# AUDIO ENGINEERING

FEBRUARY 1954

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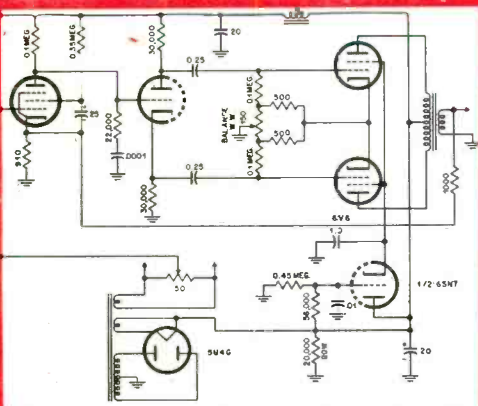

*High performance at low cost characterizes this conservatively designed amplifier, which has a regulated screen supply. Full story on page 30.*

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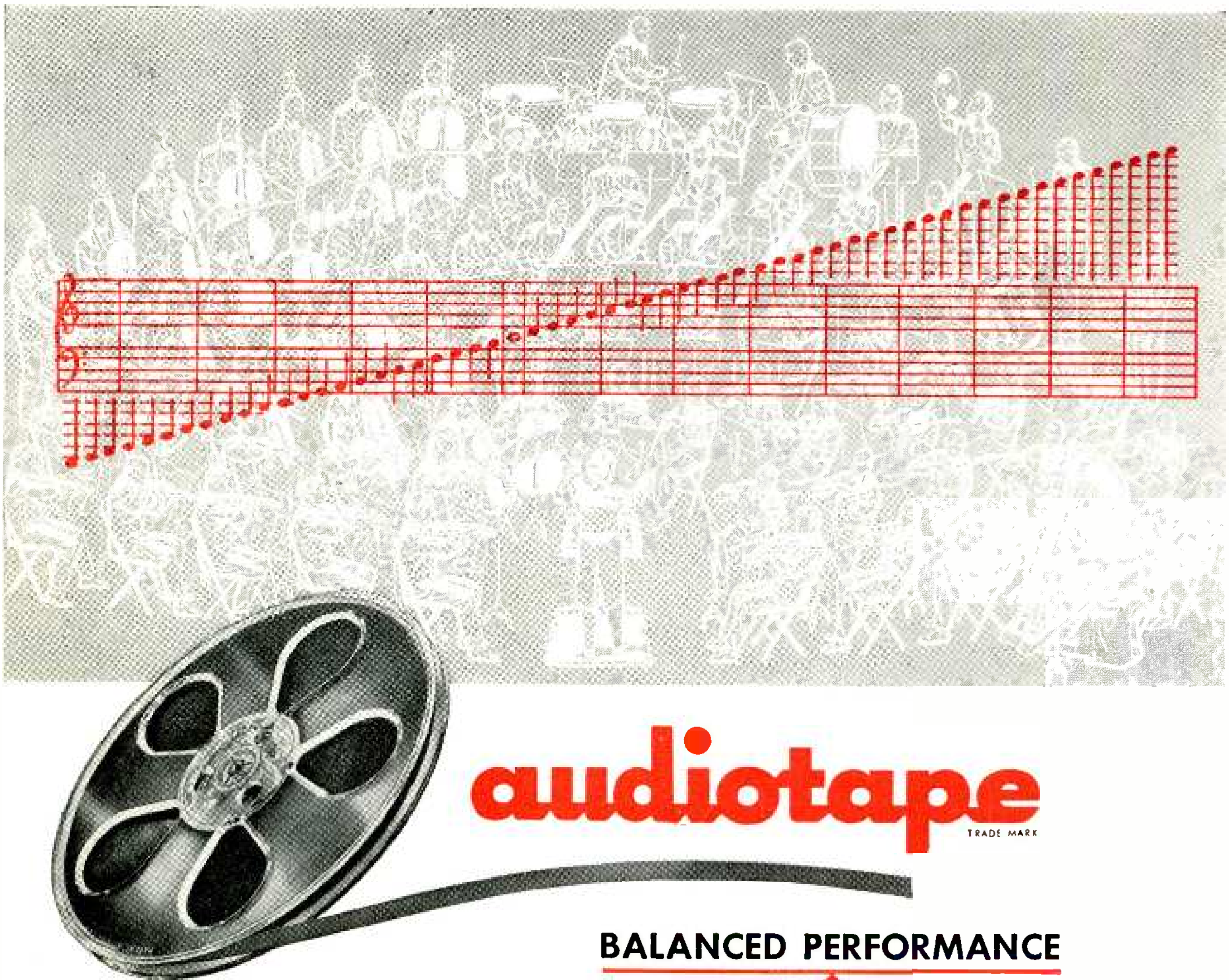


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FEBRUARY, 1954 VOL. 38, No. 2
Successor to RADIO, Est. 1917.

# AUDIO
*E N G I N E E R I N G*



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# AUDIO PATENTS

RICHARD H. DORF*

For some years now this writer has been seeking the elegant, i.e., the simple yet clever, way to make up intercoms and loudspeaker-microphone telephone sets which will not need to use a talk-listen switch. A few half-hearted commercial attempts have been made with various systems that either were Goldbergs or didn't fill the bill. The difficulty comes about, of course, because with a microphone feeding and a speaker being fed by a communication channel both live at the same time, there is normally round-the-circuit singing or acoustical feedback. The only way out is to have the microphone feeding the line but not the speaker and the line still feeding the speaker—all, of course, through amplifiers. One way of doing that is to use an oscillator which disables the microphone amplifier and the loudspeaker stage on alternate half-cycles, so that the two are never operative at the same instant. That is complicated and takes no account of the room reverberation time which could easily make the sound hang over long enough to feed back.

The other approach is through hybrid and bridge circuits, and similar cancellation networks. This is certainly much more practical in principle. The simplest and most practical looking circuit that has shown up for a long time is that disclosed in Patent No. 2,655,557 by Keith S. Stanbury of Christchurch, New Zealand. It is diagrammed in *Fig.* 1.

Believe it or not, these three tubes and the bare handful of resistors and capacitors are all the equipment necessary to do the job. $V_1$ is a microphone preamplifier, probably a 6SJ7 or similar high-gain pentode. A high-output crystal microphone would undoubtedly be used. The plate output of $V_1$ feeds the grid of $V_2$.

$V_2$, the key to the whole idea, is a phase splitter—an ordinary long-tailed or split-load or whatever-you-may-be-used-to-calling-it phase splitter. $R_1$ is the bypassed self-bias resistor and $R_2$ the cathode load resistor. Instead of a resistor for the plate load there is the high-impedance winding (which is either primary or secondary, depending on whether you are talking or listening) of a transformer, the other winding of which roughly matches the impedance of the telephone or intercom line. The $T_1$ winding is equal in impedance to the resistance of $R_2$ so that, as in all phase splitters of this type, the plate and cathode output signals are equal in level and opposite in phase.

The fact that the stage is a phase splitter doesn't bother the line for a moment. Since the large winding of $T_1$ is in the plate circuit only, it transmits to the line whatever the microphone amplifier $V_1$ tells it to.

However, note $R_3$ connected to both plate and cathode of $V_2$ through blocking capacitors $C_1$ and $C_2$. If the phase splitter is well balanced, then the voltages of opposite phase to which the resistor is connected will exactly cancel at the electrical center of the resistor, and from that point to ground microphone signals will produce no voltage. Even if balance is not perfect, the sliding balance arm will find some spot on $R_3$ where cancellation is exact. When that happens the grid of $V_3$ will receive no microphone signals and feedback and howl will not be possible.

$V_3$ will, however, receive signals from the line. Signal is transferred from the line to the winding connected to the plate of $V_2$. One end (top in the diagram) of the winding is grounded for audio through the normal filter capacitor which would appear at the output of the B-supply. The other end is grounded through $C_1$, about half of $R_3$ and the volume control. The signal in this winding will, therefore, appear across half of $R_3$ and the volume control as a voltage divider. Provided $R_3$ is as small as practicable there will be very little loss and the loudspeaker will reproduce any signal originating in the line. (Even if $R_3$ is twice as large as the volume control the loss is only about 6 db.)

Choices for $V_2$ and $V_3$ would probably

* *Audio Consultant, 255 W. 84th St., New York 24, N. Y.*

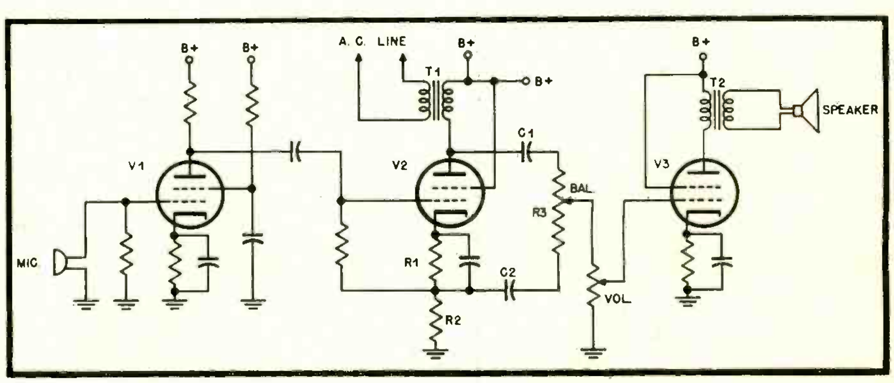


Fig. 1.

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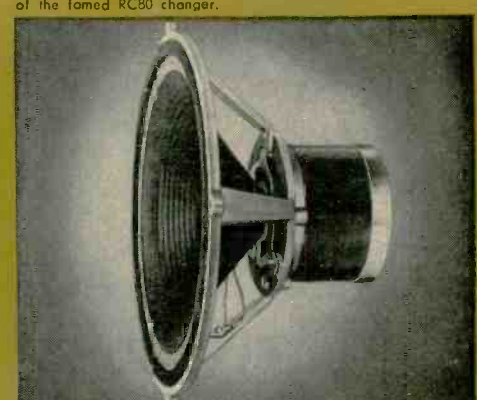

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include such small power tubes as 6V6, 6K6, and the like. One problem that may arise is that the impedances of various telephone lines may vary substantially. The setting of the balance control is dependent on the ratio of $V_2$ plate and cathode signals, which in turn depends on the relative values of the plate and cathode loads. Even if these are matched with the transformer connected to one line, connecting it to another of different impedance will reflect a different impedance to the plate winding and cause unbalance. In each case, of course, the arm of $R_3$ can be readjusted for balance, but this is a cumbersome procedure.

The inventor has found that the balance is much less touchy when transformer $T_1$ is placed in the cathode circuit and $R_2$ placed at the plate. Then, apparently, the negative current feedback encompassing the transformer helps stabilize matters so that permissible line impedance variation is much increased.

The inventor states that with microphone and loudspeaker about 4 feet apart there is room for reasonable lack of precision in the adjustment of the arm of $R_3$. Presumably the microphone and speaker might even be placed on the same panel if more precise adjustment were unobjectionable. As far as practical design values are concerned, they can be chosen as for ordinary amplifier service. If the unit is to be connected to an ordinary telephone line (which most telephone companies do not encourage) the line impedance can be assumed to be about 500 ohms; the transformer secondary should be rated to carry some d.c. and should be disconnected from the line by a switch or relay when not being used since when it is in place it will give the same effect as the handset off the hook.

**Audio-Frequency Discriminator**

Discriminators are more common at radio frequencies where they are usually used for FM detection or for frequency stabilization of an oscillator. They have uses at audio frequencies, however, including oscillator stabilization, frequency measurement, and so on. There are obvious uses for audio-frequency discriminators in radio-control circuits as well, and others which the ingenious mind will have discovered.

Resonant discriminator circuits are not usually particularly practical at the low audio frequencies; in any case wherever we can eliminate a tuned circuit in audio we do so. Oscar B. Dutton of Redondo Beach, Calif., has devised a very flexible and interesting audio discriminator and obtained for it patent No. 2,654,841, which is assigned to RCA.

The circuit of the discriminator appears in *Fig. 2.* There is little point in taking space here to explain its theory, since that requires vector diagrams and mathematical expressions which can easily be found in the patent by anyone who decides it is worth a quarter.

(*Continued on page 51*)

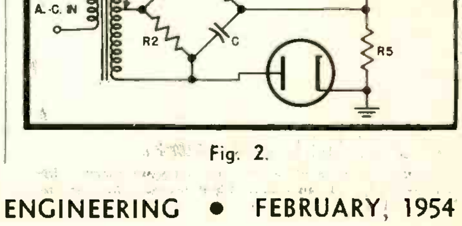


Fig. 2.

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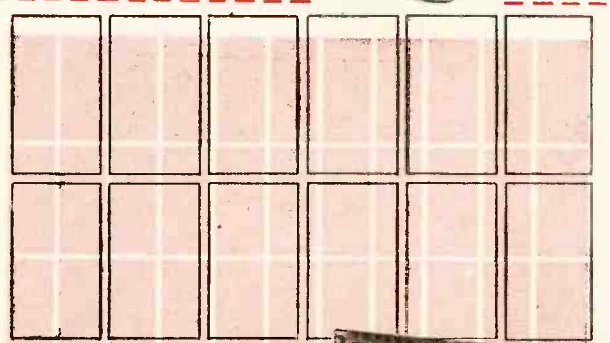

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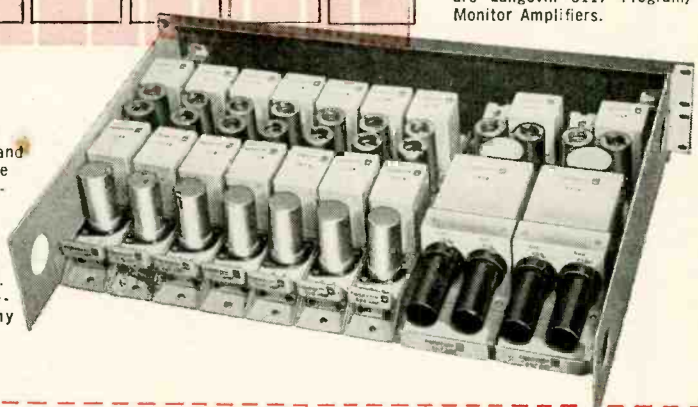

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# LETTERS

**Depends On Who Goes Where**

Sir:

A number of people have deplored in print the indiscriminate and "barbaric" (see Nat Haynes' article on page 19 of the January issue) use of the terms stereophonic and binaural. But no one, so far as I can recall, has simply and clearly set down the real difference between the two. (Or maybe everyone knows it but me.) Recently the great white light dawned and I hasten to record the thought.

In a nutshell, binaural sound transports the listener to the auditorium by placing each of his ears where they would be in the hall. Stereophonic sound, on the other hand, transports the sound to the listening room, placing each part of the sound in roughly the same spatial relationship to others as in the original. This nutshell is easy for purists to crack, but I think it gives the concepts.

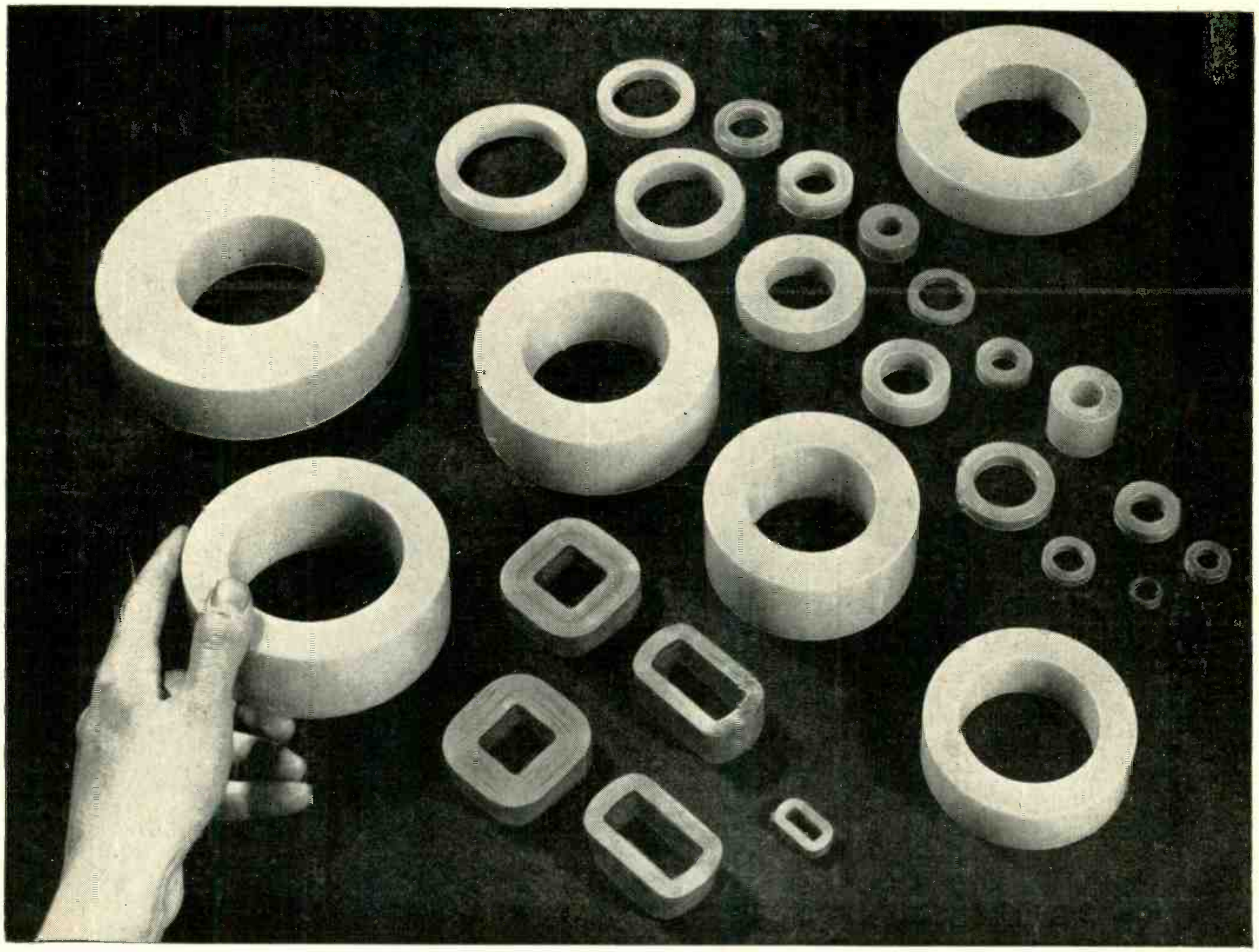
In binaural sound we place a microphone on each side of an artificial head. Each microphone represents an ear, and the listening must be done with headphones to avoid transferring sound meant for one ear to the other. When this is done, the desired effect is quite complete, assuming the microphones have the same directional characteristics as ears.

For stereophonic sound we should divide the original area into an infinite number of segments, placing a microphone in each and transferring the sound through as many separate channels to the same number of separate speakers placed in the listening room in positions identical to those of the microphones. Since infinity is a little hard to reach, we use a finite number of channels and the result is approximate; the more channels the better the result.

In stereophonic reproduction we must use loudspeakers and each speaker is then a reincarnation of the sound originating at the corresponding point. The same sound will, of course, issue from several speakers —but in various phase relationships and at various levels. That is precisely what *should* happen. We are transporting the original sound to the listening room; and certainly at any given point in the original hall the resultant sound is just what that particular stereophonic microphone picks up. Now the listener, when he moves from side to side of the listening room or moves nearer or farther from the speaker group, will have the same effects as when he makes the same moves in the concert hall.

Obviously, binaural reproduction is capable of the greatest practical perfection —as long as headphones are used. But bastardizing the whole mess by recording with two binaural microphones 8 inches apart, then playing back with two speakers 30 feet apart is not fish but foul. If you can't take the listener to the concert by giving him headphones, take the concert to the listener. Use the two channels right by placing the microphones at equal (and considerable) distances from the center of the sound spread and at least approximate something reasonable. Then the listening speakers will magnify or compress the

*(Continued on page 47)*



# London Letter

RICHARD ARBIB*

London theatre managers, who already make profits from their patrons by the sale of programmes and alcoholic drinks as well as seats, are wondering whether they will be able to obtain a source of income from the use of tape recorders. Although as yet there are only two makes of battery-driven tape recording machines on the British market, theatre managers who remember the early days of miniature photography are considering whether or not they should insert notices in their programmes that recording is prohibited, or whether it will be better to make a charge for the use of a recorder in a theatre.

This is just one of the problems which are now being considered in connection with copyright matters which have arisen as a result of the increased interest in the use of tape recorders in Britain. The sales of these machines are in no way as great as in the U. S. A., and it is only during the past year that any machines have been distributed on a nation-wide basis.

The copyright law in this country is not the same as in the U. S. A., and in some ways it is much more strict. Although no case has yet been tested in the Courts of Law, the general opinion among copyright authorities seems to be that there is no infringement of copyright if the owner of a tape machine takes a programme off the air and plays it only to his own circle of friends. If he recorded a broadcast programme of a dance band and took his machine along to his local Social Club and played the recording for a dance, then he would be infringing copyright and would be subject to a very heavy fine.

The situation of taking a machine to a public performance in a concert hall or theatre has not yet been clarified, but providing that it was not an express condition of admittance that a machine was not taken in, it would seem that copyright would not be infringed if the owner of the machine recorded the artistes and then played back the recordings only in his own home.

It is believed that there is quite a number of tape-recorder enthusiasts in various parts of the country who exchange tapes of programmes they have recorded off the air. A recent proposal that a club should be formed so that these enthusiasts could exchange tapes (somewhat in the same way as philatelists exchange stamps) has been abandoned because no one cares to subject himself to the heavy fines that may result from infringement of copyright.

In passing it is interesting to note that in this country one rarely hears the complete operas or even the songs of Gilbert and Sullivan broadcast. The reason for this is that in English law copyright of libretto or the music is protected for 50 years after the death of the author or the composer. Consequently, Sullivan's music may be played, but Gilbert's words cannot be sung or spoken for another 8 years. The only exception is when the owners of the Gilbert copyright give special permission to the B.B.C. for an extract from an opera to be broadcast, and this only happens about once a year.

Gramophone record manufacturers, however, were quick to realise that their wares might be copied on to tape, and every record sold in the British Isles bears a warning on the label that it must not be copied or re-recorded. Nevertheless, one or two record libraries exist which it is believed are well patronised by owners of tape machines.

**Purchase Tax**

The whole situation in England of the high-fidelity enthusiast is assisted somewhat by reason of purchase tax. This relic of the last war is a government tax which is imposed at varying rates on many goods at the time they are delivered to the retailer; that is, the shop pays the tax when it buys the goods. The tax is not supposed to apply to noncommercial lines or to household essentials, and it varies in value between 25 per cent for some toilet preparations and 66 2/3 per cent for fur coats and jewelry. It is 50 per cent for television receivers, record changers, gramophone records, valves, and cathode-ray tubes, but the tax does not apply at all to spare parts for radio and TV other than loudspeakers of a smaller diameter than 12 inches. Consequently, the hi fi enthusiast has tax included in the price of his pickup, gramophone motor, or record changer, pays no tax on the amplifier, and if he acquires a triple-unit loudspeaker with crossover network he pays no tax for the crossover network, pays tax on the 5- and 8-inch speakers and none on the 15-incher, neither does he pay it on a cabinet. If, on the other hand, he has no constructional abilities and wishes to buy a complete outfit built into a cabinet, he pays tax on the lot.

The paradoxical situation arises, therefore, that if one enthusiast is keen on disc records and buys a complete machine which plays them he pays 50 per cent tax on the price the dealer pays for the machine from the jobber or manufacturer. If his brother has a leaning towards tape and buys exactly the same equipment incorporating a tape deck instead of a turntable, he pays no tax whatsoever.

During each April in the last two years, when the Chancellor of the Exchequer introduces his new budget, the tape recorder manufacturers have had their fingers crossed in the hope that no tax on tape machines would be introduced, and as there is a general tendency to reduce purchase tax it is thought it is unlikely that in the next budget these machines will be taxed. At the present time it is more economic to have a recording on tape than it is on disc simply because there is no tax on the tape and there is 50 per cent tax on the disc. If tax were introduced on the tape it would be a very severe setback to tape recording in this country. There are, of course, no sales yet in this country of recorded tapes.

U. S. A. record collectors will no doubt be surprised to learn that all new records in England are sold strictly at list price, which is $5.11 for 12-inch classical long-playing records; this, of course, includes the tax.

In quoting prices of articles in England, it must be remembered that the income of the average Englishman is no more than one-third that of a U. S. A. citizen. Con-

* *Multicore Solders, Ltd., Hemel Hempstead, Herts., England.*

sequently, the comparative cost of a long-playing record to an Englishman, is really $15.

### New Star in the Record Firmament

High-fidelity enthusiasts are looking forward to the release, early in the New Year, of the first Philips long-playing record. Philips, who are controlled from the gigantic factory at Eindhoven, Holland, entered the British record market a few months ago, and although they sell LP records on the continent of Europe, so far in this country they have only marketed 78-r.p.m. discs of the light music category. However, under the able direction of Leonard Smith and Norman Newell, who joined Philips from the E.M.I. group, they have already captured many of the English theatre artistes. They have achieved enormous sales for their company by securing the original theatre artistes of the British production of "The King and I."

There is little doubt that the Philips group are bound to claim a substantial share of the British record market when they enter the LP field. They now have the rights in many European countries, including England, for the American Columbia catalogue. Until Philips entered the market, the E.M.I. group, whose British marks are H.M.V., Columbia, Parlophone, Regal, and M.G.M., and the Decca group, whose British marks are Decca, Brunswick, and Capitol, probably covered 99 per cent of British record sales, the odd 1 per cent being shared by about a dozen small manufacturers. Recently the Decca group have extended their activities by obtaining British rights for French and German records, but there is little doubt that the large Philips organization is bound to claim a share of the market hitherto enjoyed by E.M.I. and Decca.

## COMING EVENTS

Feb. 4–6—Audio Fair—Los Angeles. Alexandria Hotel, Los Angeles.

March 22–25—IRE Show and Radio Engineers Convention. Waldorf Astoria Hotel and Kingsbridge Armory, New York.

April 24—Spring Technical Conference, IRE, Cincinnati, Ohio.

May 5–7—Seventh Region Conference and Exhibit, IRE. Multnomah Hotel, Portland, Ore.

May 25–27—NARTB Broadcast Engineering Conference. Palmer House, Chicago, Ill.

Aug. 25–27—Western Electronic Show and Convention. Pan-Pacific Auditorium, Los Angeles.

Sept. 30–Oct. 2—International Sight and Sound Exposition and High Fidelity Show. Palmer House, Chicago.

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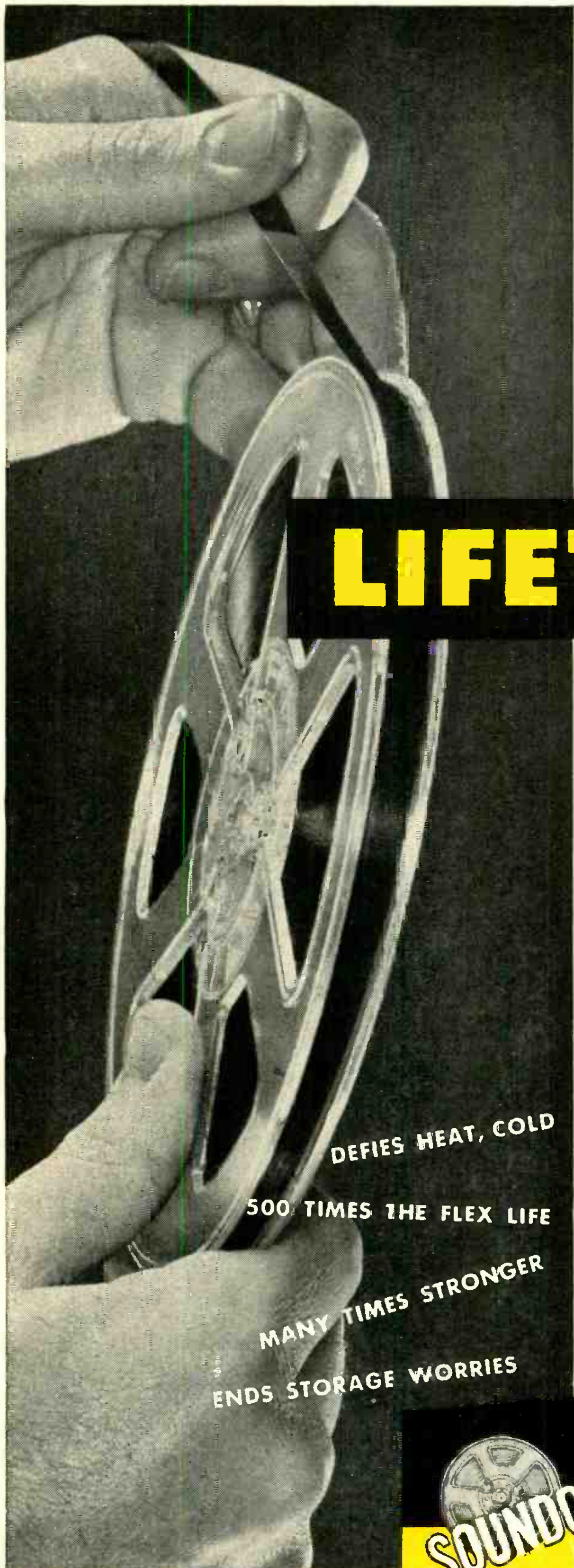


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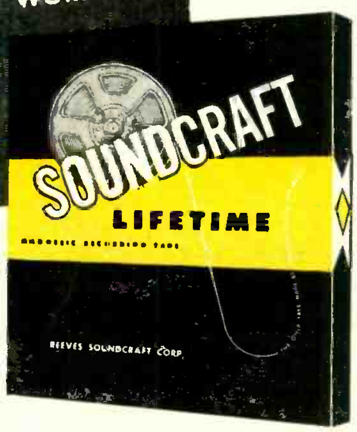


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# AUDIOLOGY

W. R. AYRES*

## Amplifier Bandwidth

Usage has indicated some frequency-range capabilities desirable in representative classes of audio reproducing systems. These vary from the restrictions of narrow-band communication to the wideness of modern high fidelity. Further, if for some reason response at one end of the audio spectrum must be limited, then response at the other end should be limited also to preserve what might be called tonal balance.

The center of the passband may be considered to be the center of the response characteristic when plotted on a logarithmic frequency scale, equal to the geometric mean (square root of the product) of the upper and lower frequency limits. The mean frequency varies from about 600 to 1300 cycles in the popularly used bandwidths given in Table 1, lower values being suitable for music, and higher values preferable for speech.

None of these bands imposes any great burden upon the vacuum tubes themselves. The principal difficulties arise with related components, coupling devices such as transformers being the chief offenders. In general, the lower the frequencies to be amplified, and particularly the lower the frequency at which full power output at low distortion is required, the heavier and more costly the amplifier will be. Design inconveniences are likewise increased if both very high and very low frequencies must be handled simultaneously, since design success at one end of the band requires methods which are detrimental to the other.

