't be entirely objective here, since I wrote the accompanying booklet, but I still must note that I immensely relished the original recording sessions and the finished disc and tape. The latter, perhaps, loses just a bit of the original high-end crispness. Anyway, I hope that any reader of my notes gets even half as much fascinated by the fabulous background and evolution of percussion instruments as I did doing the research and writing.

Odd Sounds Department

If any of your "music connoisseur" friends turn up their noses at your own (and my) taste for such noise-makers, you can point out that it is you, not they, who is a truly catholic listener, not limited to the purely arbitrary if long-time Western definition of music. What about the great and even more ancient tonal traditions of the Orient? Hear — and persuade your superior friends to hear — Angel's Chinese Opera album (35229/L), which features such strange-to-Western-ears instrumental sound qualities as those of the shrill *So-na* (Chinese oboe), *P'i-p'a* (balloon guitar), *Erh hu* (two-stringed violin), and *Tseng* (zither), as well as assorted drums, blocks, and gongs. I must admit that the vocal bands here rasp even my case-hardened nerves, but the instrumental bands are as fascinating to my ears as the richly illustrated booklet is to my eyes. (But surely the final *Dance to a Drum*, unlike the rest, is not entirely Chinese! It smacks of Western salon pseudoexoticism to me.)

For that matter, we don't need to journey as far as China for odd sounds: they're all around us, if not always associated with music in the strict sense, as Jim Fassett demonstrated in his justly celebrated *Strange to Your Ears* disc (Columbia ML 4938) and in many of Emory Cook's memorable sonic explorations. The latest of these is his new white-label series LP (004) of *Katydids, Frogs, and Forest Birds.* The frogs in particular come up with some really startling glottal accents . . .

Emory's aim with a parabolic mike scores not so much bull's-eyes as bullfrog's tonsils.

The notes recommend this as soothing "background music" for city dwellers seeking relaxation in a synthetic countryside atmosphere — and justly so. But if you're seriously interested in clearly identified and differentiated bird songs, you'll do much better with Norma and Jerry Stillwell's superb recordings of some 135 songs and calls of 49 species (Ficker Vol. 1). If I can't review this authoritatively, I can give something of a "Tested in the Home" report, since my sister (a dedicated bird watcher and listener) has been making constant, delighted reference use of this disc for a year or more.

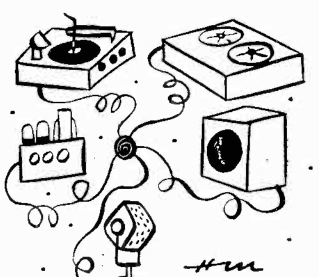
Hi-Fi Studies and Samplers

One of the first sensational hi-fi percussion demonstrations (at least since the pioneering Varese *Ionisation* on EMS 401) appeared in Capitol's *Studies in High Fidelity* (SAL 9020 of 1953), but there are more artistic and subtle examples in the sequel, *Further Studies* (SAL 9027). Again, Charles Fowler contributes informative notes, this time on the nature of hearing, and detailed ear-pointer annotations for the individual selections. But now the pieces themselves, both popular and serious, are much better chosen, played, and recorded — although there are a few moments when I'd gladly barter a fraction of the immaculate high-end purity for a bit more acoustical-environment richness, such as I do hear in the Antheil *Capital of the World* excerpt.

I have a similar reaction to Mercury's *Living Presence Sampler* (OLD 6), except for Kubelik's *Pathetique* excerpt. The wealth of tonal transparency and ultra-brilliance finally begins to seem almost too much of a good thing. But such characteristics certainly do put a sound system through its best (or worst) paces and, except as a steady diet, can be dramatically electrifying to one's ears.

Low-price samplers like this are, of course, intended primarily to whet listeners' appetites for the works represented only in tantalizing part. But they can be immensely valuable also for demonstration purposes, and one can skip the sales pitch when it is confined to the jacket-liner notes. Unhappily it isn't in RCA Victor's *Musical History of the Boston Symphony and Boston Pops* (SLR 12-11), where Milton Cross's unctuous "commercials" surround the music itself. The material itself is highly interesting, despite what I suspect is some doctoring of the historical materials (tonally, I mean; Roland Gelatt pointed out, in HIGH FIDELITY last February, some of the errors in dating). But it is odd that the modern BSO recordings aren't represented as impressively as they should be, especially in contrast with the fine recent examples of the Pops series.

Again, I'm personally prejudiced, but for me RCA Victor demonstrates its genuine mastery of hi-fi techniques far more effectively in its *Adventure in High Fidelity* (LM 1802). Whatever you may think of the elaborate booklet, with my stress on the quieter as well as ultra-dramatic hi-fi virtues (and what I now realize are overly purple annotations for the commissioned title work), I think you'll concede that Bennett's piece exploits just about every available modern resource in sonority and color, and that there are some fine examples of top-notch song and pops recordings, as well as an instructive capsule-introduction to the "Instruments of the Orchestra". Even I must confess, however, my regret that much more space wasn't given to the unique demonstrations of restricted *vs.* wide-open frequency range. (These were unique at the time; since then, other examples have become available, along with no less arresting demonstrations of various kinds of distortion, in



Tyler Turner's richly informative lecture-concert *This is High Fidelity*, Vox DL 130.)

Just Good Sound

I'll skip for now a batch of tape samplers, since more will be available for discussion soon, including some stereo examples. By this time you must be getting a little weary of strictly sound-analysis listening. In any case, if you're now sure that your system can come close to coping with the most rigorous transient tests you can inflict on it, sit back and enjoy Scherchen's *Petrouchka* (Sonotape SW 1019; also on Westminster W-LAB 7011), not only for its percussion passages (although they're miraculous in themselves), but for everything else in this unparalleled example of kaleidoscopic audio tone painting in what is the most magnificent 7.5-ips tape recording I, for one, have heard to date.

Or, if you crave something more lushly romantic, try Quadri's *Scheherazade* (Sonotape SW 3001; also on Westminster WL 5234), which is almost as good, technically at least, except for the solo violinist's rather pinched tone and somewhat sentimentalized phrasing. And if you're still game for some illuminating tonal comparisons, follow this with Steinberg's LP version (Capitol P 8305), a somewhat more sober reading with a far superior solo violinist. The fascinating comparison here is between the two treatments of the percussion passages, in the third movement especially: in the Steinberg LP they sound as they should to a listener well back in the hall; in Quadri's tape they are more brightly and "forwardly" differentiated from the full orchestral sonority. Which is better? You pays your money and you takes your choice — between concert-hall authenticity and high-fidelity spotlighting.

For stimulating lighter fare and a somewhat similar choice of recording approaches, try a couple of Angel LP's of band music: first, the *Garde Republicaine* program on 35200; then one by the Scots Guards on 35271. The former is clean as crystal, if perhaps rather dry tonally, mainly due to the distinctively French wind-playing style. But the latter, if less virtuosic musically, is miraculously "truer to life" than one ever hears in a live concert itself — one of the richest and most exhilarating demonstrations of acoustical spaciousness and sonic balance I know. The bagpipe sections are fun too, and mercifully not long, but it's the big band, especially in the two "patrol" pieces, that will irresistibly bring down the house (in more ways than one, if you advance your volume control far enough).

Some other light, jazz, and folk materials I've particularly enjoyed recently include Tovarich Kazakov, on Angel 65020, playing the *bayan* — accordion to you, but in its Rooshian guise lacking the annoying tremolo of the more familiar variety and, for once, played by an authentic musical virtuoso. Esoteric tape ES 5-7, available at reduced price to Livingston Tape Club members, presents the harpist Zabaleta in beautifully crystalline if not ultra-brilliant recordings of contemporary, but certainly not ultra-modern, music. The A-V tape (AV 851) of Josh White's *Story of John Henry* and other ballads is the most startling example of solo recorded "presence" you're ever likely to come across. Bel Canto's tape (501) of *The Best of Billy Butterfield*, Pentron's tape (RT 400) of Larry Paige's *Show Pops*, and Alphatape's (AT 1) *High Fidelity Jazz* are all fine, bracing, open recordings. Jazztape's *New Orleans* (JT 4008), by Kid Ory and Lizzie Miles, isn't quite up to these technically, but the music more than makes up for that.

