Evolution of a Recording Curve - See Page 19

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CONTENTS JULY, 1953 Vol. 37, No. 7

COVER

Tex McCrary, veteran NBC commentator, explains how the Tapak PM step-flux erase head saved many hours of editing time during his nine-week trip to Korea this Spring—a trip which resulted in some 60 hours of tape programs from the battlefront. Tex had just been showing Al Travis, "father" of the Tapak, a number of photos of how he recorded interviews with men actually under fire, in the bunkers, and even in a jet plane over the Yalu River. The recorder is spring driven and its amplifiers operate from self-contained batteries so it may be taken anywhere to obtain the on-the-spot recordings so important to present-day broadcast programming.

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

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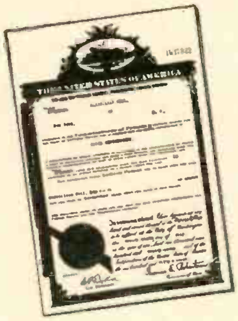

AUDIO PATENTS

RICHARD H. DORF*

As the radio art becomes more advanced and its evidences more widespread, the problem of economical use of the frequency spectrum becomes more acute. Available techniques permit use for radio tranmission of a wide but definitely limited section of the spectrum, from about 10,000 cps to around 10,000 mc. While this looks like a large range—a million to one—it effectively becomes smaller everyday as more and more services pry their way into it.

The communications theorem states roughly that the minimum amount of spectrum occupied by a given signal is directly proportional to the amount of intelligence the signal is carrying. Practically speaking, it is normally impossible to narrow the occupied bandwidth of, say, a transatlantic radiotelephone link without decreasing the upper modulation frequency. But as soon as we limit modulation below about 3,000 cps, intelligibility begins to deteriorate and soon the link becomes useless.

A highly interesting approach to the problem is indicated in a patent issued recently to John C. Steinberg, No. 2,635,146, assigned to Bell Labs. The system he discloses should make possible fully intelligible speech transmission while using a bandwidth of only a little more than 400 cps. To do this the inventor has recognized that much of the conventional speech bandwidth lies idle most all of the time; at any instant the voice is producing only a small number of essential characteristics—perhaps eight—which summarize the sound being uttered at that instant. To transmit those in the original may require a bandwidth of several thousand cps; but to analyze and summarize them requires a bandwidth of only about 50 cps per characteristic or perhaps 400 cps in all. The summary, transmitted to the receiving end of the link, may be used to reconstruct the original voice with sufficient accuracy for practical purposes.

The Formant Principle

The Steinberg invention is based on the formant theory, which accounts for the nature of sounds in a fundamentally simple way. Every voiced sound (those in which the vocal cords are used) consists of a complex waveform made up of harmonically related frequencies. The fundamental sound source is the vocal cords which produce a sawtooth waveform containing a fundamental and all harmonics in an even progression—the second harmonic having half the power of the fundamental, the third having one-third that of the fundamental, and so on. If we heard the fundamental

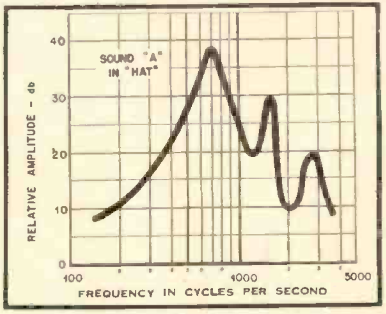

Fig. 1.

