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The Grounded Ear

by Joseph Marshall

Narrow-Spaced Stereo Recording

Last fall the Fenton Company introduced new models of the B&O ribbon mikes, and with them, the *Binor Rig*, a device for mounting two microphones about one foot apart for stereo recording. The rig includes a sound-absorbent "acoustic separator", or baffle, between the two mikes. In use, the entire assembly is mounted on a single mike stand; the stand is set up in the center and in front of the orchestra, chorus, or other source to be recorded. The microphones are each mounted at roughly a 45° angle to the sound source. They have figure-8 pickup patterns and, when thus mounted, the forward pattern is similar to that shown in Fig. 1. The acoustic separator screens and absorbs much of the sound that would normally be picked up at the rear.

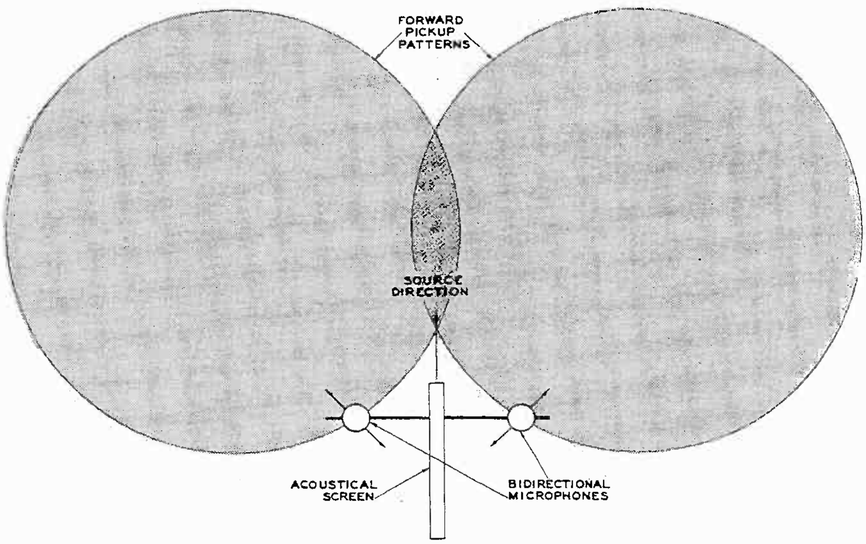
In the conventional two-channel stereo recording arrangement, the two mikes are separated from 6 to 40 ft., depending on the size of the group to be recorded. Obviously, the Binor Rig arrangement is much simpler, and amateurs especially would find it far more convenient to use. But does it work? Does it produce stereo sound? And how does it compare with the conventional wide-spaced pickup?

I received one of the first of these rigs, and turned it over to John Dougherty, a friend in Knoxville who records the Knoxville Symphony in stereo at every concert, and also does a great deal of recording of other musical groups. He has made recordings of the same group and music with the narrow-spaced Binor Rig and with the conventional wide spacing. His results are very interesting.

The Binor Rig does, in fact, produce a stereo recording. There is a clear directional effect. There is also the same spreading out of the sound source as in the wide-spaced type of stereo. The gain in presence of the sound is also similar.

There are some differences. Whether these are for better or worse will, I think, depend on personal preference. For one, wide-spaced stereo recording can produce an apparent gap or hole in the middle; with the narrow spacing such gapping is minimized. For another, the directional effects are not as marked with the narrow spacing as with the wide spacing. As far as I am concerned, this is an improvement. I find exaggerated directional effects both distracting and fatiguing. On the other hand, one stereo effect tends to be compounded for the worse with narrow spacing, and that is the effect of some solo instruments, especially horns or voices, jumping or crossing over from one channel to the other. This could be minimized, I believe, by seeing to it that the soloist is a little more off-center than he usually is, or — even more simply — by moving the Binor Rig off-center when a soloist is involved.

Fig. 1. Forward pickup pattern of Binor Rig. Mikes are set at 45° angle to sound source.



To summarize, the narrow mike spacing does give a stereo effect, but (with the exception noted above) results in less stereophonic exaggeration and better homogeneity.

I like the narrow-spaced results better. It seemed to me to provide enough of the enhancement of stereo to make the complication worth while, without paying so high a price in distractions and aberrations. It also seemed to me to result in a more realistic sound. I listen to a live orchestra from at least 50 ft. away. At that point there is little directionality, certainly far less than that engendered by the usual wide-spaced stereo recording, which seems to me to provide a perspective more nearly that of the conductor of the orchestra or that of a listener in one of the front seats of an auditorium. In any event, I commend the Binor Rig to stereo recordists, both amateurs and professionals. And I am convinced that, before committing itself definitely and irrevocably to wide-spaced stereo recording, the industry ought to give narrow spacing a thorough test.

That brings up a matter of theory. An AES paper describing the B&O mikes and the Binor Rig raised an interesting point. The paper suggested that the real virtue of multichannel reproduction was not in providing true stereophonic sound (that is, directional sound) but in widening the apparent sound source and eliminating the hole-in-the-wall effect. I am inclined to agree, especially now that I have had a taste of the narrow-spaced reproduction produced by the Binor Rig. Readers of this magazine may recall that in one of the first issues of this column I questioned whether "directionality" was necessary to a proper appreciation and enjoyment of music, and pointed out that, on the contrary, exaggerated directional effects tend to distract the ear from the music, and to produce a listening perspective which is unreal except to those accustomed to sitting very close to or in the middle of the orchestra. A year and a half of additional listening to stereo reproduction has strengthened my first opinion on this matter. Pronounced directional effects are startling and awe-inspiring when first heard, but to enjoy the music one has to learn to overlook them, and this requires a mental adjustment likely to produce fatigue.

On the other hand, there is no denying the improvement in over-all sound quality which comes from spreading the sound source and reproducing the original acoustical environment. By using two channels, even very simple systems can provide a spaciousness of sound which is almost impossible to achieve with the most elaborate and expensive single-channel systems. Also possible is an improvement in definition and clarity, and accordingly a better apparent separation of individual instruments. It seems to me that it would be wise to concentrate on these aspects of multichannel sound reproduction, and to forget most of the directionality, which is not essential information and can be distracting. Three-channel stereo tends to close up the gap in the middle and to reduce the prominence of directional effects. The closely spaced two-channel system appears to achieve a similar end with simpler means.

EL84's Taking Over

When the EL84 tube was first introduced in this country I said in this column that I wouldn't be surprised if it caused a revolution in commercial amplifiers of 15 watts or less. It isn't often that one has the opportunity to see inside the crystal ball so clearly; the revolution has occurred, and the EL84 has pretty largely taken over its field. The new power-amplifier designs are, for the most part, in two categories: 1) those in the high-power class, utilizing the 6CA7/EL34; 2) those in the under-20-watt class, using the EL84. Among the new EL84 amplifiers are the Fisher 20-A, the Bogen DB115, the Electro-Voice A15, and the Pilot AA903B. Others are on the way. These amplifiers are replacing both the 15-to-20-watt Williamson types using 5881's, 6L6's, KT66's, etc., and the least expensive 10-watt class using 6V6's. Perhaps more significant is the fact that many of them include integral preamplifiers and control units, providing on one chassis the entire electronic portion of a hi-fi system. Moreover, these integrated units are generally far more satisfactory than previous combinations; much of this success is due to the excellent characteristics of the EL84.

The new power-amplifier circuits are basically similar, although there are many differences in detail. A pentode or high-mu triode amplifier is used as an input stage. This is directly coupled to a phase inverter, which drives the

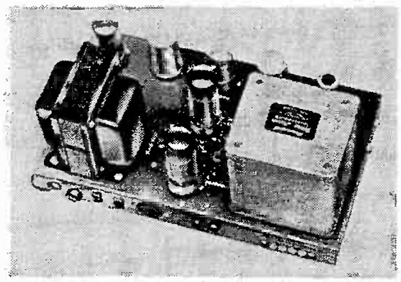
Continued on page 48

Audionews

EICO POWER AMPLIFIER

Featuring the Acro TO-330 output transformer, the *HF60* power amplifier is one of the most recent units in the EICO line. As other EICO products, the new amplifier is available either in kit form or factory assembled.

Rated power output of the HF60 is 60 watts (130 watts on peaks). IM distortion (60 and 6,000 cps at 4:1) is said to be less than 1% at 60 watts, and less than 0.5% at 50 watts. Harmonic distortion is stated to be less than 0.5% at any frequency between 20 and 20,000 cps within 1 db of 60 watts. Sinusoidal frequency response at 60 watts is said to be ±0.1 db from 16 to 90,000 cps.

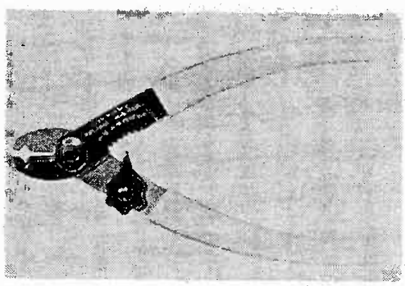


New EICO 60-watt power amplifier kit.

Price of the HF60 in kit form is $72.95. Prewired, the HF60 costs $99.95.

WALSCO STRIPPER-CUTTER

Recently added to the Walsco line of TV-radio servicing aids is the wire-stripping and clipping tool, the *Strip-Er-Clip*. The new tool features a 7-stop gauge which adjusts instantly to the correct wire size. Setting this gauge to protect against damaging wire conductors or strands is done with the thumb. The "Strip-Er-Clip" strips and clips all wires ranging from 14 to 26 gauge.



A combination wire stripper and cutter.

TRANSISTOR MANUAL

The General Electric Company has announced publication of a booklet entitled *Transistor Manual* containing basic information on transistors and their operation in circuits.

The General Electric *Transistor Manual* includes information on basic semiconductor theory, construction techniques used to make various types of transistors now on the market, basic principles of transistor circuit design, and specifications, with outline drawings, of all transistors registered with the Radio-Electronic-Television Manufacturers Association.

The booklet also contains complete explanations of transistor parameter symbols now in common use. Nineteen circuit diagrams ranging in complexity from a simple one-transistor audio amplifier to a six-transistor superheterodyne broadcast receiver are included with complete parts list for the hobbyist and experimenter. A cross-reference chart for replacement of transistors in current transistorized radios of all manufacturers is also included.

The new GE booklet is priced at 50¢. It may be obtained by writing to the Semiconductor Products Department, General Electric Company, Syracuse, N. Y., or from local General Electric tube and transistor distributors.

NEEDLE TESTER

A laboratory report on the condition of your phonograph needle can now be obtained without removing the needle from the cartridge. This can be accomplished with the Duotone *Needle Tester* now being supplied free of charge.

The needle tester is made of a special material. The test card is placed under the needle, and the needle is pressed gently into the test area of the card. The card is then sent to the Duotone Corporation in Keyport, N. J., where the impressions are analyzed and a report written.

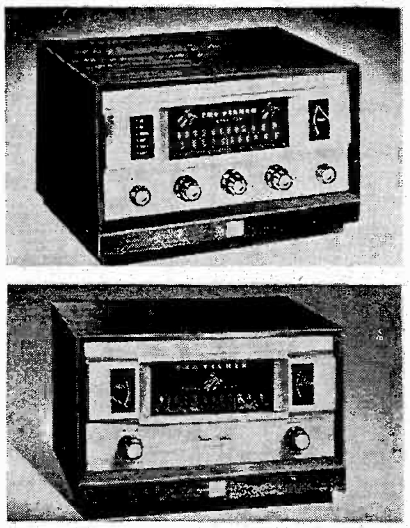
The free Duotone Needle Test Card can be obtained from record dealers, or one will be furnished on request to the manufacturer.

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.

NEW FISHER ITEMS

Fisher Radio Corporation has announced two additions to its line of high-fidelity equipment.

The *Fisher 500* is a complete radio receiver on one chassis. It includes an FM-AM tuner, audio control center, and 30-watt amplifier. The "500" features a meter for accurate tuning. Its 30-watt amplifier is said to have uniform response from 16 to 32,000 cps and is reported to be able to handle up to 60-watt peaks.



Fisher's new 500 tuner-amplifier, top, and FM-90X super-sensitive FM tuner.

There are four inputs on the unit, including a separate tape-playback preamplifier-equalizer. Output impedances are 4, 8, and 16 ohms. In addition, there is a recorder output. The "500" includes a built-in loop antenna for AM and a built-in dipole for FM reception.

Price for the "500" is $239.50. Blond

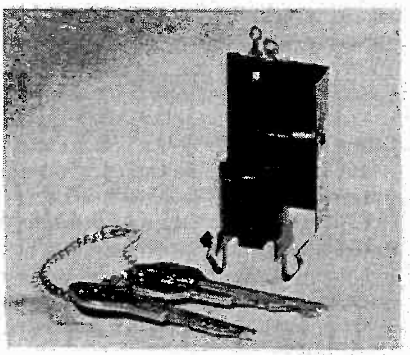
and mahogany cabinets are available optionally for $19.95.

The second new Fisher unit is the *FM-90X* FM tuner. Advertised as being extremely sensitive, the FM-90X is priced at $169.50. Fisher "Dual Dynamic Limiters" are said to provide complete AM noise rejection at all times, regardless of signal strength. Two meters are provided to aid in tuning; one indicates signal strength and the other indicates center of channel.

Mahogany and blond cabinets for the FM-90X are available optionally for $17.95. Prices are slightly higher in the Far West.

GERMANIUM TV RECTIFIERS

The Semiconductor Products Department of the General Electric Company has announced the development of three germanium rectifiers specifically designed



GE's germanium power-supply rectifier.

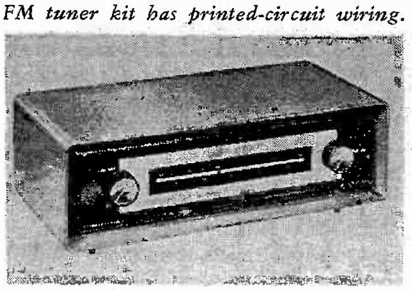
for television power-supply applications. Types 1N573 and 1N575 are half-wave rectifiers, and Type 1N581 consists of two germanium junction rectifiers connected in a voltage-doubler configuration. Extremely low forward voltage drop is said to provide a higher DC output than any other type of rectifier. A lower surge resistor is required, and this provides additional output voltage.

The new rectifiers are expected to eliminate servicing problems due to rectifier failure. The new rectifiers are reported to have a life greater than that of a TV set.

KNIGHT FM TUNER KIT

Allied Radio Corporation, exclusive distributor of Knight-Kits, has announced release of a new FM tuner kit. Printed-circuit wiring is said to speed and simplify assembly of the kit. All leads of

FM tuner kit has printed-circuit wiring.



critical length or position are prewired on the printed-circuit board. RF coils are preadjusted and should require no further alignment after the kit is assembled.

Two output jacks are provided. One can be used to feed an amplifier, and the other a tape recorder for off-the-air recording of FM broadcasts. The cathode-follower output circuit permits the use of long cables from these jacks without loss of treble or volume. Sensitivity is said to be 10 μv for 20 db quieting at any point on the FM band.

Price of the kit, including all parts, tubes, the cabinet, and complete instructions is $37.75.

TAPE BOOKLET

Which magnetic tape is the right one for a specific recording job is the subject of a new pocket-size folder supplied free on request from Minnesota Mining and Manufacturing Company. The booklet describes the characteristics of six different types of Scotch brand magnetic recording tapes and how each type is used.

ACOUSTIC INSULATION KITS

The Fibre Glass-Evercoat Company of Cincinnati has announced the development of a kit for lining interiors of radio-phonograph consoles, TV sets, and speaker cabinets. The lining material, made of Owens-Corning Fiberglas, is recommended for use on all inside portions of the cabinet except front panels. The acoustic insulation material is also excellent for use as a lining in record-changer compartments for elimination of motor noises.

The company is offering two kits. The $1.00 kit contains nine square feet of ½-inch Fiberglas insulation, glue, and applicator. The $2.00 kit contains nine square feet of 1-inch Fiberglas insulation, glue, and applicator. Both kits are packaged in plastic bags. The insulation material is also available in bulk and can be used for other insulating purposes in the home and workshop.

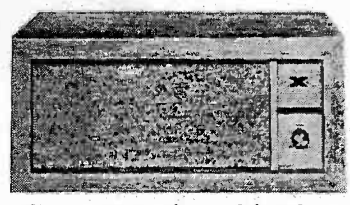
EDITALL SPLICING KIT

A new EdiTall kit for splicing magnetic recording tape is being sold through dealers of recording equipment at a list price of $8.95. The kit contains a splicing block, marker pencil, cutting blades, splicing tape, and an instruction booklet written by CBS tape editor Joel Tall.

XOPHONIC SOUND SYSTEM

The Xophonic sound system (Craftsmen *Model CX-17*) is a device to provide a delayed second source of sound. The Xophonic can be added to any sound system, whether it be radio, phonograph, or tape.

The Xophonic input is connected directly across the terminals of the existing speaker. It is not necessary to alter the connection between the amplifier and existing speaker, nor to make any other changes in an existing system, according to the manufacturer. The signal entering the Xophonic is passed through a time delay device. After this, it is amplified by the internal Xophonic am-



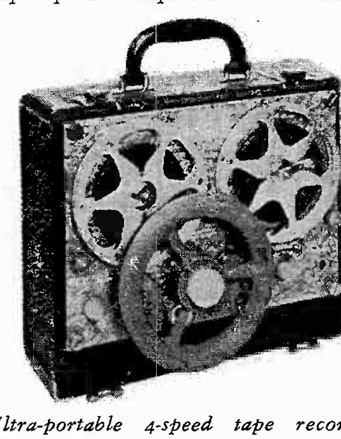
Auxiliary unit produces delayed sound.

plifier and applied to the built-in speaker. The output from the Xophonic sound system, in conjunction with the undelayed sound from the existing speaker, is said to produce a "concert-hall" effect.

PORTABLE TAPE RECORDER

Amplifier Corp. of America is now producing a 4-speed Magnemite tape recorder. This is the latest in the Magnemite line of portable, miniaturized, battery-operated, spring-motor recorders. Two models are currently available, one meeting both primary and secondary NARTB standards for flutter, wow, frequency response, and dynamic range; the other meeting secondary NARTB standards only. Tape speeds of 15, 7½, 3¾, and 1⅞ ips may be obtained from *Model 610 EM*, whereas *Model 610 DM* is adaptable for tape speeds of 7½, 3¾, 1⅞ and 15/16 ips.

Measuring 7 in. wide, 10 in. high, and 11 in. long, the 4-speed Magnemite weighs only 15 lbs., including self-contained inexpensive flashlight batteries that are said to last 100 operating hours. Tape speed is reported to be constant



Ultra-portable 4-speed tape recorder.

over the full winding cycle, with flutter of ±0.1%. Quick change of speeds is accomplished by changing capstans. Equalization for different speeds is automatic.

Complete technical specifications and prices for the 4-speed Magnemite will be furnished on request.

TIPS FOR THE WOODCRAFTER

by George Bowe

Building In, Part I

When you see a speaker set into a wall, a sliding panel that reveals an FM-AM tuner, a turntable that swings out of the side of a closet, or a TV screen that seems to hang on the wall like a picture frame, do you wish you could duplicate such installations in your own home, but feel that your skill and ability aren't up to the job? Well, some of these installations are the design of architects and the work of professional craftsmen; but many are the handiwork of amateurs who have had the courage to cut into an existing wall or to create a new one to house the equipment.

However, operating on a wall should not be done hit or miss. A knowledge of house construction and careful planning are essential to any major built-in project. Let's have a look at the fundamentals of house construction, beginning with definitions of some of the common terms which may present themselves during alterations.

Beam: a large supporting member, either solid or built up from planks on edge, usually found beneath the floor.

Bridging: wood strips used for bracing between joists or other members.

Foundation: the support, usually masonry, upon which a house rests.

Girder: a main beam that takes the place of an interior foundation wall and supports the inner ends of the first-floor joists. Girders usually carry one-fourth the weight of the building.

Joist: one of the planks set on edge and used to carry the weight of the floor and ceiling. The ends of joists are usually held by girders, beams, or bearing walls.

Partition: an interior wall that creates rooms within the house. There are two types of partitions — bearing and nonbearing. A *bearing* partition runs at right angles to and supports the ends of joists. In other words, it supports an overhead load. A *nonbearing* partition serves only as a room enclosure and supports nothing above it. Because of economy in construction, bearing partitions are put directly over one another as well as above the supporting girder.

Plate: a structural member supported horizontally on the top ends of the studs, and directly carrying the rafters.

Sill: the horizontal structural member which rests directly upon the foundation and supports the framing uprights and the ends of the floor joists.

Sole: this is the supporting plate upon which the bottom ends of studs rest.

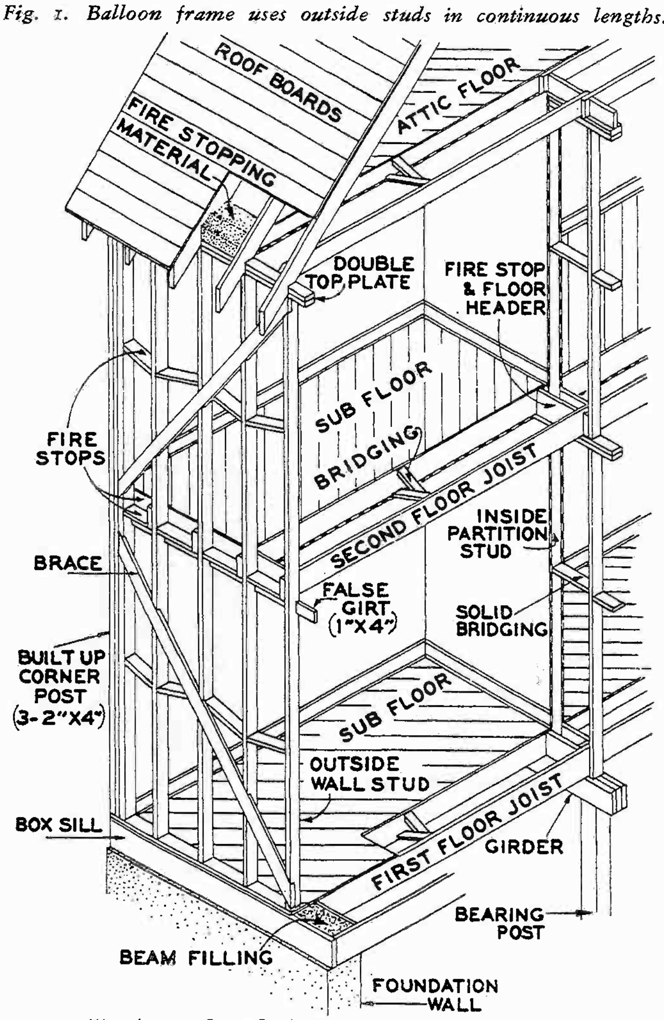
Stud: one of the vertical members (2-by-4) of outside walls and partitions used to support the weight of upper floors and provide a framework for sheathing and finish on both outside and inside.

These are only a handful of the many terms used in house construction, but knowing them can give you extra confidence when you start to construct or reconstruct.

A wood frame house is the most common and, in average construction, there are three general types: *balloon frame*, *western* or *platform frame*, and *braced frame*. In different sections of the country building procedures vary and, before any major alterations are made, it would be wise for the owner to determine the details of construction of his home. A local builder can advise him, or blueprints of the house, if available, will furnish the information.

There is a difference of opinion among builders as to the best type of framing to suit a given condition — economy usually dictates the method of construction. However, it is generally agreed that the frame of a house should be strong enough to carry its own weight

Fig. 1. Balloon frame uses outside studs in continuous lengths.



All drawings courtesy Weyerhaeuser Forest Products.

plus the weight of the floors, walls, roof, and movable items such as appliances, pianos, furniture, as well as people. It should be resistant to wind, rain (even earthquakes in some parts of the country), and able to carry loads of wet snow. In addition, it should be built to resist or reduce shrinkage and warpage, and it should be properly protected against fire hazards.

The distinguishing feature of balloon-frame construction (Fig. 1) is the outside wall studding (2-by-4) which runs in continuous lengths from the foundation to the attic floor. The ends of the second-floor joists are spiked to the sides of the studs and rest upon a false girt or "ribbon board" (usually a length of 1-by-4) that is notched into the inside edge of the studs.

In western or platform-frame construction (Fig. 2), each story is built as a separate unit. The first floor is built on top of the foundation walls as though it were a platform, the outer ends of the floor joists resting on the sills while the inner ends rest on a beam or girder. The sub floor is laid before the side walls are raised, then the wall and partition framing is run up another story to support a platform for the second floor. The attic floor consists of a third platform built upon the second-floor wall and partition framework thus making the whole house a series of platforms, each supported by independent partitions.

The studs in braced-frame construction (Fig. 3) do double duty in providing bearing surfaces for the outside walls and partitions, as well as supporting the structure. Studs of the side walls and center partition are cut to exactly the same length; the outside studs are attached at the bottom to the sill and at the top to the plate, while the partition studs are fastened to the girder and the plate. If a steel girder is used, this construction permits uniform shrinkage in the outside and inside walls.

Whichever type of construction has been used in your house, one of the most important considerations when planning a built-in for an existing wall is to determine whether the partition to be operated on is bearing or nonbearing. (The definition given earlier explains the difference.) The method of framing the opening depends on the burden of the partition. A bearing partition has a weighty responsibility which must be compensated for if studs are to be disturbed, so the question is how to tell if a partition is bearing or nonbearing. One simple method requires going to the basement and checking the location of the girder, or principal beam, of the house. The bearing posts, usually of steel or wood, support the girders. A partition above a girder is normally a bearing partition.

Another way to determine the type of partition involves lowering an electric light fixture in the ceiling of the room. Then, by seeing or feeling, determine which way the joists run. If they run parallel to the partition, it is nonbearing; if they are at right angles to the partition, chances are that it is a bearing partition. The attic is another good place to check. Wherever the ends of the joists rest is a bearing partition. If there is any doubt, seek professional advice.

When this phase of the preparation is completed, the next move is to start work. In next month's article we'll get up enough nerve to dig into the wall with the hope of leaving it more beautiful and utilitarian than we found it.

Fig. 2. Each story is separate unit in platform-frame construction.

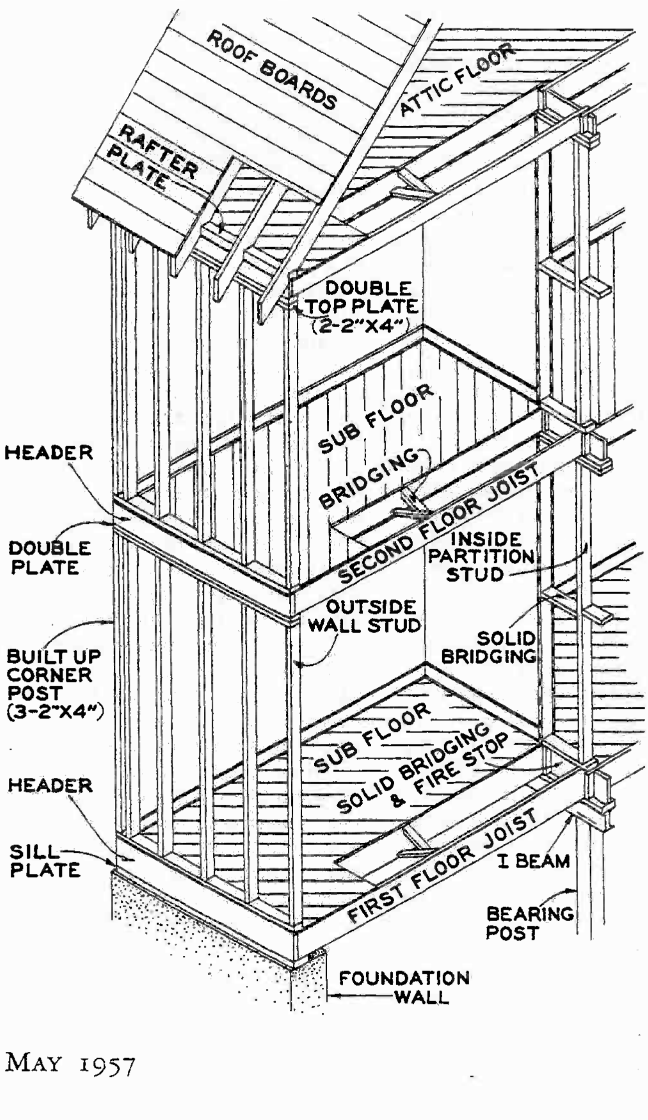
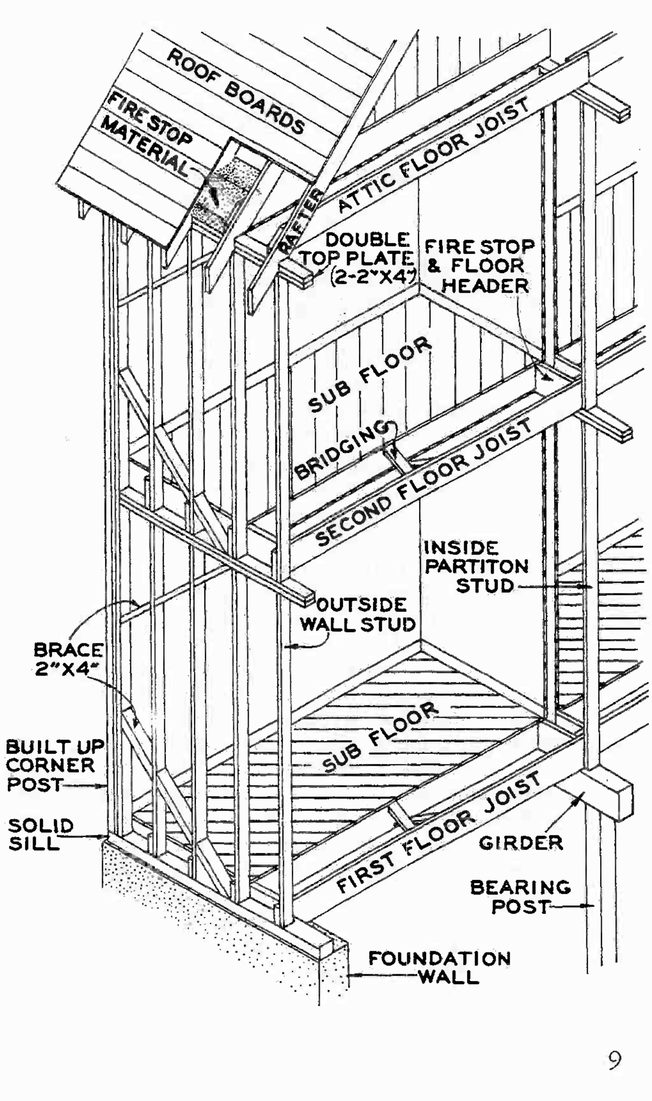


Fig. 3. Braced frame is adaptation of old New England type.



TAPE NEWS & VIEWS

by J. Gordon Holt

Don't Blame the Recorder

A letter from a perplexed reader of this column (actually, he was more apoplectic than perplexed, but no matter) contained three single-spaced typewritten pages of complaints about high hiss level from recorders. He went on to say that every recorder he had tried sounded as though it had a 20-db signal-to-noise ratio, and why wasn't something being done about this shameful state of affairs? My first reaction to this was, "Ah, he has found why critical tape recordists buy $1,000 recorders instead of $100 recorders," until I read the next paragraph of his letter. There he went on to say that he had tried Magnecord, Berlant, Presto, and Ampex machines and was contemplating trying another brand if I had any suggestions.

Something sounded wrong about this. Magnecord, Berlant, Presto, and Ampex recorders are not noted for excessive tape hiss, and I was beginning to wonder if the gentleman had ever demagnetized his tape heads.

The next paragraph (there were lots of them in his letter) started lambasting disc records. "Why," he asked, "don't

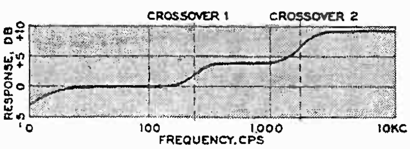


Fig. 1. Response curve of three-way system with balancing controls set too high.

the record companies do something about the excessive hiss and surface noise on records?" That rang the bell.

An inquiring letter to the outraged audiophile turned up the fact that he was using a three-way speaker system consisting of a 10%-efficient woofer, a 15%-efficient middle-range unit, and a 25%-efficient supertweeter — without attenuator controls. Consequently, his *speaker system* had a response curve vaguely resembling the unequalized RIAA recording characteristic. His middle range was up about 3 db over the bass end, and the supertweeter was running about 8 db higher than the woofer. Add to this the fact that his supertweeter was of a variety that is notorious for its wealth of sharp response peaks, and we can begin to understand why he was bothered by tape hiss and record blemishes.

I don't intend on this particular occasion to get into a dispute over loudspeaker efficiency or horns versus direct radiators, but it should be clear to anyone that a multispeaker system should produce balanced output over the audible range. Any system involving drivers of different efficiencies should be equipped with level controls, to enable the units to be matched in output. Omission of these controls, or their misadjustment when they *are* provided, accounts for more "tape-hiss" problems in the home than any other single factor.

There are really very few modern tape recorders that, when working properly, will generate offensive amounts of hiss over a smooth, well-adjusted loudspeaker system. A follow-up letter from my correspondent verified the fact that his system was no exception to this sweeping generalization; he added attenuator controls, balanced his speakers by means of a white-noise signal, and did away with his noise problems.