Audiophile's *Traditional Jazz, Vol. 6* (AP 33) not only presents some of the best Dixieland playing I've heard in years, with Doc Evans's devil-may-care cornet leading the way, but for once leaves me at a complete loss for words to describe the recording. What recording? There just doesn't seem to be any! The tonal lucidity and transparency are

Continued on page 37

Automatic Switch

In "Audio Aids" in the February issue, Mr. Charles V. Thayer suggests using the automatic switch of the Garrard changer in one's phonograph system to turn off the amplifier after the last record. His method of working this out sounds excellent for the situation he is considering; that is, where only a phonograph is involved. For outfits in which the same amplifier is also used with tuner, tape equipment, etc., a somewhat different treatment seems advisable.

The addition of an amplifier plus the other equipment could easily increase the electrical load through the changer 4 or 5 times, and this might overload the switch to the point of burning it out. Overload can be avoided by taking from the changer switch only enough power to energize the coil of a 115-volt SPST relay. The amplifier, etc., should then be so connected as to draw power directly from the source, with the relay acting as a switch in the circuit. The power drawn from the changer by the relay is negligible, but it controls the power to the other equipment.

As Mr. Thayer points out, another switch is necessary to remove control from the changer while the amplifier is warming up. In my case, I accomplished this by connecting across the contacts of the relay an EDCO Delayed Action switch. This device is similar to the ordinary toggle switches used for electric lights, but, when turned to the OFF position, it delays about a minute before opening the circuit. When using the phonograph, one flips this switch on, and immediately returns it to the OFF position. The delay feature of the switch allows the amplifier about a minute to warm up, by which time the changer will have been started and takes over control. By turning the delayed-action switch off immediately, the possibility of defeating the automatic shut-off by forgetting to turn off the switch is avoided.

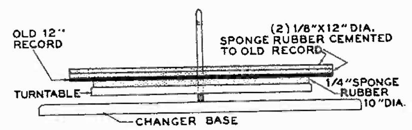
When the amplifier is used with equipment other than the changer, the EDCO switch is left in the ON position.

Allan T. Frary
Cleveland Heights, Ohio

Reduced Record Wear

If you use a record changer to play 12-inch records, you will find that record wear can be reduced appreciably by this method. Put a 1/4 by 10-inch sponge-rubber mat on the turntable. Then cement one or two 1/8 by 12-inch sponge-rubber mats to an old 12-inch record (make sure that the record is not warped and that the center hole is perfectly round). If the mats are not made with a metal grommet in the center, you may have to widen the hole to prevent the mats from sticking to the spindle of the changer.

Before cementing the second 1/8-inch mat to the first, try out the assembly with a record to see if the pickup clears the record at the end of play. The



How to raise the level of a changer arm.

arm lift on most changers can be adjusted easily.

When this device is in use, you will notice that the pickup lies practically level with the record top in both planes.

G. K. Marshalsea
S/S Exford
Hoboken, N. J.

Tape Squeal

Tape squeal and chatter are caused by mechanical stop-and-go motion of the tape past the recording head, very much in the manner of a violin string activated by the bow. When severe, tape squeal modulates the recorded sound, especially on the highs, and appears on the tape in playback. It can be "inaudible", resulting in muddied over-all tones. Tape in storage apparently loses lubrication through drying, and this may account for the very poor reproducing quality of tapes several years old which are remembered as having been excellent when first recorded.

The condition is easily corrected by the application of graphite, the type used by the writer being Dixon Graphite Art Stick No. 1710, obtainable at art-supply stores.

The felt pressure pads are lightly graphited by passing the stick across their faces, a very slight application being sufficient. The oxide side of the tape is run on fast forward and reverse, over the corner of the graphite stick which is held by hand during the process. This light application of graphite is adequate to effect a cure.

Carl F. Propson
Lumberton, N. J.

This will tend to reduce head contact, but seems an excellent idea for tapes that are otherwise unplayable. Before going ahead with the graphite treatment, make sure that the heads aren't worn, that they are clean, and that tape tension is correct. — ED.

Asphalt-Loaded Speaker System

The rear panels of my 11-cubic-foot bass-reflex enclosure were constructed for sand loading, but I made the mistake of making the panel walls too thin (1/8-inch Masonite). Sections are 1½ in. thick over all. Even though there were some 40 pounds of sand in each panel considerable resonance was evident, so I removed the sand and filled the panels with hot asphalt. The result was amazing. In fact I was so enthusiastic about the idea that a few weeks later I removed the panels again and lined all accessible interior surfaces with 1 to 1½ in. of hot asphalt and rock. The response of the system is even more remarkable than I had hoped for. On low-note organ passages the entire room vibrates, but the speaker cabinet does not. The transient response is excellent, due to the fact that nothing moves but the air and the speaker cones.

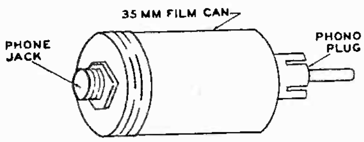
Here is a run-down of my procedure. Cut up asphalt (available at roofing companies for about $1.75 per hundred pounds) with an ax and heat the pieces in a five-gallon bucket. It may be necessary to make arrangements to do the heating outside, although I did it on the kitchen stove. Heat the asphalt until it pours like water. Be extremely careful with the hot asphalt as burns can be very painful. Keep a metal cover nearby to cover the bucket in case the material should ignite (the danger of this is relatively small). Wash ¾-inch rock, and dry and heat it in an oven. Position the enclosure and pour a thin layer of hot asphalt over the entire section to be loaded. Next add an even layer of clean, warm rock to the area. Finish by filling in with more hot asphalt to the desired depth. The material will set in about an hour and a half. Then proceed to the next section. During the final assembly, line all interior surfaces with Fibreglas in the usual manner for a bass reflex.

The advantage of this procedure is that areas which could not otherwise be loaded are easily filled with hot asphalt and rock. The result is a rigid, nonresonant enclosure.

M. E. Mowery
Los Angeles, Calif.

Adapter/Connector

To make an inexpensive, compact adapter/connector for microphone or other cables, a small metal can, like those which come with rolls of 35-mm camera film, can be used. Holes are



Film can used as a plug adapter.

cut in the top and bottom to receive the proper plugs and jacks. Because the top of the film can is removable, necessary wiring changes are made easily.

In my case, I used a phono plug pushed through a small hole in the bottom of the can, crimping the end of the plug inside and using a generous amount of solder around the lower part of the plug on the outside to hold it tight. A phone jack on the other end of the can, and the necessary wiring finished the adapter. Electrical tape can be put around the can if desired.

R. Sweeney
Houston, Tex.

Soldering-Gun Heat Loss

Electric soldering guns depend on the heat generated by a "shorted turn" for their operation. A step-down transformer, located in the gun "stock", is energized by 117 volts AC when the trigger is pressed. The secondary side of this transformer consists of one hairpin turn of heavy copper bar stock, the ends of which emerge as two large, round binding posts, commonly known as barrels. Unless a tip is connected to the barrels, the secondary side of the gun's transformer is open and no current flows. When the circuit is completed by installing a tip, an extremely large current flows in the secondary when the trigger is pressed. Most of the heat developed by this shorted turn is confined to the tip itself, since its resistance, although very small, is still considerably greater than that of the barrels and hairpin turn.

As do most other such devices, soldering-gun tips oxidize when subjected to extremely high temperatures. This oxidation affects the whole tip, including the ends under the fastening nuts. Oxidation in this area can raise contact resistance appreciably — a mere fraction of an ohm being sufficient to limit heating current to an unusable amount.

Soldering-gun manufacturers have taken special precautions in the design of tip-mounting nuts to reduce this hazard. However, it may still occur if a new tip is not properly tightened before heating, or if a properly installed tip has been in use for a long time. If your soldering gun doesn't seem to have the pep it once had, get out your wrench and tighten the nuts on the end of the barrels. Operation of the gun will be restored to normal (unless, of course, the transformer itself is defective).

