Preamp with "Presence" - See page 23

AUDIO ENGINEERING

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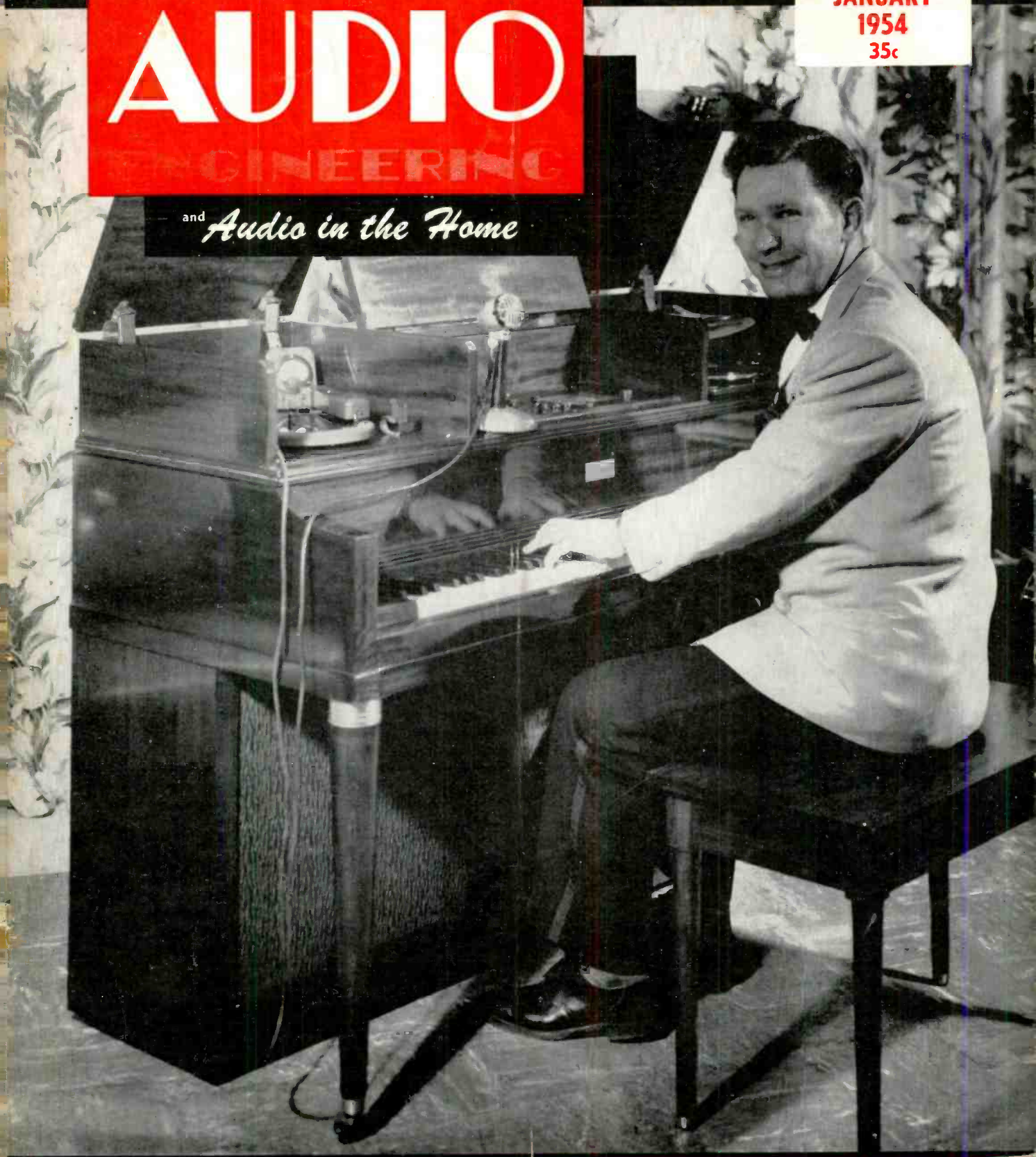
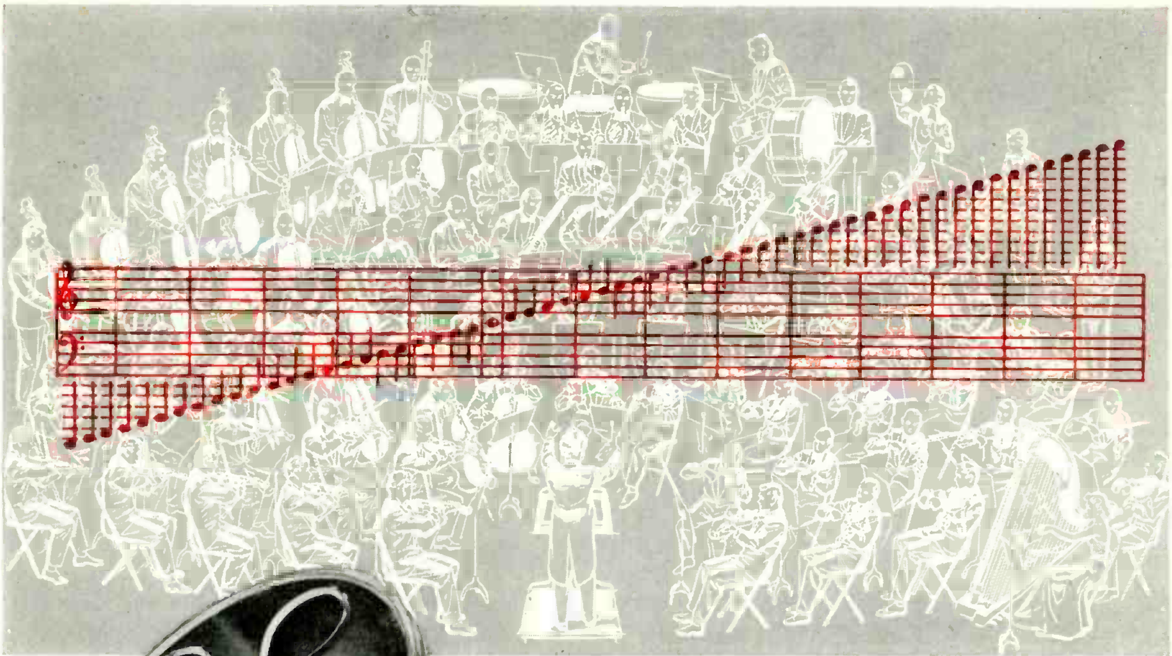
JANUARY 1954
35c



THE WORLD OF SOUND



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CONTENTS

JANUARY, 1954 — Vol. 38, No. 1

COVER

The piano that sounds like an orchestra, yet needs only one man to operate. Thus reads the headline of a flyer released by the manufacturer of the instrument, Trio-Art Piano Company, of Philadelphia. The device incorporates a record changer, an FM tuner, and a disc recorder, any or all of which may be used with the piano for a variety of purposes. The instrument was developed by Louis Luberoff, president of the company, and the photo features professional pianist Milton Bugay.

RADIO MAGAZINES, INC., P. O. BOX 629, MINEOLA, N. Y.

AUDIO ENGINEERING (title registered U. S. Pat. Off.) is published monthly at 10 McGovern Avenue, Lancaster, Pa. by Radio Magazines, Inc., Henry A. Schober, President; C. G. McProud, Secretary. Executive and Editorial Offices: 204 Front St., Mineola, N. Y. Subscription rates—United States, U. S. Possessions and Canada, $3.00 for 1 year, $5.00 for 2 years; elsewhere $4.00 per year. Single copies 35c. Printed in U. S. A. Entered as Second Class Matter February 9, 1950, at the Post Office, Lancaster, Pa. under the Act of March 3, 1879.

AUDIO PATENTS

Richard H. Dorf*

DESPITE the perorations of such male feminists as anthropologist Ashley Montagu (we discount the female feminists since they are prejudiced) to the effect that the ladies are superior to the gentlemen, very few of the men interested in high-quality sound will dispute the assertion that the members of the supposedly gentler sex are less than adept at adjusting electronic apparatus for best results. A simple example is the tuning of a radio receiver or tuner. It does not really seem to much to ask that the signal be tuned to the center of the i.f. pass band so that we have no more distortion than necessary. Yet, the lady either gives the dial a careless flick, achieving a kind of hanging-onto-the-station's-coattails effect as we catch just a glimmer of the lower sideband, or if cautioned to the take-heed point she may spend several minutes tuning over the signal so slowly and carefully that lack of audio memory makes it impossible to recognize the right point when it comes.

Tuning "eyes" and meters don't seem to help. And if we supply a.f.c. she may continue to complain about the noise between stations—the loud rush on FM or the miscellaneous noises and whistles on AM.

Having begun this way, to give the male ego a boost, we must add in the interests of truth that many males (fortunately not those technically trained) suffer from the same disease and that many women do not. Nevertheless, a rather simple invention by B. S. Vilkomerson provides very nearly the same kind of bandswitch tuning for high-quality AM and FM receivers that we find on TV sets, eliminating all noise between stations and forcing the user either to tune to the center of the signal or hear nothing whatever. The patent number is 2,639,375 and it is assigned to RCA.

The scheme is quite simple and useful. When the receiver is tuned between stations or anywhere but at the almost exact center of a signal the audio system in the receiver is inoperative. It operates only when the receiver is tuned exactly right. If *Fig. 2* represents the bandpass characteristic of a wideband i.f. system, the r.f. stages and local oscillator must be so adjusted that the i.f. center or carrier frequency fall within the shaded area before the audio will come through.

Figure 1 illustrates schematically how the system works, using as illustration an AM detector circuit. It will be obvious that it can be used on FM as well, with some small alterations. *IFT* is the last i.f. transformer and the 6AT6 is the combined diode detector and first audio amplifier. The detector diode is D_1. In conjunction with the ordinarily filter components and potentiometer, it works in the usual way. The tube is cathode-biased by R_1, which is bypassed for audio by C_1.

The 6C4 is a bias control tube which works as part of the tuning-aid system. Its cathode is in shunt with that of the 6AT6, and its grid is connected through R_3 and R_2 to the combined cathodes. Normally, (ignoring diode D_2 for the moment) it is conducting heavily. This conduction current passes through R_1 in addition to the current drawn by the 6AT6; the combined currents cause a high enough voltage across R_1 to cut off the 6AT6.

The i.f. signal is connected to diode D_2 through a crystal whose series resonance frequency is equal to the center frequency of the i.f. pass band. It does not conduct unless a signal whose carrier is in the center of the pass band—that is, a signal which is accurately tuned—appears. When this happens and D_2 does conduct, its load is R_3, through which the rectified current passes in such direction as to make the diode end of the resistor negative. R_2-C_2 is a filter which eliminates audio-frequency variations from this rectified signal and passes to the grid of the 6C4 a practically pure d.c. voltage which is negative with respect to the cathodes.

Until this signal was properly tuned, the 6AT6, as we have said, was cut off by its

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

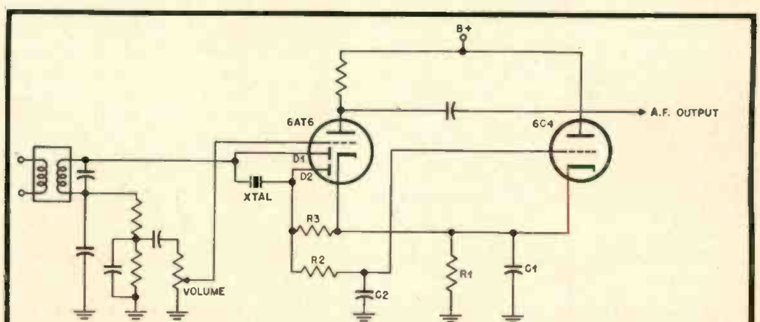
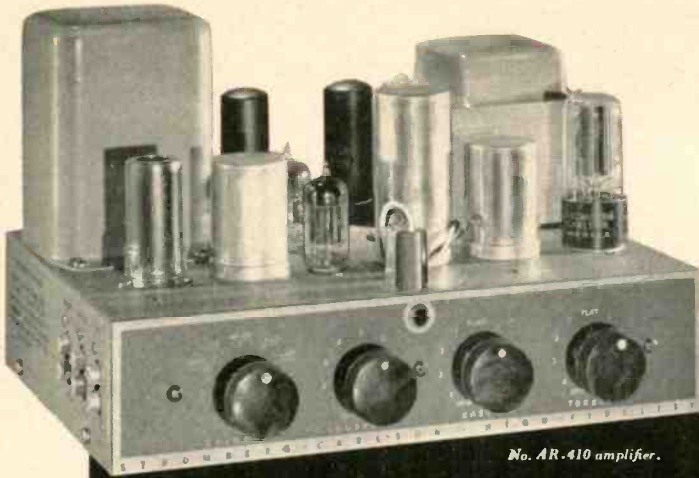


Fig. 1



No. AR-410 amplifier.

PARTIAL SPECIFICATIONS

POWER OUTPUT: 10 watts at less than 1% total harmonic distortion. Frequency response 20 to 20,000 cps. ±1 db.

HUM LEVEL: 70 db below full rated output. There is a hum balance control on the chassis.

REGULATION: Less than 2 db from no load to full load with a damping factor of 10:1.

PANEL CONTROLS: Treble Control and Power Switch: 12 db boost, 20 db droop at 10,000 cps. Bass Control: 15 db boost, 20 db droop at 30 cycles. Loudness Control: three section control to boost bass and treble as volume is decreased to follow the Fletcher-Munson curves.

INPUT SELECTOR SWITCH: 5 position: Microphone, Foreign Records, American Records, Radio, Auxiliary (television, tape recorder or crystal phono).

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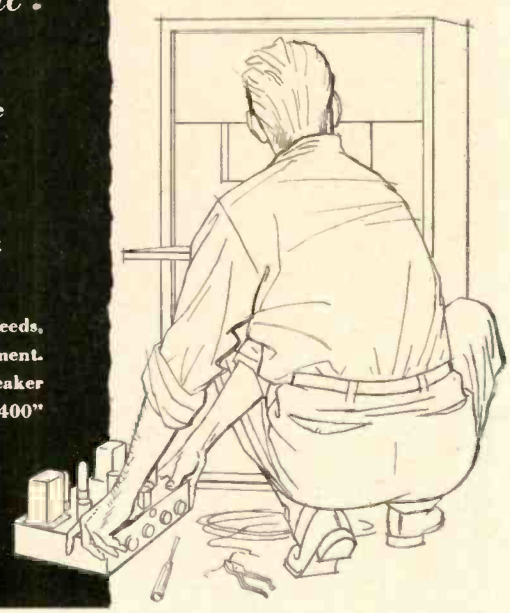

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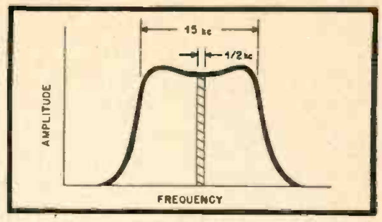


Fig. 2

high positive cathode voltage. In addition, both diodes were biased in the nonconducting direction by this same positive cathode voltage.

The small negative 6C4 grid voltage when D_2 first conducts begins to reduce the positive cathode voltage. That reduction reduces the diode bias, which in turn allows additional conduction of D_2 (and, of course, of signal diode D_1). The additional conduction of D_2 makes the 6C4 grid still more negative. There is, in other words, a sort of snowballing quasi-trigger action, so that as soon as the frequency is right and D_2 begins to conduct, the entire circuit very quickly reverts to a state where the 6C4 is almost cut off and the cathode voltage is reduced to the proper point for normal amplifier operation.

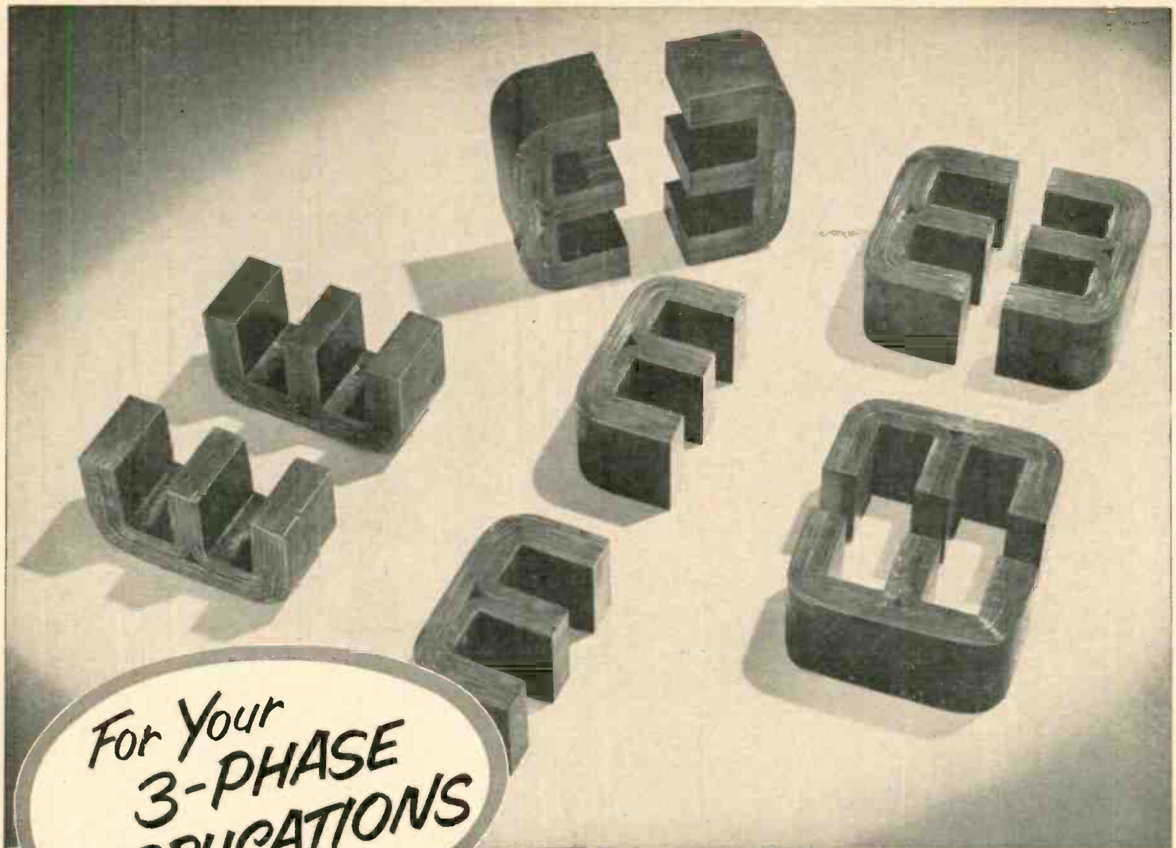
When Not to Patent

In these days of accelerated electronic development there are very few individual inventors—those not employed professionally at inventing or at least engineering—compared to 20 years ago and the earlier years when almost all inventions were made by individuals under their own steam. Still, the individual—often not an engineer or even a professional technician—very frequently does invent a new device or circuit, for the conception of an invention requires first an idea and only later, if at all, a facility with the slide rule. And all too often, the individual inventor's first thought is, "I'll get a patent!"

So he goes to a patent attorney. The attorney has a search made, singles out those aspects of the invention which are not precluded by "prior art," and prepares an application and drawings for the Patent Office. The Patent Office receives the application and after acknowledging and numbering it, goes on with its prior work until the examiner gets to the application of our inventor—which may take months because of the backlog. After looking over the application in detail, the examiner probably returns it to the attorney with comments indicating that all or nearly all the claims will be disallowed for this and that reason. If the inventor wants to proceed—and his attorney assures him, rightly, that things aren't as bad as they seem—the attorney rewords claims and specification and sends them back to the Patent Office. Again there is a wait, after which the examiner goes to work again, accepts certain claims, and disallows others. This ball-tossing can go on several times over quite a period. But after a time—almost never less than two years, often much more—things are settled and a patent is issued. This is so, provided no other parties have entered an interference in the Patent Office.

By this time the inventor has spent $300 or more on search, filing, draftsmen's and attorney's fees. If he has not succeeded in selling, leasing, or otherwise assigning rights to his invention, he is that much out of pocket; he has succeeded in cluttering up the Patent files with another specification and possibly in bolstering his ego—

(Continued on page 38)



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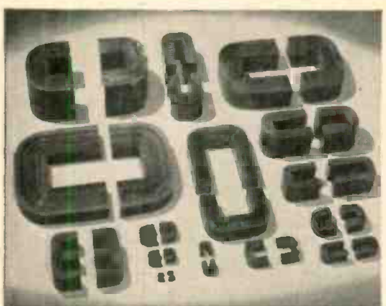

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London Letter

RICHARD ARBIB*

Tape recording enthusiasts in the U.S.A. who build up a library of tapes from programmes recorded over the air, would be envious of the wealth of transmissions of serious music which are available to the British listener.

In England, there is no commercial broadcasting. All the radio programmes are devised and transmitted by the Government controlled British Broadcasting Corporation. There are three main B.B.C. programmes which, during the daytime, can be received virtually free of interference in 90 per cent of the area of the British Isles. The Home Service is transmitted from 6:30 a.m. to 11 p.m., the Light Programme from 9 a.m. to midnight and the Third Programme from 6 p.m. to 11:30 p.m. Of these three programmes, it is the Third Programme which is specially devised to capture the interest of the lover of chamber music, operas, symphonies and all types of classical music.

50 Per Cent Serious Music

Analysis of the programmes recently issued by the B.B.C. shows that the Third Programme transmits 1,149 hours of serious music in a year out of a total transmission time of 2,167 hours. The Home Service had a serious music content of 18.2 per cent of its transmission hours. During the course of a year, the recording enthusiast who kept his receiver tuned to the Third Programme could transfer to tape practically any symphony, concerto, and chamber music written by any of the leading classical composers, and complete operas performed by many of Europe's greatest artistes. This is apart from the many programmes of instrumental music which are used to fill up at odd half hours. Many of the operas are either relays of performances from the great opera houses of the Continent, including those transmitted direct from the Bayreuth Festival at Salzburg, Austria, or high quality recordings made by European broadcasting organizations and loaned to the B.B.C.

Forty Different Programmes

If the recording enthusiast is not satisfied with the programmes transmitted from England, he can, in the evening, by twisting a dial on his tuner unit, put on to tape 30 or 40 different programmes from Continental stations.

However, there is one great snag for the hi-fi enthusiast. Owing to the hundreds of transmitters located in the Continent of Europe, there is, after dark, considerable interference from one with another. It is practically impossible in England, to obtain an entirely interference-free signal from the main B.B.C. transmitters. Once night has fallen the tape recordist often has to reduce top to tape a signal free from whistle.

There is only one B.B.C. transmitter operating on FM and this is an experimental one having a limited range. Music lovers heard with satisfaction the recent statement in the House of Commons by the Postmaster General that the B.B.C. were authorised to build a chain of FM stations but it may be a year or so before they provide the signals which are so eagerly awaited.

Recording enthusiasts in many of the leading cities overcome their difficulties by not taking the programme off the air at all. They join one of the many relay companies who pipe the B.B.C. programmes over wires to apartments or houses in the same way as the Electricity Companies distribute the current which lights and heats their homes.

Complete Operas without Breaks

Owing to the fact that an entirely interference-free signal can be obtained during the Summer, the serious music-minded tape recording enthusiast has got into the habit of recording his programmes in the Summer and listening to them in the Winter. It is, however, infuriating when one is undertaking a recording of a complete opera from Glyndebourne (the opera house built in a garden in Sussex, a Southern County of England) to obtain the first two acts with very high quality and the third act accompanied by a slight whistle. This all comes about because the performances during the six-weeks season in the Summer, commence at 5:30 in the afternoon and after an hour-and-a-half dinner interval, finish at 10:00 p.m. which is often half an

(Continued on page 37)

* *Multicore Solders Ltd., Hemel Hempstead, Hertfordshire.*

Reproduction of the original painting of "His Master's Voice" trade mark, by Francis Barraud. This painting is now kept in the Directors' dining room of Electric & Musical Industries Ltd. at Hayes, Middlesex.

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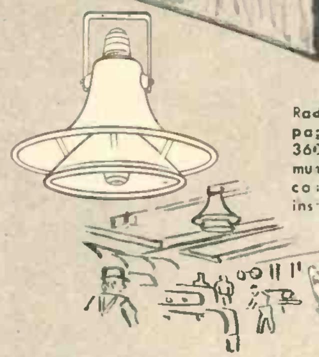
Whether the need is for music or voice, or both—for either indoor or outdoor use; whether in a fixed position in a factory or for mobile use on a vehicle, boat, train or airplane . . . there's a University speaker that can do the job best. ***Don't spend more for more than you need . . . CHECK UNIVERSITY FIRST!***



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LETTERS

Our European Correspondent

SIR:

The articles written by Edward Tatnall Canby, record critic, amateur economist, and third-rate world traveler, have dismayed me. I have taken a shower in many a European hotel and never had the maid follow me into the bathroom.

If things in Europe don't conform to what Mr. Canby is used to it is mostly because Europeans look for sound engineering and not a lot of chromium-plated gadgets. I believe European radios of good manufacturers can hold their own against anything produced in the U. S. Remember that the Ferranti pickup, the Telefunken microphone, and the Williamson amplifier are all products of old and doddering Europe.

G. VISSER,
c/o M. M. C.
Curacao, N. A.

SIR:

I wish to say that I especially appreciated Canby's fine write-up on his European trip, the one from Rome particularly. His fine understanding of what is truly real and important in life was refreshing!

HARVEY H. JESPERSON,
8012 Girard Ave.,
Lo Jolla, Calif.

When Is Equipment "Commercial"?

SIR:

Mr. Canby's analysis (November issue, page 34) of the conflict between craft-produced and mass-produced equipment was astute. I feel it was unfortunate, however, that he chose the word "commercial" to describe the mass-produced assemblies. Webster defines commercial as "executed for commercial purposes or pertaining to commerce or trade." And the patent license clause which was for so many years affixed to millions of mass-produced home radios stated that they were not sold for commercial purposes. Furthermore, some manufacturers who produce both "craft" and what Mr. Canby calls "commercial" gear also make a third line of equipment used in broadcast stations and for other definitely commercial purposes.

All of this suggests that some terminology other than "commercial" is needed to describe mass-produced equipment designed to bring better than average audio into the home. In fact, new terminology would be very useful to describe all three classes clearly.

Mr. Canby need not apologize for his promotion-mindedness. Those of us who are craft minded about this audio thing are going to need his word-mongering—and soon!

G. I. JONES,
Mgr., Electronic Sales,
Graybar Electric Co., Inc.,
420 Lexington Ave.,
New York 17, N. Y.

Crossover Networks

SIR:

It is stated in Mr. Crowhurst's article on constant-resistance crossover networks in the October issue of Æ that the total energy delivered to the speaker assembly must be constant. But this does not necessarily imply that the total acoustic energy remains constant. When the two cones move in anti-phase the sound pressures tend to cancel out, especially at the crossover frequency with the double-element filters. Both signals being equal and opposite, the resulting sound pressure will be zero.

When one of the speakers is reversed in phase the result is a 3-db rise in the crossover region. This is unconsciously done in the phasing of the system, the rise remaining unobserved, like the gradual phase change of 180 deg. from zero to infinite frequency.

Only the one-element system exhibits the correct feature of keeping the pressure-response curve straight even when one speaker is reversed. In the latter case there is also a phase shift of 180 deg. between zero and infinite frequency. Presumably this is not observable either, because transients undergo a deviation which decreases rapidly with time, the time constant being the reciprocal of the angular velocity of the crossover point.

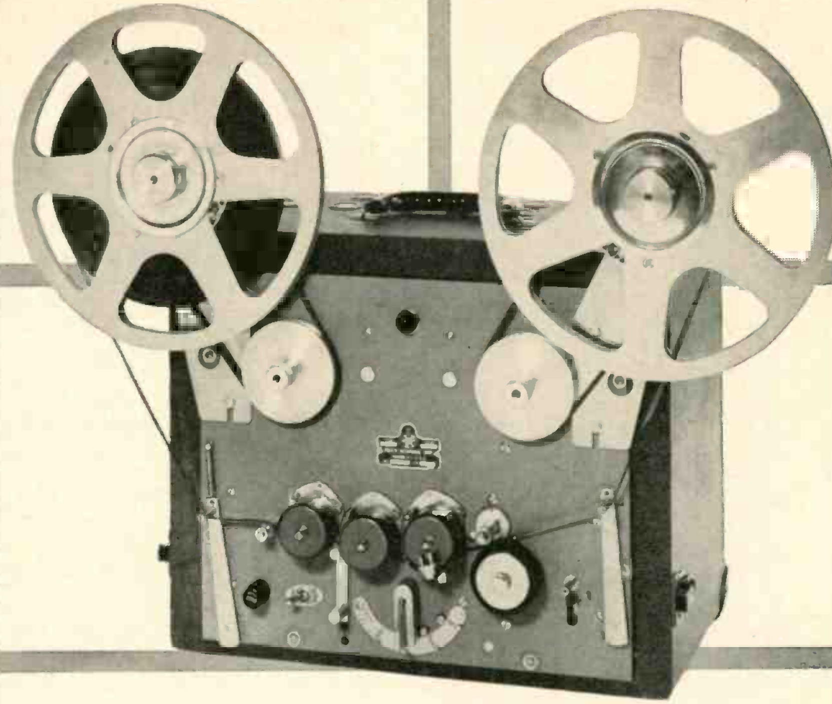
Experiments proving this point are quite easy to make. The behavior of the total pressure is to be derived from the sum of the voltages across the speakers. The Nyquist plots of the filter systems will immediately show what has been stated above.

E. DE BOER,
Physical Lab., Univ. of Amsterdam,
Pl. Muidergracht 6,
Amsterdam, Holland

(Continued on page 42)

Regardless of model . . . Presto has only one quality

Take, for instance, the finely engineered . . .