It may seem odd that anyone with an appreciation for music could listen to a system in such gross misadjustment without suspecting that something was wrong, somewhere, somehow. But when we consider the fact that many music listeners have never heard an orchestra in the flesh, this becomes a little more credible. Unless there is a ready standard for comparison between the real thing and the copy thereof, it is much too easy to fly off at a tangent and soup up the highs in the belief that hi fi, like medicine, must be unpleasant to be good. There is also a widespread belief that a multiway system with its brightness controls opened up can create the illusion of sitting in row A or even on the conductor's podium. This it will certainly do, because the closer we sit in the concert hall, the brighter the sound will be, but at the same time it will defeat whatever inherent smoothness may be designed into the speakers.

Fig. 1 shows what happens when we turn the balancing controls on a hypothetical system too high. If the frequency response of each driver is linear over its operating range (and the better the driver, the more linear it will be), its plotted response throughout its operating range will (obviously) represent a horizontal line. Consequently, when its balance control is turned up, that driver's output will increase throughout its entire range, introducing a step into the response curve at the crossover point. While the ear may superficially interpret the increased brightness as a closer listening position, it will also interpret the concurrent response steps as a series of peaks and dips, as shown in Fig. 2.

This is one of the things that can cause excessive tape hiss from a speaker system, but it is also the most convenient means for correctly adjusting a system.

Tape hiss normally consists of random energy distributed smoothly throughout the entire frequency range. If nothing in the system upsets this homogeneous energy, it will sound like the dipthong "sh", *lacking any definite pitch*, and being sufficiently subdued to ignore. If peaks are introduced by any of the reproducing equipment, these will put discontinuities into the noise distribution, imbuing the hiss or clicks or pops with

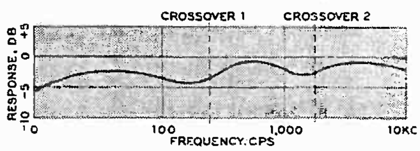


Fig. 2. The ear interprets response steps of Fig. 1 as a series of peaks and dips.

a definite recognizable pitch, and reducing the system's signal-to-noise capabilities. The ear does not, unfortunately, judge signal-to-noise ratio on an average basis; it concentrates on that frequency at which the hiss is loudest and compares the signal volume with the hiss at that frequency (which explains why a single tweeter peak can raise hob with a signal-to-noise-ratio specification). The ear behaves the same way when exposed to a response discontinuity or step (like the ones shown in Fig. 2), so if we can feed a uniformly distributed noise signal through a multiway system, we can use our ears to adjust it for optimum balance. Such homogeneous noise (dubbed "white noise" because it contains all frequencies, as white light contains all colors) can be obtained from an FM tuner set between stations, from a hum-free phono preamplifier set for microphone operation (without bass equalization or treble rolloff, and with a shorting plug inserted in the mike input), or from a blank tape.

Whatever the noise source, it should be used with all tone controls set for flat response, and at the same room volume that sounds "right" for speech reproduction. Start by turning the speaker's balance control or controls all the way off, and then stand (or sit) in your usual listening location while someone else slowly advances that control which covers the lowest secondary range. Advance this slightly beyond the point at which you begin to hear it through the roar from the woofer and listen to its effect on the woofer's sound. If the speakers are phased properly, there will seem to be an "inversion" of sound as the level of the upper range exceeds that of the woofer. The apparent peak at the woofer's upper limit will be replaced by a higher-pitched peak at the upper limit of the middle-range speaker, or by a predominance of highs if this is a two-way system. Then turn the balance control down again and bring it up slowly to the point where the woofer peak seems to disappear.

That completes the adjustment of a two-way speaker system. If there is also a supertweeter, this should then be slowly advanced until it, too, seems to predominate the system while the "inversion" should be carefully observed. If the supertweeter is set either too high or too low it can sometimes create the illusion of too much middle range. But don't be fooled — this will be caused by the middle-range response step that its misadjustment introduces. Turn the tweeter down again and bring it up to the point where it becomes barely audible through the rest of the hiss, or until the "step" between it and the middle drivers is minimized. A supertweeter with a savagely peaked response will make itself heard above the other drivers long before its average level is matched to the middle range, so it is better to leave such a tweeter set for a lower level than that required to eliminate the middle-range step.

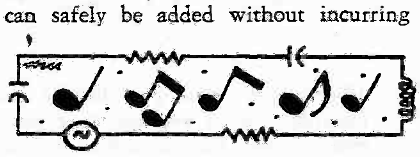
Finally, play several tapes through the system and refrain from touching the balance or tone controls until you've had time to become accustomed to the new and probably strange sound of the system. If the system was initially out of balance, there should be a marked reduction in tape hiss and in the raucousness of despised discs, but the relative lack of brilliance will probably be disappointing for a least a full week of listening.

If, after that time, you still insist on brighter sound, turn up the balance controls bit by bit, but remember what this will do to tape hiss. A recorder that is capable of a 50-db signal-to-noise ratio will put out an effective 40-db ratio if the tweeter is set 10 db higher than the woofer, and a sharp 10-db peak in the same tweeter (by no means an uncommon phenomenon) will further reduce the audible signal-to-noise ratio to 30 db. This is only a few db better than a typically mediocre 78-rpm disc, and the fact that the hiss is peaky will make it considerably more offensive to the ear than that 78-rpm disc playing through a smooth system.

As a matter of fact, the reduction in surface noise from a truly smooth speaker system can do amazing things to "scratchy" old 78's, converting their nerve-fraying surface hiss to a velvet-smooth overlay of fine graininess. The annoying effect of tweeter peaks on the clicks and pops from LP's was actually one of the major reasons why commercially recorded tapes were hailed as the audiophile's deliverance, because tapes are not subject to the scratching and dust contamination that spawns these noises on discs. Now that pickup cartridges have improved, records are packaged in plastic sleeves, and phonophiles have learned to care for discs, the commercial tape's only remaining advantages are indefinite wear-free life and applicability to stereophonic reproduction (which, it must be added, *are* advantages). Their surface hiss can be very low, but it's up to the reproducing equipment to exploit this. Excessive tape hiss can be the recorder's fault — but it usually isn't.

Another criticism sometimes unfairly directed at home tape recorders is that they suffer from poor high-frequency response. It is not uncommon for a home recorder to *sound* wide-range and lucid, and then to exhibit very poor high-frequency response on metered tests. Many a recordist has traded in a perfectly good machine (at considerable financial sacrifice) because of its measured inability to reproduce 10,000 cps, and has then been appalled to find the same shortcoming in the new recorder. Actually, there was nothing wrong with either unit. The trouble was in the test procedure, which failed to recognize the electrical characteristics of a tape recording.

Recording a 7½-ips tape to conform to the NARTB playback curve requires roughly 23 db of boost at 15,000 cps. The harmonic content distribution in natural sounds is such that this boost can safely be added without incurring



too much high-frequency overload, but the average energy distribution in natural sound bears no resemblance to the linear output from a frequency tone generator. If a response test is made with 1,000 cps set at "normal" recording level, the treble boost will begin saturating the tape as soon as the test frequency gets up beyond 5,000 cps at the same input level. Beyond satura-

Continued on page 46

by RICHARD D. KELLER

book reviews

Handbook of Semiconductor Electronics

Ed. by Lloyd P. Hunter; pub. by McGraw-Hill Book Co., Inc., New York: 544 pages; $12.00.

Here is a comprehensive guide and technical reference covering the physics, technology, and circuit applications of transistors, diodes, and photocells. Thirteen specialists in the field have contributed to this work intended for engineers and scientists concerned with the design and application of semiconductor devices.

In an attempt to collect in one place all the major principles in the field of semiconductor electronics, the editor has divided the book into four parts. Part I gives a description of transistor and diode action and the background physics of electrical conduction in solids. Part II is a survey of the technological processes used in transistor and diode fabrication. Although the many variations of basic processes are not covered, enough information is given so that one should be able to design and produce a satisfactory semiconductor device of average characteristics. In Part III, the detailed principles of transistor circuit design are given. The sections on low-frequency amplifiers and switching circuits are particularly well presented, with a wealth of technical design information. Part IV is an exceptionally thorough selection of background and reference material which includes sections on methods of analysis, a 68-page bibliography, and separate author and subject indexes.

That the industry is still in a state of some flux is indicated by the unusual transistor symbols, which are unique to this book, and by the terminology which varies to some extent from author to author.

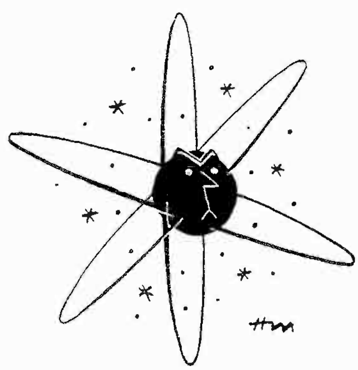
This is a fine work in a young and dynamic field.

All About Tape on Tape

Jack Bayha; narrated by Ed Condit; pub. by Tape Recording Magazine, Severna Park, Md.; duplicated by Livingston Electronic Corp.; 7-inch reel, 7½ ips, $6.95; 5-inch reel, 3¾ ips, $5.95.

Here's a most sensible approach to the subject of sound — a book well "illustrated" by the actual sounds and distortions it discusses. The tapebook is the first volume conceived, designed, and produced in the spoken rather than the written form. An audio engineer, Jack Bayha, wrote the continuity; and Ed Condit, radio and TV announcer, narrated the work. To get really into the mood of the thing, tape was used instead of letters for correspondence between author, publisher, and tape editor Don Rose, during production of the book.

What results is a work uniquely adapted to its subject. How, for instance, can a person ever comprehend the meaning of a decibel without actually hearing the difference which a certain decibel change makes in a musical passage? On this tape, a musical selection is played at normal level, and then at 3 db, 10 db, and 20 db below that level. Many people will be surprised by how little the volume is affected by a 3-db cut, and by how much sound is left after a 20 db cut. They will also be disappointed to find that 30- and



50-cps tones will probably be nearly inaudible on an average home machine when played back at the same level as easily heard 1,000-, 3,000-, and 5,000-cps tones.

The meaning of signal to noise is dramatically illustrated by musical passages with varying amounts of background hiss and noise. Undulating wow and warbling flutter are also brought home forcefully, as are overloading and nonlinear types of distortion.

Of course, some things are more easily explained graphically, as the physical meaning of head alignment and the appearance and internal differences of various types of microphones. These are treated in the 24-page illustrated booklet accompanying the tape reel.

All in all this package contains an enjoyable and informative hour for all tape enthusiasts.

Radio-Television and Basic Electronics

R. L. Oldfield; pub. by American Technical Society, Chicago: 342 pages; $4.95.

A young newcomer to the field of electronics will find this volume likely to whet his appetite for more.

About half of the book is concerned with giving a background of basic information on magnetism, capacitance and inductance, resonance, AC and DC, and electron tubes. The second half gives the broad-brush treatment to amplifiers, oscillators, microphones and loudspeakers, broadcast transmitters and receivers, high-fidelity systems and television, with a brief final chapter on transistors.

Most of the information is current and the many illustrations and diagrams are to the point. The descriptions, though simple, are clear — as, for example, the explanation of antenna systems, both transmitting and receiving types, and the explanations of television cameras and receiving tubes.

The cover of the book should certainly have received the benefit of more imaginative art work to build up the appeal to the younger generation of this basically good introductory work.

Hi-Fi Handbook

William F. Boyce; pub. by Howard W. Sams & Co., Inc., Indianapolis; 224 pages; $3.00; paper bound.

This is another of the general treatises on all phases of high fidelity.

Well illustrated with charts, diagrams, and photographs, it has particularly good coverage of loudspeakers and enclosures and modern amplifier circuits. A number of present-day commercial diagrams are given, along with discussions of high-fidelity equipment standards. Mathematics is almost completely avoided, for this volume is intended primarily for use in planning, selecting, and arranging an integrated system of properly related components.

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By Choosing the Heathkit Components
That Best Suit Your Particular Needs.

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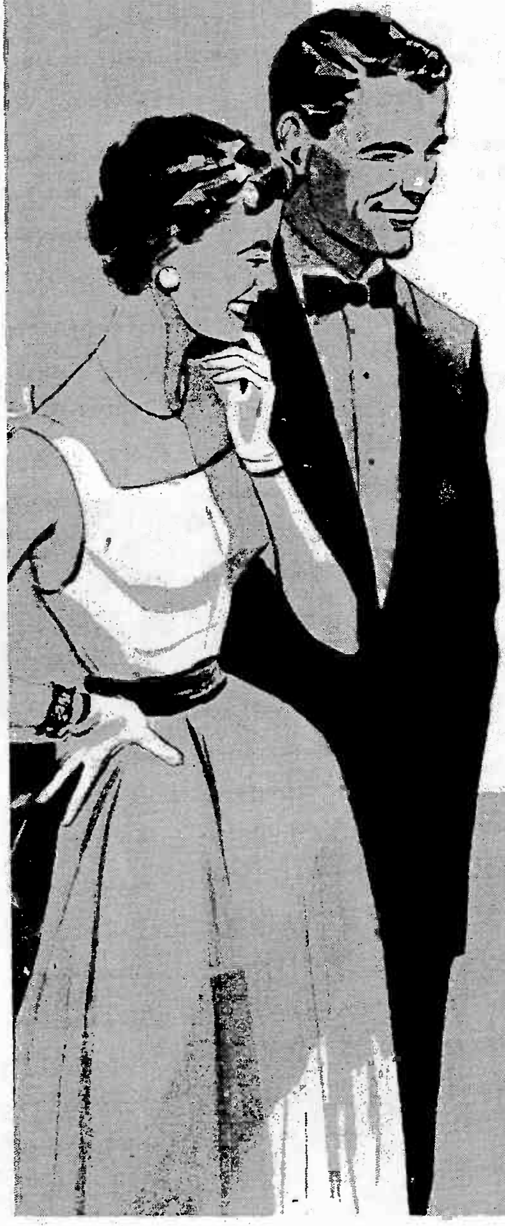
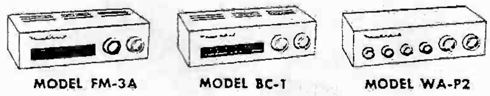
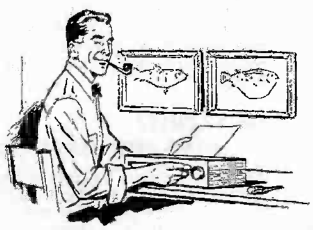


MATCHING CABINETS . . .
The Heath AM Tuner, FM Tuner and Preamplifier are housed in matching satin-gold finished cabinets to blend with any room decorating scheme. Can be stacked one over the other to create a central control unit for the complete high fidelity system.





PRE-ALIGNED TUNERS . . .
A unique feature of the Heathkit AM and FM Tuners is the fact that both units are pre-aligned. A signal generator is not necessary! IF and ratio transformers are pretuned at the factory, and some front-end components are preassembled and pretuned. Another "extra" to assure you of easy kit assembly.

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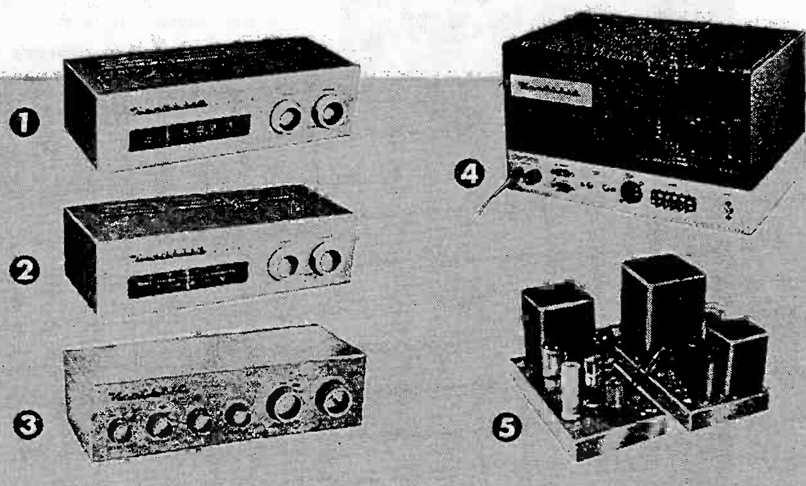

HIGH FIDELITY SYSTEM

1 HEATHKIT HIGH FIDELITY FM TUNER KIT Features AGC and stabilized, temperature-compensated oscillator. Sensitivity is 10 microvolts for 20 db of quieting. Modern circuit covers standard FM band from 88 to 108 mc. Employs ratio detector for efficient hi-fi performance. Power supply is built in. Illuminated slide rule dial for easy tuning. Housed in compact satin-gold enamel cabinet. Features prealigned transformers and front end tuning unit. Shpg. Wt. 7 lbs.

MODEL FM-3A Incl. Excise Tax (with cab.) **$25.95**
$2.60 dwn., $2.18 mo.

2 HEATHKIT BROADBAND AM TUNER KIT This fine AM Tuner was designed especially for use in high fidelity applications, and features broad bandwidth, high sensitivity and good selectivity. Employs special detector circuit using crystal diodes for minimum signal distortion, even at high levels. Covers 550 to 1600 kc. RF and IF coils are prealigned. Power supply is built in. Housed in attractive satin-gold enamel cabinet. Shpg. Wt. 8 lbs.

MODEL BC-1 Incl. Excise Tax (with cab.) **$25.95**
$2.60 dwn., $2.18 mo.

3 HEATHKIT HIGH FIDELITY PREAMPLIFIER KIT This preamplifier meets or exceeds specifications for even the most rigorous high fidelity applications. It provides a total of 5 inputs, each with individual level controls. Hum and noise are extremely low, with special balance control for absolute minimum hum level. Tone controls provide 18 db boost and 12 db cut at 50 cps, and 15 db boost and 20 db cut at 15,000 cps. Four-position turnover and four-position rolloff controls for "LP", "RIAA", "AES", and "early 78" equalization. Derives power from main amplifier, requiring only 6.3 VAC at 1A and 300 VDC at 10MA. Beautiful satin-gold enamel finish. Shpg. Wt. 7 lbs.

MODEL WA-P2 (with cab.) **$19.75**
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4 HEATHKIT ADVANCED-DESIGN HI-FI AMPLIFIER KIT This fine 25-watt high fidelity amplifier employs KT66 output tubes by Genalex and a Peerless output transformer for top performance. Frequency response ± 1 db from 5 to 160,000 cps at 1 watt. Harmonic distortion less than 1% at 25 watts, an IM distortion less than 1% at 20 watts. Hum and noise are 99 db below 25 watts. Output impedance is 4, 8 or 16 ohms. Extremely stable circuit with "extra" features.

MODEL W-5: Consists of W-5M *plus* WA-P2 Preamplifier
Shpg. Wt. 38 lbs. Express only **$79.50** $7.95 dwn. $6.68 mo.

MODEL W-5M **$59.75** $5.98 dwn. $5.02 mo.
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5 HEATHKIT DUAL-CHASSIS HI-FI AMPLIFIER KIT This 20-watt Williamson-type amplifier employs the famous Acrosound model TO-300 output transformer, and uses 5881 tubes. Frequency response is ± 1 db from 6 cps to 150 kc at 1 watt. Harmonic distortion less than 1% at 21 watts, and IM distortion less than 1.3% at 20 watts. Output impedance is 4, 8 or 16 ohms. Hum and noise are 88 db below 20 watts.

MODEL W-3: Consists of W-3M *plus* WA-P2 Preamplifier
Shpg. Wt. 37 lbs. Express only **$69.50** $6.95 dwn. $5.84 mo.

MODEL W-3M **$49.75** $4.98 dwn. $4.18 mo.
Shpg. Wt. 29 lbs. Express only

6 HEATHKIT SINGLE-CHASSIS HI-FI AMPLIFIER KIT This 20-watt Williamson-type amplifier combines high performance with economy. Employs Chicago-Standard output transformer and 5881 tubes. Frequency response ± 1 db from 10 cps to 100 kc at 1 watt. Harmonic distortion less than 1.5% and IM distortion less than 2.7% at full output. Output 4, 8 or 16 ohms. Hum and noise—95 db below 20 watts.

MODEL W-4A: Consists of W-4AM *plus* WA-P2 Preamplifier
Shpg. Wt. 35 lbs. Express only **$59.50** $5.95 dwn. $5.00 mo.

MODEL W-4AM **$39.75** $3.98 dwn. $3.34 mo.
Shpg. Wt. 28 lbs. Express only

7 HEATHKIT 20-WATT HIGH FIDELITY AMPLIFIER KIT Features full 20 watt output using push-pull 6L6 tubes. Built-in preamplifier provides four separate inputs. Separate bass and treble controls. Output transformer tapped at 4, 8, 16 and 500 ohms. Designed for home use, but also fine for public address work. Response is ± 1 db from 20 to 20,000 cps. Harmonic distortion less than 1% at 3 db below rated output. Shpg. Wt. 23 lbs.

MODEL A-9B **$35.50**
$3.55 dwn., $2.98 mo.

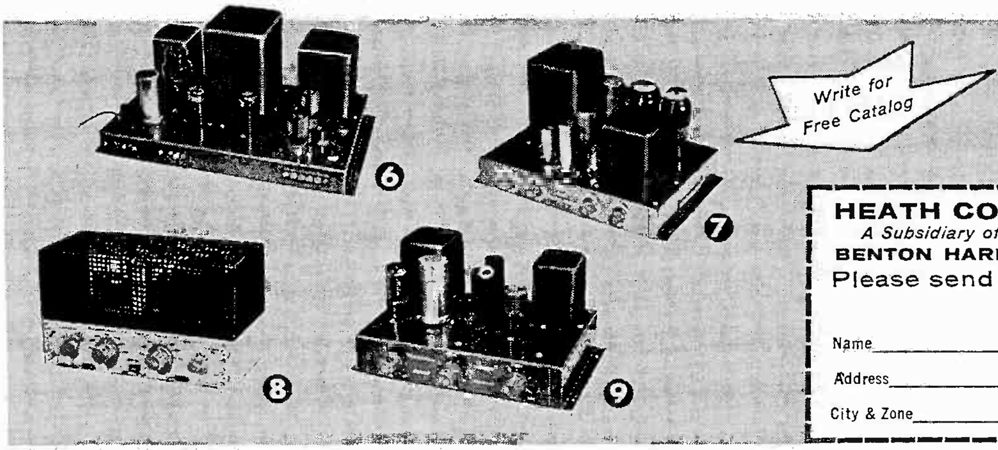
8 HEATHKIT ELECTRONIC CROSS-OVER KIT This device separates high and low frequencies electronically, so they may be fed through two separate amplifiers driving separate speakers. Eliminates the need for conventional cross-over. Selectable cross-over frequencies are 100, 200, 400, 700, 1200, 2000 and 3500 cps. Separate level controls for high and low frequency channels. Attenuation 12 db per octave. Shpg. Wt. 6 lbs.

MODEL XO-1 **$18.95** $1.90 dwn., $1.59 mo.

9 HEATHKIT 7-WATT ECONOMY AMPLIFIER KIT Qualifies for high fidelity even though more limited in power than other Heathkit models. Frequency response is ± 1½ db from 20 to 20,000 cps. Push-pull output and separate bass and treble tone controls. Good high fidelity at minimum cost. Uses special tapped-screen output transformer.

MODEL A-7E: Same as A-7D except one more tube added for extra preamplification. Two inputs, RIAA compensation and extra gain.
Shpg. Wt. 10 lbs. Incl. Excise Tax **$19.95** $2.00 dwn. $1.68 mo.

MODEL A-7D **$17.95** $1.80 dwn. $1.51 mo.
Incl. Excise Tax
Shpg. Wt. 10 lbs.



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Pharaoh had the words for it!*

Photos courtesy of the Metropolitan Museum of Art

* hearken
ye
it is indeed that
the voice of
Unibrsity
(symbol for loudspeaker)
(is) good
more than anything

The pyramid builders had no high fidelity loudspeakers, but their ancient language had the "words" for this ultra-modern development . . . as demonstrated by this translation into hieroglyphics of University Loudspeakers' slogan.

It's a slogan University proudly introduced to the high fidelity field because it summarizes our aim: *to provide you with truly better listening.*

Words can try to describe this superior sound . . . but the rich tonal pleasure offered by these loudspeakers is experienced only when you *hear* them.

So whether in hieroglyphics . . . or in Chinese, Arabic, Greek, Sanskrit or Hindustani used in other University advertisements . . . this slogan conveys our sincere invitation to visit your dealer and . . .

LISTEN *University sounds better*

Translation into Early New Kingdom monumental type hieroglyphics by Cyril Aldred, associate curator of the Department of Egyptian Arts, the Metropolitan Museum of Art, N.Y.C.

"Listen, University Sounds Better" posed novel difficulties to Egyptologists when translated to hieroglyphics. For example, the simple English request, *listen,* became *hearken ye, it is indeed that.* There was no Egyptian verb for *to sound,* so *the voice of* was substituted. And since the Ancient Egyptians used no comparative forms of adjectives or adverbs, they had no word for *better;* instead, the labored construction *good, more than anything* was substituted.

For *University* the "easy" symbol of *school for scribes* could not be used, since the name refers here to a manufacturer. *A brand new "high fidelity" hieroglyphic was developed* by "vocalizing"—phonetically spelling out—University as *unibrsity* (there was no "v" in Ancient Egyptian). Then, just as the Egyptians did when inventing a hieroglyphic for an object, a picture of the loudspeaker was added . . . thus bringing a 4,000-year-old form of picture writing up to date on 20th century high fidelity sound!

Readers' Forum

Gentlemen:

I want to thank you for making my speaker system double its value in sound. Mr. Tinkham's article in the January 1957 issue on "Stereo Speaker Placement" is worth hundreds of dollars, as it helped me double the response from my system.

I am set up for FM-AM stereo reception. I have just added a Concertone stereo tape recorder to the system and have been uncertain for some time as to speaker placement. Seems I had tried every placement except that recommended in your January issue.

I am sure I'm not alone in asking for more articles on this stereo question. It must be the coming thing, and many people (like me) know little about stereo recording and playback. More articles on stereo, please.

Thomas L. Hidley
Fallsvale, Calif.

We'll keep them coming, Mr. Hidley. See, for example, Joseph Marshall's discussion on stereo mike techniques, page 4 of this issue. — ED.

Gentlemen:

Mr. Holt's discussion with Mr. Richard L. Kaye of WCRB ("Reader's Forum", AUDIOCRAFT, December 1956) on the morality of making tape recordings from radio broadcasts, especially of disc recordings, was quite interesting. However, one very important facet has been overlooked in both arguments. There are probably many people in the same situation as I who do not make the purchase of disc recordings on a haphazard basis. I buy for a permanent collection and I want to be positive that the recording will be of lasting interest. I make a number of recordings from FM radio of music that has little or marginal appeal to me. Quite often, after listening to the music and becoming familiar with it, I will buy the particular disc involved. If not, there is a good possibility that I will purchase another recording by the same group, because I am familiar with their work. Either way it means record purchases that I would not have made otherwise. Thus, if the record companies were able to prevent me from making tape recordings of material that is broadcast over FM radio, they would only be decreasing their sales to me and might even eliminate them altogether.

In my opinion, it is to the best in-

Continued on page 42

EDITORIAL

WE have never been able to learn the reason for it beyond doubt, but it seems to be true that a man interested in high-fidelity sound is often equally interested in photography, and vice versa. Perhaps there is a combination of technical adventure and creative satisfaction to be found in each that appeals to basically the same sort of person.

At any rate, the amateur movie maker has been able to combine this activity with his sound-recording skill only to a limited extent. Photographic sound-on-film equipment, although available, is prohibitively expensive for the amateur. Professional motion pictures are now often made with the sound recorded separately but in synchronism with the picture, and then combined with it later. There are two ways in which this is done by magnetic recording means: using magnetically coated perforated film, which is sprocket-driven in synchronism with the camera; or using standard magnetic tape on a recorder that is synchronized with the camera by elaborate electronic methods. Sound is later combined with the printed film by rerecording it, still in synchronism, on a relatively narrow magnetic track off to one side of the print. These processes are impossible for the amateur to consider, so his dream of lip-synchronous sound with home movies has remained only a dream.

A recent announcement from Minnesota Mining & Manufacturing Company, makers of Scotch brand magnetic tape, describes a new process that may help to make that dream a reality. The conventional method of applying a magnetic coating track to film has involved a liquid striping process. The magnetic material is flowed on the film in a liquid dispersion and subsequently oven-dried. This produces a track with a rounded top; in the narrow track widths employed with 8-mm and double-perforated 16-mm film, the dried magnetic track has virtually a hemispherical cross section. As a result, contact with the recording and playback heads is very poor. The sound is atrocious, with high distortion and limited dynamic range.

The new process is one of laminating a dry, flat coating of magnetic material to the film. A flat strip of Scotch brand "High-Output" magnetic oxide is sandwiched between a cellophane backing and a thin layer of thermoplastic adhesive. In the laminating machine, the laminate tape is slit to the correct width and then heated to activate the adhesive. It is pressed into contact with the motion picture film, bonding the oxide to it securely. The film is then passed through a humidity chamber where the cellophane loosens its grip on the other side of the oxide; it is then removed by a stripping wheel.

The laminated track can be applied in 100-mil width to a single-perforated 16-mm film. Because of the far better head contact, this provides exceptionally good sound quality. A 30-mil track can be applied to double-perforated 16-mm film or to 8-mm film, and this can give excellent quality also, depending on the camera and projector. Results claimed for the flat laminated track are one to two additional octaves at the high-frequency end, with marked improvement in signal-to-noise ratio and lower distortion. Moreover, the laminate can be applied to unexposed film as well as printed film; according to the manufacturer, the oxide track and materials used in photographic processing have no effect on one another.

It would now seem practical to obtain decent 16- or 8-mm lip-synchronous sound by recording simultaneously *on the striped film* as the film is exposed, as soon as the necessary equipment becomes available at prices amateurs can afford. Most 16-mm projector manufacturers now have models with combination optical and magnetic sound-pickup systems. There are a few 16-mm magnetic recording cameras on the market, but they are pretty expensive. Still, we believe that there is good reason for the home-movie maker to be optomistic. Manufacturers will not long neglect a demand for a product in either the photographic or the hi-fi sound market. Now that magnetic-striped film of the requisite quality is available, relatively inexpensive 8-mm and 16-mm equipment should be forthcoming. After all, it would have a ready market in *both* fields.

We expect to have an article soon on the general subject of sound with home motion pictures and slides.

APROPOS of our recent transistor editorial, RCA has just announced commercial availability of a fully transistorized portable amplifier for use in remote radio and TV broadcast pickups. The new amplifier, model BN-6A, provides four-channel amplification and control facilities for transmission of remotely originated broadcasts to the studio via telephone lines. Although weighing only 15 lb., it is said to be capable of higher output level with lower distortion than any comparable unit available. Simply one more sign of the inevitable, in our view. — R.A.

by SCOTT J. SAUNDERS

trifunctional

speaker system

Construction details for a small bass-reflex enclosure which also serves as an end table and planter box.

WHILE most speaker enclosures are acoustically sound, not all of them make interesting or decorative furniture. Manufacturers are becoming aware of this, and a few are now giving some thought to enclosures that are attractive as well as functional.

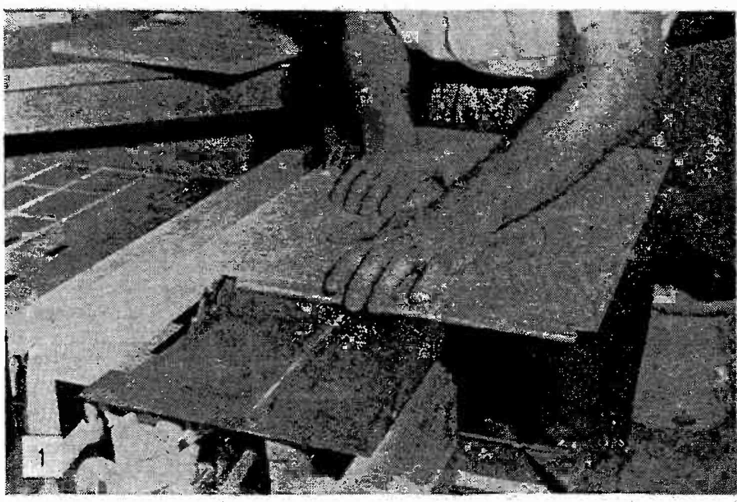
If you'd like to assemble an enclosure of your own that will match your furniture, the plans and photographs on these pages will give you a good start. The range of variations on this basic theme is limited only by your imagination.

This Formica-covered cabinet of 1½ cu. ft. was designed as a bass-reflex unit for the University Model 308 8-inch triaxial speaker. The cabinet is used as an end table, with the built-in planter box adding a novel touch. Making the cabinet is not difficult, but careful attention should be given to measurements and fitting. That old standby, ¾-inch fir plywood, is used throughout because it is strong, durable, and easy to work. To simplify construction details, each picture has been numbered. These captions give the step-by-step procedure:

Fig. 1. After top, bottom, and sides have been cut to dimensions a rabbet is cut full-length along top and bottom edges of the side pieces. Since the rabbet (¾ in. deep and ½ in. wide) runs off the ends of the wood, a guide bar is clamped to the saw table as shown, so that the cuts can be made in one pass. While the dado head is installed on your saw, cut the dadoes (¾ in. wide and ⅜ in. deep) across the top, bottom, and side pieces required for the divider and vent baffle pieces. Set the rip fence during this operation so that the dadoes will be cut in exactly corresponding places on all the panels.