Wide-range amplifier response is only one feature of an idealized high-fidelity system, and is not even desirable if the rest of the system is not idealized. For example, high-frequency distortion or noise, regardless of the origin, makes bandwidth restriction preferable to give a "clean" sound. Similarly, at low frequencies, there is little usefulness in extended response if the audibility of rumble or loudspeaker distortion distracts the listener's attention from the recorded program. Thus, if an amplifier is to be used in a variety of services, controls are needed to permit best accommodation of the many situations which may arise in amplifier usage.

It has been argued that tone controls have no place in high-fidelity sound reproduction systems, and the implication itself is incontestable. The trouble is that of the entire system only the amplifier can be made virtually beyond reproach. The sound-pickup, recording-medium, loudspeaker and listening-room characteristics are much more costly to control, and in fact seldom are to the nicety that amplification alone can be accomplished.

In view of these complications, it is perhaps not surprising that listening tests indicate preference for limiting the high-frequency response if the result is a cleaner sound, even though very high tones are obviously missing. At low frequencies, clean over-all performance with rolloff at (say) 80 cps will sound better than the buzzing and intermodulation distortion resulting from uniform amplification down to frequencies at which other system components are unsuited.

While an amplifier with wide-range response is useful in an otherwise flawless system, it is desirable in most practical sound reproduction problems to have available a variety of rolloff frequencies at both ends of the reproduced spectrum. Conveniently located at preamplifier position, these may be selected either continuously or in steps, in suitable combinations to give satisfactory tonal balance. Generally satisfactory and simply arranged are 6-db-per-octave circuits (one active reactive element), which give smooth transition and cannot possibly "ring."

An amplifier enthusiast may well wonder about the cost of uniform response exceeding the audio range at both ends, if rolloff circuits must so frequently be used for best

* *RCA Victor Div., Camden, N. J.*

TABLE 1
FREQUENCY RANGES FOR VARIOUS SERVICES

| Use of Equipment | Low | High | Approx. Mean |
|---|---|---|---|
| High intelligibility speech | 300 | 6,000 | 1,340 |
| Narrow band speech | 400 | 3,000 | 1,100 |
| Public address | 100 | 6,500 | 800 |
| Phonograph records | 50 | 10,000 | 710 |
| Broadcast studio | 30 | 15,000 | 670 |
| Proposed audibility limits | 20 | 20,000 | 630 |
| Sound motion pictures | 50 | 7,500 | 610 |


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reproduced sound. Actually, in the course of obtaining very low harmonic distortion through the use of negative feedback in the amplifier, relatively flat frequency response comes as a natural consequence with no great additional bother or expense. From an amplifier standpoint, low distortion over the entire advertised band-width usually costs considerably more than mere flat response, and best use of amplifier capability is that which best exploits the more important and costly characteristic.

# BOOK REVIEW

VACUUM-TUBE OSCILLATORS, by William A. Edson. New York: John Wiley & Sons, Inc., 1953. xv + 476 pages. $7.50.

This is the first collation of much work previously published in scattered books, monographs and magazine articles on the functions and forms of vacuum tube oscillators. Although to some this lack of originality may be a poor excuse for such a text, let the point be made at once that it is more than necessary to all those whose work requires a complete statement of oscillators, their myriad forms and types, and what may be expected of them in practical use. And, through the use of a uniform and clearly stated form of notation, the reader is able to follow the text with ease, rather than be burdened with several systems of designation, when reading separate presentations of a similar nature.

To the audio engineer this book offers much. A treatment of relaxation oscillators, multivibrators, and phase-shift oscillators is included. Notes on stability of all forms of the oscillator are adequate to aid in the design of specific units for the purpose at hand. Audio work depends more and more on oscillators for design, test, production control, and operational performance, and an understanding of the principles involved can be gained from this text, without need for long research in the technical literature. Free use of mathematics has been made, where necessary and the text is that of a college course of advanced status. The serious audio engineer will find this a splendid addition to his engineering text bookshelf.

DATA AND CIRCUITS OF RADIO RECEIVER AND AMPLIFIER VALVES, (Second Supplement), compiled and edited by N. S. Markus and J. Otte. Eindhoven, Holland: Philips Technical Library. Distributed in the United States by Elsevier Press, Inc., New York. 487 pages, illustrated, 1952.

The objective of this book, as stated by the publisher, is a "review, with full description and data, of receiver, amplifier, and rectifier valves developed during the period 1945–1950, together with their applications and circuits. A large variety of receiver and amplifier circuits employing the valves under review is also provided." The publishers' objective is most certainly fulfilled in this fourth volume of the Philips "Series of books on Electronic Valves."

The introduction to this work is devoted to a complete discussion of the limiting values for tube operation which corresponds to the maximum ratings given tubes of American manufacture. The remaining chapters are devoted to detailed

(*Continued on page 65*)

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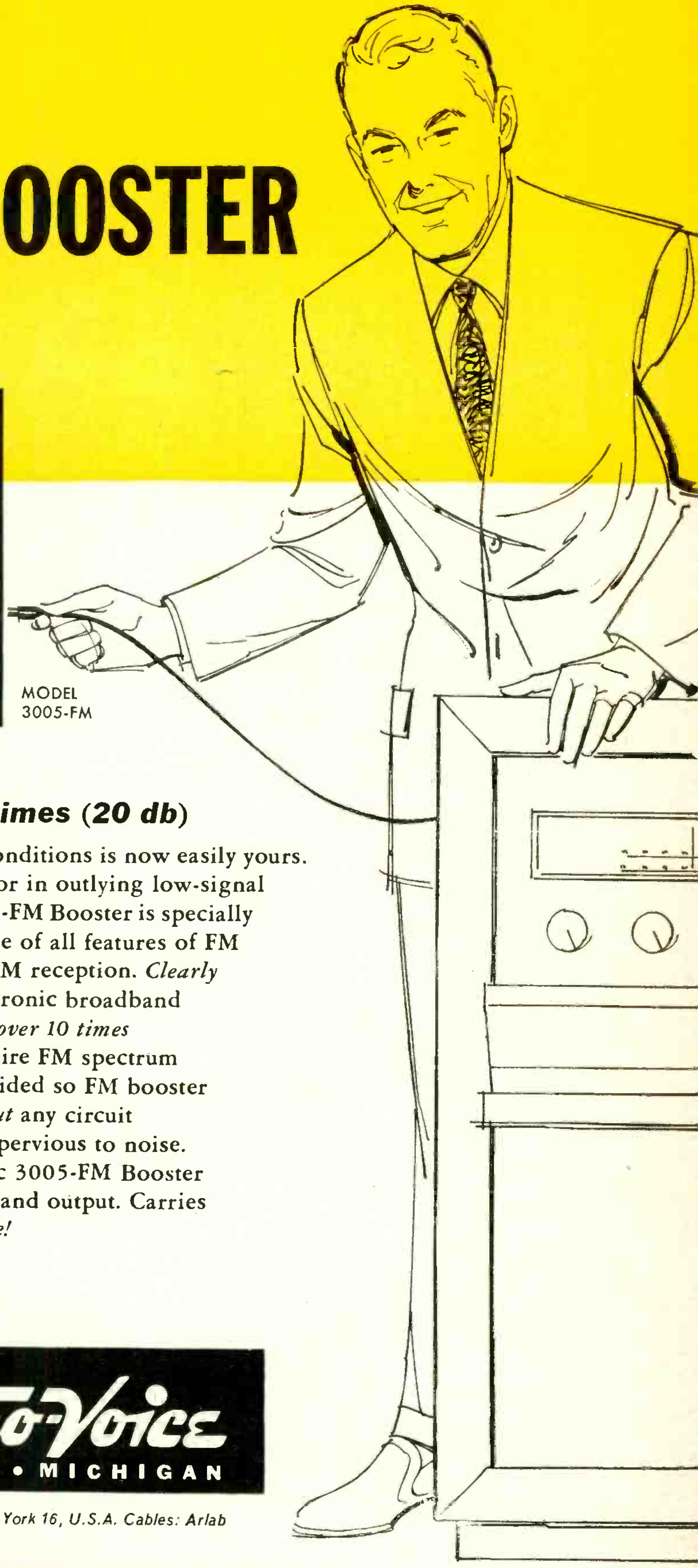

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# EDITOR'S REPORT

## THE NEW LOOK

READERS WILL UNDOUBTEDLY be surprised at the front cover of their favorite magazine this month. In fact, we were somewhat surprised ourselves when the designer first showed us his conception of what the magazine should look like. But after a few more looks, we decided that we liked it—and we most certainly hope that our readers may also find it attractive.

Design changes take a lot of time, and all of the new appearance has not yet been unfolded. But one thing is certain—your magazine will continue to serve the hobbyist and experimenter as it has done in the past. Æ has always carried the latest and most reliable in audio circuitry, loudspeaker cabinets, and plans for improvement, and it will continue to do so in spite of the fact that it will also have more and more material for the newcomer to our ranks. For it is the newcomer who brings new ideas and who may also point the way toward still further improvement. If there is less material for the professional, it is principally because there have been fewer developments in that branch of the industry over the last few years. We have so far seen the development of the LP record, hi-fi for the masses at practical prices, improved amplifiers, better tone-control circuits, lower distortion. We have seen the introduction of the loudness control which has made it possible to enjoy music without having to reproduce it at the same level as in the studio—and which is, in our opinion, one of the greatest elements in the popularization of hi-fi among people who thought that high fidelity was synonymous with high volume or high frequency.

We have also seen the trend of loudspeaker enclosures in two directions—toward the finest two-, and three-, and even four-unit systems in back-loaded corner cabinets for those who had the space for them, and toward the pint-sized cabinets which permit the apartment dweller to enjoy music much more than he ever could with boxes he could spare the room for. Even the "case goods" models—factory assembled radio and phonograph sets—have improved immeasurably in many lines. One of the more striking advances in audio equipment has been with respect to record changers. Ten years ago they were simply mechanical devices which served primarily to handle the records and impart to them an angular velocity which was approximately correct and occasionally constant; today they are remarkably efficient, accurate and constant in speed, and with practically no rumble.

Throughout the range of equipment, improvement has been great in the last few years. And the public has been quick to note the improvement and still quicker to take hi-fi out of the hobbyist's "shack" into the living room. If our prognostications about the future of audio were never stressed—it's so easy to make prophecies—certainly the content of the past eighty-two issues of Æ have indicated where our faith lies.

Thus with the new look Æ combines art with technique—which is exactly what the audio industry does in bringing through technical means the artistry of great composers, musicians, and conductors.

## EDUCATION AND TRAINING

We are regularly bombarded with inquiries about where to study audio engineering, and just as regularly we have to advise the questioner that we know of no recognized institution of learning where the subject is being taught. There are a number of technical schools —both resident and correspondence—which provide considerable training in the audio field, but none offers college-level courses in engineering with specialization in audio. We trust this will be changed before long—and suggest respectfully that the industry as a whole might sponsor a chair in audio engineering in some university. As it stands now, the audio engineer is usually a man from some other branch of engineering who has by chance been drafted into audio work and who has learned the hard way. We believe that the advantages accruing to the industry from an endowment at some recognized college would repay its cost many times over.

A similar condition has existed in the radio and TV station management field, and although college-level training is not what is required, some education along technical and executive lines is necessary. We are pleased to note that the Northwest Radio and Television School, of Portland, Oregon, is stepping up its activities in that field by planning a midwest headquarters in Chicago to open at an early date. We wish them the greatest success.

## COMING EVENTS

While a large majority of hi-fi fans employ their music systems primarily for the reproduction of classical music, we have long felt that the jazz and pops listeners have been neglected. We are pleased to announce that Robert Sylvester, entertainment editor of the New York Daily News, joins our staff of contributors next month with a column on the lighter music. Without question the devotee of jazz or the casual listener to crooners, dance bands, and "songbirds" can derive as much enjoyment from high-quality music reproduction as does the music lover who buys symphonies, operas, and string quartets. Mr. Sylvester is the author of five books, has written for most of the national magazines, says he's 28, affects a sparse crew cut, and has an interesting way with a typewriter. We believe you'll enjoy him.

## WELCOME

As a word of greeting to the many new readers who will see their first copy of Æ at the Audio Fair—Los Angeles, may we suggest that this issue is a fair sample of what to expect from a magazine whose title may have frightened away the less-than-engineer type of reader who just likes good music, well reproduced. We believe there is something in Æ for everyone.

pressed, at least formally, quite simply. If $f(t)$ is the output of the system to the *unit impulse* and $F(j\omega)$ is the frequency response of the system, then

$$f(t) = \frac{1}{2\pi}\int_{-\infty}^{\infty} F(j\omega)\varepsilon^{j t\omega}d\omega$$

$$F(j\omega) = \int_{-\infty}^{\infty} f(t)\varepsilon^{-j\omega t}dt$$

Given an arbitrary frequency-response function, however, the task of finding the transient response may still be quite difficult, although various methods of approximation are available (for example, see chapter 11 of Brown and Campbell[1]).

That a relation exists between the two suggests that both frequency and transient responses may be different expressions of a more fundamental property of the system. This is actually the case; the basic characteristic in the study of servomechanisms is called the *transfer function*. The transfer function of a linear system[2] is the Laplace transform of its weighting function—or, more simply, the ratio of the Laplace transforms of any normal response and the input that produces it. Given the transfer function for a filter, the frequency response and response to any sort of mathematically defined transient are usually calculated more or less readily.

The beauty of working with transfer functions is that the responses of many types of audio equipment can be closely approximated by fairly simple functions. Since in practical cases unavoidable variations exist between pieces of equipment of nominally identical design there is considerable advantage to studying such approximations rather than attempting much more and difficult analy-

[1] G. S. Brown and D. P. Campbell. *"Principles of Servomechanisms."* New York: John Wiley and Sons. 1948.

[2] This paper is concerned only with linear systems which, for audio equipment, implies complete freedom from introduction of harmonic distortion. The results of such work hold closely for practical systems in which distortion levels are quite low.

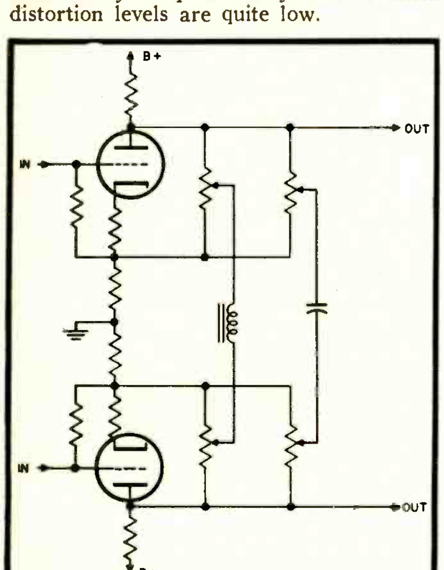



Fig. 3. Degenerative tone-control circuit.

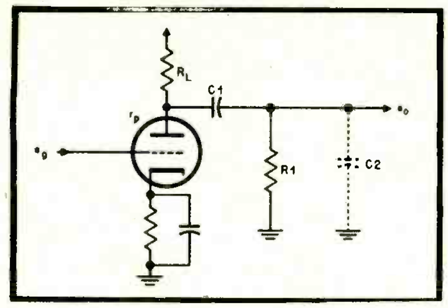



Fig. 4. Single triode amplifier stage.

ses. Furthermore, when the relationship between frequency and transient responses has been studied for some time, it becomes easier to estimate, from a frequency-response curve, the desirability of the transient response of any particular piece of equipment.

The transfer function for any system is some function of a variable $s$ ($p$ is also used). The frequency response of the system (that is, the response to a sinusoidal input) is obtained simply by substituting $j\omega$ for $s$, where $j$ is the familiar $\sqrt{-1}$ and $\omega$ is the electrical rotation, equal to $2\pi f$, $f$ being the frequency. The absolute magnitude of the resulting expression represents the amplitude of the frequency response, while the phase of the output is the arctangent of the ratio of the imaginary part of the expression to its real part. On the other hand, the time response of the system to a unit step is the inverse Laplace transform of $1/s$ times the transfer function. The transfer function, by proper manipulation, gives not only the frequency response and phase shift of a system but also the response to any other type of input for which the Laplace transform is known. Since most (but not all) commonly-encountered audio systems are of the "minimum phase" type in which the shape of the phase curve can be derived directly from the shape of the frequency-response curve, this paper will not concern itself further with phase shifts but will deal exclusively with amplitudes of responses to sinusoidal inputs.

## APPLICATIONS

The theory that has been touched upon very briefly could be expanded into a large book, and interested persons may wish to pursue the subject further.[1, 3] We shall proceed directly to simple examples illustrating the procedure previously described.

### Tone Controls

An excellent type of degenerative tone control[4] is shown in *Fig.* 3. In spite of its freedom from critical adjustments and its good control characteristics it has been avoided by some workers because the "resonant" combination made up of the bass-control choke and the treble-control capacitor has been claimed to produce "transient distortion." From what has already been said regarding the relation between frequency and transient response, however, it must be concluded that such statements are not based upon fact. The transient response of such a tone control is absolutely identical to that of any other circuit producing the same frequency response, irrespective of whether the latter does or does not contain combinations of capacitors and inductances.

[3] H. M. James, N. B. Nichols, R. J. Phillips. *"Theory of Servomechanisms."* New York: McGraw-Hill Book Co. 1947.

[4] C. P. Boegli. "The degenerative tone control." *Radio and Television News,* June 1951, p. 58.

### Audio Amplifier Stages

A single stage of voltage amplification with infinite bypass capacitors (*Fig.* 4) has the equivalent circuit shown in *Fig.* 5. The low-frequency response drops off 6 db per octave below a frequency determined by $C_1$ and $R_1$ while the high-frequency response is attenuated similarly above the point where the reactance of the input capacitance $C_2$ of the following tube equals the resistance $R_2$ of the signal source at the tube's grid. The frequency is generally calculated quite easily or it may, of course, be measured by setting up the circuit.

From a function standpoint the circuit represents a differentiating circuit with a time constant $T_1 = R_1C_1$ in series with an integrating circuit of time constant $T_2 = R_2C_2$ and with an amplifier with a gain usually equal to the mid-frequency gain of the actual circuit. The transfer function for the first is

$$\frac{T_1s}{1 + T_1s}$$

for the second it is

$$\frac{1}{1 + T_2s}$$

and for the entire stage, ignoring the gain, it is

$$G(s) = \frac{T_1s}{1 + T_1s} \cdot \frac{1}{1 + T_2s} \qquad (1)$$

Suppose now that $T_1 = 1000\ T_2$, which would define a stage whose high-frequency response was down 3 db at a frequency 1000 times that for which the low-frequency response had also dropped 3 db. For example, the $-3$ db points could be at 20 and 20,000 cps or at 100 and 100,000 cps. Eq. (*1*) takes the form

$$G(s) = \frac{T_1s}{(1 + T_1s)(1 + .001\ T_1s)} \qquad (1a)$$

where, of course, $T_1$ refers to the time constant for the low-frequency cutoff. If, for a selected $T_1$, $j\omega$ were substituted for $s$ in this expression, a plot of the absolute magnitude of $G(j\omega)$ versus $\omega$ would be the expected frequency response. On the other hand, for the unit-step input,

$$\mathcal{L}^{-1}\left[\frac{G(s)}{s}\right] = \varepsilon^{-t/T_1} - \varepsilon^{-t/.001T_1} \qquad (2)$$

(*Continued on page 56*)

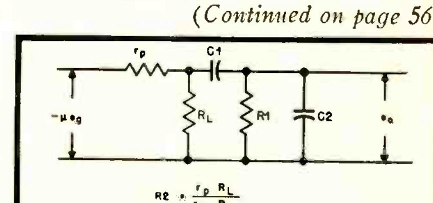



Fig. 5. Circuit equivalent to that of Fig. 4.

# A Corner Horn For The Small Listening Room

WAYNE B. DENNY*

**Large-aperture horns, desirable for adequate bass response, can be made to appear much smaller than they really are by effective use of a corner.**

Most designers and users of higher-quality reproducing equipment agree that adequate bass response requires rather large speaker enclosures. Horn speakers in particular often require 20 or more cubic feet of space for efficient radiation of low-frequency sounds. This requirement poses a problem to those who must confine their listening to apartment-sized living rooms. Too often, the person who installs a better than average audio system finds that the system—particularly the speaker enclosure—"takes over" the room to the point where it dominates the entire listening area visually as well as aurally. This may not bother the high-fidelity addict but it is likely to engender a high noise level in the form of vocal complaints from the distaff side.

Is it possible to build a speaker horn which is adequate in size but which does not completely dominate restricted living quarters? After some preliminary study it appeared possible to solve this problem satisfactorily and the unit to be described is offered as one solution. No new principles are involved but effective use is made of some well known ideas.

Inspection of *Figs.* 1 and 2 will serve to illustrate the fundamental features of the horn. The driver is back-loaded at low frequencies in the conventional manner. The horn expands toward the rear—that is, toward the corner of the room—and then expands toward the front at either side of the structure. The large portion of the horn is formed by the top panel, side panels, floor, and room walls. Room walls and floor are visible and it is this feature which makes the unit appear much smaller physically than its actual acoustic size. The entire volume beneath the top panel is of the order of 20 cubic feet! Yet it looks no larger than a moderately large corner table. Part of this deception is caused by the ratio of width to height. The height is just under 33 inches—about right to hold a table-model television receiver where it is most easily viewed. This is important in those rooms which provide but one unobstructed corner suitable for viewing and listening.

Major dimensions are shown in *Fig.* 2. As shown, the horn approaches exponential shape and provides for a theoretical low-frequency cutoff at about 60 cps. The mouth area—just over 1000 square inches—is large enough to subdue serious reflections and this aperture is augmented by walls and floor.

The structure is very solidly constructed of ¾-inch plywood. All joints are secured by wood screws and glue except the top which is, of course, removeable. Weatherstripping material is used to ensure a tight seal between the top and the walls of the room. Internally, 1 × 2-inch reinforcing strips are used along all corner joints. These strips are not shown in the diagram of *Fig.* 2 but their use is illustrated in *Fig.* 3.

Construction is relatively simple and need not deter the average amateur carpenter or cabinetmaker. The only difficulty—a minor one—is caused by the fact that several panels meet at angles other than 90 degrees. A little care is necessary to insure a solid and tight-fitting joint. All panels can be obtained from a single sheet (4 × 8) of plywood as shown in *Fig.* 4. It is suggested that all outside panels be cut as shown so that the grain of the wood is uniform in direction. The smaller panels are cut from the residue and are preferably cut oversize and planed to fit. At prices prevalent in the Midwest the entire structure can be built of fir plywood for about $25. The use of birch or similar outside ply will double the cost.

* *Grinnell College, Grinnell, Iowa.*

Fig. 1. The finished horn seems very small physically in comparison to its effective size.

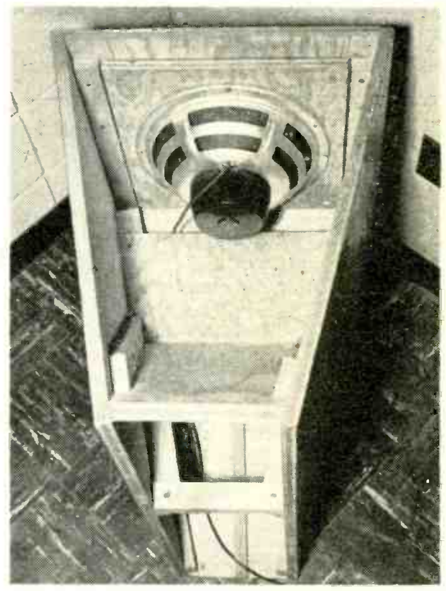


Fig. 3. This view of the enclosure turned around from its normal position, was taken from above and behind. It is useful in showing many details, though somewhat deceptive from a photographic standpoint. To avoid misunderstanding, remember that the side walls are rectangular, the top parallel to the floor.

### Performance Characteristics

A number of speaker enclosures have appeared in the literature during the past two years which employed the General Electric S1201-D speaker as drivers. A few of these descriptions have included impedance curves. For purposes of comparison, a similar driver was installed in the corner horn described here and impedance curves were prepared with the aid of the circuit of *Fig.* 5. The results are shown in *Fig.* 6. Comparison of the solid-line graph with the corresponding curves for other enclosures shows that the present unit has unusually small fluctuations of impedance with respect to frequency. Although no claim is made that such curves are completely indicative of speaker performance, the inference is that increased air loading makes the response less variable with frequency. Analysis of the data with and and without fiberglas absorbing material in the space behind the cone indicates that impedance fluctuations are smaller with the fiberglas installed. Percentage-wise, the fluctuations are small in either case within the

(*Continued on page 64*)

# The New Golden-Ear Amplifier

JOSEPH MARSHALL*

In Two Parts—Part 2

**Continuing the description of the complete amplifier installation by discussing the design and construction of the preamplifier and the tone-control sections.**

THE PRE-AMPLIFIER AND CONTROL UNIT used with the new Golden-Ear amplifier differs from conventional in several respects. First, 1.5 volt miniature battery type pentodes with d.c. on the filaments are used in the phono-preamp; second, feedback with practically no frequency boosting function is applied over the first stage and directly to the pickup; thirdly, the tone control circuit, through perhaps over-elaborate for normal use, is extremely flexible and provides direct boosting of treble and bass and narrow-band interference elimination; and, finally, the arrangement of volume and tone controls is such that with no special devices, tone compensation is automatically achieved with variations in volume level.

#### Description

A pair of 1U5's with d.c. on the filaments is used in cascade for the phono pre-amp, *Fig.* 5. The filaments are in series and the 3 volts d.c. is supplied by a rectifier fed by a 7-volt filament winding. Contact-potential bias is employed and deposited carbon resistors are used for the bias resistors, the plate loads, and the loading resistor for the magnetic pickup. As a result of these measures the noise level is very low.

Between 6 and 10 db of feedback is applied from the output of the first tube to the pickup. This further reduces the noise level, and damps the pickup, leveling the response and reducing resonant peaks. The time constant of the network is proportioned to produce bass boost below 50 cps. It is difficult to obtain sufficient bass boost at 25 or 30 cps with a single bass-boosting network. The 6 db boost at 30 cps produced by the feedback, plus that of the normal equalizer, produces a very satisfactory response and yet results in a much lower hum-level (given a low-rumble turntable) than with conventional circuits. The total noise—thermal and hum—is reduced bv these measures to less than 10 microvolts or more than 40 db below the output of a GE pickup. We never seemed to be troubled much by hum with the old reliable 6SC7 in the GE circuit; but the new preamp was a revelation, although its unmasking effect makes record scratch, as well as wanted increments of music, more evident.

The equalizing networks *Fig.* 6, are of the interstage type developed by Boegli and use his constants. A choice of six curves is available. The total gain of this phono-preamp is in excess of 500, after feedback, which is fairly comparable to that of the 6SC7 and sufficient in this case since additional amplification is available in following stages. Another VR tube is used to decouple and to reduce hum of the power supply, in the plate-supply line to the 1U5's.

The phono preamp is constructed on a separate sub-chassis and mounted with rubber shock absorbers on the pre-amp chassis. The equalizer elements for each curve are mounted inside bakelite tubes, sealed, and the switch is mounted directly adjacent to the sub-chassis to provide short leads.

* *The Bleachers, Ozone, Tenn.*

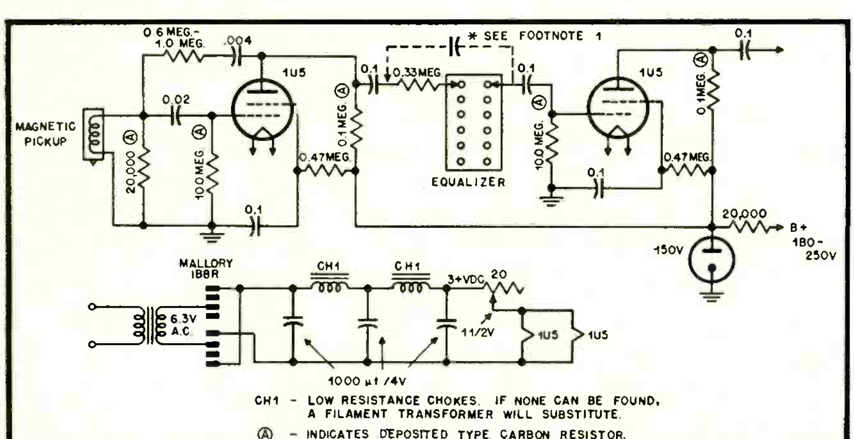



Fig. 4. Phonograph preamplifier and associated filament power supply.

#### Tone Control Circuit

The prototype amplifier contains a two-channel mixer with a choice of five inputs, through push-buttons, for each channel, as indicated in *Fig. 7.* For average home use, however, a single channel with a single switch will no doubt suffice and in that case one volume control and both 0.47-meg isolating resistors can be eliminated. Miniature tubes are used throughout to minimize Miller effect. The plate load of the mixer and of the following stages is made low to flatten the response curve, and degeneration is provided by eliminating cathode by-pass capacitors in the straight-through stages, $V_1$ and $V_2$. The preamp contains a two-section filter (in addition to the two-section filter in the power supply) for decoupling and for hum elimination, and in consequence the hum level is very satisfactory, despite the absence of cathode by-pass capacitors.

The tone-control section is somewhat unusual and consists of five parallel amplifiers. The first, or upper section, is a reference or straight-through channel and is proportioned to provide as flat a response as possible over the whole range. The volume control in this channel is the master volume control and, as we shall see, provides automatic tone compensation.

The next two sections, $V_3$ and $V_4$ are the bass and treble boost sections. The frequency discriminating network is of the Wien-bridge type. This type yields a peaked, resonant curve, rather than a mere high-pass or low-pass slope. The peak is broad but the slope beyond ½- and 2-times resonance is at approximately 6 db per octave. The resonant peak is determined by the formula $1/2\pi RC$, and can be changed by changing the values of either the capacitors or the resistors or both. In the prototype amplifier the capacitances are switched in each channel to provide a total of six peaking points in each channel—30, 60, 100, 300, 400, and 800 in the bass channel, and 1000, 2000, 4000, 8000, 16,000, and 30,000 cps in the treble channel. This is useful for experimental, measurement and laboratory purposes, but for ordinary home use a single curve will suffice. The values given yield excellent results and provide an important dividend.

The upper three channels are paralleled in the output and fed to one side of the

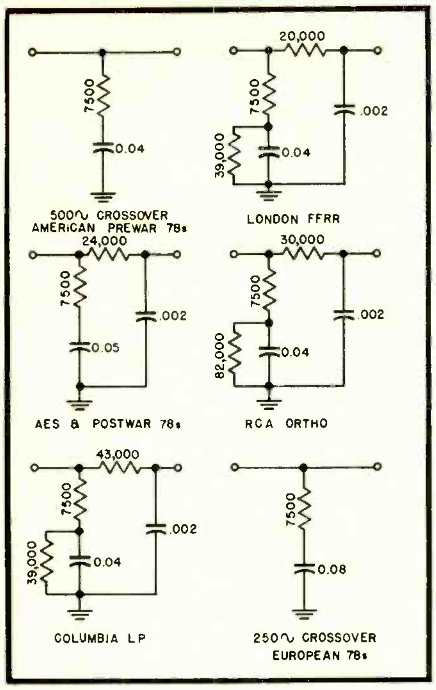



Fig. 5. Interstage equalizer networks used in the phono preamp.

cross-coupled input of the Golden-Ear amplifier. Because of this parallel arrangement the boosting is direct and (subject to the qualification noted below) independent of the volume level of the unequalized range. In other words, if the output lacks bass, the bass control is turned up, the bass is increased with no necessity for changing the volume control. The equalization curves have a slope on the far side of the peak, reducing the likelihood of aberrational operation which results when, for instance, such transients as the very-low-frequency wave form of a fading short wave signal, are boosted together with the wanted bass.