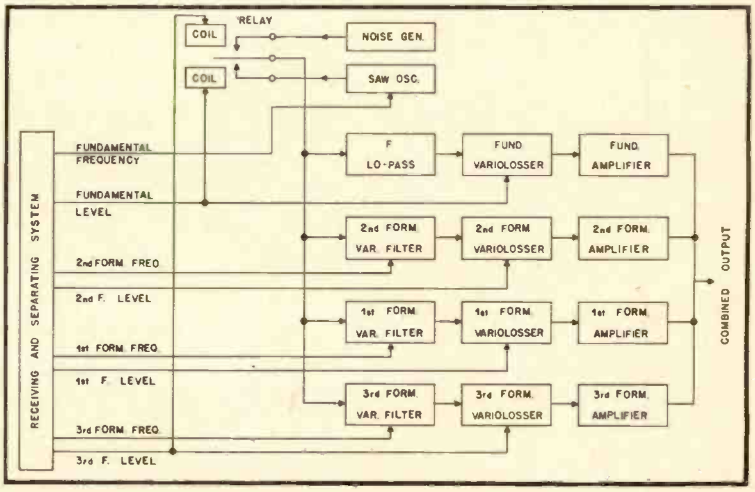

Fig. 5.

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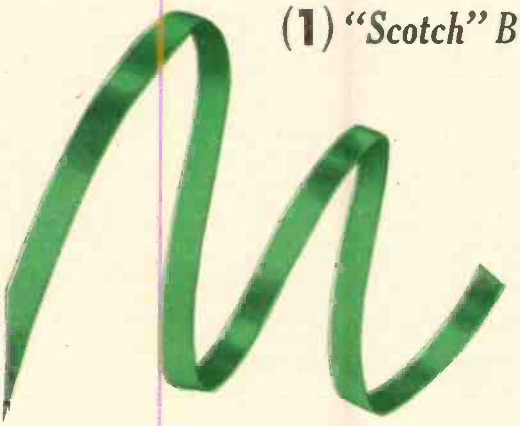

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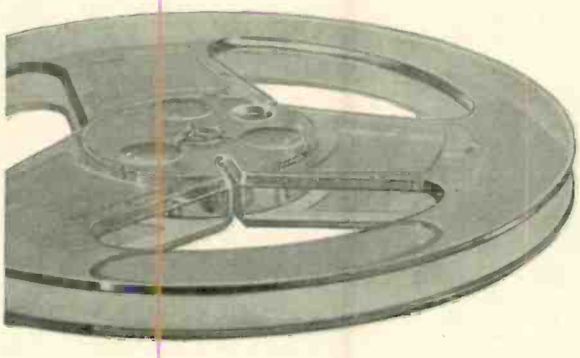

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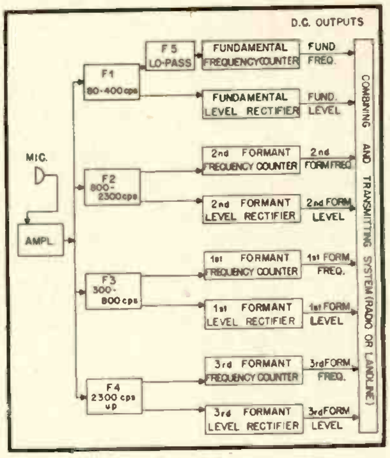

Fig. 2.

sound produced by the vocal cords of many persons we could distinguish no substantial differences between them except pitch or frequency.

The sawtooth waveform is modified, however, by the various shapes and sizes into which we can form the cavities through which the sound must pass, principally the mouth. Because of the complex nature of the cavities, at any instant they have at least two, and often three or more resonant frequencies, each resonance having a particular Q or figure of merit or efficiency. It is the resonances formed by the cavity shapes and sizes at any instant that determine the character of the voiced sound being uttered. These resonances are termed *formants*. Their frequencies are practically the same for all individuals when making identical sounds.

When making the sound "a" as in "hat," for instance, the resonance frequencies are roughly 750, 1500, and 2550 cps, and each of these resonances has a certain Q or efficiency factor. *Figure* 1 is a spectrum graph of the vowel sound in "hat." It shows the resonances and their relative Q's. The complex wave representing the sound itself will have a harmonic content depending on this spectrum. For instance, if the vocal cords are vibrating at 187 cps, the fourth harmonic (748) will be very strong, the eighth harmonic (1496) will be prominent, but less so, and the 13th and 14th harmonics (2431 and 2618) will be emphasized, but to a still less extent. If the fundamental is different, the orders of emphasized harmonics will be different, but will still be at approximately the same frequencies, because these are the speech-cavity-resonance frequencies, the formants, which always produce this particular vowel, when present in these relative efficiencies.