Fig. 2. The vent (2 in. wide by 16 in. long) is made by first cutting the sides on the saw and then drilling 2-inch holes at both ends with an expansion cutter on a hand brace. Cut on one side of the wood until the point of the cutter just shows through the other side. Turn the wood over and drill through for the circle. Cutting a hole this size one way will splinter the underside.

Fig. 3. This rectangle is for the planter box in the rear section of the cabinet. The box I used has a ⅛-inch lip all around, which rests on the top. To cut the hole, measure off the area and position the top on the saw table so that the saw blade is directly beneath one of the side lines. Turn on the motor and bring the blade up through the wood until it shows through. It is then simple to finish cutting to the desired length.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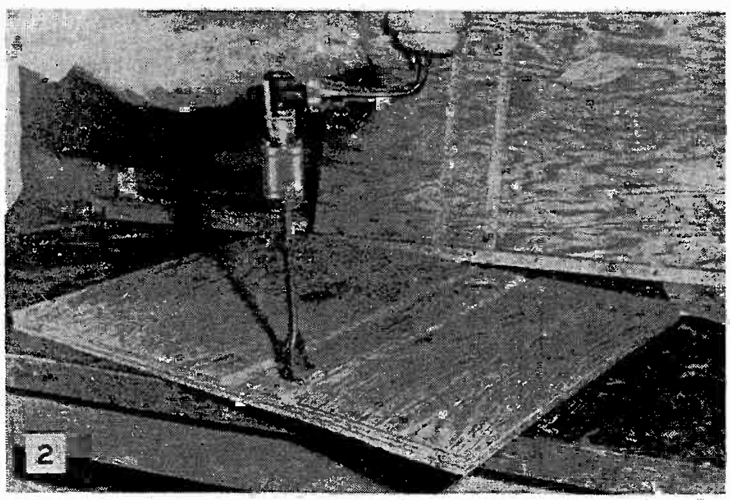
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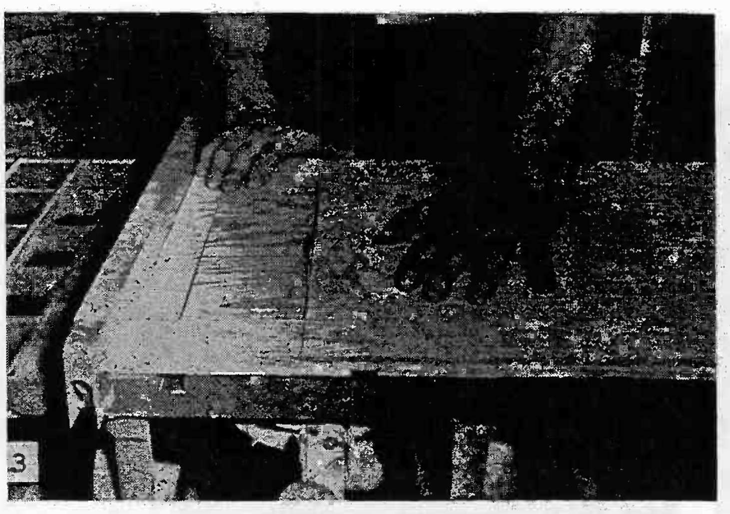

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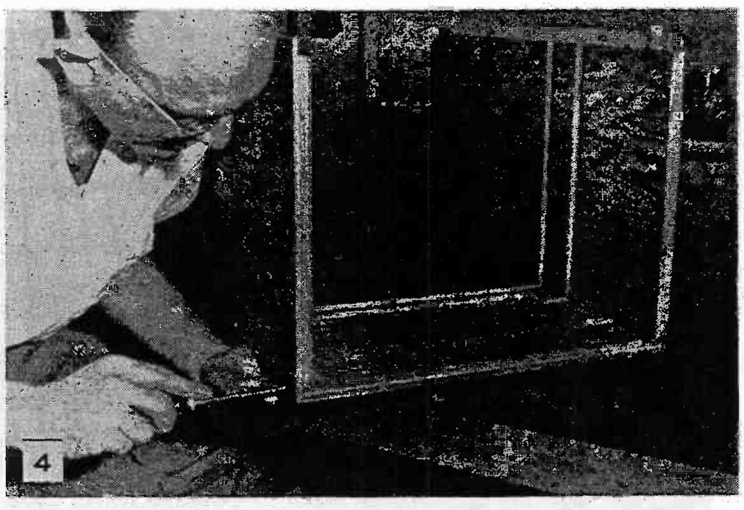

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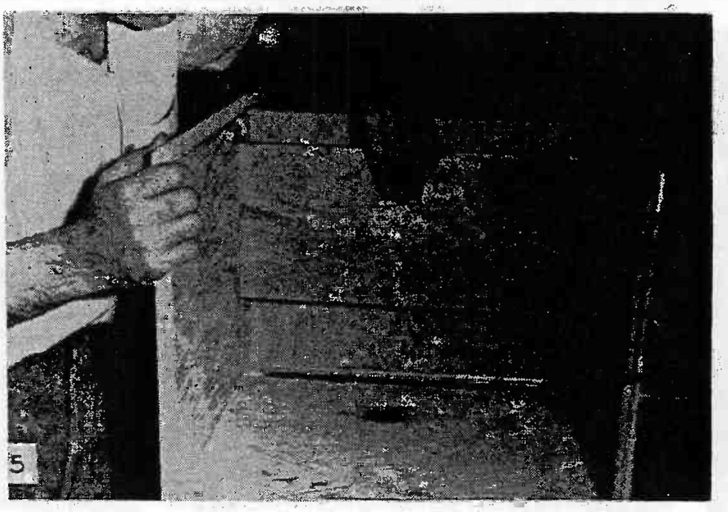

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Fig. 4. To assemble the box, drill five holes in each side rabbet to take 1-inch No. 8 flat-head wood screws. Clamp the side to the bottom and push an awl through the holes, to mark the exact location of the screw holes in the edge of the bottom panel. Using these marks as your guide, drill holes slightly smaller than the outside diameter of the screw. Locate these screw holes before trying to put the box together. Note how the bottom piece fits snugly into the side rabbets. Once these sections have been glued and screwed, they will be permanently rigid and buzz-proof.

Fig. 5. Framing support is supplied by both the box divider and the vent baffle. Here, the edges of the divider have been glue-coated before insertion, and the baffle is being slipped into place after its edges were coated with glue.

Fig. 6. After the top has been glued and screwed in the same way as the bottom, the next step is setting in the framework to serve as speaker-panel screw battens. Be sure to position these four pieces so that they are all recessed exactly ¾ in. from the front edge. Otherwise, the panel will not fit, and you will have trouble later in getting the finish molding to fit snugly. Battens for the rear panel are attached in the same way, and the rear panel may then be installed.

Fig. 7. The next step is to line the cabinet interior with some sound-absorptive material. Kimsul or similar material is recommended, but we used acoustical tile left over from another enclosure, with satisfactory results. Also, at this time, drill ¼-inch holes through the vent baffle and box divider for the speaker hook-up wire.

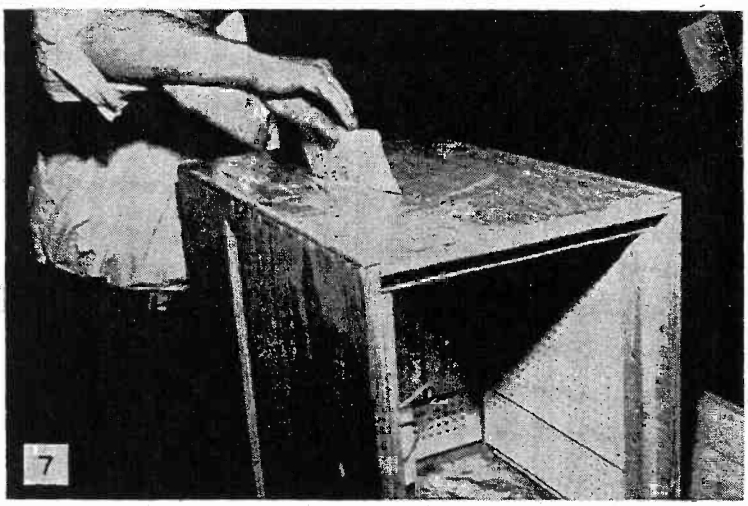
We're now at the finishing stage, the point when that plywood box is transformed into living-room furniture. Application of a plastic laminate such as Formica is not arduous, but if you've never worked with such materials, practice with some scrap before covering the box. We used a frost walnut in furniture grade, which has a dull surface.

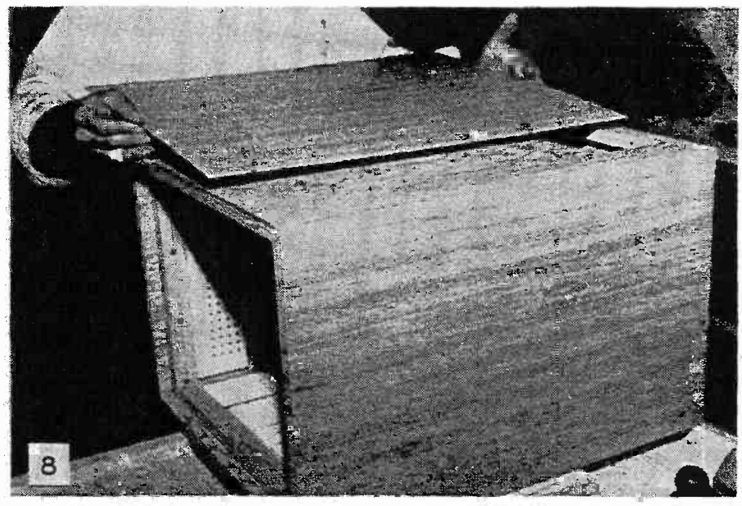
Cut the laminate about ¼ in. oversize, so that you will have material to trim off. Spread contact cement evenly over the entire surface of the two sides and also on the two pieces of laminate. Allow the cement to dry for about 40 min. By this time, a piece of kraft paper pressed to the cement should not stick to it. If it does, the cement is not yet dry enough.

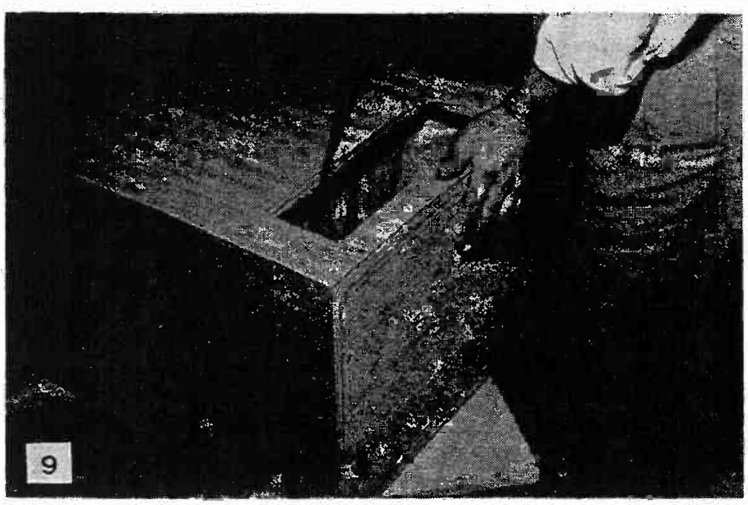
When you're ready to apply the laminate, slip a sheet of kraft paper on the wood and position it under the laminate. Make sure that you have enough trim material all around, then slowly slip out the paper, pressing the laminate down at the same time. This is the toughest part of all. Once the two cemented surfaces meet, that's it — you can't pull them apart again.

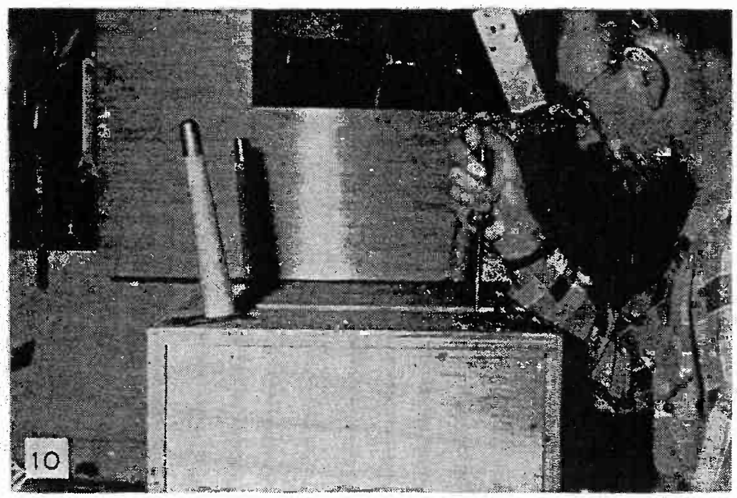
Fig. 8. Attach the side panels first and level off the overhang with a sharp-bladed plane. The laminate planes easily, so don't be afraid to bear down. Trim flush with the top. This done, coat the enclosure top and top laminate panel. Wait until the cement has dried thoroughly and join them as explained in the preceding step.

Fig. 9. Plane the overhang of the top piece flush with the sides. Use care









here to prevent chipping into the side panels. The hole for the planter box is cut out with a compass saw, keeping pressure on the saw blade always downward. Pulling up on the saw might crack the laminate.

Fig. 10. These tapered brass-bottomed wood legs come four to a set, complete with mounting brackets and screws. In addition to the four mounting holes in the brackets, there are two positioning holes: one for a vertical position, and the other for the slant effect shown here.

Fig. 11. The speaker panel (¾-inch fir plywood) fits the inside dimensions of the box. With jig or coping saw, cut a hole 6¾ in. in diameter in the exact center of the panel. Drawing diagonals from opposite corners of the panel will give you a center line. Position the speaker over the hole so that the tweeter is horizontal. Mark the location of the four mounting holes with an awl, and follow by drilling holes through the plywood to take size 12-24 machine screws. The use of lock washers when mounting the speaker is recommended.

Fig. 12. Mounting the speaker panel requires 12 screws, 3 in each side. First drill holes along the panel edges to take 1½-inch No. 8 wood screws, position the panel against the framework to mark hole locations, and drill holes in the framework slightly smaller than the thread diameter of the screws.

Fig. 13. The grille cloth is cut to size and glued to the speaker panel. Loose ends are left over the screw holes to permit removal of the speaker panel. The molding is 1½-inch mahogany, which was cut to fit outside dimensions of the cabinet.

Fig. 14. The finished speaker enclosure, complete with five different kinds of house plants — decorative as well as functional, and a handsome addition to any living room.

List of Materials

¾-inch fir plywood (finished both sides):

top .... 18 by 24 in.
bottom .... 18 by 24 in.
sides (2) .... 16 by 24 in.
speaker panel .... 14½ by 17 in.
rear panel .... 14½ by 17 in.
divider .... 14¾ by 17¾ in.
vent baffle .... 8 by 17¾ in.

Framework for speaker panel:

two pieces .. ¾ by 1½ by 15½ in.
two pieces .. ¾ by 1½ by 14½ in.

Framework for rear panel:

two pieces ... ¾ by ¾ by 15½ in.
two pieces .. ¾ by ¾ by 14½ in.

Tapered wood legs with brass bottoms:

four .... length as desired

Formica, 3 by 5 foot sheet in desired pattern.

Plastic laminate contact adhesive.

Mahogany cove molding (mitred at corners):

two pieces .... at least 18½ in.
two pieces .... at least 16 in.

Wood screws:

1-8 flat head.
1½-8 flat head.

Machine screws, 4, 12-24 by 1½.

Nuts and lock washers.

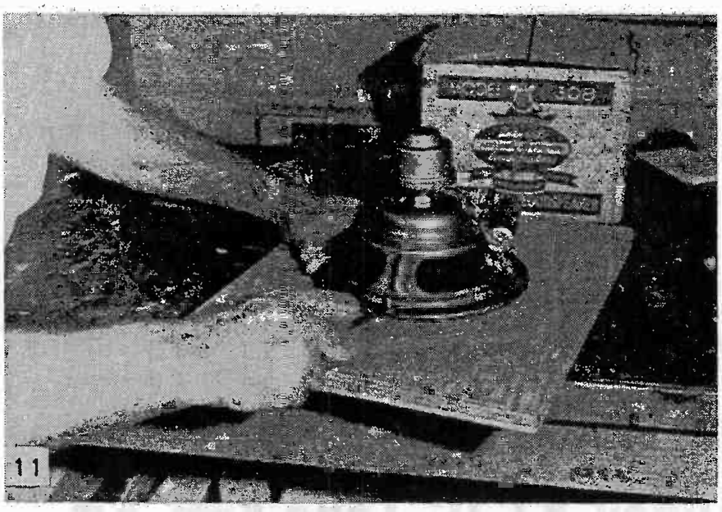
Kimsul or acoustical tile.

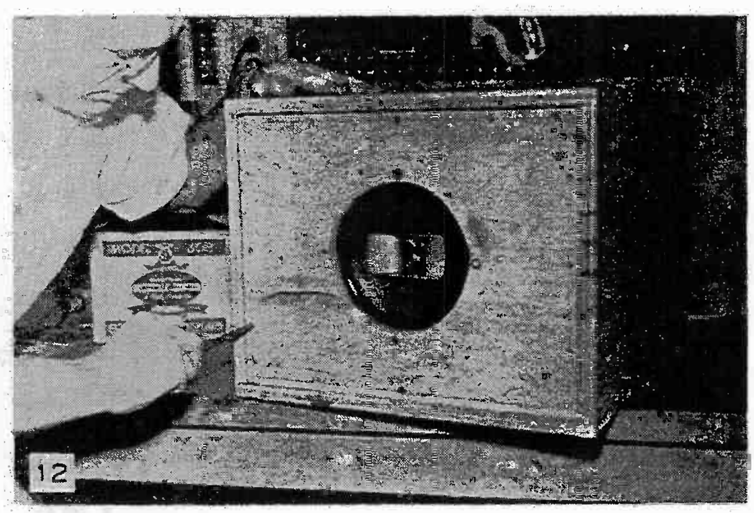
Planter box to suit.

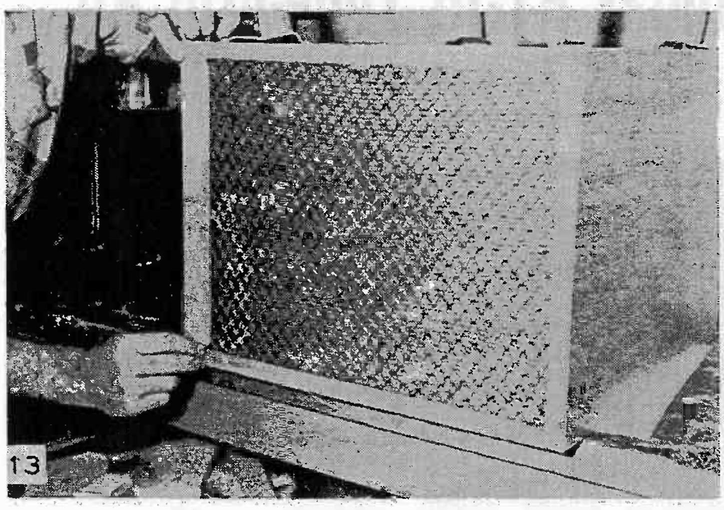
Grille cloth.

Wood glue.

Glue blocks for all permanent joints.







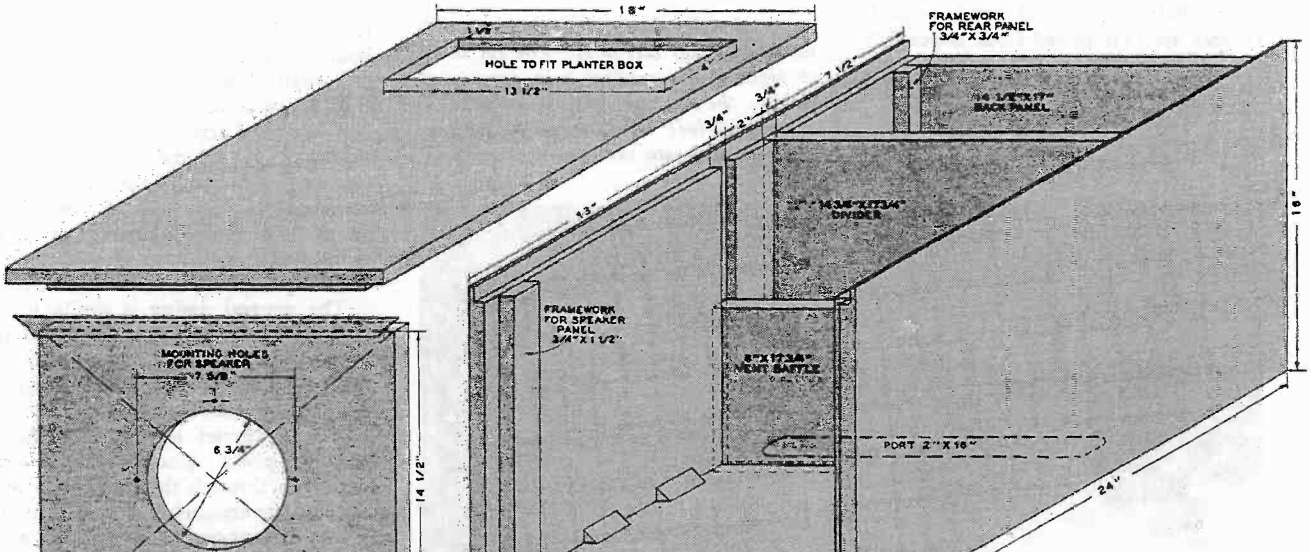


Fig. 15. Working drawing for the trifunctional speaker system. Note that dimensions of hole for planter box depend on box size.

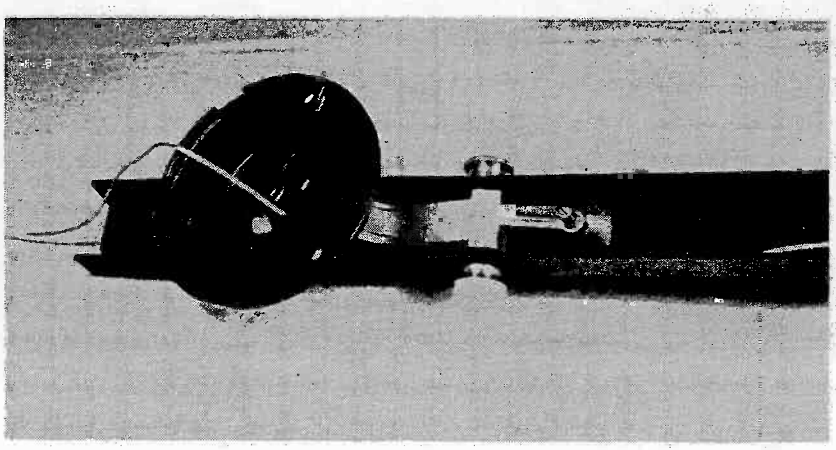
An AUDIOCRAFT *kit report*

Photos by Warren Syer

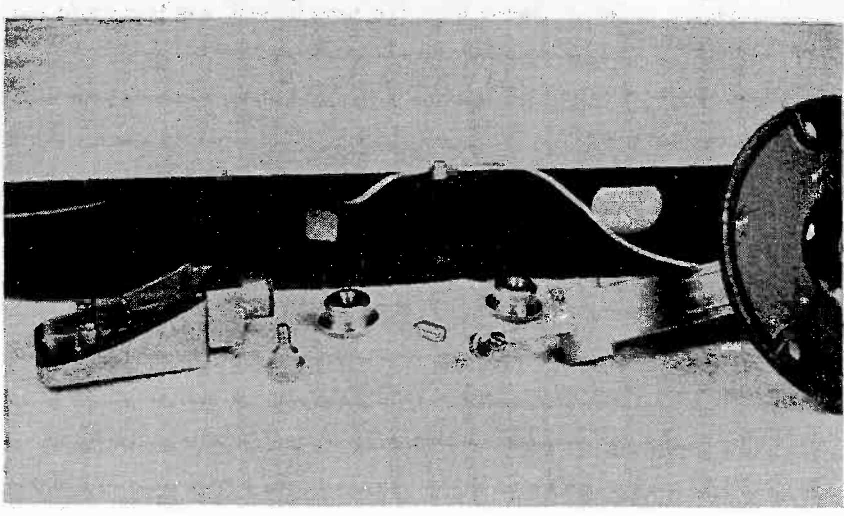
The Audax KT-16 Tone-Arm Kit

EVERYONE knows that a long pick-up arm offers better performance than a shorter one, assuming proper design of each. Popular hi-fi arms are very generally classified in two length groups: 12-inch and 16-inch arms. These terms are slightly misleading, because they refer not to the actual arm lengths but to the maximum size records they are designed to play. Still, 16-inch arms *are* longer than 12-inch arms of corresponding manufacture, and are potentially better for any record size. Since they cost little more than 12-inch models, it makes sense to buy a long arm unless you don't have room to mount it.

The half-dozen or so most popular 16-inch arms are priced from about $25 to $40; a factory-assembled Audax PRO-16 arm, for example, is $30.00 net. But the kit version of the PRO-16, identical to it in every way when assembled, costs only $17.55. This is the Audax KT-16. Because it takes about a half hour to assemble the KT-16, its exceptionally low price may be surprising. Price considerations aside, however, it is a very good arm. The low price simply makes it one of the few genuine bargains in hi-fi equipment. There is also an Audax 12-inch arm kit, the KT-12, at $14.55, which provides a similar saving. As far as we know, these are the only tone-arm kits on the market.



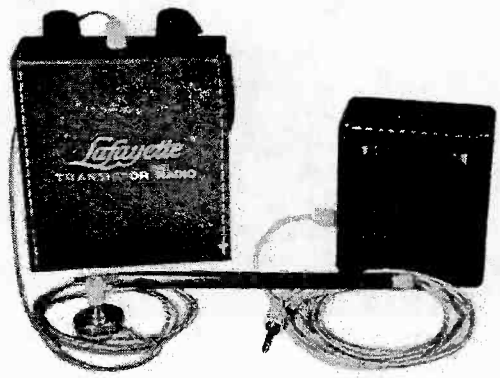
View directly above shows the KT-16's base and pivot assembly. The set screw at right limits vertical arm movement. Below, the vertical pivots before they are assembled; needle bearings thread through arm into seats on base member.



The general design is similar to that of preceding well-known Audax arms. The horizontal pivot is concentric with, and an integral part of, the base assembly. A forward projection on the base unit carries seating holes for the vertical pivot needle-bearing screws, which go through threaded holes in the sides of the channel-type arm. The pivot screws are concealed and held in adjustment by knurled round lock nuts. A counterweight at the back end of the arm channel is secured by a thumbscrew on top of the arm which rides in a

Continued on page 42

An AUDIOCRAFT *kit report*
Photos by Warren Syer



Lafayette Transistor AM Radio Kit

LAFAYETTE Radio is an electronic parts and equipment distributing firm with six large stores in New York, New Jersey, and Massachusetts, and with a large mail-order business as well. Ever since transistors became available to the public, this company has taken the initiative in stocking and advertising them as well as subminiature circuit components for use with them. It has developed and published circuit diagrams for transistorized versions of equipment from code-practice oscillators to remote-control transmitters and receivers, in a laudable (and successful) effort to excite popular interest in transistors. Later the company began to market complete kits for equipment using transistors. We watched the new kit announcements with growing curiosity until, when the KT-94 pocket-size superhet AM receiver and the matching KT-96 amplifier-speaker came along, we could restrain ourselves no longer. We asked to have them sent for an AUDIOCRAFT kit report, and here it is.

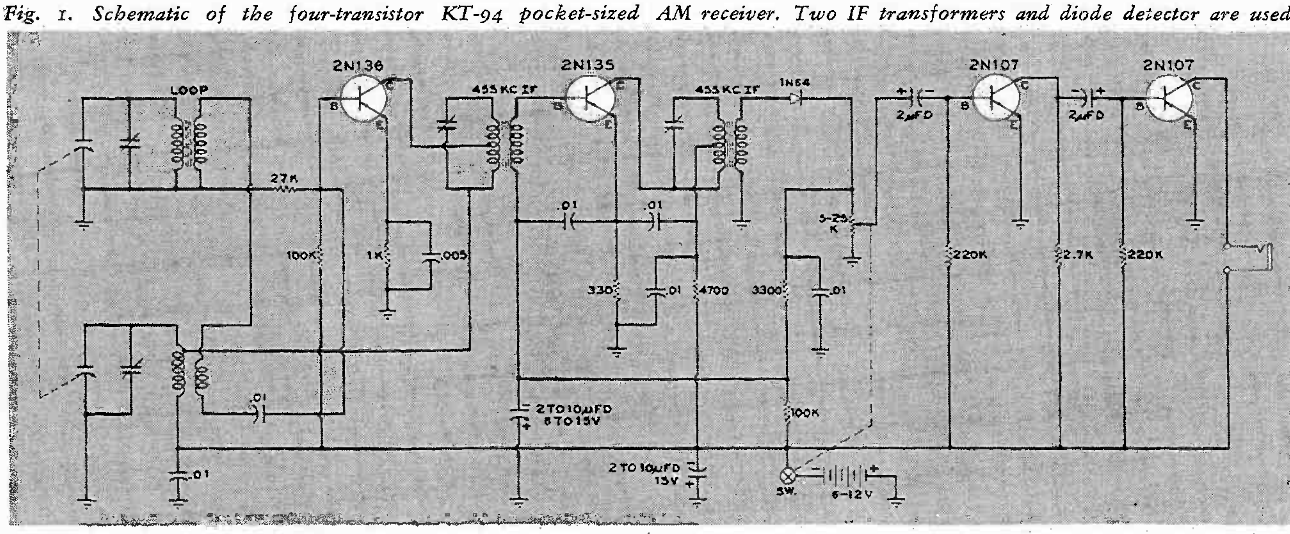
The KT-94 kit contains all parts for a 4-transistor superheterodyne AM receiver, including a punched chassis, built-in ferrite loop antenna, battery, hardware, wire, and solder: everything, in short, except tools and a soldering iron. An instruction manual gives step-by-step assembly and wiring directions, pictorial diagrams for several steps in the wiring process, directions for alignment of the completed unit with and without test instruments, trouble-shooting hints, and parts identification data.

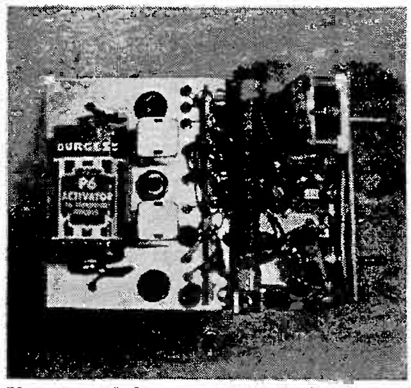
A schematic diagram of the receiver is given in Fig. 1. The ferrite loop antenna is tuned by one section of the tuning capacitor to provide RF selectivity; the other half of the tuning gang tunes the local oscillator. A 2N136 transistor functions as both oscillator and mixer. It feeds a 455-Kc IF transformer, which is followed by a 2N135 IF stage. The second IF transformer is loaded by a 1N64 diode detector, and that is followed by the volume control. A pair of 2N107's follows as a two-stage high-gain audio amplifier. Output of the last stage goes to a miniature phone jack, and will feed either a dynamic earphone or the KT-96 power amplifier.

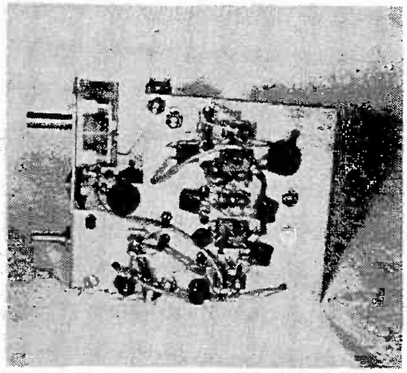
The KT-94 alone is priced at $19.95. Suitable earphones are available at $1.95 or $3.95. A leather carrying case, as illustrated, costs $1.95 extra; it has holes at the top for the two control knobs and the phone-jack outlet, and is inscribed with a calibrated dial for the tuning knob. Dimensions of the receiver in the carrying case are 4¾ in. long by 3⅜ in. wide by 1⅝ in. thick — truly a pocket-size receiver.

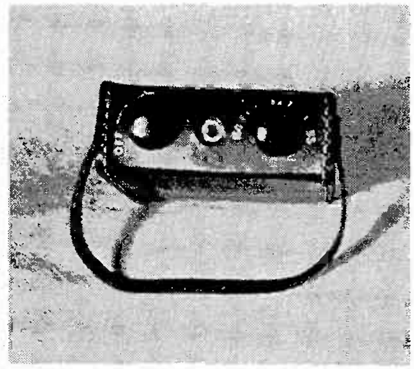
The KT-96 amplifier-speaker kit is

Fig. 1. Schematic of the four-transistor KT-94 pocket-sized AM receiver. Two IF transformers and diode detector are used.