The analytical mind, however, will discern that the amount of boost is dependent on the setting of the volume control in the master or reference channel. Assuming equal amplification in the three sections, the maximum boost at each end when the tone controls and the reference volume control are maximum is about 6 db; but can be 20 db or more when the master or reference control is near minimum. This fact is, therefore, exploited to provide automatic tone compensation with changes in volume level. With the values given in the diagram, this compensation complements the Fletcher-Munson curve closely enough for very pleasing results. If twin-triodes are used, the cost of this type of tone control is little or nothing more than that of the conventional arrangement, because the direct boosting eliminates the need for additional amplification to make up for insertion loss, and because the cost of a compensated loudness control is eliminated. It might be pointed out that if the "loudness control" effect is not desired, equalization can be maintained with changes in volume level simply by leaving the loudness control in a near-minimum position and regulating volume at the tuner or mixer.

In any event, the result is an extremely useful and flexible tone control circuit.

To give the boost channels higher gain, they are provided with a higher plate load and the cathode resistor is by-passed. More than 20 db of boost is available between 30 and 50 cps, and more than 15 db between 15,000 and 20,000 cps with very little effect on the mid-frequency range.

### The Attenuation Channels

The attenuation channels, $V_5$ and $V_6$ make use of the differential qualities of the cross-coupled inverter. If in-phase signals are fed to both grids of the Golden-Ear amplifier, cancellation will occur at the points of no phase difference and equal amplitude. The two attenuation channels are fed from the same source and operate under the same parameters (except for the frequency-discriminating network) as the reference channel; therefore, the output is of the same phase. If this output is then fed to the lower grid of the cross-coupled inverter, that portion of the signal which is in phase is attenuated and that portion which is both in-phase and of equal amplitude is completely nulled.

This phenomenon offers interesting possibilities which the author is just beginning to explore. We have never found much use for the usual type of rolloff attenuators. If the program source is good and properly equalized, and if the main amplifier is distortion free, there is no need for rolloffs. But there is one problem in high-fidelity reproduction which has always needed a good solution—and that is the minimization or elimination of certain interferences, such as the 10,000-cps beat note on the broadcast band; heterodynes on the short-wave bands; hum and turntable rumble in phonograph reproduction; line-hum in network programs, etc. The two lowest channels in the tone-control circuit represent an attempt to deal with these interferences. So far the attempt, though still in the experimental stage, is very promising.

The high-frequency channel works better than the low frequency channel because at these frequencies the parameters can be varied more easily. The .65-henry choke and the miniature 400-μμf variable capacitor form a series resonant circuit with a resonant point which can be varied from about 3000 to 12,000 cps. Because the Q of the circuit is high the resonant curve is sharp and steep. The phase shift is fairly complementary to that of the reference channel and excellent attenuation effects are obtained. The effect is that of steep rejection notches rather comparable at audio frequencies to the rejection notch of a crystal filter at radio frequencies. Single-tone heterodynes or narrow bands of interference—such as monkey chatter—can be completely eliminated by tuning the resonant circuit to the frequency of interference and adjusting the rejection control (volume control in this channel) until the interference is nullified. The 10,000-cps adjacent channel beat note can be eliminated in

(*Continued on page 54*)

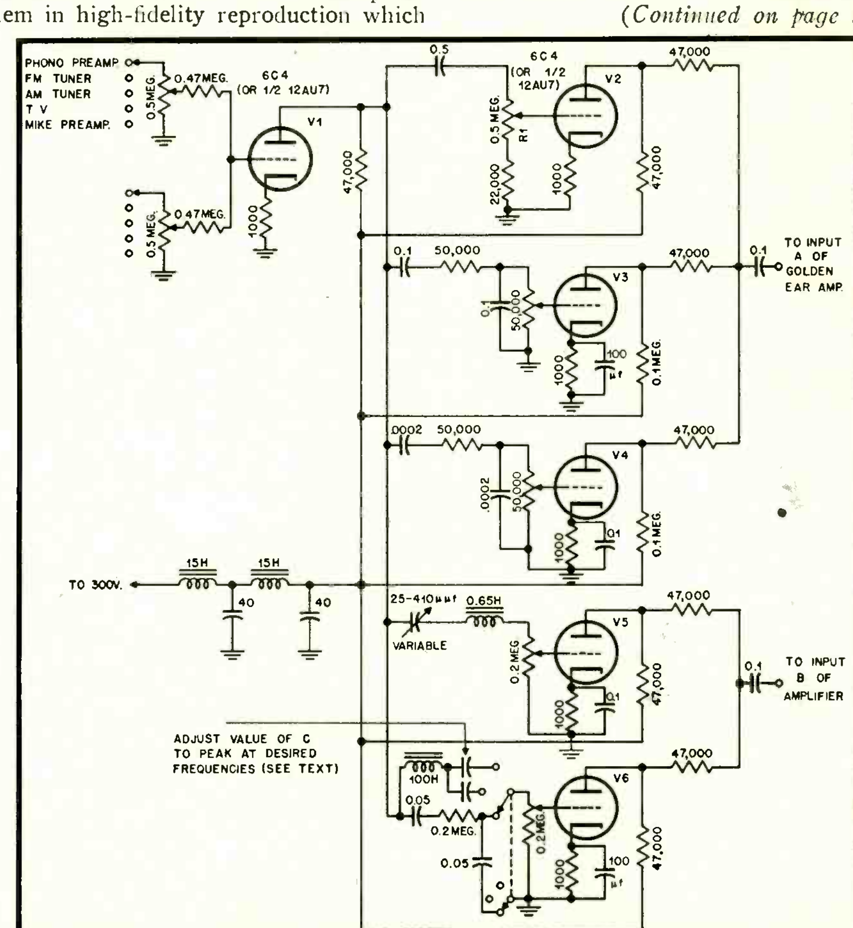



Fig. 6. Tone-control or mixer-equalizer section.

# Place Your Music Decoratively*

IRVING GREENE**

**Your music system can be a hodge-podge of knobs, switches, wires, and makeshift cabinetry — or it can be eye-catching as well as ear-filling. The author—long experienced in making installations in fine homes—offers suggestions which can be used in planning and housing your own equipment.**

DESPITE A WIDE and adequate selection of hi-fi components for music systems, there is still a dearth of suitable furniture in which to install such components. This was understandable in earlier years with massive and unwieldy components which required wide panels and deep shelves, plus the limited market for such furniture. Present design, however, considers the factors for installation into compact quarters and the necessity for decorative panels and controls. Yet the available selection of such furniture leaves much to be desired, especially with respect to styling.

One manufacturer of a popular line of hi-fi furniture makes Modern cabinets only, with the exception of one model which is Knotty Pine. Another firm widens its line by adding Traditional and Provincial. A third offers the same basic shell with a variation in hardware, legs, trim and finish to distinguish between Modern and Traditional. The quality of workmanship and material of these lines varies somewhat and the price paid for the product offered is well within reason but still the Music Lover complains—

" . . . it will not match my furniture."
" . . . it's too high . . . or too low"
" . . . quality is not good enough"
" . . . it will stand out like a sore thumb"
" . . . must it be so deep?"

So on and so on, the comments come forth. Regardless of what is offered, there is always some change wanted or needed to make the cabinet acceptable. To obtain a cabinet of finer wood and workmanship and more acceptable design other than what is available, many music lovers have turned to the custom furniture builder.

However results are often undesirable because of many factors in cabinet design which adversely affect the quality of music reproduction. Typical of the more common faults encountered are:

(*1*) To achieve a decorative touch the technically untutored cabinetmaker built a speaker compartment no better than the "torture chamber" provided by commercial radio-phono consoles. Or, if adequate volume *were* provided, the internal construction would often be poorly braced, flimsy in construction, improperly padded with acoustic material (or a poor type of material was used), made with a speaker cutout of improper diameter as well as a bass reflex port opening of incorrect dimension.

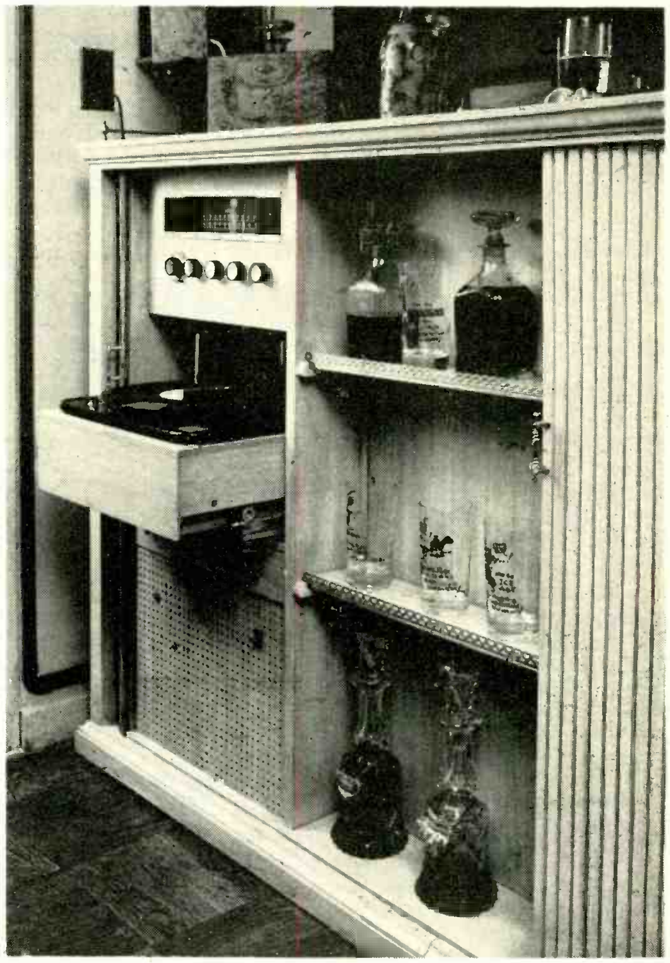


Fig. 1 (left). A regulation sized bar which houses a music system. Micarta topped to withstand liquids, this unit retains its graceful period lines to blend with existing decor. Note speaker grille in the center of the cabinet front. (Courtesy Asco Sound Corp.)

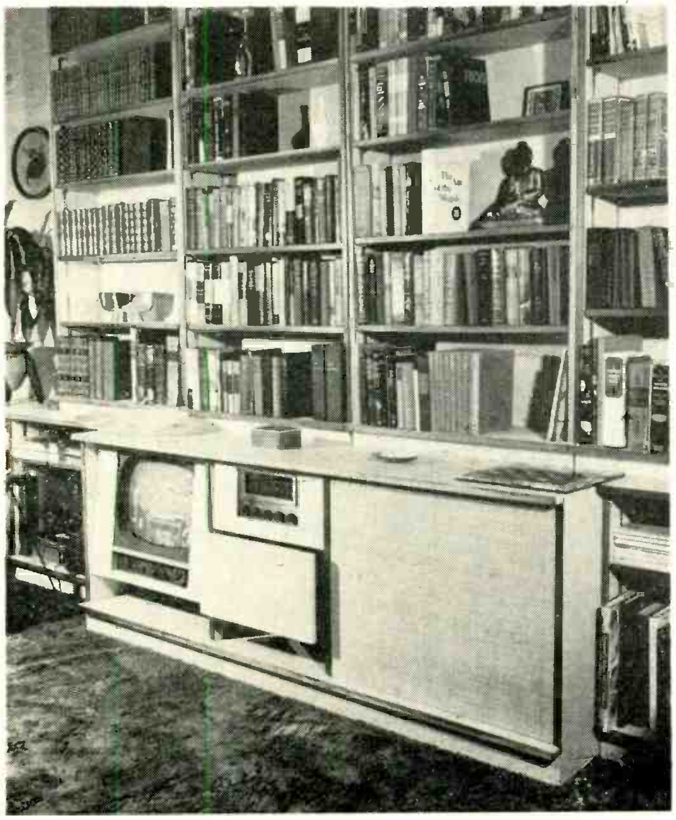
Fig. 2 (above). Rear view of bar showing tuner and record player in convenient reach of "bartender." Amplifier is located in a ventilated compartment below utility drawer. Tape recorder and storage is located at the right (out of picture), and all equipment is concealed by tambour doors when not in use. (Courtesy Asco Sound Corp.)

* Excerpted from *"The High Fidelity Handbook"* by Irving Greene and James R. Radcliffe, to be published by Crown Publishers, Inc. in the Fall of 1954. Copyright 1954 by Irving Greene and James R. Radcliffe.

** *17-49 166th Street, Whitestone 57, N. Y.*

Fig. 3 (below). Built-in wall unit. The TV set is at a comfortable height for viewing in a small room, and the remainder of the unit contains ample space for equipment as well as storage for books and records.

Fig. 4 (right). Expansive lowboy unit containing a well designed speaker enclosure. Effectiveness is augmented by the weight contributed by the books and the bookcase unit mounted atop the console. This type of unit can be expanded to fill a complete wall. (Courtesy Asco Sound Corp.)



(2) Used ¼-inch plywood for backing (in some cases no back was provided).
(3) Used a grille cloth too heavy in texture in order to match a set of drapes.
(4) Skimped on space for tuner and amplifier, often providing no ventilation facilities whatever.
(5) Sealed in tuner and amplifier units with no provision for service except to take the cabinet apart.
(6) Provided a shaky and inadequate base assembly for the phono unit using improper types of drawer slides.

These are not exaggerations, nor are these comments fabricated out of thin air. The craftsman may very well be an artist in his own right as a *cabinetmaker;* you can't expect him to be an expert in housing hi-fi components. This cabinetmaker is a very necessary adjunct to the hi-fi merchant if the music lover is to achieve his desire for good quality music reproduction and retain the decor and beauty of his home. He can make a proper cabinet but he requires counsel and assistance. This series of articles is intended to provide whatever information the cabinetmaker needs to build a cabinet that will afford adequate areas for all components from pickup to speaker.

#### OR—Build it Yourself

A great number of music lovers are probably confirmed amateur cabinetmakers in their own right and can do a job that would put a professional cabinetmaker to shame. With the proper "how-to" knowledge the task can be relatively simple. As will be seen in another part of this article, proper jointing, bracing, and finishing will result in a furniture piece that will match the music in "fidelity." A great saving in money can be effected by knowing how to buy wood—especially which types of wood are best for your purposes.

Planning can save you money, grief, dissatisfaction, and time. You may have a mental picture of a hi-fi cabinet in the form of an average radio-phono console. You may wonder how you can put such a rectangular box into your living room or den that will blend as effectively as the Regency Breakfront or the Italian Renaissance Marble-topped table. Stop right there, sit back and take a little inventory of space, especially the space that is right in the furniture itself. Maybe one of your valuable pieces can be altered to house a radio tuner, amplifier and record player. Your problem is then narrowed down to a commercial speaker enclosure which can be purchased or built to conform with existing furniture pieces. Possibly you have need for additional book shelves, this will be a good opportunity to kill two birds with the same dollar bill. Do you have long expansive windows that could stand a window seat below the sills? Again a dual purpose structure can be constructed which will effectively house a hi-fi system—speaker and all—and yet provide a plastic or leather upholstered seat for added conveniences. This unit can be painted to match the existing woodwork affording as inconspicuous a cabinet as can be obtained. Or perhaps you need a bar for entertaining and have put it off since last year? *Figure* 1 is a combination Bar-Music System with the speaker mounted so that it projects sound from the front of the bar. The rear of the speaker compartment supports removable shelves for keeping the ingredients normally required at a bar. *Figure* 2 shows the radio tuner and record player which is within easy reach of the "Bartender." Further to the right is a tape recorder and record and tape storage space. To conform with existing furniture, this cabinet was "antiqued" and finished in an ivory and gold lacquer over white South American mahogany. The bartop was made of Micarta to withstand liquor stains.

#### Bookshelves

Bookshelves are truly the "original built-in" for hi-fi music systems. They enrich the room with added charm and personality and offer many assets. If used cleverly, much storage space can be realized. A pull-down desk can be added if desired and the entire wall can be given new life with smart styling setting it off as the center of the room. The furniture of the room can then be arranged with the bookshelf-desk-storage unit-music system wall as the focal point. In *Fig.* 3 the wall unit houses a complete music system and library plus space to set a gracious piece of sculpture or other embellishment. What makes the bookshelf most desirable for a hi-fi system is the added weight the books provide to enhance the performance of the loudspeaker system. An ideal speaker enclosure should be void

# Hi-Fi Sets of Yesteryear

CHARLES N. FALLIER, JR.*

**Newcomers to "hi-fi" either don't know or tend to forget that high-quality sound was built into many radio sets in the prehistoric thirties. The author reminisces about some of the "classic" sets many of audio's Old Timers recall affectionately.**

A RECENT ARTICLE on high fidelity in a national picture magazine blithely stated that almost no one outside the engineering profession had heard of high fidelity before 1943. Perhaps the present writer should hesitate to admit that he is sufficiently fossilized to have picked up memories before that sacred date, but his brain recesses certainly yield a very strong memory of the term "high fidelity" as a familiar one back in the early thirties. The term was accompanied by quite a number of radio sets which really did give high-fidelity sound—in fact some of the AM sets then sounded better than some of the FM sets today!

The radio we had back then in the early days of the pre-War II era was a high-quality receiver built by Hammarlund. It had several stages of untuned r.f. amplification and one band-pass stage with a 4-gang tuning capacitor. The audio output stage was a pair of transformer-coupled 45's. With a few dollars worth of modernization it would at least equal the sound quality of any AM receiver on the market today!

The Hammarlund we had was not alone in its class. Some of the others are pictured on these pages. In the writer's opinion, audio amplifiers were often as good before the war as they are today, especially from a quality-of-construction standpoint. It is speakers that need improving, but they have advanced appreciably since the middle thirties.

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#### Typical Classics

The classic radios and amplifiers of the mid-thirties were marvels of engineering and workmanship that could never be duplicated today for economic reasons. Very likely, manufacturers figured then that anyone who could afford to buy a radio at all could afford a good one—so they made good ones, in small quantities. Today, with national wealth so high, the emphasis is on high production, low price, and a level of workmanship just sufficient to get by. One manufacturer, RCA, did try to sell a classic-type radio after the war, the Berkshire, but the model survived for only a few months.

*Figure* 1 is a photo of the components of the Masterpiece V, built in 1937 by the late McMurdo Silver, whose name will always be remembered by tens of thousands of high-fidelity and shortwave fans. The amplifier shown at left in the photo has been remodeled according to the Williamson circuit. The Masterpiece V had 20 tubes (including two rectifiers) and covered 140 kc to 70 mc in five bands. There were two preselectors on the first four bands, and three stages of variable-selectivity i.f., plus amplified and delayed a.v.c. Sensitivity was better than 2 microvolts with the built-in volume expander turned off and the audio power amplifier was rated at 34 watts! Note in *Fig.* 1 the special 18-inch Jensen speaker with a British-designed cone; performance was beyond 9,000 cps and special tweeters were available to extend it. *Figure* 2 is a view under the r.f. chassis illustrating the high-quality construction methods Silver used.

Fig. 1. The McMurdo Silver Masterpiece V, with remodeled audio-amplifier section.

How many old-timers remember the Scott Quaranta with its 40 functional tubes and its 100-watt class-A amplifier? Or the mastodonic Capehart with the 55-watt amplifier driving three Jensen speakers in a 5-foot-long cabinet? How about the pre-war Philharmonic by Avery Fisher and Victor Brociner?

*Figure* 3 is an underchassis photo of the tuner of an excellent high-fidelity receiver built in the middle thirties by Lincoln Walsh (now of Brook Electronics) for the now defunct American Transformer Company (remember Amertran?). WHK in Cleveland used one of these receivers to relay programs from an affiliated station in Columbus back in 1937.

Western Electric's famous 25B amplifier, built in 1924, was the first really good amplifier to be available commercially. *Figure* 4 shows it with the old spherical "bottles." Western Electric later (in 1928 or 1929) built a theatre amplifier using push-pull 211's as output tubes and also as rectifiers. A survey of the motion-picture theatres in almost any old-established community will probably reveal at least one theatre still using these antiques and enjoying their tone quality.

Western Electric was also, of course, the producer of the famous 10-A wideband tuner shown in *Fig.* 5 with newer tubes. Its vintage is about the same as the 211 amplifier. It uses a 6-gang tuning capacitor and has the original negative-mutual-coupling coil circuits. It is the AM tuner used today at New York's fabulous Waldorf Astoria Hotel! The Miller wideband tuner, first sold in 1937, is a simplified version of the WE 10-A and is still sold today.

The high-fidelity bug was already saturated with the blood of fans back in about 1938. So much was this true that Hammarlund took the Super-Pro receiver, enclosed it in a walnut console along with a 15-inch Jensen speaker in a bass-reflex arrangement, and after removing the crystal filter and some shortwave bands marketed the result as a high-fidelity receiver. And it was just that. The original Super-Pro had been used by many radio stations as a monitor because of its tone quality. Even in

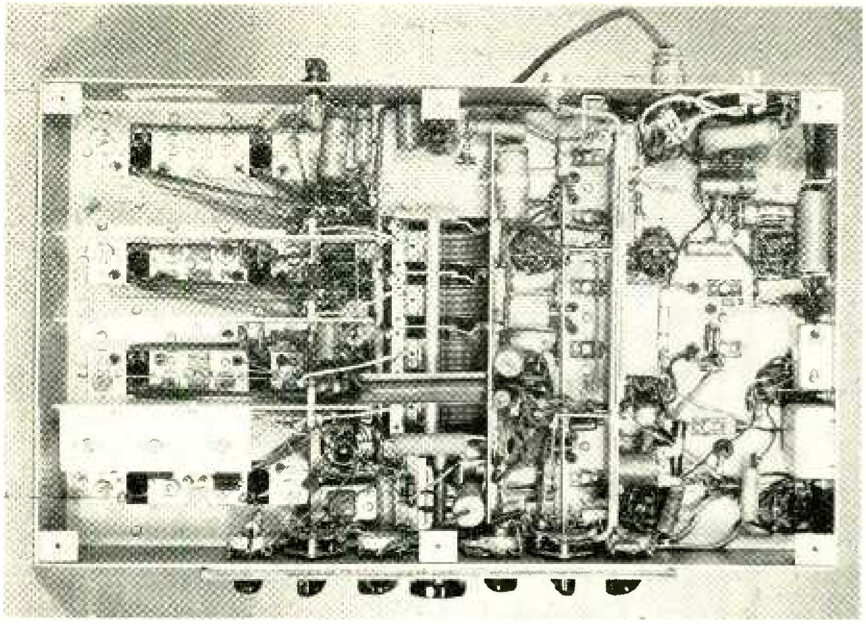

Fig. 2. Underchassis view of the Masterpiece V shows the high-quality construction.

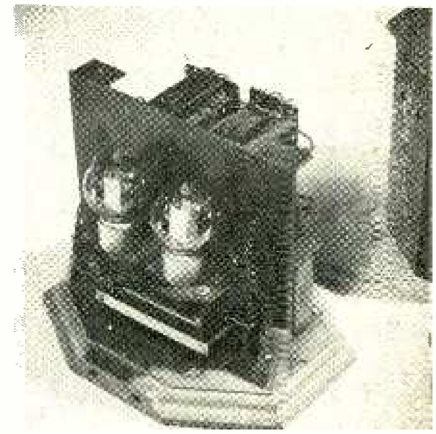

Fig. 4. This is the Western Electric 25B amplifier, built in 1924.

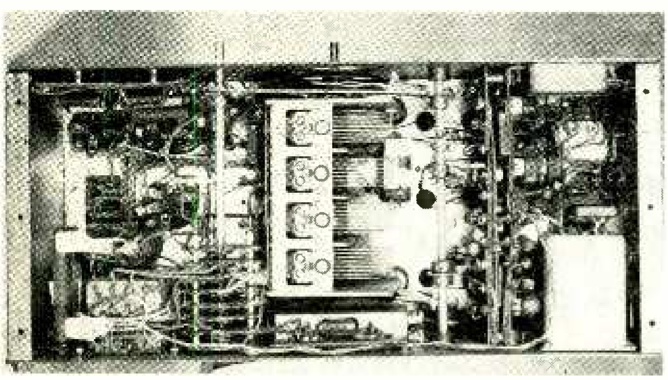

Fig. 3. Under the chassis of the Walsh high-fidelity AM tuner. The cams at the right of the tuning capacitor shift the positions of the i.f. transformer coils to vary selectivity.

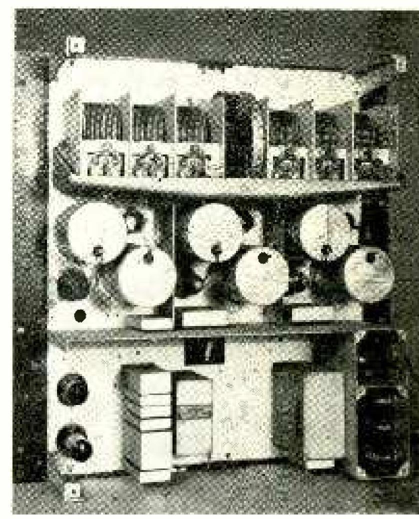

Fig. 5. The Western Electric 10-A tuner, equipped for newer tubes than those in existence in the late 20's when it was designed.

those days it passed a band 15 kc wide and had a 15-watt class-$AB_1$ power amplifier. This is what was primarily intended as a communication receiver.

Speakers then were not much below what can be obtained today. In addition to the Jensens we have mentioned so far, Cinaudagraph was building a speaker of the highest quality. *Figure* 6 shows a typical pre-war Cinaudagraph woofer—18 inches in diameter and with a 3½-inch voice coil. In 1939 Cinaudagraph built the 27-inch-diameter, 500-lb. cone-type speakers used at the New York World's Fair. The voice coil was 6-in. in diameter and the dust cover acted as the high-frequency diaphragm. Designed as woofers, they still were flat from about 30 to 10,000 cps in free air and handled 80 watts average level. They were used in 1200-cubic-foot enclosures and were accompanied by Western Electric tweeters. Bozak, who designed these speakers, still makes a very fine unit under his own name.

Components that fit in with high fidelity are not new either. For example, UTC has been building Linear Standard transformers for more years than the writer can remember. They haven't changed (except perhaps for fancier cases). Western Electric built the 350B tube, a heavy-duty 6L6, back in 1936 or earlier. The 350B will outperform any KT66 ever made.

#### Yesterday and Today

The purpose of this article is not to belittle today's high-fidelity equipment. Far from it! There is no doubt at all that the units available today—from pickup through to loudspeaker—are improvements over those about which we have been talking.

But the writer has two points to make. The first is that the present furor in the audio field is not taking place because we suddenly have designed equipment that is good. According to some authorities, whose word the writer respects, high fidelity is not necessarily extremely wide range, but is a reasonable facsimile of the original, which we had in pre-war years.

The second point is that, while today's facsimile is perhaps even more reasonable, an experiment with "A-B-C-D . . ." switching of ten good amplifiers, old and new, will show that it takes an excep-

(*Continued on page 68*)

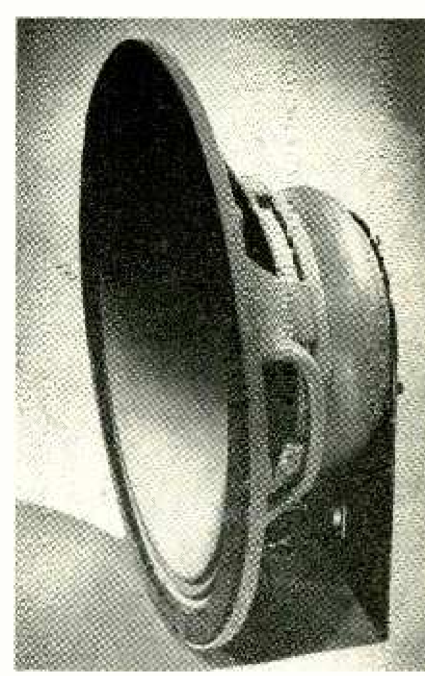

Fig. 6. A pre-war Cinaudagraph 18-inch woofer.

# A Medium-Power Tetrode Amplifier With Stabilized Screen Supply

CULLEN H. MACPHERSON*

**Regulation of the final-stage screen supply permits high negative feedback and excellent performance in an easy-to-build amplifier complete with preamplifier and tone-control stages.**

MANY OF THE MEMBERS of the audio fraternity view with alarm the increasing complexity of audio equipment. Although in most instances the addendum is accompanied by "higher fidelity," the price is sometimes higher yet. The need has been expressed for a fairly simple, self-contained audio amplifier of conservative design and acceptable performance which might be constructed for use in an apartment or small home. The subject of this article is such an amplifier.

Before beginning the design several features were fixed on as being desirable. (1) The amplifier should have inputs for both a tuner and a phonograph, with appropriate equalization for a reluctance-type pickup. (2) It should have a tone-control system furnishing both boost and attenuation of bass and treble. (3) Adequate power at low distortion should be available from the power output stage without requiring tubes of high dissipation capabilities or large power supplies. (4) The unit should be self contained and of small physical size.

A chassis 11½ × 6 × 2 inches with a 200-ma power transformer, output transformer, and 7 sockets mounted was available and design of the main amplifier was begun with this unit in mind. *Figure* 1 shows the result. The output stage was designed and constructed first, so that the tone compensation and preamplifier stages might be matched to it. Push-pull 6V6's were selected as power output tubes because of their relatively high efficiency and modest driver requirements. The 6V6's were fed from a cathodyne phase splitter which was coupled to a 6SJ7 voltage-amplifier stage. By using direct coupling between voltage amplifier and phase splitter the number of capacitors in the feed-back loop was reduced to one and the phase shift introduced by it was partially compensated for by the insertion of an R-C network between the grid of the phase splitter and ground.

It will be noted in *Fig.* 1 that the second triode of the 6SN7 is employed as a voltage regulator for the screens of the 6V6's. Deriving the screen potential from a source of low impedance such as this results in lower distortion, greater stability at peak power operation, and allows the use of more feedback around the output stage. The residual ripple present at the cathode of the voltage regulator is effectively filtered by the use of a 1-μf paper capacitor.

Since unbalance current flowing through the output transformer would cause loss of power handling capability at low frequency, steps were taken to balance the last stage. Pairs of 6V6's were selected with transconductance matched within 5 per cent. Their grids were then tied together and a 60-cps signal introduced to the grid circuit from the heater bus. Adjustment of the 150-ohm balancing potentiometer to the point producing minimum 60-cps output balances the stage dynamically.

*Figures* 3 and 4 show how the components were mounted on the existing chassis. This makes a compact and convenient arrangement, but other constructors will, of course, do as well with other arrangements.