To represent voiced speech, then, we can reduce the information transmitted to the following: (1) fundamental frequency and relative volume level, (2) at least two of the formant frequencies and their relative emphasis levels. For better intelligibility we can transmit information about three formants.

Unvoiced or aspirated speech sounds are rushes of air which are given formant characteristics by resonances of lips, tongue, teeth, and so on. Typical aspirates and explosives are *f*, *p*, *h*. The air rush, which is the source of sound itself, is equivalent to a random noise source with a strong predominance of upper-frequency components. The formants which distinguish the unvoiced sounds from one another are also in the upper frequencies.

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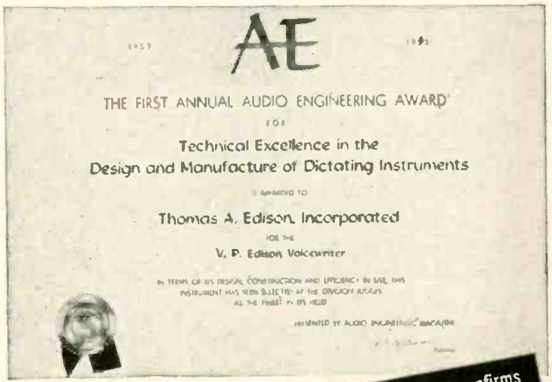

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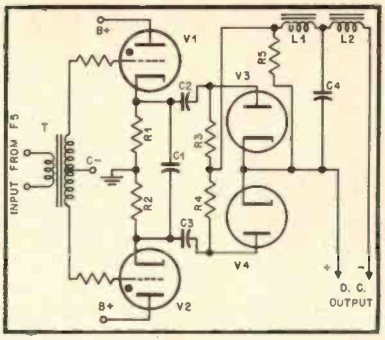


Fig. 3.

Transmitting Equipment

Figure 2 is a block diagram of most of the apparatus needed at the transmitting end of the link to analyze the eight necessary characteristics—frequency and level of fundamental and each of three formants—and produce d.c. control voltages representing them.

The speaker speaks into the microphone. His voice is amplified and fed through four filters to eight channels. Consider first the fundamental channel. Voice currents pass through F_1 which is a band-pass filter passing the fundamental voice frequencies up to about 400 cps. Next this band is passed through F_6, a low-pass roll-off filter whose output decreases with increasing frequency. The purpose of F_6 is to filter out harmonics of the fundamental voice wave so that the frequency counter will be actuated by the fundamental alone.

From F_6 the voice currents go to a frequency counter which is diagrammed in *Fig.* 3. The grids of gas tubes V_1 and V_2 are polarized by the voice-frequency voltages passing through transformer T, with opposite polarities at every instant. Assume to start that the grid of V_1 is positive and that of V_2 negative. Then V_1 is ionized and saturation current is flowing through it, while no current is passing through V_2. The cathode of V_1 is positive due to current passing through R_1, and the upper end of C_1 is charged positively with respect to its lower end.

At the next half of the audio cycle the grid polarities reverse. At the instant when the grid of V_2 becomes positive enough to fire the tube, saturation current flows in V_2 and the V_2 cathode becomes positive. This produces a pulse of positive voltage through C_1 to the cathode of V_1. Added to the existing positiveness of the V_1 cathode, the pulse makes the V_1 cathode more positive than its anode. This extinguishes the tube; since the V_1 grid is now negative, the tube remains extinguished until the next half-cycle of audio causes a similar changeover.