Upper and lower views of the compactly arranged radio. Black buttons are transistors. At right, receiver in leather case.

similarly complete, even to miniature phone plugs and cable for interconnection between the two units. It consists of an extremely compact power amplifier and 2½-inch speaker assembly in a plastic baffle box only 3 by 2⅜ by 1⅜ in. Fig. 2 is the schematic diagram. An input and phase-inverter transformer drives the push-pull 2N107

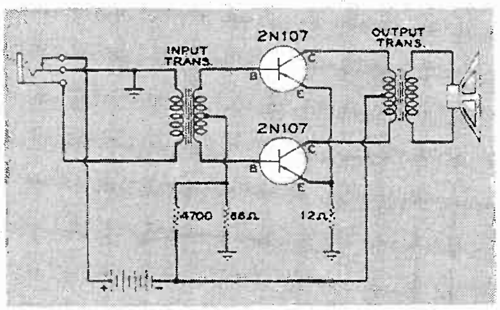


Fig. 2. Circuit of KT-96 amplifier kit. Inserting phone plug connects battery.

stage, which is coupled to the speaker through an output transformer. Even with these two transformers and a speaker, there is still room in the tiny box for a battery. Price of the KT-96 is $11.50.

Construction Notes

With a pencil-type soldering iron (virtually essential) and reasonable care, an inexperienced builder should have no great difficulties in assembling both these kits, and in aligning the receiver. There are a few tight fits, but the kits are very well engineered and the instructions are quite complete. Following are a few specific notes that may be helpful to other constructors.

The KT-94 kit: In step 8 for illustration 1A, bend or break off the small lugs at the bottom of the antenna clips before you try to mount them, so that they will remain straight. — In step 11, illustration 1A, don't solder the wire to oscillator coil terminal 5; another wire will be added later to the same terminal. — In step 13, illustration 3, there are two blue leads from the ferrite antenna; connect both to the top lug of R1. — Take care in all steps, illustrations 4 and 5, to keep wiring and components as close to the chassis as possible without actually touching it. This will assure easy insertion of the complete receiver into the leather case.

The KT-96 kit: In steps 1 and 2, illustration 1, our transformers were not equipped with screw-mounting lugs; however, it was simple to secure the transformers to the chassis by twisting the frame lugs which projected through it. — In steps 9 and 10, illustration 1, the instructions for making connections to the phone jack may be confusing. Follow the pictorial diagram and you can't go wrong.

It took us 6¾ hours to build the receiver kit, from checking the parts against the parts list to tuning in the first station, and 2¼ hours for the amplifier-speaker kit. The job could have been done faster, but we're just as well satisfied that we didn't hurry, because we didn't make any mistakes — both kits worked from the moment we turned them on. If you can't make your kit work, incidentally, Lafayette will put it in shape for $2.50 plus the cost of parts. That is good insurance, although you probably won't need it.

Audiocraft Test Results

We aligned the receiver first without test instruments, according to the instructions, and subsequently with a signal generator. The difference in performance was negligible. It can be assumed, then, that any home constructor will be able to align it satisfactorily. The procedure takes only a few minutes.

After alignment had been done, we compared the KT-94 with a ready-made pocket-size portable slightly larger in size and much higher in price. Our kit matched the performance of the larger unit in sensitivity, and was noticeably better in selectivity (the ability to separate closely spaced stations). This is not to say that it was as good as a full-sized table-model; it wasn't. But you can't carry a table model in your pocket.

One disadvantage of the Berkshires is the very low AM signal strength. In the daytime our KT-94 was able to get only a few stations, and the noise level was quite high. We took it with us on a trip to a town 55 miles from New York City; stations were received there one after another all along the tuning dial, and the noise level dropped to insignificance. In most locations, then,

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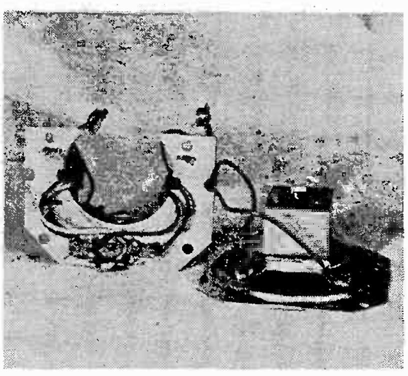
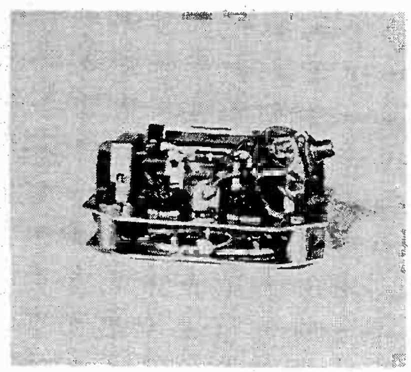
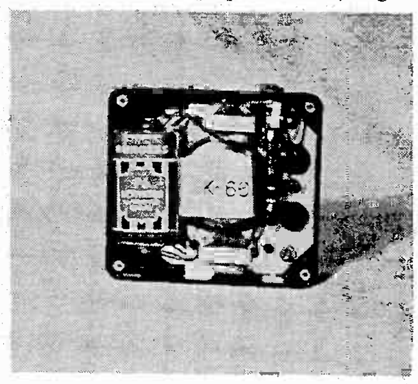
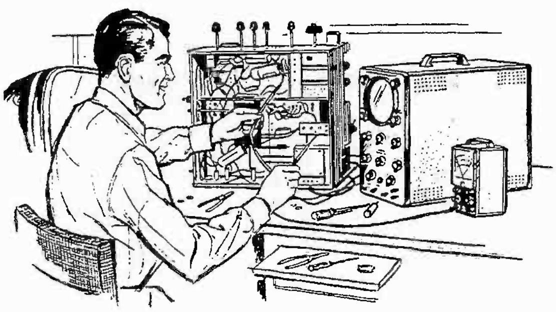
KT-96 amplifier chassis is built around the speaker magnet assembly. Everything then goes into tiny plastic box, right.









Using Test Instruments

The Oscilloscope, PART I

by DONALD CARL HOEFLER

IT doesn't take a very old-time audiophile to recall the day when high-grade electronic test instruments were so expensive that they were used only in laboratories, service shops, and in other professional applications. In those days, the average experimenter had to mortgage a year's salary to equip his home lab. Usually, he simply did without.

Today, however, any serious audiocrafter can acquire topnotch instruments at very reasonable prices — instruments that answer every need in testing, experimenting, and trouble shooting. Moreover, he can make further savings by building his own from the many fine kits now available. Designs of the leading kit manufacturers are very well engineered, and the thorough instructions assure ease of construction and operation.

One of the most fascinating (and most useful) test instruments is the oscilloscope, for it permits the audio worker to see just what he hears. This facility is valuable because the manner in which a wave may be deformed is often more significant to the eye than to the ear. Although the commonest use of the scope is in wave-form analysis, for it will immediately show up any harmonic, amplitude, or phase distortion, it is also useful in any number of other audio applications. Among them are signal tracing, A-B tests, hum balancing, damping-factor adjustments, alignment of tuners, frequency measurement, and volume-level indication. The indicating element of an oscilloscope is the cathode-ray tube, similar to that found in every television set. The internal construction of a typical scope, showing this tube mounted in place, is shown in Fig. 1. In the narrow neck of the tube is a combination of electrodes known as the *electron gun.* This gun generates a stream of electrons, which is directed to the sensitized face plate at the wide end of the tube. Whenever these electrons strike the face, the screen lights up. With some means of controlling the electron stream we can cause it to trace moving pictures, as in television, or graphical representations of electrical phenomena, as in the oscilloscope. Fig. 2 shows a pictorial version (not to scale) of the elements in a cathode-ray tube.

Electrons to form the beam are emitted from a heated cathode, just as in an ordinary vacuum tube. The first element to affect these electrons is the control grid. The relative voltage between this grid and the cathode determines the number of electrons striking the screen in a given time, and consequently the brightness of the pattern. Varying the relative voltage on this grid will alter the screen brilliance. Usually the grid voltage is held constant, however, and the cathode voltage is adjustable. The control which varies this voltage is ordinarily marked

Courtesy Heath Company

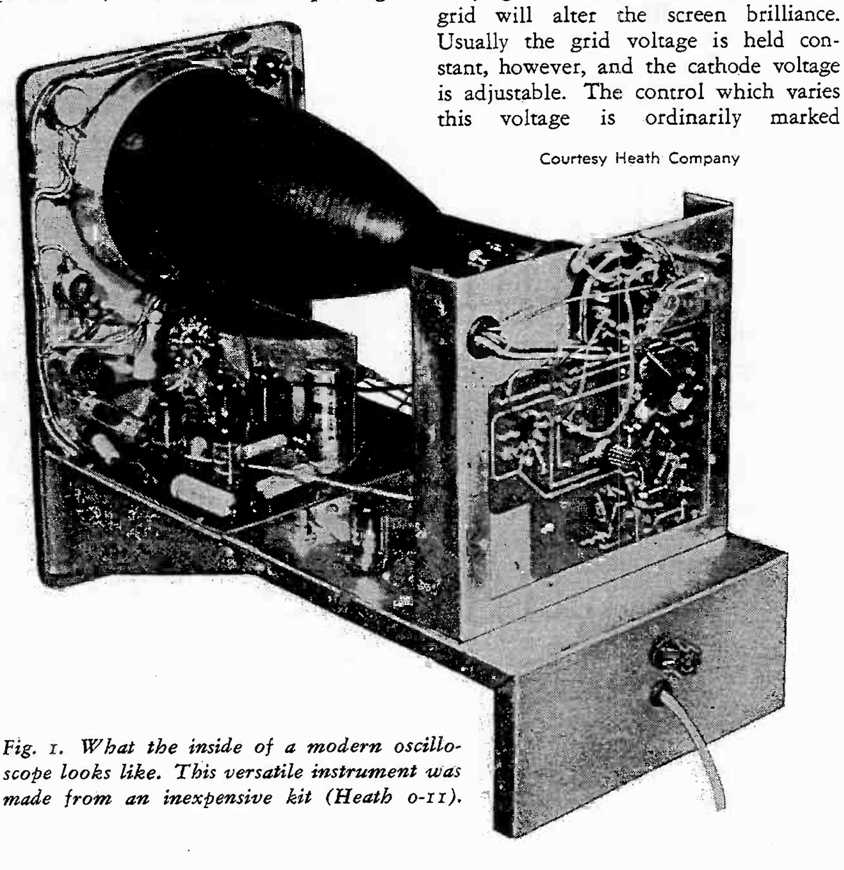


Fig. 1. What the inside of a modern oscilloscope looks like. This versatile instrument was made from an inexpensive kit (Heath O-11).

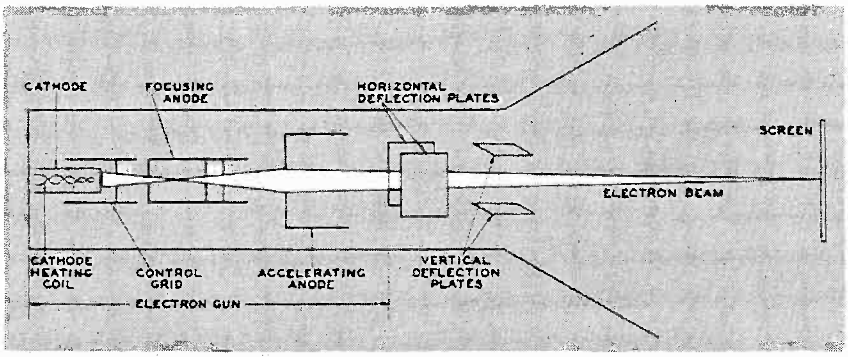


Fig. 2. How a cathode ray tube works. Electron beam "writes" on fluorescent screen.

BRIGHTNESS on television sets, while the term INTENSITY is often used on scopes.

Next in the path between cathode and screen is a cylindrical electrode known as the focusing anode. This converges the electron stream into a beam of controllable size. When the voltage on this element is properly set by adjusting the FOCUS control, the beam causes only a tiny spot to light up on the screen.

An accelerating anode works in conjunction with the focusing electrode to speed up the electron flow, and to determine the focusing characteristics. Varying the voltage on this element will usually affect the shape more than the size of the spot. The accelerating voltage is fixed on most scopes by a direct connection to ground, while the cathode is made very negative with respect to it. The instrument whose schematic diagram is given in Fig. 3 has a refinement, however, known as an ASTIGMATISM control, which can be seen at terminal 7 of the cathode-ray tube V8. Since little adjustment of this control is necessary, except after changing a tube or component, it is mounted internally on the chassis, rather than on the front panel.

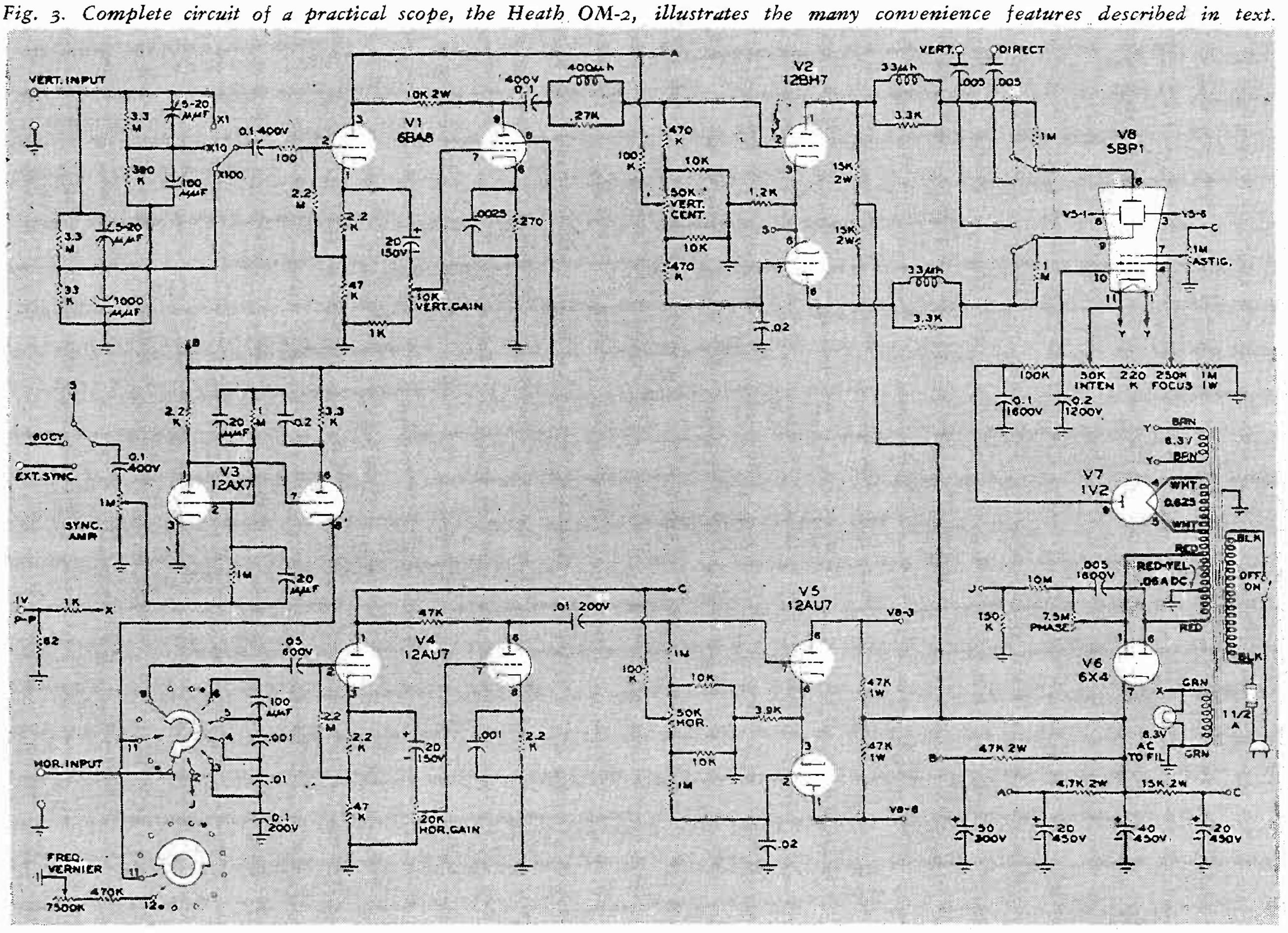
The fluorescent screen consists of a coating of certain chemicals on the inside of the glass face at the end of the tube. An electron beam striking this coating will cause it to light up in a color determined by the screen material. Some of the colors already obtained in cathode-ray tubes include white (always used in TV receivers), green (most often used in scopes), blue, and yellow.

An important characteristic of the tube's ability to trace an accurate pattern is the persistence of its afterglow, the light which remains momentarily after the electron beam has been removed. The moving spot on the screen of a cathode-ray tube appears as a picture or line pattern partly because of this afterglow and partly because of the observer's persistence of vision.

In order for the spot of light on the tube face to trace oscillograph patterns, it must move about. That is, the electron beam must be deflected as desired. At this point we come to a divergence between the tubes used in television and those in scopes, for TV deflection systems are nearly always electromagnetic, while those in instruments such as oscilloscopes and radar sets are usually electrostatic.

This system is based on the fundamental law of electric charges: like charges repel one another, while unlike charges attract one another. Since the electron is the basic unit of negative electricity, the electron beam in a scope can be attracted by a positive charge and repelled by a negative charge. Such charges are applied to two pairs of metal plates within the tube, mounted

Fig. 3. Complete circuit of a practical scope, the Heath OM-2, illustrates the many convenience features described in text.



at right angles to each other, somewhat as shown in Fig. 2.

One pair of plates, which is mounted vertically, can move the beam back and forth across the screen, and these are therefore known as *horizontal* deflection plates. The plates which are mounted horizontally control the up-and-down motion of the beam, and are therefore known as the *vertical* plates. Since the horizontal plates can move the light spot in a line anywhere across the middle of the screen, and the vertical plates can move it anywhere along a vertical center line, it should be easy to infer that the right combination of charges on *both* pairs of plates simultaneously can place the spot anywhere on the screen.

It is desirable, however, that when the spot is at rest it be at the exact center of the screen. But due to small manufacturing differences in cathode-ray tubes, this may not always be the case when no charge is on any of the deflection plates. To correct for this, or to adjust the spot off-center intentionally, a small variable DC voltage is applied to the pairs of plates by means of VERTICAL CENTERING and HORIZONTAL CENTERING controls. These and other controls already discussed may be seen surrounding the scope screen in Fig. 4.

Whenever plotting an electrical wave form graphically, it is customary that one of the co-ordinates should be time. That is, every point making up the complete curve indicates the amplitude of a voltage or current at a given instant of time. The horizontal axis of the graph is usually the time base, and since its divisions are equally spaced, it is said to be linear.

In reproducing this graphical concept on the screen of a cathode-ray oscilloscope, it is therefore necessary that we have a *linear time base.* For if we apply a signal under analysis to the vertical plates of the tube, with no voltage on the horizontal plates, all we'll see is a vertical line, regardless of the shape or complexity of the wave. To spread this line out over the screen and actually observe the signal wave form, we must have a voltage on the horizontal plates which increases at a uniform rate, moving the spot steadily in a horizontal direction and duplicating the graph time base.

Ideally, this voltage would sweep the electron beam in a straight line across the face of the tube at a uniform rate, from one side to the other. Then with no time lapse at all, it would "fly back" to its starting point and once again sweep steadily across. The voltage which very nearly accomplishes this ideal is the *sawtooth* wave form, which rises at a steady rate to a given value, then almost instantaneously drops back to its starting point.

This sweep voltage is internally generated in the scope by any of several types of sawtooth oscillator circuits. Some sets employ a gas-tube relaxation oscillator, but most systems today, including the one in Fig. 3, have a vacuum-tube oscillator, such as a multivibrator or blocking oscillator. These types are preferred because they produce less noise voltage along with greater stability and frequency range.

The length of time it takes the sweep to cross the face of the tube will determine the number of cycles observed of the signal under test. If the sweep frequency and signal frequency are equal, exactly one full cycle will be observed on the screen. But if the signal frequency is, say, 9,000 cps while the sweep frequency is 3,000 cps, then three full cycles will be shown. From this we can infer that the numerical ratio between signal frequency and sweep frequency will determine the number of cycles displayed on the screen.

It is desirable, therefore, that we be able to alter the sweep frequency in order to observe a convenient scope pattern for any signal frequency under test. Oscilloscopes have two controls for this adjustment, a coarse control for selecting a frequency range, plus a fine control for exact tuning within this range. The scope pictured in Fig. 4 has the coarse control marked HORIZONTAL SELECTOR, while the fine control is labeled FREQUENCY VERNIER.

As we will discover presently, there are occasions when some voltage other than the internal sawtooth is desired on the horizontal plates, and these contingencies are allowed for by two additional positions on the HORIZONTAL SELECTOR switch. If it is desired to apply a horizontal voltage from an external source, it is simply connected to the HORIZONTAL INPUT binding posts and the selector switch turned to the corresponding position. It is also possible to apply a 60-cps sine wave stepped down from the power line just by switching to the 60 CYCLE position. In this function there is also a PHASE control, which corrects for any undesirable phase shift between the 60-cps sweep voltage and the external signal under observation.

When the internal sawtooth sweep is employed, there is always the possibility of some frequency instability from temperature or voltage changes. For this

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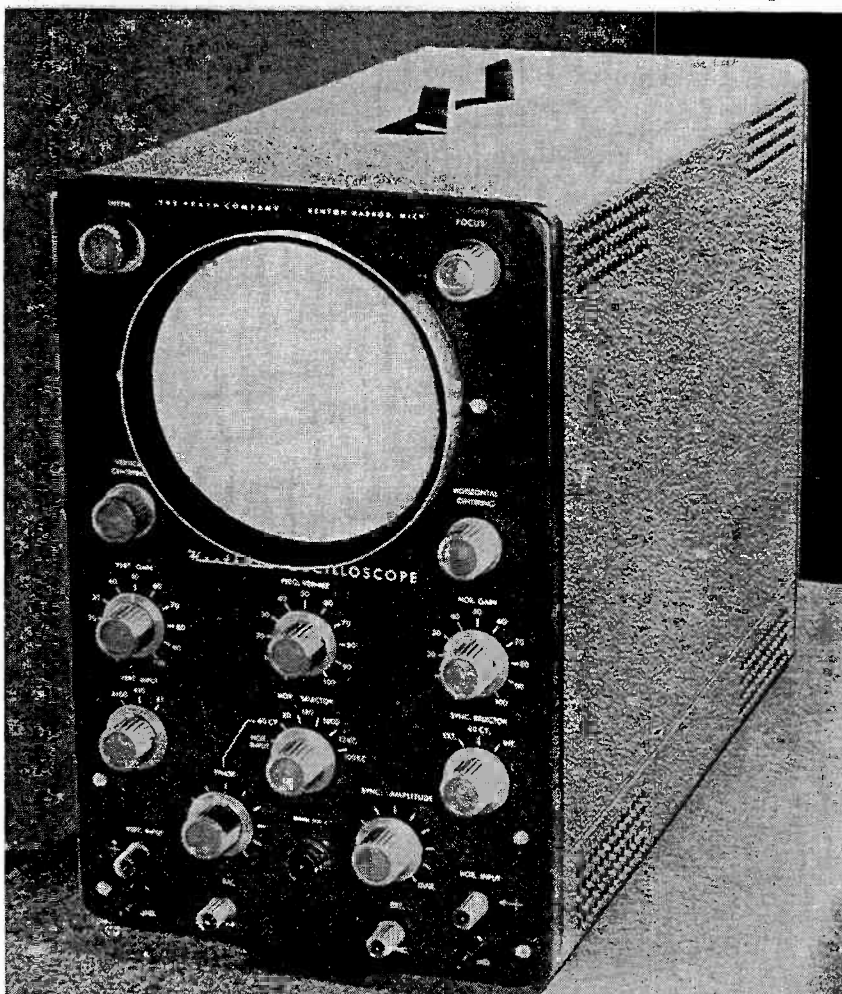
Fig. 4. These controls are easy to learn and increase the number of scope uses.



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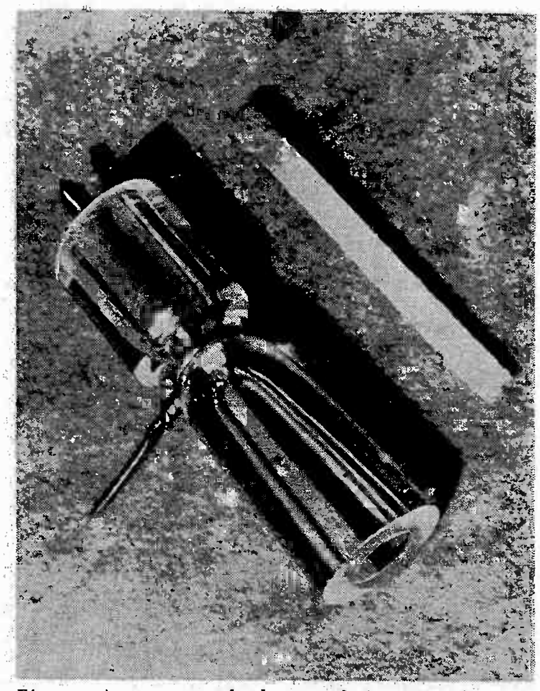

Fig. 1. A paper match shows relative size of quartz cell that is generating element of the new tweeter.

the blue-glow tweeter

First comprehensive report on the Ionovac, a new and greatly improved version of the ionized-air tweeter. This has no diaphragm mass because it has no diaphragm!

THE French physicist Klein demonstrated a completely massless sound reproducer about six years ago. Because it employed an ionized cloud of air instead of the conventional speaker diaphragm, this revolutionary new device was called the *Ionophone*. It received a great deal of deserved publicity, although no manufacturer considered it to be developed far enough for commercial success on the American market. At the end of 1955, however, DuKane Corporation acquired an exclusive North American manufacturing license from Dr. Klein, and engaged his services toward further refinement of the unit.

Since that time, intensive teamwork by DuKane engineers, Dr. Klein, and Electro-Voice Corporation has resulted in radical improvements in the Ionophone's performance, and no less drastic changes in its appearance. It is anticipated that the new device will be in dealers' showrooms by late summer or early fall. Electro-Voice will handle all distribution and sales. It is presently planned to call the American version the *Ionovac*, although this may be changed before the new model is introduced formally to the public.

How It Works

The main element of the Ionovac — the reproducer itself — is a small open-ended quartz cell the size of a peanut shell, shown in Fig. 1. At one end of the cell an electrode is inserted which reaches into a minute cavity in the central part of the cell. This cavity is about the size of an automatic pencil lead. There is a constriction in the outer section of the cell just beyond the inner end of the electrode, and a wire encircling the constriction serves as the second electrode. From the cavity gap between the two electrodes to the other end of the cell, the inner cross-sectional area increases gradually. A high-frequency horn, with a cutoff frequency of 2,000 cps, is fitted to the open end of the cell. This is shown pictorially in Fig. 2; a photograph of the assembly is given in Fig. 3.

If a high voltage stress is applied between the two electrodes, electrons are torn away from air molecules in the gap; that is, the air in the small cavity becomes ionized. The heavy positive ions are attracted toward one electrode or the other, depending on the polarity

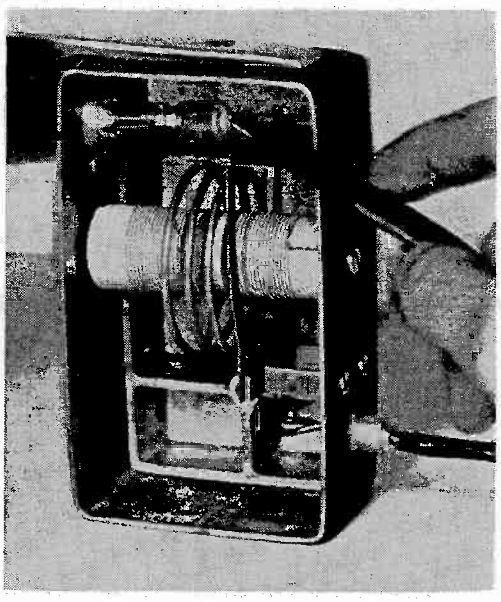

Fig. 3. Pencil points to the cell as it appears inside the horn and driver unit.

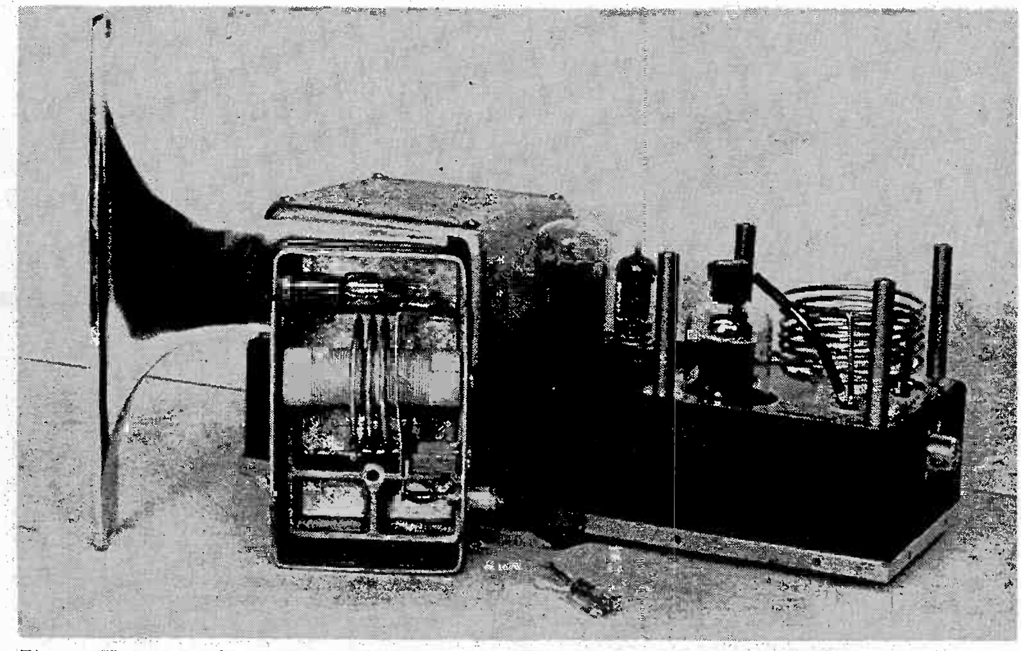

Fig. 5. Horn assembly and oscillator/power supply are connected by coaxial cable.

of the applied voltage. In the Ionovac, this high voltage is a 20-Mc radio-frequency carrier wave; thus, a cloud of ionized air is shuttled toward one electrode and then the other, back and forth within the cell, 20 million times a second. The ionized air produces a characteristic blue glow which can be seen when looking at the cell or, when the side cover is in place (Fig. 3), by looking directly into the horn mouth.

Such a frequency is obviously too high to be heard. But when the RF voltage is increased in amplitude, the oscillations of ionized air become greater; when the RF voltage decreases, the ionized air moves less violently. By making the RF voltage vary in amplitude according to an audio signal — by *amplitude-modulating* the RF carrier — the cloud can be made to expand and contract in accordance with the audio signal. This produces compressions and rarefactions in the cavity at an audio rate, which are coupled to the horn and heard as sound.

Auxiliary equipment necessary for the Ionovac, then, is a high-frequency horn, an RF oscillator that can be modulated by the incoming audio signal, and a power supply for the oscillator. The complete system is shown in simplified schematic form in Fig. 4. The high-frequency audio signal from a crossover network, which would normally be fed directly to a dynamic tweeter, is connected to the audio input terminals on the Ionovac's power-supply oscillator chassis. This signal amplitude-modulates a 20-Mc oscillator, whose output is coupled by means of RF transformers to the Ionovac cell electrodes. The input impedance is 16 ohms. Recommended crossover frequency is 3,500 cps, although the horn cutoff occurs at 2,000 cps. Theoretically, the only limit on low-frequency performance is the size of the horn used to load the cell. The power supply and oscillator chassis, with the top shield removed from the oscillator section, is shown behind the horn assembly in Fig. 5.

Performance

The most important advantage of the Ionovac, is, of course, the absence of any diaphragm mass. This produces virtually perfect transient response and the complete elimination of diaphragm resonances; the sound is effortless, transparent, and uncolored. Frequency response is exceptionally fine also, as Fig. 6 shows. The lower limit is established by the horn, and the upper limit extends well into the megacycle region. In fact, it is expected that its industrial and medical applications as a variable-frequency ultrasonic energy propagator will exceed the high-fidelity market in volume of sales.

Fig. 6 was taken at the 94-db level, for which only 0.64 volt input is required. That is just 25.6 mw across 16 ohms! Distortion at this level is stated to be less than 2%; it increases slightly with age because of electrode deterioration. According to DuKane, the

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Fig. 2. Audio modulations of RF are converted directly to sound.