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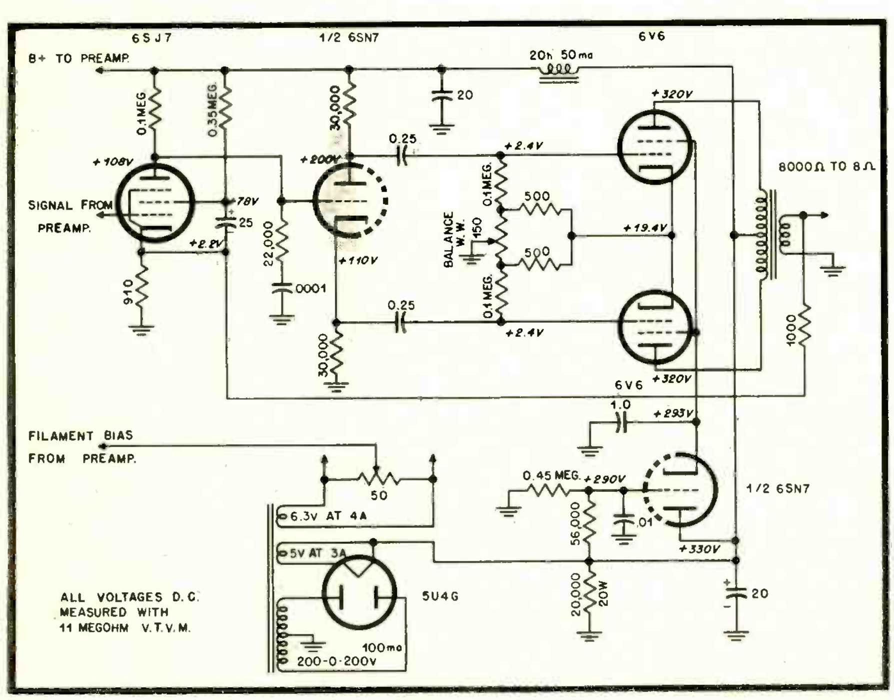



Fig. 1. The main amplifier. Half of a 6SN7-GT is used as a screen-voltage regulator. The 6SJ7 voltage amplifier and the phase splitter are direct-coupled.

### The Preamplifier

The method of bass and treble control employed in the preamplifier, *Fig.* 2, was selected because it required only two shielded leads from the amplifier proper to the treble, bass, and volume controls. Such a configuration allows simplicity of both electrical and physical arrangement. Placement of a variable resistance in the input circuit of a feedback amplifier is not the best design practice, but the only way to circumvent such a situation is either to add another stage or to place the control at an earlier point. No instability has been observed in the present arrangement, however, in a year of satisfactory operation.

The 6SN7 is arranged with triodes in cascade as a feedback pair. Use of feedback in this manner reduces tube noise, lowers the output impedance to the tone-control circuit and also effectively reduces stray signals from the tuner circuit when the latter is not in use. Injection of the tuner signal at pin 1 of the second triode furnishes isolation from both the tone control and the preamplifier.

The preamplifier is quite a simple affair by present standards and the only defense offered, if one is needed, is that it performs quite satisfactorily. The circuit is similar to that of Williamson in which bass equalization is accomplished by a grid-plate feedback loop, the turnover frequency being determined by the R-C product and the amount of feedback by the ratio between R and the grid stopper resistor. The turnover point is arbitrarily fixed at 300 cps which has been demonstrated in listening as a suitable compromise. The 6SJ7 has been found to be more quiet and less microphonic than triode pairs more conventionally used in preamplifiers. Undoubtedly the metal shell is responsible for some measure of hum reduction, and biasing the heater supply above cathode potential to prevent heater-cathode emission also contributes to reducing the output hum to the point of 83 db below 10 watts.

*Figure* 5 shows that the distortion level of the amplifier is acceptable by modern standards, and may even be said to compare favorably with the hallowed Williamson. Such performance is attributed to the action of the screen voltage regulator in holding the screen potential at a fixed percentage value below that of the plate. Undoubtedly, the large reserve of the power transformer, giving excellent voltage regulation to the power supply, is also an assisting factor. *Figure* 6 shows frequency response at 1 and 5 watts output.

In conjunction with a modified Gately Superhorn transducer the amplifier has quite smooth overload characteristics, and when deliberately overdriven to a level of 22 watts of sine wave output into a speaker load at 2000 cps, rounding, rather than clipping of the waveform was observed.

It is the writer's earnest desire to steer away from the sea of superlatives. At the present time the amplifier suits him; undoubtedly this will not always be the case. It is not to be heralded as the latest answer to the audio man's conquest of the 80-meter band. Nor is it necessarily "better than any triode amplifier." It does, however, have the appealing attributes of straightforwardness, adequate performance with respect to both power and frequency, and small physical size. It is felt that the circuit may well be appealing where budgets are modest and space limited.

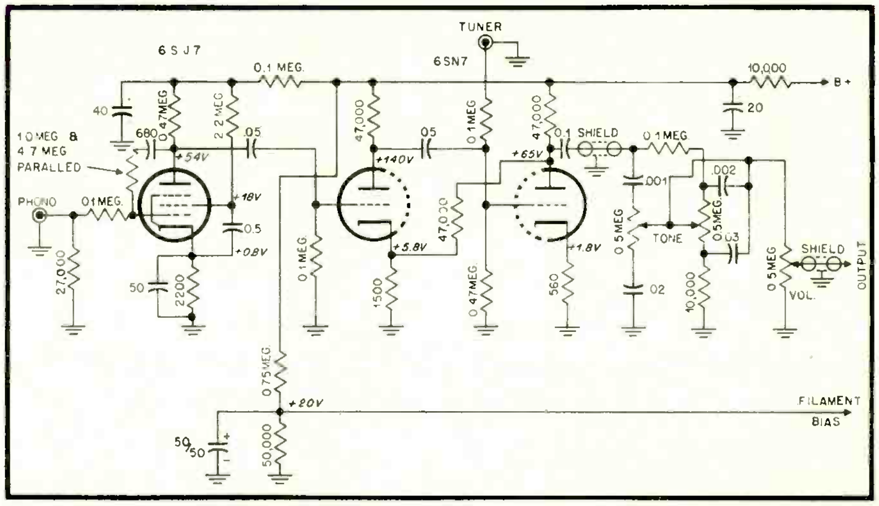
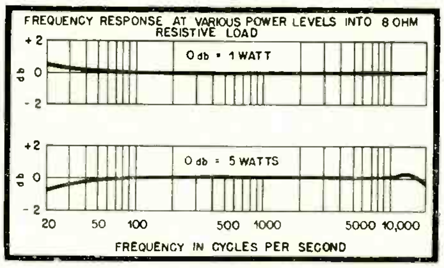



Fig. 2. The preamplifier provides for both magnetic phonograph pickup and tuner. The 6SJ7 is a phonograph preamplification stage with a simple feedback loop for bass equalization. The tone control is a single-shaft affair a center "flat" position and treble and bass boosts at the two ends of rotation.



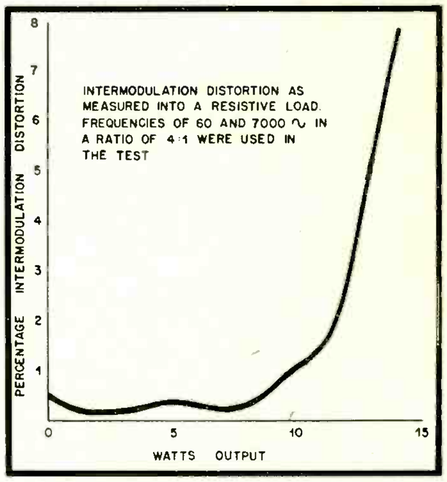
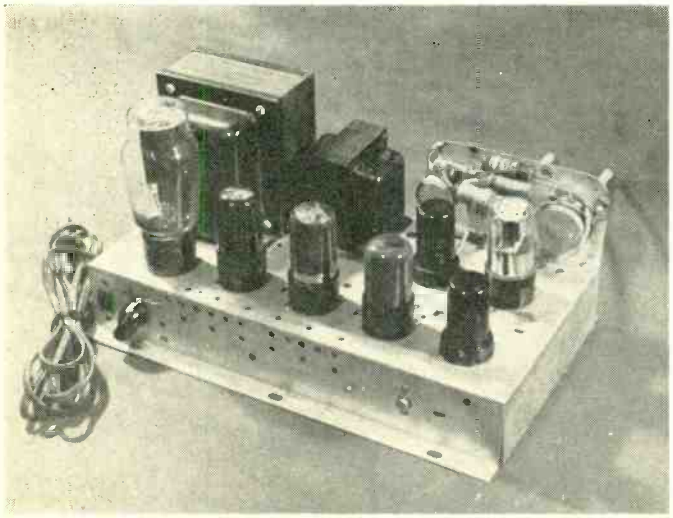




Fig. 5 (right). Distortion curve shows that intermodulation (60 and 7,000 cps, 4:1) just begins to rise above 1 per cent at 10 watts.

Fig. 6 (above). Frequency response curve made with an 8-ohm resistive load at 1- and 5-watt power levels.



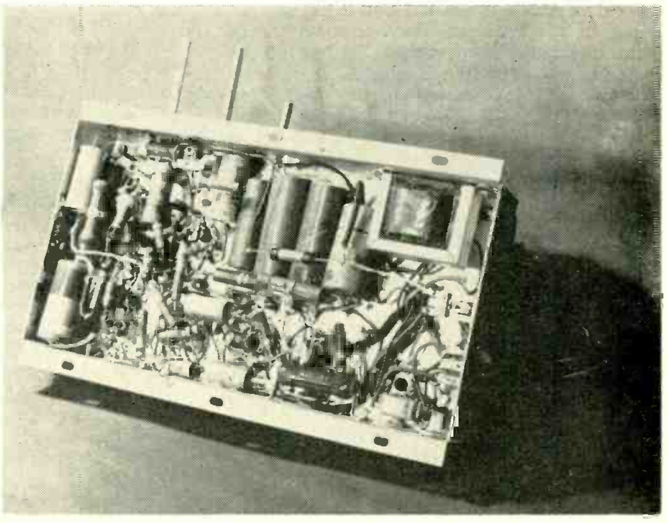


Fig. 3 (left). The entire amplifier, including preamplifier, is on a single chassis with the power supply.
Fig. 4 (right). The underside view shows that the space is well utilized.

# Conductors and Record Buyers

**Recommendations that the buyer listen before he leaps into buying recordings purely because of name conductors.**

RUDO S. GLOBUS

SEVERAL YEARS AGO, after a particularly exciting Toscanini recording session, a group of first chair men got together at ye local brewhouse, disappointed, surprised, puzzled. A sizzling performance had recorded flat, dry and distantly removed from what had actually gone on in the studio. That place where the winds had come in like whiz kids—it just wasn't there. The Maestro had seemed pleased with the tutti passage in the third movement—but it didn't quite come off in the playback.

The innocent fellows hadn't had enough experience with recording sessions. At this writing, older and wiser, the same men accept the inevitable. A hack conductor who can hardly read a score becomes a world recording celebrity. The same recorded performances heard live are just so much junk. But on records, they come alive. No wonder musicians refuse to base any judgements on what comes off grooved Vinylite. When a tenth-rate flutist suddenly learns how to phrase, loses his nanny-goat vibrato, and is compared by the learned critics to Pan himself, something must be wrong!

And something is wrong. Let's take a look at the general picture. When compared to the live performance, what does the average orchestral recording have to offer? Is the orchestral balance the same—is it natural? Is the broad dynamic picture as determined by the conductor there? Are the carefully and subtly articulated phrases reproduced authentically? Are all the selections given their true values? In the great—the overwhelming number of cases the answer is an emphatic NO!

If we ignore for a moment the eccentricities of the home reproduction system, the natural next question is—why? Considering the excellence of modern equipment, why shouldn't every recorded performance be precisely that—an accurate, faithful record of a specific performance. The musicians generally point their fingers at the bunch in the control room—fiddling around with the gain, after having set up one mike here, one mike there and then balancing everything in some screwy way. The engineers have their own scapegroats. And as far as everybody is concerned, the A & R man (artists and repertoire) is too smug for his own good—and what does he know anyway?

### The Conductor's Role

But this is only one part of the story. The conductor himself comes in for a fair share of the blame. In the great record sweepstakes of our time, there are four general types of conductor. First, we have the consummate musician who refuses to be concerned with the mysterious world of engineering. All he knows is that after rehearsals and after all the false starts, he finally comes up with a performance that is satisfactory. If the recording doesn't reproduce this adequately, he has two choices. If he is a big enough and important enough, he can and will refuse to allow these sides to be released. Finally, if he becomes tired enough, resigned enough, or convinced that this isn't his province anyhow, he gives up and lets the recording go through. One thing is absolutely certain, if the recording missed everything else, at least the tempi were accurate! If the purchaser is knowledgeable and not the hysterical, hero-worshipping "the-great-man-can-do-no-wrong" type of listener—and providing he has heard enough live performances, he will be aware of the deficiencies.

At the opposite extreme, we have the experimentalist. This is the conductor whose major concern is with sound texture. He wants every last blessed instrument picked up and knows just enough about recording techniques (namely that microphones pick up sound) that he breaks the orchestra up into units, giving each a separate mike and rejecting all takes that don't achieve the ultimate. He makes remarkable test records—but these have no relation to what is in the score, what is naturally expected in the way of balance from an orchestra and what was remotely expected by the composer when he created his orchestrations.

Our third case is perhaps the worst of the lot. He is grateful for a recording opportunity, and can't quite believe his eyes when he finds himself in a studio. He and his clinker-fed orchestra are the willing and fortunate victims of the company that can't get anybody else, either because of financial reasons or because everybody else is under contract. He behaves like a meek little lamb, putting himself at the mercy of his new benefactors. And lucky fellow—his benefactors take good care of him. What remarkable things you can do with tape and a control panel! Before too long has passed, he's become a full-fledged celebrity. Sure they tore him to pieces in the concert hall. But on records he and his sputtering meteors have just produced the finest performance in the catalogue. And even if the story doesn't turn out as well as this, what difference? He wouldn't dare complain when *forte* passages come out *fortissimo* and when *pianissimo* passages come out *forte*. His name is on a label and he's making money.

There is one select breed of craftsmen—a small number indeed—who regard a record session with the same critical ear as as they do a legitimate performance. They plan it carefully, taking pains to understand the mystique of audio engineering, and strive at accuracy. Working with sympathetic engineers and music directors, they are responsible for the tiny handful of recordings that come close to an actual live performance. They are the only conductors who really appear on a recording—a recording on the basis of which it is fair to approach performance, conductor, and orchestra critically.

There is another factor which is particularly true of present day recording techniques. How on earth anybody can adequately review a taped recording is beyond me. When some of our more dogmatic critics exultantly hail maestro X's latest job—a basket of splices deliciously pieced together—cock your eyes in their direction . . . and boo heartily. "The great man has done it again." Oh yeah? A pair of scissors, a good ear, and some torrents of sweat made that performance. It took so many sessions to get the thing right. Listen to the same genius take the whole work straight through. It will never come out the same.

### Art or Artifice

So let's face the facts. Modern recording—despite the enormous improvement in quality—is still an artifice for the most part. And this dictates some basic rules of record buying and record reviewing. Before we get into the records themselves, one important suggestion—which applies as much to setting up your own rig as much as it does to the discs themselves. Listen to music in the nude. That sounds like a simple, shrug-your-head type recommendation. It isn't so simple. Adjust your ear to the live thing. Get accustomed to normal, natural orchestral balance. Hear live orchestral dynamics the way they're meant to be heard. If you're not interested in music to begin with, of course don't bother. But if your end product is musical experience, the aforementioned is going to save you untold misery (unless you've got a tin ear). Listen to the live stuff often, repeatedly. A lot of the so-called neuroticism involved in equipment purchasing today stems from the fact that the prospective buyer doesn't know what he's listening for to begin with.

Now, presumably, you're ready for the record buying rules—which run something like this:

1. Ignore the name of the conductor and the orchestra on a label. More often than not, they will prejudice your judgement. With the enormous amount of duplication that exists today, you've got plenty of choice in terms of your basic library. Listen to all the performances, and listen to them on decent equipment. If your record dealer doesn't have an adequate rig, give him a hard time until he gets one. And if that doesn't work, see if he'll let you try the records out at home. And if that doesn't work, check your friends. If you're still out of luck, see what Canby has to say (a good idea in any case).

2. Beware the flash recording. You will undoubtedly forget the music and become hypnotized by the crystalline triangle and the gargantuan tympani. Your ear training should have precluded this possibility by now, but you can never tell. Test records have an unmistakable appeal, especially if you're inclined to be a show-off.

3. Because you have never heard of the label, the orchestra or the conductor doesn't mean that you're supposed to shy away. This sounds like a repeat of rule number one, but it really isn't. Remember that you're particularly concerned with obtaining the most adequate recording of the Brahms' first. It doesn't matter who was responsible. The fact that a given conductor made a good Brahms No. 1 doesn't prove he can do it with 2, 3 and 4.

4. Because a given recording is not the most superb technical job ever doesn't necessarily mean that it isn't for you. While it may not glisten, it may nevertheless be the best *musical* performance available with respect to performance and approximation of realistic orchestral balance and sound.

# Handbook of Sound Reproduction

EDGAR M. VILLCHUR*

## Chapter 16. Pickups and Tone Arms.

An ideal phonograph pickup traces the record groove in such a way that the instantaneous vibratory velocity of its moving system is exactly proportional to the undulations of the groove; the electro-mechanical generating system of the pickup then converts the mechanical vibrations into an output signal voltage proportional (except in the case of the effectively pre-compensated piezo-electric units) to this velocity. Neither of the above listed functions can be performed in a perfect manner, but it is possible to come fairly close to the ideal.

We will use a similar type of analysis for the pickup as we did for the loudspeaker, first considering the mechanical system, which is as important here as it was with the speaker, and then taking up the electrical system.

### Forces Acting on the Stylus

The stylus tip makes contact with the groove at the sidewalls, as illustrated in *Fig.* 16—1. When the modulated groove is dragged past the stylus various forces come into play. A massless, infinitely compliant moving system could take the twists and turns of the groove modulations without difficulty, but we are obviously not dealing with such a theoretical system. Momentum, restoring force, and resonances must be contended with, and as a result there exist horizontal forces, over and above those applied directly by the guiding walls of the groove, which act on the stylus with varying degree and sense at different times. Further horizontal forces are created by side thrust, which will be discussed in detail later, and by off-center records.

All of these horizontal forces push the stylus against the inclined wall of the groove and are directed upward. There are also other upward forces acting on the stylus, created by pinch effect, warped records, or random shocks. A tendency therefore exists for the stylus to climb up one side of the groove (from which position it cannot trace the modulations accurately, and will produce rattling and buzzing) or to actually jump out of the groove.

The tendency of the stylus to ride up or jump the groove walls is counteracted by the *vertical stylus force,* also called *tracking force,* applied by the tone arm. This force may be applied simply by the pivoted weight of the arm and cartridge,

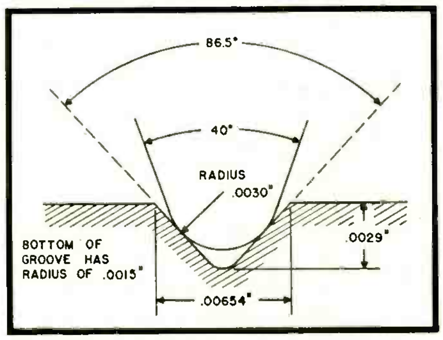



**Fig. 16—1. Typical standard record groove and stylus tip.** (After F. Langford Smith)

or by a weight counterbalanced on the far side of the tone-arm pivot, or by a combination of weight and restraining spring. It must be great enough to keep the stylus tip in firm contact with both groove walls at all times, but if it is much greater than the minimum value required record and stylus wear are increased. The correct stylus force for a particular pickup is a function of the mechanical impedance of the pickup's moving system. Older pickups with heavy moving elements and stiff suspensions necessarily used large vertical force, while modern pickups remain in proper contact with the groove at relatively light vertical force. Typical values of required stylus force in current high-quality pickups are 6 to 8 grams (0.21 to 0.29 ounces) for microgroove cartridges, and 12 to 15 grams (0.43 to 0.54 ounces) for 78 r.p.m. cartridges. The lower stylus force for the microgroove cartridges is applied over a much smaller area, so that the final force per unit area is somewhat greater for the microgroove stylus, and the apparent advantage from the point of view of record wear is not realized. Cartridges have appeared, however, which will trace both types of record at the lower figure, and a capacitive pickup is made which will trace both types of record at one gram. In all cases the manufacturer's recommendations should be followed. Reducing the stylus force below the value for which the cartridge is designed will degrade rather than improve performance. Increasing the stylus force above this value will hasten record and stylus wear, although in some cases an improperly designed arm may require a somewhat increased stylus force.

Methods of determining the tracking capabilities of a pickup[1] by intermodulation distortion measurements have been outlined, and will be described in a later chapter. A simple test, devised by McProud, is to place a 45 r.p.m. (large center hole) record on a turntable with standard spindle, in such a way that the spindle is on contact with the inside edge of the record at one point, and to play the record at 45 r.p.m. The extreme eccentricity of the record groove in relation to the turntable center subjects the stylus to large horizontal forces, which must not throw it out of the groove if the pickup is to pass the test.

Since the result of inadequate vertical stylus force is severe distortion at high-level passages, it is better to err in the direction of too much force, and to accept a little extra record and stylus wear.

Vertical stylus force is also referred to as *stylus pressure* or *tracking pressure.* This usage is recognized but discouraged by the American Standards Association, since units of pressure are in terms of force per unit area.

A further force is exerted on the stylus tip by the groove, in a direction in line with the pickup vibration axis. This is called *needle drag,* and results in a distorted tracing of the groove modulations if the pickup moving system is not longitudinally rigid.

### Tracking Error

The ability of a pickup and tone arm to maintain positive stylus-groove contact under various conditions is usually referred to as *tracking capability* (although *tracing capability* would probably be a better term). Unfortunately the term *tracking* is used in two different and independent ways in relation to pickups. As used above, the meaning is a literal one, related to the fact that the center of the needle is meant to follow the track of the groove, and the term is synonymous with "tracing." The second meaning refers to the ideally tangential relationship between the vibration axis of the pickup and the center line of the unmodulated groove. In this sense the term is used abstractly, and refers to the maintenance of a constant relationship between two variables, the angle of the pickup vibration axis and of the groove tangent at the point of stylus contact. In the latter application the word has

* *Contributing Editor,* Audio Engineering.

[1] H. E. Roys, "Determining the tracking capabilities of a pickup," Audio Engineering, May, 1950, p. 11.

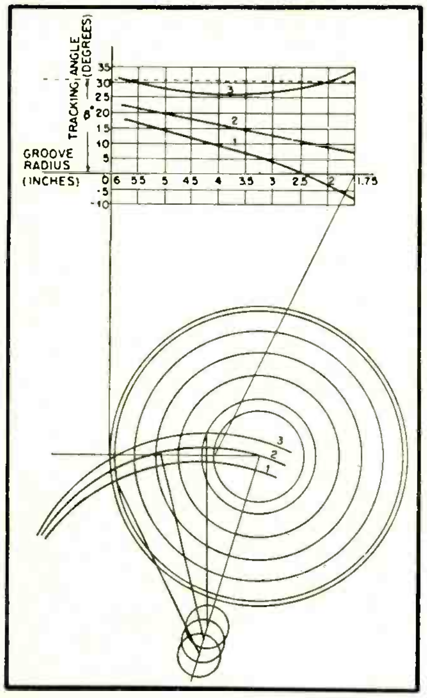


**Fig. 16—2. Tracking angle variation of the same arm at different pivot mountings.** (Values from Glover.)

the same meaning as when it is used to describe the behavior of one section of a variable capacitor, which "tracks" or keeps a constant capacitance relationship to another section with which it is ganged.

The angle between the tangent to the unmodulated groove center line and the vibration axis of the pickup (assuming the pickup to be in a horizontal plane parallel to the record) is called the *tracking angle,* and since it is rarely zero it is also called the *tracking error.* The problem of keeping a phonograph pickup tangent to the record grooves at different radii has been with us ever since phonograph manufacturers abandoned the cylinder player, in which the pivot of the overhead pickup was driven across the record by a feed screw.

The detailed discussion of tracking error that is to be part of this Handbook has already appeared in *Audio Engineering,* in an article by the writer[2] published in March, 1952. The conclusions of that article will be summarized here in order not to break the continuity of the series.

1. The main result of tracking error in modern equipment is that the vibration axis of the pickup is turned from the groove, generating harmonic distortion. This distortion is predominantly second harmonic, and may be expected to be of the order of 5 per cent on loud passages with a properly mounted, straight 8-inch arm. A correctly designed and correctly mounted offset arm of the same length will exhibit a tracking error and distortion reduced by a factor of six.

2. The use of a properly mounted offset arm does not reduce, but increases side thrust, the resultant force between fractional pull of the record groove in a direction tangent to the groove, and the restraining force of the tone arm in a direction determined by the imaginary line between the stylus point and the arm pivot. The increase of side thrust is due to the change of mounting position for the arm pivot.

3. A popular misconception about the offset arm is the belief that it is the bend in the arm which produces the reduction in tracking angle variation, due to a "virtual pivot" or other fancied cause. The variation in groove-pickup angle for any arm of given length, mounted at a specified point, must be the same whether the arm is straight, bent, or shaped like one of the snakes of an ancient Egyptian head-dress. This becomes clear if we think of a bent arm forming a rigid triangle with the line from pivot to needle. The angle between the hypotenuse of this triangle and grooves of different radii, representing the tracking angle of a straight arm, must vary exactly the same amount as the angle between the grooves and the offset pickup.

4. Reduction of tracking error in an offset arm results from the shift in pivot mounting which the offset allows us to make. It is possible to choose a mounting point for a given arm such that the arc swept across the record intersects the grooves with minimum variation of angle. This is illustrated in *Fig.* 16—2, which shows the arcs produced by the same arm from different pivots. Considering only the variation in angle at which the arc encounters each groove it will be seen that arc number 3 has the best tracking. The graph of tracking angle *vs.* radius indicates that arcs numbers 1 and 2 decrease their angles of intersection with each groove as they approach the center, while arc 3, representing a position of the pivot which *overhangs* the needle past the turntable spindle, decreases its intersecting angle only up to a minimum point, and then increases the angle again as further progress toward the center is made.

It would not be feasible to mount a straight arm to sweep arc 3, because although the variation in angle is small the actual angle at which the pickup would be held is far from the tangent.

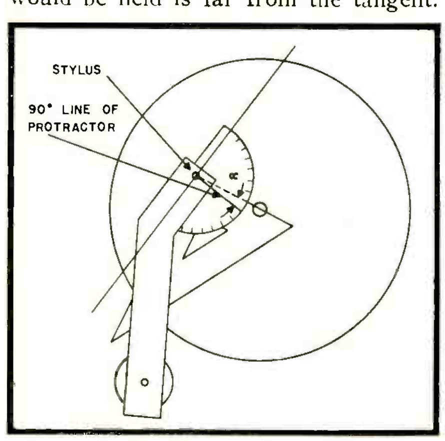


**Fig. 16—3. Method of measuring tracking error with triangle and protractor. The spindle is removed and the triangle placed over the center of the spindle hole.**

A positional bias is therefore applied to the pickup element by offsetting it $\beta$ deg. We have already seen that the variation in intersecting angle is independent of arm shape, and so we do not lose the advantage of minimum variation by this offset, while we do gain correction for the absolute value about which the tracking angle varies.

Zero tracking error may be achieved at two points, at the groove for which the offset makes a perfect correction, and at its mate on the other side of minimum. The points of zero tracking error, determined by the angle of offset, and the groove radius at which the minimum intersection angle occurs, determined by the pivot mounting, are adjusted for optimum performance. These adjustments are concerned with keeping $\alpha/r$ rather than $\alpha$ alone as small as possible, since the same tracking error creates greater distortion at the inner grooves.

The key to minimum tracking angle variation, for an arm of given length and offset, is thus the mounting of the pivot. This is specified by the overhang, or distance between the needle and the turntable spindle as the arm is swept past the spindle. Mounting data for offset arms of different lengths is given in Table 16—1. A straight arm requires that the needle be underhung, as may be inferred from *Fig.* 16—2.

**TABLE 16—1**

| Length of tone arm (pivot to needle tip) | Optimum offset angle, degrees | Optimum overhang in inches, with offset of column 2 |
|---|---|---|
| 6.5 | 28 | .64 |
| 7 | 26 | .60 |
| 7.5 | 24 | .56 |
| 8 | 22 | .52 |
| 9 | 20 | .47 |

It is of importance to note that the position of the stylus tip in relation to the pivot of a given tone arm may vary significantly with different cartridges and needle assemblies. The designer of a particular record changer may have determined the mounting position of the tone arm on the basis of a crystal pickup whose stylus tip is in a very advanced position relative to the cartridge. In such a case the overhang of styli in magnetic pickups may become woefully inadequate, and the offset of the tone arm will serve only to increase the tracking error beyond what it would be with a straight arm. The writer has found such inadequate overhang in record changers to be not uncommon.

Until such time as a standardized position for the stylus tip relative to the tone arm is generally accepted by manufacturers, the user of a record changer would do well to check the overhang of his stylus. One make of pickup cartridge is supplied with a mounting arrangement whereby the cartridge can be moved forward or backward in the arm, but even here the writer has found that some changer tone arms do not allow room for the cartridge to slide forward far enough. The front section of the tone arm head may have to be cut away, and

[2] E. M. Villchur, "Pickup tracking error," Audio Engineering, March, 1950, p. 17.

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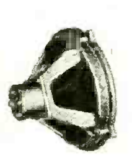

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the cartridge made to protrude beyond the end of the arm.

The direct measurement of tracking error within a degree or so is not difficult and can be performed with a triangle and protractor. (The protractor must have the usual small hole at the center of its horizontal line, which serves to lock the stylus in proper position for the measurement.) The method is illustrated in *Fig.* 16—3. For a record changer the maximum tracking error should be kept below 5 deg. at the outer grooves, and below 2 deg. at the inner grooves. For a professional tone arm the standards are more stringent. In some cases it may be necessay to make something of a sacrifice in the tracking error of short arms, in order to decrease an unacceptably great side thrust, by decreasing the angle of offset and the amount of overhang.

**Mechanical Vibratory System of the Pickup**

Although pickups vary in type, the simplified mechanical diagram and equivalent electrical circuit of *Fig.* 16—4 may be used to represent the basic mechanical system of many modern units. In the case of the piezoelectric group, $C_{ss}$ becomes a more complex circuit containing inductance as well as capacitance.

The circuit and mechanical system of *Fig.* 16—4 exhibit three major resonances, as shown in *Fig.* 16—5; one in the bass (preferably in the sub-sonic region) one in the low treble, and one in the upper frequencies. The elements involved in these resonances are not too obvious, and will be discussed in some detail.