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- Three-motor drive system.
- No friction clutch or friction brakes.
- Heavy-duty construction throughout.
- Separate erase-recording-playback heads.
- Twin speed: 7½"/sec. or 15"/sec.
- Frequency response 50 to 15,000 cps.
- Reel size: 7" standard, 10½" with RA-1 adapter.
- Flutter: at 7½"/sec., 0.25 — at 15"/sec., 0.20.
- Available in 110 or 220 volts and 60 or 50 cycles.
- Weight: 41 lbs.

The completely portable PRESTO RC-7 is a precision recorder in every detail. Yet it's rugged and durable for heavy-duty field recording, and equipped with every feature this service demands. Built around a sturdy 3-motor drive, the RC-7 contains the same high-quality components found in Presto's fine studio equipment.

The RC-7 has separate recording and reproducing heads. Monitoring from tape is instantaneous. Mechanical friction devices, which always require constant adjusting, are totally eliminated from the RC-7, and virtually no adjustment is needed throughout the life of the machine. Note the RC-7's other features in the column at the left.

All of PRESTO's engineering experience as the world's foremost producer of precision recording equipment has been devoted to making the RC-7 the outstanding leader in fine tape recorders, in flawless performance, simplicity of operation, and long and thoroughly satisfactory service.

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enables owners of the RC-7 and 900-R1 recorders to use 10½" reels. Carries out all normal functions, such as fast forward and rewind speeds. Easily attached.

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audiology

W. R. AYRES*

Feedback from Output Transformer Tertiary

Since introduction in practical form in the late thirties, the popularity of negative feedback has spread to being included in practically all commercial power-amplifier designs of high specification performance. As with most complex problems, there is no unique solution to that of applying controlled degeneration, and many variations upon several basic schemes have been applied.

Whether the sample of voltage fed back should be taken from the output transformer primary or secondary, or from a tertiary winding, depends upon the characteristics wanted, and upon the required stability and permissible cost. Tertiary feedback has been a useful compromise offering much of the advantage sought with secondary feedback, with greater freedom from parasitic oscillation. While stability requirements may necessitate use of a primary feedback plan, the lower hum, distortion and output impedance possible with tertiary feedback often warrant its serious consideration.

Assuming solution of the oscillation problem, secondary feedback could presumably out-perform a tertiary feedback plan on all counts. But in applying extensive feedback by the secondary method, maintenance of unconditional stability, if possible at all, tends to be more a laboratory curiosity than a production reality. Influence of the form of feedback upon potential amplifier stability has been described earlier in this series.[1]

The more important advantages of tertiary over primary feedback are the relative convenience of feeding back to a single-ended input stage from a push-pull output stage, and reduction of hum due to plate-supply ripple. To account for the latter, consider *Fig.* 1 in which an output transformer is shown with primary, tertiary and secondary windings, each available for feedback. With primary feedback (only), plate-supply ripple is divided across the load and tube in series. Since the plate (to ground) impedance is made very low by the feedback, practically the full plate-supply ripple appears across the load. Secondary or tertiary feedback makes the impedance looking into the transformer primary very low compared with the tube impedance, so only a small fraction of the plate-supply ripple appears across the load.

Through study of the situation depicted in *Fig.* 2, it may be seen how high-frequency amplifier stability can be made almost as good with tertiary feedback as with the primary feedback plan. Shown single-ended for simplicity, the high-frequency transformer coupling network of *Fig.* 2 is represented as three leakage inductances and three shunt capacitances. All quantities including the load impedance are shown referred to the primary side of the transformer. Subscripts p, s, and t refer to primary, secondary, and tertiary, respectively. L_{pt} is the leakage inductance between primary and tertiary, etc. The load impedance, if a cable and loudspeaker, is principally capacitive in the high-frequency range where oscillation troubles customarily arise.

Oscillation due to feedback connection is the result of a basically degenerative circuit actually being regenerative at some frequency (usually above the desired pass-band). It naturally follows that the feedback loop would preferably be devoid of phase-shifting elements effective in the pass-band, and that the transition to a regenerative circuit outside the pass-band would occur at such extreme frequencies

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

[1] Audiology, "Feedback from output transformer secondary," Audio Engineering, July 1953. Also Audiology, "Stability testing of feedback amplifiers," Sept. 1953.

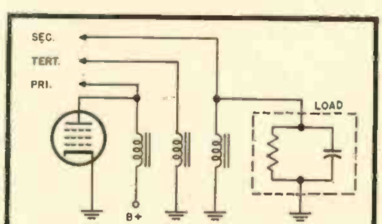


Fig. 1

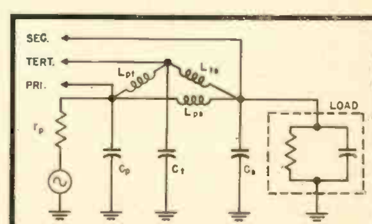
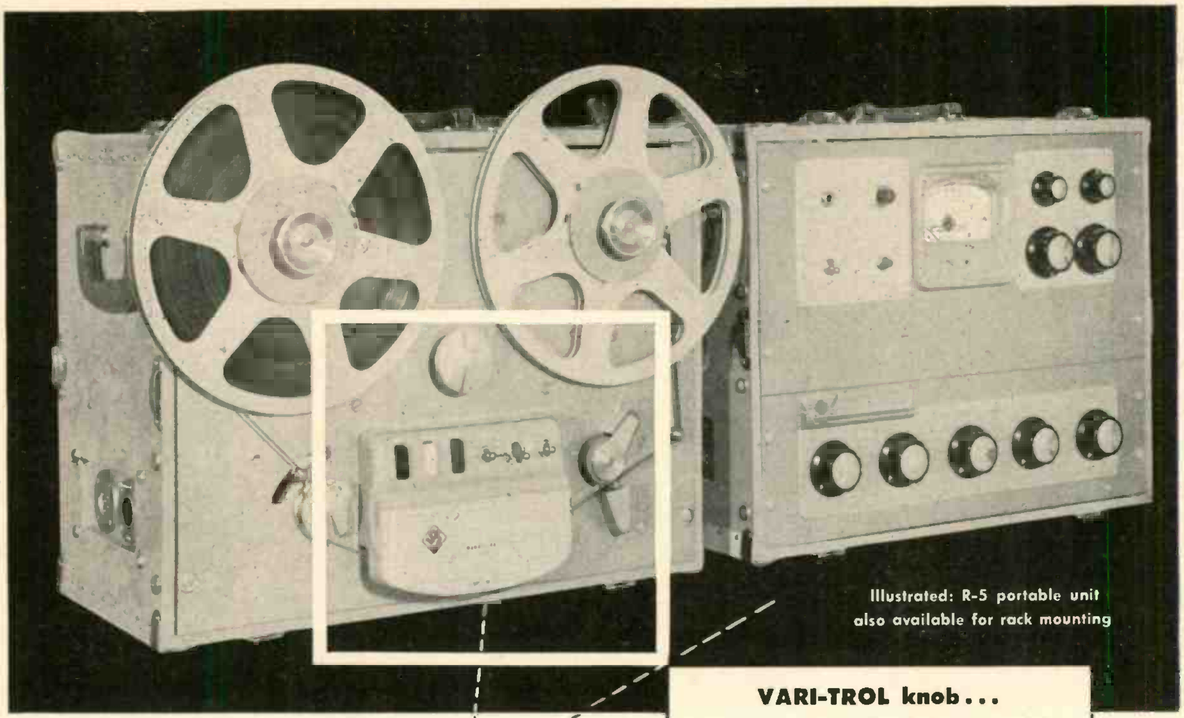


Fig. 2



Illustrated: R-5 portable unit also available for rack mounting

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the sensational one knob editing control to wind or re-wind tape at continuous or variable speeds . . . moves the tape in either direction at full or playing speeds, or stops tape instantly. An exclusive feature found only in the Stancil-Hoffman R-5.

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that the amplifier gain would not permit oscillation. Particularly when the feedback loop encompasses several stages, the output transformer is not the only circuit element contributing phase-shift, although it is perhaps the greatest single offender.

When the voltage sample for feedback is taken directly at the load (secondary feedback), phase-shift from generator to output depends upon the load (over which the designer usually has no control), and can exceed 180 deg. in this part of the loop alone. This of course can occur even with the load disconnected; however, then the frequency for 180-deg. phase-shift may be high enough that the amplifier gain is insufficient for oscillation. For this reason, secondary feedback amplifiers may be stable at no load and yet oscillate with a certain range of capacitive loads connected.

When the feedback signal is sampled at the primary winding (primary feedback), the phase-shift from generator to feedback sampling point cannot possibly exceed 90 deg. regardless of transformer or load resonances, so the stability obtainable would appear to be maximized through use of the primary feedback connection.

At high frequencies the tertiary winding (provided for feedback purposes only) is separated from the primary by a leakage inductance L_{pt}, and from the secondary by leakage inductance L_{ts}. Additionally, the tertiary winding has a distributed and terminating capacitance C_t, but this is small and independent of the amplifier load. Similarly the effect of an associated tertiary feedback network is usually negligible. Clearly then, if the leakage inductance between primary and tertiary is much smaller than that between secondary and tertiary, the phase difference between primary and tertiary voltages can be small and practically independent of the load. An output transformer of this characteristic permits application of tertiary feedback in practically the same quantity as the amount of primary feedback usable with the same transformer and associated amplifier circuit.

With either primary, secondary, or tertiary feedback, the phase-shift from output generator to the feedback sampling point can be reduced through employment of a tube with low plate resistance r_p. Feedback to an earlier stage does have the external effect of producing a low output impedance as measured at the load terminals or at a power amplifier plate, but in so far as a single feedback loop gain-phase characteristic is concerned, the source impedance for the transformer primary winding is simply r_p of the output stage. A point favoring primary feedback is that this consideration is rarely significant, adequate stability being obtainable even with very high plate resistance in the output stage.

For improvement of high-frequency stability, one may in effect lower the transformer source impedance at high frequencies through use of a "parasitic suppressor," consisting preferably of a series resistance and capacitance connected from plate to B+ (ground). Employment of this device to an extent materially effective in improving stability usually has the undesirable side-effect of severely limiting power output at high audio frequencies.

A more powerful method is that of using a minor loop within the major feedback loop. One simple way is that of including (in addition to tertiary feedback) a minor primary-feedback loop from power amplifier plate to (say) the cathode of the preceding stage. The primary-feedback circuit itself is readily made stable, and it provides a low transformer source impedance within the tertiary feedback loop. An important

(*Continued on page 54*)

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EDITOR'S REPORT

1953 IN RETROSPECT

It is an almost universal custom for magazine editors, news commentators, radio stations, and other organs of communication to look back over the past year every time the last number on the calendar changes. And since we number ourselves in one of those categories, we feel constrained to do likewise.

It is this observer's opinion that 1953 will be remembered as the year that the public found out about hi-fi—at least in the advertisements in consumer media. We have been beating our drums—and sometimes our gums, chest, and even at times the air waves—on behalf of good *audio in the home* since 1947. Since we have enjoyed good music reproduction equipment ourselves for years, we have felt that everyone should be able to have the same pleasure, and we have done our best to "sell" the idea throughout the world. So, after six years of carrying the Word, we find that everyone is getting into the act—many just translating the already-available technical material into language the layman can understand, while others just extol the idea without actually telling how to achieve such a Nirvana.

When Æ was first launched, there were so many who were unfamiliar with the word "audio" as to cause doubt that a magazine would ever attract the public—particularly the non-technical reader—if the strange word appeared as a title. Yet in the first year that Æ was on the public newstands, its paid circulation increased approximately 48 per cent, which proves something. Another bit of evidence of the interest in this subject lies in the fact that Æ now has just under 200 life subscribers—readers who believe in audio as well as in Æ. To date no wag has yet thought to inquire if "life" meant his or Æ's, but this may be the result of the wording on the life subscription card, which states plainly that the holder will receive Æ for "the rest of *his* natural life." (Italics ours.) One of the most flattering compliments Æ has ever received was a check in the amount of $185 from a company *in the business* of making tape recorders and other audio equipment—the $185 was for seven life subscriptions and two 2-year subscriptions. DuKane Corporation may not have got the first life subscription card, but they are certainly responsible for the greatest individual number of them. We thank DuKane, and we appreciate the compliment.

Perhaps we blow our own horn too much, but we have never forgotten the second issue of *Radio News,* which appeared sometime before 1920. Its then editor, Hugo Gernsback, mentioned the reception accorded the first issue and concluded with a phrase essentially like this: ". . . yet we believe that one must blow loudly and lustily upon his own horn for fear it may not be blown upon." History has proved that *Radio News*—now developed into *Radio and Television News*—had reason to cite its own merits, for it too was a pioneer in the field. Remember that radio broadcasting and the tremendous business associated with it had not started by then, although it had been described by Nicola Tesla as early as 1894.

So it was with Æ—in 1947 only a few of us *aficionados* knew what high-quality sound reproduction was. We like to number ourselves among the first in the hi-fi field, yet every so often we mention the date of our own initial interest, only to find that the person to whom we are speaking was interested in hi fi two years before we were. Someday we are going to trap someone into claiming he had a push-pull audio amplifier—a.c. operated, of course—in 1905.

1954 IN PROSPECT

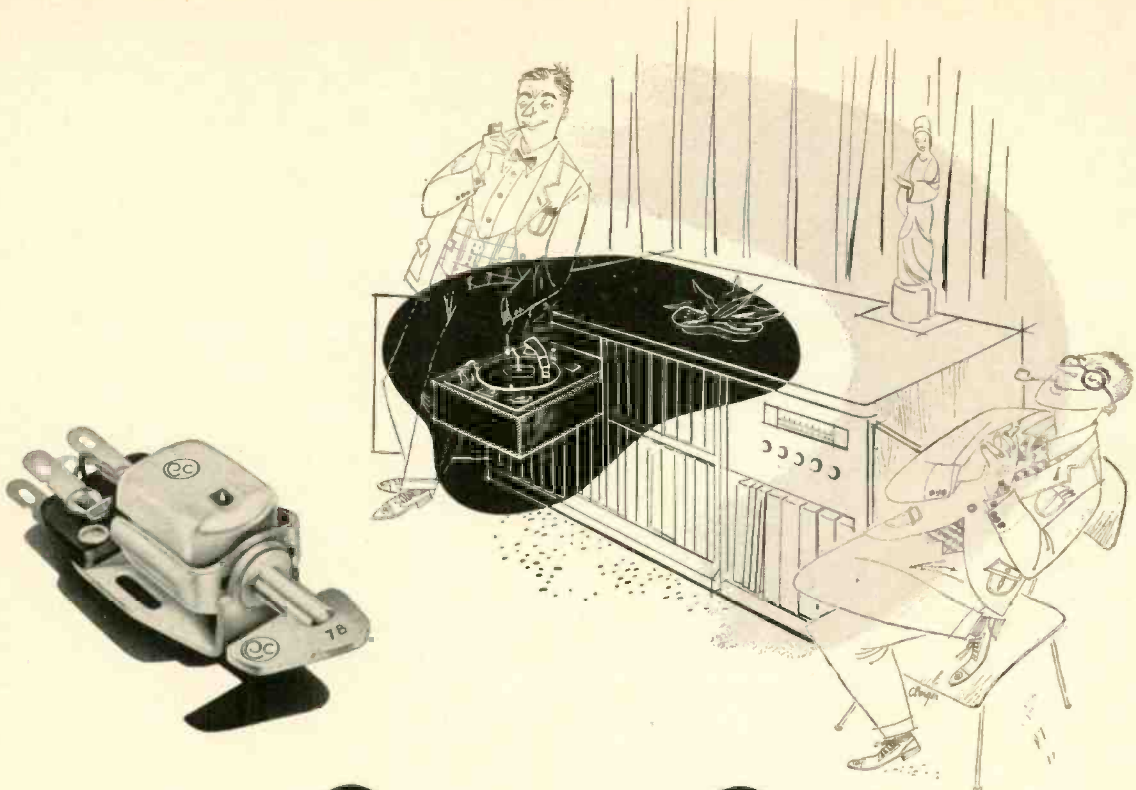
What is there to look forward to in 1954?

We believe that the major trend in the next year will be toward simplification. As we have long pointed out, it is not necessary to have an exact equalization curve for every possible record characteristic—it is better to provide adequate flexibility and then to set the controls to make the music sound right. With the influx of new families into the hi-fi fold, more and more record libraries will be built on LP's and 45's, both of which are fairly well standardized as to recording characteristics. Thus the amplifier of the future will have one position for phonograph, one for radio, and possibly several more for TV, tape recorder, spare, auxiliary, and what not. But—in spite of the article on page 23—it will not be necessary to provide so many equalization curves because most records will play correctly with the same position. Suitable tone controls will provide the required flexibility. Already the newer ceramic pickups are designed to fit the presumed average characteristics, and they play well into a "flat" amplifier. While big loudspeaker enclosures will continue to be popular with those who can afford both the cost and space for optimum performance, there is certain to be a continued trend toward the smaller housings with performance more closely approaching the Big Berthas. Record changers and transcription players with only two speeds are almost sure to be introduced—the speeds being 33 1/3 and 45, of course—and with less complication there is certain to be improved performance with respect to flutter and rumble. Tuner sensitivity will move rapidly toward the 1-μv point to ensure quieting which is entirely adequate for high-quality reception even in the fringe districts. The power amplifier is fairly well stabilized—10 watts being the minimum acceptable, and 30 to 40 watts being standard for the larger installations.

That, anyhow, is our guess, and like the panelists in one of our favorite TV shows—"What's My Line?"—we should be entitled to one free guess before the questioning starts. What's yours?

VILLCHUR AGAIN LECTURER

The spring session of Mr. Villchur's course on sound reproduction begins at New York University on February 3; classes meet every Wednesday from 7:00 to 9:45 p.m., and continue until May 19. Registration may be effected at N.Y.U. Division of General Education, Washington Square, New York beginning January 18.



"I'm glad I waited..."

Here's how I solved a problem that bothered me . . . and may be bothering you.

Many of my favorite recordings happen to be 78's. They mean as much to me as any of my newer LP's or 45's. Changing pickups was often a real nuisance—and yet I wasn't willing to give up the superior quality of my two Pickering cartridges.

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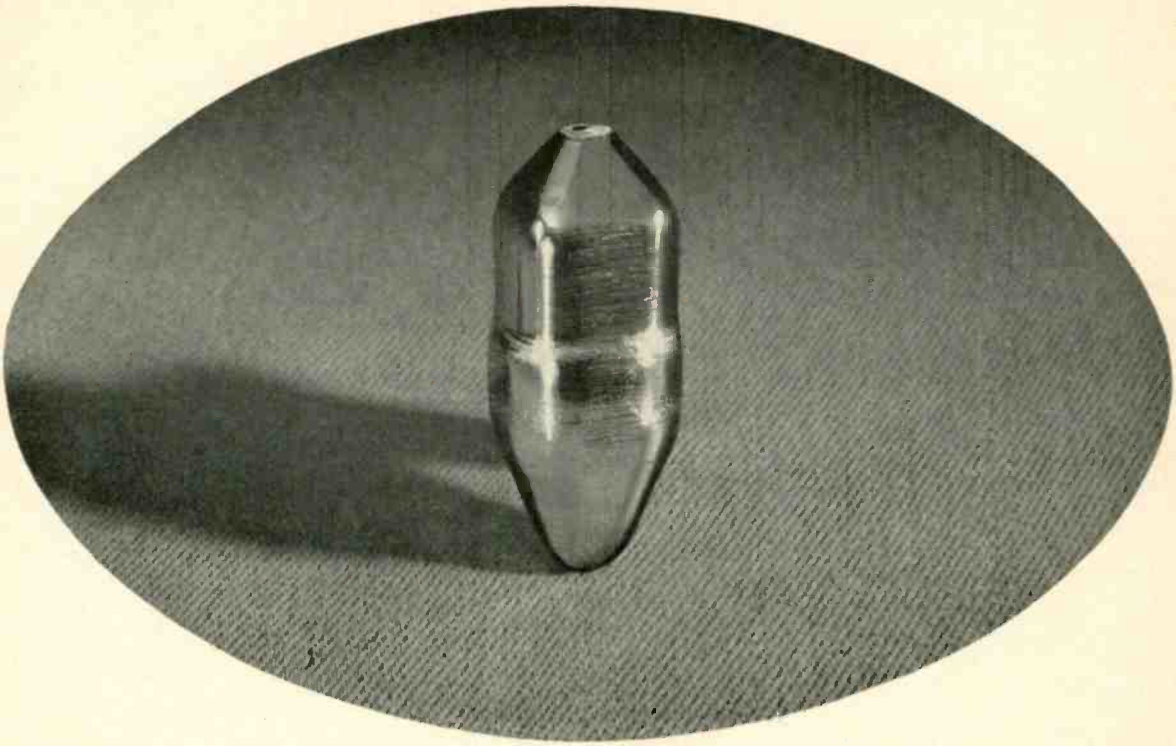


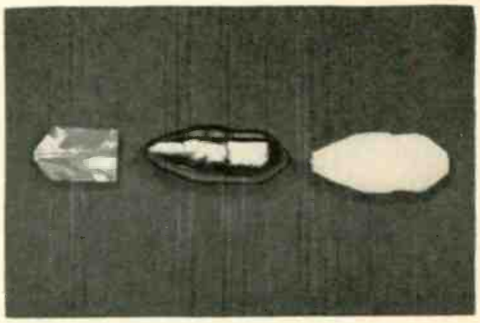
Germanium crystal grown at Bell Telephone Laboratories (life size). It is sliced into hundreds of minute pieces to make *Transistors*. Transistor action depends on the flow of positive current-carriers as well as electrons, which are negative. Arsenic —a few parts per 100,000,000—added to germanium produces prescribed excess of electrons. With gallium added, positive carriers predominate. Latest junction type *Transistor* uses both kinds of germanium in the form of a sandwich.

THEY GREW IT FOR TRANSISTORS

Heart of a ***Transistor*** – Bell Telephone Laboratories' new pea-size amplifier – is a tiny piece of germanium. If ***Transistors*** are to do their many jobs well, this germanium must be of virtually perfect crystalline structure and uniform chemical composition. But it doesn't come that way in nature.

So–Bell scientists devised a new way to *grow* the kind of crystals they need, from a melt made of the natural product. By adding tiny amounts of special alloying substances to the melt, they produce germanium that is precisely tailored for specific uses in the telephone system.

This original technique is another example of the way Bell Laboratories makes basic discoveries – in this case the ***Transistor*** itself – and then follows up with practical ways to make them work for better telephone service.



Section of natural germanium, left, shows varying crystal structure. At right is sectioned single crystal grown at Bell Laboratories.

IMPROVING TELEPHONE SERVICE FOR AMERICA PROVIDES CAREERS FOR CREATIVE MEN IN SCIENTIFIC AND TECHNICAL FIELDS

BELL TELEPHONE LABORATORIES

The New Golden-Ear Amplifier

JOSEPH MARSHALL*

In Two Parts—Part 1

Combining virtual direct coupling, neutralization, two feedback loops, and a high degree of balancing, this unit is reasonably free of distortion at normal volume levels. The companion preamplifier offers several unusual features worthy of study.

Audio amplifier design and components have made tremendous strides in the past few years and there are several commercial amplifiers available today capable of reproduction which, for all practical purposes, is as good as it has to be for even the more critical ears and beyond the various program sources, broadcast or recorded, in over-all fidelity. The Williamson circuit, for instance, though simple, produces results which are very hard to quibble with. And yet the Golden-Ear Complex, frustrated in the absence of sheer perfection, continues to drive many of us into expending much brain energy, money and time, trying to reduce the remaining short distance to be traversed to achieve perfect reproduction. The amplifier described herein represents still another effort at producing an amplifier with the least possible distortion of all forms, and the maximum possible width of frequency response. Its band-width is limited principally by the output transformer and with the best available today runs nearly flat from 2 or 3 cps to over 100,000 cps; amplitude distortion is nearly non-existant except in the top 3 db of the power output where it is just measurable; intermodulation is a fraction of one per cent except again in the very top 3 db of the output; the transient response is almost completely flat throughout the entire audio range of 20 to 20,000 cps; the amplifier is so stable that nearly 100 per cent feedback has to be applied to drive it into oscillation and the period of oscillation when it occurs is between 20 and 40 cycles *per minute*. The power output depends on the output tubes used —a pair of 6AR6's will produce 20 watts of nearly distortion-free output, while 807's, 5881's, KT66's and the like will deliver 15 watts; with an appropriate power supply and output transformer, Ultra-Linear tetrode or Extended Class A operation may be employed to double the output.

* *The Bleachers, Ozone, Tenn.*

Design Principles

The cardinal principles of hi-fi design can be summarized in the following rules:

1) Operate the various stages under parameters producing as little distortion as possible.
2) Cancel as much as possible of what distortion is produced by balanced configuration or feedback or both.
3) Make the amplifier and indeed the whole reproducing chain as non-resonant as possible by keeping the response curve as flat as possible not only over the audio range but for three or four octaves above and below the audible range.
4) Eliminate, neutralize, or minimize all positive feedback loops which might cause oscillation, regeneration, hang-over, or other transients.

Now let us see how these principles

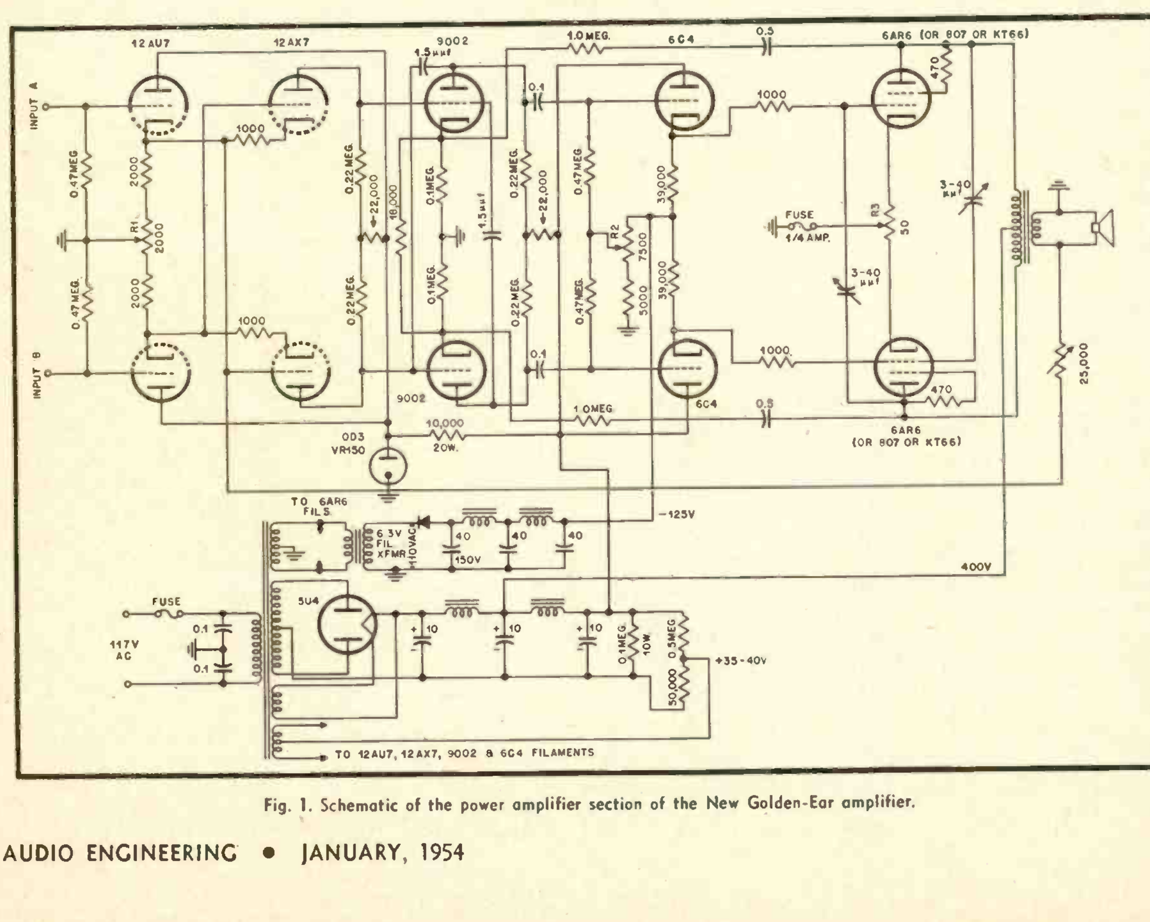


Fig. 1. Schematic of the power amplifier section of the New Golden-Ear amplifier.

are expressed in the practical amplifier diagrammed in *Fig.* 1.

At first glance the circuit resembles that of the Childs amplifier which employs the cross-coupled inverter and which contributed the excellent cathode follower driver used here; but there are several very significant differences. The design is eclectic, using elements derived from others, but in an original combination. The distinctive features are, first the means of broadening both the high- and low-frequency response; second, the high degree of balance and of distortion cancellation; third, the low degree of phase shift which permits huge amounts of inverse feedback; and finally, the minimization of positive feedback and consequent flatness of transient response.

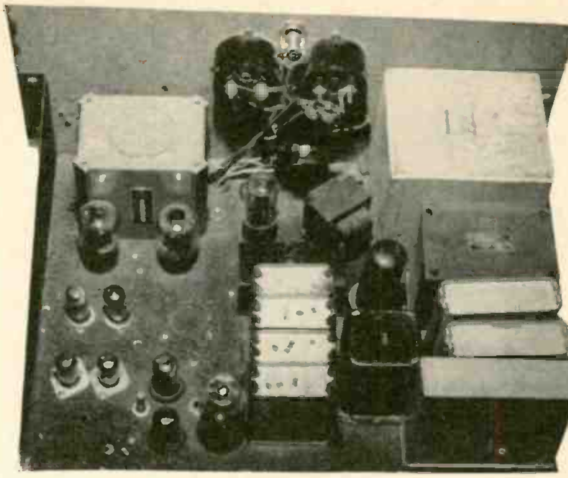


Fig. 2. Top view of the power amplifier chassis.