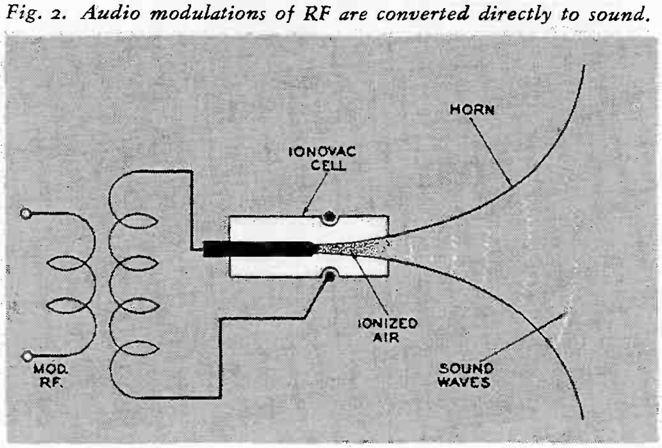
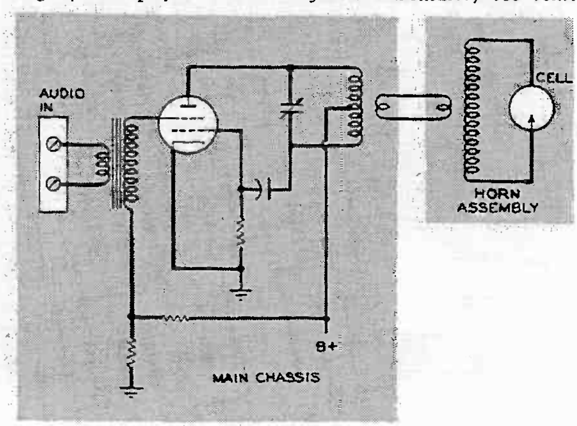


Fig. 4. Simplified Ionovac system schematic; see text.



TRANSISTORS *in Audio Circuits*

by PAUL PENFIELD, JR.

Vb: Parameters; Equivalent Circuits

LAST month we developed several equivalent circuits and discussed the parameters which went with them. Those mentioned were h-parameter sets for grounded-emitter (h_e), grounded-base (h_b), and grounded-collector (h_c) circuits, as well as r parameters for both grounded-base and grounded-emitter circuits.

The relationships between the various sets are shown in Table I. To transfer values from any one set to any other, use the appropriate set of formulas. For example, if the transistor parameters are given in the h_b set by the manufacturer, and you want to use the r set, use the equations in the second row, fourth column of the table.

We have gone to considerable trouble to derive seemingly complicated equivalent circuits that only approximate the AC behavior of the transistor. Is it really worth it? What good are these circuits?

The circuits are useful for a number of purposes. First, in designing or analyzing circuits, it is convenient to separate, as far as possible, the DC bias-network calculations from the AC-signal computations. DC conditions must be computed using the characteristic curves of the transistor, as explained last month. For AC calculations we can use the equivalent circuit and equations in terms of the four parameters of the particular set used; we don't have to look at the graph. This makes our job much easier.

Second, it is convenient, when describing a transistor briefly, to quote four numbers instead of showing the whole graph. Different transistors can be compared quickly and easily on the basis of their parameter numbers.

Third, the effect on the AC signal of a variation in, say, quiescent voltage or temperature can be computed quickly provided that the parameters are known at the various temperatures, quiescent voltages, etc. It is easier to give this information numerically than to give several characteristic-curve plots for various temperatures.

Fourth, from these parameters and equivalent circuits, important quantities such as input impedance and current gain can be calculated. These cannot be obtained from the graphs without a lot of work.

A Comparison

It is interesting to compare directly the actual volt-ampere characteristics of the transistor with our approximate equivalent circuit. We are now in a position to do so.

Fig. 9 shows the grounded-emitter collector family of a typical transistor. Note that this in effect gives a value for I_c provided that V_{ec} and I_b are known. In other words, it expresses I_c as a function of V_{ec} and I_b.

Our equivalent circuit gives an equation for I_c, incrementally, as follows:

$$I_c = h_{fe} I_b + h_{oe} V_{ec} \qquad \ldots (15)$$

Fig. 9, left. Actual grounded-emitter characteristic curves.

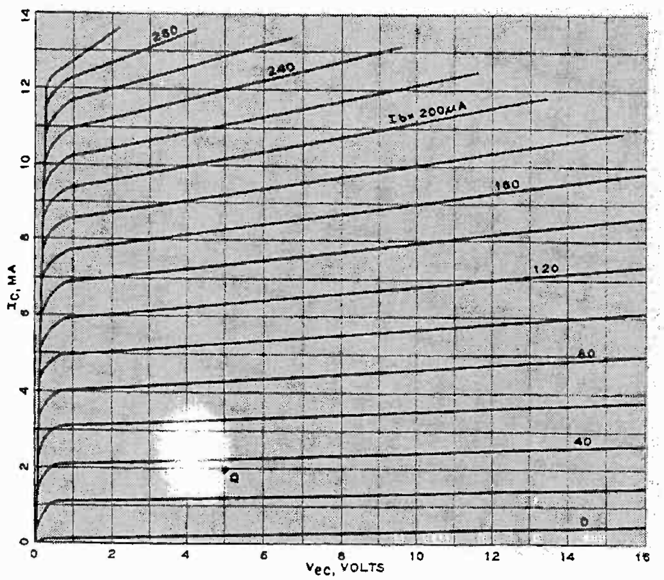
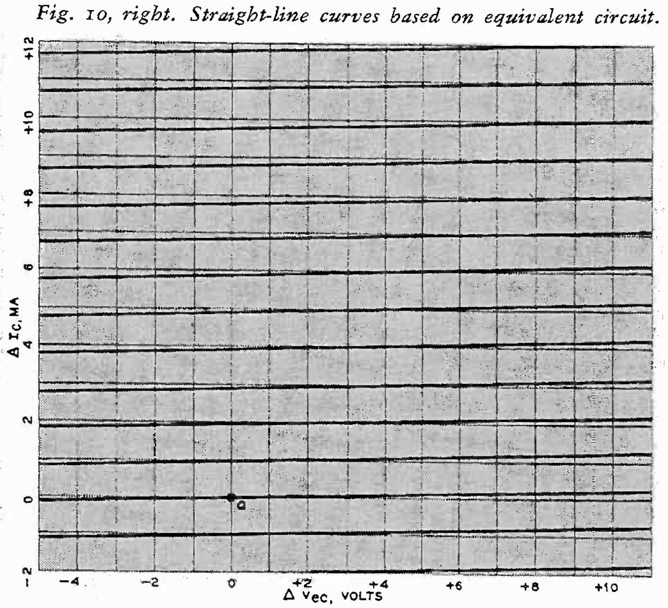


Fig. 10, right. Straight-line curves based on equivalent circuit.



Using typical values for h_{fe} and h_{oe} of 49 and 25×10^{-6} mhos, respectively, this function can be graphed. Fig. 10 is the result.

Because of the assumed linearity of the equivalent circuit, the graph has lines which are straight and equally spaced. The zero-voltage, zero-current point is actually the point Q on Fig. 9, since our equivalent circuit is an incremental model not concerned with DC.

In comparing Figs. 9 and 10, note that the two agree quite well in a region around Q. Further away from Q, transistor nonlinearities are encountered, and the agreement isn't so good. At saturation or cutoff the linear equivalent circuit is completely wrong. Use of the equivalent circuit will be valid only if we restrict operation to incremental voltages and currents small enough to remain within the linear region. This is the small-signal restriction.

Because of the assumptions made in deriving the equivalent circuits, they cannot explain noise, high-frequency response, distortion, biasing, temperature effects, etc. For these, we must either resort to the graphs, or modify the equivalent circuits somehow, or look elsewhere. However, equivalent circuits provide us with an easy way to calculate such quantities as input and output impedance, current and voltage gains, optimal terminations, etc. In the next issue we will use the equivalent circuits for calculations in actual circuits, to find single-stage amplifier formulas.

Further Reading

Low-Frequency Equivalent Circuits

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Coblenz, A., and Owens, H. L. *Transistors: Theory and Applications.* New York: McGraw-Hill, 1955, pp. 90-126.

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Continued on page 45

Table 1: Parameter Conversions

	h_e	h_b	h_c	r
h_e		$h_{ib}=\frac{h_{ie}}{1+h_{fe}}$ $h_{rb}=\frac{h_{ie}h_{oe}}{1+h_{fe}}-h_{re}$ $h_{fb}=-\frac{h_{fe}}{1+h_{fe}}$ $h_{ob}=\frac{h_{oe}}{1+h_{fe}}$	$h_{ic}=h_{ie}$ $h_{rc}=1$ $h_{fc}=-(1+h_{fe})$ $h_{oc}=h_{oe}$	$r_b=h_{ie}-\frac{h_{re}}{h_{oe}}(1+h_{fe})$ $r_e=\frac{h_{re}}{h_{oe}}$ $r_c=\frac{1+h_{fe}}{h_{oe}}$ $r_d=\frac{1}{h_{oe}}$ $\alpha=\frac{h_{fe}}{1+h_{fe}}$ $\beta=h_{fe}$
h_b	$h_{ie}=\frac{h_{ib}}{1+h_{fb}}$ $h_{re}=\frac{h_{ib}h_{ob}}{1+h_{fb}}-h_{rb}$ $h_{fe}=\frac{-h_{fb}}{1+h_{fb}}$ $h_{oe}=\frac{h_{ob}}{1+h_{fb}}$		$h_{ic}=\frac{h_{ib}}{1+h_{fb}}$ $h_{rc}=1$ $h_{fc}=-\left(\frac{1}{1+h_{fb}}\right)$ $h_{oc}=\frac{h_{ob}}{1+h_{fb}}$	$r_b=\frac{h_{rb}}{h_{ob}}$ $r_e=h_{ib}-\frac{h_{rb}}{h_{ob}}(1+h_{fb})$ $r_c=\frac{1}{h_{ob}}$ $r_d=\frac{1+h_{fb}}{h_{ob}}$ $\alpha=-h_{fb}$ $\beta=\frac{-h_{fb}}{1+h_{fb}}$
r	$h_{ie}=r_b+r_e(1+\beta)=\frac{r_b+r_e}{1-\alpha}$ $h_{re}=\frac{r_e}{r_d}=\frac{r_e}{r_c(1-\alpha)}$ $h_{fe}=\frac{\alpha}{1-\alpha}=\beta$ $h_{oe}=\frac{1}{r_d}=\frac{1}{r_c(1-\alpha)}$	$h_{ib}=r_e+r_b(1-\alpha)=r_e+\frac{r_b}{1+\beta}$ $h_{rb}=\frac{r_b}{r_c}$ $h_{fb}=-\alpha$ $h_{ob}=\frac{1}{r_c}=\frac{1-\alpha}{r_d}$	$h_{ic}=\frac{r_e}{1-\alpha}+r_b=r_e(1+\beta)+r_b$ $h_{rc}=1$ $h_{fc}=-\left(\frac{1}{1-\alpha}\right)=-(\beta+1)$ $h_{oc}=\frac{1}{r_c(1-\alpha)}=\frac{1}{r_d}$	$r_d=r_c(1-\alpha)=\frac{r_c}{1+\beta}$ $r_c=r_d(1+\beta)=\frac{r_d}{1-\alpha}$ $\alpha=\frac{\beta}{1+\beta}$ $\beta=\frac{\alpha}{1-\alpha}$
Typical Values	$h_{ie}=3{,}000$ ohms $h_{re}=1.0\times10^{-3}$ $h_{fe}=49$ $h_{oe}=25\times10^{-6}$ mhos	$h_{ib}=60$ ohms $h_{rb}=5\times10^{-4}$ $h_{fb}=-0.98$ $h_{ob}=0.5\times10^{-6}$ mhos	$h_{ic}=3{,}000$ ohms $h_{rc}=1$ $h_{fc}=-50$ $h_{oc}=25\times10^{-6}$ mhos	$r_b=1{,}000$ ohms $r_e=40$ ohms $r_c=2$ megohms $r_d=40{,}000$ ohms $\alpha=0.98$ $\beta=49$

BASIC ELECTRONICS

by Roy F. Allison

XVI: Thermionic Emission

In the very first chapter of this series there was a discussion of electrical conduction. Readers will recall that good electrical conductors are distinguished by having fewer than four outer-shell electrons in their atomic structures, and that these "excess" electrons are easily separated from the parent atoms. When the atoms are relatively dense (closely spaced), these electrons are free to move about within the conductor in a continuous process of exchange: a wandering electron caught by an atom knocks one of that atom's original electrons out of the shell; that electron may wander to the next atom and knock an electron out of *its* outer shell; and so on. Such electrons are aptly called free electrons. They are in a state of constant agitation which produces entirely random electron movements from atom to atom.

If a difference of electrical potential is applied across the conductor, such as from a battery, the random motion of free electrons becomes concerted in a general drift from the negative potential toward the positive. Electrons are supplied to the conductor by the negative battery terminal and are taken from it by the positive terminal in equal quantity; thus, while there is a continuous flow of current through the conductor, it remains on the average electrically neutral, maintaining enough electrons within itself to balance the positive atomic nuclei.

It it interesting to speculate on the effects of this random motion of free electrons at the surface of the conductor, when the conductor is not subjected to an external difference of potential. Would it not be probable that some free electrons at the surface, which happened to be traveling in the right direction, would escape from the metal? Possibly, but in doing so such an electron would leave a net positive charge on the conductor (Fig. 1) which would attract the negative electron back to it. The electron, if it is to escape completely, must have enough kinetic energy — it must be moving fast enough — to overcome this pull-back force or *surface barrier.* In normal conductors at normal temperatures the free electrons do not have enough kinetic energy to escape.

They can be made to escape, however, in several ways. For instance, the surface barrier can be modified by a strong electrostatic field, such as would be obtained if an adjacent conductor were made very positive with respect to the first. In Fig. 2, electrons leaving conductor A would be subjected to two opposing attractions: that from conductor A, whose surface would be made positive by loss of the electron, and that from conductor B, which has a positive charge to begin with. Some electrons would make the journey to B; others would return to A. If there were no external connection between the two, conductor B's charge would soon be neutralized to such an extent that it could no longer attract electrons across

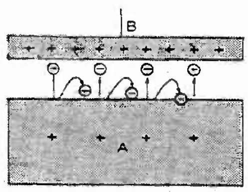


Fig. 2. It is possible that emission may occur if surface barrier is modified by application of strong electrostatic field.

the gap, and conductor A would simultaneously build up such a positive charge that no electrons could escape. On the other hand, if electrons were continuously drained off B to maintain its charge, and electrons were supplied to A so that its charge remained neutral, a small continuous current could flow across the gap. It would be an inefficient method of transfer, however, unless the medium in the gap (air, for example) were to become ionized.

Another way in which electrons can be made to escape is by increasing their kinetic energy. This can be done by several means. Among the most important are photoelectric emission, secondary emission, and thermionic emission. Some materials will emit electrons when their surfaces are struck by light, as Fig. 3A

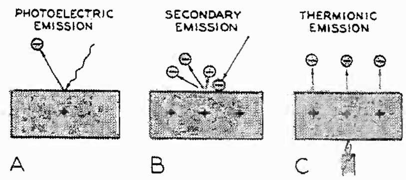
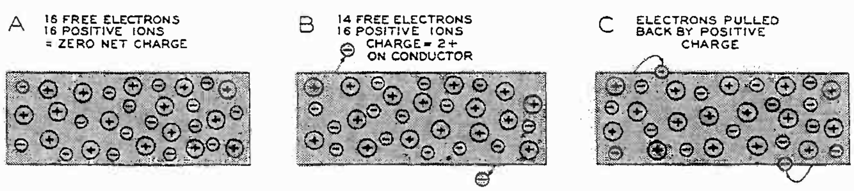


Fig. 3. Three methods by which electron emission may be accomplished by increasing the kinetic energy of free electrons on the surface of a conductor.

shows; in photoelectric emission the extra kinetic energy needed for electron escape is supplied by photons (light energy). In secondary emission, Fig. 3B, a high-velocity electron striking the surface may supply enough kinetic energy for the escape of several secondary electrons. And in thermionic emission, Fig. 3C, the kinetic energy needed for escape may come from heat applied to the conductor. It is this method with which we are most concerned.

Conducting materials differ in the temperature at which it becomes possible for electrons to escape completely. Once that temperature is reached for a given material, however, small increases in temperature produce very great increases in the number of escaped electrons. If there is no positive electrode nearby to attract the escaped electrons, they cluster in a group close to the conductor from which they were emitted, because it will be positive with respect to them and will still attract them. A condition is soon reached in which additional escaping electrons are repelled by the negative cluster, and fall back to the surface of the material as fast as they are emitted. This electron cloud in equilibrium (Fig. 4) is known as a *space charge.* If the temperature is increased, the space charge becomes greater in size; if it is decreased, the space charge becomes smaller.

Fig. 1. Surface-barrier action prevents free electrons from escaping a conductor at normal temperature. Electrons do not have enough velocity to clear the field.



Now, suppose that another conductor is brought into close proximity with the first, and the two are connected in a circuit such as that shown in Fig. 5. With the switches in position 1, the positive battery terminal is connected to the second conductor and the negative

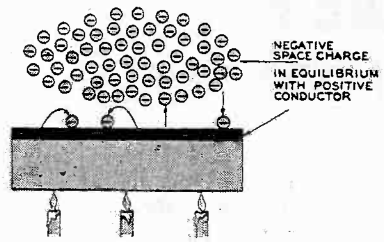


Fig. 4. Space-charge formation from thermionic emission of heated conductor.

terminal to the heated conductor. Electrons will be drawn from the space charge to the positive electrode (the *anode*). This will diminish the space charge and disturb its equilibrium with the negative electrode (the *cathode*); more electrons will then be permitted to escape from the cathode to replenish the space charge. It is easy to see that this will be a continuous process as long as the battery maintains the difference in potential between anode and cathode. There will be a DC current flow from cathode to anode.

If both switches are thrown from position 1 to position 2, the battery terminals are reversed: the negative terminal is connected to the top conductor, and the positive terminal to the emitter. The former anode now repels electrons from the space charge. But this conductor isn't heated; there is no way in which electrons can escape from it. Current flow ceases abruptly. Thus, this device will

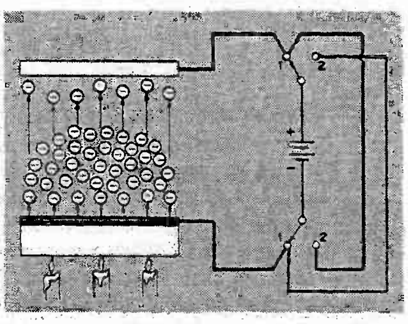


Fig. 5. Continuous current flows from emitting conductor across gap to another conductor on which a positive potential is maintained by battery. Operating the switches reverses battery polarity, and current ceases. This is a simple rectifier.

conduct current in one direction but not in the other. It is a simplified form of a two-element vacuum tube — a *diode*, or *rectifier*, in which the emitter corresponds to the vacuum-tube cathode and the other conductor to the vacuum-tube anode or *plate*. Fig. 6 is the schematic notation of a vacuum-tube diode.

We have said that different materials vary in the temperature necessary to permit complete escape of free electrons. There are four materials in common use as cathodes: mercury, tungsten, thoriated tungsten, and a combination of barium and strontium oxides. Mercury-pool cathodes are used when extremely large currents must be passed by a rectifier. An auxiliary electrode initiates an arc in the mercury vapor that exists between the pool and the anode. Ionization of the vapor occurs, permitting very large currents to flow, sometimes hundreds or thousands of amperes. Mercury-vapor rectifiers or *ignitrons* are used only in heavy industry.

Tungsten cathodes require relatively high temperatures for emission, nearly 2,200° Centigrade. That means a lot of heating power. It is the only material suitable for plate voltages above 3,000, however, and must be used for very high-power electronic applications.

Thoriated-tungsten cathodes are used in medium-power tubes and operate at intermediate temperatures, usually about 1,600° C. This lower operating temperature is achieved by adding thorium

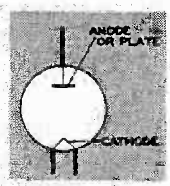


Fig. 6. Schematic symbol for a diode.

oxide to tungsten, and heating the cathode momentarily to 2,200° C., which reduces some of the oxide to pure thorium. An extremely fine coating of thorium remains on the cathode's surface. Thoriated-tungsten cathodes are usable with plate voltages up to 3,000; above that, pure tungsten must be used.

Oxide-coated cathodes are composed of nickel or nickel-alloy bases coated with a mixture of barium and strontium carbonates which, when heated, are converted to oxides. The main advantages of an oxide-coated cathode are high emissive efficiency and low operating temperature (1,000° to 1,100° C.), which is conducive to long life. They are used in virtually all radio and TV receiving tubes, including those for audio applications. The upper plate-voltage limit for a tube with an oxide-coated cathode is about 500 v.

All ordinary tubes are enclosed in a glass or metal jacket which is sealed after all possible air has been evacuated. The main reason for this is to prevent ionization of gas molecules; the heavy positive ions formed would be strongly attracted to the cathode. Such ion bombardment would destroy the cathode coating quickly. Even in highly evacuated tubes, some air gases remain that have been adsorbed by the metallic elements. Most of these and other impurities are rendered harmless by a substance called a "getter" which is put in the tube for that purpose. Still, enough ionization may occur with a plate potential above 500 volts to destroy an oxide-coated cathode.

Cathodes (except mercury-pool types) are heated by an electrical current provided specifically for that purpose. Originally, all cathodes were of the filamentary *directly heated* type; two examples are shown in Fig. 7. The emitting material is coated directly on the heating wire or filament itself, and emission

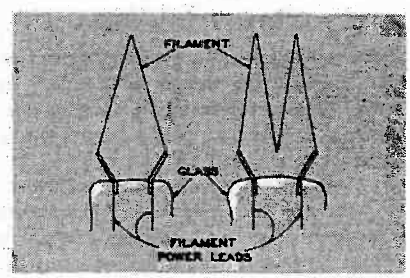


Fig. 7. Two types of directly heated cathodes, which may be called filaments.

occurs from the filament. The filament *is* the cathode. This is the most efficient cathode-heating method, and it is still used in tubes for battery-operated portable radios, where it is especially important to keep current drain to a minimum. It is also used in some AC-operated power-supply rectifiers, for which a small AC voltage on the cathode is of no importance.

Except for power-supply rectifiers, however, an AC heating voltage directly on the cathode would introduce intolerable hum, distortion, or both. Accordingly, most tubes have *indirectly heated* cathodes. These employ a heater winding inside a sleevelike cathode. There is no connection between the two; the heater wire is ordinarily of tungsten or a tungsten alloy, coated with an electrical insulating material. Its configuration depends on the shape of the cathode. Two common indirectly-heated cathode shapes, of round and oval cross section, are depicted in Fig. 8, with heaters that

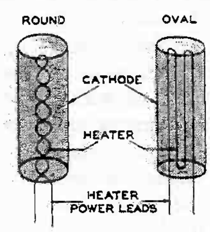


Fig. 8. Two types of indirectly heated cathodes. There is no electrical connection between the cathode and its heater.

might be used with them. Other shapes are sometimes used for special applications. Even with AC power used on the heater, the cathode heat remains virtually constant, not fluctuating with the heating current.

Continued on page 45

Kit-Building Tools

Anyone starting on the fascinating work of kit construction is advised to have on hand such items as soldering equipment, a wire stripper, long-nose pliers, diagonal cutters, and screw drivers.

Certain additional tools, such as the following, may also be of great value: a drill-press vise for holding rotary switches; tweezers for picking up small objects; a drift pin, 1/16 in. in diameter, for lining up holes; open-end or box wrenches from 1/2 in. down to the sizes included in a set of ignition wrenches; an ordinary old-fashioned doorknob (this will accept any square-shank tool such as a countersink or a screw-driver bit and will work in close quarters).

For soldering in close quarters, a soldering pencil is ideal. Heating units with Tiplets can be obtained in 23 1/2-watt and 37 1/2-watt sizes. The smaller iron will work on printed circuits, but not so well on other joints. When using the 37 1/2-watt size, it is a good plan to insert a switch in the line cord. A 50-watt soldering gun is excellent for most soldering in electronic kits.

Edward H. Marsh
Purcellville, Va.

Positioning Tape-Recorder Replacement Heads

While changing over to Dynamu heads in my Pentron PMD-1 tape recorder, I came across a neat expedient that converted a tricky, tedious maneuver into a comparatively simple one.

The positioning of the heads must be accurate to within 1/64 in., and it is no easy matter to achieve this degree of accuracy with the two heads attached to the same bracket. The record/playback and erase heads must both be 1/64 in. below the center line of the tape after the tape guide is properly positioned, so that the bottom of the tape is ⅜ in. above the bottom of the base.

To facilitate this adjustment, remove 6 to 8 in. of the coating toward the end of a reel of tape. (Cleaning fluid or other solvent will do this completely and easily.) Measure 1/64 in. below the center of the tape at each end of the clear space and draw a line with ink or grease pencil between these two measurements. Now mount the tape in the reels on the recorder so that the clear space is taut against the heads and adjust the heads so that the top of each pole piece coincides with the measured line.

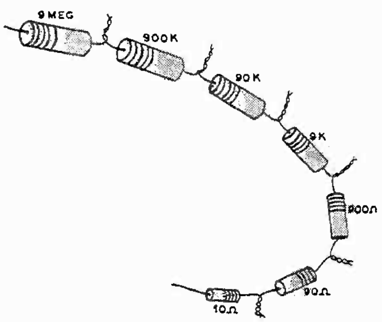
This procedure can be used to check the alignment and positioning of the pole pieces in any recorder. Fine adjustment of head azimuth should be completed afterward, according to output strength as the playback head is tilted slightly to and fro without moving it out of position entirely.

Ezra T. Clark, M.D.
Danville, Calif.

Microvolt Signal Source

It is not unusual to find audiophiles working with low-level amplifiers of one sort or another—usually mike or phono preamps. When designing such equipment it is sometimes useful to have a calibrated source of variable-frequency AC voltage. Ordinary signal generators or audio oscillators have no provision for the extremely low voltages sometimes needed (as low as 1μv).

Using the device shown, a considerable range of voltage can be obtained easily and cheaply from an ordinary audio generator. The common ½-watt



Voltage divider for reducing the output of a signal generator in steps of ten.

resistors (perhaps selected for accuracy with a good ohmmeter) are merely soldered together as shown, so that clips can be used to make contact between them.

There are two ways to use this voltage divider. One way is to connect the entire resistance (10 MΩ) across the signal generator, set the voltage at the signal-generator output terminals, and tap off that portion of the voltage which is the right amount. Each time you move the top tap down one notch, you cut the voltage at the probe down by a factor of ten. Thus, to get 21 μv, set the generator at 2.1 volts output and connect across 100 of the 10,000,000 ohms. At higher tap points, allowance should be made for the loading effect of the amplifier input resistance.

This way is useful if the resistance "seen" by the amplifier input terminals is not of interest. The next method is useful if this resistance is critical.

Connect the amplifier input across as many ohms of the voltage divider as necessary (within a factor of three either way) and set as much of the divider across the generator as is necessary to produce the desired voltage. For example, to get 120 μv with an internal resistance of 10 ohms, connect the generator above the 90-K resistor, and set the generator to 1.2 v.

The only difficulty with this arrangement is that sometimes hum will leak into the voltage divider, but usually this is not important. In any case, shielding will help.

Paul Penfield, Jr.
Brookline, Mass.

Screen Barrier for High Frequencies

With infinite-baffle mounting, 50% of the energy delivered by a speaker may be usefully radiated as sound from the front of the cone. With reflex mounting, an additional 20% from the back of the cone may be delivered through the vent as useful energy. This leaves from 50% to 30% of the energy radiated by the speaker to be wasted or to react out of phase with the useful radiations. Adverse effects can be reduced by quieting the unused portion of sound energy.

It is possible to erect a barrier which interferes with sound reflection and is effective in changing the higher frequencies into heat. Experiment has shown that metal screen with a fine mesh (such as galvanized flyscreen) and which has sufficient mass to be inert is effective in presenting surfaces that diffuse sound instead of reflecting it. This makes the absorption job easier for the standard acoustical-material lining of the enclosure walls.

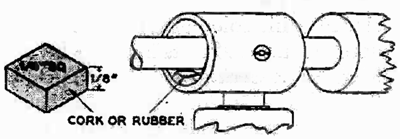
The screen is suspended between the back of the cone and the opposite reflecting surface of the enclosure. I have found that the effect of this screen is to clarify the sound.

Joseph W. Ridgway
Argos, Ind.

Tone-Arm Cushion

Owners of Rek-O-Kut tone arms are undoubtedly well pleased with this fine product, but let's hope they have not damaged a stylus by accidentally dropping it on the surface of the turntable base.

My insurance, after one such accident, took the form of securing a piece of cork 1/4 in. square and 1/8 in. thick to



How to limit vertical drop of tone arm.

the inner surface of the arm-pivot housing, just under the arm and at the forward edge of the cylindrical housing. This allows sufficient movement of the arm for the most extreme vertical requirements, but prevents the arm from dropping the stylus to any surface below that of the turntable.

A. J. Neil
Farmingdale, N. Y.

Homemade Printed Circuit

A quick printed circuit for experimental work can be made up using twine and metallic paint. First, draw up a layout of the circuit; then transfer it to the base. Measure the lines of the circuit layout with a piece of twine. The string is dipped into the metallic paint (such as *Silver Print*), the excess allowed to flow off, and then laid on the circuit until a line of paint is left on the base. The twine should be thick enough and sufficiently saturated to leave at least a 1/8-inch trace. In some cases, the line may have to be overlaid a second time.

One caution: lugs should be used for all connections. Touching up along the wiring and around the lugs may be done with a fine paintbrush. This method is a little neater than trying to paint the entire circuit.

Jim Cost
Eufaula, Ala.

Poor Man's Chassis Punch

Those of us who are given to occasional experimentation with and construction of electrical gadgets sooner or later find ourselves confronted with the problem of making holes in a metal chassis. Persons fortunate enough to own a power drill and a selection of bits can sometimes circumvent the problem by drilling holes for jacks and some miniature-tube sockets. Experimenters who are unwilling to invest in a set of chassis punches which would see use only occasionally must find another way to make these holes. I did it with a conventional brace and an adjustable bit having a radius variable between 1/2 and 2 1/2 in. To drill a neat hole of any diameter of which your bit is capable, locate the center of the hole and mark the spot with a center punch. Then drill a small hole at this point just large enough to permit the pilot bit to pass through. Next take a small block of hardwood (the harder the better), place it behind the small hole in the chassis, pass the pilot bit through this hole, and start it into the wood block. You are now ready to begin the serious drilling. Steady the chassis in a wood vise or have a friend hold it. Drill slowly and firmly, being careful to keep the drill perpendicular to the work at all times.

2/Lt. Loue A. Stockwell
Harlingen, Tex.

This method may work on aluminum chassis, but don't try it on steel. — ED.

Turntable Cover

In many home high-fidelity systems the turntable is located on the top of any available cabinet or shelf. While the arrangement is ideal for convenience, the turntable's exposed position soon results in the accumulation of a layer of dust and lint which transfers to the next record played.

The turntable can be protected with any removable covering of cloth or plastic, but perhaps the neatest-appearing solution is a felt turntable cover which is already cut to size. A turntable felt suitable for a 12-inch turntable can be purchased from such firms as the Burstein-Applebee Company for less than 50¢, and after pressing to remove wrinkles it forms a neat, removable dust cover for your turntable. Felts are available for all sizes of turntables up to 16 in. in diameter.

R. D. Dickson
Palm City, Calif.

Cartridge Mounting

Owners of the Rek-O-Kut tone arm and the Fairchild 225A cartridge have undoubtedly decided that the respective manufacturers have conspired to make the mounting of the cartridge as difficult as possible. The Fairchild cartridge is lacking in thickness as compared to the depth of the Rek-O-Kut head. It must be mounted with spacing blocks if the stylus is to contact the record.

The Rek-O-Kut is supplied with two sets of blocks and two sets of mounting screws. The proper combination is the *short* blocks and the *long* screws. Getting the blocks to stay in place despite the jiggling that necessarily goes on during the mounting procedure is nearly impossible unless a *bare touch* of Duco cement is applied to the blocks. The blocks will then stay in place either on the screw posts within the Rek-O-Kut head or on the cartridge itself. I find that it is easier to stick the blocks to the screw posts.

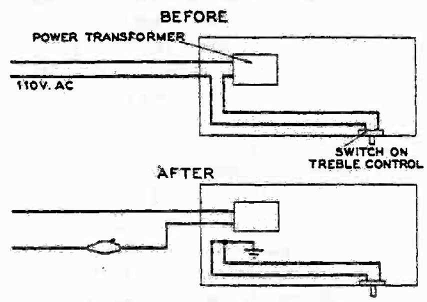
It should be noted that this sticking is not permanent or very secure even temporarily. However, if one's touch is reasonably light, it will make a nearly impossible job fairly easy and quick.

Warren H. Corning
Winnetka, Ill.

More About Hum

If hum in your hi-fi system defies all the usual cures, take a look at the line-voltage wiring to the ON-OFF switch. Sometimes, despite careful shielding, this part of the circuit creates a strong 60-cycle field that can be picked up in the preamplifier stages.

The cure is simple. At the power transformer, disconnect the two wires



External AC power switch to reduce hum.

leading to the switch and ground them to the chassis, making the switch inoperative. Then connect the free AC lead to the terminal left open on the power transformer, and solder it permanently in place.