The first resonance, $F_1$, is usually called tone-arm resonance, and is sometimes considered to be related to flexing of the arm. Such flexure is not, however, the cause of the primary bass resonance of the system, and we have assumed the tone arm in this case to be essentially rigid. The mass-elasticity system involved is the whole mass of the tone arm and cartridge (less the moving elements), and the compliance of the stylus

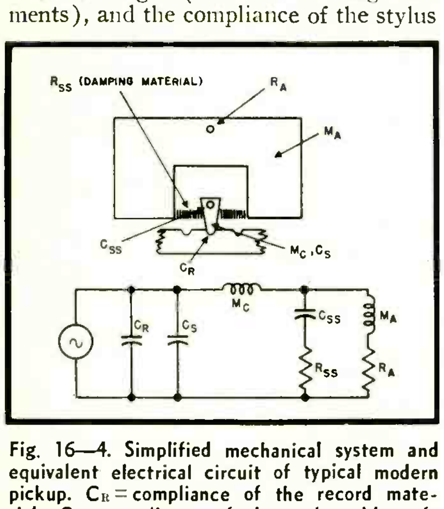


Fig. 16—4. Simplified mechanical system and equivalent electrical circuit of typical modern pickup. $C_R$ = compliance of the record material; $C_S$ = compliance of the stylus; $M_C$ = effective mass of moving element of the cartridge; $C_{SS}$ = compliance of stylus suspension; $R_{SS}$ = resistance of stylus suspension; $M_A$ = effective mass of tone arm and cartridge; $R_A$ = resistance at tone arm pivot (used in special pickups only)

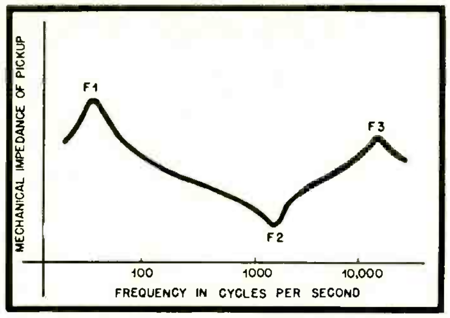


Fig. 16—5. Mechanical impedance of pickup system of Fig. 16—4, showing three major resonances. An additional peak due to torsional resonance in the tone arm may appear above $F_1$.

suspension, with force applied via the sylus to the compliant suspension. The tone arm mass either follows the stylus motion, or moves in the opposite direction from the stylus, or remains still, depending on the frequency of the stimulus in relation to resonance.

The analogy to certain mechanical systems, used previously on several occasions and consisting of a weight suspended from one's hand on a long rubber band, serves us well here. The rubber band represents the stylus suspension; the weight, the tone arm. If we apply a force to the rubber band at a very low frequency, the weight will move up and down in unison with our hand, and there will be no relative motion between the weight and the hand. This is analogous to the situation where the stylus is tracing a groove in which the recorded frequency is substantially below the $F_1$ resonance. The entire tone arm moves with the stylus, and since there is no relative velocity between the moving and stationary elements of the pickup there is no voltage output.

At resonance the suspended weight moves with maximum excursion and out of the phase (approximately 90 deg.) with motion of the applied force. The same thing happens in the pickup. The stylus is forced in one direction by the record groove, while the arm and cartridge move out of phase, and the relative velocity between moving and stationary elements in the cartridge is increased beyond what it should be to represent accurately the groove modulation. There is thus a signal voltage peak at resonance, and an increased tendency for the stylus to lose perfect contact with the groove.

Above resonance the system becomes "compliance-controlled"; the weight on the rubber band and the tone arm act increasingly as though they were immovable. The velocity of the stylus excursions relative to the record become the same as the excursion velocity relative to the cartridge, which is the condition that we want.

The circuit of the electrical analogy exhibits the same sort of behavior. It should be noted that the generator in this case is a constant-current generator, whose voltage rather than current output is changed by a variation of load. This represents the fact that with proper groove tracing the stylus modulation velocity relative to the record is always correct (not counting tracing distortion inherent in the recording system—see Chapter 9), and the result of a change in the mechanical impedance of the pickup moving system is merely to call for more force; the actual velocity of the stylus relative to the record cannot be influenced so long as there is proper contact.

We may withdraw the circuit for $F_1$, as in (A) of *Fig.* 16—6, ignoring those elements that are not significant at the bass frequencies involved, and we find that we have a parallel resonant arrangement, with maximum impedance at the resonant frequency (maximum force has to be exerted on the stylus to make it follow the groove, since the whole tone arm must be swung out of phase) and maximum loop current at resonance (the moving element has maximum velocity relative to the cartridge and arm).

Since we cannot abolish tone arm resonance we live with it by rendering it innocuous, keeping the resonant frequency below the useful audible range. This calls for a highly compliant stylus suspension, or a heavy tone arm. It should be noted that counterweights located behind the tone-arm pivot simultaneously reduce the vertical tracking force on the stylus and add inertial mass to the tone-arm mass-elasticity system, the last effect lowering the resonant frequency. When the resonant frequency is low enough the only lateral tone-arm motion is the slow sweep across the record, and response to random stimuli.

One method of further reducing the effects of tone arm resonance is to apply damping fluid at the tone-arm pivot.[3]

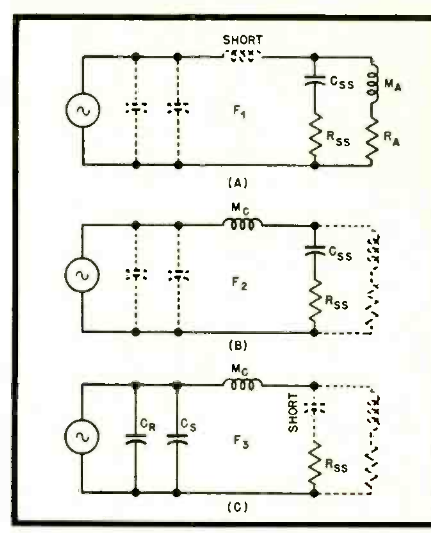


Fig. 16—6. Equivalent circuits of the pickup mechanical system of Fig. 16—4, with significant elements at the three major resonances shown in solid line.
(A) at the $F_1$ resonance between the effective mass of the tone arm and cartridge and the compliance of the stylus suspension.
(B) at the $F_2$ resonance between the effective mass of the moving elements of the pickup and the compliance of the stylus suspension.
(C) at the $F_3$ resonance between the effective mass of the moving elements of the pickup and the compliance of the stylus and of the record material.

[3] William S. Bachman, "The application of damping to phonograph reproducer arms," *Proc. I. R. E.*, Feb., 1952, p. 133.

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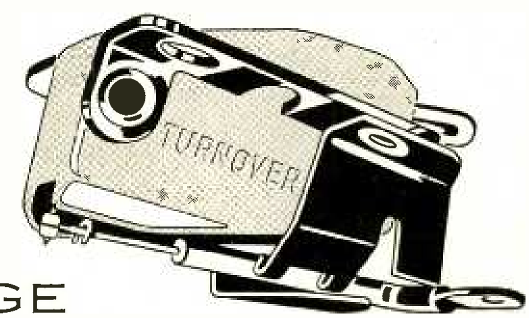


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The typical frequency response—with no equalization—is flat within ± 3 db from 30 to 15,000 cycles on the new RCA 12-5-51V test record. Similar flat outputs are obtained from records cut to LP, NAB, AES, and other modern characteristics.

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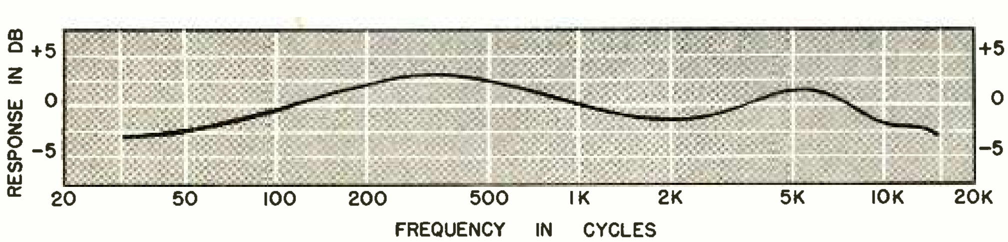


TITONE TURNOVER RESPONSE ON RCA 12-5-51V RECORD

**TITONE TURNOVER**
*List Prices*

| | | |
|---|---|---|
| 9980-S | (Dual-sapphire) | $9.50 |
| 9980-SD | (.001 Diamond) (.003 Sapphire) | 34.00 |
| 9980-D | (Dual Diamond) | 56.00 |

*Electronic Applications Division*

## SONOTONE CORPORATION

*Elmsford, New York*

Although the idea of purposely applying friction at the pivot seems contrary to all ideas that used to be generally accepted about tone arms, the fact is that a moderate amount of mechanical resistance at this point does no harm. The mechanical system is damped so that the resonant peak is reduced or eliminated, and the response to stimuli tending to unseat the stylus, such as forces created by warped and off-center records or by random shocks, is likewise reduced. In addition the frictional force resisting motion of the tone arm across the record finds itself in opposition to, and tends to counterbalance, side thrust.

The mechanical resistance introduced at the tone-arm pivot in damped tone arms is quite different from the random friction that would be found in cheap pivots. The latter friction is erratic, nonlinear, and varies with the velocity of the moving parts, while viscous damping introduces a mechanical resistance whose value is independent of velocity, as the value of its electrical analogy, resistance is independent of current flow. *Figure* 16—7 illustrates a ball-and-socket type of tone arm pivot in which the tone arm ball subjects a viscous fluid (a silicone oil), to shear forces.

We have assumed the tone arm to be rigid and free of break-up and torsional resonances, for the purpose of simplification. While such a condition cannot be achieved in absolute terms, a high-quality tone arm is essentially free of such resonances.

The second resonance illustrated in the graph of *Fig.* 16—5, $F_2$, is created by the mass-elasticity reaction between the stylus suspension and the mass of the stylus and armature assembly, that is, the moving mass of the pickup. This is strictly a cartridge resonance, and does not involve the tone arm; at the treble frequencies involved the tone arm acts like the rock of Gibraltar and is substantially motionless relative to the unmodulated center line of the record groove.

The mechanical impedance at $F_2$ has a minimum rather than a peak value; we have seen previously that where vibratory force is applied to the mass element of a mechanical mass-elasticity system the impedance is minimum at resonance. Since the mechanical impedance of the moving system of the cartridge is minimum at $F_2$, a minimum of force is required to make the stylus follow the groove convolutions.

But the resonance at $F_2$ has no effect on pickup output voltage. The tone arm is, at this frequency, at rest except for its slow sweep, and the mechanical resonance does not influence stylus velocity relative to the vibration axis of the pickup.

*Figure* 15—6 (B) is a simplified version of the electrical circuit analogous to the pickup, with those elements which are not significant at $F_2$ shown in dotted line. The series resonant circuit has minimum impedance at resonance, but the current through $M_C$, representing velocity, is unaffected because of the constant-current nature of the generator. A minimum voltage across the load, however, is required to maintain the same current flow, representing the fact that minimum force is required to make the stylus follow the groove.

The third resonance shown in *Fig.* 16—5, $F_3$, takes place due to the reaction between $C_S + C_R$, the compliance of the stylus and record material, and $M_C$, the mass of the stylus and armature. At this high frequency the mass reactance of the tone arm is very great, the stylus suspension stiffness reactance very low, and we can think of the stylus as travelling down the groove free of lateral influence from either the tone-arm mass or the suspension stiffness. The mass of the stylus assembly acts as though it were suspended by the elastic material of the record, and also interacts with its own distributed compliance; at resonance there is maximum deformation of the record material, and in some cases of the stylus, in such a direction as to create an increase in output voltage. The accentuated velocities at $F_3$ can also cause rattling and buzzing.

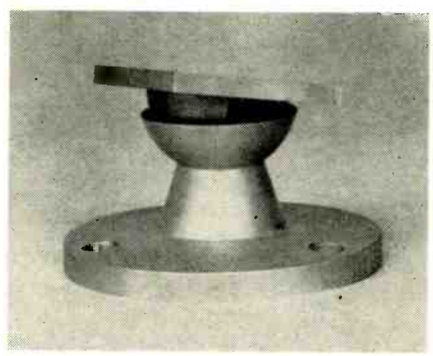

Fig. 16—7. **Commercial damped tone arm pivot in which a viscous liquid is placed between the ball and socket.** (Courtesy Gray Research and Development Co.)

Mechanical damping may be applied to the needle assembly, although the increased mechanical impedance created thereby calls for an increased vertical stylus force. (Such mechanical damping also has an effect on the $F_1$ resonance, but can be nowhere near the value required for critical damping). The choice of a needle assembly of low mass and high internal lateral rigidity raises the frequency of the $F_3$ resonance to a less annoying portion of the spectrum, in some cases above the range of useful frequencies.

Since the compliance of the record groove is involved in the resonance at $F_3$, it should be expected that this upper resonance will vary in frequency with different record materials, and such is the case. Vinyl records create a sharp drop in the resonant frequency of $F_3$ as compared to the resonant frequency on shellac records, due to the increased compliance of Vinyl.

*Figure* 16—6 (C) illustrates the equivalent electrical circuit of the pickup mechanical system, with only those elements that are significant at $F_3$ shown in heavy line. The parallel resonant circuit has maximum impedance at resonance, and there is maximum loop current flow through $M_C$.

An old-fashioned acoustical pickup had to be efficient, and the vibrating stylus had to do a lot of work. The mechanical impedance of the moving system was high and the resonances undamped. There has been a progressive tendency to design pickups with very low mechanical reactances, which means low moving mass and high compliance, so that not much mechanical energy is required to start the system moving, and not much energy is stored in momentum or elastic tension during the vibration. The mechanical Q of the moving system is further reduced by the use of damping elements. The result is a pickup of low mechanico-electric efficiency and low output voltage, but uniform and extended frequency response, low distortion, and low stylus force requirements.

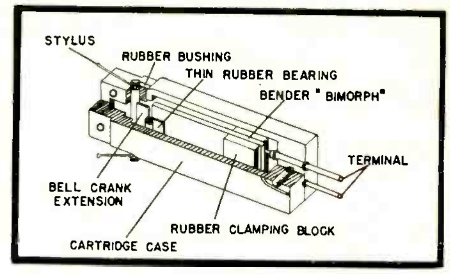


Fig. 16—8. **Structure of "bender" type turnover crystal pickup.** (Courtesy Brush Electronics Co.)

#### The Piezoelectric Pickup

The piezoelectric pickup,[4] also called the "crystal" pickup, applies force to a special type of material which generates an electrical potential difference between its surfaces when pressure is applied. The material that was used almost universally in former years was Rochelle salt (a crystal formation "grown" from an aqueous solution) but other crystalline materials, including barium titanate ceramics, have been found to be less subject to moisture and temperature effects, and are used today in addition to Rochelle salt.

The force developed at the stylus is applied to slabs cut from the crystal, arranged and coordinated with the orientation of the slabs with respect to the original crystallographic axes in such a way that a particular type of deformation results in the desired output voltage. The mechanical transmission system between the stylus and the piezoelectric element provides a mechanical advantage, so that the condition of large displacement and relatively low force existing at the stylus tip is transformed to a condition of large force and low displacement (on the order of a few millionths of an inch) at the crystal holder. *Figure* 16—8 illustrates the mechanical system of a "bender" type crystal pickup. Another common type of crystal cartridge is the "twister." In recent years crystal pickups have been made without the stiff moving system and high mechanical impedance of former units.

The electrical output of a crystal

*(Continued on page 69)*

[4] *Piezotronic Technical Data,* Brush Electronics Co., Cleveland, 1953.

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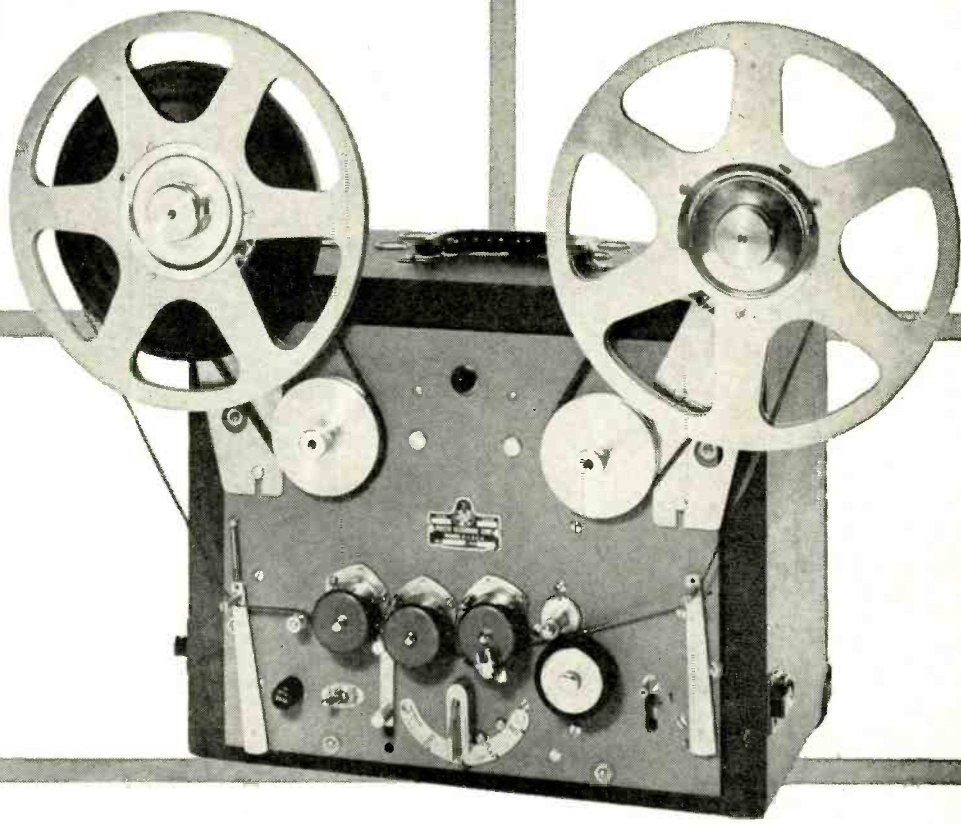
**Take, for instance, the finely engineered . . .**



# PRESTO RC-7 TAPE RECORDER

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# Audio ETC

Edward Tatnall Canby

## PLANS FOR A PIPELESS ORGAN

BUT first, a word on record speeds: My tangled grape-vine tells me that the great boom in "EP" (Extended Play) 45's is suddenly at an end as far as the classical departments are concerned. Strange are the quirks and perversities of economics! I would have said that the EP was sure fire for the lighter classics, overtures, opera excerpts, show tunes, and many another shortish work. In fact I did, if you'll remember. One slightly odd bit of evidence for the above was as follows. Vox issued a monthly release sheet called "Off the Record," in the corner of which was a large 45, plugging that company's line of EP's. A month or so back it was replaced by a new sheet, and guess what the name was. "ON the record." No mention of 45 anywhere on it. You tell *me* what such off-again-on-again titles indicate, but the 45 is out in any case. (Maybe somebody else had the name. I had a column m'self called "On The Record" until last year.)

Forty Fives in the 5 and Dime seem to be going strong. I bought some classical samples recently, just to see what was going on. Nice plastic, good looking, for 69¢ a record, EP. The music was by, among other organizations, something called "State Opera Company," and I'll bet my hat it came right off some comfortable old 78's of the earlier 1930's. The labels were probably missing so they had to make up new names. (One disc absent-mindedly listed one outfit as performer on the cover and a different one on the record.)

Frankly, with no further direct knowledge than this, I feel a distinct small voice inside me when I hear these bargain items that says—something's wrong in Lower Slobbovia. Maybe . . . maybe not. These records come on LP as well as 45 in the dime stores, and the music is well done, too. No complaint there. But I'd feel happier with a certified pedigree.

RCA has a new and very legitimate line of ultra-low priced LP reissues from the dignified Victor catalogues of the pre-war period. Some have assumed names too, but only because the well known organizations who once made the records do not now want to compete with themselves. Strictly above-board, and anyone who knows a few discs can figure out who the performers were in no time.

* * * *

### Pipeless Organ

After playing the Finn Viderø organ records from the Haydn Society (see p. 45) I got into an hour's phone call about organ tone with Jan Syrjala who is an acoustical engineer and a bug on organs to boot. What about these mechanical valve systems and the odd sounds created as the pipes speak? No question at all that these sounds are desirable—but what I asked him was, could they be duplicated with any precision by purely electronic means? In fact—I went on—if you were to design a purely electronic organ to match as closely as possible a typical 18th Century classic style organ with its strong and varied tone colors and its unusual independence of stops, what would it cost and what would be the general approach to construction? Thus began a fine speculation.

Not exactly a question to be answered casually over the phone—but he took the idea under advisement with considerable enthusiasm. Since then I've had a tablecloth session with him at a local restaurant and we've made a combined beginning. The thing begins to sound extremely interesting—wholly as a theoretical problem.

### Musical Aims

Syrjala, luckily for me, agrees that there are certain very positive musical advantages found in the classic organ which we must preserve to the utmost extent possible. Not only the tone colors, the special attack sounds, the breathy hiss of air, but more important, the extreme independence of the individual pipes and ranks of pipes. Above all, if we are going to approach the musical utility of a true organ we must avoid what is most necessary in commercial electronic instruments, the doubling-up of vital functions. That is the big point.

In my non-electronic ignorance I had always thought that a complex musical overtone pattern was a sound that could not be duplicated by electrical means; I'd assumed that electrical sound patterns would necessarily be grossly simplified, a mere approximation, a crude imitation of the genuine natural effect. There, it seems, I was wrong and so are many other musicians who have disliked electronic musical instruments. The trouble is in the commercial aspect. A "practical" electronic instrument is for reasons of economy almost bound to be "impractical"—i.e. unsatisfactory in sound—to a good musician. He tolerates these debased and weak-kneed noises only for their convenience and because possibly the alternative would be for him no sound at all.

But given time, cash, space, equipment, it seems that a remarkably accurate electronic reproduction of any natural steady sound can be created and, moreover, a variety of authentic attack noises are possible; thus the tone of a given organ pipe may very well be closely duplicated and so, as well, a whole rank of similar pipes and, continuing, a whole system of ranks—a complete organ. It can be done. But at what pains! Let me give you our preliminary thoughts.

### The "Real" Organ

First, what do we have as competition?

An average sized classic organ—not a mammoth modern one—has perhaps between 5000 and 7000 pipes, speaking very roughly. A quite small but adequate organ for the great music of the 18th Century composers might have as few as, say, 1500 pipes. (So we figured it out—with a few more than 20 stops altogether). Such an organ could be acquired for a sum ranging from $15 thousand to $18 thousand, at a guess. Not a big or loud organ, but it would be one that had a thoroughly flexible set of independent ranks of pipes, a minimum of short-cut couplings, enough variety in the stops to allow for the full range of contrasting tone colors that was customary

(*Continued on page 48*)

# *The publisher of a fascinating new magazine explains its purposes and offers you the first copy with his compliments...*


MUSIC at HOME is a completely new kind of magazine, planned to help everyone find more entertainment in hi-fi records, tape and FM radio. The wealth of intriguing articles, dramatically illustrated, covering both music and equipment, express the concept that music is for everyone, and the more realistic the reproduction, the more enjoyable the music — whether the original was a symphony orchestra, a hot trombone, or a crooner giving out with the blues!

With the perfection of LP records, tape recorders, FM radio, and hi-fi equipment, people are coming to realize that music can make a more important contribution to the home than any other form of entertainment.

It has a special appeal to each member of the family, from the little tot who, with uncertain steps, responds to the rhythm of tunes for children, to the grandparents for whom music recreates happy events of days gone by. And for those ages in between, there is music for dancing, for relaxation, and for the pure joy of listening. This assumes, of course, that what is heard from the loudspeaker is an accurate recreation of the original music, which we have come to call hi-fi reproduction.

The purpose of MUSIC at HOME is to help you:

1. Select the best recordings of the kind of music you enjoy the most,

2. Learn more about the many exciting uses of tape recorders,

3. Find the FM stations that are providing top-quality programs,

4. Select the kind of hi-fi equipment suited to your particular needs, within the limits of your budget,

5. Install the equipment so that it will be both decorative in appearance and fine in performance,

6. Use the equipment correctly, so that you will have all the thrilling enjoyment from your music that hi-fi reproduction can provide.

In short, MUSIC at HOME is a how-to-do-it magazine, filled with articles and special features planned for the thousands of people who are interested in learning more about this wonderful form of home entertainment.

The special offer below is extended so that you can have the first issue with my compliments, and see for yourself how interestingly the subjects of music and hi-fi equipment are presented in MUSIC at HOME.

Milton B. Sleeper

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EDWARD TATNALL CANBY*

### SEASON'S HIEST ODDITIES

* **Musical Gadgetry** (vol. 1). Assorted mechanical music machines.
**Spectrutone AH-1002**

Here is merely a 99 44/100 per cent perfect reproduction of the world's original hi-fi music makers. If these awesome machines can sound as potent as they do here, imagine the fi of the originals themselves: intermodulation distortion, none, harmonic distortion, none whatsoever, transients, perfect! All this, of course, if we accept the sounds of the original, as is. "Distortion" there is, and plenty, notably in the little matter of pitch. But then, out-of-tune hurdy gurdy music is much nicer than the same in perfect tune. Adds the salt and pepper. . . .

The disc, to get to practicalities, comes via the inspiration of Weathers Industries, who did the recording, called Acoustimetric Sound Tracing, which gets 20,000 cps on the disc, by microscopic inspection—even if you can't hear it. You'll be delighted and horrified in one instant by these extraordinary noise makers. Bells, xylophones, reeds, drums, castanets, and other noises not to be described in words, greet the hi-fi amplifier joyously. The fanciest "demonstration" material to hit the grooves yet I'd say—but take out neighbor insurance before you begin. Oddly enough, a few of the recorded bands contain interesting music; the Bell-and-Xylophone Piano and a gadget called a Mandolin Piano play some old-line blues music that is the real stuff, and almost human. You'd swear somebody was at the keyboards . . . or maybe two or three players with lots and lots of hands and fingers. Rush right out and acquire this dilly . . . or write to Spectrutone Associates, 66 E. Gloucester Pike, Barrington, N. J. if you get blank stares at your local record dealer.

†*e **Austrian Folk Music** (WL 3009); **Galops, Polkas and Potpourris** (WL 3007); **Waltzes for Band** (WL 3005). Deutschmeister Kapella Band.
**Westminster**10

If you've merely heard bands at football games, you'd better give this ancient and honorable and very Austrian ensemble an audition. It's comfortable, tubby, solid, beery, occasionally a bit out of tune—nice—and about as different from a peppy U. S. band as you can imagine. They have a perfectly enormous bass drum, for your woofers, and a huge cymbal section (maybe it's just one, close-by) plus some fetching bells, for the tweeter section. Super-hi fi, the only limitation in the 20,000 range being Westminster's continuing sharp pre-emphasis, which must do odd things in the ultrasonic region.

An extra in the series was a very serious disc of Xmas carols for band—the playing of a batch of U. S. favorites by these Austrians struck me as the funniest Xmas sound of the season. Still available, if you want 'em.

*i **Curtain Time.** (Light music series). Leslie Bridgewater and the Westminster Light Orch.
**Westminster WL 4005, 6, 7** et al.

An odd sort of in-between music, drawing from numerous classical sources (as we might call them), the works arranged for "light" orchestra in a semi-background style, yet not of the sentimental or wired-music sort so familiar to us. Superb recording, close-to with excellent solo instrumental effects and a good, vibrant background liveness, makes the set valuable for hi-fi equipment owners who are ready to tread very gently in the direction of classical music per se —that is, as music, not sound effects. Music by Schubert, Mendelssohn, Raff; Old English and French folk tunes, and the like, all tastefully and painlessly arranged for easy listening.

* 780 Greenwich St., New York 14, N. Y.

### KEY

- * Outstanding recorded sound for the type of music.
- † Noticeably good or interesting performance.
- 10 Ten-inch LP record.
- B Big bass.
- c Close-to miking—edgy highs.
- cc Crashing cymbals galore
- d Distortion
- dd Distortion in loud passages
- e Extra-sharp pre-emphasis of highs—use more roll-off.
- f Flatter-than-average high end—use less roll-off.
- i Intimate, close-to recording in good liveness.
- L Big, blown-up liveness.
- r Extreme reverberation interferes with music.
- y Lacks highest highs.

### JOHANN STRAUSS

*eL **Strauss: Overtures, Polkas and Marches.** Philadelphia "Pops", Ormandy.
**Columbia ML 4686**

*Bi **Strauss: Four Great Waltzes. (Wiener Blut, Wine Women & Song, Vienna Woods, Emperor).** Minneapolis Symphony, Dorati.
**Mercury MG 50019**

yf **Strauss: Wiener Blut, Blue Danube, Vienna Woods, Voices of Spring.** Vienna Symphony, Moralt.
**Epic LC 3004**

ydd **Favorite Strauss Waltzes and Overtures.** Vienna Philh., Boehm; Radio Leipsig Symph., Abendroth, Kegel.
**Urania UR-RS 7-21**

f **Orchestral Favorites by Strauss and Offenbach.** The Strauss Orch., Lanner.
**M-G-M E3032**

Of these only the first two rate as wide-range normal "hi-fi" records. but all are decidedly listenable. In addition to the numerous standard waltzes in duplication (all done in their long, complete form with introduction), the polkas and the not too familiar Waldmeister Overture are of special interest, as listed.

The Phila. disc has the usual huge, blown-up Philadelphia liveness with excellent lows and highs and low distortion—but the sound is too big for Strauss, giving an almost pompous effect. (My taste—you may feel otherwise.) The playing is typically American, big, accurate and brisk, a bit on the hard, glittery side. (Our imported conductors become Americanized quickly enough.) The Dorati waltzes on Mercury are more unassuming in style—Dorati is good for this music. Recorded with the usual single Telefunken, placed in this case, I'd say, a bit close; the effect is slightly on the intimate side as to liveness. A huge, solid bass and fine cymbal highs make this outstanding as to sound.

The Epic, Urania and M-G-M discs are none of them up to conventional standards for newly made LP's, though for musical listeners the deficiencies are small. The Epic has weakish high highs and what seems to be a flat high end—it plays best with no roll-off at all. (Perhaps from "flat" 78 discs, not pre-emphasized in the American copying? The flat high end has been noted here many times before in the earlier English Columbia LP reprints, on the Columbia label.)

M-G-M's record has similarly light pre-emphasis, in contrast to most of M-G-M's records, which tend towards extreme sharpness; it plays back best with about 8 db roll-off on my equipment. M-G-M's conductor, Lanner, inherits the tradition direct from his grandfather who played under Strauss himself; he does a nice performance, again on the intimate side, the strings occasionally a bit ragged in intonation. The Epic record comes from Vienna and also represents an authentic tradition here somewhat more symphonic. These two would be my choice for tops, musically speaking.

Urania's "Request" low-priced record is from numerous takes, probably as usual off the air or from broadcast performances. Not bad at all, but, as often is the case in this sort of disc, the louder parts tend to distort while the rest remains sweet and pleasant to the ear. A bargain, at the price, nicely styled to the German taste.

*B **Graduation Ball.** (Music of Johann Strauss). Complete ballet. New Symphony, Fistoulari.
**London LL 883**

All-Strauss, arranged in a continuous score for a ballet and employing many unfamiliar items from the huge Strauss repertory. (The familiar waltzes we all know are a tiny part of the total Strauss output; many unknown waltzes are, I hear, in our own Library of Congress.) The best of ffrr sound, with a huge bass and nice highs—a bit on the heavy side, somewhat as in the Columbia disc above.

### OUT OF THE PAST

1* **Masterpieces of Music before 1750.** Danish soloists and ensembles, Woldike.
**Haydn Society HSL-B (3)**

I'm in the midst of these—if I waited to play all of them before writing there'd be an indefinite delay, since I keep going back over ones I've already played. In other words, here's one type of recording I like a lot!