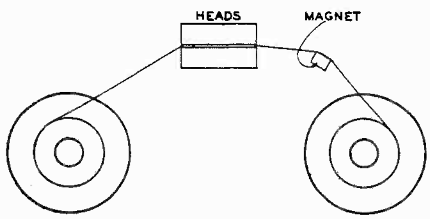
Retightening of the tip nuts is recommended after all long periods of soldering-gun operation, even though no appreciable loss of heat is noted. It will pay off in neater connections, faster work, and will prevent wear and tear on the nervous system.

N. V. Becker
Hollywood, Calif.

Semi-Bulk Eraser

When a bulk eraser is not available and it is desired to erase a tape completely, the common holding magnet that comes with magnetic bulletin boards provides a satisfactory substitute.

Holding magnets generally come encased in plastic covers with one side open to expose the poles of the magnet. These poles are usually polished so



Holding magnet erases at rewind speeds.

that, when used as an erasing device, they will not abrade the tape. To play it safe, a few swipes with an oil stone will remove any irregularities.

To use the magnet as a full-track eraser, it is necessary merely to form a loop of tape and hold the magnet against the coated surface. With a little practice, tape erasure can take place at rewind speeds, providing complete erasure in about a minute.

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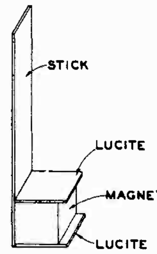
A more desirable arrangement might be to equip the magnet with a handle and two tape guides. A further refinement would be to grind the edges of the magnet to present a curved surface to the tape. After grinding, the edges should be polished with an oil stone and cleaned with alcohol.

DC erasure leaves the tape with some



Magnet mounted in convenient handle.

noise that is readily removed during the subsequent recording process. It has the advantage of being more complete than the erasure normally provided by the recording machine's erase head.

E. J. Stachura
Arlington, Va.

Hi-Fi Sound from TV

If you have a good hi-fi system, there is a simple method of obtaining good sound from your TV set. It is necessary, first, to determine which tube in the TV set is the first audio-amplifier tube. It is usually a type 6SQ7 or its miniature counterpart. Also, make certain that your TV set is transformer operated; that is, the tube heaters are heated from a winding on the power transformer and not connected in series, such as in AC-DC receivers and in some portable and other TV sets.

Remove the first audio-amplifier tube and substitute a male octal socket with the audio connecting lead attached to the pins normally connected to the grid and cathode of the tube. (In the event that the tube being replaced is a miniature type, a miniature socket would have to be used.) Consult a tube manual to obtain the pin numbers for the grid and cathode connections. The shield of the connecting cable should be attached to the cathode connection, and the center wire to the grid connection.

Next, attach an RCA standard phono plug to the other end of the audio connecting cable. Then plug the octal socket into the tube socket of the TV set, and the phone plug into the high-impedance input of the preamplifier or amplifier of your hi-fi set, and you're ready to go. It should be noted that the volume control of the TV set will still be operative, although it may be more convenient to control volume from the preamp.

Arthur E. McConnaughey
Dayton, Ohio

BASIC ELECTRONICS

by Roy F. Allison

IX: Alternating Current

THE behavior of circuit elements has been studied so far in this series only with DC voltages or step functions. *DC* is the abbreviation for direct current, which is taken to mean continuous current in a single unchanging direction. A pure DC voltage, such as that obtained from a battery, is also reasonably constant in magnitude as well as direction.

A *step function* is an abrupt, non-repetitive change in DC potential, such as is obtained when a battery is suddenly switched in or out of a circuit. A simple DC source was used with resistive circuits; it was necessary to employ step functions in determining the characteristics of inductors and capacitors.

Now let us go one step further. Fig. 1 is a diagram of a circuit in which either of two 10-volt batteries is selected by switch S. The batteries are connected in opposite directions. In position 1 the current is counterclockwise, making the top of resistor R 10 volts positive with respect to the bottom. Throwing S to position 2, however, connects the other battery in the circuit. Its reversed polarity causes current in a clockwise direction; the top of R is now 10 volts negative with respect to the bottom.

In order to plot the voltage source variations graphically, we must establish a reference point in the circuit to which the voltages at other points may be compared. Suppose we choose the bottom end of R as the reference point. This we shall call "ground", although it may or may not be connected electrically to the earth. Since the earth is a reservoir of electrons in virtually un-

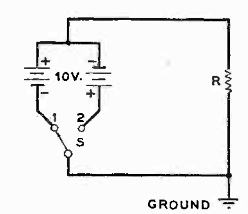


Fig. 1. Circuit to produce AC voltage.

limited number, it makes sense to consider it at zero potential, to which all other potentials are referred. Thus, an electrical connection may often be made from one point in a circuit to a pipe buried in the ground. One conductor or "side" of the house power line circuit is usually grounded. Even when such a connection is not actually made, the reference point of zero potential in a circuit is called ground. The diagrammatic symbol for ground is that shown in Fig. 1.

Let us then draw a horizontal line which represents units of time along its length. Its altitude represents zero potential; positive potentials are drawn above the line, the distance proportional to magnitude, and negative potentials are drawn below the line. A scale along the left-hand margin, if furnished, is calibrated in units of magnitude, and other lines identified by the scale are often supplied. This is shown in Fig. 2. Now we are about to plot the voltage across R, with the potential at the bottom end of R as reference. Suppose we begin the chart while the switch is in position 1. Obviously the voltage at the top of R is +10, and will remain at that value until the switch is moved to position 2. So long as the switch is not moved, the chart is a horizontal line at the +10-volt level that moves to the right as time elapses. When S is snapped to position 2 the voltage abruptly changes to —10, and the chart line must be drawn sharply downward to the —10-volt level. There it remains, moving to the right as time goes on. If the switch is put back into position 1 the voltage reverses polarity almost instantaneously, going back up to +10 volts. Our chart line moves abruptly upward again to the +10-volt line, where we shall let it stay until it moves off the chart at the right-hand end.

It is easy to visualize what would happen if we flipped the switch continually at regular intervals. Voltage across R, and current in R, would reverse polarity and direction regularly. Rather than single-direction current we would have current that alternated in direction, or *alternating current* (AC). The voltage across R, which is the source voltage, would be alternating voltage — but it isn't usually called that. It is, unfortunately, labeled *AC voltage.*

Having grown weary of operating the manual switch, let us replace it with a motor-driven switch that does the voltage-reversing job with a precision and speed we cannot match. Assume that the motor rotates at 600 revolutions per minute (rpm). With each revolution it throws the switch from position 1 to position 2 and then back again; let us assume also (wonderful switch!) that the time of transfer from one position to the other is zero, and that the durations in each position are equal. The voltage across R, still using the potential at the bottom end as reference, would then appear as in Fig. 3.

Since the motor speed is 600 rpm, the shaft rotates ten times every second. The switch is thrown twice — from position 1 to position 2 back to position 1 — during each revolution. That means that the switch remains in each position for exactly 1/20 second,

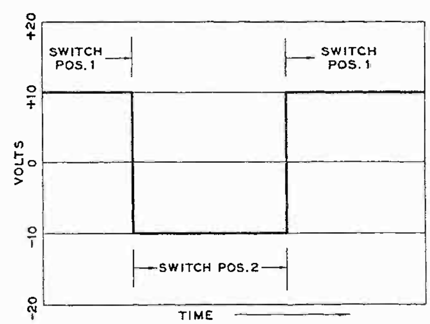


Fig. 2. Chart of the voltage across R.

or .05 second. On our chart, therefore, the voltage changes polarity at each .05-second interval. The chart covers a total time of 0.3 second; there are six direction changes plotted.

This is clearly a repetitive phenomenon. If we had plotted the following 0.3-second segment of time we would have obtained exactly the same pattern. It repeats itself endlessly, or until we turn off the switching motor. The name given to a single occurrence of any repetitive phenomenon is a *cycle*; a complete to-and-fro movement of a pendulum, for example, is a cycle. The pattern repeats itself fully during a cycle.