(*Continued on page 44*)

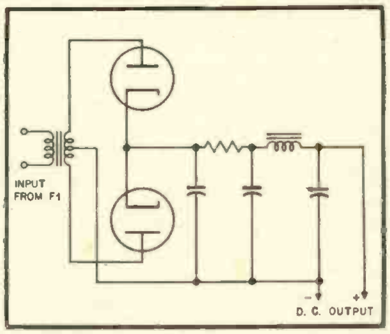
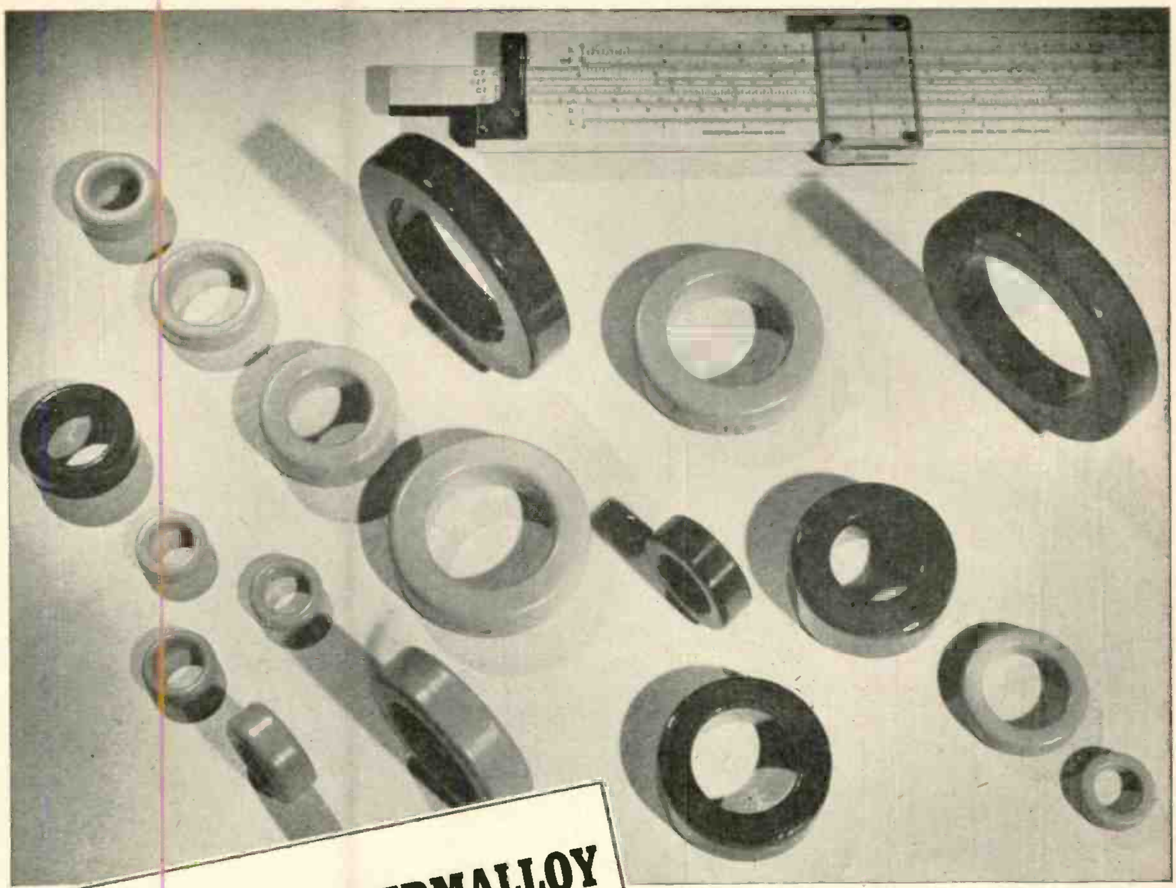


Fig. 4.