The "Masterpieces" set is the latest in that long series of historical illustrations on records that began with the old Columbia History, years ago, and went on with the never-ending Anthologie Sonore. This one is exceptional. (1) It is recorded with top modern technical quality. (2) The performances—as far as I've got—are without exception highly musical and beautifully styled. Too often the historical urge is accompanied by pedantic, dry unmusical performance from the musicological-minded promoters. (3) The music is played directly out of a published book, note for note—Masterpieces of Music before 1750 (Norton), which presents all of these works in score, accompanied by brief and informative background material, a few pages for each example, in a dignified but unpedantic way that assumes intelligence in the unknowing reader.

The book prints the music in a form that is more or less playable at the piano—but never was the inadequacy of this method of music study better illustrated. Or, should I say, seldom has the advantage of the music itself in terms of actual sound been better proved. Most of the examples are meaningless hash on the piano, especially the earlier vocal works; in these sensitive Danish performances (with a fine batch of incredibly able small choir boys) the music is real, alive and intelligible. If you want to study early music history—here's your chance. Buy both, book and records, and settle down for a couple of month's pleasant listening.

1* **Italian Classical Symphonists.** Italian Chamber Orchestra, Newell Jenkins.
**Haydn Society HSL-C (6)**

—And here's another and bigger collection from the Haydn Society, in contrast, spreading out widely over one area in history. This period, the 18th century (mostly the later 18th in this collection) was extraordinarily prolific and the standards of musical knowledge and for composition were higher then than in our own day—by far. (Don't believe it? Every performer in those days was assumed to know how to compose too; to play a concerto was to write one and new works were expected as a matter of course from every musician of leadership on each occasion that he performed. Mozart was merely one of hundreds—if the greatest among them—who supplied music in this fashion, for his own performance as well as for others.)

We are familiar with the very top works of this time, by Bach and Handel, Mozart and Haydn. But until recently we virtually never heard samples of the vast range of lesser but still often very listenable works that made up the solid background. The Jenkins collection contains a large number of works most of which have been unheard since the 18th century. The supply, of course, is inexaustible but these are most revealingly chosen—all are interesting, well written, felicitous in the sound, and some are really excellent. The recording is top quality, with a quiet, modest wide-range sound well balanced and without stunts. The playing is unassuming, allowing the music maximum freedom to have its own say. Only the vocal works are a bit difficult to take. The soloists are not proficient enough to put us at our ease. If you have any sort of a yen for the music of Mozart's and Haydn's time, you'll enjoy exploring this set at long leisure.

ddr **Charpentier (Marc-Antoine): Assorted works.** Ch. Orch. of Concerts Pasdeloup, Chorus of Jeunesses Musicales de France, soloists, L. Martini.
**Haydn Society HSL 2065.**

This one promises as much as the others, but is not music that is as easy to listen to, nor is it as successful a recording. The music, for instruments, chorus and solos, are of the Couperin period, Louis XIV, and will ring a familiar and pleasant bell for those who have enjoyed Couperin, Lully, and Rameau. Highly ornamented, episodic, it has the characteristic sound of 17th century music—with the grace and splendor of 17th century France, where the similar works of the German Schutz reflect the spare simplicity of Germany during the 30 Years War.

The recording is done in a large church, contemporary with the music. But alas, monaural microphones didn't operate in those days and the building, authentic or no, is not good for the music as it appears on discs. Too much reverberation. Technically the job is imperfect; soft parts are good but the loud parts are often painfully overloaded—whether on the original tape or in the copying I could not say. The vocal soloists are merely adequate, which is not enough in this music. The Chorus of young singers is fine, as is the orchestra. A potentially valuable record that isn't as successful as it could have been.

†* **J. G. Walther, Georg Boehm: Chorale Variations.** Finn Videro, organ.
**Haydn Soc. HSL 3066**

†c **Bach: Variations on "Sei Gegrusset": Five Chorale Preludes.** Finn Videro, organ.
**Haydn Soc. HSL 3063.**

Two superb records of the increasingly popular "Baroque" organ, the old, highly colored instrument of the 17th and 18th centuries now being built anew or reconstructed in examples all over Europe and the United States. Both these organs are Danish, one brand new, the other rebuilt; both foresake the electrical action for the far clumsier but more musical mechanical valve system of Bach's day—a deliberate retrogression that will have many an engineer baffled!

Take it from me, the old organs make good listening (though nothing at all like the big modern organs we hear on some hi-fi records). And the mechanical action definitely is an asset in sound, (a sound asset, I should say) because it not only makes for important transient percussive sounds that are vital to the music, but the initial effects of the tone are controllable, by the manner in which the organ key is depressed, slowly or fast. The chief characteristic of the older organs, beautifully illustrated here, was a vast and startling variety of contrasting and highly individual tone colors, plus an over-all nasal rich-overtoned effect that is odd for our ears but allowed for music of great complexity. The richer the overtone content the more easily a sound stands out from other sounds.

The first record above, a later recording, is a beautiful job, ideally balanced as to liveness and distance. The second disc, made a few months earlier with a different organ, is an extraordinary clinical close-up, badly microphoned from the musical point of view—too close—but of great interest in the super-hi-fi picture it gives of the hissing and clanking of the old-type valve mechanisms, the slow speaking of some pipes, the generally breathy sound of an organ at work. A fine disc to add to your hi-fi sound-effects department. Finn Viderø ("Feeteruh") is a good organist who knows this sort of music well. Complete registrations for all the music on the back of the jacket—invaluable for organ students.

### MADRIGAL

*1 **Wilbye: English Madrigals.** Randolph Singers. **Westminster WL 5221**

Superb close-to recording has featured the considerable series of Randolph Singers discs from Westminster. Diction is beautifully clear and with the texts invariably printed for the eye to follow, maximum sense may be made of the music. This group sings with great expressivity and an unusually high regard for the words themselves—which too many singers ignore these days. Pitch and balance are good too; the only flaw, if it is that, is in the somewhat nervous vibrato style of delivery used by the singers. Not that this is unusual today in trained voices —it is the normal sound. Nevertheless it seems clear that in older vocal music there was much less vibrato, a steadier vocal tone, leading to a blending of harmonies more like that of a string group or organ. The old English Singers of years ago had such a blend and no one who heard them will soon forget it.

John Wilbye was one of the finest composers of English madrigals—those rapturous, highly emotional yet formalized songs of love for pure voices which cultured people were expected to sing at sight around a hostess' table in the 16th century. This study of the works of one man is, again, the sort of new project that is particularly welcome on LP—both for the student of music and for the know-nothing amateur, who will find each one of these more pleasant than the last, the uniformity of style and inspiration a help in appreciation rather than a hindrance.

The peculiar half-humorous stylized polish of the serious English madrigal is an interesting contrast to the much more violent and outspoken music of the Italian madrigal.

**Adriano Banchieri: Festino (madrigal comedy).** Primavera Singers; Blanche Winogron, virginals. **Esoteric ES 516**

An unusually interesting item—a complete "evening" of semi-connected madrigals once offered together as an entertainment, complete with an M.C. (the composer) and, in this case, as much horse-play as any modern TV show. The madrigal style of entertainment came shortly before the development of solo vocal writing and opera.

These are Italian madrigals. In Italy, then as now, Italians were explosive—emotions were all hot or all cold. Here the comic element is sheer buffoonery cast in the madrigal form, as frothy as Harpo Marx—witness the enclosed complete text (English-Italian)—and more than a little crude by our prudish modern standards. The style of the music is of course not familiar to most of us and so possibly, without the text, may not at first make its point; you might easily judge on one hearing that this was deadly serious "classical" music. But read the description of the comedy, imagine the actual scene of the entertainment, follow the words, and you'll soon see that this was a real "show," as popular as a good musical or a Jimmy Durante program is today.

The Primavera Singers, not unlike the Randolph group (they have a tenor in common), is less clear in its diction, notably in the ladies' parts, and has not to my mind the verve and vigor of the Randolph ensemble. Indeed, they sing the more racy passages here as though they were so much mumbled church Latin! A more boisterous, though no less disciplined performance would be in order. I'd say.

## RECORDER

c **Handel: Four Sonatas for Recorder and Continuo.** Alfred Mann, recorder. **Vox PL 7910.**

†* **In Memoriam Edith Weiss Mann (Trio Sonatas for recorder, oboe, violin and harpsichord by Telemann, Peputsch, A. Scarlatti).** Alfred Mann, recorder, Lois Wann, oboe; Edith Weiss Mann, harpsichord continuo. **Westminster WL 5314**

The first of these was made a summer or so ago in Germany; the second record is from tapes that I made, in Edith Weiss Mann's New York apartment during her last illness. I'm happy to be able to boast that in spite of some amateurish technical troubles I ran into—mostly fixed up by Westminster in the processing—my efforts seem to have beat the Germans.

The German-made Vox recording of Alfred Mann suffers. I venture to suggest, from too-dead acoustics and/or too-close microphoning. The recorder sound is somehow lack-lustre, dampened, without its proper sheen and brilliance; It's too whistle-like. The harpsichord is too close (a wiry. metallic tone) and too loud in the balance. In this somewhat closet-style atmosphere I can't feel that Alfred Mann was at his musical best, though the lovely Handel music comes through engagingly even so.

The Westminster disc (mine) has a better, more realistic liveness. a truer recorder sound and a more natural balance between the instruments. The recorder is a devilish instrument to record. (It's a "whistle" flute blown from the end, centuries old and now extensively revived to play the large amount of music originally written for it.) Its low tones are almost inaudible though lovely, its higher tones are loud with extraordinary transient peaks and resonances and there are powerful difference tones generated in ensemble playing that are fine for human ears but extremely hard on electronic equipment. The harpsichord is easy enough to take down but it, too, is often badly recorded from too close a position, which captures instead of its smoothly golden tone an unlovely collection of mechanical clicks, clanks, and steely twangs that does the instrument gross injustice.

The "In Memoriam" record deals with these problems and I think we did a good job (except, alas, for the final piece which somehow came through with no highs over about 3000 cps. My fault. The rest is hi-fi.) The recorder and oboe are rich and full-toned, the harpsichord is neither too loud nor too close, without unpleasant mechanical sounds, and the bass quality is particularly nice. (Actual mike distance was about 6 feet, a single Altec in a small and live studio apartment). The mike placement gives maximum fullness to the music.

The record is issued as a memorial to the harpsichordist, who died some months after the recordings were completed. She was an indominable musical figure of great influence in Germany and this country for almost fifty years and her leadership in musical ensemble playing was powerful, as is quickly to be heard here. Her harpsichord, a Steingraber, had the finest sound of any I have yet heard and I recommend it to those who may be doubtful. The tonal combination of oboe, recorder and harpsichord is especially colorful and effective on hi-fi equipment.

*** Bach's Royal Instrument, vol. 3, (Toccata & Fugue in D minor, C minor Passacaglia, "Little" G minor Fugue, etc.)** E. Power Biggs, Organ in Symphony Hall, Boston.
**Columbia ML 4500**

Technically a big recording for the hi-fi enthusiasts. This is a new, modern organ compromised for both old and new music; Biggs' playing sounds more like conventional church-organ than the above, but the tone colors are good, the clarity great (no blur of sound), the tempos rather slow and careful—altogether one of Biggs' best. Might find a 30-cycle note if you look hard, too. Heartily recommended.

**c Rameau, Suite in E minor; Suite in A minor.** Fernando Valenti, harpsichord.
**Westminster WL 5128**

The E minor suite is familiar, the A minor less so. Valenti's Rameau is brilliant but a trace on the mechanical side; the rhythms jangle, the elaborate ornament is not integrated into the melodic line as a Landowska does it. Good, but it could be better musically. (Valenti falls down similarly in Bach, lacking a feeling for phrasing and shape, in spite of his fabulous technique.)

**Handel-Fekete, "Alceste" Suite; "Festival" Suite.** Vienna State Opera Orch., Fekete.
**Colosseum CLPS 1012**

Not unlike the Water Music recording above—this is an arrangement from several Handel oratorios. A good, reedy sound to Fekete's instrumentation, not as symphonic as the Water Music above, which is all to the good. The parts taken from vocal solos sound a bit strange here, the whole is a bit romantic for Handel; but this is far better than other recent Fekete offerings and is recommended. Well recorded with excellent miking.

## LETTERS

*(from page 6)*

sound area according to the relationship between their separation and those of the microphones, and hearing both speakers with both ears will be correct and pleasing rather than a basic defect.

For a really weird *faux pas* in this department note the recent motion picture, "The Robe," in which two actors converse with their heads about 8 inches apart on the right side of the screen. The rightmost voice issues from the speaker at the right of the screen, while the other comes from the center speaker, some tens of feet away. It's just what happens when you record binaural and play back with widely separated stereophonic speakers.

Richard H. Dorf
255 West 84th Street
New York 24, N. Y.

## AUDIO ETC.

*(from page 40)*

and is still needed in the music, including at least two mixture stops, extra ranks of high-pitched pipes that play along with the fundamentals to add more brilliant overtone coloration. Mixtures were heavily used in the 18th Century. So that is that. Two hundred years ago, mind you, we could have acquired an organ of this type that cannot be surpassed to this day. Now—how about electronics?

### Tone Producing

As I get it, we would need three basic tone makers for our electronic replica, operating together. First, a basic tone oscillator with associated circuits to produce a steady tone of the required and specific wave form—and, given a *single tone,* it seems that a very fair imitation of most kinds of organ sound could be so managed. But there is more. Secondly, we must produce an *ictus,* an initial accent or attack sound, and this sound varies tremendously from one type of organ pipe to another. Nevertheless, since these sounds (excluding mechanical noises) are air-generated, we can give a fair approximation of them. Some, for instance, sound a brief "ping" a twelfth (3rd harmonic) above the fundamental before the main tone speaks. Naturally, the complexity of this tone would vary and innumerable separate problems might be encountered. Added to our one oscillator tube we can install a second "pre-tone" tube to cover most of this department; a third tube would be needed for controlling the other two, determining the relative level and duration of the pre-tone and the starting of the main tone. (As the pre-tone fades down the main tone comes up.) Three tubes and two complex functions, interlocked—and still there is a third. Hiss.

A hiss sound is a vital necessity from a musical point of view; that is, it is an asset which as musicians we are not prepared to sacrifice. It must be available at various levels and at many different frequency bands; pipes differ in this respect. A white-noise generator is therefore a necessity, in addition to the tone and the pre-tone generators, and there must be more filters to deliver it as needed and where needed.

So, for a *single tone* we have a minimum of three tubes and a slice of a white-noise generator, as well as the complex circuitry that accompanies these, this of course excluding the entire power amplifier and speaker arrangement. Leave that for a moment. I can conceive of the building of such a single tone producer, imitating a single true organ pipe, as an interesting hobby project which might take a couple of weeks, in the designing, building and adjusting.

### Independence

But a single tone does not an organ make, to paraphrase an old saw. We are aiming at a minimum organ that will duplicate the services of some 1500 pipes—1409 is the figure we hit, adding up stops and mixtures, pedal, great and *positiv.* Double functions? That was my first question—and, says the rigorous Mr. Syrjala, there are very few short cuts we can take. True, a single tone oscillator for, say, square waves might be fed to numerous different circuits to make the different individual "pipes" at the given frequency, and so on, thus allowing for enormously fewer elements. Another would generate sawtooth waves. But no, and here I agree. One of the most distrusted effects in organ building is that of duplication or overlapping of function, where the sounds are not truly independent. This is for good reasons. The minute and subtle degrees of out-of-tunedness, out-of-phasedness, between separate organ pipes (as in separate instruments in an orchestra) is tremendously important in giving the sense of musical independence that is at the very basis of musical construction—and, indeed, is the whole reason for employing strongly differentiated tone colors in the first place. Music lives vertically by its harmonic relationships, but it lives horizontally, lengthwise in time, by the existence of separate and distinct lines of melody which combine and recombine, imitate, echo, yet remain themselves. The slightest weakening of that independence of sound is detrimental to the musical life and individuality of these lines.

A single oscillator source for two or more fundamental tones—even though these be modified into radically differing tone colors—is not to be tolerated, if we stick to our original intention. Each tone, each "pipe" that is intended to be as an individual (in a family or rank) must have its own oscillator, and thus be free to live separately in any musical environment. This is of first importance and it is here that we must break quite away from the commercial necessities where this sort of compromise has been varyingly necessary.

Only one compromise is possible, in the special case of the mixtures, where in the true organ two or more "color" pipes are coupled to sound always together. Our simplified instrument has two mixture stops postulated, one with two ranks (two pipes for each pitch) and the other with three —five complete sets of pipes, 61 pipes to the set. We can afford to use a single oscillator for the two pipes in one mixture and the three in the other (and similarly if we had fancier mixture stops) because there is no independence here and we can probably come fairly near to reproducing the wave form of the combined pipes with one filter circuit.

That means a slight saving in oscillators. Instead of 1409, we need merely 1226 of them—*more than twelve hundred separate three-tube double-purpose tone and pre-tone generators with associated circuits.* As we see it, there is no way to reduce this number unless we make compromises in the way of multiple functions that we are not going to make—or unless we "build" a smaller organ. Remember, this is already a quite small one, merely 22 stops. Yet keep in mind that all of this is quite "practical" in a vital sense, namely, that it *can* be done, and without unusual trouble, I'd say, compared to more routine electronic design and construction jobs of a technically similar nature. How about the electronic "brains"? Much more complex.

**Voicing**

There is another aspect of this independence which would lead us to the same conclusion. Don't think that a rank of organ pipes, a stop, contains a set of pipes that produce all the separate pitches but with identical wave forms aside from frequency. Far from it! Within every stop the tone qualities change progressively and with the utmost finesse from one end to another, from low to high. Each pipe has its own characteristic, shaped to fit into the general "curve" of the stop as a whole—sixty one pipes in this country (58 in older organs). The voicing of a stop to give a uniform and pleasing range of color from low to high is an incredibly tricky art. To realize this sort of over-all frequency curve in our electronic stops we should in any case have to set each oscillator and filter combination progressively to give a slightly different wave form within the general type—perhaps one harmonic becoming more prominent, another falling away. Here is an equally solid reason for requiring a *separate* tone generating system for each pipe, except for the mixture combinations, as above.

**Air Hiss**

I managed to persuade Syrjala the idealist to admit that the necessary air hiss could be managed for all stops from one white-noise generator, tapped off for every "pipe" that needed it. No doubt the differing qualities of hiss could be simplified without too much trouble to a reasonable number of filter circuits (whether three or a hundred I do not know, but remember that most air hiss approximates a pitch, i.e. is limited to a restricted frequency band). Level sets and filters, then, for as many different hiss circuits as might be needed. Almost every pipe needs some, as you can hear in a good close-up organ record like the Viderø discs reviewed in this issue.

#### Power

So far so good—and no power amplifiers yet. Syrjala did a lightning menu calculation as to power requirements, so far. Here they are (gulp!):

Filament power *alone*, approx. 1000 amps at 6 v.

Plate, very roughly 5 amps at 300 volts. Take *that!*

Assuming that we have our signals under control, how about the final power stage? Ideally we should have a power amplifier and speaker for every "pipe," but this is hopelessly impractical and a compromise will not make for vital losses. Syrjala suggests at least three audio channels, one for each major section of the small organ, the Great (lower manual), *positiv* (upper manual) and pedal (feet). In the true organ the pipes of some stops are spread out fairly widely, but generally speaking, pipes of a feather flock together, since each stop is a "voice" that sings by itself as an individual.

With three amplifier channels and three speaker set-ups we can get a fairly good acoustical approximation of the spread-out sound of a true organ—especially in a live chamber where directionality is confused. (For obvious reasons the old mechanical organs did not have "choir" pipes off at a distance, nor are these to be considered other than special effects.) Our speakers, however, must be of the very best and the enclosure is most important, for two reasons.

First, the low tones of the keyboard stops are, I gather, 64 cps, the lowest small-organ pedal is 32 cps. Those tones really "roll" in the genuine organ; we must roll them out too, without faking. And, it seems, there is a power problem. The two most efficient sound producers are the human voice and the organ. (Some authority said so back in the 19th century —I didn't get his name.) The voice may be as much as 95 per cent efficient, at a rough guess, and the organ pipe possibly 85 per cent. A really punk speaker system gets up to 5 per cent and the best commercial horn-loaded systems reach into the 60 per cent class. So I'm told, anyhow. Whether the figures are exact or not is beside the point; here we will obviously need a lot of power—the amount will depend on the usage. So—three big, low-distortion power amplifiers, and one *very* big speaker system and two big ones make our final tone production expense. Not a bit less, if you are aiming to recreate the sound of a small true classic organ! Again, it can be done, without too much trouble, if someone really wants to.

#### Et al

How about the vast control functions of such an electronic organ? Strangely enough, this is not an essential problem here though the details might take an agonizingly long time to work out. The reason is simple. Though the old mechanical tracker action is desirable, the fact is that many rebuilt and new classic-style organs are equipped with electrical valve and "switching" controls. These basic and well developed systems could, I expect, be adapted pretty much "as is" to our special electronic organ and therefore constitute a kind of neutral element. In any case, for the sake of this somewhat theoretical argument we'll put that problem aside.

These are the essential points. There are fascinating areas of detail-speculation which those who are far more expert than I could take up. We spent some time, for instance, on the matter of the "nick," a tricky sort of scoring of lines or grooves in the speaking part of an organ pipe that results in a reduction of the non-harmonic (or should I say spurious harmonic) sounds it generates in its various parts. This involves an area of acoustics that is full of dreadful obscurities to this day, I gather, though the organ builders of 300 years ago were already well onto the practicalities involved. The old organs, without nicks, produced a stronger, rougher sort of tone quality; nicking reduced the "abrasive" sounds and led to more elegant tones but also more spineless ones.

We, today, having outgrown the Victorian age, now prefer the stronger sounds, as we like many other things on the raw side, our new music included. The *absence* of nicks on the old-type organs means that we face a greater problem in electronically imitating the old tone qualities, since the rough non-harmonic sounds are anything but natural to the simpler tube circuits. A challenge, not only in the designing but in a philosophical way—as I hope this entire project is.

These are the preliminary steps we might take in our attempt to reproduce by every modern means at our disposal a kind of musical sound that was perfected and practical back when the American Colonies were still isolated settlements on a wilderness continent. It's a funny world.

(P.S. I'm rather hoping that readers who are skeptical or enthusiastic or practical-minded or ingenious will give us their comments and elaborations, or their corrections. I take no responsibility for quoting Jan Syrjala correctly nor did he offer these speculations on other than, shall I say, a conversational basis. But the idea is a stimulating one. Wanna make something out of it?)

## PATENTS

*(from page 4)*

What happens, anyway, is that $R_1$-$R_2$-$R_3$-$C$ is a frequency sensitive bridge circuit and the voltages are combined in the rectified output in such a way that at the null-frequency zero voltage (d.c.) appears across $R_4$ and $R_5$ in series. At frequencies above and below null d.c. of polarity indicating whether frequency is high or low appears between the output terminal and ground. The d.c. is, of course, pulsating, and if pure d.c. is desired a simple filter consisting of a resistor in series with the output terminal and a capacitor shunting the outboard end of the resistor and ground will provide it. The only thing to watch in adding such a filter is not to make the resistance and capacitance any larger than necessary since this will make for long time constant with resulting slow d.c. level response to frequency changes (if that matters).

The null frequency is that at which $R_1$, $R_2$, $R_3$, and $C$ have identical impedances. $R_3$ or $C$ can be made variable, in which case adjustment of the variable will give a range of about two octaves in the null without changing $R_1$ and $R_2$ and the non-variable element. The Q of the discriminator output curve is, of course, much smaller than for resonant discriminators but is adequate for many applications. $R_5$ and $R_6$ can have fairly high values compared to the bridge impedances; these are very easily determined by experiment. 1N34 crystal diodes will work quite well, though they will not give as steep curves as the tube rectifiers since the crystals have a finite back resistance. The transformer can be anything available—a push-pull output transformer, for instance—though interstage transformers with high-impedance secondaries will be less satisfactory. Since only voltage is really being dealt with, impedance matching is of no importance.

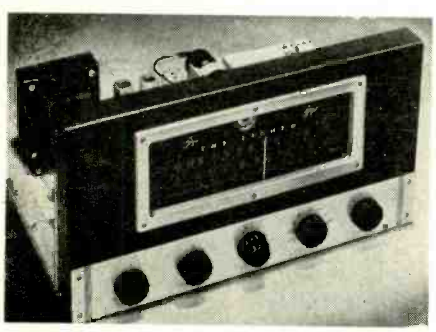
Copies of any U. S. patents can be had for 25¢ each (no stamps) from The Commissioner of Patents, Washington 25, D. C.

# NEW PRODUCTS

• **Audio Control Center.** Unique in both physical design and in circuitry, the new Fairchild preamplifier-equalizer represents a thorough departure in basic concept of such devices. Performing every function of a complete audio control center, the unit requires adjustment of only two

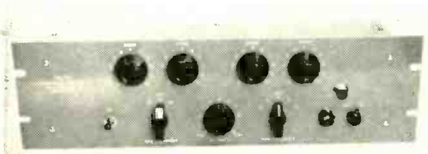
knobs for normal operation. The Fairchild "Balanced Bar" controls permit adjustment to match the acoustical requirements of the room in which the equipment is used. Intermodulation is less than 0.05 per cent and total harmonic distortion is less than 0.01 per cent at 1 volt output. Frequency response is 20 to 50,000 cps within ± 0.5 db. Selector switch permits operation with or without loudness compensation. Seven input channels have individual level adjustments. Accurate equalization is provided for all records, American and foreign, standard and microgroove. Fairchild Recording Equipment Corp., 154th St. and 7th Ave., Whitestone, N. Y.

• **FM-AM Tuner.** Virtually every feature considered desirable in a tuner for home music systems is present in the new Fisher Model 70-RT. Included with the



tuning elements is a phonograph preamplifier with separate tone controls, adjustable record equalization, and variable loudness control. Among the 70-RT's general features are separate front ends for AM and FM, self-contained power supply with separate d.c. supply for all audio tube filaments, and shock-mounting on both main and sub-chassis. The circuit includes 15 tubes. FM sensitivity affords full limiting on signals as low as 1 microvolt. AFC action is variable and may be switched out of circuit from front panel. Frequency response is 20 to 20,000 cps within ± 1 db. AM section has adjustable IF bandwidth and includes a 10-kc whistle filter. The audio amplifier and control system are complete in every respect, and afford a measure of performance usually expected only of professional equipment. For complete specifications write Fisher Radio Corporation, 45–41 Van Dam St., Long Island City 1, N. Y.

• **Professional Program Equalizer.** Remarkable operating flexibility is afforded by the new Pultec Model EQP-1R program

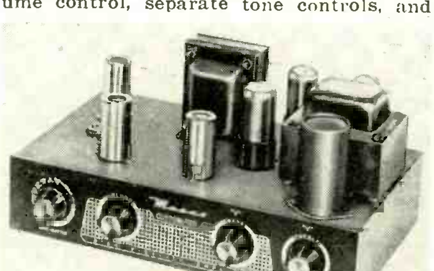


equalizer recently introduced by Pulse Techniques, Inc., 1411 Palisade Ave., West Englewood, N. J. A low-impedance passive equalizer followed by an amplifier to restore insertion loss, the unit has balanced input and output at 150, 250, or 600 ohms. Low-frequency boost and attenuate curves at 30, 60, and 100 cps permit correction of bass deficiencies without disturbing mid-low frequency characteristics. Five high-frequency boost curves permit correction at 3, 5, 8, 10, and 12 kcs. A band-width control permits varying these curves from sharp to broad. Separate controls allow boosting any high frequency while attenuating on a 10-kc shelf curve. Noise level is 92 db below +10 dbm, and distortion is 0.15 per cent.

• **Moderate-Priced Single Record Player.** Continuously variable speed ranging from 29 to 86 rpm is among the chief features of the high-fidelity record player now being introduced to dealers throughout

the country by David Bogen Company, 29 Ninth Ave., New York 14, N. Y. Designated Model B-50-3, the player will accommodate records up to 16-in. in diameter, and is equipped with a turntable top made of grooved rubber to minimize record surface wear. Although continuously variable in speed, the player locks in, without the use of a stroboscope, at 78, 45, or 33-1/3 rpm. Wow measures less than 0.5 per cent. Motor is of the four-pole type and affords constant speed with line variations form 95 to 125 volts. The pickup arm is equipped with ball bearings and requires a tracking pressure of only 4 to 6 grams for microgroove recordings; it may be adjusted up to 39 grams for normal operation.

• **Ten-Watt Hi-Fi Amplifier.** Frequency response of 20 to 20,000 cps within ± 0.5 db and less than one per cent distortion at rated output combine to produce remarkable performance in the new Masco Custom Ten amplifier. Operating features include bass- and treble-compensated volume control, separate tone controls, and



a recorder output jack which permits simultaneous recording and monitoring. The input-selector switch provides five steps of record equalization in the magnetic-pickup position. A socket and plug are provided for remote pilot light installation, and extension shafts are supplied to simplify installation in any cabinet. Full information and technical specifications on the Custom Ten will be supplied by Mark Simpson Mfg. Co., 32–28 49th St., Long Island City 3, N. Y.

• **Flyweight Tape Recorder.** This new model in the Magnemite series of tape recorders is a compact weatherproof unit designed for rugged field use. Weighing but eight pounds, the recorder employs a governor-controlled electric motor which will operate four hours on a single set

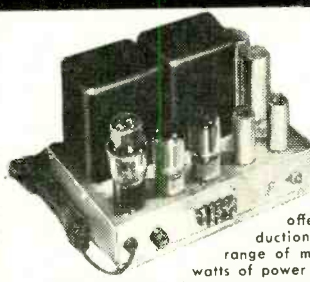
of standard flashlight cells. A built-in indicator shows when motor batteries are due for replacement. By powering the miniaturized amplifier independently of the motor, an amplifier battery life of 100 hours has been achieved. The recorder is available in three models with operating speeds of 15/16, 1-7/8, and 3.75 ips, respectively. Dual-track recording time on the respective models ranges from four hours to one hour on a 600-ft. spool. Frequency range of the 3.75-ips model is 50 to 5000 cps, making it entirely suitable for broadcast interviews and other assignments where better-than-average quality is essential. The two slower-speed models are excellent for reference recording, customer interviews, field reports, and the like. The Flyweight is housed in a handsomely-finished case of anodized aluminum. For technical specifications and prices, write to Amplifier Corp. of America, 398 Broadway, New York 13, N. Y.