Our alternating-current pattern must go through two complete reversals before it begins to repeat itself. It doesn't matter at what point in the pattern the measurement of a cycle is begun, so long as the measurement is ended at the next identical point. Single cycles are marked off at two places in Fig. 3. Each occupies the same time: 0.1 second. Thus, a complete cycle occupies the time of both a negative and positive half-cycle.

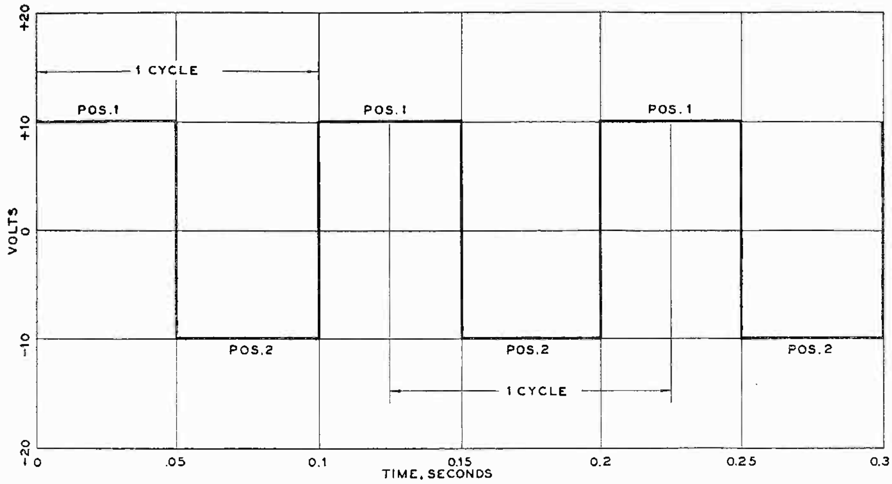


Fig. 3. An AC voltage of square wave form. Frequency is determined by cycle period.

The total time required for a single complete cycle is called its *period* — in this case, 0.1 second. If it takes 1/10 second for each cycle, then obviously 10 cycles will occur every second. This is the *frequency* of alternation: 10 cycles per second (cps). To find the frequency of any AC wave form, simply take the reciprocal of the period expressed in seconds. To find the period when the frequency is known, divide 1 by the frequency in cps. The period of a 1,000-cps frequency is .001 second, or one millisecond. Frequency of a wave form having a period of .025 second is 40 cps.

Frequency is such a common term that the Greek prefixes *kilo* and *mega* are almost invariably used to make the larger numbers less unwieldy. Kilo refers to thousands of cycles per second; mega to millions of cycles per second. Their abbreviations are Kc and Mc, respectively. It is easier to say or write 14.5 Kc than 14,500 cps, and 10.7 Mc than 10,700,000 cps. Occasionally when written, and often when spoken, the term "cycles" is substituted for "cps". If you hear someone talking about a peak in his speaker system at 50 cycles, you can assume that he means 50 cps.

Effective Value

We have reproduced one cycle of the AC voltage in Fig. 4. It can be seen that it is symmetrical about the zero line; each half-cycle is of the same width and is the same distance above or below the line. The *average* value of the wave form is patently zero. Does this mean that the alternate half-cycles cancel and nullify each other's effect? If not, how can the total effect be equated to that of a simple DC source?

The answer to the first question is, of course, no. The two half-cycles occur at different times. Current in the circuit is continuous except during the instant that it changes direction and, so far as power developed in the resistive load is concerned, the direction of the current doesn't matter.

That leads us directly to the second question's answer. The logical way to correlate alternating and direct currents (or voltages) is by their effects on the

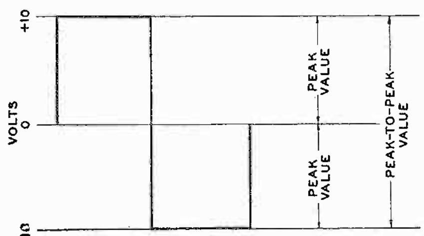
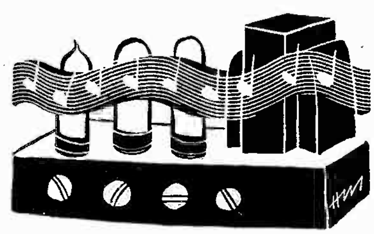


Fig. 4. Effective value is peak value.

load: that is, by the relative amounts of power developed in the load. Referring to Fig. 4 again, it will be seen that the source voltage swings from +10 to −10 volts, or to a peak-to-peak swing of 20 volts. The maximum swing *from the zero line* at any one instant, however, is the peak voltage, which is only 10 volts. That is the maximum voltage ever developed across the load; it merely changes direction each half-cycle. And for this wave form — a square wave — that voltage exists continuously except for the brief instants when it reverses polarity. For practical purposes, then, there are 10 volts across the load continuously. This will develop precisely the same power in the load as 10 volts DC. It follows that the *effective value* of a symmetrical square wave is the peak value, or half the peak-to-peak value.

The same relationship does not exist for a sine wave, the wave form most often associated with AC. This is discussed in the following chapter.



CENTURION

Continued from page 18

screwing down top piece 26. Also, before panel 26 goes into place, run the proper pair of wires in from the cable harness and fasten them to the woofer's terminals.

Step 14. After painting panel 29, attach the grille cloth with a stapler and mount your T35 or T35B very-high-frequency driver on the panel. You may have some problems getting panel 29 in place. Install it from the front. Don't "angle" it; it's too tight a fit for that. Put it in squarely, bowing the panel and applying a little pressure. If it just won't go you may find it necessary to do some chiseling, planing, or sanding on the top of brace 22.

In conclusion: I'm sure that I was asked to test assemble this unit because my ineptness with the screw driver and glue pot is no secret to the editorial staff of this magazine. My total work time was about 15 hours. I could do another in half that time. Even with the minor irritations encountered, I must say that the design details of this unit have been beautifully worked out. The money saved and the satisfaction gained by this job have been quite a revelation. The briefest and most sincere testimonial that I can offer is, "I did it, and it sounds fine."

AUDIOCRAFT Test Results

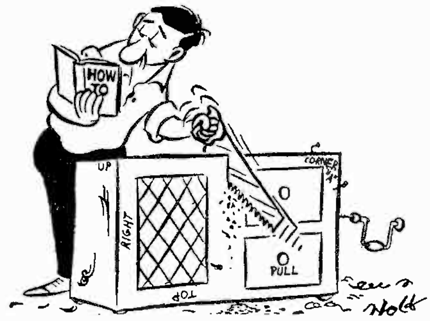
Not only does it sound fine, but it looks good too. Exterior surfaces are of birch plywood with solid poplar trim; it is adaptable to either clear finishing or staining.

Our constructor hadn't yet decided how he wanted to finish it when this was written, but it is obviously amenable to any choice. If you aren't experienced in the techniques of wood finishing it would be well to look into the finishing kits offered by Electro-Voice.

The Centurion is only 42 in. high, 29 in. wide, and 22½ in. deep. It looks — and sounds — much like a miniature Georgian. According to ear tests, in a room 14 by 32 ft., bass was at full strength down to about 42 cps. At 39 cps a slight amount of doubling could be detected, but there was still a reasonable amount of fundamental left at 35 cps. Although it is necessary to use the Centurion in a room corner, placement in the corner doesn't seem critical; we were unable to detect any significant difference in sound for positions up to 10 in. from the corner. There is accentuated response in the 150-cps region which, in music reproduction, gave the bass a fullness that was not at all objectionable: several listeners were delighted with the full-bodied bass. On male voices there would be some coloration from this

Continued on page 33

Audiophile's Bookshelf



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CENTURION

Continued from page 31

response bump, and on this point the Georgian is clearly superior.

There are also some regions of slightly increased response in the lower and upper high-frequency ranges, which give an illusory projection of human voices and brass instruments, and a bite to strings. These are the familiar characteristics of Electro-Voice speaker systems. Level controls on both middle-range and high-frequency drivers permit wide adjustments in balance, but the type of sound cannot be changed — nor would a great many want to change it.