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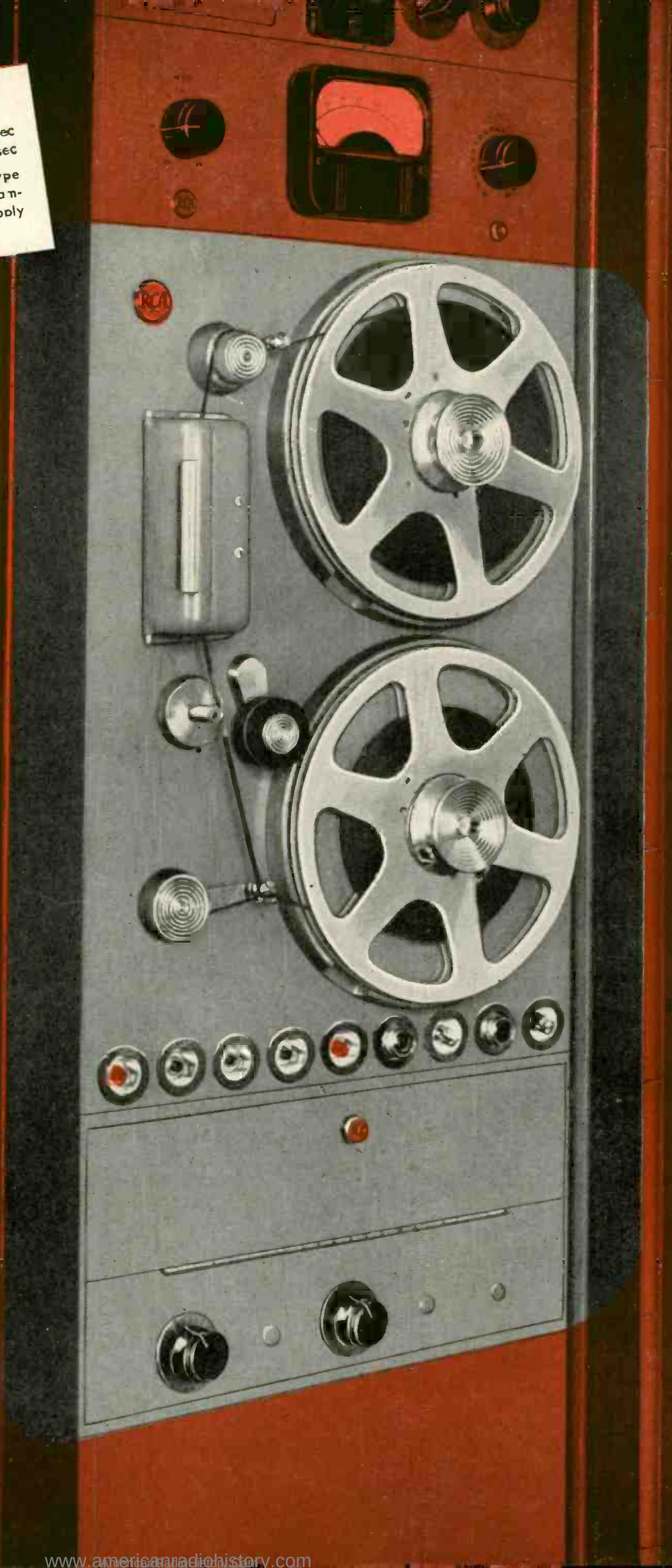

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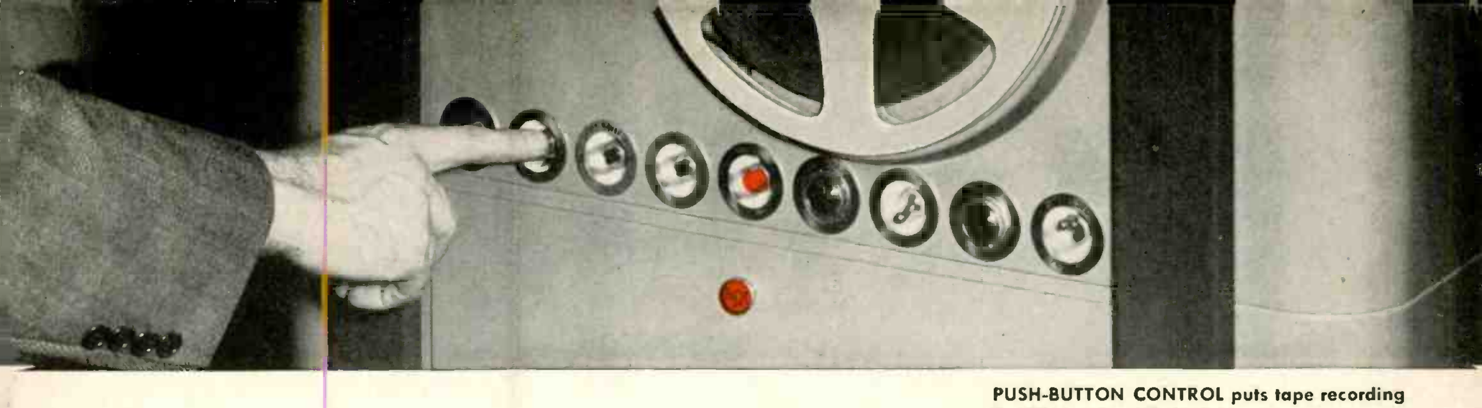