• **Professional Tape Recorder.** Extremely compact for the excellent performance it affords, the new Stancil-Hoffman Model R5 tape recorder uses standard quarter-inch magnetic tape and is well-suited for

master recording of musical performances as well as for motion picture dialogue and sound effects. When rack-mounted, the complete assembly—recording amplifier, playback amplifier, power supply, and

(*Continued on page 68*)

# HARVEY the House of Audio



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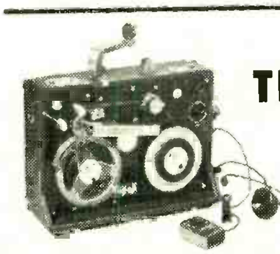

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Unquestionably the finest FM tuner ever made. This successor to the famous 646B incorporates every important advance developed in the art of FM reception. Sensitivity is 2 microvolts for better than 40db quieting. Frequency response is 30 to 40,000 cycles ±1db. Waveform distortion is less than .5% for 100% modulation. Provides 2-volt output to high impedance, and .2 volts to 600 ohms. Front panel includes slide-rule dial, tuning meter, signal strength meter, tuning control, radio frequency and audio gain controls, and power switch. Power supply is self-contained. Supplied complete with tubes.

| | |
|---|---|
| **Chassis only** (for custom installations) | **$325.00** |
| **Relay Rack Model** | **335.00** |
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Provides full frequency range coverage and wide angle high-frequency distribution. **SPECIAL $24⁶⁰**

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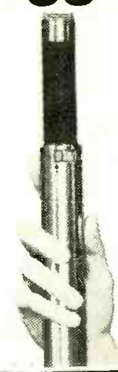
## SHURE Vagabond "88"
## WIRELESS MICROPHONE SYSTEM



A new instrument with practically no limit to its applications. This microphone embodies a self-contained FM transmitter thus eliminating the restrictions imposed by microphone cables. The user has complete freedom of movement over an area of from 500 to 5000 square feet. No license of any kind is required, and no technical skill, for its operation. The microphone-transmitter operates at a frequency of 2 megacycles, and is furnished with a specially designed receiver which operates on standard 115 volt AC. Output of receiver is 2 volts for a source impedance of 10,000 ohms and .02 volts for a source impedance of 1,000 ohms. Receiver signal can be fed into any amplifier or PA system. Weight of the microphone-transmitter is only 16 oz. Complete Wireless Microphone System including tubes, batteries, stand adapter, and lavalier cord.

**$700.00**

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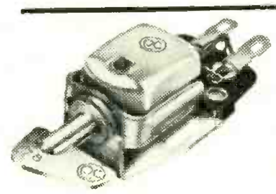
**Model 403-C**
## CONSOLE TAPE RECORDER

A truly professional unit of proven quality and performance. Frequency response: 30 to 15,000 cycles ±2db at 15 inches/sec., 30 to 15,000 cycles ±4db at 7½ inches/sec., and 40 to 10,000 cycles ±2db at 7½ inches/sec. Flutter and wow are under .2% at 15 inches/sec. and under .25% at 7½ inches/sec. Timing accuracy is ±3.6 seconds for a 30-minute recording. Signal-to-noise ratio is over 55db by NARTB standards.

Complete with record and playback amplifiers; power supply; separate erase, record, and playback heads; meter control panel; two standard 10½" NARTB reels; input selector for microphone or line; and internal output line termination.

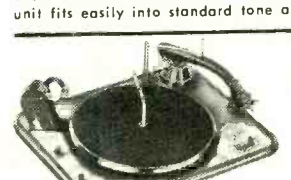
**$995.00**



The NEW
## PICKERING
## TURN-OVER PICKUP

**Model DD-260 with diamond stylii** **$60⁰⁰**

Engineered and constructed with the care and craftsmanship which have gained Pickering Cartridges a position in the top ranks, the new model DD-260 has been designed to play standard as well as microgroove records at 33⅓, 45, and 78 rpm. It consists of a cartridge, swivel-mounted, and provided with a lever-knob for convenient turnover. The model DD-260 is provided with 2 diamond stylii. The entire unit fits easily into standard tone arms.



## GARRARD
**CROWN**
**RECORD CHANGER**
**Model RC-90**

An entirely new changer with outstanding innovations. A new type of 4-pole motor provides absolutely silent operation, and freedom from wow, waver, and rumble. Gives instant selection of speeds with all three speeds adjustable ±3 rpm. Other features include: gentle pusher platform, weighted turntable, manual position for single records, finger-lift for manual use of tone arm, muting switch, automatic shutoff, and interchangeble plug-in cartridge heads.

**Model RC-90** Record Changer .......... **Less cartridge $66.00**

## R.C.A. MICROPHONES

Broadcast quality units of tested and proven performance ideal for on-the-air and recording studio applications. Known to, and preferred by leading sound engineers.

| | |
|---|---|
| **Model 44-BX** (Ribbon) | **$129.00** |
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# HARVEY RADIO COMPANY, INC.

**103 W. 43rd Street, New York 36, N. Y. JUdson 2-1500**

# GOLDEN EAR AMPLIFIER

(*from page 23*)

this manner with very little effect on the audio frequencies below 8000 cps. Similarly, beat notes within the 3000 to 12,000 cps range are also nullified with an aberrating effect on the rest of the spectrum small enough so that the over-all effect is a great improvement.

It is somewhat more difficult to achieve comparable results at the low end of the audio range because the size of inductors and capacitors becomes too great for easy variation. We intend to fit a variable inductor of about 100 henries with a knob control; meanwhile, in its absence we resonate the circuit with parallel capacitances by cut and try methods. Though our experiments are still limited, they indicate that 60-cps hum can be nulled with relatively little effect on the rest of the bass spectrum, if the inductor is of sufficiently high Q. Similarly, turntable rumble can be minimized—once the resonant frequency is found—with less attenuation of the rest of the bass, than with rolloff attenuation. For general rolloff below 50 cps a Wien bridge filter resonant at 10 cps is switched in. This produces good nulls of interference below 40 cps with little attenuation above 50 cps. No values are given for the inductor-capacitor combinations since they will have to be determined by cut and try methods in any case. The two positions for 60-cps hum and for turntable rumble, can be worked out empirically with whatever inductor is at hand.

We repeat that our experience with this method of nulling interference is still limited; but the results are promising and the circuit is commended to other experimenters for additional investigation. This method of control does produce some distortion, but it is by no means as great as that produced by band-elimination filters inserted directly in the signal channel.

For maximum decoupling and best over-all transient response the preamplifier is fed from a separate power supply rather than from that which supplies the Golden Ear amplifier. Actually, this is not extravagant. In our case the same supply provides voltage to the FM tuner. This supply is entirely conventional and needs to provide 250 to 300 volts at about 50 ma. The filament winding feeding the preamp filaments is returned to a point about 35 volts positive to keep the hum level minimum.

### Appendix 1

The New Golden Ear amplifier is very simple to adjust. The following procedure is recommended:

(1). With power tubes removed, adjust balance of the voltage amplifier section, by adjusting $R_1$ for zero voltage between plates of 9002's.

(2). With power tubes still out, adjust bias control until a VTVM indicates that the proper bias voltage (−55 for 6AR6's and −35 to −38 for 807's, etc.) appears at the output tube grids.

(3). Insert power tubes and balance them by adjusting $R_3$ for equal plate currents.

(4). Now adjust over-all feedback to desired point.

(5). Balance entire amplifier by connecting "off" grid of input to signal grid, feeding signal to input, and adjusting $R_1$ for null in output.

### Appendix 2

Since the preceding article was written, the output stage of the amplifier has been converted to the Ultra-Linear circuit by substituting an Acrosound T-300 output transformer, removing the neutralizing capacitors, and adjusting bias for Class A operation. (Since in Ultra-Linear operation the screen is isolated from the plate, interelectrode capacitances are the same as in tetrode operation and no neutralization—of the output tubes—is necessary). Both the power sensitivity and the power efficiency were greatly improved. The power output with 6AR6 tubes approaches 40 watts with less than 1 per cent distortion. Since the distortion levels of the original version were already too low for accurate measurement with available instruments, we cannot state the degree of improvement in the Ultra-Linear version quantitatively. But the listening quality is still further improved. Especially notable is the ability to handle high power peaks with a cleanness unprecedented in the author's experience. This is partly, of course, the result of the greater power reserve, but appears also to reflect an improved transient response especially at low frequencies. In any case, whether measured by instrument or ear, the Ultra-Linear version seems to the author to approach the ideal amplifier so closely that it is difficult to conceive how further improvement could be effected, much less discerned. Unless it is desired to use a standard output transformer already on hand, the author highly recommends the Ultra-Linear configuration.

For a detailed analysis of the development and theory of the new Golden Ear circuit and a description of the low-cost version the reader is referred to:

"Extending Amplifier Bandwidth," by Joseph Marshall. *Radio-Electronics* Sept. and Oct. 1953.

"The Junior Golden-Ear Amplifier," by Joseph Marshall. *Radio-Electronics,* November, 1953.

### Component Specifications

For the information of those who may be interested in constructing the Golden Ear amplifier, it must be admitted that the original model was built with surplus parts. However, the following components or their equivalents would serve satisfactorily in the amplifier:

| | |
|---|---|
| Power transformer | Stancor 8412 |
| Input choke | Stancor C-1721 |
| Filter choke | Stancor C-1420 |
| Bias supply chokes | Stancor C-1003 |
| Output transformer | UTC LS-57 for triodes<br>Acrosound T-300 for Ultra-Linear. |
| Extra filament transformer | Stancor P-5014. |

# NEW LITERATURE

• **Centralab,** 900 E. Keefe Ave., Milwaukee 1, Wis., covers its Model 1 and Model 2 variable resistors in a new catalog which will be mailed on request to Dept. J-33. Model 1 controls are sub-miniature size units of 5/8-in. diameter and are rated at 0.1 watt. Model 2 controls are standard 15/16-in. diameter, rated at 0.5 watt. In view of the excellent manner in which the units are illustrated—both photographically and in dimensional drawings—and described, this publication stands out as an excellent example of industrial publishing. Requests should specify Catalog No. 42–164.

• **Alden Products Company,** 117 N. Main St., Brockton 64, Mass., is now distributing the 1954 edition of the company's handbook titled "Ideas-Techniques-Designs." It provides new data and planning sheets on the company's plug-in components and basic chassis for unitized equipment, and stresses the advantages of quick interchangeability. The book is available to designers and manufacturers writing on company letterhead. Requests should be addressed to Dept. HB.

• **Government Service Division, RCA Service Company,** Camden, N. J., has recently published a new manual on electronic circuits for use by both commercial and military personnel. This latest volume in the RCA Electronic Training Series contains more than 100 pages of text, circuit diagrams, and operation analyses of 77 basic circuits. Diagrams and text are those used in the extensive RCA factory training program for its own production personnel. Basic circuits illustrated and analyzed range from simple receivers to complex radar gear and computers. Single copies are priced at $1.60 and may be ordered direct.

• **L. F. Grammes and Sons, Inc.,** Allentown, Pa., in a recently published 12-page booklet, gives tips on name-plate design and selection. Based primarily on the importance of name plates to sale value of products, the publication outlines the facts which should be considered in working from basic design to final selection. These include the specific purpose of the name-plate identification, appropriate shapes and sizes, variety of metals available, fastening, and types of lettering.

• **Yardney Electric Corporation,** 105 Chambers St., New York 7, N. Y., is offering free of charge a new Yardney Silvercel application guide, designed to facilitate cell model selection and to furnish pertinent technical data concerning Silvercel applications. The pocket-size guide features a rotating selector disc which indicates the correct Silvercel for any particular requirement. On the reverse side are characteristic curves and an outline of charging methods.

• **Precision Equipment Company,** 3702 N. Milwaukee Ave., Chicago, Ill., has just published a new catalog which should be in the hands of all persons whose responsibilities include operation and maintenance of an industrial plant. Many new items have been added to Precision's standard line which consists of steel shelving, lockers, ladders, and other storage and maintenance equipment. All items are clearly illustrated, described, and priced. Copy will be mailed on request.

• **Mycalex Corp of America,** Clifton, N. J., tells how to design parts to be machined from Mycalex glass-bonded mica in a new 24-page book titled "From One Designer to Another." Written in shop language, it contains tables, specification charts, and work-bench sketches. An index is included for easy reference. Discussed in detail are such points as sizes and shapes, inserts, tolerances, threads, contours and profiles, and grades.

## TRANSIENT RESPONSE

*(from page 20)*

which is what we have defined to be the transient response.

For this illustration the numerical calculations have been carried out for five typical stages: (1) one with a response of 20–20,000 cps, (2) one with a response of 1000–100,000 cps, (3) one with a response of 100–100,000 cps, (4) one with a response of 20–100,000 cps, and (5) one with a response of 0–100,000 cps. The results are shown in *Fig.* 6. The manner in which the extended high-frequency response has improved the transient response is quite evident. The effect of extending the low-frequency response, however, is almost negligible, from which we might conclude that, so far as transient response is concerned, low frequencies are of little importance.

The statement that a woofer (low-frequency speaker) has an "excellent" transient response thus appears rather silly.

### Cascaded Amplifier Stages

The effect of cascading two or three identical stages may be found by similar calculation. Since the low-frequency cutoff has already been shown to have little effect on the transient response, identical stages with a response from 0 to 16,000 cps are chosen; the response will be down 3 db at 16,000 cps for single stage, 6 db for two stages, and 9 db for three stages. The transient responses are shown in *Fig.* 7, and the detrimental effect of cascading is easily seen. This is partly attributable to the reduced high-frequency response with cascaded stages. The "charging time" for a resistor-capacitor combination is the time required for the capacitor to reach $1-1/\varepsilon = 0.632$ times its steady-state charge. A comparison between single- and multi-stage amplifiers is provided by noting the time constants required to cause the "charging times" as defined above to be the same. If the single-stage amplifier time constant is taken as 1.0, that for the two-stage must be about 0.465 and for the three-stage must be about 0.308, so that the time constants are roughly inversely proportional to the number of identical stages.

### The Human Ear

The frequency response of the human ear together with all the other bodily apparatus associated with it in its function of transferring sound impressions to the brain has been determined indirectly by Fletcher and Munson. Their "equal loudness" curves—too well known to require detailed explanation here—actually represent, at least at higher frequencies, an inversion of the frequency response, much the same as if the response of an amplifier were given in terms of the input voltage required to produce a flat output. The higher-frequency portions of these curves, say from 1000 cps upward, are all remark-

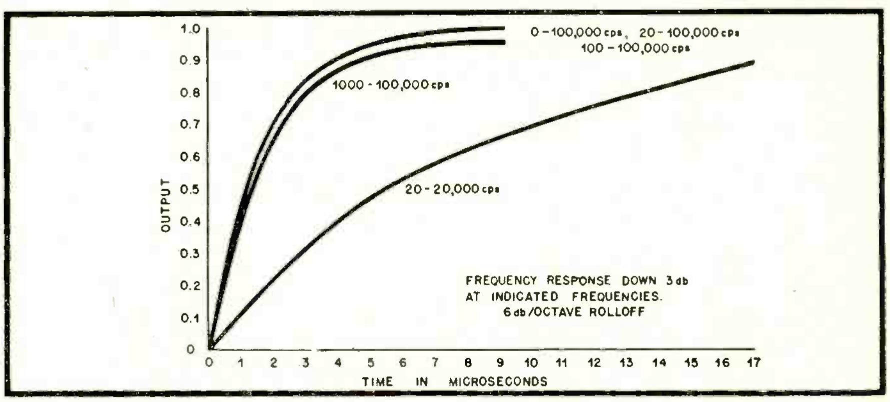



Fig. 6. Transient responses of typical amplifier stages.

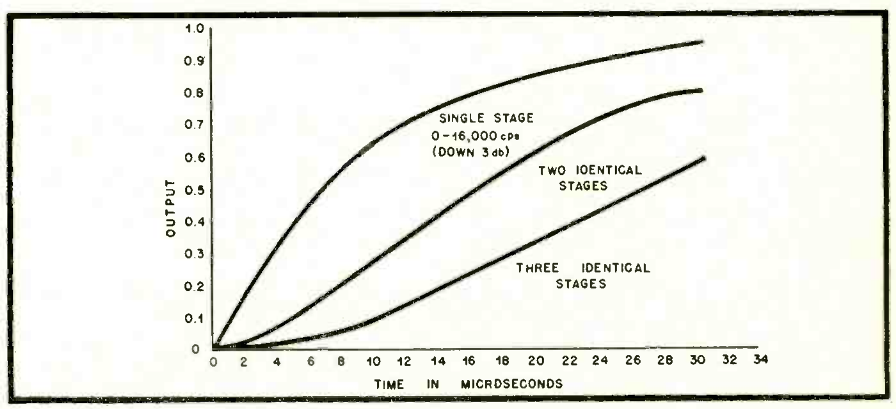



Fig. 7. Transient responses of cascaded stages.

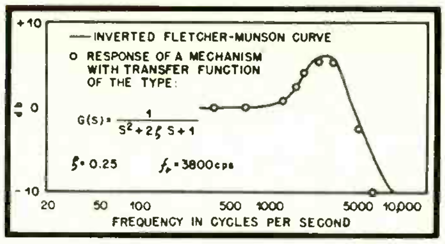



**Fig. 8. Frequency response of the ear at a typical loudness level.**

ably parallel and surprisingly similar to the frequency response of a circuit of mechanism having the transfer function

$$G(s) = \frac{1}{T^2s^2 + 2\zeta Ts + 1} \qquad (3)$$

In this equation $\zeta$ is called the damping coefficient; when $\zeta$ is less than 1.0 the circuit is said to be underdamped. The frequency response is then flat at lower frequencies, rising to a peak at the resonant frequency above which it falls off at 12 db per octave. In *Fig.* 8 the response of a mechanism resonant at 3800 cps with $\zeta = 0.25$ has been superimposed on a representative response curve for the ear; the closeness of the fit is at once evident.

The time response to a step input shows a train of damped oscillations, as shown in *Fig.* 9. Sources of sound likely to cause such excitation are somewhat rare among musical instruments, since the mass of that part of the mechanism producing the sound must be quite small in comparison to the forces acting upon it. A chime struck hard with a heavy hammer, or a triangle, would approximate the requirements.

#### Reproducer Response

Suppose we assume, however, that some instrument can produce a sound transient similar to the unit step. Our problem is to find how high the frequency response of an amplifier and speaker must extend so that if every other component of the reproduction system were perfect, the ear would not be able to distinguish between the reproduction and the original.

The transfer function of the ear has been given in Eq. (*3*). The Laplace transform of the transient response to a step input for the ear is, then

$$\frac{G(s)}{s} = \frac{1}{s(T^2s^2 + 2\zeta Ts + 1)} \qquad (4)$$

The transfer function of the reproducer may be considered $1/(1 + nTs)$ defining a circuit or mechanism whose response extends to $n$ times the natural resonant

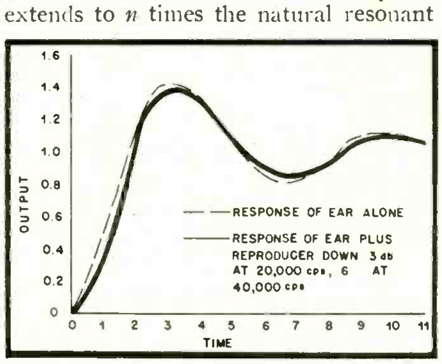



**Fig. 9. Transient response of the ear at a typical loudness level.**

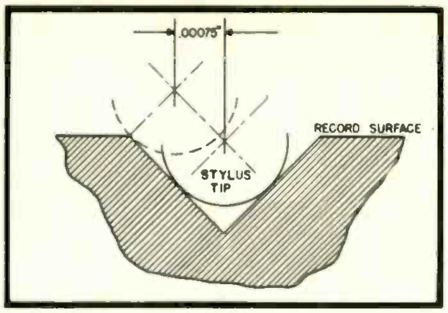



Fig. 10. Record groove and stylus geometry.

frequency of the ear and then drops off at 6 db per octave. For the ear and equipment together the transient response has the Laplace transform

$$\frac{G(s)}{s} = \frac{1}{s(T^2s^2 + 2\zeta Ts + 1)(1 + nTs)} \quad (5)$$

Finding the inverse transform of this equation is admittedly somewhat tedious, and will not be performed here.

*Figure* 9 shows the response of the ear alone to a unit step and also the response of the ear plus equipment whose frequency response is down 3 db at 20,000 cps (6 db at 40,000 cps). The two curves are almost indistinguishable leading to the conclusion that the frequency response of the equipment is better than necessary for first-class reproduction. It must be remembered that since no sources of this type of transient actually occur in practice, the criterion is more rigid than is really necessary.

The speaker is the limiting factor in most present-day reproducing apparatus. The curves of *Fig.* 9 imply that in conjunction with an amplifier of reasonably good frequency response—say, to 30 or 40,000 cps—and low output resistance, a speaker system whose response extends smoothly out to 15 or 20,000 cps should be completely adequate. Examination of most speaker response curves shows numerous peaks which have a detrimental effect on the transient response. Future development in high-quality speakers should apparently be directed toward smoothing the response rather than extending it.

One naturally wonders why such outstanding results are experienced with amplifiers, like the Williamson, whose responses extend to around 100,000 cps. We can only assume that it is not the frequency response but rather the low distortion and good speaker damping that accompany it, to which the improvement may be ascribed.

#### Phonograph Pickups

Phonograph pickups generally have a fairly flat frequency response at lower frequencies, rising to a peak at the point of needle resonance and dropping off rapidly above it. Here again the damping coefficient determines the height of the peak. The damping is partially regulated with the aid of resilient damping blocks, but it is also affected by the material of which the record is made, the shape of its grooves, and the weight that is placed on the pickup head. In what follows the damping coefficient will be considered fixed for a given cartridge, which implies that the uncontrolled variables are the same for all discs. This is not strictly true in practice, and the response curves obtained with a given pickup and various test records will have peaks of slightly different heights.

The maximum groove width of a microgroove record has been set by Columbia at .003 inches. *Figure* 10 shows a stylus with a tip radius of .001 inches resting in a groove of this width, and it can be seen that the stylus can move a short distance (.0075 inch) to either side of center before the spherical tip begins to encounter the edge of the groove: that is, before the groove begins to lose control of the stylus.

If the discs are cut at 200 lines per inch with grooves of the specified dimensions, the maximum displacement of the middle of the groove to either side of center can be .001 inch; at greater displacements adjacent grooves may run into each other. The effect of resonance is to cause the stylus to oscillate with a greater amplitude than that of the record groove. Before the groove loses control, therefore, the maximum deflection of the stylus from its center position can be .001 + .00075 = .00175 inches, or 4.86 db above .001 inches. To insure satisfactory tracking, therefore, the frequency response of the cartridge should have a resonant rise of no more than 4.86 db at the maximum frequency of interest. *Figure* 11 shows how the minimum frequency at which the resonance peak may be located is related to the height of the peak if the maximum recorded frequency extends to 15,000 cps, as is the case with most present-day commercial discs. Frequency records are customarily recorded at lower levels than commercial music discs, so a pickup that tracks on the former may not perform satisfactorily on the latter.

The actual motion of the stylus in the groove for a unit-step input to the recording microphone is shown in *Figs.* 12 and 13. In computing the data the response of the entire recording system was assumed to roll off at 6 db per octave above 15,000 cps. The stylus excursions of the pickup with the 14 db response peak are quite pronounced. Damped oscillations are excited not only by modulations of the record groove but also by particles of dust and other irregularities on the record, which act to produce a continuous noise output known as needle scratch. Needle scratch will obviously be much worse with a

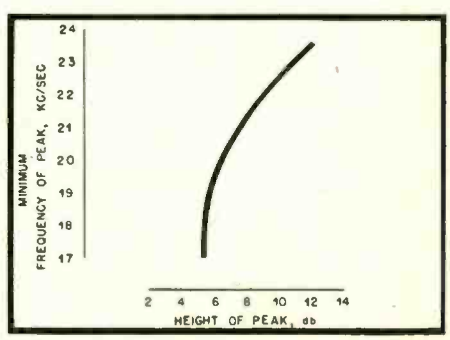



Fig. 11. Approximate location of stylus resonance peak for proper tracking on a disc recording frequencies up to 15000 cps.

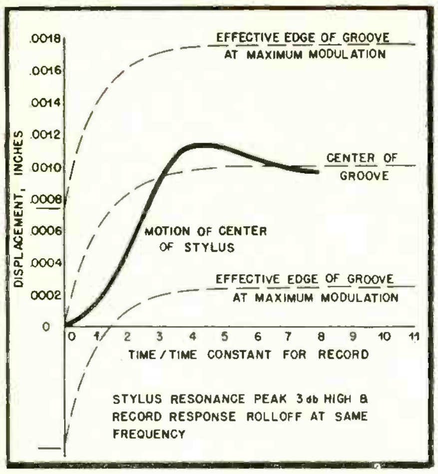



Fig. 12. Tracking of stylus in record groove.

pickup of poor damping than with one of good, so that the height of the frequency-response resonant peak is a measure of the needle scratch that will be experienced with the pickup. Crystal cartridges are generally not damped nearly so well as magnetic units and thus usually have a considerably higher scratch level.

### Frequency-Response Peaking

*Figures* 14 and 15 illustrate the frequency and transient responses of an amplifier whose frequency response drops off 12 db per octave above the turnover frequency. Also shown are response curves for an amplifier differing from the previous one only in that the frequency response goes through a peak 1.32 db high before the rolloff ($\zeta = 0.50$). The peaking results in a considerable improvement in the transient response. Where the frequency response of an amplifier or component is limited by uncontrollable conditions, the transient response will be improved by introducing a small peak of this type at the upper frequency limit. So long as the peaks are similar in shape the transient response is, of course, absolutely independent of the manner in which the peak is made to occur.

### Conclusion

One of the main purposes of this paper has been to emphasize a fact al-

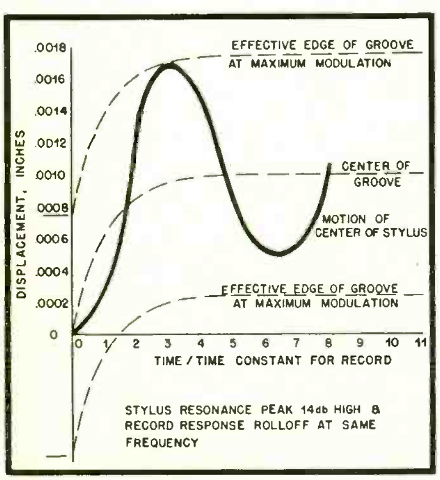



Fig. 13. Tracking of stylus in record groove for signal of greater amplitude than Fig. 12.

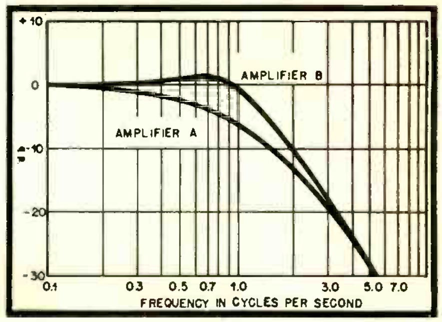



Fig. 14. Frequency responses of two typical amplifiers.

ready (but evidently not widely) known, namely, that transient response and frequency response are different expressions of the same thing. If the frequency response of a piece of audio equipment has been stated with sufficient accuracy, therefore, the transient response need not be separately described. The frequency response, as a matter of fact, gives a good deal more information about an audio component than has generally been appreciated; it is, for example, a better criterion of the tracking ability of a pickup than the result of any other test so far devised.

An attempt has also been made to establish, at least qualitatively, some requirements for amplifier and component responses upon a mathematical rather than an intuitive basis. The examples given in this paper have necessarily been rather brief and idealized; the fact that much more work can be done in the way of elaboration and refinement is readily recognized. Investigations of this type should pay rather rich dividends in pointing the way to improvements in many commercial components.

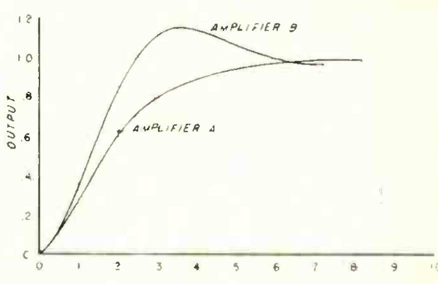



Fig. 15. Transient responses of the amplifiers used for Fig. 14.

## ERRATA

Howard Souther, Manager, Reproducing Components Division, Electro-Voice, Inc. calls our attention to two errors which appeared in John F. Wood's article "A New Wide-Range Phonograph Cartridge" in the December issue. In the first column of page 23, the formula should read:

$$e.m.f. = N \frac{d\theta}{dt}$$

and in the second column of page 52, the lateral compliance was incorrectly stated—the paragraph should read:

3. Lateral compliance should be 1.0 $\times 10^{-6}$ cm/dyne or higher, with maximum allowable . . .

# DECORATIVE

(*from page 27*)

a transcription arm more than 18 inches long. As shown in *Fig.* 9, the special design of the lift top has made possible installing this system into an enclosure that by comparison is only a fraction of the size a commercial unit would have to be. Note that the unit has retained its smart modern lines and is completely functional providing room for more than 300 LP records as well as space for books and magazines. *Figure* 10 illustrates the speaker enclosure mounting a special driver unit. This corner enclosure is located diagonally across the room from the equipment console in a room that only measures 12 × 16 ft.

**Traditional, Regency, Provincial?**

No task is harder than trying to add a cabinet of Traditional, Regency, or Provincial design into a room of family heirlooms rich in their own period and placed as if the room were built for them. Mixing a new cabinet that does not actually have any period into such a room, is like painting one wall bright red and hanging a loud bell that rings every five minutes. It just won't work. The commercially available hi-fi furniture of a particular period may fit, but only in a limited number of situations. What is the answer? Simply this, rebuild an existing piece of furniture to house the equipment. Most speaker manufacturers do make speaker enclosures that are of a quality and style that will permit adding them to existing room schemes based on traditional periods of various types. Though limited in selection, the number available is such that the problem of housing the speaker is nothing compared to the problem of housing the equipment. Perhaps you do not have a particular article of furniture that can be altered to house a system. If this is the case, a suitable piece can be obtained from your regular furniture house or, an Antique dealer may have just the piece you would like and chances are it is reasonable enough, if your tastes do not run toward collectors items. Modification or conversion of an average furniture piece can be quite reasonable, as little as $35 or as high as $100 to $250 depending upon the piece.

Selection of a piece of period furniture is limited by two important factors—internal dimensions and physical design. The latter is most important, for if the physical design consists mainly of drawers and long carved or turned legs, conversion is impractical as there is very little volume within the cabinet to house a system, This type of cabinet is called "case goods" by the cabinet-maker trade. Some types of case goods are massive and have very small legs or feet supporting them, however, they are also undesirable as the numerous drawers are fitted into an endless amount of cross bars and braces which are difficult to remove without weakening the entire

Fig. 11. An "old-timer" brought up to date. An early Electrola cabinet modified to house a radio tuner, amplifier, and transcription turntable. (Photo by the author)

**Fig. 12. A complete music system from pickup to tape recorder, with a corner bass-reflex speaker enclosure adjacent. Styled in Early American Colonial accented with Dutch influence, this unit is quite compact, measuring 48 in. wide, 42 in. high, and 24 in. deep. See chart of minimum dimensions, Table 1.**

structure. Other units which fall into the case goods category are: chests, commodes, dressers, buffets, bureaus, highboys, lowboys, desks, and vanities. Some of the units listed may have been made with two or four doors, without any drawers; those listed as undesirable are supposedly fitted with drawers. The commode and some chests have been successfully converted, but they usually had one or two drawers on the bottom with ample space behind a pair of doors.