The Practical Circuit

The author has been much intrigued by the cross-coupled inverter ever since it was described by van Scoyoc five years ago, and called attention to it in an earlier article.[1] We have used it now in several forms not only in audio amplifiers, but in 'scope amplifiers, voltmeters, and distortion meters, and the more extensive the usage the greater the admiration for it. As far as we can see it has no faults as a phase inverter and many virtues not possessed by any other. It can be balanced both in amplitude and frequency response at least as well as the best transformer; if the output voltage is held below 50 volts or less, it is distortion-free; on the low side, its response is down to direct current, and on the high side to more than 50,000 cps; it has inherent voltage and current inverse feedback; and finally, since the input tube is a cathode follower, it presents a very light load to any input and provides a good low-frequency response with a reasonable input capacitor.

With such an excellent phase inverter at hand, and with new output transformers also available flat for an additional octave or more at each end than the best ones, the problem was to keep the response of the amplifier between inverter and output transformer comparably flat.

The direct coupling of the phase inverter immediately suggested that the direct coupling be maintained throughout the entire amplifier, for a really flat low frequency response. Those who tried direct-coupling in its heyday, 15 years ago, will remember the headaches involved. Many of these can today be eased. The cross-coupled inverter, for instance, makes a stable push-pull d.c. amplifier of 3 or 4 stages quite practical. Unfortunately, there were two serious deterrents. One was the fact that for the highest output with lowest distortion we wanted to use big triodes with fixed bias. This is not impossible to achieve with direct coupling but it is difficult. Another was that we would require a power supply (or two in series) delivering 800 volts or more.

Actually, the very difficulty self suggested the solution. Unless a driving transformer is used, the only practical high-fidelity method of coupling fixed-bias power triodes to an R-C coupled amplifier is through a cathode follower which may be direct coupled to the power tubes. But a cathode follower has a very high input resistance. Therefore, a moderate sized coupling capacitor would produce a time constant which would extend the frequency response down to 1 or 2 cps, or even lower. If then, the amplifier were designed in the form of *two* direct-coupled sections, one containing the phase inverter and voltage amplifiers, and the other the cathode follower directly coupled to the output tubes, and if we then joined these two sections with a capacitor at the cathode follower input, we would have an amplifier which, for all practical *audio* purposes, is as good in low-frequency response as a direct-coupled amplifier but, being isolated so far as direct current is concerned into two sections, would require only a single 400-volt power supply and would permit the use of fixed bias on the output tubes; it would, moreover, be much more stable than a d.c. amplifier.

The practical amplifier fully realized the expectations and produced no construction or adjustment headaches whatever; indeed, it was, if anything, easier to adjust and keep in adjustment than any other amplifier we had ever used. It is, to be sure, somewhat extravagant in the use of tubes, but the direct coupling holds down the number of component parts to a number no greater than that in much simpler amplifiers, and the performance is quite superior.

The Amplifier Circuit

The 12AU7 and 12AX7 comprise the cross-coupled inverter. This is direct coupled to a pair of 9002's, as driver amplifiers. Miniature tubes were used up to the power stage to hold down tube capacitance. Either a 12AU7 or a 12AX7 could be used instead of the 9002's. The former would yield a somewhat higher output and be more suitable for use with 6B4's in the output stage; the latter would yield more gain and permit more feedback or obviate the need for additional voltage amplification. The 9002's, however, are excellent tubes for the purpose and provide a gain of about 17—as against 12 for the 12AU7—and a practically undistorted output of 60 volts per side.

The 9002's are coupled to the 6C4 cathode followers (one 12AU7 would serve identically) through a 0.1 µf capacitor. Since the effective input resistance of the cathode follower is ten times the grid resistor, or in this case, 5 megohms, the time constant is 0.5

(*Continued on page 46*)

Fig. 3. Underside of the power amplifier chassis.

[1] Joseph Marshall, "For golden ears only," Audio Engineering, April 1950.

Stereophonic Nomenclature

N. M. HAYNES*

A complete lexicon of terms is proposed to end the present confusion of jargon on stereophonic and binaural sound.

ANYONE INTERESTED in the art of stereophonic reproduction cannot help but recognize the state of confusion which exists in the terminology generally used.

Such terms as binaural, trinaural, point source, diffused source, source free, multichannel, true binaural, panoramic, spatial reproduction, bistereonauralphonic have already seen the light of day. Descriptions, too, of "in the round," "auditory perspective," "focus," plus a host of explanatory and translatory errors have piled up a linguistic hodgepodge in a field where such confusion need not exist.

Along with the flush of a new (or rebirth of an old) art will be heard the cry of the hucksters, salesmen, advertisers, and pseudo-technicians who use and embrace terms which serve their blaring needs but are nevertheless confusing and meaningless in character. To systematize stereopohonic terminology and attempt to bring intellectual order out of a chaotic scramble of expressions is the hopeful intent of the writer.

Stereophony is analogically rooted in the history of stereoscopy, a phenomenon which was first correctly explained by John Kepler in 1611. During the past three hundred and forty years, a series of optical terms describing equipment, techniques, and effects have become well established. This time proven heritage should be carefully examined for help in clearing the rubble of stereophonic semantics.

Philosophy of Modern Nomenclature

Ideally, from the semantic viewpoint, words should convey maximum information with minimum effort. This implies avoidance of specialized nomenclature which is clear only to those skilled in a specific art. Special meanings given to common terms understood by a select few contradict the modern concepts of free exchange of information. It would be ironical and contradictory for a scientist skilled in optics, or a physician in physiology, or a psychologist expert in visual illusions to be baffled by monstrous stereophonic nomenclature. That such monstrosities have appeared is regrettable; their perpetuation is inexcusable.

A 75 per cent redundancy in the English language[1] is caution enough to avoid the addition of useless words. No one can deny that new effects, techniques, and equipment require new descriptive terminology, but a haphazard conglomeration of unrooted, confusing, and philologically meaningless terms is contrary to the basic concepts of language. By analogy, root, or classification new words should at least imply if not express their meanings.

If we sort the rubble of contemporary stereophonic terminology through a three-compartment sieve labelled "Technique," "Effect," and "Analogy," we can quickly separate and classify useful terms and recognize the need for additional systematized nomenclature.

The Greeks Had a Word for it

Stereo . . . is a combining form from the Greek *stereos,* meaning hard, firm, solid. It is used in scientific terms to express hardness, firmness, and solidity. By leaning heavily upon optically accepted terms which have withstood the test of time, we can readily begin from the term *stereoscopic,* which implies the effect of localizing matter in space visually. *Stereoophonic,* by physiological and neurological analogy would then refer to the effect of localizing sound sources in space.

Translatory problems are well recognized and it is no surprise to find amusing explanations for stereophonic reproduction. One example is, "*Stereos* in Greek means volume. Stereophonic would indicate that you can hear volume, which seems contradictory. Yet, we are able to 'focus' our ears on part of a sound source; for instance, we can distinguish one conversation from a confusion of voices and assign it therefore some sort of volume."

This queer definition stems from the translator's failure to recognize an idiom of our space-time continuum. The volume he means to describe is not one of sound intensity but the goemetric measure—a volume of space. A more acceptable and meaningful explanation would be, "*Stereo* in Greek means solid or the volume occupied by solids in space. Stereophonic would indicate that you can localize sound in space."

In the analogous field of microscopy, there are three general types of instruments. The common or standard microscope is equipped with one eye-piece and one or more objectives (nose-pieces); the binocular microscope has with two eyepieces (for simultaneous viewing with both eyes) and the usual set of objectives; and the stereo microscope has two eyepieces and a jointly used set of objectives. The stereoscopic microscope produces a stereoscopic effect. It is not called a binocular microscope because not all binocular microscopes are stereoscopic! Though prism binoculars provide stereoscopic vision as a by-product of their construction, they are not specifically designed for stereoscopy. In fact, the stereoscopic effect is artificially exaggerated because of the increased spacing of the objective lenses (which are usually approximately twice as far apart as the eyepiece lenses). This stereoscopic exaggeration is not a by-product of Galilean field glasses.

The term binaural means *of or pertaining to, or used by or with, both ears.* Two earphones or earmuffs are *binaural.* The use of this "equipment" term in place of the "effect" term *stereophonic* is a pure and unadulterated barbarism! In just the manner that "binocular" does not imply or express "stereoscopic" so "binaural" does not imply or express "stereophonic." Similarly, the term "true binaural" is a premeditated barbarism, for it also mixes techniques and equipment. Monstrous terms like bistereonauralphonic result from abortive terminology applied to combinations of faulty techniques and corrupt effects. Such gobbledegook should be looked upon as premeditated nonsense, as it undoubtedly was by its originator.

If we group our suggested nomenclature into four logical divisions and use self-explanatory or analogical terms where they exist, much of our present confusion will vanish. Furthermore, nomenclature will at least have meaning to nearly all in acoustics and be understandable to many in other scientific fields.

Terminology For Stereophonic Effects

Stereophonics, *n.*: The science which treats of the recording, reinforcement, or reproduction of sound in such a manner as to provide a sensation of spatial distribution of the original sound sources.

Stereophonist, *n.*: One versed in the use or manufacture of stereophonic equipment.

Stereophony, *n.*: The art of using, designing, or manufacturing stereophonic equipment.

Stereophonically, *adv.*: In a stereophonic manner; by means of stereophonic equipment.

Stereophonism, *n.*: The state of being stereophonic.

Stereophonous, *a.*: Same as stereophonic.

(*Continued on page 54*)

* *Engineering Vice-President, Amplifier Corp. of America, 398 Broadway, New York 13, N. Y.*

[1] Shannon, C. E., "Preduction and entropy of printed English,' *Bell Syst. Tech J.*, Vol. 30. No. 1 (Jan., 1951), pp. 50–64.

Design Of A Professional Tape Recorder

WILLIAM F. BOYLAN* and WILLIAM E. GOLDSTANDT**

Design and operational features of a new high-quality machine.

The present state of the magnetic recording art has made possible the design of recording equipment with extremely high performance standards—excellent frequency response, low distortion and flutter—and so on. While performance standards are of the greatest importance, a survey of individuals and requirements in the professional recording field made it plain that certain purely operational features were very much in demand as well, such as ease of tape handling, precise and instant control of tape motion, good editing facilities, accurate timing, portability, and other similar points.

These factors were taken into prime consideration in the design of the new tape recorder pictured in *Fig.* 1. In addition to fulfilling the high performance standards required in quality professional work, the machine provides extremely quick and easy operation. It consists of two major units, the tape transport and the record-reproduce amplifier unit which includes the high-frequency oscillator. Both major assemblies may be mounted in the console as shown, in a portable carrying case which is furnished, or in a standard 19-inch relay rack.

Tape Transport Unit

The complete tape transport, shown in *Fig.* 2, is constructed on a standard 19-inch rack-mounting panel. The panel is 12½ inches high and the mechanism extends 8 inches behind the panel.

One of the principal design objectives for this project was to produce a mechanism which would afford easy operation and tape handling. In order to accomplish this, considerable effort was directed to the problem of panel layout. Among the people interviewed, the general trend of opinion indicated that the normal tape direction should be from left to right in both relay rack and console mounted machines. This arrangement dictated a front panel 19 inches wide with the height of the panel kept to a minimum to preserve portability.

In any professional recorder certain minimum components should be included in the panel layout. These are a constant-speed capstan and pressure roller assembly, a tape tensioning or hold-back device, a take-up system to spool the tape after it passes the capstan, erase, record, and reproduce heads, compliance arms, and an inertia-stabilizing roller to filter out tape speed irregularities produced as the tape leaves the pay-off reel. The layout of these components not only governs the performance of the unit to a great extent, but also affects the simplicity of operation. In the machine being described the tape path is straightforward and free of loops and curves around guiderollers.

A 3-position function control lever is included. Its positions are marked OPERATE, LOAD, and EDIT. When the lever is placed in the LOAD position the compliance arms, tape guide, and head covers are put in such a position that "straight-line" or "slot" loading of the tape is permitted. This feature eliminates most of the inconvenience normally encountered in tape threading. The head covers are open wide in the LOAD position for ease of head inspection and marking of tape.

After the machine has been loaded with tape, the control lever is placed in the OPERATE position. This brings the compliance arms and head cover back into their normal positions. In the OPERATE position, the tape does not come into contact with the heads except during normal forward operation. This allows the tape to be run at high speed forward or rewind without excessive wear on the heads. When the tape is moving in the normal forward direction, as for playback or record, the tape guide and head cover are solenoid-actuated to cause the tape to engage the heads.

When the control knob is placed in the EDIT position the pushbutton switches are locked out of the circuit, and the tape is held against the heads. If one

Fig. 1. The new Magnecord M-80 recorder in its console cabinet. A portable case is also provided.

* *Assistant Chief Engineer and* ** *Mechanical Engineer, Magnecord, Inc., 225 West Ohio Street, Chicago 10, Ill.*

Fig. 2. Top view of the tape transport unit. "Drop-into-slot" tape threading makes for easy operation.

reel hub is then grasped in each hand the tape may be moved back and forth across the heads, permitting easy and rapid cueing.

In addition to the function control lever, other controls located on the front panel include four pushbutton switches labeled REWIND, STOP, FORWARD, and HI FWD (high speed forward). Two rotary switches are located on the lower right-hand side of the panel, one of which controls the tape speed, 7.5 or 15 inches per second. The other rotary switch turns the recorder mechanism on and off.

A record warning indicator light is provided on the transport unit panel which tells the operator when the unit is ready to record. This indicator light is lit when the record-playback switch (located on the front panel of the amplifier) is in RECORD position. When the tape is not in motion the indicator is lit by d.c. from the amplifier, and when the tape is in motion it is excited by the high-frequency bias supply, which operates only when the tape is moving forward at recording speed.

The complete transport unit consists of eight unitized assemblies. These are two reel motor and brake assemblies, capstan-drive assembly, stabilizer roller assembly, head assembly, front-panel assembly, pushbutton control box housing the control relays, and the high-frequency bias-erase oscillator which also includes the power supply for the solenoids.

Each of the two reel assemblies consist of a torque motor mounted directly on the front panel, as illustrated in *Fig.* 3, with a brake assembly mounted on the rear end bell of each motor. Solenoid actuated band brakes provide for the necessary differential braking to keep the tape at constant tension during braking so that it does not throw loops when it is stopped after high-speed running. During normal forward operation a reverse torque is applied to the pay-off motor, which maintains a relatively constant tape tension while the tape is being unwound from the pay-off reel. Slightly greater torque is applied to the take-up motor to provide sufficient torque to spool the tape.

The tape is pulled by a direct-drive assmbly consisting of a 600/1200-r.p.m. hysteresis synchronous motor with an integral ground capstan. A flywheel is mounted on the rear shaft extension of the motor. The capstan drive operates with the same characteristics in the horizontal as in the vertical position. Timing accuracy in the neighborhood of 3 seconds in 30 minutes can be expected.

The stabilizer assembly consists of a flywheel, tape roller and bearing housing, compliance arm guide, and tape-break switch. It filters out effects of tape sticking as well as high-frequency flutter components caused by the pay-off reel.

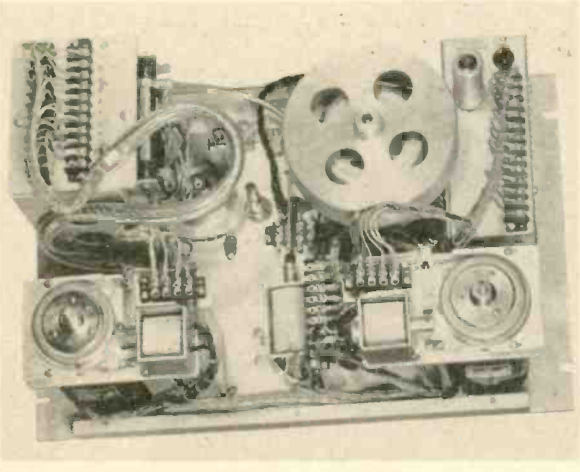


Fig. 3. Underside of the transport unit.

Head Assembly

The high performance characteristics of the M-80 recorder are dependent to a large extent on the precision record and playback heads as well as the head mounting assemblies and tape guides. There are three heads in this assembly, illustrated in *Fig.* 4.

The erase head is a low-impedance device requiring approximately 1 ampere of ultrasonic current. It is of the double-gap variety, which assures complete erasure.

The record head is a new unit developed specifically for this recorder. Its impedance is approximately 50 ohms at 1,000 cps. Precision lapping such as that used in optical work has been employed to assure a very straight and uniform gap. Since recording is done with the trailing edge of the gap, the straightness of the gap edges is more important than the gap width itself. The record head gap length is in the order of .0007 to .001 inch. The reason for this large gap is to

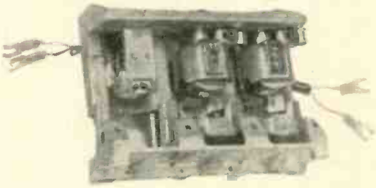


Fig. 4. The three heads are mounted in a complete subassembly.

reduce the noise recorded on the tape due to residual localized d.c. magnetizations of very small magnitude.

The reproducer head is similar to the record head in construction except that the gap length is of the order of .00025 inch. The reproduce head is even more critical than the record head and greater care is taken in manufacture to assure uniform gap length as well as gap edges. The impedance of the playback head is approximately 6,500 ohms at 1,000 cps. There are two determining factors which dictate the impedance of the head. As the impedance is increased, greater output voltages are obtained, lowering the requirements of the playback amplifier equivalent input noise. However, as the impedance is increased, lower resonant frequencies of the head and connecting cable are encountered. The resonant frequency of the head and cable should be higher than the highest frequency to be reproduced.

The heads are mounted in triple-shielded Mu-metal cans to reduce hum pick-up. Glass tape guides are employed.

The front panel assembly contains mountings for the control box and oscillator unit, plus the pressure roller assembly, compliance arms, tape guide linkages, and the power on-off switch and tape speed selector switch. *Figure* 3 is a rear view of the unit showing all the assemblies in place.

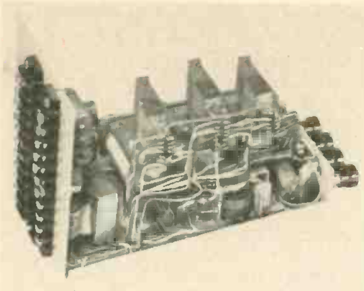


Fig. 5. The control box assembly contains the relays and relay power supply as well as the control buttons.

Control Box Assembly

The control box assembly, shown in *Fig.* 5, is contained in a special mounting shell. All relays, pushbutton switches, and the relay power supply are mounted on a single chassis and are readily accessible for servicing during operation by simply removing the chassis from the mounting assembly. Four relays are located on this chassis, three for normal forward, rewind, and high forward. These three relays have interlock circuits to prevent any two operations from occurring at the same time. To prevent tape breakage, the normal forward relay is locked out of the circuit until the machine is stopped.

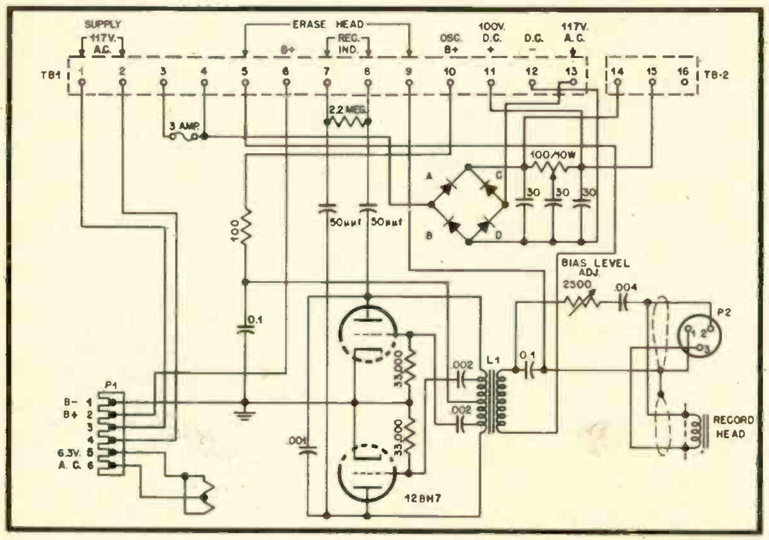


Fig. 6. Schematic of the bias oscillator and relay power supply.

Fig. 7. The amplifier unit is mounted on a 19-inch rack panel.

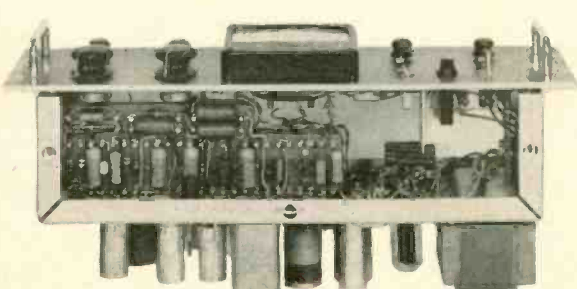


Fig. 8. Side view of the amplifier unit with side panels removed shows "dish mounting" with tubes horizontal. Components are board mounted for easy replacement.

An additional time-delay relay—the time delay being acomplished by an R-C network—is included to supply a voltage surge to the take-up motor when the machine is initially started in a normal forward mode. This feature prevents the occurrence of a loop of tape between the capstan and the take-up motor when the machine is started, resulting in smoother starting.

Terminals are provided on the control box assembly for remote control connections.

The oscillator assembly contains the high-frequency erase and bias oscillator circuits, as well as a 115-volt L-C-filtered d.c. power supply used to energize the solenoids. The oscillator is a push-pull Hartley as shown in the schematic of *Fig.* 6, using a 12BH7. This tube has a higher plate dissipation rating than the previously used 12AU7 and should give longer service without replacement. A special, improved, high-Q oscillator coil has been employed, to result in lower even-order harmonic content.

The oscillator coil secondary feeds the erase head in series with an 0.5-μf coupling capacitor. This capacitor has the funtion of resonating the erase head inductance at the operating frequency of the oscillator, which is approximately 70 kc. Approximately one ampere of high-frequency current is supplied to the erase head. The voltage drop caused by the reactance of the 0.5-μf capacitor is used as the supply voltage for the record-head bias. Lower harmonic content is achieved by feeding the record head from a voltage source developed across a capacitive reactance, which results in lower noise being recorded on the tape. The bias current is fed through a rheostat which is used for bias adjustment.

Record And Reproduce Amplifiers

The amplifiers are mounted on the standard 5¼ × 19-inch rack mounting panel shown in *Fig. 7*. *Fig.* 8 shows the chassis mounting the tubes and major components in a horizontal position. The front panel contains the controls. An input selector switch provides for operation from a high-impedance balanced or unbalanced bridge input or a 50-ohm microphone. The VU meter function switch has three positions, record level, playback level, and bias measurement. The record-playback switch includes a REMOTE position allowing the record or playback function to be controlled from a remote location. A monitor jack is provided on the front panel to provide monitoring directly from the program source or from the tape. The monitoring voltage is switched simultaneously with the VU meter. An equalizer switch suits equalization to 7½- or 15-inch-per-second tape speed.

The record amplifier consists of three stages of voltage amplification V_1, V_2, followed by an output stage V_{3a} which supplies current to the record head and contains the pre-equalization.

The input stage is a newly developed form of the cascode circuit described by

(*Continued on page 60*)

Preamp with "Presence"

C. G. McPROUD

Introducing a circuit which departs from "flat" to provide the elusive quality called presence, and which incorporates most of the features desired by the critical listener.

WHILE THE GENERAL TREND in amplifier and equipment construction has usually been in the direction of completely "flat" response curves, it is well established that certain types of correction are useful to compensate for microphone placement, for deficiencies in equipment, and for personal preference. However, the use of a separate control for increasing "presence" has not been introduced in home equipment to date, although it has been used in professional equipment for many years—although not necessarily by that name.

In the early 30's, certain types of loudspeaker systems in theatres were in need of some form of correction in the mid-range to increase the illusion of realism. It is probable that the deficiency was due to the speakers themselves, but in any case a correction in the form of a small boost somewhere between 2000 and 3000 cps was introduced to improve presence. The boost was of the order of 4 db, and was usually located at 2700 cps.

Following some experimentation along these lines, it was found that the addition of a boost ranging from 4 to 6 db at 2700 cps gave the illusion of moving a solo violinist out in front of the loudspeaker, or of causing the singer with a popular band to step out in front. Admittedly the effect is slight, but it is sufficiently noticeable to warrant its inclusion in the amplifier to be described.

The Complete Circuit

Every so often, a confirmed experimenter feels the urge to make a change—usually having in mind the desire to add one or more operating features which appear to be desirable. Reviewing the real or fancied faults in existing circuitry, the writer planned a preamplifier and tone-control amplifier which would incorporate all of the desired features. Taking the steps one by one, they add up about as follows:

Some preamplifiers do not operate as quietly as would be desired—having a hiss or hum level too high for complete satisfaction. Furthermore, it was felt that the low-frequency boost required for magnetic pickups began to flatten off too soon, resulting in insufficient bass in the lowest range—that is, below 50 cps. Some amplifiers have insufficient compensation characteristics for the most critical listener, and while the trend for the newcomers to hi-fi seems to be to reduce the number of available curves—largely because those who are entering the hi-fi field "fresh" will generally build their libraries exclusively from the LP and 45 catalogs—there is some advantage to having complete flexibility.

The tone-control circuit first described by Baxendall[1] and more recently for use with American tubes by Barber[2] offers some interesting possibilities. Principal among these is the variation in the inflection point as the amount of boost or cut is changed. The advantages of this show up when using a wide-range loudspeaker system with usual source material—both records and radio programs.

In addition to the presence control, it also seemed desirable to incorporate a low-pass filter system into the amplifier, and the L-C network described by Markow[3] was investigated for the purpose.

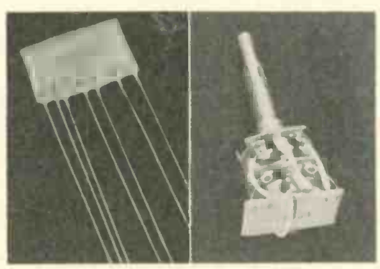


Fig. 1. (Left), Centralab Couplate for the tone-control circuit. (Right), the Couplate assembled on a dual-concentric control.

And as this writer has long been a proponent of the loudness control, this too had to be included—but with some form of decompensation which could easily be an uncompensated volume control.

Adding these up, one arrives at the astonishing figure of eight as the required number of controls, nearly as bad as the early TV sets before the trend toward simplification resulted in sets with only two knobs. Follownig the same procedure, the amplifier was planned to use only four "apparent" knobs—each being a dual concentric control. Thus the phonograph preamplifier becomes a dual switch each with five positions; the tone control becomes a dual-concentric assembly of two potentiometers; the presence control and the low-pass filter switch are combined into a third unit; and the fourth consists of another dual-concentric control—one section being the loudness control and the other being a volume control.

Obviously, few of these units are readily available from jobber stocks, so they were described to Centralab, and the four complete units were soon forthcoming. Centralab engineers had already designed the Senior Compentrol, which combines the loudness control with a volume control, and which employs a printed circuit "Couplate" with all the compensating elements. A study of the Baxendall circuit indicated that another Couplate could be built with three capacitors and four resistors in a single unit, as shown at the left in *Fig.* 1, and assembled onto the dual potentiometer at the right. Thus the construction of the entire tone-control circuit is considerably simplified. A standard line of Centralab units—available primarily to manufacturers—included dual concentric switches and dual units with a switch and a potentiometer. These were kept in mind during the layout of the amplifier circuit, and when the requirements were settled, the problem of making the controls was left to Centralab. All four units are available for anyone who wishes to duplicate the amplifier.

One of the features of the construction is the use of "custom-built" mounting boards for many of the components. While resistor-board construction is not uncommon in factory-built equipment, it is less often encountered in hand-crafted units because of the difficulty of obtaining these strips with terminals located ideally for the particular circuit being built. However, with the Alden terminal cards, any desired number of terminals may be installed exactly where the user wishes. *Figure* 2 shows the main terminal board with the four sockets attached to it and with most of the terminals in place. Detailed information about the terminal boards and the method of using them is included with the constructional data.

Preamplifier Details

The amount of low-frequency boost available from the conventional equalized feedback circuit depends upon the gain available from the two tubes. Consider, for example, the use of two sections of a 12AX7 with gain of around 40 for each

[1] *Wireless World*, October 1952.

[2] Basil T. Barber, "Flexible tone control circuit," AUDIO ENGINEERING, September 1953.

[3] Elliott W. Markow, "Record improvement with h. f. cutoff filters," AUDIO ENGINEERING, November 1952.

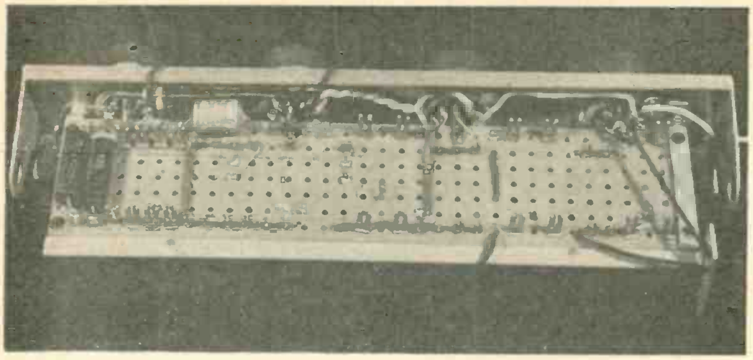


Fig. 2. Resistor mounting card assembled in small chassis with four sockets attached. Terminal lugs may be staked into any desired holes in the board, and thus fit any circuit. Grid and input circuit components are on the top side; plate and decoupling components are located on the bottom.

section, or a total gain of 1600. This corresponds to approximately 64 db. For an output of 1 volt and an input of 10 mv at 1000 cps, a gain of 100 is required, which is 40 db. This gain must be available at 1000 cps. However, to provide the low-frequency boost required for proper equalization of magnetic pickups, it is necessary that an additional gain of 20 db be available at 50 cps (for a 500-cps turnover). Since the maximum gain available from the tube is around 64 db and 40 is required at 1000 cps, the remaining 24 is all that is available for boost of the low frequencies. Now the frequency-response curve does not consist of two straight lines, but is composed of the flat portion above turnover, plus a portion which increases with lowering frequency at the rate of 6 db per octave, plus a portion which is again flat, but which represents the total gain of the two sections of the tube without feedback. These three straight lines are joined with curving sections, as shown in *Fig.* 3.