Generally, this system sounds far more impressive than its price would indicate. We had the B line of drivers, which made the total cost a bit over $200. At other times we have heard these compared directly with the de luxe line, and were struck by the superior smoothness and transient response of the higher-priced components. This is not to say that the B drivers are inadequate; only that, in our opinion, the difference is worth the extra cost.

AMPLIFIER DESIGN

Continued from page 19

as to be 75 volts above the 275 starting point, or at 350 volts.

Thus we can see the justification for swinging the voltage scale the opposite way around for the second tube. The current scales are back to back for the following reason: the operating point chosen is —70 on each grid. This gives the combination of plate current and voltage represented by the straight dashed lines, about 10 ma in each tube at 275 volts. But because these two currents are in opposite directions in the output transformer, their magnetizing effect in the output transformer neutralizes and is the same as if no current were flowing.

Composite Curves

Let's consider another possibility: while both grids are at the same potential of —70 volts, suppose there is a momentary reactive voltage from the transformer that makes the first tube plate +25 volts from the mean value of 275 and the second tube plate —25 volts. Following the respective curves for —70, the first tube's current rises to about 23 ma, while the second tube's current drops to about 4 ma. The resultant effective current in one half of the primary of the output transformer is the difference, or 19 ma.

If we plot a number of such difference values we shall get, approximately, the straight line joining the two 70-volt curves. It is here drawn as a straight line to which it does form a very good approximation in practice. It will probably have a slight curvature, because the two sets of curves do not exactly equalize one another.

In a similar way we can produce resultant curves, which are again approximately straight lines, for other combinations of grid voltages. If the grid input is such as to drive the first grid 10 volts positive from its bias value, that is, to — 60, the same swing will drive the second grid 10 volts negative to — 80, so we can average the currents between these two curves at different combinations of plate voltage and produce another approximation to a straight line for this condition. In this way the whole family of composite curves was produced for Fig. 2.

Each line joining pairs of curves represents a composite plate-current/plate-voltage "curve" for a particular combination of grid voltages. The composite represents the magnetizing effect upon one half of the output transformer's primary.

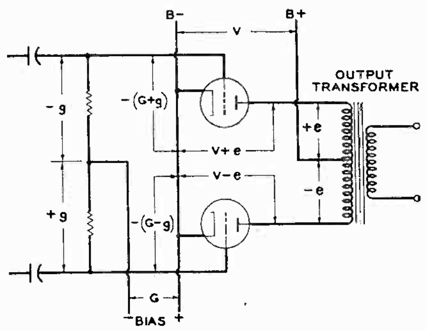


Fig. 3. This schematic of a push-pull output stage shows the justification for the method of construction employed in Fig. 2. When one grid swings positive of the bias (G) by an excursion (g), the other swings negative by the same amount. Similarly in the plate circuit, when one plate is negative of the mean value (V) by a swing (e), the other swings positive by the same amount.

Now we can look at the picture in a different way, taking our point of view from each individual tube. The straight solid line across the composite tube characteristics represents the load line for both tubes together; it considers only the output transformer and the two tubes as a composite source. But each tube has to "see" an individual load line. This is represented by the dotted curves that lead away from the straight load line.

These two curves add to produce the solid straight line. It will be noted that the dotted curves intersect the individual tube characteristic curves at the same values of voltage (represented by being in the same vertical line) that the solid load line intersects with the composite straight line.

Notice also that the curvatures, both of the individual load lines and of the individual tube characteristic curves, when added together in this manner, offset one another and produce a close approximation to an ideal set of characteristic curves — both the load line and the individual composite characteristics are all straight lines. The great advantage of this condition is that when the load becomes reactive, so as to open out into an ellipse as studied in the previous article, no appreciable increase in distortion occurs, even if the reactance effect becomes considerable.

The load line drawn in Fig. 2 is not actually the optimum load for these characteristics. It was drawn at an angle that was convenient to show how the composite characteristics work. In practice the optimum load, as given in the tube data, is that represented by the portions of dashed line at the top and bottom of the chart. To avoid confusion, these are not joined at the center, and the full length of this optimum load line, out to the zero grid characteristic curves, would go off the chart to a plate current of approximately 125 ma. This is going up to a much higher plate current than allowed for in the characteristic plotted in Fig. 1.

This method of operation is rendered possible by the fact that the high currents occur only for a part of the time represented by the full excursion of the load line. During almost half of the signal period, when the load line runs out to these extremities, one tube is completely inoperative. This means that the plate dissipation, on an instantaneous basis, can go up to at least twice the nominal maximum rated continuous value.

This tube can be pushed even harder by using positive grid drive. Then the plate current goes up to about 212 ma on positive-going peaks, giving a rated output of 18 watts. Even with this large excursion the maximum-signal plate current, measured as the average for the two tubes, is only 138 ma.

The efficiency of such a stage is obviously quite high compared with single-ended operation. For 18 watts output, the plate supply has to be 275 volts at 138 ma, which is about 38 watts. This represents a much higher efficiency than can be achieved with single-ended tubes.

With some of the larger triode output tubes, it is even possible to get an output equal to or greater than the combined dissipation rating of the tubes. There is a British transmitting-type triode capable of using a 1,000-volt plate supply and rated at 100 watts plate dissipation. By operating this in Class-AB push-pull, with grid current drive, it is possible to get as much as 250 watts audio from the two tubes, without exceeding the average dissipation of 100 watts each. This means that the plate-circuit efficiency is better than 50%.

Now we come to another question in

Continued on next page

AMPLIFIER DESIGN

Continued from preceding page

the operation of push-pull output stages: how to provide the grid bias. If we are *not* running into the positive grid-drive region, it is possible to use a method of plate-to-grid coupling similar to that used for other stages. It is not particularly necessary to use a low-resistance source, but cathode bias has a serious limitation in this kind of circuit, for reasons which will appear in a moment.

The conditions shown in Fig. 2 are based on the use of a fixed bias of 70 volts. In this example, the combined plate current changes from about 20 ma for the two tubes when there is no signal to about 90 ma for the 5.5-watt output achieved without the grids going positive, or 138 ma for the 18-watt output achieved by using positive grid drive.

If we had used a bias resistor to give 70 volts bias at 20 ma we should need a cathode resistor of 3,500 ohms. But when the plate current rises to 90 ma the same resistor will give a bias of over 300 volts. Of course, this is assuming that we get our 275 volts plate to cathode in each case, which is obviously impossible. If, in the quiescent condition, we had a plate-supply voltage made up of 275 plate to cathode plus 70 cathode to ground, this would mean a B+ supply voltage of 345. Obviously, when the drive is applied, the 345-volt supply will have to divide itself between plate to cathode and cathode to ground. This would probably be about fifty-fifty, meaning there will be about 170 volts from plate to cathode and 170 volts bias.

It is evident that the operating points on the curves are modified from zero to maximum signal for this type of operation, but it *is* possible to use cathode bias with considerably reduced output.

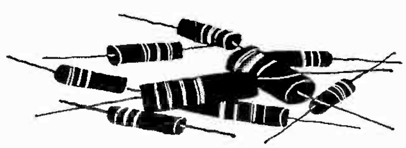
An example is given in the tube data manual, using 275 volts maximum plate voltage and a bias resistor of 775 ohms. The zero-signal plate current is quoted as 36 ma. This will give a cathode-to-ground voltage of about 28 volts, so the over-all supply voltage should be a little over 300 volts. If we now consider maximum-signal operation, at 90 ma we shall have a bias voltage of 70, which is 42 volts more than we had at zero-signal output. If we had 275 volts from plate to cathode at zero signal, we shall get only 233 volts plate to cathode under maximum-signal conditions.

This means that the curves for producing the composite characteristics *at maximum signal* will have to be moved along so that the 233-volt points coincide, instead of the 275-volt points as in Fig. 2. Obviously this will reduce the maximum available output. It also changes the optimum load for achieving maximum output. For fixed-bias condition, the recommended plate-to-plate load is 3,200 ohms, while for cathode bias it is 5,060 ohms.