To turn the system off and on, install a hand switch of the type used on heating pads at some convenient point in the cord leading to the power supply from the AC wall outlet. This arrangement removed the cause of the last bit of bothersome hum in my dual-chassis amplifier and preamplifier.

L. E. Johnston
Madison, Wis.

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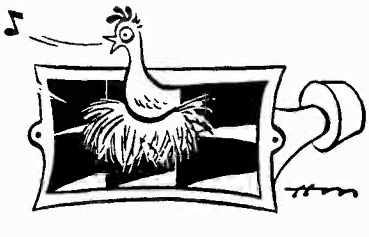


Sound-Fanciers' Guide

by R. D. DARRELL

Strictly for the Birds?

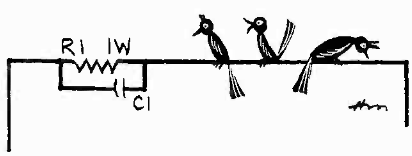
. . . a bird of the air shall carry the voice, and that which hath wings shall tell the matter. ECCLESIASTES, 10:20

By the time this appears in print, the spring avian invasion will be well under way. A sound-level meter placed outside my windows probably will be showing sound levels close to those currently reached in the quite different New York City "Birdland", or inside my living room during a strenuous tape-and-disc reviewing session. At the moment I write, however, all is relatively quiet at the local feeding stations, which are still patronized only by such regular customers as the jays, juncoes, chickadees, nuthatches, *et al.* (This winter we have been mercifully spared the gluttonous evening and rose-breasted grosbeaks.) So it's a special pleasure to anticipate the feathered visitors soon to arrive, plus flocks of others which never reach these parts in person, by transferring (thanks to the receipt of a big batch of out-of-season recordings) my bird-listening activities to loudspeaker sources.

Only one of these is really new, but it's novel in every sense of the word: the singular example of *musique concrète* contrived by Jim Fassett as his compositional Opus 1, entitled with literal accuracy a *Symphony of the Birds* (Ficker C 1002). If you heard this in the recent CBS broadcast as a Sunday afternoon Philharmonic Symphony intermission *divertissement*, you probably consider it merely another example of the amusing tape trickery for which Fassett is famous (*Strange to Your Ears*, etc.) — but a more attentive hearing of the disc itself is likely to revise that opinion radically. Trickery it is, all right, and in the slowed-down, speeded-up, and montaged edition most of the original bird-song materials have become quite unrecognizable, yet the over-all result is amazingly expressive. For this truly is a miniature symphony with admirably contrasted yet cumulative movements, ranging from an elegaic *Andante e lirico* based on ostinato whistling motives, through a hoarsely growling scherzo *Buffo* with engaging bits of quasi two-part counterpoint, to an eerily moving *Misterioso* starring what well might be an eloquent solo double bass.

And besides the symphony itself, there are ingratiating spoken annotations by the "composer", describing and illustrating the basic materials and their metamorphoses. On the second side is a series of some thirteen avian solo passages in both natural and slowed-down versions.

This extraordinary record didn't simply appear out of the blue as a new American attempt to catch up with European experimentations in "concrete" music making; it is, rather, the climax of Fassett's long obsession with recorded bird songs, begun long ago when he first became acquainted with the sonic documents of Cornell University's Laboratory of Ornithology, and further developed when he discovered that a vast broadcast audience shared his fascination with the blithe songsters and the fantastic varieties of tonal qualities revealed in taped analyses and syntheses of their songs. And by lucky happenstance (perhaps prompted by this column's July and November 1956 citations of Jerry and Norma Stillwells' Ficker LP's,



from which Fassett drew the basic materials of his *Symphony of the Birds*), Cornell University Records has just sent me most of their earlier releases, including not only the original stimuli of Fassett's (and many others') obsession, but also its most striking manifestation: the famous Fassett broadcasts of 25 May and 30 November, 1952, entitled *Music and Bird Songs* (Cornell 10-inch LP).

This last still remains a delightful document, but no real *aficionado* will be content until it is joined on the shelves and turntable by the original Kellogg and Allen *American Bird Songs*, Vols. 1 and 2 (representing well over 100 species), released in part on 78's, some as early as 1942, and in their present augmented 12-inch LP forms in 1954-55. These, together with the 1954 10-inch, 78-rpm disc *The Mockingbird Sings*, are "musts" for every bird watcher and listener. Since the recordings themselves are still so satisfactorily clear and faithful, they are of uncommon interest also to every omnivorous sound fancier. A newcomer to these ornithological domains is perhaps best advised to start off with the condensed 10-inch LP included with color plates and descriptive notes in the 1954 "talking book" *Songbirds of America in Color, Sound, and Story*, but this, for all its visual attractions, is not likely to satisfy him as well in the long run as the more extensive recordings mentioned earlier.

Yak-Yak Soloists and Ensembles

Quite frankly, however, I remain at heart more of a sonic than an avian connoisseur, and although the Cornell and Ficker bird-song discs have both delighted me on a single hearing and added immeasurably to my appreciation of the live artists, I'm soon willing to turn them over to my sister and other more insatiable bird-life students. I derive more lasting relish from two other Cornell 12-inch LP documentaries: the 1956 Borror and Alexander *Songs of Insects*, and the 1954 Kellogg and Allen *Voices of the Night.* Like any country dweller, I'm familiar enough with many of the sounds emitted by what I lump collectively as the "yak-yak boys", but until I made the belated acquaintance of these discs I had never realized the full virtuosity, or the frequency, dynamic, and transient extremes that are exploited by a bewildering variety of crickets, grasshoppers, cicadas, frogs, and toads. The wildest *musique concrète* has nothing to beat the razz, buzz, lisp, sputter, grunt, and snore repertory disclosed so vividly here! Both these discs are admirably calculated to put pickups and loudspeakers to the cruellest possible response tests, but more than that they are a revelation of Nature's anticipations of human attempts to expand the full resources of sonic innovation. Even for the most alert and catholic-minded audiophiles, they prove that there are old as well as new worlds of sound to explore. My only regrets are that I have been so tardy in discovering these particular oddity discs, and that I couldn't have beaten Herbert Kupferberg to the sheer inspiration of subtitling the 1954 nocturnal tone poem *Toad und Verklärung.*

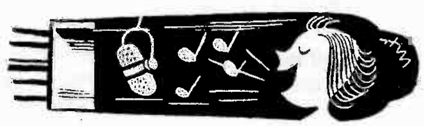
Organological Odyssey (Cont.)

It's reluctantly indeed that I leave the breezy out-of-doors consorts of feathery coloraturas, warty basso profundos, and six-legged concussionists for the musty confines of massed organ pipes, old, new, and synthetic. The music, to be sure, may exhibit (in more than a punning sense alone) higher degrees of organization, but in a world where, as Bishop Heber's hymn reminds us, "every prospect pleases, and only man is vile," it is perhaps inevitable that human musicians in general seldom can match the zest and spontaneity of their nonhuman colleagues. And organists, in particular, frequently display a sense of musicianship which, by symphonic standards at least, is curiously inert if not actually slipshod. Too often *their* standards seem to be set by the nonconcertizing church organist who, however rigorous his training and however sincere his love for music, has come in time to accommodate both his performance and his choice of repertory to the noncritical tastes of his once-a-week listeners.

I won't argue the point here, but merely suggest that you compare for yourself some of the recorded works of such notable (and genuine) artists as Weinrich, Walcha, Coci, *et al.*, discussed in this column on various previous occasions, with the unfortunately more typical program by William Watkins (McIntosh MM 106) on the 1940 Aeolian-Skinner organ of the Calvary Methodist Church in Washington, D.C. I mean no disrespect for Mr. Watkins; he never plays really badly, he includes some Bach and Handel as well as too much Langlois, Dupré, and Whitlock, and he chooses his registrations without obvious lapses in taste. But it's all so lacking in authority, rhythmic grace, and aesthetic substance! And while the recording itself is admirably clean, there is no justification whatever for the disc's ambitious title of *An Adventure in High Fidelity Organ Sound.*

Even more characteristic of the limp "meditations" into which organ playing too often subsides, especially when it is intended mainly as an "interlude" of some sort or (as in the present case) frankly background music of a vaguely devotional cast, is the series of Summit recordings preserving the popular broadcast programs of Porter Heaps dozing over the console of Chicago's WGN studio organ. There are some ten 12-inch LP's of these, but the three sent me have been more than I could listen to for more than a side each. For this isn't really music making intended to be *listened to* at all, but rather to relax in as in a warm bath — as is clearly enough indicated by the titles themselves: *The Beautiful Garden of Prayer* (Summit 508; more-or-less familiar hymns), *Music for Meditation* (504; Schubert's *Serenade* and other "light classics"), and *Calm Music* (505; Nevin's *Mighty lak' a Rose* and ditto). The only point of active interest I can find in them involves Mr. Heaps's strange knack of making one lethargically throbbing sentimentalized melody sound like every other one; while from a technical point of view the limited registrational and dynamic varieties give no opportunity for checking how good the apparently excellent recording actually is.

Sonically, the Frescobaldi Toccata, Ricercar, and Bergamasca program by Eduard Müller (Decca Archive ARC 3054) is far more stimulating, for the Innsbruck "Silver Chapel" organ heard here dates in part from the sixteenth century; as restored in 1950-52, it retains many of the most distinctive renaissance and early baroque stop qualities, some of which are extremely piquant for all their wheeziness. But while Müller is anything but lax or sentimental in his performances, the music itself (despite its historical importance) is, unfortunately, pretty monotonous to modern ears by reason of its interminably sustained pedal points and rather naïve



passage work. One gets a far better idea of Frescobaldi's true genius from the overside Toccata, Partite, Corrente, Canzona, and *Aria detta la Frescobalda*, played by Fritz Neumeyer on a 1695 Nobili harpsichord. Here the music itself is much more varied, vigorous, and distinctive, while the very *sec* lutelike or guitarlike early-harpsichord tonal qualities (vastly different from those of later and modern instruments) are both unusual and fascinating. Incidentally, they demonstrate, even more effectively than the oddest organ stops on the A side, the remarkable purity of the Deutsche Grammophon recording.

The only other notably serious organ LP I have this month let me down sadly, for I had anticipated a striking advance on the 1950 Biggs-Burgin Columbia version of the Poulenc *Organ* Concerto (one of the finest modern organ concerted works), which was in its day a masterpiece of technology. Indeed, it still is. In contrast, the new disc by Elsasser with the Hamburg Philharmonic under Winograd (MGM E 3361) is aurally coarse and harsh, although probably the musicians involved are more responsible than the engineers. Certainly the soloist seems intolerably mannered and he doesn't redeem himself by his choice of the meandering, pompous Hanson Concerto overside, or by his blatant reading of it.

For once, it was almost a relief to slide back into the shirt-sleeved, popcorn-munching, second-balcony informality of Reginald Foort's *Intermission at the Mosque* (Cook 1059X). It's the same old slap-bang movie-organ pops stuff I've howled about so fiercely in the past, but this disc is at least flawless technically, so in the good old critical evasion I can safely substitute for my usual condemnation the ambiguous, "Those who like this sort of thing will like this a lot." And those who would like to know what an Allen electronic organ sounds like may also like the brimful Voto tape (B60-T30, 7 in.) of Bill Andrews's pops program, *Down Melody Lane.* He lost me only halfway down, though, for while there are some 25 scheduled changes of tune, there was little apparent change in the paralyzing tempos and broken-hearted vibratos. I still claim there is something about organs, even the *ersatz* variety, which tends to drug their players (and presumably a good many auditors, too). I must owe my own immunity to some unsuspected inoculation in the past, since I find — even after repeated exposures — no symptoms of succumbing to this virulent sonic sleeping sickness!

Home and Auditorium Pianos

Well, I did play the piano, if never the organ, for a time (as a composer-friend once remarked, more in sorrow than anger, "with great feeling — for the keys!"), and perhaps for that reason I'm more susceptible to this keyboard instrument's attractions, which for some listeners are as limited as those of the organ. At any rate, if pressed to back up my claim for the piano's greater programmatic and sonic-variety potentialities, I have impressively ponderable evidence in the pertinent releases currently at hand, each of which is exceptionally novel in at least one respect.

In Agi Jambor's seven Toccatas and four Fantasias by Bach (Capitol PBR 8354, two 12 in.) the outstanding appeal lies in the music itself, which includes some of Bach's boldest and most imaginative keyboard creations, crowned by the magnificent Toccata in C minor, S. 911, with its gloriously buoyant final double fugue which has been a favorite of mine ever since I first heard the Marcel Maas Columbia 78's of it over 20 years ago. All or most of the other fine Toccatas and the less imposing Fantasias have been occasionally recorded since, but never as well as, or in an integral collection like, this. Miss Jambor plays here with far more communicative vitality than in her rather colorless Partitas (reviewed in this column last February); and again, her scrupulously clean, pedal-less playing is re-

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FM stations up-to-date

Compiled by BRUCE G. CRAMER

THE following list of 610 United States FM stations was taken directly from FCC records and is accurate to January 15, 1957. In addition to call letters and frequency (in megacycles), the channel (CH) number (see Table I), the effective radiated power (ERP) in kilowatts, the antenna height (HT) in feet above average terrain, and the latitude (LAT) and longitude (LONG) in degrees are shown for each station.

Effective radiated power is defined as the transmitter output power (minus line losses) times the antenna power gain. In the case of 10-watt educational stations which have been marked by an asterisk, the power listed is the transmitter output since their effective radiated power is not shown in FCC records.

Antenna height above average terrain is defined as the height of the radiation center of the antenna above the average height of all terrain which lies between 2 and 10 miles from the antenna. In the case of 10-watt educational stations which have been marked by an asterisk, the height listed is the antenna height above ground at the transmitter site, since their height above average terrain is not shown in FCC records.

Construction permits for new stations are indicated by "CP". Such stations may already be broadcasting under this permit. Some old stations have requested changes in power, antenna height, or location; these are indicated by:

DP **Decrease in power**
IP **Increase in power**
DH **Decrease in antenna height**
IH **Increase in antenna height**
CL **Change in location**

The data shown in each case are the new data. Where several changes are made, only the most significant is indicated.

The following table gives the channel number according to frequency for each of the 100 FM channels. Just as television channels are numbered from 2 to 83, FM channels are numbered from 201 to 300. In the station listing, the channel numbers are abbreviated by dropping the superfluous first digit (a 2 or 3). Two digits are easier to remember than three or four, so that some listeners may wish to recalibrate their dials in channel numbers going from 1 to 100. The first twenty channels have been set up by the FCC for exclusive use by noncommercial educational stations.

Table I

Freq (Mc)	Chan No.	Freq (Mc)	Chan No.	Freq (Mc)	Chan No.	Freq (Mc)	Chan No.
88.1	201	93.1	226	98.1	251	103.1	276
88.3	202	93.3	227	98.3	252	103.3	277
88.5	203	93.5	228	98.5	253	103.5	278
88.7	204	93.7	229	98.7	254	103.7	279
88.9	205	93.9	230	98.9	255	103.9	280
89.1	206	94.1	231	99.1	256	104.1	281
89.3	207	94.3	232	99.3	257	104.3	282
89.5	208	94.5	233	99.5	258	104.5	283
89.7	209	94.7	234	99.7	259	104.7	284
89.9	210	94.9	235	99.9	260	104.9	285
90.1	211	95.1	236	100.1	261	105.1	286
90.3	212	95.3	237	100.3	262	105.3	287
90.5	213	95.5	238	100.5	263	105.5	288
90.7	214	95.7	239	100.7	264	105.7	289
90.9	215	95.9	240	100.9	265	105.9	290
91.1	216	96.1	241	101.1	266	106.1	291
91.3	217	96.3	242	101.3	267	106.3	292
91.5	218	96.5	243	101.5	268	106.5	293
91.7	219	96.7	244	101.7	269	106.7	294
91.9	220	96.9	245	101.9	270	106.9	295
92.1	221	97.1	246	102.1	271	107.1	296
92.3	222	97.3	247	102.3	272	107.3	297
92.5	223	97.5	248	102.5	273	107.5	298
92.7	224	97.7	249	102.7	274	107.7	299
92.9	225	97.9	250	102.9	275	107.9	300

Of interest to many FM listeners is a plot of the location of FM stations within a radius of, say, 200 miles. The latitude and longitude are therefore given with each station. Knowing the listener's location (which can be obtained from a road map showing latitude and longitude) and the miles per degree of latitude and longitude (from the following table), a complete station map can be plotted to any desired scale, starting with a plain sheet of paper. Proper antenna rotor setting for each station can be indicated by dividing the map with radial lines from the listener's location.

Table II

Middle Lat. Deg.	Miles per Deg. Lat.	Miles per Deg. Long.	Middle Lat. Deg.	Miles per Deg. Lat.	Miles per Deg. Long.
25	68.8	62.7	38	69.0	54.6
26	68.8	62.2	39	69.0	53.8
27	68.8	61.7	40	69.0	53.1
28	68.9	61.1	41	69.0	52.3
29	68.9	60.5	42	69.0	51.5
30	68.9	60.0	43	69.0	50.7
31	68.9	59.3	44	69.0	49.8
32	68.9	58.7	45	69.1	49.0
33	68.9	58.1	46	69.1	48.1
34	68.9	57.4	47	69.1	47.3
35	68.9	56.7	48	69.1	46.4
36	68.9	56.0	49	69.1	45.5
37	69.0	55.3	50	69.1	44.5

Information regarding outstanding stations, network affiliation, and storecast stations was obtained from sources of questionable reliability. Nevertheless, it was considered of sufficient value to be included. This information was coded as follows:

A **American Broadcasting Company**
C **Columbia Broadcasting System**
M **Mutual Broadcasting System**
N **National Broadcasting Company**
O **Outstanding Station**
S **Storecast Music**

FM activity in Canada is meager; the 32 Canadian stations are listed mainly for those living near the border who want a complete record of stations in their area. This information was taken from a U.S. Government Printing Office publication corrected to July 1, 1955. Unfortunately, the height and exact location of stations were not available.

Mexico has two FM broadcast stations, both beyond reception in the United States.

	CITY	CALL	CH	(Mc) FREQ	(Kw) ERP	(Ft) HT	LAT	LONG
ALABAMA								
	Albertville	WAVU-FM	86	105.1	4.5	360	34.24	86.16
	Alexander City	WRFS-FM	91	106.1	4.6	240	32.95	85.99
M	Andalusia	WCTA-FM	51	98.1	10.0	200	31.32	86.45
A	Anniston	WHMA-FM	63	100.5	3.6	140	33.67	85.85
	Birmingham	WAFM	58	99.5	72.0	780	33.49	86.80
		WJLN	84	104.7	23.0	590	33.48	86.81
C-CP		WBRC-FM	95	106.9	15.0	800	33.49	86.80
	Clanton	WKLF-FM	65	100.9	.370	255	32.84	86.68
	Cullman	WFMH-FM	66	101.1	5.3	165	34.20	86.78
	Decatur	WHOS-FM	23	92.5	8.6	200	34.60	87.01
A	Lanett	WRLD-FM	75	102.9	10.0	330	32.87	85.22
C	Mobile	WKRG-FM	60	99.9	3.0	310	30.72	88.06
M	Talladega	WHTB-FM	46	97.1	9.2	210	33.44	86.12
	Tuscaloosa	WUOA	19	91.7	15.0	120	33.21	87.55
M		WTBC-FM	39	95.7	17.5	320	33.20	87.53
ARIZONA								
N-CP	Globe	KWJB-FM	62	100.3	11.0	2270	33.34	110.87
	Mesa	KTYL-FM	84	104.7	16.0	140	33.41	111.88
	Phoenix	KFCA	03	88.5	.010*	75*	33.48	112.09
		KELE	38	95.5	18.0	115	32.45	112.07
O	Tucson	KTKT-FM	58	99.5	3.1	–7	32.24	110.98
ARKANSAS								
	Blytheville	KLCN-FM	41	96.1	21.0	360	35.92	89.87
CP	Jonesboro	KASU	20	91.9	.760	82	35.83	90.68
M		KBTM-FM	70	101.9	8.0	200	35.85	90.66
	Mammoth Spring	KAMS	80	103.9	.310	125	36.55	91.55
	Pocahontas	KPOC-FM	49	97.7	.390	170	36.28	90.96
M	Siloam Springs	KUOA-FM	89	105.7	2.6	465	36.19	94.56
CALIFORNIA								
C	Bakersfield	KERN-FM	31	94.1	9.1	240	35.34	119.04
S		KQXR	68	101.5	14.5	360	35.52	119.07
	Berkeley	KPFB	07	89.3	.150	–100	37.87	122.27
		KPFA	31	94.1	54.0	1330	37.87	122.22
		KRE-FM	75	102.9	9.9	–70	37.85	122.30
	Claremont	KSPC	14	90.7	.010*	75*	34.10	117.71
IH	Eureka	KRED	42	96.3	5.6	1520	40.73	123.95
O	Fresno	KRFM	29	93.7	68.0	1880	37.08	119.43
N		KMJ-FM	50	97.9	7.3	630	36.69	120.05
A		KARM-FM	70	101.9	7.4	360	36.85	119.84
O	Glendale	KFMU	46	97.1	58.0	750	34.16	118.20
S		KUTE	70	101.9	11.6	630	34.16	118.20
	Hollywood	KRHM	34	94.7	58.0	2835	34.23	118.07
M		KHJ-FM	66	101.1	16.8	2950	34.23	118.07
IP	Long Beach	KLON	01	88.1	1.2	425	33.80	118.16
		KFOX-FM	72	102.3	1.0	120	33.78	118.19
		KNOB	76	103.1	.320	420	33.80	118.16
CP	Los Angeles	KXLU	04	88.7	.010*	75*	33.97	118.42
		KUSC	18	91.5	2.9	150	34.02	118.28
O		KFAC-FM	22	92.3	17.5	2810	34.22	118.06
C		KNX-FM	26	93.1	67.0	2870	34.23	118.07
CP		KPOL-FM	30	93.9	17.0	540	34.08	118.18
A		KABC-FM	38	95.5	4.3	2800	34.23	118.07
		KRKD-FM	42	96.3	54.0	475	34.08	118.20
O-IP		KCBH	54	98.7	75.0	1260	34.12	118.39
CP		KHOF	58	99.5	16.5	260	34.14	118.23
CP		KMLA	62	100.3	58.0	1190	34.12	118.39
CP		KFSG-FM	78	103.5	12.5	200	34.08	118.26
		KPLA	82	104.3	7.1	64	34.10	118.33
CP		New	86	105.1	17.0	180	34.14	118.23
		KBMS	90	105.9	18.0	770	34.16	118.20
M	Marysville	KMYC-FM	60	99.9	4.9	150	39.14	121.55
	Modesto	KBEE-FM	77	103.3	11.5	150	37.64	120.99
		KTRB-FM	81	104.1	4.7	260	37.67	120.98
	Ontario	KEDO	28	93.5	310.0	–110	34.08	117.66
	Pasadena	KWKW-FM	52	98.3	.330	–530	34.16	118.08
CP	Sacramento	KGMS-FM	33	94.5	36.0	180	38.61	121.54
CP		KJML	37	95.3	1.0	140	38.63	121.39
N-O		KCRA-FM	41	96.1	11.0	380	38.64	121.56
A		KFBK-FM	45	96.9	3.2	260	38.57	121.48
M		KXOA-FM	00	107.9	12.5	170	38.60	121.45
	San Bernardino	KVCR	20	91.9	770.0	–240	34.09	117.31
	San Diego	KSDS	02	88.3	.375	37	32.72	117.15
N		KFSD-FM	31	94.1	33.0	425	32.72	117.07
S		KSON-FM	84	104.7	13.0	210	32.72	117.16
	San Francisco	KALW	19	91.7	3.3	70	37.76	122.41
O		KEAR	47	97.3	10.0	680	37.74	122.44
C		KCBS-FM	55	98.9	35.0	640	37.79	122.41
N		KNBC-FM	59	99.7	45.0	1240	37.69	122.44
A		KGO-FM	79	103.7	3.8	1180	37.76	122.46
S	San Jose	KSJO-FM	37	95.3	1.0	–610	37.33	121.86
IP	San Mateo	KCSM	15	90.9	.160	–100	37.58	122.33
	Santa Ana	KWIZ-FM	44	96.7	1.0	160	33.75	117.91
CP	Santa Barbara	KRCW	48	97.5	17.5	2890	34.53	
CP	Santa Clara	KSCU	11	90.1	2.45	–65	37.35	121.94
	Santa Monica	KCRW	10	89.9	.400	–310	34.01	118.47
S	Sausalito	KDFC	71	102.1	33.0	1050	37.85	122.50
	Stockton	KCVN	17	91.3	3.40	70	37.98	121.31
COLORADO								
	Boulder	KRNW	47	97.3	2.0	–730	40.06	105.27
CP	Colorado Springs	KSHS	13	90.5	.610	1760	38.84	104.82
		KRCC	17	91.3	.165	–480	38.86	104.83
CP	Denver	KTGM	86	105.1	10.0	9	39.74	105.07
O	Golden	KFML-FM	53	98.5	2.35	580	39.73	105.24
O	Manitou Springs	KCMS-FM	74	102.7	10.0	–780	38.85	104.84
CONNECTICUT								
CP	Brookfield	WGHF	36	95.1	20.0	500	41.49	73.43
	Danbury	WLAD-FM	52	98.3	.340	280	41.38	73.45
O	Hartford	WFMQ	29	93.7	7.0	750	41.56	72.84
N-O		WTIC-FM	43	96.5	8.0	705	41.77	72.81
S	Meriden	WMMW-FM	39	95.7	7.0	740	41.56	72.84
A	New Haven	WNHC-FM	56	99.1	10.0	630	41.44	72.94
A	Stamford	WSTC-FM	44	96.7	.650	305	41.07	73.54
CP	Storrs	WHUS	13	90.5	.010*	80*	41.81	72.26
DELAWARE								
	Dover	WDOV-FM	34	94.7	8.3	200	39.20	75.56
N	Wilmington	WDEL-FM	29	93.7	20.0	460	39.82	75.53
O-CP		WJBR	58	99.5	20.0	330	39.83	75.52
DISTRICT OF COLUMBIA								
N	Washington	WRC-FM	30	93.9	20.0	410	38.92	77.06
C		WTOP-FM	42	96.3	20.0	390	38.95	77.08
O		WASH	46	97.1	15.0	470	39.04	77.06
		WOL-FM	54	98.7	20.0	485	38.89	77.20
		WFAN	62	100.3	20.0	320	38.95	77.00
S		WWDC-FM	66	101.1	20.0	410	39.00	76.06
M-O-CL		WGMS-FM	78	103.5	20.0	440	39.04	77.17
A		WMAL-FM	97	107.3	20.0	475	38.94	77.09
FLORIDA								
A-M	Daytona Beach	WNDB-FM	33	94.5	8.5	330	29.23	81.04
M	Gainesville	WRUF-FM	81	104.1	12.0	350	29.64	82.42
N	Jacksonville	WJAX-FM	36	95.1	7.7	560	30.29	81.75
C		WMBR-FM	41	96.1	50.0	850	30.31	81.65
		WJHP-FM	45	96.9	9.7	350	30.30	81.74
	Miami	WTHS	19	91.7	5.0	215	25.79	80.19
		WAHR-FM	30	93.9	13.0	170	25.77	80.14
C		WGBS-FM	42	96.3	1.55	80	25.79	80.19
N		WCKR-FM	47	97.3	15.5	285	25.78	80.19
O		WWPB	68	101.5	8.5	275	25.77	80.20
M	Miami Beach	WKAT-FM	26	93.1	285.0	430	25.79	80.14
C	Orlando	WDBO-FM	22	92.3	25.0	460	28.55	81.41
A		WHOO-FM	43	96.5	59.0	460	28.58	81.45
		WKIS	62	100.3	16.5	300	28.55	81.43
A	Palm Beach	WWPG-FM	50	97.9	3.6	235	26.61	80.04
N	Panama City	WDLP-FM	55	98.9	1.6	300	30.17	85.61
	Tallahassee	WFSU-FM	18	91.5	.010*	81*	30.44	84.29
	Tampa	WTUN	05	88.9	.770	240	28.04	82.47
N		WFLA-FM	27	93.3	46.0	910	27.84	82.26
C		WDAE-FM	64	100.7	65.0	390	27.94	82.46
		WPKM	84	104.7	10.5	160	27.93	82.48
	Winter Park	WPRK	18	91.5	.330	90	28.59	81.34
GEORGIA								
C-O	Athens	WGAU-FM	58	99.5	4.4	258	33.94	83.40
	Atlanta	WABE	11	90.1	4.8	300	33.75	84.39
O		WGKA-FM	25	92.9	9.4	270	33.79	84.38
N		WSB-FM	53	98.5	52.0	1050	33.76	84.36
C		WAGA-FM	77	103.3	36.0	960	33.80	84.33
M-O	Augusta	WBBQ-FM	79	103.7	10.5	72	33.46	81.99
		WAUG-FM	89	105.7	5.5	100	33.46	91.94
C	Columbus	WRBL-FM	27	93.3	25.0	570	32.47	85.06
	Gainesville	WDUN-FM	80	103.9	340.0	175	34.32	83.83
M	La Grange	WLAG-FM	81	104.1	2.3	180	33.04	85.03
A-M-CP	Macon	WNEX-FM	45	96.9	4.1	415	32.85	83.66
C		WMAZ-FM	56	99.1	3.0	170	32.83	83.65
M	Newman	WCOH-FM	44	96.7	.330	240	33.36	84.81
C	Savannah	WTOC-FM	47	97.3	7.9	397	32.07	81.09
	Swainsboro	WJAT-FM	69	101.7	.970	110	32.59	82.36
M	Toccoa	WLET-FM	91	106.1	.730	190	34.59	83.30
ILLINOIS								
A	Bloomington	WJBC-FM	68	101.5	5.1	425	40.46	89.01
CP	Carbondale	WSRV	20	91.9	22.0	300	37.71	89.23
	Carmi	WROY-FM	47	97.3	11.0	210	38.08	88.20
C	Champaign	WDWS-FM	48	97.5	27.0	430	40.09	88.25
	Chicago	WBEZ	18	91.5	16.0	550	41.88	87.63
		WENR-FM	34	94.7	4.3	580	41.88	87.64
CP		WDHF	38	95.5	30.0	270	41.72	87.68
C		WBBM-FM	42	96.3	10.5	560	41.88	87.63
O		WNIB	46	97.1	11.0	210	41.88	87.72
		WEHS	50	97.9	21.0	200	41.83	87.71
O		WFMT	54	98.7	29.5	550	41.89	87.63
O		WEFM	58	99.5	44.0	560	41.88	87.63
S		WFMF	62	100.3	33.0	540	41.89	87.62
N		WMAQ-FM	66	101.1	24.0	640	41.88	87.64
CP		WCLM	70	101.9	17.0	480	41.89	87.62
O		WSEL	82	104.3	40.0	500	41.88	87.63
C	Decatur	WSOY-FM	71	102.1	31.0	460	39.88	88.94
	De Kalb	WNIC	16	91.1	.010*	120*	41.93	88.77
	Effingham	WSEI	39	95.7	20.0	295	39.13	88.49
	Elgin	WEPS	01	88.1	.010*	78*	42.04	88.27
S-DP	Elmwood Park	WLEY	90	105.9	3.2	250	41.93	87.81
	Evanston	WNUR	07	89.3	.010*	75*	42.05	87.67
S-O		WEAW-FM	86	105.1	36.0	240	42.05	87.71
	Harrisburg	WEBQ-FM	60	99.9	4.2	305	37.72	88.54
	Jacksonville	WLDS-FM	63	100.5	9.0	340	39.74	90.20
	Mattoon	WLBH-FM	45	96.9	23.0	190	39.50	88.37
	Mc Comb	WWKS	17	91.3	17.0	280	40.46	90.68
	Mt. Vernon	WMIX-FM	31	94.1	15.2	550	38.37	88.92
	Oak Park	WOPA-FM	72	102.3	1.0	250	41.88	87.79
	Olney	WVLN-FM	25	92.9	18.5	290	38.71	88.08
	Paris	WPRS-FM	52	98.3	1.0	225	39.61	87.73
C	Peoria	WMBD-FM	23	92.5	2.5	550	40.57	89.53
C	Quincy	WTAD-FM	58	99.5	27.0	770	39.97	91.33
A		WGEM-FM	86	105.1	8.3	640	39.95	91.33
A	Rockford	WROK-FM	48	97.5	16.0	300	42.28	89.04
C	Rock Island	WHBF-FM	55	98.9	3.7	380	41.49	90.47
C-O	Springfield	WTAX-FM	79	103.7	6.7	315	39.79	89.60
	Urbana	WILL-FM	15	90.9	300.0	500	40.00	88.63
INDIANA								
	Bloomington	WFIU	79	103.7	33.0	300	39.17	86.52
	Connersville	WCNB-FM	62	100.3	9.8	270	39.64	85.15
	Crawfordsville	WBBS	92	106.3	1.0	58	40.04	86.90
CP	Elkhart	WCMR-FM	36	95.1	4.4	200	41.66	86.00
N		WTRC-FM	64	100.7	9.7	350	41.65	85.98
CP	Evansville	WPSR	14	90.7	4.5	100	40.00	87.55
		WEVC	18	91.5	1.9	100	37.97	87.53
		WIKY-FM	81	104.1	19.0	450	37.99	87.60
	Gary	WGVE	01	88.1	.010*	70*	41.53	87.34
	Greencastle	WGRE	19	91.7	.010*	80*	39.64	86.85
	Hammond	WJOB-FM	22	92.3	3.1	400	41.60	87.48
	Hartford City	WHCI	20	91.9	.010*	80*	40.46	85.38
	Huntington	WVSH	20	91.9	.010*	85*	40.89	85.50
	Indianapolis	WIAN	11	90.1	.120	60	39.81	86.12
CP		WFMS	38	95.5	4.5	110	39.78	86.16
		WAJC	83	104.5	8.8	35	39.78	86.15
	Jasper	WITZ-FM	84	104.7	1.65	280	38.35	86.94
	Madison	WORX-FM	44	96.7	.350	290	38.74	85.36
	Marion	WMRI-FM	95	106.9	31.0	275	40.55	85.65
	Muncie	WWHI	18	91.5	.010*	110*	40.20	85.39
		WMUM	81	104.1	7.4	240	40.15	85.38
	New Albany	WNAS	01	88.1	.800	–32	38.30	85.81
	Newcastle	WYSN	16	91.1	.010*	98*	39.94	85.36
		WCTW	73	102.5	4.0	250	39.94	85.36
	South Bend	WHFS	67	101.3	8.6	74	41.68	86.24
C	Terre Haute	WTHI-FM	60	99.9	7.4	330	39.54	87.39
	Wabash	WSKS	17	91.3	.010*	71*	40.81	85.83
		WAIU-FM	48	97.5	4.6	88	40.78	85.82
	Warsaw	WRSW-FM	97	107.3	34.0	230	41.22	85.84
	Washington	WFML	93	106.5	14.0	320	38.65	87.17
IOWA								
	Ames	WOI-FM	11	90.1	16.0	480	41.99	93.69
	Boone	KFGQ-FM	57	99.3	.310	200	42.09	93.91
M	Clinton	KROS-FM	41	96.1	13.0	400	41.86	90.20
N	Davenport	WOC-FM	79	103.7	33.0	490	41.55	90.45
	Des Moines	KDPS	01	88.1	1.5	105	41.59	93.64
N		WHO-FM	62	100.3	24.0	690	41.65	93.35
M	Dubuque	WDBQ-FM	77	103.3	15.0	335	42.50	90.70
	Iowa City	KSUI	19	91.7	17.5	90	41.66	91.53
C	Mason City	KGLO-FM	66	101.1	16.0	230	43.15	93.24
	Muscatine	KWPC-FM	59	99.7	.780	290	41.45	91.08
	Storm Lake	KAYL-FM	68	101.5	8.9	370	42.63	95.16
	Waverly	KWAR	06	89.1	.010*	110*	42.76	92.49
KANSAS								
	Emporia	KSTE	04	88.7	.350	105	38.42	96.18
	Lawrence	KANU	18	91.5	35.0	620	38.96	95.26
	Manhattan	KSDB-FM	01	88.1	.010*	80*	39.18	96.58
	Ottawa	KTJO-FM	01	88.1	.010*	80*	38.60	95.27