From this, it is seen that there is hardly sufficient low-frequency boost available from a 12AX7 to provide full equalization for the AES curve nor for the 800-cps turnover, if the compensation is to extend fully to the lowest frequencies to be passed. This discussion does not apply to the New Orthophonic curves, since they roll off with a maximum required boost of 18.6 db at 30 cps. The LP and NARTB curves are similar in the low-frequency range.

When tubes with less gain than the 12AX7 are employed, the difference is even more noticeable, which may account for a deficiency in low-frequency boost when a 12AY7 is used in a circuit designed for the 12AX7.

To correct fully for the necessary low-frequency boost, it is apparent that more gain is required from each of the tubes (or tube sections). The logical answer is to use two pentodes. Some pentodes are too noisy for this service, considering that the input signal is in the range of 30 mv. The circuit was first built up with 5879's, but these tubes—while of excellent low-noise characteristics—have hardly sufficient gain to give the desired low-frequency boost. The Genelex Z729, recently introduced in this country, is claimed to have even lower noise and hum than the 5879, but it has an available gain about equal to that of a 6AU6. The latter tube is likely to be somewhat noisy in low-level applications, particularly if a.c. is used on the heater. With the Z729, however, suitable performance with respect both to gain and noise has been achieved.

The circuit is relatively conventional. A feedback circuit from the plate of the second tube returns to the cathode of the first, and frequency corrective circuits are introduced in the feedback loop. Series capacitors control the turnover frequency, with the New Orthophonic rolloff being obtained by connecting a shunting resistor across one of the capacitors. The turnover frequencies available are 800, 500LP (for New Orthophonic), 500, 400 (AES), and 300.

The high-frequency rolloff is provided by connecting suitable capacitors and resistors across the feedback resistor to give rolloff of 4, 8, 12, and 16 db in addition to a flat position. All of the switching is accomplished by a Centralab Series 30 switch—the panel section consisting of a single deck with two 5-position switches and the rear section consisting of another single deck with one 5-position switch. All of the resistors and capacitors are mounted on the resistor board, with flexible leads connecting to the switch. The schematic of the preamplifier is shown in the left portion of the over-all schematic, *Fig.* 4. The response curves of the preamplifier section are shown in *Fig.* 5. It will be noted from the schematic that no provision has been made for switching inputs. The preamplifier has input and output jacks—the input coming directly from the pickup and the output being fed to a selector switch on the tuner. The output of the tuner switch if fed back to the input of the tone-control section, and its output is fed in turn to the power amplifier. There is no reason why the switching should not be incorporated in this chassis if it is desired, but for the writer's application the tuner switch was most convenient. Furthermore, this method provides complete flexibility and permits easy interconnection of other preamplifiers or tone-control amplifiers for comparative tests—a condition which is often required in this particular installation.

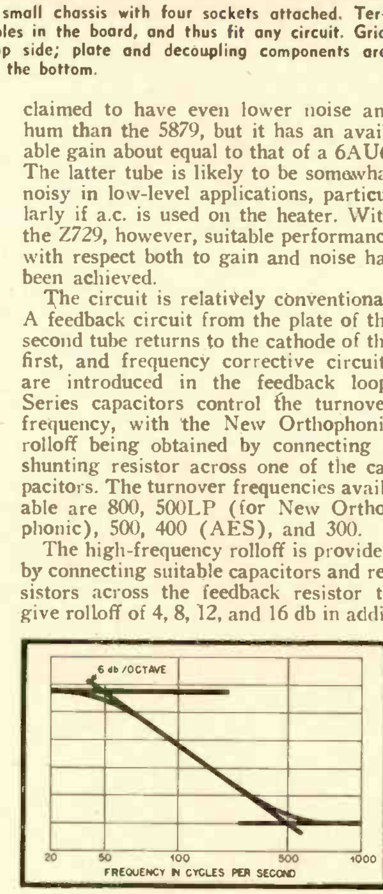


Fig. 3. Construction of the curve obtained from feedback network around two tubes. Curve is asymptotic to two straight lines.

Tone-Control Section

The remainder of the circuit comes under this heading, although there are several other functions incorporated in this section of the amplifier. The first step consists of the "presence" circuit, which includes R_{13}, R_{14}, R_{15}, C_{14}, C_{15}, and L_1. This is a simple loss network with a tuned circuit in the shunt leg. The tuned circuit is shunted by a 50,000-ohm linear pot which varies the amount of boost from 0 to 6 db. The boost is approximately linear with respect to the amount of rotation of the pot. The L-C circuit is tuned to 2700 cps, and listening tests have shown that the L-C ratio prescribed gives about the best effect. A smaller inductance and larger capacitor could be tuned to the same frequency, but the "bump" in the response curve is narrow, and the subjective effect is not as desirable.

The Baxendall circuit provides no gain from the first tube section since it is used as a cathode follower. Furthermore, there is rather more high-frequency equalization in the tone-control circuit than is considered desirable. Since additional gain was necessary, the first section is used as an amplifier with improved performance throughout. In the final form the control section requires an input of .08 volts for an output of 1.0 volts which gives some leeway for operation of the volume and loudness controls.

With the Couplate and the dual pot, it is only necessary to connect four wires between the tube chassis and the control to have a complete low- and high-frequency tone-control circuit. The response curves obtained are plotted in *Fig.* 6 for the center or flat position and for two degrees of both boost and cut. The second section of V_3 feeds the volume control and the first section of V_4 is located between the volume control and the loudness control, giving complete isolation between the two controls and eliminating any interaction. The final tube section, V_{4b}, is a cathode follower which feeds the low-pass filter circuit.

The filter circuit is an adaptation of the network described by Markow,[3] and is connected at the output of the cathode follower. This circuit requires the use of another inductance, but the performance meets the specification laid down before the construction was begun. The control

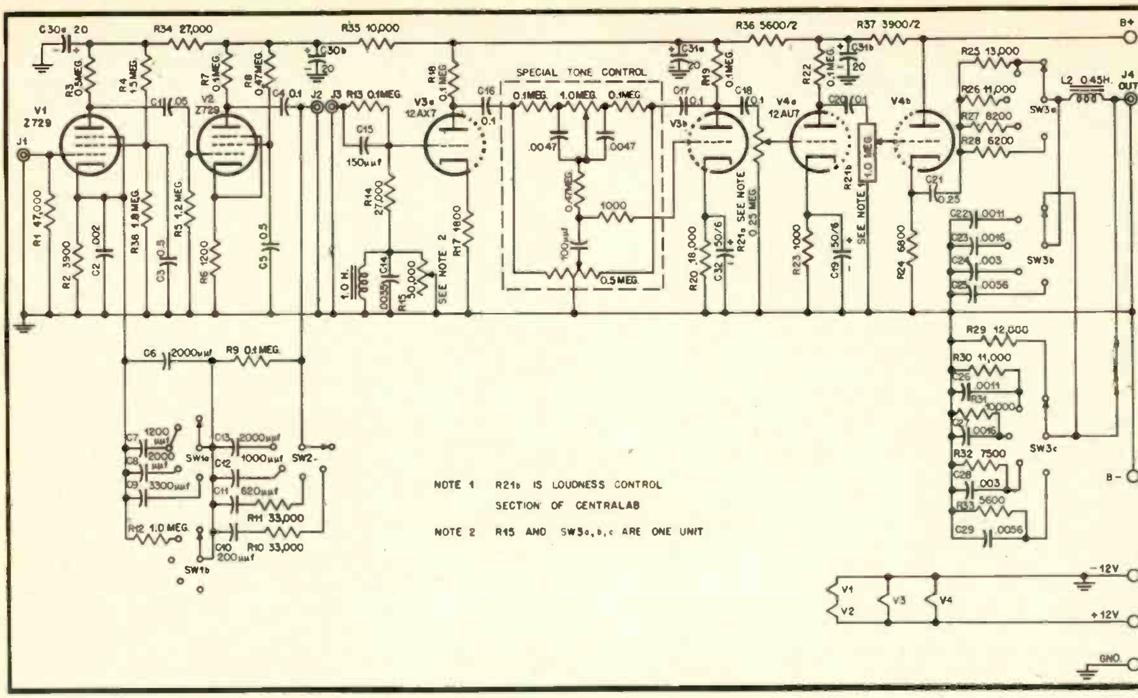


Fig. 4. Overall schematic of the preamplifier and control sections.

is a Centralab 30a unit, and consists of four 5-position switches mounted on two decks and operated by the outer shaft, together with the presence control—a 50,000-ohm linear pot operated by the inner shaft. Three of the switch sections are used in the filter circuit, while the terminals of the fourth serve as tie points for the matching resistors, R_{15}, R_{16}, R_{17}, and R_{18}. The eight capacitors and the four terminating resistors are mounted on another Alden terminal card, as shown in *Fig*. 7. The frequency-response curves for the filter section are shown in *Fig*. 8.

It may be argued that the presence of the filter network after the output of the cathode follower detracts from the advantage of the follower as an output source—usually considered desirable in case the power amplifier is to be located at some distance from the control section. However, for this particular application the two units are to be located close enough that a three-foot cable will be used for making the connection, and the impedance of the output under the worst condition—that is, at "flat"—is of the order of 11,000 ohms, and a shunt capacitance of 300 μμf could be tolerated with a droop of only 3 db at 50,000 cps. Under these conditions, therefore, it was considered preferable to locate the filter at the output of the control-unit rather than at some earlier section of the circuit.

Volume and Loudness Controls

In order to provide loudness-control action in the amplifier, and yet to be able to use as much or as little compensation as might be desired, both types of controls are provided. A 0.25-meg volume control is located between V_{3b} and V_{4a}, and the compensated control is located between V_{4a} and V_{4b}. The Senior Compentrol employed here consists of two controls with concentric shafts—the volume control being operated by the outer shaft and the loudness control being operated by the inner shaft. Any degree of compensation can be obtained quite readily. The response curves of the loudness-control section, *Fig*. 9, are shown for the maximum-volume condition, and for conditions where the 1000-cps level is 10, 20, and 30 db below maximum, respectively.

Circuit values have been adjusted for minimum IM distortion at normal output, resulting in a figure of 0.7 per cent at 2 volts. There is adequate gain from any tuner with which the amplifier has been used, and the output from typical LP records is within 6 db of that from the AM and FM tuners being used.

Considered from the standpoint of the number of controls in the amplifier, this unit seems to have overstepped the boundaries of the current trend toward simplification. However, viewed from the front panel, there are only four knobs—apparently—and these are arranged in a convenient fashion. There is sufficient flexibility for the most critical listener, yet for the other members of the user's family—those who would normally be confused by eight controls—the preamplifier switch may simply be left in the 500LP and – 12 position, and the tone, presence, and filter controls can be left in the "flat" position. Either of the level-controlling knobs may be used to set volume. The choice of knobs and switch position arrangement on the preamplifier control is such that the 500LP and the – 12 position are coincident, and could easily be arranged to be "straight up" in

(*Continued on page 55*)

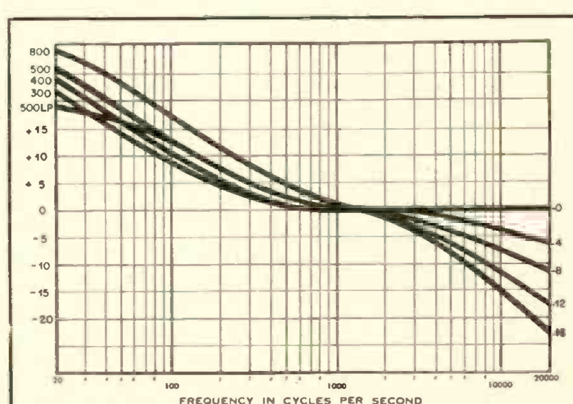


Fig. 5. Measured curves obtained from the preamplifier section.

Adventures With a Bass Reflex

MILTON S. SNITZER*

This clear, straightforward story outlines the only satisfactory way to design, build, and adjust a useful bass-reflex enclosure.

FOR A GOOD MANY YEARS, the writer's audio setup has been improving in all directions except perhaps the most important—that of the loudspeaker and its enclosure. It is true that about a year and a half ago I did obtain a high-quality 10-inch loudspeaker, but this loudspeaker went right into my "temporary" speaker enclosure. This enclosure which had been temporary for the previous 9 or 10 years, consisted of a rather nondescript bass-reflex enclosure which had been built into the lower section of an old corner bookcase. Its outstanding characteristics were a muddy bass and plenty of hangover. The volume, as nearly as I could figure it because of the irregular shape, was too small for the speaker, being less than 3 cubic feet. The port, all of 28 square inches, was less than one-half the area of the speaker cone so that it produced practically no low-frequency radiation. As a matter of fact, there was no discernable difference in sound quality with the port closed up. I think now that the port was put into the enclosure for appearance's sake only. Later, an impedance curve taken with the speaker in this enclosure showed a pronounced peak at the resonant frequency of the speaker, at which frequency the top and rear panels of the enclosure buzzed wildly, and there were several small peaks between 90 and 130 cps as well. Finally, I resolved to replace my temporary enclosure.

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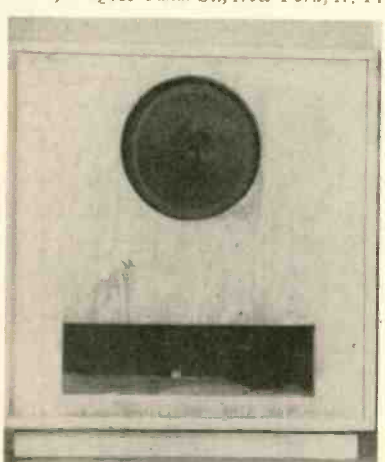


Fig. 1. The enclosure during experimentation.

Limits Set

Sometimes the design of a bass-reflex enclosure can be very difficult in that the designer doesn't know quite where to start because of all the variables. In this case, however, certain definite limitations existed at the start. The enclosure was also going to serve as a table for a TV receiver; therefore, it had to have a top surface that could accommodate the set comfortably and a height that would not raise the TV receiver above a comfortable viewing level. A 2 by 2-foot top surface would allow enough overhang for the TV set and a 2-foot height would put it at a comfortable viewing level. So 2 feet was established as the basic dimension. It was also decided to put casters on the enclosure so that could be moved easily in case the rear of the TV set had to be gotten into. The casters could easily be hidden inside a 2-inch recessed toe base. The result appears in *Fig.* 1.

The next consideration was the proper size of port to be used. This is easily determined from the basic formula for a Helmholtz resonator or from design charts based on this formula.[1] In order to use the formula or the charts, it is first necessary to know the enclosure volume and the resonant frequency of the unmounted speaker. With a 2-foot cube constructed of ¾-inch stock and with the front recessed by ½ inch (to allow for grill cloth mounting), the inside dimensions are 22 × 22½ × 22½ inches. This produces an inside volume of just under 6½ cubic feet. Deducting the volume to be occupied by the speaker itself, a rear panel brace, a horizontal partition (to be discussed later), and the volume to be occupied by the padding when it is tightly compressed, yields a net internal volume of 6.2 cubic feet.

Next, it is necessary to know the resonant frequency of the 10-inch speaker to be used. This was measured with an accurately calibrated audio oscillator, an a-c volt meter (set to its 2.5-volt range), and a resistor. The resistor used was a 90-ohm, 10-watt, noninductive unit which happened to be available. The resistance and power rating are not critical. With the output of the oscillator connected through the resistor to the unmounted loudspeaker, and with the meter connected across the speaker voice coil, it is possible to measure the required resonant frequency. With this set-up, as the oscillator frequency is varied, the voltage across the speaker changes in direct proportion to its impedance. Hence, at the frequency at which the impedance rises to maximum (this is at cone resonance), a voltage peak also occurs. The results of this procedure are shown in *Fig.* 2 where the actual voltage across the speaker is plotted for frequencies from 30 to 300 cps. Note that the unmounted speaker resonates at about 58 cps and that the amplitude of the resonant peak is over five times the amplitude at 30 cps.

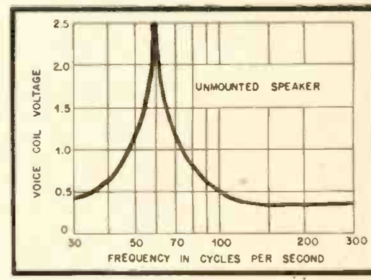


Fig. 2. Impedance curve of the unmounted speaker shows its 58-cps resonance.

Now that we know that the volume of the enclosure is 6.2 cubic feet and that the resonant frequency required is 58 cps, reference to the design formula or charts shows that the port area should be close to 60 square inches. This area is practically the same as the cone area of the speaker; hence, it appeared to be a good choice. The port was actually made 16 × 4½ inches, or 72 square inches, to allow for tuning.

Another problem had to be considered before actually starting construction; this had to do with the cubical shape of the enclosure. Since experimenters in the field have found that resonant frequency of a cubical enclosure of certain volume and port area is somewhat higher than that of a rectangular enclosure with the same volume and port area, it was decided to compensate in advance for this effect. This took the form of a horizontal partition, mounted midway between the bottom of the speaker and the top of the port as shown in *Fig.* 3. This partition extends across the entire width of the enclosure and back a distance of 15 inches. Such a partition has the effect of reducing the resonant frequency of the enclosure.

[1] AUDIO ENGINEERING, Dec., 1950, p. 22, and July, 1951, p. 14.

(Continued on page 49)

Handbook of Sound Reproduction

EDGAR M. VILLCHUR*

The Power Supply, Hum and Noise. Chapter 15, Part II.

Hum Pick-up from Alternating Fields

HUM INTRODUCED into the output stage of an amplifier by pick-up from a.c. fields requires efficient coupling to the source, such as that provided by close proximity of the input and a power transformer. In low-level stages the coupling need only be slight to cause trouble. A bad case of hum induction, for example, can result from locating a record changer in such a position that the magnetic cartridge is allowed to swing into the field of a nearby power supply.

High-impedance circuits are especially susceptible to hum pick-up. The impedance between ground and the "hot" lead receiving the hum voltage forms the lower arm of a voltage divider, as illustrated in *Fig.* 15—7, and the value of upper arm determines how much of the hum will be introduced. When there is a likelihood of hum and noise pick-up in long high-impedance cables, therefore, it is advantageous to use an impedance stepdown device such as a transformer or cathode follower at the beginning of the cable, and to match the line to the input circuit at the other end of the cable, if necessary.

Hum is picked up from both electromagnetic and electrostatic fields—from the former by inductive coupling and from the latter by capacitive coupling. There are two basic methods of avoiding such pick-up; careful placement of parts and leads, and shielding. The specific precautions for decreasing pick-up by parts, leads, or by the tube itself include:

1. Careful placement, relative to a.c. fields, of conductors carrying low-level signals. Power-supply components and low-level stages must be kept far apart, if possible on separate chassis.
2. The use of shielded power components.
3. The use of shielded audio transformers.
4. Mounting inductive components in a particular physical position, which makes for an angle between the signal carrying conductor and the hum field providing minimum coupling.
5. Use of metal tubes and grid-cap shields. (It should be noted that aluminum shields placed over glass tubes will deflect electrostatic fields only.)
6. The use of tubes with top grid connections, to remove the grid socket pin from an adjacent heater pin or other danger point.
7. Twisting a.c.-carrying pairs for field cancellation.
8. Shielding of critical leads. (Again it must be noted that the braid of shielded wire is non-magnetic, and that such shielding will only be effective against capacitive pick-up.)
9. Connecting the chassis to earth (actual ground). This is for the purpose of eliminating capacitive hum pick-up from the a.c. power line through the somewhat obscure path shown in *Fig.* 15—8. An amplifier grid is coupled to the earthed side of the line through the grid's capacitance to earth C_{GE}, and the amplifier ground is coupled to the other side of the line through the chassis-to-line capacitance C_T in the power transformer. A voltage divider is formed by the grid resistor and the grid-to-earth impedance C_{GE}. A good cold water or waste pipe ground connected to the chassis shorts out C_{GE} and anchors the chassis at earth potential. It is necessary to test for the best power plug polarity because of the unbalanced grounding of one side of the power line. An indication of hum due to earth-capacitance effects is the tendency of the hum amplitude to change when one's hand is brought into contact with the chassis.

A useful procedure for determining whether hum is being coupled between two points is to introduce a grounded sheet of iron as a test shield between the point of entry and suspected malefactor. For capacitive coupling a non-ferrous shield will work. If the result of such a test is doubtful the unit in question can be temporarily removed physically, with extension leads providing the electrical connections.

* *Contributing Editor,* AUDIO ENGINEERING.

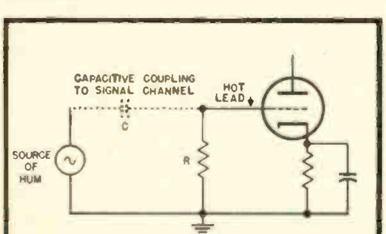


Fig. 15—7. Voltage divider formed by coupling path between the grid and hum source as upper arm, and grid-to-ground impedance as lower arm. The lower the relative value of R, the less the hum.

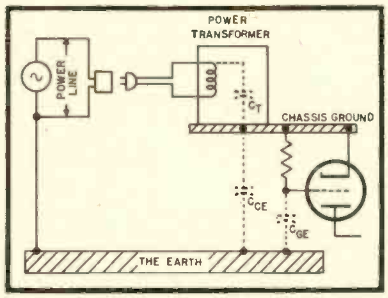


Fig. 15—8. Hum pick-up from the line due to grid-to-earth capacitance. C_T = capacitance between transformer primary and case, C_{CE} = capacitance between chassis and earth, C_{GE} = capacitance between grid and earth. For relief, C_{CE} must be shorted out by earthing the chassis, or the grid must be shielded from earth.

Hum from Tube Heaters

All of the elements of a vacuum tube are immersed in the field of the heater. Both electrostatic and electromagnetic coupling takes place, and the electron stream itself is directly influenced by the heater field. In addition, there are two high-resistance paths of direct connection between the tube elements and heater. Leakage in the insulating mounting supports of the tube or in the tube socket material provides one, and thermionic emission from the heater to the cathode provides the other.

There is considerable variation among different tube types and between different tubes of the same type as to their susceptibility to heater hum. Certain tubes have been designed especially for use in low-level circuits where hum and noise must be kept to a minimum. Anti-

TABLE 15—1
LOW-NOISE TUBES

Tube Type	Characteristics
12AY7	Dual triode μ (each section) = 40. Heater center-tapped.
RCA 5879	Pentode. In triode connection, μ = 21. Average hum value as triode under optimum conditions, referred to grid, listed as less than 4 μv. Two interwound heater coils have opposing magnetic fields.
RCA 1620	Pentode (low-noise 6J7)
W.E. 347-A	Glass triode, top cap, μ = 16
Genelex Z729 (provisional designation)	Pentode (British). Mfr. lists maximum hum voltage, referred to grid of 1.5 μv at voltage gain of 180.

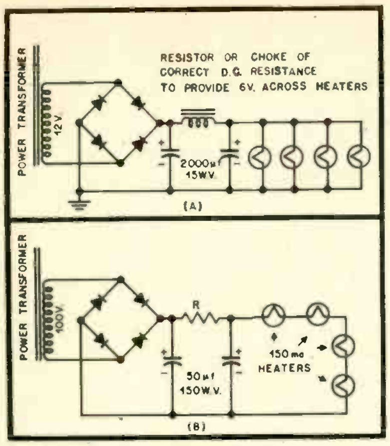


Fig. 15—9. A—Low voltage d.c. heater supply. B—Low current d.c. heater supply. R provides the correct voltage drop for the tube section and is preferably of the negative-temperature-coefficient type to protect the heaters from initial current surges.

hum design precautions include the use of structures which provide minimum capacitance between the heater and the other tube elements, the use of double-wound or center-tapped heaters with opposing magnetic fields for each half, and special care in the manufacture and processing of heater insulation material. A list of low-noise voltage amplifier tubes appears in Table 15—1.

There are several ways of reducing or eliminating hum due to heaters. The most effective method, of course, is to use d.c. or an a.c. of supersonic frequency[1] as the "A" supply. Two types of d.c. supply are illustrated in A and B of *Fig.* 15—9. A third method of securing d.c. appears in *Fig.* 15—10. The heaters of the most critical stages are connected in series with the cathodes of the output stage, forming part of the bias resistance, and a.c. signal variations are kept out of the heater circuit by a high value of cathode bypass capacitor.

[1] R. W. Smith, "Heater supplies for amplifier hum reduction," AUDIO ENGINEERING, August, 1948, p. 26.

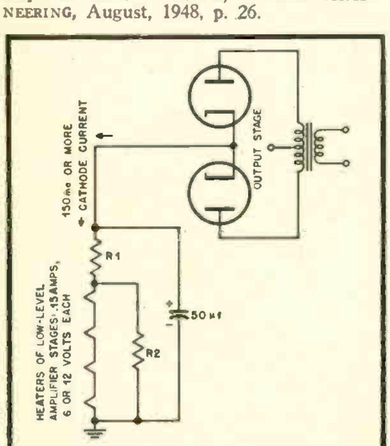


Fig. 15—10. Method for providing the heaters of low-level stages with d.c. R_1 must be of such value as to keep total bias voltage at correct value; R_2 keeps heater current at 150 ma.

This circuit involves no extra parts and should be used whenever applicable. Construction of a fairly elaborate d.c. supply ought not to be necessary except where unusually low levels of signal are to be amplified or where an especially low hum level is required.

The hum resulting from a.c. heater operation may be reduced considerably by the circuits appearing in A and B of *Fig.* 15—11. When the adjustable tap of the potentiometer bridging the heater circuit is grounded, the voltage on one side of the heater, relative to ground, is always opposite in phase to the voltage on the other side of the heater, and cancellation occurs between the opposing electrostatic fields. The application of positive d.c. voltage to the heater circuit, as illustrated in B of *Fig.* 15—11, makes the heater positive with respect to the cathode and prevents emission from heater to cathode, but keeps the potentiometer center-tap at a.c. ground potential.

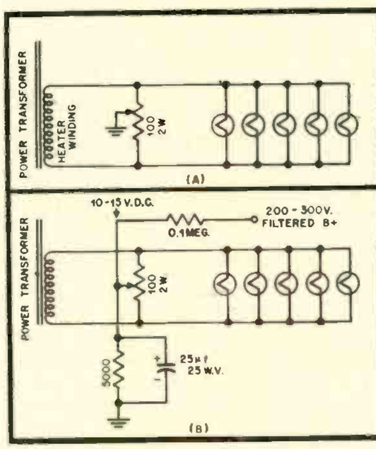


Fig. 15—11. A—Effective circuit for reducing hum resulting from a.c.-operated heaters. B—Elaboration of method shown in A, including positive bias on heater to prevent heater-to-cathode emission.

In some cases, particularly in low-gain amplifiers, the circuit designs of *Fig.* 15—11 may be simplified and sufficient hum reduction still achieved. The potentiometer may be replaced by a center-tapped resistor, or a center-tapped transformer heater winding may be used, and occasionally simply grounding one side of the heater line is adequate. The heater circuit must never be left floating with respect to ground, however, because the heater winding, normally part of the main power transformer, is coupled capacitively to the high-voltage winding. When the heater winding is grounded the coupling path to the h.v. winding acts as the high-impedance upper arm of a voltage divider in a closed circuit, with the relative impedance of the lower arm, formed by the heaters themselves, insignificantly small.

Other measures helpful in combatting heater hum are bypassing one or both ends of the heater to ground, reducing the heater voltage to 10 or 15 per cent below its rated value, and using tube sockets of low-leakage material.

Heater-to-cathode coupling is most troublesome when the cathode is not at or close to a.c. ground potential—when the cathode resistor is unbypassed, and especially when the unbypassed resistor is of high value. The use of cathode load resistors or of unbypassed cathode bias resistors in the design of low-level stages, therefore, must be accompanied by care with regard to hum.

It is quite easy to determine whether or not the heater of a stage is a source of significant hum. The heater supply is disconnected from the stage, a six-volt battery is substituted temporarily, and the new hum output is compared to the old by ear or oscilloscope. Determination of whether the heater is acting as a source of hum can often be made even without the battery, by noting whether the hum disappears instantaneously when heater voltage is removed, or merely fades gradually with cooling of an indirectly heated cathode. If the heater has been at fault the hum will cease immediately upon removal of the voltage.

Chassis Currents as a Source of Hum

A metallic chassis or other ground return has minute a.c. voltage drops appearing across parts of it. These voltages are created by the considerable flow of alternating current in heater or high-voltage return circuits. Voltage drops may also be created by current induced in a section of a chassis or ground return wire (effectively forming a 1-turn coil called a "ground loop") by the alternating field of some inductive component.

Figure 15—12 illustrates how voltage created by chassis current may inadvertently be introduced into the signal channel by wiring which places the difference in chassis potential between the ground returns of the grid and cathode resistors. The return path from the heaters to the transformer winding passes between points A and B of the chassis. It might seem that the resistance between these points must be so small as to be of no significance. But a simple application of Ohm's law will reveal the fact that with the heavy heater current flowing, let us say 3 amperes, a resistance of only .00033 ohm will create an IR drop of 1 millivolt. This voltage is 1/10th that of the signal output of a G.E. variable-reluctance cartridge, or only 20 db down from the cartridge signal level.

The relief required in the circuit of *Fig.* 15—12, that of connecting the cathode and grid resistor ground returns at

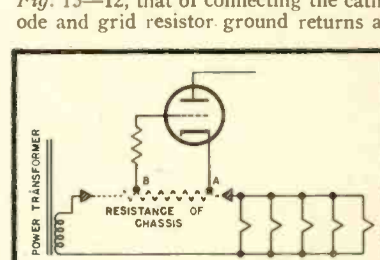


Fig. 15—12. Introduction of hum voltage between grid and cathode due to flow of a.c. return current through chassis.

the same point, is obvious. In order to avoid hum from chassis currents entirely, the physical sequence of ground-return connections is often planned so that the situation illustrated cannot occur. An effective method is to ground all returns to a tinned copper bus bar, beginning with the heater and filter capacitor returns and the center tap of the high-voltage winding, continuing with returns of the output stage and each voltage amplifier in order, and ending with the lowest-level stage on the chassis. The bus bar is connected to the chassis at one point only, the signal input jack of the amplifier.