TEST INSTRUMENTS

Continued from page 25

from volts into db before it is plotted on the graph. Once this combination of settings has been established, the frequency of the signal generator can be varied above and below 8,000 cps in order to plot a curve on the graph. Each time the frequency is changed, the output reading on the VTVM should be brought back to its reference setting by adjusting the output control of the signal generator. The meter of the signal generator will then indicate whether more or less signal input had to be used to obtain the same power output, and it will indicate this in terms of db steps. This is the information that should be plotted on the graph. Keep in mind, however, that the polarity indicated on the meter of the signal generator must be reversed when the value is plotted on the graph. In other words, if the signal generator meter indicates +1 db, it indicates that *more* signal had to be injected into the



amplifier to maintain the same power output and, therefore, the amplifier is "falling off" and is "down 1 db". This should be plotted on the graph as —1 db, just the reverse of the polarity indicated by the signal generator meter. More signal input will be required as the amplifier gain decreases.

Fig. 3 is a reproduction of the kind of chart that should be used to plot your frequency-response curve. The figures on the left-hand scale of the graph represent decibels, both positive and negative. The response of your amplifier can be determined in terms of plus or minus db for all frequencies between 10 and 100,000 cps and plotted on this graph.

Notice that a curve already exists at the low-frequency end of this graph in dashed-line form. This curve actually shows the frequency-response deviation of the VTVM (the Heathkit Model V-7A) used to make the output measurement. If your amplifier were perfectly flat from 10 cps to 100,000 cps, and its response were measured with this meter, its *measured* response would be down as indicated by the dashed line because of the "fall-off" below 40 cps due to the VTVM. This is normal for a multi-function VTVM such as is used in this case. A straight AC VTVM would have a more nearly flat response at the lower frequencies, since it is designed purely for AC measurements, particularly in the audio range. Combining functions in a multi-purpose VTVM, however, requires some compromise in the low-frequency response of the AC section of the meter. This must be taken into consideration when plotting the frequency-response curve. If the curve resulting from the frequency run exactly follows the dashed line at the low-frequency and of the curve, it represents flat amplifier response in this area. In other words, the dashed line represents the 0-db line from about 50 cps downward, when this VTVM is used.

This graph has been reproduced large enough that you can actually plot the frequency response of your amplifier right on the sheet. Start at some frequency in the mid-range area, and switch the signal generator frequency control in steps to the higher frequencies and in steps to the lower frequencies, each time making sure that the output remains exactly the same as indicated on the VTVM. Plot the differences in input voltage on the graph. Again, it should be emphasized that the relationship between the amplifier response and the meter reading on the signal generator is exactly opposite. When the meter pointer swings positive away from 0 db, your curve should be plotted negative, and vice versa. Should the change in input level be such that another position of the attenuator must be used to restore the output reading on the VTVM, 10 db should be added or subtracted from the actual meter reading because the attenuator works in steps of 10 db.

You may want to run a series of response curves for your amplifier at various power levels. This can be done easily by changing the reference output level. Separate curves can be plotted for each power level on the same sheet of graph paper. Different colored pencils can be employed to identify the various curves. A series of response curves can be taken at the same power level to find the effect of different tone-control or equalizer settings, if these controls are included in the amplifier.

It should be emphasized once more that frequency response is only one of a number of factors that determine the final listening quality of a high-fidelity system. Still, the results of such tests can be interesting, and are often revealing in some instances. The tests are relatively easy to run, and require only the two pieces of basic test equipment described; therefore, frequency-response testing might be a rewarding project for the audiophile who is anxious to learn more about his equipment and test instruments by using them in actual test situations.

FM ANTENNAS

Continued from page 21

corresponding to "FM/Q Sr." design.

3) Transmission lines: for 300 ohms, standard brown polyethylene flat ribbon 40 ft. long. For 72 ohms, standard RG-59/U coaxial cable of equivalent length.

Signal strength was observed directly on a sensitive vacuum-tube voltmeter connected in the tuner circuit to indicate maximum intensity of the signal voltage at resonance. Results are given in the table below.

Frequency	Station	Distance	300 Ohms	72 Ohms
87.7 Mc	WRGB-TV	97 miles	2.7 volts	2.75 volts
92.2	WFLY	84	2.5	2.5
93.1	WHYN-FM	27	3.3	3.4
95.7	WMMW-FM	28	3.4	3.3
96.4	WTIC-FM	17	3.5	3.2
99.1	WNHC-FM	38	3.3	3.2
100.7	WCOP-FM	78	2.5	2.4

It is obvious that the signal level was reduced very little by use of the 72-ohm line. The noise pickup, on the other hand, was very much less. It follows that the signal-to-noise ratio was substantially increased.

Summary

The previous discussion, together with the results of the performance tests, indicate that the 72-ohm line offers special advantages that have heretofore been overlooked. There are some advantages in the use of this line that cannot be obtained with any of the other systems. Coaxial cable, when used for transmission lines of less than 100 ft. in length, offers a better signal-to-noise ratio than can be realized with a 300-ohm balanced line. Additionally, 72-ohm cable is more resistant to effects of the weather, such as rain, salt spray, and snow or ice, all of which can cause severe attenuation of signal strength in the conventional 300-ohm line. Because the cable is both electrically and physically protected, it will outlast the usual "poly" line by many years.

Much of the insertion loss of the coaxial cable can, fortunately, be compensated for by a high-gain antenna capable of delivering a much greater signal voltage than the usual folded dipoles. The multi-element Yagi, such as the FM/Q design used in the tests, offers a maximum attainable gain which largely overcomes the higher insertion loss of the coax.

The predominantly high gain that can be realized with a well-designed Yagi (stacked if necessary), and open-wire line offering the least insertion loss, make this combination the best system that can be recommended to fringe listeners.

WOODCRAFTER

Continued from page 9

overloading the blade and, if the lumber is green, apply beeswax to the blade.

The Jig Saw

Despite a slight outward resemblance to the band saw, the jig saw is entirely different. As its name implies, the blade dances a jig of short up-and-down strokes. It is driven by a so-called pitman movement, which utilizes a connecting rod to convert a rotary motion to a reciprocating one.

The jig saw, or scroll saw as it is often called, is one of the safest and simplest of power tools to operate—even youngsters can learn to use it safely and correctly. The operator follows much the same rules of procedure as he does when using the band saw. This type of saw is designed primarily for internal and external irregular cutting, and for intricate scrollwork. The size of the machine is determined by the measurement of the throat: that is, the distance from the blade to the upright portion of the overarm. Popular home workshop sizes run from 18 to 24 in.; a 24-inch jig saw will cut to the center of a 48-inch circle. Cutting is done on the downward stroke, so the blade must be inserted in the chucks with the teeth pointing downward. Inverting the blade would cause the cutting action to take place on the upward stroke, and would produce tremendous vibration, with the stock being pulled away from the table. The back of the blade should rest lightly against the blade guide, which keeps it running true. Attached to the same rod as the blade guide is a forked piece of metal called the hold-down. This keeps the work from being lifted off the table on the up-stroke of the blade. The hold-down should always rest snugly on the stock while cutting.

There are many sizes and types of blades used on the jig saw. Generally speaking, the same rule applies here as with the band saw: always use the largest blade with the coarsest teeth that will cut the stock cleanly and also cut the sharpest curve in your pattern. For softwoods use a blade with fairly large teeth; for hardwoods use a blade with fine teeth. The following are the types of blades most commonly used:

1) Jigsaw blades—usually single-toothed and used for cutting wood. They are inserted in both upper and lower chucks.

2) Jeweler's blades—often called piercing blades; they are used for cutting metal. Must be attached to both chucks.

3) Saber blades—heavier, coarser blades for rapid cutting on thick stock, and for internal cutting where curves are not too sharp. Mounted in the lower chuck only.

The following chart indicates the proper blades for average jigsaw work:

As with the band saw, the table of the jig saw tilts to permit bevel cuts up to 45°. Two operations unique to the jig saw, however, are filing and sanding. Various shapes of files can be fastened

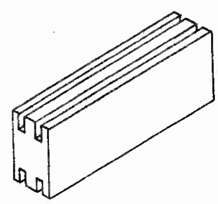


Fig. 3. Circular-saw kerfs for resawing.

in the lower chuck to provide a power file for smoothing all types of edges. Similarly, sanding attachments are available with curved and flat surfaces to suit the work.