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LETTERS

When is it Finished?

SIR:

Browsing through back issues of Æ, I note the wealth of ideas it contains toward improvement of home music systems. While these articles are of immense help to both technical and not-so-technical readers, I wondered whether they did not constitute such an overabundance of riches that the individual hardly knows were to stop with his own system. In other words, when is a system finished?

My own criterion for answering this question may be of some interest to others. The judgment can be made only by the owner of the system and then preferably when he is sincerely interested in high-quality sound, has investigated the field, and has heard a number of different systems. It makes no difference whether he is a tyro who can't tell the difference between a resistor and capacitor or a combination of the ten best audio engineers rolled into one.

The judgment is made like this: If at least two weeks have gone by since any alterations were made and the owner suddenly finds he is listening to the *music* and not to the audio system—don't touch it any more. This requires a small amount of introspection and is even more sensational in the case of the experienced audio engineer who has a hard time not listening to the system rather than the music.

As a matter of personal experience, I feel that my system is finished. Today I hear audio only when the record is poor—the rest of the time I hear music. I have no urge to change this or that, and I resist actively any suggestion that I see whether adding Gimmick X might give me a little more bass.

It may be a little difficult for eager fans to stop fiddling with the system, but I think we should all remember what we sometimes tend to forget—audio systems are about as useful as dinosaurs unless they enable us to enjoy the program material—music or what not—more.

RICHARD H. DORF
Audio Patents Dept.,
AUDIO ENGINEERING

Control Amplifiers

SIR:

I learned about Æ through the *Saturday Review*-Canby route. After subscribing in 1949 my troubles began.

I bought the highest priced hi-fi combination that I could find and according to everyone who heard it, it was all wrong. But through the help of Æ and particularly Villchur's Handbook of Sound Reproduction series, I have been able to put together a fairly acceptable hi-fi outfit.

The main stumbling block has been the compensating control preamplifier. Each one seems to have some desirable features but leaves out others I consider necessary. Every manufacturer offers different controls, curves, and channels. As a user, I have some different ideas.

First, I would like a selector switch to cover the record characteristics for at least three LP types and for the 78's that are needed (even though I never play them). These should be so labeled that they could be set by inspection because I—and a number of my friends—do not, due to age, hear the higher frequencies. How can I set a variable treble control to compensate for the pre-emphasis when I can't hear it?

Also, I would like two input channels for

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- One to ten simultaneous duplicates (slave recorders can be purchased one at a time as needed)
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- Any standard reel sizes up to 14-inch
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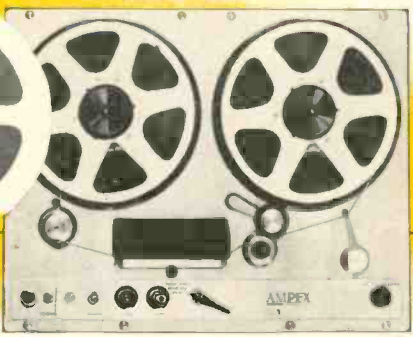
*From master tapes of suitable quality.



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magnetic pickups with a terminal strip arranged so that resistors could be installed readily to match each type of pickup. I use two turntables, and it would be convenient to be able to switch from one to the other. Most present models of preamplifiers provide for different types of pickups when two or three inputs are offered.

I would also like a series of filters that cut off rather abruptly at 4000, 7000, and 10,000 cps, for example. These could be used for playing some of the older long-playing records. I find it practically impossible to cut out the disagreeable fuzz of some of the soprano voices on the older LP's with the conventional treble rolloff control.