The average furniture piece that is easily converted was usually designed for dining rooms. Once modified, they blend very nicely into living rooms or dens. The types most commonly used are Dutch "dry sinks," breakfronts, credenzas, and sideboards. A nice old-fashioned clothes press is large enough to house an entire system with a 24-inch television screen. For small apartments, end-table-type commodes are ideal. Another type simple to convert is the corner cupboard, some of which will effectively house a loudspeaker too. For speaker units alone, the corner or book-case commode (small type 30 in. high) is good; the interior can be braced easily or can be rebuilt to conform to most types of enclosure design. Front doors can be reinforced, replacing the solid wood panel with brass grille or, they can be secured as a solid front of the enclosure if the rear of the cabinet is used as an access for the speaker.

Another example of how to solve this problem of traditional cabinetry is shown in *Fig.* 12. Using a cabinet of a real "old-timer"—the Electrola—(this was when equipment was more expensive than furniture), a complete music system was installed with little modification. A new motorboard for the transcription arm and turntable and a matching panel to mount the radio tuner in the former speaker compartment were the only changes. The power amplifier is set into an unobtrusive corner at the bottom of the cabinet. The loudspeaker is wall-mounted in another part of the room.

Before making a final decision re-

**TABLE 1**
**MINIMUM CABINET SPACE REQUIREMENTS**
**(in inches)**
**for average high-fidelity components**

| Component | Height | Depth | Width |
|---|---|---|---|
| FM tuners | 15 | 12 | 11 |
| AM-FM tuners | 16 | 12 | 12 |
| Amplifiers—one chassis | 17¼ | 12 | 10 |
| Amplifiers—two chassis | 17½ | 16 | 15 |
| Record changers | 16½ | 16 | 14 |
| Manual record players | 21¼ | 16½ | 14 |
| Tape recorders | | | |
| mounted vertically | 21 | 16 | 16 |
| mounted horizontally | 22½ | 16 | 14 |
| TV chassis—up to 17-in. | 24 | 24 | 24 |
| TV chassis—up to 27-in. | 32 | 24 | 27 |
| 10-in. record storage | *** | 12½ | 11 |
| 12-in. record storage | *** | 14½ | 13 |
| 7-in. tape storage | *** | 8 | 8 |
| 10½-in. tape storage | *** | 11½ | 11½ |

* Calculated for Magnecordette and smaller units

** Calculated for Concertone 1500 series and smaller units

*** Width depends upon existing or contemplated record or tape collection. Average LP album is roughly 0.7 in. wide. Single LP record will fit about 7 to the inch; 78 r.p.m. albums measure from one-half to two inches. The width of tape boxes is roughly ⅝ in. for the 7-in. reel and ⅞ in. for the 10½-in. reel.

garding a furniture piece, check the internal dimensions to make sure that they will be adequate to house the various components of the music system. Inspect the unit thoroughly to determine whether the radio tuner, amplifier, and record changer can be mounted on a single shelf across or possibly one atop the other. Perhaps the unit is deep enough to mount a radio tuner with all control facilities into a panel with a basic power amplifier behind it. Some units may have ample space to house a system from pickup to speaker; others may just be large enough for the components without the speaker. An ideal unit should permit mounting the equipment high enough to operate the controls from a sitting or standing position. If compromises are to be made, the radio tuner and/or amplifier controls should be up high, the record changer, which is usually loaded and set just once for 8 or 10 records can be mounted into a lower section of the cabinet with a minimum of inconvenience. A manual record player (using a transcription arm and turntable) should be mounted in the upper part of the cabinet, preferably under a lift lid or on a base mounted on good quality ball-bearing slides. Do not hesitate to mount the radio tuner and/or amplifier with the controls and dial facing up in a horizontal plane, vacuum tubes are designed for mounting in any position, even upside-down if necessary. Also, most types of radio dial stringing will permit normal operation with the dial in both a vertical and horizontal plane. The accompanying chart lists space requirements for the average components. In addition, ample provision for ventilation must be made.

The simplest style—and also about the least expensive—of traditional cabinetry to custom build is the Early American or Dutch Colonial. *Figure* 13 shows a unit made of cherry wood patterned in Early American. The speaker enclosure, a rear-loaded bass-reflex design depicts an Early American corner commode. Note that a complete system from record player to television, including a tape recorder is housed in this comparatively compact enclosure, 42 in. high, 48 in. wide, and 24 in. deep.

If the traditional cabinet were simple in design, requiring very little carved trim and inlay work, the average cabinet-maker can easily make a reproduction for a price that is within reason. It is the heavily carved and inlaid period pieces which are costly and require a skill found only among expensive cabinet-craftsmen. Unless a great deal of patience, effort, and money are expended, a custom-made cabinet in one of the many early American and European periods is not practical. It can still be lots more fun and lots cheaper to make the rounds of the used furniture or antique dealers.

# CORNER HORN

*(from page 21)*

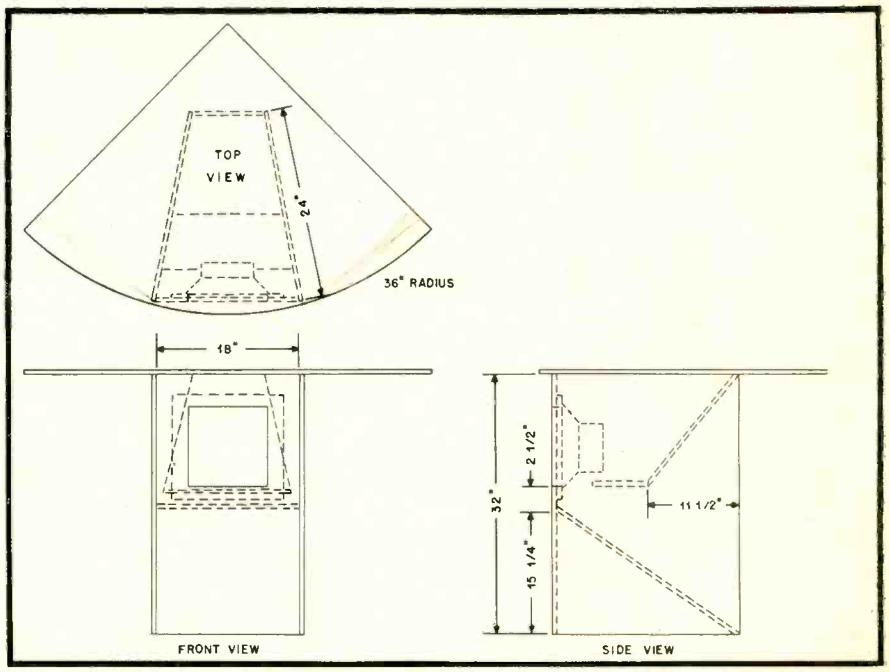



**Fig. 2. These three views show the general makeup and major dimensions of the enclosure. Dimension details can be changed to suit other speakers.**

frequency range from 30 to 400 cps.

A rule of thumb procedure for checking the damping of a loudspeaker consists of starting and stopping a small electric current through the voice coil. After the circuit is *closed* the speaker is subject to heavy electrical damping in addition to mechanical and acoustic damping. After the circuit is *broken* an open circuit exists and the damping is exclusively mechanical and acoustic. The difference in sound, if any, provides some indication of the coupling between the cone and the air. Using a single dry-cell as a current source, this test was applied repeatedly to the corner horn enclosure and no audible difference between *make* and *break* was found. It was inferred, therefore, that the damping was adequate and that transient response would be satisfactory. The latter conclusion was substantiated by listening tests. One simple test is to listen to a *good* recording of percussion instruments. Bartok's *Sonata for Two Pianos and Percussion* (Victor) is satisfactory for this purpose.

No finite horn, no matter how carefully designed and constructed, is completely free from resonance phenomena. The horn which has been described exhibits a slight resonance and this is shown by the shape of the impedance curves of *Fig.* 6. There are two humps in the impedance curve where the impedance rises about 30 per cent above the nominal voice-coil impedance. The two humps are nearly symmetrical about the free-cone resonant frequency. This suggests that the resonance frequencies of horn and driver are the same, a desirable condition. There was no deliberate attempt to bring about this desirable state of affairs, the curves just came out that way.

If the horn is used in conjunction with drivers for low-frequency reproduction only, it may be expected that the resonant frequency of the driver may be somewhat lower than for the one shown. If so, a slight readjustment of the internal panels may be desirable. It is for this reason some of the internal dimensions have been omitted. For example, slight changes in construction will per-

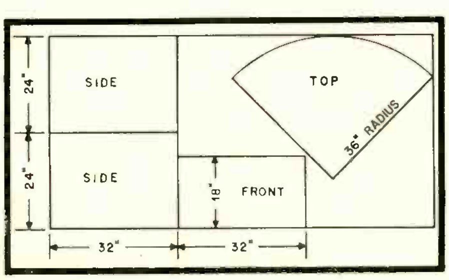



**Fig. 4. How to cut all the main panels from a single 4×8-foot sheet of plywood.**

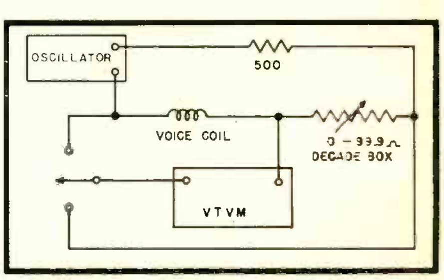



**Fig. 5. Circuit used for impedance measurements. At each frequency the decade resistance is adjusted for similar voltmeter readings in both switch positions. The resistance is then equal to the absolute value of voice-coil impedance.**

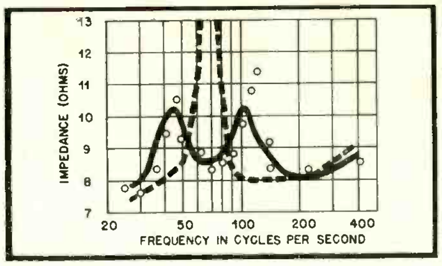



Fig. 6. The solid line shows the impedance curve of the GE speaker in the enclosure, with fiberglas completely filling the space behind the driver. The dots show irregularities which occur when the fiberglas is absent. The dashed line shows impedance peak of the driver without an enclosure.

mit the use of a 15-inch driver. Under such circumstances the throat area is easily increased, with a consequent decrease in horn length. Fortunately, the design of the enclosure is such that changes of this type are easily made after construction is nearly complete.[1]

[1] Apparently not all General Electric Model S1201-D cones have the same resonant frequency. If a driver of different resonant frequency is used it should not be expected that the impedance curves will be identical to the ones shown in *Fig.* 6. However, if the fluctuations in impedance with frequency are not severe, good results may be anticipated.

## BOOK REVIEW

(*from page 14*)

descriptions of tube structure, operating characteristics, and application of both "rimlock" and noval base tubes. An addendum lists a variety of test equipment along with operating data and skeleton circuits. —*Lewis S. Goodfriend*

ELECTRONIC ORGANS, by Robert L. Eby. Wheaton, Ill.: Van Kampen Press, Inc. 213 pages, illustrated, 1953. $5.00.

There is certainly room in the technical literature for a modern book covering principles and practices in the growing field of electrical and electronic organs. While Mr. Eby's book is not as thorough in its treatment of the subject as might be desired and appears to be a guide more for the purchaser of organs than for designers and builders, it gives a great deal of useful information about the organs of six American manufacturers. These are: Allen, Baldwin, Conn, Hammond, Minshall, and Wurlitzer. There are also brief descriptions of the Lowrey Organo, the Michigan Pedal-Vox, Hammond Solovox, Haygren Electronic Harp, and some discontinued types and models.

In the case of each major brand, the book gives fairly superficial explanations of the principles, with, in some cases, block diagrams and schematics (no parts values). This is followed by catalog-type descriptions of the various models, and installation data.

While it is doubtful that technically minded readers will cull much information from Mr. Eby's book, prospective organ buyers and others who desire a first look at the field as a whole will be interested in this glimpse of a fascinating and constantly growing facet of the electronic art. —*Richard H. Dorf*

# Exhibitors and Papers at the AUDIO FAIR—LOS ANGELES

THE SECOND ANNUAL Audio Fair—Los Angeles will be held in the Hotel Alexandria February 4, 5, and 6. The magic word "hi-fi" is expected to draw a record crowd. With this in mind, approximately 83 manufacturers of audio equipment are participating in the largest exhibition of high-fidelity sound-reproduction equipment ever to hit the Pacific Coast. Exhibit space has been doubled over that of last year, and the Fair will ocupy the hotel ballroom and four floors.

The part that audio aids are playing in modern education will receive special emphasis at the 1954 Fair. Another feature will be hearing tests for all Fair-goers by Los Angeles State College educators. There will also be a display of the work currently being done by L.A.S.C. in audiometry.

Moving rapidly into the mass consumer market, the hi-fi industry expects to sell between 200 and 300 million dollars worth of high-fidelity phonograph and audio components this year. Sales of components for home installations, according to predictions, should pass the 100-million-dollar mark.

The admission-free show is sponsored by the Audio Engineering Society.

| EXHIBITOR | ROOM |
|---|---|
| Acousticraft | 402 |
| Altec Lansing Corp. | 521 |
| American Microphone Co. | 459 |
| Ampex Corporation | 412 |
| Angel Records | 532 |
| Angle Genesee | 463 |
| Audio Devices, Inc. | 565 |
| Audio Engineering Society | 578 |
| Audio Exchange | 532 |
| The Audio Fair—Los Angeles, Inc. | 566 |
| A-V Tape Libraries, Inc. | 587 |
| Benjamin Sound Co. | 308 |
| Bell Sound Systems, Inc. | 409 |
| Berlant Associates | 581 |
| David Bogen Co., Inc. | 512 |
| British Industries Corp. | 315-318 |
| Brook Electronics, Inc. | 448 |
| Bushnell Electronics | 442 |
| Califone Corp. | 501 |
| California Record Dist. | 429 |
| Capitol Records, Inc. | 505 |
| Columbia Records, Inc. | 540 |
| Conrac, Inc. | 515 |
| Craig Movie Supply Co. | 449 |
| Crawfords, Inc. | 407 |
| Crestwood Record Div. | 561 |
| Electro-Voice, Inc. | 479 |
| Fairchild Recording Eqpt. Corp. | 343 |
| Ferranti Electric, Inc. | 481 |
| Fisher Radio Corp. | 481 |
| Gates Radio Co. | 534 |
| Gateway To Music | 557 |
| General Electric Co. | 579 |
| High-Fidelity House | 309 |
| High Fidelity Magazine | 443 |
| Hollywood Electronics | 486 |
| Jensen Mfg. Co. | 560 |
| Karlson Associates, Inc. | 548 |
| The Kelton Co., Inc. | 440 |
| Kierulff Sound Corp. | 586 |
| Paul Klipsch & Associates | 406 |
| Koessler Sales Co. | 401 |
| James B. Lansing Sound, Inc. | 460 |
| Los Angeles State College | 330 |
| Magnecord, Inc. | 461 |
| Magnetic Recorders Co. | 439 |
| McIntosh Laboratory, Inc. | 456 |
| Mercury Scientific Products, Inc. | 501 |
| Minnesota Mining & Mfg. Co. | 441 |
| Minthorne Music Co. | 506 |
| Mitchell Mfg. Co. | 328 |
| Newcomb Audio Products Co. | 584-585 |
| Pacific 'Hi Fi' Center | 314 |
| Penny-Owsley Music Co. | 418 |
| The Pentron Corp. | 447 |
| Perlmuth-Colman Associates | 528-529 |
| Pickering & Co., Inc. | 379 |
| Pilot Radio Corp. | 415 |
| Precision Electronics, Inc. | 563 |
| The 'Press' | 539 |
| Radio Corp. of America | Assembly Room |
| The Radio Craftsmen, Inc. | 487 |
| Radio Magazines, Inc. | 543 |
| Radio Products Sales Co. | 556 |
| Radio & Television News | 502 |
| Rauland-Borg Corp. | 536 |

## LIST OF EXHIBITORS

| | |
|---|---|
| Reeves Soundcraft Corp. | 457 |
| Regency Div.—I.D.E.A., Inc. | 518-520 |
| Rek-O-Kut Company | 550 |
| Revere Camera Company | 541 |
| River Edge Industries | 420 |
| Hermon Hosmer Scott, Inc. | 549 |
| Sonotone Corporation | 537 |
| L. J. Smith Company | 485 |
| Stephens Mfg. Corp. | 421 |
| Stromberg-Carlson Co. | 414 |
| Sues, Young & Brown, Inc. | 337 |
| The Tetrad Company | 320 |
| Thorens Company | 450 |
| Tung-Sol Electric, Inc. | 436 |
| The Turntable | 547 |
| T & W Electronic Consultants | 542 |
| Universal Radio Supply Co. | 514 |
| University Loudspeakers | 509 |
| Utah Radio Products Co., Inc. | 405 |
| V-M Corporation | 538 |
| Waldon Associates | 547 |
| Weathers Industries | 465 |
| Webster-Chicago Corp. | 559 |
| Westminster Recording Co., Inc. | 428 |

## PAPERS TO BE PRESENTED

The following papers will be presented during the Fair:

MONOGROOVE STEREOPHONIC DISC RECORDING, by John T. Mullin, Bing Crosby Enterprises, Hollywood, Calif.

THE TOWER OF AUDIO, by John T. Mullin.

A VERSATILE AUDIO FREQUENCY OSCILLATOR, by C. L. Stephens, Allison Laboratories, Puente, Calif.

A POWER AMPLIFIER CAPABLE OF PROVIDING OPTIMUM DAMPING FOR LOUDSPEAKERS, by G. H. Grey and G. W. Downs.

THE MECHANICS OF GOOD LOUDSPEAKER DESIGN, by Abraham B. Cohen, University Loudspeakers, Inc., White Plains, N. Y.

SURVEY OF FLUX RESPONSIVE MAGNETIC REPRODUCING HEADS, by Otto Kornei, Clevite-Brush Development Co., Cleveland, Ohio.

A UNIDIRECTIONAL MICROPHONE UTILIZING A VARIABLE DISTANCE BETWEEN THE FRONT AND BACK OF THE DIAPHRAGM, by A. M. Wiggins, Electro-Voice, Inc., Buchanan, Mich.

MOTION PICTURE SOUND RECORDING AT USAF LOOKOUT MOUNTAIN LABORATORY, by Howard Tremaine.

A NEW PROFESSIONAL QUARTER-INCH TAPE RECORDER REPRODUCER, by William V. Stancil, Stancil-Hoffman Corp., Hollywood, Calif.

A CRITICAL ANALYSIS OF FEEDBACK ACTION, by Harold Klimpel.

THE FLOATING DIAPHRAGM AS A LOW FREQUENCY RADIATOR, by William C. Benjamin, William C. Benjamin Sound Co., Mt. View, Calif.

ETCHED CIRCUITS FOR AUDIO, by K. B. Howard, Tri-Dex Electronics.

PRACTICAL CONSIDERATIONS IN THE EQUALIZATION OF MAGNETIC RECORDERS, by Richard Hoskin, Berlant Associates, Los Angeles, Calif.

SEQUENTIAL RECORDING WITH ONE TAPE RECORDER, by Richard Hoskin.

force. The Weathers pickup is of this type.

3. Another pickup that requires an auxiliary oscillator is the Zenith "Cobra,"[8] but in this case the carrier is amplitude modulated. The stylus varies the distance and the mutual inductance between a resistive vane and a coil, varying the resistance reflected into the coil.

4. Pickups have also been designed where the stylus is physically coupled to the anode of a diode vacuum-tube,[9] where the moving system makes use of magnetostriction effects,[10] and where the stylus motion is used to modulate a light beam. (The latter system was used in a pre-war Philco record player.)

### Styli

Phonograph styli, or needles, normally have spherical tips designed to fit into the record groove in the manned illustrated in *Fig.* 16—1. The radius of the stylus tip is .001 inches for microgroove records, and from .0025 to .003 inches for 78 r.p.m. records.

The requirement of minimum vertical response for a pickup may be fulfilled by the design of the stylus assembly, which can be given such high vertical compliance as to take up vertical motion in itself rather than transmitting such motion to the generating element. The stylus should, however, have maximum lateral rigidity, so that none of the groove modulation of the tip is short-circuited in the distributed compliance of the stylus shank (see *Fig.* 16—4), and it should also have maximum rigidity along the line of the vibration axis of the pickup, in order not to introduce needle drag distortion.

The material of the stylus tip must be resistant to wear and capable of high polish. It is generally considered at present that diamond is the best, and, in the long run, the cheapest of stylus materials. The wear conditions of three styli, made of diamond, sapphire, and osmium, are illustrated in *Fig.* 16—9. Diamond and sapphire styli went out of fashion in the first decades of the twentieth century, but have returned to popularity in recent years.

#### References

B. B. Bauer, "Tracking angle in phonograph pickups," *Electronics*, March, 1945, p. 110.

John G. Frayne and Halley Wolfe, *Elements of Sound Recording*, John Wiley and Sons, Inc., N. Y., 1949, pp. 239–261.

Harry F. Olson, *Elements of Acoustical Engineering*, D. Van Nostrand Co., Inc., 2nd ed., 1947, pp. 303–318.

F. Langford Smith, editor, *Radiotron Designer's Handbook, 4th Ed.*, RCA, Harrison, N. J., 1952, pp. 706–727.

E. S. Mallet, "The determination of gramophone pickup tracking weights," *Electronic Engineering*, May, 1950, p. 196.

[8] Henry P. Kalmus, "Pickup with low mechanical impedance," *Electronics*, Jan., 1946, p. 140.

[9] H. F. Olson and J. Preston, "Electron tube phonograph pickup," AUDIO ENGINEERING, Aug., 1948, p. 17.

[10] Stanley R. Rich, "Torsional magnetostriction pickup," *Electronics*, June, 1946, p. 107.

# Industry Notes ...

Nostalgic to audio old-timers is the announcement that **Pilot Radio Corporation** will place emphasis on broadcast advertising in its 1954 merchandising campaign. Remindful of the days when such names as **Freshman, Eveready, Majestic,** and **Atwater Kent** dominated the airwaves, **Pilot** has just signed a 52-week contract with New York's WQXR. Both high fidelity components and complete matched systems will be featured in commercial copy. **Geller and Berger, Inc., Pilot's** advertising agency, will supervise with Alfred Paul Berger as account executive.

**Thorens Company,** sole U. S. distributors for **Thorens S. A.,** Switzerland, manufacturers of sound reproduction equipment and musical instruments, has just completed a new warehouse and general office building at New Hyde Park, N. Y. Facilities include a laboratory and sound demonstration room . . . **Allen D. Cardwell Manufacturing Corp.,** pioneer manufacturer of electronic equipment, has been purchased by **Chesapeake Industries, Inc.** Cardwell president Ralph H. Soby will be retained as head of the company and no change in management policy is contemplated. Among other **Chesapeake** subsidiaries are **Pathe Laboratories, Inc.,** of New York and Hollywood, and **Television Center, Inc.,** New York.

# Industry People ...

**Louis Shappe,** president of Shappe, Wilkes, Gilbert & Groden, Inc., New York advertising agency, is back at his desk after an illness of several months—has resumed his post as administrative read of the agency in addition to personally servicing a number of accounts . . . Genial **Ed Cornfield,** than whom there is no one better liked in the electronics industry, has joined Pilot Radio Corporation as sales manager . . . **Gil Demsky,** formerly a member of Harvey Radio Company sales staff, has joined Music Age, Inc., Paramus, N. J., as high fidelity consultant. . . . **Jerry Greenberg** has joined the firm of Adolph L. Gross Associates, Inc., New York, as vice-president . . . **Jules J. Bressler** and **Grant Shaffer** have been appointed manufacturer's representatives for Metropolitan New York and the State of Michigan, respectively, by ORRadio Industries, Inc., makers of Irish brand magnetic recording tape . . . Industry friends offering deepest sympathy to **Charles Shankman,** president, Peerless Radio Distributors, Inc., Jamaica, N. Y., on the death of his mother January 8.

## ADVERTISING INDEX

# NEW "M" TYPE TOROIDS Maximum Q Minimum Size

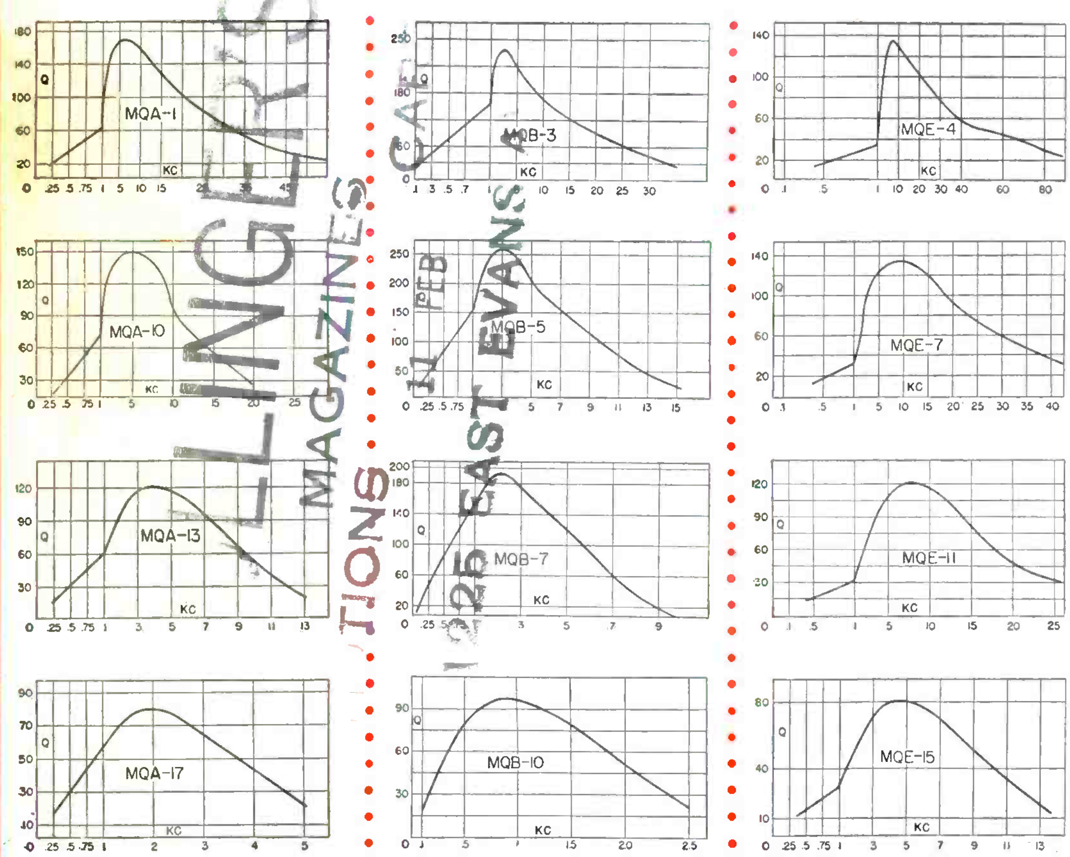
**UTC Permalloy Dust Toroids** have been the standard of the industry for over 15 years. The **MQ series** of coils provide the highest Q factor in their class (see curves below), with miniaturized dimensions. All units are **hermetically sealed** to MIL-T-27 Specifications.

The **stability** is excellent. For the MQE-7 the inductance change is less than 1% for voltages from .1 to 3 volts. The MQA-13 change is less than 1% for applied voltages from .1 to 20 volts. The MQB-5 change is less than 1% for applied voltages from .1 to 50 volts. DC is permissible through the coil (values listed below). Inductance is virtually independent of frequency temperature and vibration.

**Hum pickup** is extremely low due to the toroidal winding structure, with windings uniformly spread over the core. The case is of high permeability, affording additional shielding such that close spacing of units can be effected, the coupling attenuation being approximately 80 DB.

**Other values of inductance** than those listed are available on special order at the price of the next higher listed value.

## TYPICAL Q CURVES




### MQA TYPES

| Type No. | Inductance | *DC Max |
|---|---|---|
| MQA-1 | 7 mhy. | 250 |
| MQA-2 | 12 mhy. | 200 |
| MQA-3 | 20 mhy. | 150 |
| MQA-4 | 30 mhy. | 125 |
| MQA-5 | 50 mhy. | 100 |
| MQA-6 | 70 mhy. | 80 |
| MQA-7 | 120 mhy. | 60 |
| MQA-8 | .2 hy. | 50 |
| MQA-9 | .3 hy. | 40 |
| MQA-10 | .5 hy. | 30 |
| MQA-11 | .7 hy. | 25 |
| MQA-12 | 1 hy. | 20 |
| MQA-13 | 1.5 hy. | 17 |
| MQA-14 | 2.5 hy. | 13 |
| MQA-15 | 4 hy. | 10 |
| MQA-16 | 6 hy. | 9 |
| MQA-17 | 10 hy. | 7 |
| MQA-18 | 15 hy. | 5 |
| MQA-19 | 22 hy. | 4 |

*This value of D.C. (MA) will drop the coil inductance 5%. Values of D.C. below this will show proportionately (linear) less inductance drop. For example, MQE-1 will drop ½% in L with 13.5 MA.

### MQB TYPES

| Type No. | Inductance | *DC Max. |
|---|---|---|
| MQB-1 | 10 mhy. | 400 |
| MQB-2 | 30 mhy. | 250 |
| MQB-3 | 70 mhy. | 170 |
| MQB-4 | 120 mhy. | 120 |
| MQB-5 | .5 hy. | 60 |
| MQB-6 | 1 hy. | 40 |
| MQB-7 | 2 hy. | 30 |
| MQB-8 | 3.5 hy. | 22 |
| MQB-9 | 7.5 hy. | 16 |
| MQB-10 | 12 hy. | 11 |
| MQB-11 | 18 hy. | 9 |
| MQB-12 | 25 hy. | 8 |

### MQE TYPES

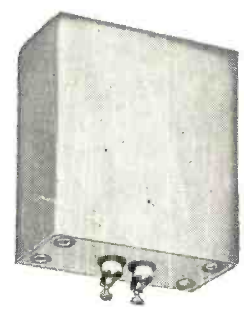
| Type No. | Inductance | *DC Max. |
|---|---|---|
| MQE-1 | 7 mhy. | 135 |
| MQE-2 | 12 mhy. | 100 |
| MQE-3 | 20 mhy. | 80 |
| MQE-4 | 30 mhy. | 65 |
| MQE-5 | 50 mhy. | 50 |
| MQE-6 | 70 mhy. | 40 |
| MQE-7 | 100 mhy. | 35 |
| MQE-8 | 150 mhy. | 30 |
| MQE-9 | .25 hy. | 22 |
| MQE-10 | .4 hy. | 17 |
| MQE-11 | .6 hy. | 14 |
| MQE-12 | .9 hy. | 12 |
| MQE-13 | 1.5 hy. | 9 |
| MQE-14 | 2 hy. | 8 |
| MQE-15 | 2.8 hy. | 7.2 |

**MQE CASE**

Length ............ 1 1/16"
Width ............ 1/2"
Height ............ 17/32"
Unit Weight ............ 1.5 oz.

**MQA CASE**

Length ............ 1 9/32"
Width ............ 1 1/16"
Height ............ 1 23/32"
Unit Weight ............ 4 oz.



**MQB CASE**

Length ............ 2 9/16"
Width ............ 1 13/16"
Height ............ 2 13/16"
Unit Weight ............ 14 oz.

## United Transformer Co.

150 VARICK STREET NEW YORK 13, N. Y.

EXPORT DIVISION: 13 EAST 40th STREET, NEW YORK 16, N. Y., CABLES: "ARLAB"