The jig saw and the band saw are both versatile machines. Whichever you select, buy it with an eye to the future—get it large enough to handle the increased production which, in time, your experience will demand of it. And be sure to get a quality brand—there is nothing so irritating as to work with inferior power tools.

		BLADE			
MATERIAL	STOCK THICKNESS	TYPE	THICKNESS, INCHES	WIDTH, INCHES	TEETH PER INCH
Softwood	⅛ in. or less	Jig saw	.010	.045	18
Softwood	¼ in. or more	Jig saw	.020	.110	10
Hardwood	⅛ in. or less	Jig saw	.010	.055	16
Hardwood	¼ in. or more	Saber (straight cutting)	.028	.250	20
Jewelry Metals	Light work	Jeweler's No. 1/0			
Jewelry Metals	Heavier work	Jeweler's No. 2			

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Vernon 6534 — 1-10

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100 N. Western Ave.
Haymarket 1-6800 — 1-11

Allied Radio Corp.
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Davis 8-8822 — 1-11

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TW. 1-5871 — 1-5

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COpley 7-7530 — 1, 2, 4, 5, 8-10

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Detroit
Hi-Fi Studios
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Diamond 1-0894 — 1-6, 8-10

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Pass Christian
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185 or 301W — 1-5, 8, 9

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Jefferson 1-3110 — 1-10

St. Louis
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6383 Clayton Rd.
Parkview 1-6500 — 1-5, 9

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LO. 3-5840 — 1-11

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6-3538 — 1-6, 8-10

TENNESSEE

Kingsport
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CI. 5-1471; 5-2651 — 1, 2, 4, 6, 8-11

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Prospect 3-2312 — 1-5, 8, 9

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CApitol 2266 — 1-4, 8, 10

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Singer Electronics
1555 Third Ave.
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WISCONSIN

Milwaukee
The Hi-Fi Center, Inc.
4236 W. Capitol Drive
Uptown 1-2113 — 1-5, 9, 10

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Payette Radio Limited
730 St. James West
UNiversity 6-6681 — 1-11

Toronto
Electro-Voice Sound Systems
141 Dundas St., W.
EM. 8-7750-8301-8302 — 1-11

SIGNAL INJECTOR

Continued from page 23

less of load, because the injector will rarely be used in circuits for which the impedance is less than this. The frequency and wave form would also be stabilized by the permanent load.

Fig. 6 shows the output wave shape for 1 K, 10 K, 100 K, and 1.7 megohms (1.7 megohms happens to be the input

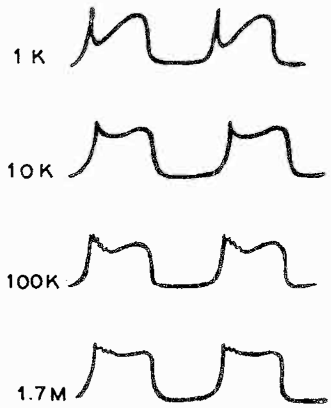


Fig. 6. Wave form at various load values.

impedance of our oscilloscope, which accounts for our maximum load value). The sound of this wave form is very much like that of a perfect 1-Kc square wave. Within limits it can be as useful in evaluating frequency response and stability.

Cost of parts for the signal injector: slightly less than $9.

GROUNDED EAR

Continued from page 5

and, since each one handles only a fraction of the output a single one would, the distortion of the speaker system is far below average. I have, I think, a good, sharp and experienced ear, and the sound of my system seems no worse to me at 5 watts than it does at 500 mw. For that matter, I often listen to it for hours at a time with peak output levels far in excess of 5 watts, and I have not experienced any of the fatigue which would be expected to accompany a badly distorting system.

Nevertheless, though I think my experience, reinforced now by that of others, does seem to indicate that a relatively low output level is sufficient for home listening, I want to urge caution in interpreting and applying this fragmentary evidence. Particularly, I caution against jumping to the conclusion that high-power amplifiers are unnecessary. There is some evidence that high-power amplifiers are better even at very low levels than low-power amplifiers. I myself hear a difference between my favorite 60-watt Golden Ear amplifier and the small 5-watt unit I designed to test the low-output theory, even when both are operating at 300-mw peaks. Two of my readers who measured both small and large amplifiers reported the same thing. Finally, I know of a most interesting experiment, using an ingenious (and, from an engineering standpoint, objective) method of measurement, which appears to demonstrate pretty conclusively that even extremely fine high-power amplifiers produce much higher amounts of distortion at relatively low levels than most of us imagined. I understand these experiments will be reported soon and I cannot, in justice to the researchers, anticipate their publication. But if the implication is correct, it would appear that even a 50-watt amplifier is none too good, even at home levels.

This may not be at all inconsistent with our own findings. It is conceivable that, although an output of 5 watts is the maximum needed for a high degree of realism in the home, it takes a 50-watt amplifier to deliver that 5 watts with sufficiently low distortion to make the 5 watts real and tolerable. As a matter of fact, this has long been a rule of thumb in the broadcast industry.

At any rate, the question of How Much Power Output will still be a question for some time apparently, for, even if our reports that the loudness provided by less than 5 watts is sufficient turn out to be true and representative, it still leaves unanswered the question of how much sine-wave power output an amplifier must be capable of to deliver a tolerable and undistorted 5 watts of complex musical wave form.

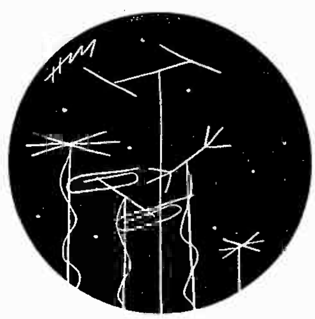
SOUND FANCIER

Continued from page 27

such that nothing seems to exist between the performance and oneself but some space and air. As far as I'm concerned, greater technical praise than this can't be given to anything in all audio.

And Just Good Music

But nowhere in all music is there balm for one's soul as well as for one's ears to match Mozart's. I've been listening with



inexpressible gratification to four early quartets by the New Music Quartet

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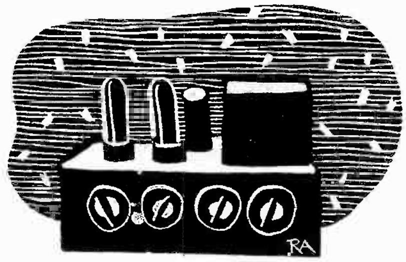
Abbreviations

Following is a list of terms commonly used in this magazine, and their abbreviations. The list is arranged in alphabetical order.

alternating current	AC
ampere, amperes	amp, amps
amplitude modulation	AM
audio frequency	AF
automatic frequency control	AFC
automatic gain control	AGC
automatic volume control	AVC
capacitance	C
cathode ray tube	CRT
characteristic impedance	Z_o
current	I
cycles per second	cps
decibel	db
decibels referred to 1 milliwatt	dbm
decibels referred to 1 volt	dbv
decibels referred to 1 watt	dbw
direct current	DC
foot, feet	ft.
frequency	*f*
frequency modulation	FM
henry	h
high frequency	HF
impedance	Z
inch, inches	in.
inches per second	ips
inductance	L
inductance-capacitance	LC
intermediate frequency	IF
intermodulation	IM
kilocycles (thousands of cycles) per second	Kc
kilohms (thousands of ohms)	K
kilovolts (thousands of volts)	KV
kilowatts (thousands of watts)	KW
low frequency	LF
medium frequency	MF
megacycles (millions of cycles) per second	Mc
megohms (millions of ohms)	MΩ
microampere (millionth of an ampere)	μa
microfarad (millionth of a farad)	μfd
microhenry (millionth of a henry)	μh
micromicrofarad	μμfd
microvolt (millionth of a volt)	μv
microwatt (millionth of a watt)	μw
milliampere (thousandth of an ampere)	ma
millihenry (thousandth of a henry)	mh
millivolt (thousandth of a volt)	mv
milliwatt (thousandth of a watt)	mw
ohm	Ω



permanent magnet	PM
potentiometer	pot
radio frequency	RF
resistance	R
resistance-capacitance	RC
resistance-inductance	RL
revolutions per minute	rpm
root-mean-square; effective value	RMS
synchronous, synchronizing	sync
television	TV
ultra high frequency (radio)	UHF
vacuum-tube voltmeter (multipurpose)	VTVM
vacuum-tube voltmeter for AC measurements only	AC VTVM
variable reluctance	VR
very high frequency (radio)	VHF
volt	v
volt-ampere	va
voltage, or potential difference	E
volts, center-tapped	vct
watt	w