Other devices for avoiding chassis current hum are:

1. Connection of ground returns in the same physical sequence as described above, but to the chassis itself.
2. Grounding grid and cathode returns from the same stage at the same point, with special care to make a low-resistance joint.
3. Use of non-magnetic chassis to avoid concentration of electromagnetic fields. (This involves a sacrifice of the electromagnetic shielding effect of the chassis.)
4. Use of low-resistance copper or copper-plated chassis.

A.c. currents may also flow in the ground cable between interconnected chassis or between the record player and chassis. The chassis ground of one unit may be at a different potential from that of the other chassis relative to the a.c. supply, due to line bypass capacitors, reverse plug polarity, different heater-ground circuits, and so on. This potential is difference is sometimes measurable when each unit is plugged in but not connected to the other. Efforts must be directed at eliminating the source of the voltage difference and at arranging circuit layout and cable ground points in such a way that the undesired current flow cannot introduce hum into the amplifying channel. The IR drop of the inter-chassis current may also be decreased by connecting the two chassis together with heavy copper braid, making contact over a large area of metal.

Hum caused by chassis currents is the most difficult to trace; critical analysis of the circuit and of the physical layout is required. Suspected sections of the circuit may be checked by experimental changing of the physical locations of ground-return connections. Another useful test is to short out temporarily two chassis points between which hum voltage is presumed to exist by heavy pressure of a screw driver or by the connection of copper braid.

Modulation Hum

Hum may be picked up in r.f. circuits, but not in the ordinary way. The interstage networks or transformers coupling r.f. stages cannot possibly pass hum frequencies directly; hum can only get through such networks as the sideband of a radio-frequency signal. In order for line-frequency components to appear in the signal, therefore, they must not only be introduced into the signal channel but they must modulate an r.f. carrier. When the hum-modulated carrier has passed an r.f. coupling device the existence of hum is attested to only by the presence of two new radio frequencies equal to the carrier plus the hum frequency and the carrier minus the hum frequency. It is for this reason that hum whose source has been in r.f. stages is called modulation hum and only appears when an r.f. signal is also present.

We have already seen that two mixed signals will be subject to intermodulation and produce sum and difference frequencies only when they are passed through a nonlinear device. Hum introduced into the converter stage of a superheterodyne receiver (which is purposely made nonlinear to mix the local-oscillator and incoming-signal frequencies) will therefore be most readily incorporated into the r.f. signal as an additional set of sidebands. It is commonly picked up by heater-to-cathode leakage, and the stage must be treated in the same way as a low-level audio amplifier.

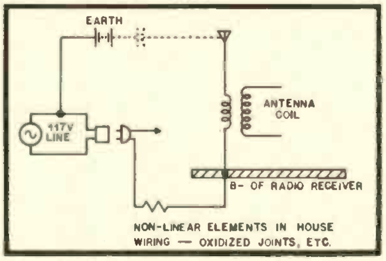


Fig. 15—13. Introduction of modulation hum in antenna circuit.

Modulation hum is also introduced in the antenna circuit. *Figure* 15—13 shows how the a.c. line is in series with the r.f. input terminals of an a.c.-d.c.-type radio receiver, for one plug polarity. The 60-cps voltage is completely blocked by the r.f. antenna transformer, but oxidized joints and other nonlinear elements in the power line create 60-cps modulation of the r.f. The common preventive measure, other than testing of plug polarity, is to install a bypass capacitor across the line, establishing a short path for the r.f. signal across the a.c. power generator.

The type of circuit illustrated in *Fig.* 15—13 ties B– directly to one side of the line. A similar analysis applies to receivers with transformer power supplies, where the path from the line to B– is completed by the capacitance between the power transformer primary and chassis. Connection of an external ground to such a receiver shorts out the modulating voltage.

General Methods of Hum Reduction

The best type of hum reduction is the discovery and elimination of the causes. There are situations, however, where reduction below a given point is not practical, or where one is already committed to somewhat undesirable conditions. In addition to the design principles discussed above there are general techniques of hum reduction that work on hum due to any source. These techniques should not be applied as a substitute for good workmanship, but alongside it. They may also be used as a weapon against tenacious elements of hum which are due to conditions that cannot readily be corrected.

Negative feedback reduces all hum generated within the feedback loop (although if the feedback voltage is secured from an unbypassed cathode resistor there will be more hum generated). The signal-to-hum ratio is reduced in the same proportion as harmonic distortion, provided the signal amplitude is boosted back to its former value. Gain within the feedback loop is, of course, sacrificed.

The outputs of push-pull tubes are combined out of phase, and much of the hum originating in the stage will be cancelled. The degree of cancellation will depend upon how similar the hum voltage generated in each tube is to that of the other, and how well balanced the tubes are. It may be necessary, in the case of filamentary-cathode tubes such as the 6B4, to try several combinations of individual tubes before a quiet pair is found. Devices to improve the balance of push-pull tubes are hum reducing devices; in the absence of better facilities minimum hum output, with the phase splitter tube removed from its socket, may be used as a rough indication of balance. Circuits which are designed to balance the input signals to each push-pull grid have no effect on hum except indirectly, in that unbalanced input signals will influence the setting of any potentiometer controlling the balance of the tubes themselves.

Bass-boost networks must be inserted in as low-level a stage as possible so as not to accentuate hum introduced before them. This is the reason preamplifiers for magnetic pickups do not provide the required bass equalization in their output circuits.

Occasionally it is found that reducing hum from a particular source raises the total hum level. This occurs because the eliminated hum had been out of phase with, and was partially cancelling, hum from other sources. Such cancellation may be used in a controlled manner. The "hum-bucking" coil, linked inductively to the field coil of electrodynamic speakers and placed in series with the speaker voice coil is an example of purposeful cancellation. Circuits allowing more sensitive balance of the injected out-of-phase voltage have been designed.

(*Continued on page 39*)

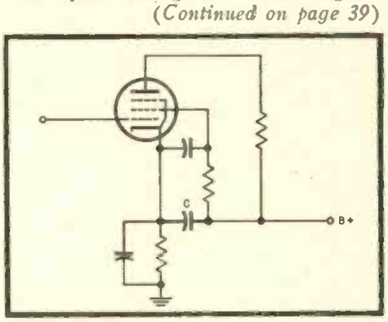


Fig. 15—14. Circuit for cancelling plate-supply ripple and regeneration due to inadequate filtering and decoupling. The value of C_1 in relation to the cathode-to-ground impedance determines the value of the cancelling voltage. (After Wen-Yuan Pan)

Audio ETC

Edward Tatnall Canby

Parallel and Stepwise

Craft and Commercial

Since writing in the November issue about the new commercial mass-produced "hi-fi" phonographs and their craft-style competition (that was written back in mid-September) I've had a good chance to study vast reams of advertising, attend press parties—and read correspondence. Nobody, but nobody, has written in as interestingly on the subject as Mr. Leon Ferguson, who operates a record shop in Memphis.

Mr. F. has just added a hi-fi department to his store, and refutes me clearly and explicitly on one point: he sells both commercial phonographs *and* net-price craft-style components, all in the same show room, and he invites listening via full-page newspaper ads. On the one hand, he offers several brands of "factory assembled high fidelity phonographs", as he puts it, and on the other, the component parts to "build your own high fidelity home music system"—both types illustrated in parallel columns in the same ad. Small-company components, at regular net.

This is an interesting experiment, still only a few weeks old when I got the information. In that short time, one of the two types had already sold 9 to 1, roughly, over the other—I leave you to guess which, since the information was confidential! But the important thing is that here, at last, a wide-awake record store man has realized that not only do records and machines naturally go together, but that records and good equipment, up-to-date equipment, are decidedly of equal interest, to the record collector. Why shouldn't any small record shop do the same? A lot will be trying soon—though few, I fear, will be enterprising enough to offer both types of playing equipment as does Mr. Ferguson, the craft and the commercial. A trend? I certainly hope so.

Parallel

Which brings up a point I've had in mind ever since one large manufacturer showed both his "commercial" and his "component" lines in one press demonstration. I think it's clear to most of us that net-price hi-fi of the craft type gives more *audio* for the money than the ready-made commercial hi-fi (so named) at prevailing list prices. It does, at least, on levels above the very lowest where, as suggested in November, mass production has a big edge.

Convenience—big selling point of the commercial machine—is, however, another and very legitimate attribute. People do buy commercial machines by the millions just because they are, in fact easy to buy and install, simple to operate, good looking—but most of all, easy to buy and simple to operate. That's a true balancing factor for lots of folks.

Mr. Ferguson has neatly laid out his "line" of thought in these very terms. His ads offer EITHER the simplicity and convenience of the new "factory-assembled" phonograph OR the greater sound value of the component-type system. Note well that the *economies* of the latter are stressed —"it saves you plenty!"—but that its less great convenience is admitted. (Not in so many words, for etiquette in ads allows for nothing derogatory except in glittering dangling comparatives—"the better soap" or "more chocolat-y than ever". In ad language, he says "it takes little technical ability to assemble these parts . . . all you do is plug together and install anywhere in your own home.") A well struck balance, putting the situation into simple alternatives that can be directly demonstrated via the equipment he offers.

This approach is what I can best call the Parallel Comparison, offering *equal*, but different alternative values—emphasizing the economies of craft-type hi-fi components.

Not So Simple

Of course it really isn't quite that simple. Mr. Ferguson has rightly tailored the situation to fit his own judiciously limited offerings. A few basic items of each type for sale, an uncluttered, uncomplicated shop and a simple, easily grasped sales policy. Good. Yet if we look beyond his shop to the larger scene, we know that the Parallel Comparison isn't that way any more.

What about the readily-assembled machines, put together from craft-type components and sold at net-price economy? What of the semi-component models, with perhaps anonymous amplifiers and speakers but still essentially component-type in construction, which are now hitting the big department stores? And what of the sort of thorough installation service that even Mr. Ferguson is likely to have to provide —giving his customers, on demand, what amounts to a ready-to-play machine completely installed? Though most newcomers to hi-fi still think you must do your own soldering, and are thereby enormously disturbed, we know ourselves that if any progress has been made in component distribution, it has been, these last years, in the greater and greater degree of pre-assembly made available—to meet this very need, more and more adequately. An old story in these columns.

Thus, it's not necessarily true that EITHER we buy convenience, one-piece and mass produced, OR we buy good audio —and do our own laborious putting-together. It's only partly true.

Not enough people know that cabinets now come with holes bored in them and many a dealer will put a speaker or a changer right into them for you, and wire the whole up as well. Not enough people know that most component equipment comes with the plugs already on and the dealer will plug in the plugs for you, if you don't dare. Not nearly enough people know how *convenient* a flexible home system can be, and how good looking, for a reasonable price and no effort except kibitzing. You don't really have to move a finger if you don't want to. Right, dealers? (Groans from the dealers, who would dearly love to get out of the installation part—but they can't.)

Stepwise

So much for the argument that EITHER we buy commercial, for convenience and laziness and what-have-you, OR we buy craft, for audio value, and inconvenience, combined. Now, look closely and hard at

(*Continued on page 52*)

THE MAGNIFICENT

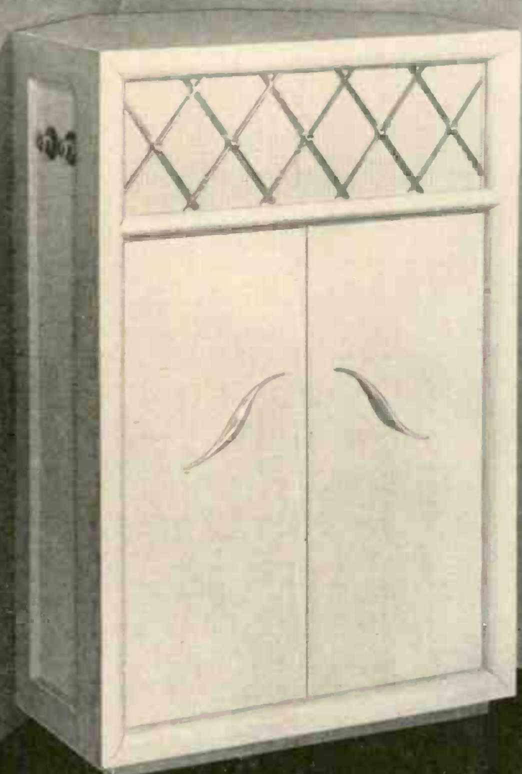
Georgian

ELECTRO-VOICE

KLIPSCH FOLDED HORN

4-WAY LOUDSPEAKER SYSTEM

Utilizing the Authentic Klipsch "K" Horn Type Indirect Radiator for the Extreme Bass



The luxurious cabinetry of this corner enclosure is skillfully combined with the most advanced high-fidelity engineering to give you a superlative, integrated 4-way reproducer. The magnificent GEORGIAN utilizes the famous Klipsch "K" horn with special EV 15" driver in the bass section. Electrical network makes the first crossover at 300 cps to a compression type, horn-loaded mid-low frequency driver with 58" path length. From 1000 to 3500 cps, a special E-V diffraction horn through an acoustical crossover gives smooth, augmented treble tones. Above 3500 cps, the E-V Super Sonax very-high-frequency driver takes over to provide the silkiest extended high frequencies out to and beyond the range of audibility. This multiplicity of crossover points and the specially designed crossover network permit a smooth transition from one section of the spectrum to another. Besides, the GEORGIAN is the first loudspeaker system ever to incorporate the vital "presence" control as well as a brilliance control. With its cleanliness of reproduction and extended range, you can now enjoy all the reality of living music in your home.

Selected Mahogany or Blonde Korina veneers in lustrous hand-rubbed finish.

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Includes Electro-Voice 15WK Low-Frequency Driver, 848-HF Coaxial Compression Type Mid-Bass and Treble Driver Assembly, T-35 Super Sonax Very High Frequency Driver, X336 Complementary Crossover Network utilizing full m derived ½ section crossovers, and two AT-37 Presence and Brilliance Controls.

GEORGIAN 4-Way System, Complete.
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EDWARD TATNALL CANBY*

OLD MAN BACH†

†**Bach: Mass in B Minor.** Chorus, Orch. Radio Berlin, Lehmann. Soloists.
Urania UR-RS 2-1 (2)

This two-pocket album, in Urania's lower priced "Request" series without notes or booklet, contains, as I found to my surprise, the best B Minor Mass I have yet to hear on records—and that includes some of the more celebrated versions.[1] This one, first, is straightforward, without fancy conductor's showings of temperament; the tempi are reasonable and good, instead of exaggeratedly slow or fast, the dynamics are as common sense would dictate, the diction of the chorus is good, the words spoken intelligibly and sensibly. What a relief—after so many freakish versions of this sort of music!

More than this, the performance, while not sensational in any dramatic way, is thoroughly musical in every aspect, the soloists—a miracle—are all good and well balanced among themselves and every one of them sings Bach naturally and like Bach, not like Verdi or Wagner! The chorus is a bit bouncy at times, but seldom, and the prevailing feeling is one of thoughtfulness and concern with the meaning of music and text. Best of all, the physical set-up of forces is wholly in the new manner —that of Bach himself more or less—with a reasonably small chorus, a small orchestra of the right instruments rightly balanced, a discreet harpsichord (not exaggerated); the solo arias are done with a perfect understanding that they are essentially chamber music for vocal solo, with often only a single instrumental solo as assisting obbligato and a single cello and the discreet harpsichord as accompaniment. The old grandiose style of doing Bach (which led merely to general fuzziness on discs) "orchestrated" these lovely in-between numbers to symphony orchestra size and so spoiled the contrast between them and the big chorus-orchestra numbers—not to mention the more delicate balance between solo instrument and voice.

What else? That's not the end of the virtues here. The recording, doubtless another radio tape, is good, adequately wide in tonal range and without unpleasant distortion. the mike arrangement gives the chorus billing, in the foreground and very much alive with the orchestra beautifully balanced against it. The solo singers are neither too close nor too loud —a common complaint in many a new Bach record. The somewhat studio-like acoustics are not dead enough to kill the music; rather, the good details are brought out. And, with a few watts extra power, the loud parts can sound just as big and impressive as if there *were* 400-odd performers. Congrats to the Request Series.

Mind you, in 1936 (and for many a year after) there was only one huge version of the B Minor Mass on records, running to a fabulous 34 sides, weighing perhaps 50 pounds, costing $25.50. I never could afford more than a few excerpts from it. This modern version, ever so much better and clearer and more authentic, weighs exactly 1 pound 10 ounces and costs about $8. All hail the LP!

*****Bach: St. Matthew Passion.** (1) Anon. Chorus and Orch., Scherchen. Soloists.
Westminster WAL 401 (4)
(2) Amsterdam Toonkunstchoir, Concertgebouw Orchestra, Mengelberg. Soloists. (1939) **Columbia SL-179 (3)**

Here is another of the super-Bach works in two versions—the Westminster is unabridged, accounting for the 4 discs, while the Mengelberg version was recorded at a performance in 1939.

These big works—the St. Matthew, and St. John Passions, the B Minor Mass—from Mendelssohn's time in the 1830's on for a century were performed in huge and inspiring mass productions, using orchestras of super-symphonic size and choral groups in the hundreds. In late years we have finally gone back to an approximation of the original Bach intentions, with a very much smaller group, the original instrumentation (as noted above) —and a net gain in clarity and sense that more than makes up for any loss of grandeur.

The Mengelberg version comes from an annual tradition that went back for decades and decades of that ancient conductor's incredibly long stay with the great Dutch orchestra; it represents, in effect, a performance of about 1895, in the grand manner exaggerated. Romantic, temperamental in ways that are almost unbelievable today. Great, gusty crescendos, ominously slow and majestic tempi, weird swoopings and gaspings in the chorales and the solos, all were part of the old Mengelberg style, which might be compared to a dramatic reading by Sarah Bernhardt, or Shakespeare by Sothern and Marlowe! Crazy, eccentric, of another time—and yet interesting too, for old Mengelberg in his eighties was still a great musician. The grand dramatic moments of the story of the passion of Christ are musically capitalized to the full and with effect, if in bizarre ways.

The Scherchen version, done by a middle-old conductor who is a mere youth beside Mengelberg, is an odd contrast. Physically it is far more modern, more authentic and better recorded. It uses the now standard smaller group, the proper instruments, achieves the right chamber music balance in the solo parts. The solo voices are good, notably the superb bass Jesus of Heinz Rehfuss. (The tenor evangelist, Hugues Cuenod, has a voice that is too tight and nervous in spite of fine musicianship.) The recorded sound is hi-fi and ultra-clear. (Mengelberg's solos are, to put it mildly, atrocious, the recitative a travesty of the true style.) All of which would seem to give Scherchen and Westminster the palm with no further ado—yet. . . .

There's a dogmatic, hard quality in Scherchen's Bach that is not good. His interpretations of many passages are as inexplicable—soft when loud would seem called for, rough when mildness is seemingly implied, and so on—as Mengelberg's are eccentric, and as Fritz Lehmann's in the Mass, above, are eminently reasonable. This St. Matthew does *not* rise to eloquent heights of inspiration—and Mengelberg's does, style or no style.

More specifically, as an old choral singer and long-time lover of choral music I feel strongly that Scherchen ignores the text, both the over-all meaning and the specific textual expression of the musical phrases; he plays the music like a symphony, and he forces the chorus—and the soloists—to be symphonic instruments, whose words are merely mumbled conveniences towards tone production. His crescendi and his climaxes are purely of an instrumental kind, not tied to the flow of the living German; his chorale hymn melodies are as though harmonizations for vocal background, wordless. This is extremely disturbing to anyone who has felt the power of Bach to express words, to cry out in living word-phrases. It is a hurt that no choral singer can forgive.

Scherchen treats his soloists to the same—they are hauled unrelentingly with the most rigidly mathematical time-beating straight through their ornamental phrases, as though they were of the most secondary importance and their words quite meaningless, which is anything but the case.

Therefore, I do not like this St. Matthew, and in spite of many lovely moments (that superb Jesus, again, is worth the whole album) if it came to a choice between the two, I would turn to Mengelberg. His is the greater, if crazier, performance.

Bach: The 48 Preludes and Fugues of the "Well-Tempered Clavier."
†(1) Rosalyn Tureck, piano.
Vol. 1: Decca DX-127 (3)
Vol. 2: Decca DX 128 (3)
*(2) Isolde Ahlgrimm, pedal harpsichord. **Vol. 1: Columbia SL-191 (3)**
(vol. 2 to come)

*****Bach: The Six French Suites.** Isolde Ahlgrimm, pedal harpsichord.
Columbia ML 4746.

Never rains but it pours. Here again—think back to the 30-odd years during which record collectors waited and waited for a complete version of the monumental "48" preludes and fugues that would be generally available! These all came in one mail delivery.

The "48," two sets of preludes and fugues, two pairs for each key on the piano octave keyboard, did a lot more than prove that tempered pitch would work. For a century or so they were almost the only known works of Bach and they have influenced every great composer and a couple of billion mere listeners and would-be keyboard artists during some two centuries. They are not meant for piano—there was no piano worth hearing at the time. It's a question whether some weren't better suited for the clavichord, which uses delicate struck strings. but many most certainly were played on the big harpsichord, with its two keyboards, its numerous ranks of tone color, its massed

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

[1] Vox's PL-6074 (4) lists the same performers, may be from same original.

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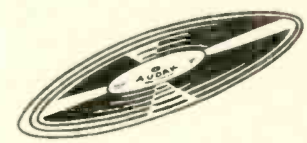

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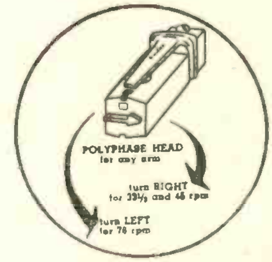

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doubling-up of octaves for big climaxes. (The harpsichord plucks the strings mechanically.)

Bach on the piano is always a compromise, adding more expression in the loud-and-soft aspects, adding the nice blurrings of the sustaining pedal which the harpsichord does not have, losing heavily in clarity because of its relative lack of sharp overtone color. A thick mass on the piano is mud, where on the harpsichord its details stand out clearly. Yet thousands of pianists have made good adaptations for the piano's own expression, and Rosalyn Tureck, above, is one of the best available choices for a good job of Bach on this relatively monotonous instrument. Monotous, that is, when used for Bach.

Tureck's Bach "48" is beautifully done on the whole, with a due sense of the original intention, a good feeling for the best way to bring the music out in this different medium, and a minimum of "pianism"—the playing of Bach as though it were half-baked Rachmaninoff. She gets a finer clarity in the complicated parts than any pianist I've heard recently except Gieseking and her phrasing and rhythm are impeccable. Nevertheless, enough is enough. These works, after an hour or so, become more and more obviously non-pianistic, the piano itself has a more and more monotonous sound. Occasionally, Tureck tries too hard for variety by using staccato harpsichord imitations and the like. Taken individually, these are top performances— and most people will want to hear them that way, especially piano students, who can learn much.

But piano students may learn even more from the Ahlgrimm harpsichord records now launched by Columbia to cover the entire Bach keyboard literature aside from the organ music. Here is a good match to the great Landowska in her RCA Victor recordings!

Ahlgrimm is far less of a virtuoso dramatist, more the objective and careful musician, than the incomparable Landowska, who will remain forever in her own special category. This younger woman is a fine "normal" musician who plays Bach with the utmost authority and clarity and musicianship, with complete ease and considerable technique, if without the Landowska fervor (and eccentricity). Pianists will find almost as much to interest them in Ahlgrimm's detail work with fingers and rhythms and tone colors as in the Landowska discs—and these are very much better recorded for harpsichord sonority. Indeed, I don't think I've heard a better harpsichord sound.

But the special feature here, aside from top recorded sound, is the pedal harpsichord. This is a copy of a device that Bach is known to have used, a keyboard machine with a special section at floor level operated like an organ by a pedal board for the feet—thus allowing for the organist's triple-play technique, using both hands, plus the feet, heel and toe. (A pedal *piano* is impracticable because piano tone is influenced by pressure, which cannot be well controlled in the feet; but the harpsichord and organ tones are almost independent of pressure—one is a valve mechanism, the other a "click"-type pluck of a string.)

You might guess that on records a pedal harpsichord would sound like any other, since we can't see the pedals in action and we don't know which limbs are playing what music. But, interestingly enough, it turns out that the pedals make a vast difference in the musical effect. The reason is simple, as any organist will know.

Organ technique, with pedals, puts the bass line of the music frequently down in the feet, leaving the left hand with only inner parts and no bass. Pianists, however, learn quickly to feel that the bottom notes are *always* under their left hand fingers. There is no odder feeling for a pianist than his first try at an organ, with the bottom of the music detached and shifted to his feet! Like eating chicken with the toes.

Bach, you see, was an organist—that's why he liked the pedal harpsichord. His playing was organ-conscious, on any instrument; he would write big, solid bass passages, for any instrument or orchestra, or chorus, at the drop of a pencil and, as an organ technician, would instantly transfer these to any pedal board that found itself beneath *his* feet—organ or otherwise. Pianists, lacking this pedal-sense, sometimes do not hear the pedal element in Bach's keyboard music, nor are ordinary harpsichordists too aware of it—though the big 16-foot harpsichord can mechanically double the bass notes in hefty octaves to give a pedal effect.

On the Ahlgrimm pedal harpsichord, then, you will hear a remarkable number of big, sonorously detached passages that come, manifestly, from the lady's feet. And, in these familiar Bach works played thus with an unfamiliar technique, some surprising and wholly legitimate effects (if we know Bach) come out. Interesting, and listening organists will get itching toes.

Volume Two is due soon. Meanwhile the single LP of the six French Suites, the short and tuneful works often heard and played, is a supplement, or a beginning if you don't want to tackle a whole album at once. Not as good as the "48" job.

†*Bach: Complete Works for Solo Violin. Rolph Schroeder, using the curved bow. Notes and supervision by Albert Schweitzer.
Columbia SL-189 (3)

Here's an extraordinary novelty—for those who have got far enough in Bach and/or violin (playing or listening) to get its full import.

The violins we use today, the best of them, were made centuries ago in Italy; the rest are imitations of the old ones. The instrument itself has scarcely changed at all. The bow, on the other hand, is a different story; the present backwards-curved "straight" bow with its hairs tightly stretched by a screw mechanism dates from a mere century ago, well after Bach's time.

The straight bow plays loudly and lightly, thanks to its great tension. But, over the curved bridge, it cannot play more than three of the four strings and that only with a heavy and loud dig. (The curved bridge keeps the fiddler from accidentally scraping more than one string at a time when he's playing single tones.) In Bach's day the much older curved bow was still used. The arch of this bow allowed the hairs to be slackened until they could curve over all four of the strings to play a solid chord—a strange and very pleasant string effect. More, the player controlled tension of the hairs with his thumb; for faster single notes he tightened them up. Not enough tension for today's loud tones, but for that disadvantage, there were the other advantages.

Not since Ole Bull, the eccentric Scandinavian violin genius of the late 19th century, has a big violinist used the old bow. Too limited, of course, for concert use—and one might ruin one's technique for Tchaikowsky and Vieuxtemps and Lalo and Paganini! But this man, Rolph Schroeder, became interested many long years ago, worked to design a modern equivalent (and improvement) to get Bach's arched bow effects, introduced it—and lost everything in the war. He started again afterwards, and here he is, with the enthusiastic blessing of the great Albert Schweitzer.

The unaccompanied sonatas and partitas—including the great Chaconne so often played in transcriptions for piano, orchestra, guitar and what have you—are, even here, not exactly easy fare for the uninitiate. A solo violin, even with complete chords, must still suggest, sketch, imply a lot for the inner ear.

However, if you know the works a bit and have listened to the great fiddlers do their level best to play "chords" that are no more than scratchy arpeggios across the strings, you'll really be amazed at the quiet, smooth way in which the complete harmonies of all four strings roll out of this violin from the Bach-style bow. In spite of Heifetz, Szigeti, Schneider and a host of others who play with the modern bow—this is the way the music was written to be played.

How is Mr. Schroeder musically? Not unlike Schweitzer himself; slow, careful, deeply thoughtful, highly musical and with a deep understanding of these works, a German-style thoroughness that in some sections may seem to lack "zip." But that, of course, is merely according to our somewhat hysterical American taste. Superb violin recording in a big liveness, good for both music and instrument and superior to the deadened sound of the recent Heifetz (straight bow) recording.

KEY

- * Outstanding recorded sound for the type of music.
- † Noticeably good performance
- †† Outstanding or especially interesting performance
- [10] Ten-inch record.
- [B] Big bass
- [c] Close-to miking but in good liveness
- [d] Some distortion
- [f] Flatter-than-average highs—use less rolloff.
- [l] Low level (more surface noise).
- [n] Narrow, rather distant sound; lacks body.
- [p] Pops and crackles—noisy surface.
- [y] Lacks high highs
- [v] Vocal solo(s) close-up, loud.

BIG-ORCHESTRA—WAGNER

†**Wagner: Siegfr. Rhine J.; Funeral March; Fire Music.** Wurttemberg, Leitner, [10]**Decca DL 4072**

Wagner: Tannhauser, ††Faust Overtures. Wurttemberg, Leitner; Munich Phil., F. Reiger. [10]**Decca DL 4061**

War-horses, except the Faust overture, unusual enough in this good performance to make surprisingly good listening. Odd suggestions of Parsifal and Siegfried Idyll are notable.