	CITY	CALL	CH	(Mc) FREQ	(Kw) ERP	(Ft) HT	LAT	LONG
	Wichita	KMUW	06	89.1	.010*	110*	37.72	97.30
C		KFH-FM	62	100.3	11.0	410	37.71	97.24
	KENTUCKY							
C	Ashland	WCMI-FM	29	93.7	2.75	200	38.45	82.61
M	Bowling Green	WLBJ-FM	66	101.1	8.6	190	37.00	86.40
	Central City	WNES-FM	70	101.9	21.5	215	37.27	87.14
	Fulton	WFUL-FM	85	104.9	.500	155	36.52	88.90
	Henderson	WSON-FM	58	99.5	20.0	400	37.83	87.55
C	Hopkinsville	WHOP-FM	54	98.7	8.7	210	36.87	87.47
	Lexington	WBKY	17	91.3	2.3	170	38.04	84.51
A		WLAP-FM	33	94.5	3.5	320	38.12	84.45
	Louisville	WFPL	07	89.3	.150	360	38.23	85.71
		WFPK	20	91.9	19.5	295	38.24	85.76
	Madisonville	WFMW-FM	30	93.9	2.5	375	37.35	87.49
	Mayfield	WNGO-FM	34	94.7	2.3	160	36.76	88.64
		WKTM-FM	96	107.1	.510	250	36.74	88.68
M	Owensboro	WOMI-FM	23	92.5	19.5	375	37.74	87.12
		WVJS-FM	41	96.1	45.0	370	37.78	87.16
N	Paducah	WKYB-FM	27	93.3	31.0	380	37.01	88.61
C		WPAD-FM	45	96.9	36.0	335	37.10	88.62
	LOUISIANA							
A	Alexandria	KALB-FM	45	96.9	11.0	380	31.31	92.42
	Baton Rouge	WLSU	19	91.7	1.3	410	30.42	91.17
		WBRL	51	98.1	7.6	480	30.42	91.18
M		WAFB-FM	82	104.3	3.2	315	30.42	91.14
A-N	Monroe	KMLB-FM	81	104.1	17.0	220	32.49	92.10
IH	New Orleans	WWMT	39	95.7	44.0	215	29.94	90.08
		WRCM	46	97.1	5.9	250	29.96	90.08
N-IH		WDSU-FM	87	105.3	3.4	590	29.95	89.96
C	Shreveport	KWKH-FM	33	94.5	13.5	390	32.70	93.88
N		KTBS-FM	43	96.5	14.0	320	32.68	93.86
A		KRMD-FM	66	101.1	11.5	200	32.51	93.75
	MAINE							
CP	Brunswick	WBOR	16	91.1	.010*	60*	43.91	69.96
CP	Caribou	WFST-FM	49	97.7	.190	185	46.89	68.05
M	Lewiston	WCOU-FM	30	93.9	13.0	250	44.09	70.19
	MARYLAND							
S	Annapolis	WNAV-FM	56	99.1	16.6	370	38.98	76.52
	Baltimore	WJ8C	01	88.1	.125	145	39.33	76.59
C		WCAO-FM	74	102.7	20.0	400	39.39	76.72
O-CL		WITH-FM	82	104.3	20.0	470	39.29	76.74
	Bethesda	WUST-FM	92	106.3	.500	320	38.98	77.11
C	Cumberland	WCUM-FM	75	102.9	1.25	–4	39.64	78.74
A-M-O	Hagerstown	WJEJ-FM	84	104.7	9.4	1340	39.70	77.51
S	Oakland	WRNC	38	95.5	16.5	300	38.86	76.90
	MASSACHUSETTS							
	Amherst	WAMF	01	88.1	.010*	79*	42.37	72.52
		WMUA	16	91.1	.010*	109*	42.39	72.53
	Boston	WERS	05	88.9	18.0	55	42.36	71.08
		WGBH-FM	09	89.7	15.5	550	42.21	71.11
		WBUR	15	90.9	20.0	50	42.35	71.08
		WHDH-FM	33	94.5	20.0	455	42.35	71.07
M		WNAC-FM	53	98.5	20.0	410	42.43	71.09
		WCOP-FM	64	100.7	20.0	495	42.41	71.21
C		WEEI-FM	77	103.3	20.0	430	42.43	71.09
	Brockton	WBET-FM	49	97.7	.800	275	42.07	71.04
O	Cambridge	WXHR	45	96.9	20.0	400	42.46	71.18
	Greenfield	WHAI-FM	52	98.3	1.0	–240	42.59	72.62
M	Lowell	WLLH-FM	58	99.5	12.2	600	42.65	71.22
	New Bedford	WBSM-FM	47	97.3	2.5	330	41.64	70.92
DP		WNBH-FM	51	98.1	.860	380	41.62	70.92
A	Pittsfield	WBEC-FM	32	94.3	1.0	–185	42.45	73.25
CP	South Hadley	New	03	88.5	.010*	60*	42.26	72.58
	Springfield	WEDK	19	91.7	.010*	100*	42.12	72.55
C-IP		WHYN-FM	26	93.1	3.2	1000	42.24	72.65
		WMAS-FM	34	94.7	1.35	175	42.11	72.61
O-IH	Waltham	WCRB-FM	73	102.5	9.2	180	42.36	71.26
	West Yarmouth	WOCB-FM	32	94.3	1.0	155	41.63	70.24
CP	Williamstown	WCFM	11	90.1	.010*	80*	42.71	73.20
	Winchester	WHSR-FM	20	91.9	.010*	93*	42.45	71.13
C	Worcester	WTAG-FM	41	96.1	10.0	640	42.31	71.90
	MICHIGAN							
	Ann Arbor	WUOM	19	91.7	115.0	440	42.41	83.92
	Benton Harbor	WHFB-FM	60	99.9	9.2	230	42.08	86.47
	Coldwater	WTVB-FM	52	98.3	.260	230	41.92	85.01
	Dearborn	WKMH-FM	62	100.3	7.1	190	42.26	83.25
	Detroit	WDTR	15	90.9	2.0	170	42.38	83.12
		WJBK-FM	26	93.1	30.0	440	42.46	83.21
C		WJR-FM	42	96.3	24.0	483	42.37	83.08
N		WWJ-FM	46	97.1	50.0	480	42.45	83.17
		WBRI	50	97.9	3.3	430	42.41	83.11
A-O		WXYZ-FM	66	101.1	14.0	410	42.36	83.07
		WDET-FM	70	101.9	52.0	320	42.38	83.24
S-DP		WMUZ	78	103.5	19.5	180	42.41	83.12
	East Lansing	WKAR-FM	13	90.5	74.0	270	42.71	84.48
	Flint	WFBE	36	95.1	1.3	130	43.02	83.67
		WFUM	96	107.1	.400	175	43.02	83.70
C-O	Grand Rapids	WJEF-FM	29	93.7	115.0	420	42.42	85.53
A		WLAV-FM	45	96.9	1.75	210	42.96	85.67
	Highland Park	WHPR	01	88.1	.010*	94*	42.40	83.10
	Hillsdale	WBSE-FM	80	103.9	.740	170	41.92	84.64
	Kalamazoo	WMCR	71	102.1	36.0	160	42.29	85.61
S-O	Oak Park	WLDM	38	95.5	20.0	430	42.46	83.20
CP	Royal Oak	WOAC	07	89.3	.010*	126*	42.49	83.15
		WOMC	82	104.3	18.0	380	42.47	83.12
N	Saginaw	WSAM-FM	51	98.1	1.7	330	43.42	83.92
	Sturgis	WSTR-FM	76	103.1	.285	210	41.78	85.42
	MINNESOTA							
N	Mankato	KYSM-FM	78	103.5	47.0	525	44.17	94.03
CP	Minneapolis	KWFM	46	97.1	9.7	70	44.93	93.22
		KTIS-FM	53	98.5	5.3	250	45.00	93.35
M-CP		WLOL-FM	58	99.5	9.7	320	44.96	93.20
N	St. Cloud	KFAM-FM	84	104.7	15.0	425	45.53	94.17
A	Winona	KWNO-FM	48	97.5	18.5	610	44.03	91.64
	MISSISSIPPI							
A	Gulfport	WGCM-FM	68	101.5	3.0	300	30.37	89.08
N	Jackson	WJDX-FM	75	102.9	50.0	600	32.26	90.11
IP	Meridian	WMMI	18	91.5	.650	115	32.39	88.70
	MISSOURI							
	Clayton	KFUO-FM	56	99.1	6.7	260	38.64	90.31
M	Jefferson City	KWOS-FM	53	98.5	.765	310	38.58	92.20
M	Joplin	WMBH-FM	41	96.1	70.0	450	37.08	94.54
O	Kansas City	KCMO-FM	35	94.9	56.0	390	39.07	94.58
	Kennett	KBOA-FM	55	98.9	6.9	320	36.22	90.08
	Poplar Bluff	KWOC-FM	33	94.5	14.0	215	36.72	90.37
	St. Louis	KSLH	18	91.5	12.5	400	38.62	90.24
O		KCFM	29	93.7	21.5	550	38.63	90.19
C	Springfield	KTTS-FM	34	94.7	9.1	660	37.22	93.24
	West Plains	WKPM-FM	30	93.9	3.4	130	36.74	91.83
	NEVADA							
	Reno	KNEV	38	95.5	10.5	–690	39.52	119.81
	NEW HAMPSHIRE							
	Berlin	WMOU-FM	79	103.7	10.0	160	44.46	71.17
A	Claremont	WTSV-FM	91	106.1	4.8	1000	43.40	72.30
IH	Manchester	WKBR-FM	39	95.7	3.6	940	42.98	71.59
	Nashua	WOTW-FM	92	106.3	1.0	195	42.74	71.49
	NEW JERSEY							
	Asbury Park	WJLK-FM	32	94.3	1.0	250	40.22	74.05
	Bridgeton	WSNJ-FM	55	98.9	9.0	480	39.46	75.21
	Newark	WBGO	02	88.3	20.0	220	40.74	74.18
		WAAT-FM	34	94.7	13.5	540	40.79	74.26
CP		WHFI	74	102.7	2.8	420	40.74	74.17
	New Brunswick	WCTC-FM	52	98.3	1.0	110	40.49	74.42
CP	Paterson	WPAT-FM	26	93.1	20.0	310	40.85	74.18
	Princeton	WPRB	80	103.9	.850	195	40.35	74.66
	Red Bank	WFHA-FM	62	100.3	1.8	105	40.35	74.07
	South Orange	WSOU	08	89.5	2.0	370	40.75	74.25
S	Trenton	WTOA	48	97.5	14.5	275	40.23	74.77
	Zarephath	WAWZ-FM	56	99.1	4.8	175	40.53	74.57
	NEW MEXICO							
	Albuquerque	KANW	06	89.1	.350	–55	35.08	106.64
O-DH		KHFM	42	96.3	1.45	–11	35.08	106.58
A	Los Alamos	KRSN-FM	53	98.5	4.6	–33	35.88	106.30
IP	Mountain Park	KMFM	50	97.9	13.0	220	32.95	105.82
	NEW YORK							
A	Allegany	WHDL-FM	39	95.7	43.0	830	42.03	78.45
M	Auburn	WMBO-FM	41	96.1	18.0	520	42.76	76.53
M	Binghamton	WKOP-FM	37	95.3	.420	320	42.07	75.91
C		WNBF-FM	51	98.1	4.6	950	42.06	75.95
	Brooklyn	WNYE	18	91.5	20.0	415	40.69	73.98
S-IP	Buffalo	WBNY-FM	25	92.9	94.0	570	42.64	78.72
		WXRC	77	103.3	4.6	230	43.00	78.82
		WWOL-FM	81	104.1	.750	200	42.83	78.80
C		WBEN-FM	93	106.5	52.0	1320	42.66	78.63
	Cherry Valley	WRRC	70	101.9	5.4	1080	42.79	74.69
A	Corning	WCLI-FM	91	106.1	4.2	500	42.16	77.04
	Cortland	WKRT-FM	60	99.9	14.0	710	42.56	76.15
	De Ruyter	WRRD	86	105.1	5.3	560	42.78	75.84
	Floral Park	WSHS	12	90.3	.350	112	40.72	73.70
	Hempstead	WHLI-FM	52	98.3	1.0	250	40.68	73.61
	Hornell	WWHG-FM	87	105.3	8.3	560	42.29	77.67
	Ithaca	WITJ	19	91.7	.010*	80*	42.44	76.50
C-O		WHCU-FM	47	97.3	40.0	730	42.46	76.39
		WRRA	79	103.7	5.6	890	42.39	76.67
A	Jamestown	WJTN-FM	27	93.3	9.5	735	42.04	79.08
CP	Lockport	WUSJ	57	99.3	.750	270	43.17	78.71
A	Massena	WMSA-FM	87	105.3	13.0	335	44.90	74.88
	New Rochelle	WNRC-FM	28	93.5	1.0	190	40.93	73.78
	New York	WKCR-FM	10	89.9	.010*	130*	40.81	73.96
		WFUV	14	90.7	3.5	200	40.86	73.89
S		WHOM-FM	22	92.3	11.0	630	40.75	73.98
IH		WNYC-FM	30	93.9	18.0	540	40.71	74.00
A		WABC-FM	38	95.5	1.5	1270	40.75	73.99
O		WQXR-FM	42	96.3	11.0	630	40.75	73.97
N		WRCA-FM	46	97.1	1.1	1445	40.75	73.99
		WEVD-FM	50	97.9	20.0	340	40.72	73.92
M		WOR-FM	54	98.7	1.7	1260	40.75	73.99
O		WBAI	58	99.5	18.0	520	40.77	73.97
C		WCBS-FM	66	101.1	1.5	1270	40.75	73.99
S		WBFM	70	101.9	10.3	650	40.75	73.98
CP		WFMX	82	104.3	15.0	560	40.77	73.97
O		WWRL-FM	86	105.1	20.0	235	40.74	73.91
O	Niagara Falls	WHLD-FM	53	98.5	46.0	420	43.01	78.99
	Patchogue	WALK-FM	48	97.5	15.0	520	40.84	73.03
A	Poughkeepsie	WKIP-FM	84	104.7	2.3	1120	41.49	73.95
	Rochester	WRNY-FM	50	97.9	7.7	460	43.17	77.66
		WHFM	55	98.9	20.0	390	43.14	77.58
	Schenectady	WGFM	58	99.5	6.0	805	42.64	74.00
	South Bristol	WRRE	36	95.1	5.3	990	42.75	77.43
	Springville	WSPE	01	88.1	.010*	70*	42.55	78.67
	Syracuse	WAER	01	88.1	.730	24	43.04	76.13
		WDDS-FM	26	93.1	35.0	690	42.95	76.03
N		WSYR-FM	33	94.5	10.0	480	42.94	76.12
O	Troy	WFLY	22	92.3	5.4	840	42.64	74.00
	Utica	WRUN-FM	89	105.7	4.3	490	43.06	75.42
C	Watertown	WWNY-FM	63	100.5	15.4	470	43.96	75.84
	Wethersfield	WRRL	99	107.7	5.4	460	42.62	78.29
O	White Plains	WFAS-FM	80	103.9	.120	675	41.03	73.83
	NORTH CAROLINA							
	Asheboro	WGWR-FM	22	92.3	10.0	650	35.72	79.81
A-M	Asheville	WLOS-FM	82	104.3	9.2	130	35.61	82.59
	Burlington	WFNS-FM	30	93.9	2.8	250	36.11	79.45
M		WBBB-FM	66	101.1	3.8	410	36.10	79.48
	Chapel Hill	WUNC	18	91.5	15.5	135	35.91	79.06
N	Charlotte	WSOC-FM	78	103.5	35.0	415	35.24	80.82
S-O	Chingman's Peak	WMIT	95	106.9	36.0	3100	35.74	82.29
C	Durham	WDNC-FM	86	105.1	36.0	380	36.04	78.97
	Elkin	WIFM-FM	65	100.9	.350	–35	36.25	80.87
M	Fayetteville	WFNC-FM	51	98.1	14.0	290	35.08	78.93
	Forest City	WBBO-FM	27	93.3	1.5	345	35.35	81.90
A	Gastonia	WGNC-FM	70	101.9	11.1	890	35.23	81.28
	Goldsboro	WEQR-FM	45	96.9	41.0	360	35.40	78.01
	Greensboro	WGPS	10	89.9	.010*	98*	36.08	79.81
CP	Greenville	WWWS	17	91.3	4.5	135	35.61	77.36
M	Henderson	WHNC-FM	23	92.5	9.0	260	36.35	78.38
	High Point	WHPS	07	89.3	.010*	75*	35.96	80.01
		WHPE-FM	38	95.5	13.0	395	35.91	80.03
A		WMFR-FM	58	99.5	8.0	350	35.96	80.01
		WNOS-FM	62	100.3	2.7	195	35.96	80.03
	Laurinburg	WEWO-FM	43	96.5	9.2	216	34.76	79.42
M	Leaksville	WLOE-FM	33	94.5	20.0	96	36.50	79.77
	Lexington	WBUY-FM	32	94.3	.300	210	35.84	80.23
N	Raleigh	WPTF-FM	34	94.7	15.0	560	35.79	78.76
M		WKIX-FM	41	96.1	29.5	420	35.79	78.74
O		WRAL-FM	68	101.5	54.0	325	35.77	78.62
	Reidsville	WREV-FM	71	102.1	1.6	330	36.39	79.65
A	Rocky Mount	WEED-FM	21	92.1	.270	160	35.96	77.83
O		WFMA	64	100.7	33.0	400	35.91	77.84
M	Salisbury	WSTP-FM	93	106.5	2.9	250	35.69	80.50
	Sanford	WWGP-FM	88	105.5	.490	340	35.44	79.22
M	Shelby	WOHS-FM	41	96.1	2.6	460	35.29	81.57
	Statesville	WSIC-FM	89	105.7	2.4	335	35.80	80.89
	Tarboro	WCPS-FM	82	104.3	7.0	260	35.93	77.57
	Thomasville	WTNC-FM	52	98.3	.450	250	35.89	80.10
A	Winston-Salem	WAIR-FM	26	93.1	34.0	370	30.09	80.28
N		WSJS-FM	81	104.1	41.0	160	36.16	80.30
	OHIO							
	Akron	WAPS	06	89.1	1.3	44	41.09	81.52
A		WAKR-FM	48	97.5	4.4	260	41.08	81.52

	CITY	CALL	CH	(Mc) FREQ	(Kw) ERP	(Ft) HT	LAT	LONG
	Alliance	WFAH-FM	69	101.7	1.0	160	40.93	81.13
	Ashland	WATG-FM	67	101.3	10.2	380	40.84	82.36
	Ashtabula	WICA-FM	79	103.7	40.0	270	41.81	80.79
	Athens	WOUI	18	91.5	.010*	72*	39.33	82.10
O	Bellaire	WTRX-FM	63	100.5	9.0	500	40.04	80.77
	Bowling Green	WBGU	01	88.1	.010*	90*	41.38	83.65
A	Canton	WHBC-FM	31	94.1	15.0	390	40.75	81.44
C	Cincinnati	WKRC-FM	70	101.9	15.5	530	39.12	84.50
O		WSAI-FM	74	102.7	14.7	550	39.10	84.56
		WCPO-FM	86	105.1	12.5	590	39.13	84.50
DP	Cleveland	WBOE	12	90.3	9.1	360	41.47	81.59
		WERE-FM	53	98.5	20.0	620	41.34	81.74
C		WGAR-FM	58	99.5	31.0	410	41.31	81.69
N		WHK-FM	64	100.7	11.5	620	41.36	81.67
		WDOK-FM	71	102.1	9.4	120	41.41	81.68
A		WJW-FM	81	104.1	2.8	510	41.32	81.73
CL		KYW-FM	89	105.7	3.7	900	41.39	81.69
M	Cleveland Hts.	WSRS-FM	37	95.3	1.0	250	41.50	81.57
	Columbus	WOSU-FM	09	89.7	14.0	300	40.03	83.06
		WCBE	13	90.5	17.5	540	39.96	83.00
A		WCOL-FM	22	92.3	24.5	380	39.97	83.02
		WVKO-FM	34	94.7	52.0	220	40.05	83.06
C	Dayton	WHIO-FM	56	99.1	19.0	515	39.72	84.15
	Delaware	WSLN	16	91.1	.010*	152*	40.30	83.07
	Elyria	WEOL-FM	97	107.3	15.0	290	41.27	82.01
O	Findlay	WFIN-FM	63	100.5	8.2	240	41.01	83.63
	Fostoria	WFOB-FM	44	96.7	1.0	215	41.10	83.40
	Fremont	WFRO-FM	57	99.3	1.0	200	41.35	83.12
	Kent	WKSU-FM	01	88.1	.010*	96*	—	—
A	Lima	WIMA-FM	71	102.1	15.0	250	40.68	84.11
A	Marion	WMRN-FM	95	106.9	25.0	330	40.62	83.13
	Mt. Vernon	WMVO-FM	29	93.7	2.9	270	40.40	82.44
	Newark	WCLT-FM	62	100.3	8.5	370	40.03	82.40
	Oxford	WMUB	03	88.5	.830	130	39.51	84.73
C	Portsmouth	WPAY-FM	81	104.1	7.0	520	38.71	83.00
M	Steubenville	WSTV-FM	78	103.5	3.1	880	40.34	80.62
	Toledo	WTDS	17	91.3	.730	200	41.68	83.59
CP		WMHE	23	92.5	10.0	135	41.66	83.65
		WTRT	60	99.9	8.8	160	41.62	83.62
N		WSPD-FM	68	101.5	23.0	440	41.65	83.54
A		WTOL-FM	84	104.7	1.3	156	41.65	83.54
	Wooster	WWST-FM	83	104.5	13.0	330	40.79	81.90
C	Youngstown	WKBN-FM	55	98.9	25.0	490	41.06	80.64

OKLAHOMA

	CITY	CALL	CH	FREQ	ERP	HT	LAT	LONG
	Norman	WNAD-FM	15	90.9	7.0	400	35.29	97.50
IP	Oklahoma City	KOKH	05	88.9	11.0	155	35.49	97.54
	Stillwater	KAMC-FM	19	91.7	.380	8	36.12	97.08
		KSPI-FM	30	93.9	3.9	300	36.10	97.05
	Tulsa	KWGS	13	90.5	4.1	350	36.15	95.94

OREGON

	CITY	CALL	CH	FREQ	ERP	HT	LAT	LONG
	Eugene	KWAX	16	91.1	.010*	77*	—	—
		KRVM	20	91.9	400.0	-40	44.06	123.10
N		KUGN-FM	56	99.1	.390	60	44.07	123.07
	Grants Pass	KGPO	45	96.9	3.1	-1650	42.42	123.33
	Oretech	KTEC	01	88.1	.010*	70*	42.31	121.75
	Portland	KEX-FM	22	92.3	56.0	955	45.49	122.70
		KPFM	46	97.1	3.3	900	45.49	122.69
M		KPOJ-FM	54	98.7	4.4	1100	45.45	122.55
S		KQFM	62	100.3	17.0	960	45.49	122.69
C		KOIN-FM	66	101.1	48.0	1390	45.52	122.73

PENNSYLVANIA

	CITY	CALL	CH	FREQ	ERP	HT	LAT	LONG
O	Allentown	WFMZ	64	100.7	4.8	835	40.57	75.43
C	Altoona	WVAM-FM	61	100.1	360.0	-345	40.49	78.40
	Bethlehem	WGPA-FM	36	95.1	10.0	630	40.62	75.29
CP	Bloomsburg	WHLM-FM	93	106.5	8.8	650	41.00	76.50
	Butler	WBUT-FM	49	97.7	.720	290	40.84	79.90
	Chambersburg	WWPC	36	95.1	4.7	-85	39.93	77.68
		WCHA-FM	40	95.9	.700	240	39.93	77.70
CP	Coudersport	WFRM-FM	44	96.7	.110	690	41.75	78.00
C	Dubois	WCED-FM	71	102.1	3.2	660	41.04	78.70
O	Easton	WEEX-FM	52	98.3	1.0	115	40.71	75.22
		WEST	00	107.9	11.0	50	40.67	75.21
N	Erie	WERC-FM	60	99.9	9.7	400	42.06	80.04
C	Harrisburg	WHP-FM	47	97.3	1.55	-35	40.30	76.95
	Havertown	WHHS	07	89.3	.010*	80	39.98	75.30
N-M-IP	Hazleton	WAZL-FM	50	97.9	6.0	630	40.94	75.97
C	Johnstown	WARD-FM	21	92.1	.285	-87	40.33	78.92
N		WJAC-FM	38	95.5	8.3	1070	40.37	78.98
A-M-O	Lancaster	WLAN-FM	45	96.9	6.7	80	40.05	76.34
N		WGAL-FM	67	101.3	3.8	215	40.04	76.31
	Lebanon	WLBR-FM	61	100.1	.720	290	40.36	76.46
A	Meadville	WMGW-FM	62	100.3	10.0	585	41.63	80.18
	Philadelphia	WRTI-FM	11	90.1	.010*	179	39.98	75.15
		WHYY	15	90.9	20.0	460	39.95	75.17
		WPWT	19	91.7	.180	10	39.95	75.17
M		WIP-FM	27	93.3	20.0	430	39.95	75.17
S		WIBG-FM	31	94.1	20.0	355	40.08	75.16
O		WFLN	39	95.7	20.0	490	40.06	75.24
S		WCAU-FM	51	98.1	10.0	660	40.04	75.24
A-O		WFIL-FM	71	102.1	10.0	270	40.10	75.26
S		WPEN-FM	75	102.9	20.0	420	39.95	75.17
		WHAT-FM	87	105.3	20.0	290	40.00	75.21
	Pittsburgh	WDUQ	18	91.5	2.75	-5	40.45	79.98
S-O		WKJF	29	93.7	40.0	470	40.44	80.03
		WWSW-FM	33	94.5	20.0	500	40.46	80.00
		WJAS-FM	59	99.7	24.0	470	40.41	80.04
	Pottsville	WPPA-FM	70	101.9	2.8	650	40.83	76.21
IP	Scranton	WUSV	10	89.9	1.35	-390	41.41	75.66
C		WGBI-FM	67	101.3	1.8	1200	41.43	75.75
O	Sharon	WPIC-FM	75	102.9	26.0	455	41.22	80.47
	State College	WDFM	16	91.1	.250	-10	40.80	77.87
C	Sunbury	WKOK-FM	31	94.1	4.4	875	40.79	76.70
	Warren	WRRN-FM	22	92.3	3.0	450	41.81	79.17
M	Washington	WJPA-FM	82	104.3	4.0	360	40.19	80.23
N	Wilkes-Barre	WBRE-FM	53	98.5	2.25	1160	41.20	75.82
CP		WYZZ	77	103.3	3.1	975	41.18	75.87
N-IP	Williamsport	WRAK-FM	62	100.3	4.0	1220	41.19	76.98
O		WLYC-FM	86	105.1	.840	1150	41.20	76.97
	York	WNOW-FM	89	105.7	1.2	465	40.00	76.69

RHODE ISLAND

	CITY	CALL	CH	FREQ	ERP	HT	LAT	LONG
C	Providence	WPRO-FM	22	92.3	15.0	560	41.80	71.47
		WPFM	38	95.5	3.2	170	41.83	71.42
		WTMH	68	101.5	20.0	500	41.85	71.78
O		WPJB-FM	86	105.1	20.0	500	41.81	71.47
	Woonsocket	WWON-FM	92	106.3	.390	215	41.99	71.51

SOUTH CAROLINA

	CITY	CALL	CH	FREQ	ERP	HT	LAT	LONG
	Anderson	WCAC	66	101.1	6.4	330	34.51	82.64
N	Charleston	WTMA-FM	36	95.1	10.0	385	32.82	79.98
C		WCSC-FM	45	96.9	36.0	330	32.82	80.00
IH	Columbia	WUSC-FM	10	89.9	.010*	129*	33.98	81.03
N		WIS-FM	33	94.5	1.3	270	33.95	81.00
A		WCOS-FM	50	97.9	5.3	260	34.02	81.01
A	Dillon	WDSC-FM	25	92.9	8.8	290	34.37	79.40
	Greenville	WESC-FM	23	92.5	12.0	360	34.89	82.47
N-O	(Greenville)	WFBC-FM	29	93.7	10.5	1110	34.94	82.41
N	Greenwood	WCRS-FM	39	95.7	5.0	435	34.21	80.17
	Orangeburg	WORG	74	102.7	4.6	110	33.52	80.87
M	Rock Hill	WRHI-FM	52	98.3	.650	310	34.91	81.01
	Seneca	WSNW-FM	51	98.1	9.4	330	34.69	82.99
C	Spartanburg	WSPA-FM	55	98.9	4.9	520	34.98	81.99
		WDXY	63	100.5	9.2	420	34.98	81.97

TENNESSEE

	CITY	CALL	CH	FREQ	ERP	HT	LAT	LONG
N	Bristol	WOPI-FM	45	96.9	9.7	260	36.60	82.16
C	Chattanooga	WDOD-FM	43	96.5	4.2	1040	35.16	85.32
M	Greeneville	WGRV-FM	35	94.9	4.6	250	36.16	82.84
A	Jackson	WTJS-FM	81	104.1	50.0	640	35.65	88.83
	Johnson City	WJHL-FM	64	100.7	8.1	620	36.32	82.34
N	Kingsport	WKPT-FM	53	98.5	10.0	960	36.53	82.59
	Knoxville	WKCS	16	91.1	.310	73	35.99	83.92
DP		WUOT	20	91.9	23.5	125	35.96	83.96
A		WBIR-FM	27	93.3	2.85	350	35.95	83.95
	Lenoir City	WLIL-FM	62	100.3	8.8	190	35.77	84.28
	Memphis	WMCF	59	99.7	.300	940	35.17	89.89
O	Nashville	WHCY	90	105.9	3.1	47	36.16	86.76
	Paris	WTPR-FM	50	97.9	9.2	220	36.28	88.29