SOUND FANCIER

Continued from page 37

(Columbia ML 5003); the four last ones by the Budapests (Columbia SL 228); two of the greatest piano concertos, K. 466 and 503, by Gieseking with the Philharmonia Orchestra under Rosbaud (Angel 35215); and four horn concertos by James Stagliano with the Zimbler Sinfonietta (Boston 401). I know theoretically that some technical comments are in order. I might point out, for example, the appropriate differences in acoustical environment for the NMQ's light but champagne-like style in the diverting early works and for the Budapests' more richly romantic approach to the big late ones; I might praise, too, the skill of Angel's engineers in maintaining perfect tonal equilibrium as well as contrast between the full-bodied orchestra and Gieseking's pearly pianism; and I surely should call special attention to the astonishingly warm yet pure acoustics of the new Kresge Auditorium at M.I.T., which are heard for the first time on records in the Boston horn-concerto disc. But — fanatical hi-fi demonstrator that I am — for once I'm willing to let the engineers and equipment play subservient roles to the performers, as they do in turn to the composer. These are demonstration discs too, but what they demonstrate best is the inexhaustible wellspring of Mozart's musical imagination. And nothing in all sonic drama can be more exciting and profoundly satisfying than that.

TAPE NEWS

Continued from page 13

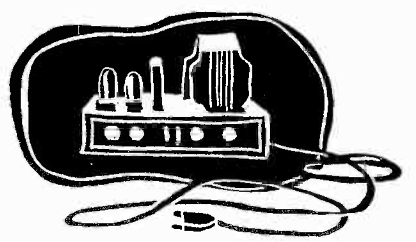
output. Then, on future occasions, the test results with the same test tape and same playback volume-control setting will indicate whether or not any part of the playback circuit is beginning to deteriorate. If the output is found to deviate widely from the original figure, steps can be taken to track down the trouble. It is rarely that a component in a tape recorder will suddenly fail without warning; it will more likely begin by deteriorating gradually, and the output level check will show this up before the component has had time to fold up completely.

The standard zero-db test signal can also be used for checking the bias setting on a recorder, within fairly wide limits. Most tape recorders have their record level indicators so adjusted that they will read full modulation when they are recording at the standard zero-db level. Consequently, a tape recorder that is functioning properly will play back a 400-cps tone that was recorded on it at "normal" volume-indicator reading at exactly the same level as it plays the standard test tone. A wide deviation between the playback level of the standard tone and one recorded at full level on the machine in question may indicate a failing component, an inaccurate record level indicator, or incorrect bias current adjustment for the brand of tape being used. (High-output tapes will always give a much higher reading on playback than will standard tapes, so this comparison is invalid as far as they are concerned.)

The third performance check should be another over-all frequency-response run, to observe the results of any changes that may have been found necessary as a result of the previous tests.

If the bias current was changed, it may be necessary to adjust the record equalization to correct for response deviations at the high end. In a recorder lacking such variable equalization, the bias current may be juggled to hit a compromise between low distortion and extended high-frequency response. Many recorder manufacturers recommend setting the bias for peak output from the tape, but I have found that distortion can be reduced significantly by adjusting the bias to a slightly high setting — just enough to cause a ¼- to ½-db reduction in level from the tape. This will produce a slight high-frequency loss, but any recorder that will benefit from the slight reduction in distortion is also likely to include a means of compensating for this loss.

Finally, after the recorder has been brought to the peak of its electrical performance, the transport mechanism (under the motor-board panel) should be cleaned, wiping all idler drive surfaces with alcohol and cleaning all metal drive contact surfaces with carbon tetrachloride (while holding your breath, in a well-ventilated room). Then the braking surfaces should be wiped clean with alcohol, and the braking and reel-holdback tensions



should be checked against the values recommended in the recorder's service manual. For this purpose, one of those little spring scales that are used for weighing mail will come in handy. A scale calibrated up to 25 oz. should serve the purpose.

Finally, if the instruction manual indicates that any of the bearings should be oiled at this time, follow the instructions. Be careful not to over-oil any of the bearings, and wipe all excess oil

Continued on next page

TAPE NEWS

Continued from preceding page

away with a lintless cloth. Be particularly careful not to get oil on the drive surfaces; this will cause serious speed variation and may even stall the unit right in the middle of an important recording project.

For those who intend to keep a recorder for more than five years, it is also a good idea to return it to the manufacturer every two years for a complete factory overhaul. This is the best guarantee a recordist can have that his unit will always be working as well as when new.

READERS' FORUM

Continued from page 15

need to be urged to keep high performance in mind.

I object to modern design only when it interferes with function. Should we not be able to obtain an accurately graduated frequency scale, AVC, tuning meter, high sensitivity, coverage of the FM- and TV-frequency bands, and, on AM, good selectivity, variable IF bandwidth and RF gain, as well as such important items of modern design as block letters and gold-plated knobs?

Perhaps the most effective way to convince the manufacturers of the error of their ways would be not to buy their products until the minimum requirements of design have been satisfied. How is the manufacturer to know what to do when he and all of his competitors are doing the same thing? It would seem to be up to the public, through letters to the editor and people like Mr. Marshall, to tell them what is wanted and to encourage them to be different.

May I close by saying that I have always enjoyed the articles by Mr. Marshall.

Frederick Kavanagh
Indianapolis, Ind.

Gentlemen:
I am not a "letter to the Editor" writer, but I feel disposed to let you know how much I enjoy your magazine. I subscribe to several electronics magazines and am an avid reader of them on anything pertaining to audio craft. I have no technical engineering training to fit me for this, the most fascinating hobby that I have found in 50 years, but I am gradually absorbing knowledge. If I had to confine myself to one instead of 5 magazines in this field today, it would be yours. I have subscribed for one year only, because I doubt if you can keep the standard you have set. I hope you can, and you will find me among your longer-term subscribers if you do.

Lionel C. Holm
Arlington, Va.

We see no apparent reason why we should not maintain our standard. Who knows, we might even manage to improve with time. We hope Mr. Holm will be with us for many years to come. — Ed.

TRADERS' MARKETPLACE

Here's the place to buy, swap, or sell audio equipment. Rates are only 20¢ a word (including address) and your advertisement will reach 20,000 to 35,000 readers. Remittance must accompany copy and insertion instructions.

MAKE $100 WEEKLY spare time with your tape recorder. Send 25c refundable. Valentine Sound, 4253 Farmdale, North Hollywood 5, Calif.

SALE! Moving to new quarters. Big reductions on entire stock of guaranteed, new equipment. Send us your list of desired components for our price quotations. Monmouth Music House, Box 432A, Freehold, N. J.

RECORDED TAPE MUSIC, recording tape, accessories, discounts. Efsco Sales, 270-S Concord Ave., West Hempstead, N. Y.

WANT A VERY LOW RESONANCE SPEAKER? Ask your dealer to demonstrate the Racon floating cone, foam suspension. Or write for literature and prices to Racon Electric Co., 1261 Broadway, New York 1, N. Y.

RECORDS FROM YOUR TAPES. Finest professional equipment. Low prices. Free information. Valentine Sound, 4253 Farmdale, North Hollywood 5, Calif.

PROFESSIONAL RECORDING SERVICE: Tapes made, copied, masters cut, processed, pressings made — short runs our specialty — all AMPEX 300's, Telefunken and Altec, HYDROFEED Lathes, monofusion presses. Components Corporation, 106 Main St., Denville, N. J. Phone: Rockaway 9-0290.

ADVERTISING INDEX