Wagner: Flying Dutchman, Tannhauser Ov., Ride of Valkyries. . . . Vienna Philh. Knappertsbusch. **London LL 800**

[c]**Wagner: Lohengrin Preludes, Tannhauser Ov., Meistersinger Prelude, Ride of V.** Detroit S., Paray. **Mercury MG-50021**

The Vienna disc is full-bottomed, solidly played with plenty of German atmosphere. Not as "stringy" as many earlier ffrr records—and the better for it. A routinely good performance, very accurate. The Paray is a Frenchman's idea of German music—excitingly different and at times grotesque, as in the bouncy, shallow Meistersinger Prelude. But the lighter parts are sheer Mercury! Interesting and amusing, if not good Wagner, worth a dozen of the routine sort.

SIBELIUS

[ln]**Sibelius: Symphonies #5, #6.** Stockholm S., Ehrling. **Mercury MG 10142**

[†f]**Sibelius Symphony #1.** Royal Philh., Beecham. **Columbia ML 4653**

***Sibelius: Symphony #2.** London S., Collins. **London LL 822**

†***Sibelius: Four Legends. (Lemminkainen Legends.)** Danish State Radio Symph., Jensen. **London LL 843**

Here's part of the current Sibelius comeback, via LP. The Mercury Swedish series is technically so-so, the sound rather distant and not well defined; performance is competent but undramatic. (Includes all the symphonies.) Beecham's Sibelius on Columbia is a much more effective musical job, but it pulls out the stops and turns on the juice to the limit. (Probably what Sibelius had in mind. . . .) Good recorded sound, with the usual lesser preemphasis in the highs that Columbia reserves for its English reissues. The London Second Symphony is superbly recorded, played in somewhat routine fashion, to my ear. The Legends (including the familiar Swan of Tuonela) get an intense and businesslike performance, minus the extra sentimentality so dear to most Sibelius interpreters. Good, for my ears!

HIGH RUSSIAN

***Rimsky-Korsakov: Scheherezade.** Vienna State Opera Orch., Quadri. **Westminster WL 5234**

Same Radio Berlin Symph., Rucht. **Urania UR-RS 7-19**

If you want hi-fi, get the Westminster, but it's only fair to say that the familiar and beloved score is given a strictly businesslike once-over here that smacks of "get-it-over-with-quickly." I'd swear Westminster has added a few pots and pans to Rimsky's score, just for the fi of it. As to Urania's "Request" series (low priced) version, it's neither tired nor too-hasty, but a very adequate and alive performance that will never hurt the music-minded. Not as hi as Westminster's, but plenty good on its own, with pots and pans in reasonable balance. A faintly radio-tape sound, the highs not entirely clean, though hardly bad enough to bother most people.

†***Rimsky-Korsakov: Skaska; Snow Maiden Suite. (Snegourotchka).** Philharmonia, Fistoulari. **M-G-M E3017**

†***Rimsky-Korsakov Program.** Philh., Fistoulari; Susskind; London Symph., Weldon. **M-G-M E3045**

The Snow Maiden is full of good humored and nicely orchestrated marches interspersed with bird songs and other intriguing sounds—very well played, beautifully miked; the early Skazka is a pompously colorful work about a legendary tomcat. Both enjoy really superb recording from the acoustical standpoint, as do the companion sections (which vary somewhat) in the Rimsky collection. The latter includes the one-movement piano concerto (Jacquinot) on Russian themes, and a number of interesting odds and ends from the Rimsky catalogue, all excitingly played as well as beautifully miked. M-G-M continues to amaze in records like these which, one might think, would tend towards the superficially popular under such a label! Only some surface noise and the extreme high pre-emphasis (with a bit of distortion) keep these from the absolutely top category.

*B**Moussorgsky: Pictures at an Exhibition. Stravinsky: Fire Bird.** Phila. Orch. Ormandy. **Columbia ML 4700**

lyn **(Same two works)** Radio Leipsig Symph., Abendroth; Borsamsky. **Urania UR-RS 7-18**

Contrast! The Philadelphia recordings are of a common Ormandy sort where war-horses are involved—meticulous, beautifully accurate, a bit heavy, intense, yet somehow on a high level of utter routine. Fire Bird comes off better than Pictures in this respect. Superb big bass and sharp highs, in the usual big resonance. The Urania radio tape ("Request" again) is much inferior as to quality, with unimpressive highs and a narrow, distant sound; level is low and the Pictures break uncomfortably two numbers from the end thanks to non-variable grooving. Performances are fast, nervous, probably due to (radio) time deadlines. Not so hot, and no bargain.

***Prokofieff: Classical Symphony (#1). Glinka, Russlan and Ludmilla Ov. Borodin: Steppes of Cen. Asia. Moussorgsky: Night on Bald Mt.** Suisse Romande, Ansermet. **London LL 864**

A mouth-filling pot-pourri, with some lovely and very accurate string playing, careful, musical performance, an unusually slow tempo for the first movement of the Classical, which is as sharp as pins and needles even so. Good high-level job for this type of disc.

yd**Tchaikowsky: Symphony #6 ("Pathétique").** Amsterdam Concertgebouw, Van Kempen. **Epic LC 3003**

Tchaikowsky: Romeo and Juliet; Ov. "1812"; Capriccio Italien. Amst. Concertg., Van Kempen. **Epic LC 3008**

These Tchaikowsky performances on the new label are good to my ear—clean, accurate, avoiding the excess of schmaltz that too many of our own home orchestras favor, yet keeping the spirits high (or low as the case may be) and the interest keen. Some will prefer the juicier type of interpretation. New labels often run into technical trouble at first: the Pathetique disc has a tinny unpleasant sound in the highs that suggests an unclean upper middle and no top; the Romeo and Juliet disc, same outfit, is much better, with only a trace of the same sound. Both are basically well done as to acoustics and the Romeo, with the other two items played with verve and even humor, rates very nearly excellent. Just that slight disorder of the upper regions.

(Two more Romeos are waiting—sorry, I've reached capacity!)

LONDON LETTER

(*from page 6*)

hour after dark. Practically every opera performed during this short season is transmitted in full by the B.B.C. on at least two occasions, so generally, your enthusiast has the opportunity of avoiding breaks when changing reels, by picking up the missing portions during the second performance.

Although no figures are published, it is generally thought that the sales of LP records are less per head of population in England than in the U.S.A. Perhaps the fact that so much good music is available daily on the air in England is the explanation.

Readers who would like these letters to deal with any specific subject, are invited to write me at: Richard Arbib, Multicore Solders Ltd., Hemel Hempstead, England.

I wonder how many record enthusiasts realize that the famous "His Master's Voice" trademark, which appears on the millions of R.C.A. Victor discs, was devised to publicise cylindrical records?

If you were a very privileged visitor to the vast E.M.I. factories at Hayes, Middlesex, England, you might be fortunate enough to be invited to lunch in the directors' dining room. On the wall you would see the original painting of "His Master's Voice." If you examined it carefully, you would see quite clearly the outline of an old fashioned phonograph under the gramophone.

The history as to how all this came about was recently revealed by the British H.M.V. Company.

The idea of the picture was conceived and executed by Francis Barraud, whose paintings were exhibited at the Royal Academy. He was the fourth son of Henry Barraud, the celebrated animal painter. Towards the end of the last century, when his brother died, his dog Nipper became attached to Francis. They became such fast friends that he eventually took Nipper to his own home and there he remained throughout his little life.

Barraud had inherited from his brother a small phonograph of the type that employed wax cylinder records, as well as a number of records. When he played these records he noticed the peculiar interest which Nipper took in the sound of the voices (which perhaps resembled that of his late master), that came from the trumpet. Watching him one day, Barraud conceived the idea of putting Nipper and the phonograph on canvas and giving it the title "His Master's Voice".

When the picture was finished, it showed Nipper listening to an old-fashioned cylinder phonograph, and it occurred to the artist that it would be an excellent trade mark for a manufacturer of these instruments. He took it to the most prominent cylinder phonograph manufacturing company, and was sadly disappointed when they did not seem at all impressed by the originality and beauty of the picture. He mentioned his failure to an artist friend, who suggested that the picture might be brightened up by painting a brass horn in place of the black one which was used on the phonographs of that period. Mr. Barraud had never seen a brass horn, and upon enquiry learned that one could probably be borrowed from a small company in Maiden Lane, off the Strand, called The Gramophone Company.

On a very memorable day in September, 1899, Barraud came into the little office of the then infant Gramophone Company, and asked for the loan of a brass horn. This somewhat unusual request brought forth explanations, which resulted in the Manager, William Barry Owen, immediately requesting to see the painting itself. The painting, which was then still in the hands of the hesitating phonograph company, was eventually refused and returned to Mr. Barraud, who at once brought it to Mr. Owen, with a suggestion that he could easily paint out the phonograph and paint in a gramophone. It took only a short time to do this and the picture then entered into the possession of The Gramophone Company.

After the picture had been adopted as a trademark by the British Company, it was eventually used by most of their Overseas Associates with the exception of certain Eastern Countries, where a dog is an unclean animal.

Some of you may be interested to know what happened to Nipper. He died in the earlier years of this century, and was buried in the garden of the studio which Barraud occupied in St. John's Wood, London, which is only a few hundred yards from the vast E.M.I. St. John's Wood Recording Studios, where the majority of the English H.M.V. records have been recorded during the last 20 years.

PATENTS

(from page 2)

at high cost. The invention is now at least two years behind the times, so any chances he may have had are diminished. The question is—should he have done it?

The answer depends on a few points. First, not every invention has commercial possibilities. Before even seeing an attorney, the inventor should have enough familiarity with the field of the invention or people in it to determine roughly whether it is the sort of thing someone might want to manufacture for profit. Does it do a new job? An old job better or cheaper? Is it a job worthwhile doing? Can it be made on a production basis without too many skilled hand operations? And so on.

If possible the inventor should try to interest a prospective assignee or two before applying for a patent. While many companies will not even look at an unprotected invention for fear of later being accused of stealing it, some will—and almost always they will be scrupulously honest. In addition, the inventor can protect himself to a good degree by detailing the invention in writing and mailing it to himself or a friend or attorney by registered post. If the envelope is retained unopened the date of registry is presumptive evidence of the date of conception.

If a buyer or assignee is found, let him pay the patenting costs and by all means consult a patent or general attorney before concluding any agreements. But if no commercial interest seems to exist, take a deep breath and try to evaluate the idea from a purely nonenthusiastic, impersonal standpoint. You can save a lot of money by *not* applying for a patent on an invention you won't be able to sell. And at the very least you can earn an encouraging fee by writing an article about it for this or some other magazine. Many fine inventions are uncommercial in character but of interest to many people who would like to read about them.

SOUND HANDBOOK

(*from page 29*)

Figure 15—14 illustrates a method[3] for cancelling out ripple from the plate supply of a stage, which at the same time opposes motorboating. The voltage divider formed by *C* and the cathode-circuit impedance, across which the B+ ripple appears, injects a portion of this ripple at the cathode of the tube, out of phase with the ripple normally appearing on the following grid. The value of C is adjusted so that the injected voltage is of the correct amplitude.

A method for cancelling line-frequency hum is shown in *Fig.* 15—15. The source of cancelling voltage is the heater winding, which must be grounded at some point, and the point of injection is a voltage-amplifier cathode. The rheostat R_1 allows adjustment for best cancellation and the ability to compensate for changed hum conditions, while the fixed resistor R_2 prevents the injected hum from being increased to such a point that the resultant total hum is equal to or greater than the original amount. A certain amount of corrective phase shift may be inserted by using a capacitor in series with R_2.

The first time the circuit of *Fig.* 15—15 was used by the writer it produced a 20-db reduction in 60-cps hum and the effect was fairly stable, although the control had to be readjusted every few months. On another occasion the hum-balancing circuit had very little effect except to change the waveform of the hum. If the phase of the cancelling hum is hopelessly distant from a 0- or 180-deg. relationship with the original disturbance, no adjustment of the potentiometer will do any good.

The introduction of out-of-phase hum voltages must not be attempted without observing certain precautions. The neutralizing hum must always be injected at a point on the same side of a volume control, tone control, or selector switch as the source of hum being cancelled. If this is not the case a change in the setting of the control will destroy the counterbalance and cause the hum to reappear, perhaps more strongly. It is also necessary to guard against the reap-

[3] Wen-Yuan Pan, "Circuit for neutralizing low-frequency regeneration and power supply hum," *Proc. IRE*, Sept., 1942, p. 411.

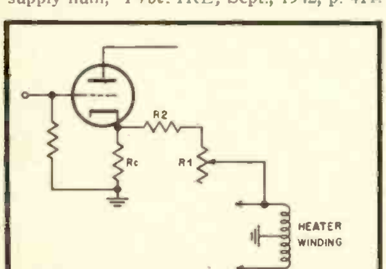


Fig. 15—15. Circuit for cancelling line-frequency hum. A capacitor in series with R_2 can be used for corrective phase shift to bring the phase of the cancelling voltage opposite to that of the voltage being cancelled.

pearance of hum due to changes in the characteristics of the hum being neutralized, and periodic readjustments of hum balance may be necessary.

Tracing Hum Sources

The technique of tracing the source or sources of hum appearing in the output of an amplifier is, of course, based upon a knowledge of the ways in which hum gets into the signal channel. Testing must not be done haphazardly or the work may degenerate into inefficient puttering, confused by a complex hum which has several sources. The stages should be cleaned up in order, beginning with the output stage and working back. The usual method is to remove the tubes of all the stages of amplification preceding the stage being investigated, and to work on the amplifier in that condition until the hum level is satisfactory. If the hum has been created by currents which flow only when the tubes of earlier stages are working, the lower-level tubes must be allowed to remain in their sockets, but their signal output should be grounded out by an alligator-clip lead.

Determining the predominant frequency of hum being traced, by oscilloscope or even by ear, often furnishes a clue as to the source. Thus B-supply hum from a fullwave power supply has a fundamental frequency of twice the line frequency, while the fundamental frequency of heater-induced hum is the same as that of the line. There are several ways in which an oscilloscope can be used to determine the hum frequency; probably the simplest method is to adjust the controls for a screen pattern of one full cycle (hum to vertical input) with a line-frequency test signal (available on the scope) as horizontal time base, and then to count the number of cycles of hum that appear on the screen. Two cycles will mean 120-cps hum, and one cycle, 60-cps.

Microphonics

The elements of a tube cannot be anchored with perfect rigidity and therefore may be set into vibration. Such vibration introduces itself into the signal by influencing the electron stream of the tube and microphonic noise, typically a high pitched, pure-toned sound like that of a tuning fork, may be produced. It is called "microphonic" because of the translation of mechanical vibration into an electrical disturbance. When the vibration is caused by sound from the speaker an acoustical feedback system is set up which can work the tone into a self-sustaining howl.

Tubes in low-level circuits are most subject to microphonics. Occasionally other components, such as tuning capacitors, exhibit the same behavior. Certain tubes, like the 6C4, are well known for their microphonic tendencies, while other tubes are especially designed to resist microphonic vibration.

Measures taken to prevent microphonic effects include:

1. Replacement of microphonic tubes, even though the tubes may be perfectly normal electrically.

2. Shock-mounting the tube sockets

of critical low-level stages on rubber or similar material.

3. Physical location of critical stages to avoid mechanical or acoustical disturbance, particularly from the loudspeaker.

4. Choice of anti-microphonic tube types in original design (see Table 15—I).

Random Noise

Noise voltages are generated by the random, uneven flow of electrons in a resistor or within a vacuum tube. The random electron motion in a resistor is called thermal agitation and goes on constantly without any outside source of voltage. Random noise in the tube results from shot effect, collision ionization, and other causes, which all add up to the fact that individual electrons do not arrive at the plate in orderly sequence but at random, like buckshot hitting a target.

Thermal noise generated in an input resistor determines the ideal limit of the signal-to-noise ratio, and hence the lowest value of signal which may be used as input. The thermal voltage across a conductor is directly proportional to the resistance and temperature of the conductor, and also directly proportional to the width of the frequency pass band. Within the determination of these factors, thermal agitation in a resistor is irreducible.

At 63 degrees the r.m.s. thermal agitation voltage across a resistor may be expressed as:

$$E^2 = 1.6 \times 10^{-20} \times R\ (f_2 - f_1),$$

where E = r.m.s. volts of noise, R = resistance in ohms, and, $(f_2 - f_1)$ = frequency pass band in cps.

Random noise generated within a tube varies greatly with tube type and with individual tubes. In general, pentodes generate more of this kind of noise because of the random distribution of electrons between screen and plate. The relationship to frequency bandwidth is the same as that of thermal agitation noise in a resistor.

The noise voltage developed within a well designed triode with a gain of 20, not counting hum, may be expected to be of the order of 28 microvolts at the plate.[4] Since the amplification is 20 we would compare the signal at the grid to a noise voltage of 1.4 microvolts.

Noise may be specified either in an absolute level or as a signal-to-noise ratio. If the noise is measured without consideration of frequency the results are unweighted. When a more accurate determination of practical nuisance value is desired a noise reading may be weighted by a frequency characteristic inverse to the appropriate Fletcher-Munson frequency-*vs*-loudness contour.

References

RCA Receiving Tube Manual, RCA Tube Dept., Harrison, N. J., 1950, pp. 33–56.

F. Langford-Smith, *"Radiotron Designer's Handbook," 4th ed.,* RCA, Harrison, N. J., 1953, Chap. 12, Sec. 10.

[4] Harry F. Olson, *"Elements of Acoustical Engineering,"* D. Van Nostrand Co., 2nd ed., 1949, p. 293.

LETTERS

(from page 8)

Jensen Woofers

SIR:

We were very much interested to read in the November issue of Æ a description of how to convert a Jensen Auditorium speaker to a woofer.

However, we regret very much that we no longer are making any 18-inch cone housings, either for our catalog line or for contract customers. We have received quite a few letters as a result of the article and have been forced to advise the writers that we cannot supply 18-inch speakers. Of course, if we receive a sufficient number of letters, a special run may be justified.

I should like to suggest that there are many old 14-inch Auditorium speakers in the field available at bargain prices and they make very good woofers, especially with horn loading.

KARL KRAMER
Technical Service Manager,
Jensen Mfg. Co.,
6601 S. Laramie Ave.,
Chicago 38, Ill.

Advertising Claims

SIR:

I want to raise a cry of protest out of the wilderness of current hi-fi advertising. For many years it was possible to read ads about new products and decide from the data therein whether the equipment would or would not do a certain job in a certain way. Claims could usually be found to be fairly accurate by making tests. Thus a faith was built up by the manufacturers among the technical and nontechnical people who read the ads.

Now that hi fi for the masses is here (in itself a very fine thing), manufacturers are succumbing to the temptation to use ordinary consumer-goods advertising techniques even in technical publications such as Æ. This usually involves ads made up by consumer agencies and written by ordinary copywriters whose only acquaintance with technical matters is schooling in the technique of the superlative.

The result is a hodgepodge of wild claims and false superlatives on a precisely equal level with soap advertising; and the whole thing does nothing but confuse the ordinary man when he tries to select equipment. When he sees the "super-power Hercules 6V6 amplifier with no distortion and infinite frequency range" selling for only $29.50, the "specifications" of its ad writeup look just as good as those of the really fine amplifier selling for three to six times the price. It is only when he pays his $29.50 and gets the Hercules home that he realizes it doesn't really sound as good as his neighbor's old 6L6 (no-feedback) amplifier.

Would it not be possible for the audio manufacturing industry to indulge in a bit of introspection and come up with a more reliable and realistic approach toward consumer advertising?

RICHARD H. STANTON,
8329 Kirkwood Drive,
Hollywood 46, Calif.

NEW LITERATURE

• **Jensen Manufacturing Company**, 6601 S. Laramie Ave., Chicago 38, Ill., is distributing a convenient proposal form for use by dealers in recommending high fidelity music systems for customers. The new form provides space for listing first, second, and third choices of all hi-fi components. Thus a dealer can give his customer a written expression of three recommendations of components based on specific needs and in various cost brackets.

• **Asco Sound Corporation**, 115 W. 45th St., New York 36, N. Y., satisfies needs of both novice and initiate in "Sound Advice," the company's new 1954 catalog. Unique in its convenient pocket-size format, the 148-page book contains a thorough approach to all aspects of high fidelity written by Irving Greene, director of the Asco Sound Studios, as well as product listings of virtually all well-known equipment manufacturers. Copy will be mailed free on request.

• **Federal Telephone and Radio Company**, 100 Kingsland Road, Clifton, N. J., comprehensively explains the design, application, specifications, and circuitry of selenium rectifiers in the second edition of Federal's Selenium Rectifier Handbook. Also covered are power supply circuits for such applications as phonographs, audio amplifiers, mobile radio, photocell amplifiers, and intercommunication systems. Expanded to 80 pages, the second edition is sectionalized for rapid reference, with three major divisions of technical material. Priced at fifty cents, the book is available through any Federal distributor, or may be ordered direct from the company.

• **Arrow Audio Center**, 65 Cortlandt St., New York 7, N. Y., includes an informative section titled "The How, What, Why, and Where of Hi-Fi" in a new 104-page catalog which will be mailed free on request. Profusely illustrated, and complete with specifications of most of the high fidelity equipment on the market today, the Arrow catalog is an excellent buying guide. Write for it.

• **Engineering Products Department, RCA Victor Division**, Camden 2, N. J., is releasing an attractive and informative folder titled "Custom-Built Equipment for Television" which will be of distinct value to holders of station CP's. Illustrated with photographs and drawings of major stations now on the air, the folder is an excellent thought stimulator for anyone expecting to build a station in the future. Requests should specify Catalog B.30.

• **Carter Motor Company**, 2648 N. Maplewood Ave., Chicago 47, Ill., is now releasing its new Catalog No. 553, a complete listing of the entire line of Carter d.c.-to-a.c. converters. In addition to product listings, the catalog contains a selector chart showing correct Carter converters for operating leading makes of wire and tape recorders, sound projectors, and phonograph motors. Electrical and mechanical specifications, performance charts, and other vital information are arranged in convenient and attractive form. Request for copy should be addressed to Dept. 6.

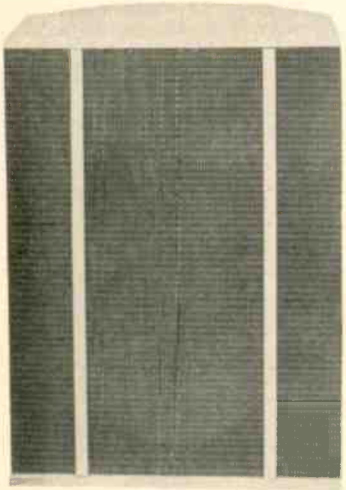
• **Standard Electrical Products Company**, 2240 E. Third St., Dayton, Ohio, illustrates and describes the full line of Adjust-A-Volt variable-voltage transformers in a distinctive new 18-page catalog which will be sent on request. Design and construction details, dimensions, and performance characteristics of the various models of auto-, isolating, and metering transformers are included.

• **Telex, Inc.**, Telex Park, St. Paul, Minn., manufacturer of hearing aids and electro-acoustical equipment, has issued a catalog sheet on the Telex Twinset, said to be the lightest twin magnetic receiver ever made. Weighing but 1.6 ounces, the unit contains two tiny receivers which are rested on the temples (not on the ears), sound being piped to the ears through a slender tubular arm.

• **Cal-Tronics Corporation**, 11305 Hindry Ave., Los Angeles 45, Calif., has recently published a new 12-page bulletin titled "Electronic Test Equipment." In addition to introducing the company and its services, the booklet illustrates and describes the various types of equipment the firm manufacturers. The devices shown are highly specialized in nature and will be of interest principally to advanced engineers.

NEW PRODUCTS

• Cabinart Klipsch Enclosure Kit. Complete from hardware to pre-cut baffle, the new Kit series recently announced by G & H Wood Products Company, 75 N. 11th St., Brooklyn 11, N. Y. is based on the Klipsch corner horn enclosure design by Cabinart for 12- and 15-in. speakers. Known as the K-12 and K-15, the enclosures are supplied in unfinished birch

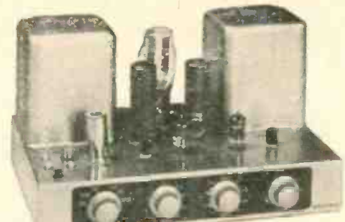


which can be finished in exact style and color desired. Easy-to-follow assembly and finishing instructions are included.

• Two-Motor Two-Speed Tape Recorder. Tape recordings approaching professional quality can be produced with the new Masco Model 53 recorder in which flutter and wow content have been reduced to less than 0.3 per cent at 7.5 ips. Up to two hours of recording on a single 7½-in. spool is afforded at 3.75 ips. Inputs are

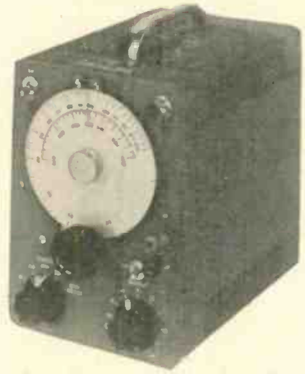
provided for microphone, radio or phonograph; outputs for external speaker, external amplifier, or telephone line. Timing indicators under both supply and take-up spools indicate recording time consumed and permit quick spotting of desired portions of tape for editing. Full technical specifications are available on request from Mark Simpson Mfg. Co., 32-28 49th St., Long Island City 3, N. Y.

• Knight 24-Watt High-Fidelity Amplifier. Although low in price, the new Knight amplifier recently introduced by Allied Radio Corporation, 100 N. Western Ave., Chicago 80, Ill., affords many of the features usually expected only in much more expensive equipment. Frequency response at 24 watts output is 20 to 40,000 cps within ± 0.75 db. Harmonic distortion is less than one per cent and intermodulation less than two per cent at rated output. Four inputs are provided; one for



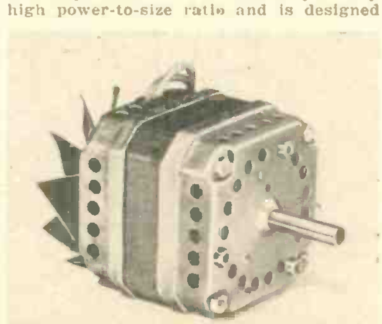
magnetic cartridges, two for tuner, crystal cartridge, or tape recorder, and one for high-impedance microphone. Three-position equalizer provides flat playback or equalization for NARTB or AES recording curves. Separate bass and treble tone controls are calibrated from −16 to +16 db. Screwdriver-type adjustments are afforded for balancing out hum, balancing output tubes, and for adjustment of bias.

• Extended-Range Audio Oscillator. Suitable for making measurements requiring a sine-wave signal from 20 cps to one megacycle, the Model 411 oscillator is a resistance-capacitance-tuned unit with cathode follower in the output circuit. Frequency accuracy is maintained through the use of deposited-carbon resistors in the frequency determining network. Low-level measurements are facilitated by a panel switch which reduces output voltage,



distortion and hum content. Additional information will be supplied on request by The Clough-Brengle Co., Dept. AE, Chicago 40, Ill.

• Shaded-Pole Motor. Engineered for use in phonographs, tape recorders, and similar devices, the new Model MS-3600 shaded-pole motor has an exceptionally high power-to-size ratio and is designed

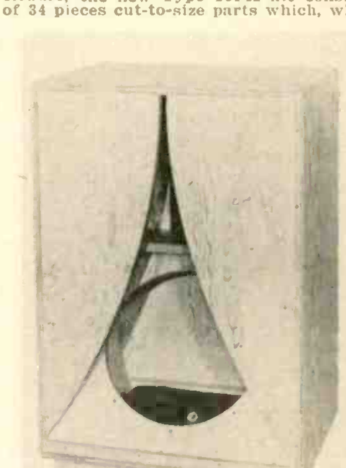


to withstand high temperature, yet is low-priced for application in mass-produced equipment. Built for continuous-duty operation, it is equipped with self-aligning oil-impregenated sleeve bearings and dynamically balanced rotor. Shaft diameter and length may be specified by the customer. Provision for two-speed operation is available on order. Complete information may be obtained from Electro Engineering Products Company, Inc., 609 W. Lake St., Chicago 6, Ill.

• Tape Identifying Label. The annoying problem of visually identifying program material on sound tape reels is solved by the Irish "Reel Tab," which is being offered free to professional tape users. Designed to replace the china marking pencils and the makeshift scraps of paper which are used so frequently for this purpose, the Reel-Tab fits snugly beneath the edges of any type of 7-in. plastic or

metal reel, whether the reel is full, partially full, or empty. Requests for the Reel Tab should be addressed to Nat Welch, Orradio Industries, Inc., T-120 Marvyn Road, Opelika, Ala.

• Karlson Enclosure Kit. Exactly the same size and construction as the finished model of the Karlson Ultra-Fidelity enclosure, the new Type 15PK kit consists of 34 pieces cut-to-size parts which, when



assembled, will afford the same standard of high-fidelity performance. The kit is made up of rough plywood which furnishes a good surface for the application of veneer, or it may be used as is in hidden installations such as walls, closets, and the like. Constructed of ¾-in. plywood throughout, the kit is supplied with cutout for 15-in. speakers with 12-in. adapters available on request. Karlson Associates, Dept. 1A, 1379, E. 15th St., Brooklyn 30, N. Y.

GOLDEN EAR AMPLIFIER

(*from page 18*)

which brings the response down to about 2 cps before phase shift sets in. The capacitor would be made larger but this value fits in well with the values of the feedback loop, as we shall see.

To maintain the best possible balance, all the resistors in the two opposite sides are matched to about 1 per cent. It is not necessary to use precision resistors. Ordinary resistors can be matched on a bridge or even an ohmmeter. Out of any five of a given value, two can usually be found which match to 2 per cent or better. To insure against changes in value, be careful not to overheat the resistors when wiring them in place. If a large pair of pliers grips the lead between the soldering point and the resistor body, most of the excess heat will be dissipated in the pliers. Even inexpensive carbon resistors, if not overheated, will maintain their value to 1 per cent for years. The remaining unbalance of the whole amplifier can later be balanced to one per cent or better by adjusting R_1.