TEXAS

	CITY	CALL	CH	FREQ	ERP	HT	LAT	LONG
	Abilene	KACC-FM	20	91.9	.160	53	32.46	99.71
	Austin	KHFI	52	98.3	.700	125	30.30	97.74
	Baytown	KREL-FM	21	92.1	.820	190	29.78	95.02
	Beaumont	KRIC-FM	48	97.5	14.0	360	30.06	94.12
	Cedar Hill	KDFW	00	107.9	88.0	770	32.55	96.98
	Cleburne	KCLE-FM	32	94.3	.330	190	32.38	97.40
	Corpus Christi	KCCT-FM	38	95.5	.340	280	27.79	97.40
	Dallas	KNER	01	88.1	.010*	76*	32.80	96.65
		KSMU-FM	07	89.3	.010*	60*	32.86	96.79
		KVTT	19	91.7	.780	135	32.78	96.81
C		KRLD-FM	23	92.5	40.0	480	32.89	96.64
M		WRR-FM	66	101.1	68.0	500	32.78	96.76
O		KIXL-FM	83	104.5	25.0	470	32.78	96.72
CP		KSFM	87	105.3	11.0	200	32.76	96.76
	Denton	KDNT-FM	92	106.3	.760	270	33.23	97.17
	El Paso	KVOF-FM	03	88.5	.010*	185*	31.76	106.49
A-N-O	Ft. Worth	WBAP-FM	42	96.3	52.0	475	32.75	97.27
	Houston	KUHF	17	91.3	9.8	320	29.72	95.35
C-O		KTRH-FM	66	101.1	29.5	470	29.76	95.36
N		KPRC-FM	75	102.9	48.0	550	29.73	95.46
A-CP	Lubbock	KSEL-FM	42	96.3	9.6	195	33.58	101.83
	Nacogdoches	KELS	61	100.1	.330	175	31.59	94.62
	Plainview	KHBL	01	88.1	.010*	90*	34.19	101.73
IH	San Antonio	KONO-FM	25	92.9	3.8	410	29.44	98.48
S		KAML-FM	47	97.3	8.3	185	29.44	98.55
		KISS	58	99.5	12.9	570	29.39	98.35
		KOKE	68	101.5	15.0	310	29.50	98.41
A	Texarkana	KCMC-FM	51	98.1	1.4	275	33.45	94.07

UTAH

	CITY	CALL	CH	FREQ	ERP	HT	LAT	LONG
	Ephraim	KEPH	05	88.9	.010*	80*	—	—

VIRGINIA

	CITY	CALL	CH	FREQ	ERP	HT	LAT	LONG
	Arlington	WARL-FM	86	105.1	2.05	500	38.90	77.15
CP	Charlottesville	WTJU	17	91.3	.010*	101*	38.03	78.51
		WINA-FM	37	95.3	.800	235	38.02	78.50
	Crewe	WSVS-FM	84	104.7	14.0	450	37.20	76.17
	Harrisonburg	WEMC	19	91.7	.010*	78*	38.47	78.88
		WSVA	64	100.7	7.2	345	38.45	78.91
N	Lynchburg	WWOD-FM	61	100.1	.940	170	37.44	79.21
N	Martinsville	WMVA-FM	42	96.3	2.9	625	36.70	79.85
A	Newport News	WGH-FM	47	97.3	36.0	180	37.04	76.41
	Norfolk	WFOS	13	90.5	.010*	75*	36.80	76.27
		WMTI	18	91.5	1.45	96	36.89	76.30
O		WRVC	73	102.5	8.7	95	36.88	76.29
	Richmond	New	06	89.1	.010*	124*	37.58	77.45
C		WRVA-FM	33	94.5	25.0	460	37.51	77.50
		WCOD	51	98.1	34.0	430	37.58	77.49
M		WRNL-FM	71	102.1	50.0	240	37.62	77.43
N		WLEE-FM	75	102.9	21.5	300	37.60	77.51
C-CL	Roanoke	WDBJ-FM	35	94.9	14.5	1940	37.20	80.16
M-N		WSLS-FM	56	99.1	10.5	1910	37.20	80.15
A		WROV-FM	79	103.7	2.3	-20	37.27	79.97
	Winchester	WRFL	23	92.5	13.4	1390	38.96	78.02

UTAH

	CITY	CALL	CH	FREQ	ERP	HT	LAT	LONG
	Logan	KVSC	01	88.1	.010*	84*	41.74	111.81
CP	Salt Lake City	KBFM	21	92.1	.195	70	40.79	111.89
N		KDYL-FM	54	98.7	1.2	2970	40.61	112.17
C		KSL-FM	62	100.3	5.9	-390	40.77	111.89

WASHINGTON

	CITY	CALL	CH	FREQ	ERP	HT	LAT	LONG
	Cheney	KEWC-FM	10	89.9	.010*	62*	47.49	117.58
	Pasco	KALE-FM	80	103.9	.580	160	46.24	119.18
	Seattle	KUOW	13	90.5	3.4	100	47.65	122.31
A-S		KING-FM	51	98.1	15.0	410	47.63	122.35
O		KISW	60	99.9	2.1	350	41.70	122.32
C		KIRO-FM	64	100.7	4.5	470	47.40	122.44
	Spokane	KREM-FM	25	92.9	4.8	720	47.62	117.37
	Tacoma	KCPS	15	90.9	.070	90	47.16	122.52
		KTOY	19	91.7	3.5	450	47.25	122.45
		KTNT-FM	47	97.3	10.2	410	47.25	122.46

WEST VIRGINIA

	CITY	CALL	CH	FREQ	ERP	HT	LAT	LONG
C	Beckley	WJLS-FM	58	99.5	34.0	1050	37.59	81.11
	Charleston	WKNA-FM	48	97.5	9.0	124.3	38.38	81.71
	Huntington	WHTN-FM	63	100.5	53.0	560	38.39	82.47
M	Logan	WLOG-FM	77	103.3	2.1	725	37.86	81.98
M	Martinsburg	WEPM-FM	32	94.3	.810	170	39.46	77.84
M	Morgantown	WAJR-FM	57	99.3	1.0	10	39.62	79.95
	Oak Hill	WOAY-FM	31	94.1	14.5	660	37.96	81.15
C	Parkersburg	WPAR-FM	93	106.5	8.9	280	39.29	81.53
A	Wheeling	WKWK-FM	47	97.3	16.0	470	40.10	80.70
C		WWVA-FM	54	98.7	7.4	470	40.10	80.87

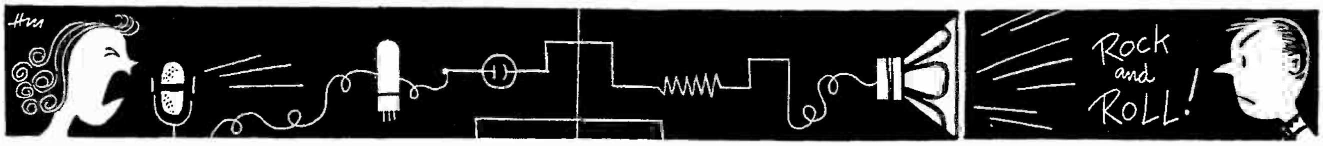
WISCONSIN

	CITY	CALL	CH	FREQ	ERP	HT	LAT	LONG
	Appleton	WLFM	16	91.1	10.5	130	44.26	88.40
	Chilton	WHKW	07	89.3	51.0	740	44.03	88.29
	Colfax	WHWC	02	88.3	50.0	740	44.96	91.67
	Delafield	WHAD	14	90.7	52.0	500	43.03	88.39
N	Eau Claire	WEAU-FM	31	94.1	60.0	360	44.83	91.45
	Glandale	WFMR	43	96.5	24.5	35	43.13	87.91
	Greenfield	WWCF	35	94.9	37.0	1300	43.43	89.22
	Highland	WHHI	17	91.3	50.0	596	43.05	90.37
	Highland Township	WHSA	10	89.9	38.0	450	46.47	91.57
	Holmen	WHLA	12	90.3	39.0	840	43.95	91.13
M	Janesville	WCLO-FM	60	99.9	15.5	200	42.66	89.04
	Madison	WHA-FM	04	88.7	22.0	185	43.08	89.40
A-M		WISC-FM	51	98.1	1.0	105	43.02	89.40
N		WIBA-FM	68	101.5	45.0	1010	43.03	89.85
O		WMFM	81	104.1	7.5	80	43.09	89.35
	Marshfield	WDLB-FM	80	103.9	.250	250	44.68	90.17

	CITY	CALL	CH	(Mc) FREQ	(Kw) ERP	(Ft) HT	LAT	LONG
	Merrill	WLIN	64	100.7	9.35	260	45.19	89.67
A	Racine	WRJN-FM	64	100.7	15.0	265	42.71	87.83
M-IP	Rice Lake	WJMC-FM	42	96.3	26.0	540	45.51	91.77
A-S	Sheboygan	WHBL-FM	62	100.3	63.0	235	43.72	87.73
	Wausau	WHRM	20	91.9	114.0	790	44.84	89.69
M	Wisconsin Rapids	WFHR-FM	77	103.3	2.1	360	44.42	89.83

CANADA

CITY	CALL	CH	(Mc) FREQ	(Kw) ERP
ALBERTA				
Edmonton	CKUA-FM	51	98.1	.352
	CJCA-FM	58	99.5	.414
	CFRN-FM	62	100.3	.279
BRITISH COLUMBIA				
Vancouver	CBU-FM	89	105.7	1.4
Victoria	CKDA-FM	53	98.5	.370
MANITOBA				
Winnipeg	CJOB-FM	76	103.1	.250
NOVA SCOTIA				
Halifax	CHNS-FM	41	96.1	.250
Sydney	CJCB-FM	35	94.9	.630
ONTARIO				
Brantford	CKPC-FM	34	94.7	.250
Cornwall	CKSF-FM	83	104.5	.525
Fort William	CKPR-FM	32	94.3	.250
Kingston	CFRC-FM	20	91.9	1.270
	CKWS-FM	42	96.3	.350
	CKLC-FM	58	99.5	.310
Kirkland Lake	CJKL-FM	29	93.7	.250
Kitchener	CKCR-FM	44	96.7	.350
London	CFPL-FM	40	95.9	4.440
Ottawa	CFRA-FM	30	93.9	.383
	CBO-FM	77	103.3	.380
St. Catherine	CKTB-FM	49	97.7	.250
Sarnia	CHOK-FM	48	97.5	.250
Timmins	CKGB-FM	33	94.5	.425
Toronto	CJRT-FM	16	91.1	9.9
	CBC-FM	56	99.1	11.9
C	CFRB-FM	60	99.9	.600
M Windsor	CKLW-FM	30	93.9	.250
QUEBEC				
N Montreal	CBF-FM	36	95.1	3.860
	CBM-FM	64	100.7	3.860
A	CFCF-FM	93	106.5	7.7
Quebec	CHRC-FM	51	98.1	.595
Rimouski	CJBR-FM	68	101.5	.570
Verdun	CKVL-FM	45	96.9	10.2



READERS' FORUM

Continued from page 17

terest of not only the record company, but the radio station and all others concerned, that noncommercial recording take place. There is also the fact that this further spurs the record companies to produce discs of increasingly better quality that cannot be attained through recording from the air.

R. K. Beamer
Lyndhurst, N. J.

Gentlemen:
Please do not stop the "Basic Electronics" series that you have been publishing. This is the most important part of the magazine as far as I am concerned. It has been a great help to me.

John P. McDermott
Stratford, Conn.

We have no intention of dropping the "Basic Electronics" series. It was forced out of the magazine twice because of lack of space, but we hope that this will not happen again. — ED.

Gentlemen:
Having enjoyed a subscription to your magazine for a year now, it seems an opportune time to tell you so. The articles are fine and the subject material is "on the beam".

Dr. John D. Seagrave's articles on "Minimizing Pickup Tracking Error" (December 1956 and January 1957) were especially stimulating. Having in hand the copy of *Consumer Reports* to which he refers, I calculated additional examples from the data given there. The calculated values are astonishingly close to those apparently obtained by experiment. Where there was a variation, I am inclined to think that the optimum values were not discovered during the testing.

An interesting angle not dwelt on particularly in the article is that variable-reluctance cartridges or, more rightly, velocity pickups have twice the distortion of amplitude types such as ceramic. No doubt a very fine advertising point for the latter.

Dr. Seagrave's equation (24) for m_{opt} should, I believe, be expressed as follows:

$$m_{opt} = \frac{57.3}{L_{cos}\beta}\left[\frac{1}{2} - \frac{1}{1 + \frac{4R_1R_2}{(R_1 + R_2)^2}}\right]$$

H. C. Palmer, P. Eng.
Grimsby, Ont.

Mr. Palmer's result is the correct expression for m_{min} *under optimum choice of* β *and D, and correctly gives a negative value. Careful scrutiny of the text above Eqn. (24) in my article will reveal that the definition of* $m_{opt} = m_1 = m_2 = -m_{min}$, *and its value is correctly given, with positive sign, by my Eqn. (24). I am obliged to Mr. Palmer for his interest and patience in tracking down what looks like an egregious error, since the two expressions differ in that the only term containing* R_1 *and* R_2 *is inverted. That the two expressions differ only in sign may be demonstrated as follows. In the bracketed part of Eqn. (24), let x represent the term in question, so that we have*

$$\frac{1}{2} - \frac{1}{1+x} = -\frac{(1-x)}{2(1+x)},$$

while, for the other version, we would have

$$\frac{1}{2} - \frac{1}{1+\left(\frac{1}{x}\right)} = \frac{1}{2} - \frac{x}{1+x} = \frac{1-x}{2(1+x)}$$

which is numerically identical, with reversed sign.

John D. Seagrave
Los Alamos, N. Mex.

AUDAX KT-16

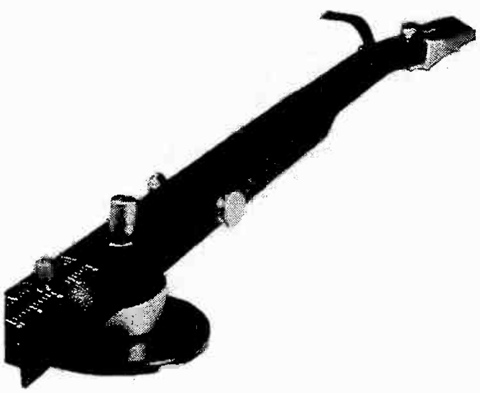
Continued from page 22

longitudinal slot; the counterweight can be adjusted over a wide range by loosening the thumbscrew and moving it (and the weight below) back or forward along the slot. A small indicator arrow rides on two rails at the top of the slot with the thumbscrew, and there are calibration scales on each side. They are index scales only, since an exact stylus-force scale would depend on the weight of the cartridge used, but they do furnish a simple means to duplicate a previously established stylus-force adjustment. This is a new feature, as is the removable pickup mounting head, which will now accept just about any cartridge, including "turn-around" types.

Construction Notes

Detailed assembly instructions and clear photographs are furnished with the kit. Its assembly is quite a simple matter;

we could find no place at which any reasonably careful builder might have difficulty. Even using the utmost care, the task should not take more than 30 minutes. It is worth taking a little extra time on steps 7 and 8: adjustment of the vertical pivots. When the lock nuts are tightened they may have some effect on the pivot adjustment; after you've tried it three or four times you'll probably be able to compensate for this in your adjustment of one pivot screw before that lock nut is put on. The final adjustment should be that which provides perfectly free movement of the arm about these pivots,



Audax KT-16 tone arm fully assembled.

but with the minimum bearing play that will permit this. Note, incidentally, that these bearings and the horizontal bearing are already lubricated; no additional lubrication is needed, nor is it desirable.

Instructions for mounting the arm are given also, of course, and an ingenious method has been devised to obtain exact stylus overhang. More about that in the next section.

Audiocraft Test Results

Design of a pickup arm, no less than that of a loudspeaker or pickup cartridge, involves a great many compromises among conflicting requirements. To minimize tracking error, the distance between the stylus and the horizontal pivot should be as great as possible. But if the arm is made too long it becomes inconvenient to mount, it may be impossible to eliminate torsional resonances, and it may become so heavy that the cartridge cannot track off-center records. Yet it must not be too light either, or the cartridge's stylus compliance will resonate with the arm's effective mass at a frequency inside the audible range.

In the KT-16, the distance from stylus to horizontal pivot is about 12 3/16 in., which may be longer than average for 16-inch arms but not so long that it cannot be mounted on most turntable bases. Torsional and other body resonances have been dealt with by employing a channel-shaped body, and by changing the dimensions of the channel cross section about half-way down the arm. Lateral arm/cartridge resonance is, with any good pickup cartridge, well below turntable rumble frequencies, but not so low that off-center tracking is impaired.

It should be noted that the effective mass in either the lateral or vertical plane is determined by the arm's rotary inertia about the pivot acting in that plane. The main center of mass in the arm is the counterweight; the cartridge is a minor center of mass. Now, the horizontal pivot in the KT-16 is much closer to the counterweight mass than the vertical pivot is; accordingly, the vertical inertia is appreciably greater than the lateral inertia. In most cartridges the vertical compliance is a lot lower than the lateral compliance. The KT-16's greater vertical inertia is apparently intended to compensate for this difference, thus bringing the *vertical* arm/cartridge resonance down to a harmless frequency also. Vertical arm/cartridge resonance is generally ignored in pickup-arm design; as a matter of fact, this is the only conventional-type arm we know of in which vertical inertia exceeds lateral inertia.

Friction in the horizontal pivot and, when properly adjusted, the vertical pivots, is virtually nil.

The arm does not have built-in provision for height adjustment, although enough base lift pads are supplied to make the arm suitable for use with any standard turntable. It is important to observe the mounting instructions concerning height for two reasons: first, the correct height adjustment will put the vertical pivots at nearly the same height as the stylus in playing position, so that the stylus's longitudinal excursions will be minimized on a warped record, and wow from this cause will be correspondingly reduced; second, it will aid in obtaining correct stylus overhang distance.

Stylus overhang distance plays a major part in determining the amount of distortion caused by tracking error. It can be adjusted properly when mounting the arm by measuring it directly, with the cartridge installed and the stylus at record-playing height; or the horizontal pivot can be mounted away from the turntable center pin by a distance equal to the stylus-to-pivot dimension minus the desired overhang. In either case, the base mounting bolt holes should be drilled oversize, to permit small movements of the arm in order to obtain the exact dimension needed. The latter method is ordinarily simpler, and in most cases is the only dimension given in the manufacturer's instructions.

For an arm of the KT-16's length and with its multipurpose offset angle, the optimal overhang distance for LP's is 0.636, or very nearly 5/8 in. This will

Continued on next page

AUDAX KT-16

Continued from preceding page

result in a maximum distortion index of 0.39°/in., which is exceptionally good. Means have been furnished in the KT-16 kit to obtain accurate arm placement by measurement of the distance from the turntable center pin to the horizontal pivot. A paper tube is supplied which is used as a sleeve for the center pin. The arm height is adjusted until a rule resting on this tube and the top of the base assembly (which projects upward through a hole in the arm) is level with the turntable; then the arm base is adjusted in position until the distance between the center of the tube and the center of the base assembly is exactly 11 7/16 in. This will give the proper overhang distance for standard pickup cartridges (those in which the stylus tip is 7/16 in. in front of the cartridge mounting holes). For non-standard cartridges, add the amount by which stylus-to-mounting-hole distance differs from 7/16 in. to the 11 7/16 in. base mounting distance.

If you intend to use the arm for playing LP records only, you may want to change the offset angle to the calculated optimal LP value for an arm of this length, which is 17½°. It can be done with most cartridges by mounting them in the pickup head so that they are not quite parallel with the head; enough play in the mounting holes is usually found so that the required angle can be obtained. Then, with an overhang distance of 0.521 in., the maximum distortion index *for LP's only* will be reduced to 0.23°/in., which is excellent indeed.

In summary, we can find no design flaws in the KT-16, and it does have many commendable features, some of them unique. It is obviously an outstanding buy.

OSCILLOSCOPE

Continued from page 27

reason all good scopes have provision for applying synchronizing signals to the sawtooth generator. Without this feature, the pattern on the screen would drift across to the right or left instead of remaining fixed in position.

The scope shown in Fig. 4 has three choices of synchronizing signals through the SYNCHRONIZING SELECTOR switch. A small sample of the signal under observation is applied to the sweep oscillator control grid when the switch is in the INTERNAL position. In the 60 CYCLE position the power-line frequency acts as the control. If some other source of synchronizing signal is desired, it is simply applied to the EXTERNAL SYNCHRONIZING binding post, and the switch thrown to the EXTERNAL position.

In all three cases, the amount of synchronizing voltage applied to the sweep generator is governed by the setting of the SYNCHRONIZING AMPLITUDE control. Since this signal reduces the output of the sawtooth, it is customary to use as little synchronizing voltage as is necessary for stability.

Both the vertical and horizontal pairs of plates are driven by vacuum-tube amplifiers, whose outputs are controlled by the VERTICAL GAIN and HORIZONTAL GAIN controls. There is also a step attenuator at the input of the vertical amplifier, controlled by the VERTICAL INPUT knob. The signal under test is normally applied at the VERTICAL INPUT binding posts, although it may, if desired, be connected directly to the vertical plates of the cathode-ray tube.

Since it may be desirable at times to have the scope indicate absolute values of peak voltages, the instrument illustrated has a 1-volt peak-to-peak signal coming out at a binding post, thus making calibration a fairly simple matter.

Now that we are familiar with the operation of a typical high-grade oscilloscope, next month we shall begin a discussion of the many audio applications of this versatile tool.

BLUE-GLOW TWEETER

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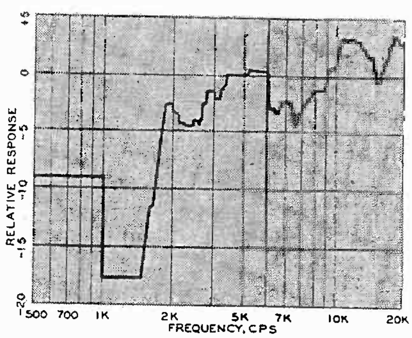

Fig. 6. Frequency response at 94-db level. Crossover is recommended at 3,500 cps.

cell should be replaced about as often as a diamond pickup stylus, and will cost about as much. Distortion increases with input level also. Maximum input (corresponding to 100% oscillator modulation) is said to be 17 watts. Assuming linear increase in output with increasing input, that would produce an output level of better than 122 db. With no audio input, there is no audible output whatever. Consequently, the dynamic range of the Ionovac is extremely wide.

Closest estimates of price for the complete system are between $140 and $150. Thus, the Ionovac will be used only in the finest speaker systems — as it well deserves to be.

TRANSISTORS

Continued from page 31

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High-Frequency Equivalent Circuits

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BASIC ELECTRONICS

Continued from page 33

Heaters are rated according to the voltage across them that will produce the required cathode temperature. Some common heater voltages are 1.25, 1.4, 2.0, 2.5, 2.8, 5.0, 6.3, 12.6, 18.9, 25.0, 32.5, 35, 45, 50, 70, and 117 v. Many tubes have tapped heaters so that they are usable on 1.4 or 2.8 v., for example, or 6.3 or 12.6 v. It is important to maintain the proper heater voltage within a small margin—say, within 10% of the nominal value. Too high a voltage on the heater for an oxide-coated cathode will cause permanent loss of some of the coating, which reduces the maximum emission and shortens the tube life. With too low a voltage, on the other hand, there may not be enough emission to maintain a space charge; that leaves the cathode without protection from ionic bombardment and, with high plate

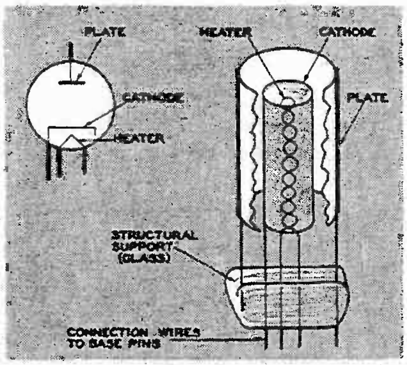
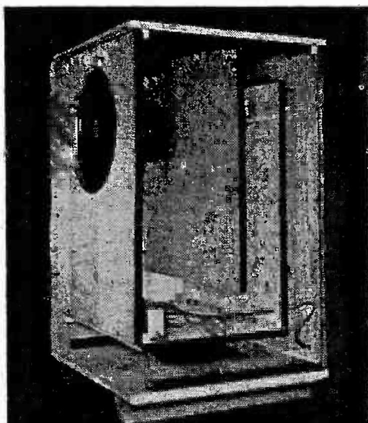


Fig. 9. Schematic symbol for diode tube with an indirectly heated cathode, and its corresponding internal construction.

voltages, may force excessive momentary emission.

The plate of a vacuum tube may have any of a great variety of physical shapes. Whatever its form, it must be of a material that adsorbs little gas and gives it up easily in a vacuum; that will not emit free electrons at the temperatures it will reach in operation; and that radiates heat well. In normal receiving tubes these requirements are met satisfactorily by sheet-metal alloys of nickel, iron, or tantalum, punched and pressed into the desired shape and usually given a black color to aid in heat radiation. Fig. 9 shows the construction of a typical diode rectifier with an indirectly heated cathode.



TRANSISTOR RADIO

Continued from page 24

we believe that its performance would be perfectly adequate, more than might be expected from a receiver of this type.

Sound through the earphone was agreeably well balanced, and seemingly less distorted than that of most AM table models. It is rather exclusive, though; that's where the amplifier-speaker kit is convenient. We didn't dare make any distortion or power measurements, because the former was obviously high and the latter low. Still, it provides a means to make the receiver heard intelligibly and easily throughout a reasonably adequate area. What more can you ask of a unit no larger than a pack of cigarettes?

We don't know how long the battery will last in either unit. They have been in normal use now for better than two months, without showing any signs of giving up. When they must be replaced eventually, the cost will be slight, and they are readily accessible.

As a conclusion, we should say that these kits furnish valuable experience in working with transistor equipment. They are inexpensive, work very well, and are useful on beach excursions or picnics—and for solitary listening late at night or when the rest of the family is clustered around the TV set.

TAPE NEWS

Continued from page 11

tion the tape simply cannot produce any more output, so the additional boost above 5,000 cps that is needed to maintain flat playback response just doesn't get recorded; the measured high-frequency response falls off throughout the rest of the upper range.

It follows that all 7½-ips frequency-response tests should be made with the record volume set at least 20 db below normal or zero recording level. Even at this reduced level there is likely to be some tape saturation above 12,000 cps, and it is possible that residual playback noise or bias oscillator interference will keep the meter indication high enough to prohibit lower readings. What all this adds up to is that there is often no positive way for a home recordist to measure his machine's frequency response beyond 10,000 or 12,000 cps, and my personal feeling about this is one of hearty indifference. As long as a 7½-ips recorder meets its specifications out to 10,000 cps, it will usually meet them out to 13,000 or 15,000 cps. At the same time, if it does happen to be lacking 2 or 3 db at 15,000 cps, there are few individuals who could detect the loss through the inherent distortion in that range. A compulsive perfectionist may sweat blood over the remote possibility that he is being cheated out of a couple of db in this half-octave, but if he *were* able to run tests out to 15,000 cps he might find more than 3 db variation from one

PROFESSIONAL DIRECTORY

TRADERS' MARKETPLACE

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

reel to another of the same kind of tape.

Suffice it to say that, if a 7½-ips recorder's bias current and record equalization are set as recommended to match the tape being used, and the recorder meets its specifications to 10,000 cps when checked at — 20-db level, it is performing as it should be.

SOUND FANCIER

Continued from page 37

corded with transparent clarity and beautifully proportioned room-size piano tone.

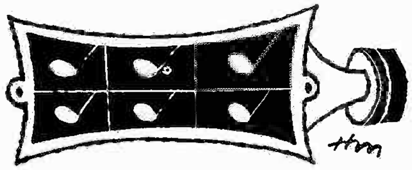
Eugene List's recorded sonorities are perhaps a trifle harder in his Gottschalk program (Vanguard VRS 485), if scarcely less lucid. Like Miss Jambor in her earlier appearance, he is perhaps overrestrained in the projection of his own personality. But here again it is the music which is irresistible, of course in a very different way. Gottschalk was one of the true great originals of all music, as well as the legitimate father of the distinctively American tonal idiom, and after many years of neglect he is at last given his proper due here. Even the lavender-and-old-lace Civil-War-era tear jerkers (*The Dying Poet, Maiden's Blush*, and *Last Hope*) prove to have something more than crinolined sentimentality alone, while the pioneering explorations of Caribbean and ragtime rhythms (in *The Banjo, Bamboula, Pasquinade, La Savane*, etc.) can delight us no less freshly than some of them once delighted Berlioz and Liszt. Whether you have known nothing of Gottschalk before, or known him only in the catchy but overstylized orchestral transcriptions in Hershey Kay's *Cakewalk* Ballet (Columbia ML 4616 of 1952), you'll relish making his exuberantly jaunty acquaintance in a disc survey of his best original scores which offers the most stimulating choice of program materials of the year.

But for sound above all, it will be Ernst Levy's Unicorn LP's which most startlingly reveal new dimensions of recorded piano tone. Levy himself seems to be an extraordinarily assured, opinionated, and self-consciously eloquent pianist of the old grand-manner school. His Beethoven *Appassionata* and op. 111 Sonatas on UNLP 1034 (there are two, op. 109 and op. 110, on UNLP 1033, which I haven't heard), and his turbulently romantic Liszt Sonata in B minor and *Bénédiction de Dieu dans la solitude* on UNLP 1035, are tremendously dramatic projections despite — or partly because of — their idiosyncratic mannerisms. But what gives them their most exciting impact here is a dramatic range of record sonorities authentically scaled to a big grand piano's dynamic potentialities when heard in an acoustically ideal concert-hall environment.

Peter Bartók has made some fine piano recordings in the past, but he has never before worked in an ambience as spacious and vibrant as that of the MIT Kresge Auditorium, and I'm sure he will not be reluctant to share honors here with the designers of that miraculous hall. The results themselves are impossible to describe adequately in words alone. If you're familiar with the reproduced sound of pianos played "under wraps" in comparatively small rooms or studios only, or in the blurred reverberance of most concert halls, you'll hardly be able to believe your ears when you listen to the range achieved here between ethereally floating pianissimos and overpoweringly thunderous yet never distorted or out-of-focus fortissimos. C. G. Burke's term for these sonic qualities, *stereomorphic*, is the perfect one, for they approach the breadth, depth, and lift of stereo sound more closely than any other single-channel recordings I have ever heard. But — fair warning! — only the finest of home sound systems can ever do adequate, to say nothing of full, justice to these astounding discs.

Atonement for a Youthful Folly

Out of a rapidly accumulating stack of current orchestral releases awaiting attention, there's only one I want to single out this month, for in the domains of symphonic sound I'm momentarily so spellbound by two of the most magical examples of stereo orchestral tapes I've encountered to date (Rodzinsky's Tchaikovsky *Nutcracker* Ballet and Fourth Symphony, Sonotape SWB 9002 and



9001), that I'm temporarily incapable of dealing adequately with even the finest of symphonic LP's. The exception of Chadwick's *Symphonic Sketches* (Mercury MG 50104) is not made on the basis of recording quality (although that's impressively "Olympian" in its sensational dynamic range, occasionally excessively spotlighted solo passages, and what seems like more stress on the frequency extremes than one ever hears in live concert experience); nor is it primarily for Howard Hanson's performance (although that is probably the most sympathetic and skillful of his long phonographic career). It is the music itself, and above all its composer, which demand a special, personal tribute.

For when I was very young and cal-

Continued on next page

SOUND FANCIER

Continued from preceding page

low, I studied composition briefly with George Whitefield Chadwick, who was then director of the New England Conservatory of Music and, to my muddled mind, the very archetype of reactionary pedant. I had no use whatever for what I thought was his hopelessly old-fashioned music; consequently, I threw away an invaluable opportunity to profit by his considerable pedagogic talents. But years later I began being haunted by occasional broadcasts of a piece of his—*Noël*, on an early Hanson RCA Victor 78—and before long was forced to conclude that the composer of this beautifully bittersweet soliloquy had a genius I had never recognized. And now, hearing this *Noël* again, I am more than ever convinced that it is one of the authentic jewels of American repertory.

Nor is it the only attraction in the present suite, which also contains, in addition to the more familiar rollicking *Jubilee*, a diverting *Hobgoblin* scherzo, and a remarkable, too long neglected *Vagrom Ballad*, in which Chadwick reveals an almost revolutionary rowdiness and gusto such as I once found among native composers only in the still ignored works of Henry F. Gilbert. After some thirty years I hope it is not too late to acknowledge my youthful stupidity and lay a very sincere wreath of honor on Chadwick's grave. Other American composers have perhaps accomplished more, particularly in the larger architectural forms, but no one has yet given us a melody more poignantly and unforgettably poetic than the haunting English-horn theme of *Noël*.

GROUNDED EAR

Continued from page 5

EL84's in push-pull, usually as pentodes. The very high sensitivity of the EL84's as pentodes requires very little drive and permits large amounts of feedback. Minimization of coupling networks permits the use of high feedback factors with good stability. The high stability of the power-amplifier section, in turn, makes it possible to use successfully the same power supply for the preamplifier section.

Efficiency of EL84's is high, so that a simpler power supply can be used, with lower voltages and smaller, less expensive transformers. This saving in cost and space permits the inclusion of refinements (such as rumble and scratch filters) which previously could be found only in much higher-priced equipment. The consumer profits because he can now buy for $75 performance and quality he could not buy for twice that a year or two ago.

ADVERTISING INDEX