The Driver and Output Stages

The cathode follower, direct-coupled to the power tubes, is the circuit developed by Ulric Childs and works very well indeed. In fact, it is the only method the author has used which is entirely foolproof and adaptable to different types of output tubes. The cathode and grid resistors of the follower are matched. Bias to the power tubes is adjusted with the pot R_2, and the output tubes are balanced by the pot in the cathode legs, R_3. Any of the big triodes (or tetrodes as triodes) except possibly 300A's and the 6AS7, can be used in this circuit providing only that the output transformer and power supply are suitable. The 6AR6's are the optimum tubes delivering 20 watts with only nominal distortion. The drivers are driven a trifle hard to supply the 60-plus volts needed by 6B4's but they can manage it. 807's, KT66's and 5881's will provide 15 watts with very low distortion and their lower driving requirements improve the over-all gain by a factor of between 50 and 100 per cent. Using a set of adapter sockets, the author has tried all these tubes (except the 6AS7 and 300A) in the circuit and all work comparably well, although to repeat, the 6AR6 appears to be the optimum tube.

Having achieved a more than satisfactory low-frequency response, the next problem was to improve the high-frequency response. The cross-coupled inverter and the cathode follower driver, offered no problems. The first section of the inverter is a cathode follower and the second section is fed by the very low impedance of the cathode follower; moreover, the second section has considerable inverse feedback of both the current and voltage type. The combination therefore has an extremely good high-frequency response. The 9002's and the output tubes, however, were a different matter. Ordinarily, the high-frequency output of triodes begins to fall off at 15,000 cps or even less because of the Miller effect. The first measure was to neutralize these two stages. This was done with fixed 1.5 μμf capacitors with the 9002's, and with 3–40 μμf ceramic trimmers in the case of the output tubes. Neutralization corrects for the Miller effect, all but eliminating it, and extends the high-frequency response considerably beyond 20,000 cps. However, it doubles the output capacitance. This was the reason for using miniatures. The output capacitance of 9002's is about 1 μμf, as against 3 μμf for each section of a 6SN7. Thus even after neutralization, the output capacitance of the miniatures, and therefore the high-frequency response, is better than with the larger tubes unneutralized.

No adjustment of the neutralization for the 9002's is necessary. The power tubes, fed from a separate filament winding, are neutralized by opening the filament circuit and adjusting the neutralizing capacitor for minimum output with a steady tone applied to the amplifier input.

Neutralization brought the high-frequency response to about 50,000 cps but this was still not as good as desired. Therefore, an inner feedback network was introduced from the plates of the output tubes to the cathodes of the 9002's. Since the cathode resistor is 0.1 megohm, it was easy to keep phase shift down. For 10 per cent feedback, 1.0-meg series feedback resistors could be used. With a 0.5 μf bathtub capacitor, the time constant was 0.5, or the same as that of the coupling to the cathode follower. Thus, in effect, the two capacitors neutralize each other and extend the flat response below 2 cps. This loop provides about 16 db of feedback which is sufficient to extend the high-frequency response to nearly 100,000 cps. The amplifier response from input to plates of the output tubes is now flat from 2 cps to nearly 100,000 cps.

This feedback network includes the two stages responsible for most of the distortion—the drivers and the output tubes; and therefore reduces the distortion by a factor of six. Since the feedback is balanced (the feedback resistors are matched) it also produces dynamic and frequency balance.

With so little phase shift in the amplifier proper, it is obvious that the feedback which can be applied from the transformer secondary to the input is limited only by the phase shift of the output transformer and the sacrifice in gain which can be tolerated. Although balanced feedback could be used, the unbalanced, single-ended type, suffices to perform the two jobs which need to be done—first, to compensate for any irregularities and slopes in output transformer response, and second, to provide additional cancellation of distortion. We have applied as much as 40 db of feedback, in addition to the 16 db of the inner loop, before instability resulted. In practice, however, about 18 to 20 db is more than sufficient to do the job and still leave sufficient gain to produce full output with an input signal of 10 volts, easily provided by the triode amplifier of a tuner. With a total feedback factor, so far as the drivers and output tubes are concerned, of between 30 and 50, depending on the feedback of the main loop, it is no wonder that distortion is reduced to an insignificant minimum even at full output.

One other factor remained for solution before such stability could be achieved. The flat frequency response was one item on the way to a good transient response. There remained the minimization of feedback loops. These loops, of course, exist in every amplifier using a common power supply and triode tubes. Neutralization eliminates the feedback loops through tube capacitance. The rest was a matter of adequate decoupling. Although the amplifier has five stages, two of these are cathode followers and produce no phase shift. Therefore, the amplifier can be considered a three-stage device. Nevertheless, decoupling down to 2 cps or less presented a problem. In this amplifier, as in the original Golden Ear amplifier, it was solved by the use of a VR tube in the input stage. The VR tube is the best of all decoupling devices. After all an element which will smooth the long period variations of a d.c. supply, has a very low impedance to a.c. even of periods as low as 1 or 2 cps. The VR tube simultaneously performs two other functions: as an excellent hum filter, it delivers very pure d.c. to the amplifier input stages; it also stabilizes this stage by maintaining a constant voltage. Since the whole balance of the amplifier is dependent on the stability of this first stage, an extremely stable d.c. amplifier is achieved.

Actually, the amplifier alone can be driven into oscillation only by applying something between 90 and 100 per cent feedback—in other words, oscillation sets it just before the input signal is completely cancelled out. Indeed, even when the preamplifier, with four additional stages, was fed from the same power supply, the stability was still remarkable, although the transient response deteriorated considerably.

It will be noted that the over-all feedback network, being direct coupled, will unbalance the input stage since the feedback resistor and voice coil appear in parallel with the cathode resistor. Therefore, after feedback is adjusted, the balance control should be readjusted. D.c. balance may be measured by connecting a VTVM from plate to plate of the 9002's and adjusting for zero voltage. Better over-all balance, however, is obtained by using the following method: after balancing the output tubes with their cathode balancing potentiometer, connect the "off" grid of the inverter to the signal grid, feed in a constant-tone signal and adjust the balance control for a null in the output. The cross-coupled inverter is a differential amplifier and if the same signal is fed to both grids and the amplifier is fully balanced, complete cancellation occurs. (This fact makes the circuit highly useful for distortion measurement and phase angle measurement and indeed with slight modifications this amplifier could serve as a distortion measuring amplifier.) At any rate in this way the whole amplifier can be balanced almost perfectly from input to output.

A few details remain. Since failure of the output tube bias supply would apply a high positive voltage to the grids of the output tubes with almost inevitable damage to them, a ¼-amp fuse is placed in series with the output cathodes and ground. A rise of plate current such as would occur with a bias failure, will blow the fuse, opening the plate-supply circuit and protecting the tubes until repairs are made.

The cathodes of the 9002's and the 6C4's are 50 volts or more above ground. The center-tap of the filament winding feeding these and the cross-coupled inverter, is therefore returned to a positive voltage of around 40 volts, provided by a high-resistance divider across the power supply. Actually this makes little if any discernible difference in the hum

level which is completely inaudible, even with ear at the woofers and even when 6B4's are used. However, it is good insurance against heater-cathode leakage and breakdown.

The bias supply should deliver −125 volts if 6AR6's or 6B4's are used. The same value will do for other tubes, but as little as 105 will suffice for 807's, KT66's and the like. The author used a 150-volt power transformer, of the type used in TV boosters, but a filament transformer used backward, as diagrammed, will serve.

It will be seen that all five rules of design are faithfully followed: (1) distortion is held down by operating high-power tubes at a fraction of their maximum output, and the voltage amplifiers well below their maximum output; (2) nearly perfect balance and a huge amount of feedback in two loops results in a high degree of cancellation of what distortion is produced; (3) by virtual direct coupling, neutralization, and feedback the amplifier is made non-resonant from nearly d.c. to more than 200,000 cps, and finally, by neutralization and effective de-coupling, the amplifier is made extremely "stiff" and resistant to oscillation, regeneration, or the formation of various transients.

Performance

It is easy to be extravagant about one's own brain child and hand work, particularly when instrumentation bears out subjective impressions. As Æ has pointed out editorially, audio design is approaching the stage where instruments of distinctive character, rather than mere reproducers, are being produced. The new Golden Ear amplifier has a distinctive character. It is very clean, particularly in the bass—much cleaner than any previous amplifier used by the author. This is partially because of the extended bass response but perhaps more because of the really extraordinary transient response which reduces the production of ringing and other forms of transients to a point of mere academic rather than practical import, and therefore greatly improves the definition of the reproduced sound. The measurable aberrations over the normal operating range of 6 milliwatts to 10 or 12 watts are very small—too small for accurate measurement on the author's rather crude home-made instruments—and too small for discernment by ear. No doubt time will provide circuit and components improvements which offer hope of further perfection; but for the moment, the Golden-Ear Complex is satisfied more completely than ever before, and there is hope that this satisfaction will last long enough to channel brains and energy into other, less well-realized channels—including those of making an adequate living.

GO WEST!
AUDIO FAIR—L.A.
February 4, 5, 6
Alexandria Hotel

BASS REFLEX

(from page 26)

Fig. 3. A horizontal partition was inserted to avoid the raised resonance frequency of a cubical enclosure.

The enclosure was constructed of ¾-inch plywood throughout. All joints were grooved, glued, and screwed so as as to be rigid and airtight. A vertical brace, about 3 inches wide was mounted inside the back to prevent low-frequency panel resonances. The 15-inch partition which was glued and screwed to the front panel and to the two side panels prevented any low-frequency panel resonances at these points. A double thickness of ½ inch Fiberglas acoustic insulation was tacked to all inside surfaces.

As mentioned previously, the front of the enclosure was recessed by about ½ inch so that the plastic grill cloth could be attached. How this was accomplished is shown in *Fig.* 4. After the operation of the enclosure was checked (as described below), the grill cloth was stapled to the front panel. Then ¾-inch triangular molding trim (⅜ inch thick) was tacked into place, forming a neat, picture-frame effect.

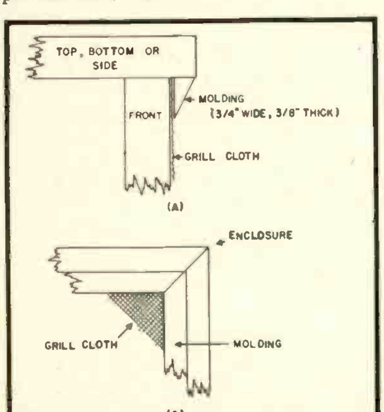


Fig. 4. Side view (A) and front view (B) show how the grill cloth was attached to give a professional appearance.

Checking Operation

The usual method of tuning a bass-reflex enclosure is to adjust the port until the mounted speaker has two impedance peaks of about the same amplitude about equally spaced above and below the free-space resonance of the speaker. To obtain the impedance curves of the speaker-and-enclosure combination, the same set-up was used as had been employed previously to check the resonance of the speaker alone.

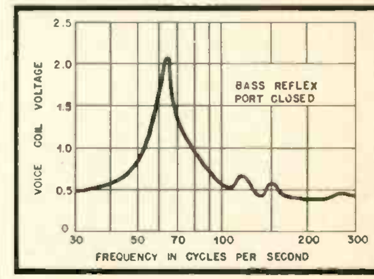


Fig. 5. This was the speaker impedance curve with the port completely blocked.

As the first step, a piece of scrap ¾-inch stock was screwed over the port, closing it entirely. The "infinite baffle" so produced behaved just about as expected; its impedance curve appears in *Fig.* 5. Note that a single large peak occurs at about 64 cps; this is about 10 per cent higher than the resonant frequency of the unmounted speaker. The amplitude of this peak is almost as great as that of the resonant peak of the unmounted speaker. In addition, smaller peaks occur at about 125 and 155 cps.

Next, one-third of the port was opened by screwing a smaller piece of scrap stock over two-thirds of the opening. With a port area of only 24 square inches, the impedance curve appeared as shown in *Fig.* 6. The large peak has moved up to 68 cps and its amplitude has been reduced substantially. Also, the amplitude of the two small higher-frequency peaks has been reduced. Note that the curve rises at 30 cps indicating the possibility of a definite peak at this or a slightly lower frequency. Unfortunately, the low-frequency limit of the audio oscillator used was 30 cps so that it was not until later measurements were taken that it was realized that there existed a peak in the vicinity of 30 cps.

Next, two-thirds of the port was uncovered, with the results shown in *Fig.* 7. The large peak has continued to move slowly upward in frequency—it is now at 70 cps—and downward in amplitude.

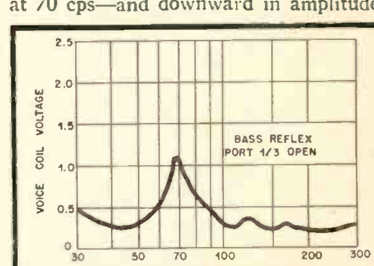


Fig. 6. Impedance curve with port area reduced to 24 square inches.

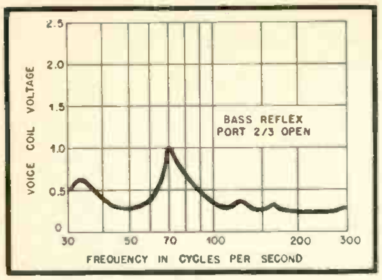


Fig. 7. A 48-square-inch port produced this curve.

In addition, a pronounced low-frequency peak is now seen to exist at about 33 cps.

The port was then completely opened with the results as shown in *Fig.* 8. Both peaks have moved upward slightly in frequency; the larger peak occurring at about 73 cps and the smaller peak occurring at 36 cps. Note also that the amplitudes are somewhat more equalized, with the amplitude of the larger peak having been reduced and the amplitude of the smaller peak having been increased compared to the previous figure. The high-frequency minor peaks have all but disappeared.

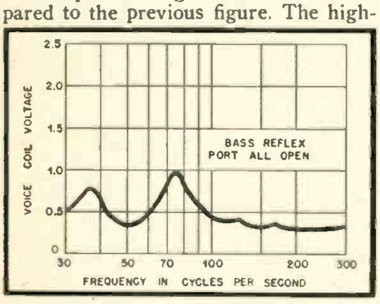


Fig. 8. Using the entire port area produced this impedance characteristic.

At this point, it was decided to try the effect of damping the port. A ½ inch thick layer of Fiberglas was stretched over the open port, with the result, that both peaks were lowered in frequency somewhat. The low-frequency peak was reduced considerably in amplitude, but the amplitude of the higher-frequency peak was actually increased somewhat (see *Fig.* 9). As a further experiment, the enclosure was moved from the corner where it is to be used and where all the curves shown were taken to another location against the longer wall in the room. When this was done, the curve of *Fig.* 8 was obtained except that the 73-cps peak moved up to about 78 cps.

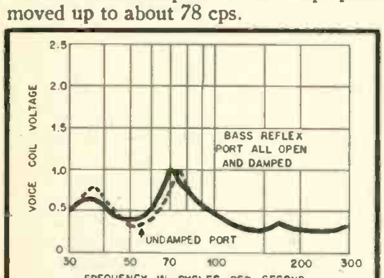


Fig. 9. Placing damping material over the port did not produce very great change, as these comparison curves indicate.

How The Adventure Turned Out

If the impedance curve of the 6.2-cubic-foot bass-reflex enclosure with a port area of 72 square inches is compared with the curve of the unmounted 10-inch loudspeaker as in *Fig.* 10, it can be seen that the enclosure resonates at a frequency about 6 cps lower than the 58-cps resonant frequency of the speaker. A somewhat smaller enclosure or a larger port probably would have raised the low-frequency peak from 36 cps to perhaps 40 cps, and the high-frequency peaks from 73 cps to perhaps 85 cps. It also would probably have boosted the low peak by a tenth of a volt and lowered the high peak by a tenth of a volt to make the two amplitudes exactly equal. However, it was decided, especially after a listening test, to leave the enclosure just as is. In the first place, at the slow rate at which the resonances increased with larger port areas, it would appear that a considerable increase in port area would be required for perfect tuning. Since the port now extends almost the entire width of the front panel and almost the entire height up to the support for the partition, it would not be practical to increase its area very much. Secondly, we are not using a high-quality 12- or 15-inch speaker here with a cone resonance of 40 to 50 cps, but we are employing a good 10-inch speaker having a somewhat higher cone resonance (58 cps). In such cases it is usually recommended that the enclosure be tuned slightly below the speaker resonance. When this is done, a slight extension of low-frequency response results and no peaks exist above 80 cps to mar reproduction.

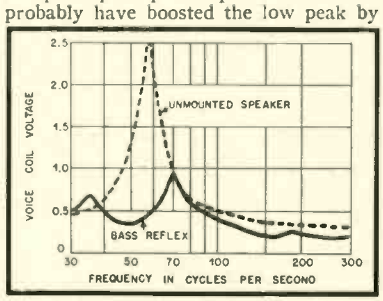


Fig. 10. These two curves show the results of the final bass-reflex enclosure.

Fig. 11. The finished enclosure, ready for use.

All that was left to do was to put on the plastic grill cloth (see *Fig.* 11).

AUDIO ETC.

(from page 30)

a wholly different comparison that has now made its appearance and will be heard from increasingly this year—everywhere. It is a comparison of the utmost importance for all those who are building and distributing craft-type components, an argument that must be studied hard as a new "line" which would seem directly to contradict the very basis of the above-discussed and very familiar Parallel Comparison. It is, in my improvised terminology, the Stepwise Comparison.

The argument is, namely, that the mass-produced "hi-fi" phonograph is the best buy for the Great Middle Class of record collectors, the modestly priced big value for the multitude; whereas the component lines of hi-fi equipment are super-duper near-professional parts for the home, costing more, designed for the connoisseur, the privileged few, the Man who can Afford . . . etc., etc. A very familiar argument, needless to say, in other fields, notably autos and liquor, but what about hi-fi? Is not this a somewhat remarkable "line" in view of long-familiar values? Haven't we been saying, claiming, all along that hi-fi components are more economical than commercial counterparts?

There is truth to be found here, contradiction or no. It is quite true—and I suggested this in November—that craft-type manufacture is by definition specialized, relatively small-scale, and cannot expand its advantageous standards into real mass production. Yes, the craft hi-fi industry has expanded tremendously—as a whole. But that whole is still made up of very many separate parts and these operations continue to be, relatively, small-scale.

Craft-type equipment, which is inherently of good quality, is not really practicable below a certain quality level, as we know. It can't compete in the bottom price areas. But the big-company argument is that it can't compete *at all* in terms of true mass production. We, say the big companies, are the only ones who can bring audio quality, in a practical form, to the millions; better a sensible compromise and huge production than nothing at all, for the millions whom craft hi-fi cannot possibly reach.

A rather tough argument to answer, though to my ear it doesn't ring entirely right. I think this kind of persuasion savors a wee bit of the publicity office, OR what is sometimes called institutional advertising. One might suggest that *if* craft-type hi-fi could reach the millions in terms of its own publicity, on an equality with the information concerning commercial machines, it might very well expand enough to take care of a rather large number of those very same millions, without losing its essential quality. Somehow, I can't feel that the said millions are unduly deprived by craft hi-fi's inability to reach them, nor can I quite feel that mass production is the one great benefactor, in this case! Still—there's a lot to be said for this line. Just look up the figures on units sold, say, of the Columbia 360, which has a year's lead on the other newer machines.

Component hi-fi, in the large-company

view, is for the few, who want the best. That implies very definitely that component hi-fi costs more. Now if the complementary craft lines offered by these companies (built in part by smaller hi-fi makers) were actually sold at levels that competed with the already existing small-company offerings, the argument would be senseless; money for money, these large companies would be running themselves out of their own market. Why try Soandso's hi-fi table phonograph when Soandso's own hi-fi components obviously give you better sound?

Therefore it is not at all surprising to find that large-company craft component lines are specifically arranged to fit *above* the fanciest of the mass-type machines as to cost, thus limiting them rather pointedly to the deluxe category. Component hi-fi, then, is by definition deluxe hi-fi in this arrangement, and must be necessarily, to support the whole argument. That's the way you'll find it, with only a few exceptions. This is the Stepwise Comparison, with craft hi-fi on the top step.

Which leaves an unexpected and happy loophole for the smaller established craft-type makers—through which they will undoubtedly wiggle with adroitness. If according to the Stepwise Comparison large-company component lines *must be more expensive* than the best of the ready-made machines—which means that an ensemble must sell for perhaps $200 at a minimum—then small-company craft hi-fi has the field to itself in the area *directly competing* with the "hi-fi" mass produced phonograph! A good idea.

And that, finally, brings me around to Mr. Ferguson again. Though he is, nominally, a professed apostle of the Parallel Comparison, trading craft quality directly against mass-produced simplicity and convenience, in actuality he is, price for price, trading low-cost craft hi-fi alongside of *similarly priced* mass production hi-fi—and there he has the bull by the tail! For he is taking the Stepwise Comparison, negatively, for what it's worth—to him. Lots.

* * * * * *

An interesting situation. I've noticed that, following the developing wave of hi-fi, many small radio and record stores are now adding modest displays of hi-fi equipment (using the term always in its popular and present sense) to supplement their records, radios, TV and toaster lines. Here an amplifier, there a changer or a hi-fi table phono or the Columbia XD extension speaker. In most cases these added hi-fi attractions are large-company lines, either commercial or craft type. (Mr. Ferguson is one of the few record dealers I've heard of who feature *only* small-company craft hi-fi.)

Which means that most small stores are, whether they know it or not, following the philosophy of the Stepwise Comparison. EITHER you buy a moderately priced one-piece mass produced unit OR you buy, on a higher step, the deluxe, fancy, custom, special separate components. More expensive—of course. No suggestion at all, in this philosophy, that for *equal* cash there are economical choices in both types, that sound for sound, craft components can make the more economical system, not the more expensive. That's where Opportunity is still knocking at our doors. Open up!

AUDIOLOGY

(from page 12)

practical objection to this plan is that the primary feedback portion of the system may increase output hum to greater extent than the tertiary feedback reduces it. To avoid this difficulty, a variation has been used in which a dividing network shifts the sampling point from primary-feedback at high frequencies to tertiary (or even secondary) form at low frequencies.

One of the most powerful of easily applied systems is that of cathode-follower connection of the tube to the output transformer primary, with major-loop feedback of tertiary form to an early point in the amplifier. While the cathode follower is simply one form of primary feedback, it has here the advantage of low output hum due to plate supply ripple. The abnormal grid-signal requirements of a cathode-follower power output stage may be reduced to more readily attainable magnitude by including only a portion of the primary turns in the cathode circuit, the remainder being in the plate circuit.

With adequate attention given to transformer design and the provision of low primary source impedance within the major feedback loop, the tertiary feedback method makes possible the usual desirable features of a high-quality audio amplifier, with a degree of stability not realizable in a secondary-feedback system.

STEREOPHONIC NOMENCLATURE

(from page 19)

Stereophonic, *a.*: Pertaining to or adapted to the stereophone (see below); produced by the stereophone, as *stereophonic* magnetic tape recordings; *stereophonic* sound system, *stereophonic* reproduction.

Terminology For Stereophonic Equipment

Stereophone, *n.*: An acoustical system in which a plurality of microphones (or other transducers), transmission channels, and reproducers are arranged so as to provide a sensation of spatial distribution of the original sound sources to the listener.

Stereophonic sound system[2] **(Stereophonic loudspeaker system)**: A sound system in which a plurality of microphones, transmission channels, and loudspeakers are arranged so as to provide a sensation of spatial distribution of the sound sources to the listener.

Stereophonic headphone system: A sound system in which a plurality of microphones, transmission channels, and stereo-headphones are arranged so as to produce the sensation of spatial distribution of the sound sources to the listener.

Stereo-headphones: A pair of headphones, each of which can receive sound from a separate audio system.

[2] An American Standards Association definition of "Acoustical Terminology" sponsored by the Acoustical Society of America in cooperation with the Institute of Radio Engineers proposed for trial and study Feb. 15, 1949 and approved and adopted by the ASA July 31, 1951 (Z24.1–1941). In keeping with the suggested terminology and to differentiate it clearly from a stereo-headphones system, it should be changed to *stereophonic loudspeaker system*, as indicated in parentheses.

Stereo-loudspeaker: A loudspeaker system consisting of two or more loudspeakers placed in two or more loocations, and which can be energized by a stereophonic amplifier system so as to produce a stereophonic effect.

Stereo-microphones: Two or more microphones so spaced apart and connected to a stereophonic amplifier as to enable stereophonic recording or reinforcement.

Stereo-cephaloid microphone: A plurality of microphones arranged within a structure designed to produce diffractoins and acoustic pickup patterns simulating normal human hearing.

Terminology For Stereophonic Techniques

Loudspeaker stereophony: The art of producing stereophonic effects with loudspeakers.

Headphone stereophony: The art of producing stereophonic effects with headphones.

Multi-channel stereophony[3]: The art of producing stereophonic effects with more than two electrical transmission channels.

Terminology For Deficient Stereophonic Effects

It is to be anticipated that improper technique, defective equipment, or detrimental environment will result in impaired stereophonic effects. Descriptive nomenclature for some common deficiencies follows:

Crossed stereophonism: Sources originally in the right field are heard in the left ear and vice versa. (In headphone stereophony crossing earphones produces this effect.)

[3] May be called *3-channel* or *4-channel stereophony*, etc., to indicate the number of transmission channels used.

Diphonic stereophonism: Produces two localizations for a single sound source.

Multiphonic stereophonism: Produces multiple localization of a single sound source.

Dynamic diphonia: Slight movements of listener's head produces abrupt shifts in apparent sound source positions. Produced when stereo-loudspeakers are not properly phased and the listener is positioned between loudspeaker acoustic fields.

Diffused stereophonism: Produces the effect of spreading point sources of sound, characterized by loss of precise localization.

Compressed stereophonism: The condensation of a wide acoustic field into a narrow area. Occurs when a 100-piece orchestra spread across a 50-foot stage is played back to sound as though it were coming from a 10-foot stage.

Expanded stereophonism: The opposite of compressed stereophonism.

Reverberatory stereophonism: Occurs when stereophonic effects are diminished or lost because of excessive reverberation during pickup or reproduction.

Reflective stereophonism: Occurs when stereophonic effects are diminished or lost because of excessive reflection during pickup or reproduction.

This suggested terminology now makes it relatively simple to describe any kind of stereophonic system or effect with minimum ambiguity or confusion. For example, the barbaric "binaural" recorder would be completely and simply described as a two-channel stereophonic recorder (or simply as a stereophonic recorder) which can obviously be used for either headphone or loudspeaker stereophony. A recording (tape, disc, or film) made for stereo-headphone listening only would be labeled "For Stereo-Headphones." The now famous Bell Telephone Laboratories stereophonic demonstration equipment would be labeled "Three-Channel Enhanced Stereophonic Loudspeaker System." A more complex system would be described as a "Six-Channel Stereophonic Loudspeaker System."

Any form of defective stereophonic reproduction could be clearly described, as, for example, *crossed reverberatory stereophonism,* indicating that the acoustic fields are crossed and that the stereophonic effect is diminished or destroyed by excessive reverberation.

It is the writer's hope that the suggested or similar nomenclature will soon become standardized so that literature describing developments, measurements, and deficiencies in stereophonic recording, reproducing, or reinforcing equipment will be meaningful to all who are interested in the art.

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PREAMP WITH "PRESENCE"

(*from page 25*)

the normal playing position for LP records. Similarly, the two indicating points on the tone-control are arranged to be "straight-up" when in the flat position, and the control tapers are designed to have a "flat" range of at least 15 deg. The non-indoctrinated user can be told to leave the filter and presence control alone—if that would solve the problem.

Construction

The construction of this unit follows fairly simple lines, with the possible exception of the resistor board which was used in the prototype. While there is no particular need for this type of construction, it does simplify the work to some extent.

Figure 2 shows the resistor mounting card used in the original model. The resistor card, together with the tube sockets which are mounted on the card, was attached to a channel designed for mounting onto the chassis with rubber grommets. With the Genelex Z729 tubes, however, the extra care in reducing microphonics has turned out to be unnecessary, and the sockets may just as

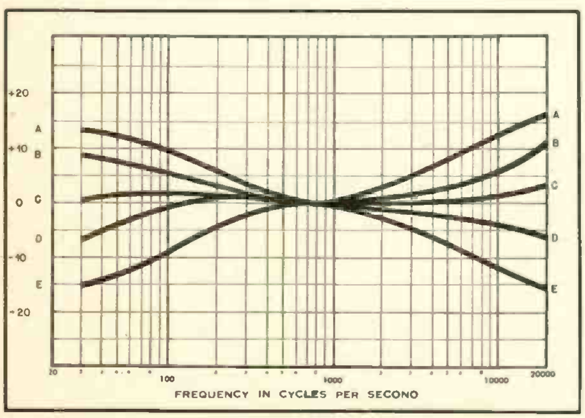


Fig. 6. Curves showing the limits of tone control action, together with an intermediate curve for both boost and cut.

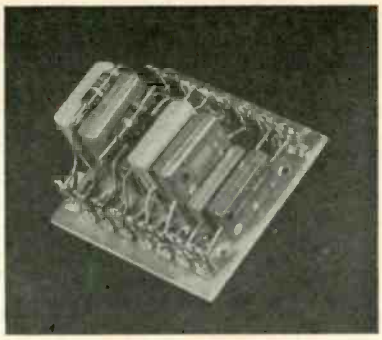


Fig. 7. Mounting of the components for the low-pass filter circuit. The input impedance-adjusting resistors R_{25} to R_{28} are mounted on the switch.

well be mounted on the chassis. Adequate room is available on a 3×5×13 chassis, although the original was made on a 3×6×14 base—a size which is rather difficult to obtain. Layout of the terminal card is not difficult, but since every constructor has his own ideas of just how he wishes to do the job, specific layout is not indicated. With the Alden terminals, however, it is possible to arrange the terminals so that all of the grid-circuit components—as well as the cathode resistors and their by-pass capacitors, and the compensating resistors and capacitors—may be placed on one side of the board, and the plate and screen resistors, together with the decoupling resistors and certain other components can be placed on the other. This requires that the bottom of the chassis be cut out to provide access to the "bottom" of the resistor board, since changes may be required during the construction or—possibly—afterwards when service becomes necessary.

The mica capacitors used in the equalizer circuits may best be Silver Micas, since they may be obtained with the closest tolerance. The small amount of shift in values can readily be tolerated without apparent effect, but most constructors will wish to take advantage of the 10 per cent tolerance of this type of component. The two inductances listed may be any type of toroid available. If the entire installation is to be used at some distance from any hum-producing fields—such as a phonograph motor—less expensive units may be used. But for complete freedom from the effect of any external fields, the toroid is the answer.

The original unit built by the author takes the place of one which has been in service for several years, and is powered by the same supply that has been in service since it was originally described in the series on "Residence Radio Systems," published in 1948. This supply was designed to furnish 12 volts d.c. at a maximum drain of 1.0 amps, and with a relatively low ripple. The unit has been tested with a 6.3-volt a.c. supply and has been found entirely satisfactory, provided the latter is suitably center-tapped to ground the circuit as near to the zero-potential point as possible.

While the circuit shown makes no provision for switching between phono, radio, TV, tape recorder, or any other possible source, there is no reason why the builder could not place another switch in the circuit and arrange to accommodate any desired number of signal sources. However, most modern tuners provide switching facilities, and this unit is designed to furnish only the basic requirements of a sound system—the preamp, the tone-control facilities, and some means for controlling the volume.

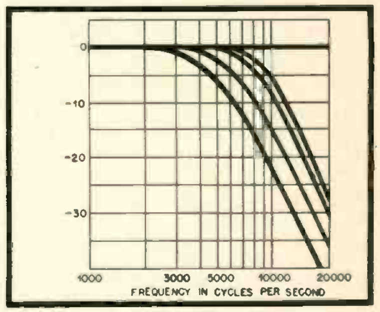
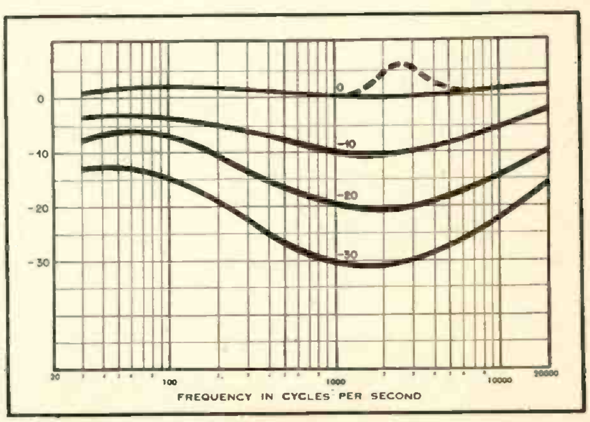


Fig. 8. Curves of low-pass filter action.

Reference to *Fig*. 7 will show the arrangement of the components—except the inductance—used in the low-pass filter circuit. The four capacitors at the left are shown with their shunting resistors, and are—from left to right—C_{13} to C_{16} respectively. The next four

Fig. 9. Response of the Senior Compentrol for maximum and for −10, −20, and −30 db output at 1000 cps.



capacitors are C_{25} to C_{28} respectively. One end of each of the capacitors and resistors is grounded, and leads connect from the other terminals to the two arms of Sw_3. Construction is not critical, since the impedances are low at this point in the circuit.

Special Components

Special units are listed for several of the components, but all are available. The preamplifier switch—consisting of two 5-position decks, one with one arm and one with two, and both being actuated by a dual-concentric assembly—is listed as part number SPP-3002, a Centralab Type 30c switch. The Baxendall tone control unit is available completely assembled as Centralab part number C3-300, and consists of the two pots assembled as a dual-concentric unit together with the Couplate. The combination presence control and filter switch is available as Centralab part number SPB-3001. The Senior Compentrol is already available as Centralab part number C2-100. All units have standard bushings (3/8–32) 5/8 in. long, with the inner shaft 1 9/16 in. long, measured from mounting surface, and the outer shaft 1 1/16 in. long, measured from the mounting surface. This provides sufficient room for any panel up to 5/8 in. thick.

Several types of knobs are obtainable for these controls, since the dual-concentric control has become quite common on TV sets. The writer's TV set is a "home-made" Techmaster 630 mounted in a bleached oak corner speaker cabinet, and the knobs used are those normally used on the RCA 8TS30 receivers. To have matching knobs, the same type were used. Tan knobs are obtainable as stock numbers 73227 and 73231; the dark brown knobs are stock numbers 73226 and 73230. Four of each are required. Other types of knobs may be obtained from various sources, but may entail some searching. All of the Centralab units may be obtained on order from any Centralab distributor.

Performance

The performance curves of the several functions of this amplifier have been shown in *Figs*. 5, 6, 8, and 9. The presence control may appear to be another example of painting the lily, and in this era of attempting to obtain a response curve which is completely flat from zero to infinity may appear to be unnecessary, but it is only suggested that a quick trial be made of the idea before passing judgment. Like many circuit arrangements, it is not always possible to pass upon their effectiveness until one has an opportunity to listen to the results, and it is this writer's opinion that "somthing new has been added" when the presence control is turned from off to on. The effect is neither ear shattering nor eye opening, but as one approaches the optimum in performance it requires only a small change to outwit the law of diminished returns. If we can "cheat" the response curve just enough to make the change reasonably perceptible, we have accomplished something worthwhile, and the time and money have not been spent in vain.

Parts List

C_1	.05 μf 600 v., Aerolite
C_2	.002 μf, molded paper
C_3, C_5	0.5 μf, 600 v., paper
C_4, C_{16}, C_{17}, C_{18}, C_{20}	0.1 μf, 600 v., Aerolite
C_6, C_8, C_{13}	2000 μμf, mica
C_7	1200 μμf, mica
C_9	3300 μμf, mica
C_{10}	200 μμf, mica
C_{11}	620 μμf, mica
C_{12}	1000 μμf, mica
C_{14}	3500 μμf, mica
C_{15}	150 μμf, mica
C_{19}, C_{32}	50 μf, 6 v., electrolytic
C_{21}	0.25 μf, 600 v., Aerolite
C_{22}, C_{26}	1100 μμf, mica
C_{23}, C_{27}	1600 μμf, mica
C_{24}, C_{28}	3000 μμf, mica
C_{25}, C_{29}	5600 μμf, mica
C_{30}, C_{31}	20–20 μf, 350 v., electrolytic (Mallory FP-227)
L_1	1.0 H, toroid inductance
L_2	0.45 H, toroid inductance
R_1	47,000 ohms, ½ watt
R_2	3900 ohms, ½ watt
R_3	0.5 meg, 1 watt, low noise
R_4	1.5 meg, 1 watt, low noise
R_5	1.2 meg, 1 watt
R_6	1200 ohms, ½ watt
R_7, R_{13}, R_{16}, R_{19}, R_{22}	0.1 meg, 1 watt, low noise
R_8	0.47 meg, 1 watt
R_9	0.1 meg, ½ watt
R_{10}, R_{11}	33,000 ohms, ½ watt
R_{12}	1.0 meg, ½ watt
R_{14}, R_{15}	27,000 ohms, 1 watt

(*Continued on page 62*)

A Perfect Loudspeaker: A New Reproducer Philosophy

LEUNG CHO YUK*

Many a valid concept long precedes the technology necessary to make it a reality. This writer's concept is interesting despite the fact that present-day techniques could not make it a product.

The controversy aroused in the article, "The Great Loudspeaker Mystery,"[1] makes the writer feel that the art of loudspeaker designing is still in its infancy. No wonder it is being looked upon as a kind of mysticism. Before the perfection of any art or science it is always a mystery to our bewildered minds. Its understanding *may*, of course, be regarded as a kind of metaphysical philosophy.

It seems that there are two schools of opinion about the construction of a perfect speaker diaphragm. It is a pity, however, that they both tend towards the two extremes—the infinitely rigid cone, and the very flexible one. It seems to this writer they are both right in a way, but, inconceivable as it may seem to adherents of either group, they both lack something. However, before putting forward a new argument, let us have a little discussion about nature and the way we often try to imitate her.

It is undeniably evident that our ears hear and that our mouths speak. This may lead one to the assumption that our ears and mouths are, electromechanically speaking, equivalent to the microphones and loudspeakers in an electro-mechanical acoustic transmission system; many designers, indeed, carry out their designs according to this principle. The idea sounds reasonable enough. But in the writer's opinion, only the ear is good enough for us to imitate. This does not mean that we should only design microphones. On the contrary, we should also design loudspeakers—by imitating some of the special features of the *ear mechanism*. The reason why we should *not* imitate the mouth (the human voice producer) in designing speakers is that the way in which our mouth produces sound is too complex to imitate. It is, after all, a generator, not an imitator; yet it requires an air flow of variable intensity and velocity, stretched vocal chords with variable length and tension, very involved co-operative movements and effects of various muscles, teeth, tongue, lips, nose, larynx, and so on. And with all of this the mouth can produce sounds only within a very limited frequency band and over a very limited range of various types of characteristics.

Certainly the highest standard we ought to demand of speaker design is nothing more than to satisfy our ears, so that when we listen to a speaker we may have as nearly as possible the same feeling we would have if we were hearing the real thing. Actually, what we want from a system (from microphone to speaker) is to have it do the work of "acoustical space shortener" or "acoustic energy preserver" so that it can, electronically or otherwise, take our ears to, or back to, the actual scene —the origin of the sound.

The translation of acoustical or mechanical vibration to electrical nerve impulse in our human hearing apparatus takes place in the cochlea. The electrical impulses are then sent to the brains, so that we can feel the sensation of sound. The cochlea is a coiled, liquid filled tube divided longitudinally by the basilar membrane into an upper and lower gallery.[2] The basilar membrane is composed of about 24,000 tightly stretched fibres. It is assumed that each fibre is resonant to a certain frequency, whereupon we may assume that these 24,000 fibres are resonant to 24,000 different frequencies, which can well cover the audible frequency range, from 20–20,000 cps. This explains why we can hear clearly and vividly and distinguish two almost similar tones. Though there is some nonlinearity in our hearing systems, the deficiency is tolerable, since we are born like that and probably would be very unhappy if the nonlinearities were somehow miraculously straightened out.

In the designing of a perfect speaker, the diaphragm should be made to resemble that of the basilar membrane in that it should be composed of about 24,000 individual units. Each unit should then be made to resemble the rigid disc described by one school of opinion as the perfect diaphragm (though the construction of such a disc is still an enigma) so that each unit can respond to one frequency only, as claimed by the mastermind of the perfectly flexible diaphragm. The units should, however, be connected together in such a way that each of the individual units should have no influence on and not be influenced by any other unit. In such a case, the whole diaphragm resembles

* *6 Rednaxela Terrace, Caine Road, Hong Kong.*

[1] H. A. Hartley, Audio Engineering, Jan., 1953.

[2] Edgar M. Villchur, "Handbook of Sound Reproduction," chap. 6, Audio Engineering, Nov., 1952.

a really flexible diaphragm, yet consists of thousands of individual and independent rigid discs.

Though the perfect speaker diaphragm described above seems at the moment very difficult or even impossible to construct, it is strictly sensible, and before rejecting the idea the reader will do well to remember that before any problem is solved it begins as an enigma. Scientifically speaking, nothing is impossible. Our forefathers would certainly have been willing to swear that you could never see a man who is 1,000 miles away; today we call it television and think the old ancestor was terribly backward!

Even in designing present-day speaker systems we are following my trend of thought. Look at the coaxial and triaxial speaker systems. Each of the two or three units is mechanically and electronically separated and decoupled from the other unit or units, so that each may work independently within its own frequency range. Results so obtained have been found to be much more satisfactory than a single unit.

There is no reason why development cannot be extended to the perfect speaker diaphragm described. Though it may still be a long time before our technology is equal to the task, it is certainly worthwhile to think about this principle and try it when we can. So let us go back to our labs and start all over again!

BOOK REVIEW

PRINCIPLES OF TRANSISTOR CIRCUITS, Edited by Richard F. Shea. New York: John Wiley and Sons, Inc., 535 pages, illustrated, 1953. $11.00.

While some of the material in this book may be familiar to those who have followed the technical reports on transistors issued by Bell Telephone Labs, there is a large amount of new material which has not been published before. Heretofore the best available material on transistors all in one place was the famous November 1952 issue of the *Proceedings of the IRE*. This text is the work of nine engineers at General Electric. The task of harmonizing all the manuscript into a uniform easily readable text, was undertaken by Richard F. Shea.

For those not familiar with matrices there is a separate chapter on matrix methods of circuit analysis and there is additional information on the fundamentals of matrix algebra in the appendix. Since many engineers are more familiar with vacuum tubes than with these new substitutions for electron tubes, the editor has gone to special pains to indicate the resemblances to vacuum-tube circuits. The introductory chapter on semiconductor principles plus the second chapter on forms, types, and characteristics of transistors, both read in conjunction with Chapter 14 on circuit design by duality will help the engineer with little knowledge of transistors.

The level of the book is graduate school but the practicing engineer will be able to read this text with understanding and profit.

—*D. T. Armstrong*

PROFESSIONAL TAPE RECORDER

(*from page 22*)

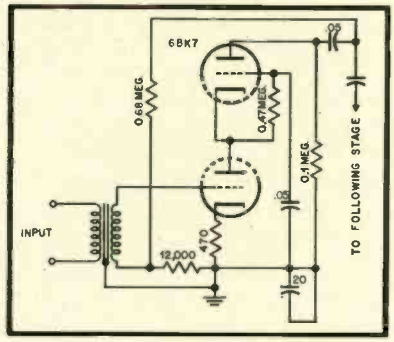


Fig. 9. Schematic of the cascode preamplifier stages in the amplifier section.

Valley and Wallman[1] and shown in *Fig.* 9. The use of this input stage results in lower equivalent input noise than most microphone preamplifiers commercially available. The production units have shown an input noise figure of the order of –127 dbm. The newly developed 6BK7 tube is used. The high amplification factor and low plate impedance of this tube make it well suited for cascode application. The input stage is capable of handling input levels at high as –20 dbm without exceeding 1 per cent total harmonic distortion. The large input signal handling capability and the low noise figure result in an ideal microphone amplifier input stage. Approximately 6 db of inverse voltage feedback is carried around the input stage to increase the level handling capabilities.

The output stage V_{3a} consists of a constant-current, inverse-feedback amplifier, with a large cathode resistor to provide the feedback. Equalization is accomplished in the cathode circuit by employing a small bypass capacitor across the cathode resistor, resulting in higher gain with higher frequency. This method is used for the 15-inch tape speed. At 7½ inches a greater slope of the equalizer curve is required and a series resonant circuit is used to shunt the cathode resistor. Equalizations are of the order of 8 db at 15 kc for 15 ips, and 16 db at 15 kc for 7½ ips.

The response of the recording amplifier is flat from approximately 30 cps to the point where the high-frequency pre-emphasis begins. It is the opinion of the authors that low-frequency pre-emphasis should not be used in the record amplifier, to eliminate the possibility of overloading the tape with high-level, low-frequency tones.

The plate of the output stage connects directly through an 0.5 μf capacitor to the record head. A potentiometer is provided in the ground return of the record-head circuit. The bias current passes through this potentiometer, and a voltage proportional to the bias current is developed across it. A portion of this voltage is tapped off and fed to the VU meter as the bias reading.

A second voltage amplifier also feeds a cathode-follower stage which supplies record monitoring voltage to the VU meter and to the phone jack. The output impedance of the cathode follower is approximately 600 ohms. This impedance, together with the 3,300-ohm VU meter series resistor, constitutes the proper impedance and time constant for proper damping of the VU meter. The over-all apparent gain of the record amplifier at the microphone input is 95 db. This means than an input level of –95 dbm is required for a zero level recording.

Reproduce Amplifier

The output voltage from the reproducer head is fed directly to the first grid of a 12AU7 input stage connected in a cascode arrangement. Several types of tubes were tried in the input stage; these included a low-noise pentode and various dual triodes. However, it was found that the 12AU7 connected in the cascode arrangement resulted in the lowest over-all noise figure. The output of this stage feeds the first section of a 12AX7 dual-triode cascode amplifier.

The output of the first section of the 12AX7 is fed back through an inverse feedback loop to the cathode of the input stage. This is a frequency-selective voltage feedback network which results in over-all frequency characteristics very closely in agreement with the standard NARTB playback curve. This curve consists of approximately 25 db of additional gain at 50 cps above the 1000-cps gain, while the gain at 15 kc is approximately 10 db below the 1-kc gain.

The over-all gain of the playback amplifier is approximately 75 db at 1000 cps. There is an additional gain of approximately 25 db at 50 cps. Since most of the noise consists of low-frequency components, the gain affecting the noise output is of the order of 95 db. Calculations will show that the equivalent input noise due to the input stage is phenomenally low. This is a criterion which must be satisfied to achieve over-all high record-playback signal-to-noise ratios. It may be safely stated that with any high-quality recorder the determining noise should be confined strictly to the tape output noise, and the amplifier noise

[1] Valley and Wallman, "*Vacuum Tube Amplifiers*," McGraw-Hill Book Co., 1948.

should be held at least 6 db below that.

The playback gain control is located between the second and third stages of the amplifier. The gain control is followed by two stages of triode amplification and an output stage consisting of one-half of a 12AU7. The output transformer has two 600-ohm secondary windings, one of which is carried directly to the output terminal, a barrier strip on the rear of the chassis. The other secondary winding is used for developing constant-voltage inverse feedback around the output and driver stage, and also to supply voltage to the monitor jack and the VU meter. There is approximately 20 db of feedback around the output and driver stages, which results in distortions of less than 1% at the full rated output of +16 dbm.

When the equalizer switch is in the 7.5 position an R-C network is connected across the cathode of the driver stage to increase the high-frequency response by about 6 db at 15 kc so that frequencies up to 15 kc may be played back at 7½ inches per second.

The power supply for the amplifiers consists of a transformer-fed, single-phase, fullwave rectifier, followed by an R-C low-pass filter. Filament voltage for the input stages of each of the two amplifier sections is supplied from a rectified 18-volt winding of the power transformer to maintain low hum content. A.c. power for the amplifier is obtained from the tape transport unit through a power cable and connector. The plate and filament voltages are supplied to the bias oscillator on the tape transport unit through this power cable.

Performance Figures

The over-all performance of the M-80 is well within professional standards, not only in an electrical and mechanical sense, but also in terms of fulfilling professional operational requirements. Starting time for the tape is less than 0.1 second and stopping takes place within 2 inches of tape when using the operating speeds. Flutter and wow are under 0.1 per cent r.m.s. at 15 ips and less than 0.15 per cent at 7.5 ips. The signal-to-noise ratio is better than 58 db, based on a level giving a maximum of 3 per cent harmonic distortion.

The frequency response for the over-all recording-playback operation is shown by the two curves of *Fig.* 10 to be within 2 db from 30 to 15,000 cps at 15 ips, and within 4 db at 7.5 ips. The total harmonic distortion for maximum indicated level of 0 VU on both record and playback is less than 1 per cent.

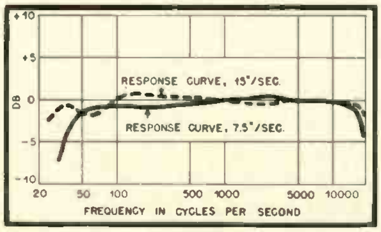


Fig. 10. Response curves of the M-80 at 7.5 and 15 inches per second.

"PRESENCE"

(*from page 57*)

R_{15}	50,000 ohms, linear pot, (combined with Sw_3)
R_{17}	1800 ohms, ½ watt
R_{20}	18,000 ohms, ½ watt
$R_{21a, b}$	Centralab Senior Compentrol
R_{23}	1000 ohms, 1 watt
R_{24}	6800 ohms, 1 watt
R_{25}	13,000 ohms, ½ watt
R_{26}, R_{30}	11,000 ohms, ½ watt
R_{27}	8200 ohms, ½ watt
R_{29}	12,000 ohms, ½ watt
R_{31}	10,000 ohms, ½ watt
R_{32}	7500 ohms, ½ watt
R_{33}	5600 ohms, ½ watt
R_{35}	10,000 ohms, 1 watt
R_{36}	5600 ohms, 2 watt
R_{37}	3900 ohms, 2 watt
R_{38}	1.8 meg, 1 watt
Sw_1, Sw_2	Preamplifier switch, Centralab 30c type, special (see text)
Sw_3	Centralab 30a type, combined with R_{15}, special.
J_1, J_2, J_3	Amphenol 80-PC2F receptacle
J_4	Amphenol 80-C receptacle
Tone Control	Centralab Couplate No. 12614, with 1.0-meg front section and 0.5 meg tapped rear section dual-concentric controls
V_1, V_2	Genelex Z729
V_3	12AX7
V_4	12AU7

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Industry Notes...

Triad Transformer Corporation, Venice, Calif., has put into operation a profit-sharing plan for which all employees, except major executives, are eligible. The plan takes into consideration earnings, accumulated seniority, and position. It is part of a continuing employee participation program which already includes a federally-chartered employees' credit union. Approximately 400 persons will be affected.

RCA Victor Division of the Radio Corporation of America has started construction on a group of ultra-modern buildings in Camden, N. J., to serve as administration and laboratory headquarters for its Home Instrument and Service Company activities. Scheduled for completion this Fall, the project will contain five interconnected buildings and will occupy a 58-acre tract in Camden's Cherry Hill section. The new buildings will house 1400 employees.

Helipot Corporation, with headquarters in Pasadena, Calif., celebrated the inauguration of its new eastern plant in Mountainside, N. J., on December 3. Some 500 prominent guests attended at the invitation of Dr. A. O. Beckman, Helipot president, and Donald C. Duncan, general manager.

Ampex Corporation is planning to prove that high-speed duplication of recorded tape is as practical and economical as pressing discs in a tape duplication exhibit at the Los Angeles Audio Fair. Fair visitors will be offered the opportunity of having a duplicate of their favorite tape made on-the-spot at no cost—all they need do is bring the recorded tape and an equal roll of blank tape to the Ampex exhibit. A 1200-ft. spool can be copied in four minutes.

One of the electronics industry's oldest trade marks will soon become evident in the hi-fi field when **Freed-Eisemann** introduces a complete line of home music system components. Initial production will include AM-FM tuners, preamp-control units, amplifiers, and complete AM-FM receiver chassis.

James B. Lansing Sound, Inc., Los Angeles, has expanded its facilities to include a new building for housing offices, cabinet and paint shop, research laboratory, and warehouse. Located adjacent to the company's main building, which will be devoted entirely to production, the new structure will permit doubling the number of factory and office employees.

Allied Radio Corporation, Chicago, was host at the December 16 meeting of the Chicago Acoustical and Audio Group. In addition to a sumptuous dinner, members were treated to a variety of impressive demonstrations by **Ampex Corporation** and **Electro-Voice, Inc.** Speakers included Electro-Voice's Howard Souther, Allied president A. D. Davis, and CAAG president George Bonvallet.

Industry People...

Dr. Leslie Hill has been appointed director of research for the Pentron Corporation—formerly developed electronic equipment for the British and Egyptian governments . . . Changes in sales organization of Browning Laboratories, Inc., find **Ralph L. Purrington** as vice-president and director of sales; **Roy E. Lonnberg** as sales manager of high-fidelity equipment; **Lee Maserian** as sales manager of industrial test equipment, and **Robert L. Gagnon** as applications engineer . . . Management promotions at Brush Electronics Company include **Douglas C. Lynch** who becomes executive vice-president; **C. J. Mayers**, vice-president and treasurer; **B. H. VanHouten**, vice-president and director of employee relations; **A. J. W. Novak**, general sales manager; **W. C. Hall**, controller, and **F. W. Anderson**, budget director . . . **Thomas D. Walsh** and **George R. Loux** have been named vice-presidents of The National Company.

ADVERTISING INDEX

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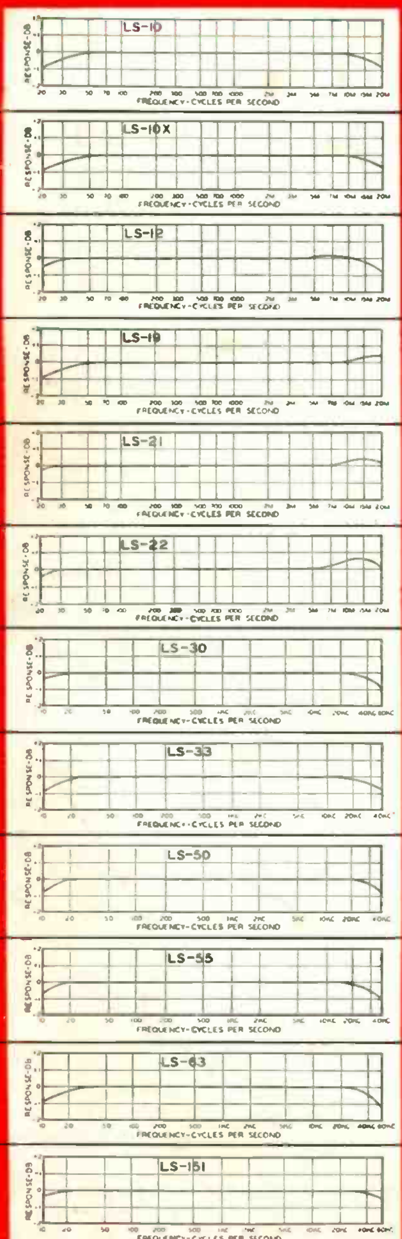

* UTC LINEAR STANDARD transformers are the ONLY audio units with a GUARANTEED uniform response... ± 1 DB from 20 to 20,000 cycles.

INPUT TRANSFORMERS

Case Size	LS-1	LS-2
Length	3⅛"	4 7/16"
Width	2⅝"	3½"
Height	3¼"	4 3/16"

Type No.	Application	Primary Impedance	Secondary Impedance	± 1 db from	Max.† Level	Relative* hum	Unbal. DC in prim'y	Case No.	List Price
LS-10	Low impedance mike, pickup, or multiple line to grid	50, 125/150, 200, 250, 333, 500/600 ohms	60,000 ohms in two sections	20-20,000	+10 DB	−74 DB	.5 MA	LS-1	$25.00
LS-10X	As above	As above	50,000 ohms	20-20,000	+10 DB	−92 DB-Q	.5 MA	LS-1	35.00
LS-12	Low impedance mike, pickup, or multiple line to push pull grids	50, 125/150, 200, 250, 333, 500/600 ohms	120,000 ohms overall, in two sections	20-20,000	+10 DB	−74 DB	.5 MA	LS-1	28.00
LS-12X	As above	As above	80,000 ohms overall, split	20-20,000	+10 DB	−92 DB-Q	.5 MA	LS-1	35.00
LS-15X	Three isolated lines or pads to one or two grids	30, 50, 200, 250 ohms each primary	60,000 ohms overall, in two sections	20-20,000	+10 DB	−92 DB-Q	.5 MA	LS-1	37.00

INTERSTAGE AND MATCHING TRANSFORMERS

Type No.	Application	Primary Impedance	Secondary Impedance	Response	Max.† Level	Relative* hum	Unbal. DC in prim'y	Case No.	List Price
LS-19	Single plate to push pull grids like 2A3, 6L6, 300A. Split secondary	15,000 ohms	95,000 ohms; 1.25:1 each side	± 1 db 20-20,000	+12 DB	−50 DB	0 MA	LS-1	$26.00
LS-21	Single plate to push pull grids. Split pri. and sec.	15,000 ohms	135,000 ohms; 3:1 overall	± 1 db 20-20,000	+10 DB	−74 DB	0 MA	LS-1	26.00
LS-25	Push pull plates to push pull grids. Medium level. Split primary and sec.	30,000 ohms plate to plate	50,000 ohms; turn ratio 1.3:1 overall	± 1 db 20-20,000	+15 DB	−74 DB	1 MA	LS-1	32.00
LS-30	Mixing, low impedance mike, pickup, or multiple line to multiple line	50, 125/150, 200, 250, 333, 500/600 ohms	50, 125/150, 200, 250, 333, 500/600 ohms	± 1 db 20-20,000	+15 DB	−74 DB	.5 MA	LS-1	26.00
LS-33	High level line matching	1.2, 2.5, 5, 7.5 10, 15, 20, 30, 50 125, 200, 250, 333, 500/600	50, 125, 200, 250, 333, 500/600 ohms	± .2 db 20-20,000	15 watts			LS-2	30.00

OUTPUT TRANSFORMERS

Type No.	Application	Primary Impedance	Secondary Impedance	Response	Max.† Level	Relative* hum	Unbal. DC in prim'y	Case No.	List Price
LS-50	Single plate to multiple line	15,000 ohms	50, 125/150, 200, 250, 333, 500/600	± 1 db 20-20,000	+15 DB	−74 DB	0 MA	LS-1	$26.00
LS-52	Push pull 245, 250, 6V6 or 245 A prime	8,000 ohms	500, 333, 250, 200, 125, 50, 30, 20, 15, 10, 7.5, 5, 2.5, 1.2	± .2 db 25-20,000	15 watts			LS-2	35.00
LS-55	Push pull 2A3's, 6A5G's, 300A's, 275A's, 6A3's, 6L6's, 6AS7G	5,000 ohms plate to plate and 3,000 ohms plate to plate	500, 333, 250, 200, 125, 50, 30, 20, 15, 10, 7.5, 5, 2.5, 1.2	± .2 db 25-20,000	20 watts			LS-2	35.00
LS-63	Push pull 6F6, class B 46's, 6AS7G, 807-TR, 1614-TR	10,000 ohms plate to plate and 6,000 ohms plate to plate	30, 20, 15, 10, 7.5, 5, 2.5, 1.2	± .2 db 25-20,000	15 watts			LS-2	25.00
LS-151	Bridging from 50 to 500 ohm line to line	16,000 ohms, bridging	50, 125/150, 200, 250, 333, 500/600	± 1 db 15-30,000	+18 DB	−74 DB	1 MA	LS-1	27.00

The values of unbalanced DC shown will effect approximately 1.5 DB loss at 30 cycles.
* Comparison of hum balanced unit with shielding to normal uncased type. Q Multiple alloy magnetic shield.
† 6 MW as ODB reference.

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