But so what—my speaker is still l - - - y.

E. E. BENEDICT,
3318 Calle Fresno,
Santa Barbara, Calif.

(Suggested solution—design and build your own. Then when you are satisfied, we'll be glad to publish the story about it. ED.)

Information, Please

SIR:

In an old moving picture about the life of Mozart—"The Mozart Story"—a short part of one of his quartets is played. I would be grateful if someone would tell me from which of the quartets that part was taken.

Here is a suggestion that might add to the value of Æ—add a Question and Answer department. Audio hobbyists usually have many questions that they would like to have answered, and undoubtedly many of them would be of general interest.

DAVID FONSECA,
555 Notre Dame Ave.,
Chattanooga 11, Tenn.

(We answer questions by mail now, provided they are accompanied by a self-addressed, stamped envelope. Does anyone agree that a Q & A department would be worthwhile? ED.)

Stereo Photos

Sir:

Some months ago you started running stereoscopic photos and implied that this would be a continuing feature of our valuable publication. Having just received the current issue of Æ and again noted the absence of the interesting variety afforded by stereo pictures, I am moved to write and say that here is one reader, at least, who would be pleased to see this instructive editorial feature revived. . . .

CARLETON C. LONG
138 College Ave.,
Beaver, Penna.

(So far, no contributor has offered any articles with stereo photos. We should still be pleased to accept them, however, and shall carry on this idea with some future staff-written articles. ED.)

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A truly superb instrument with frequency response of ±0.3 db, 20 to 40,000 cps at rated 20 watts output. Harmonic distortion less than 0.5% at rated output, less than 0.3% at 10 watts. Intermodulation distortion less than 0.4% at 1 watt (home level), 0.7% at rated output (measured at 60 and 7,000 cycles 4 to 1 ratio). Output imp., 8 and 16 ohms. 4-position input selector—for magnetic pickup, crystal pickup and 2 auxiliary. Dimensions: 14" x 9" x 8" high.

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audiology

W. R. AYRES*

Feedback from Output Transformer Secondary

NEGATIVE OR INVERSE FEEDBACK has made possible extensive improvement in the performance of amplifier circuits. That form known as secondary feedback has been employed in many audio power amplifiers, and consists of sampling the output transformer secondary voltage and applying it in degenerative phase to an early portion of the amplifying system.

Whether the output voltage should be sampled at the primary, secondary, or tertiary winding is the outcome of many considerations; no one connection is best in all respects. Simply stated, principle would appear to support secondary feedback as the universal choice, because it includes the output transformer in the feedback path. Experience shows, however, that the improvement in fidelity made possible through choice of this form of feedback is often worth less than its added cost for equivalent stability and utility.

Briefly and broadly, amplitude variation, phase shift, and harmonic distortion are reduced through degenerative feedback roughly by the factor $1/(1-A_v\beta)$, where A_v is the amplification in the absence of feedback, and β is the portion of amplifier output voltage fed back for comparison at the beginning of the feedback loop. In general, and particularly with secondary feedback, the original amplification A_v is a complex quantity; i.e., there is phase shift as well as change in amplitude. If β is real only (readily realizable in audio amplifiers with either primary or secondary feedback), then the gain with feedback is also real to the extent that $A_v\beta \gg 1$. Both phase shift and variations in amplification may be reduced by negative feedback methods.

The Case For Secondary Feedback

Features advantageous in principle, and accounting for attractiveness of the method are:

1. Assuming given gain reduction with feedback, the bandwidth over which response of fine flatness may be obtained is in general greater with secondary than with primary feedback. So long as the feedback factor $A_v\beta$ can be maintained negative and materially greater than unity over the required band, over-all amplification is essentially independent of the forward gain A_v, which of course includes the transformer.

2. At low frequencies, lower distortion due to core nonlinearity is obtainable with secondary feedback than in a primary feedback circuit having the same gain reduction, because of more favorable X/R ratio.[1]

3. Hum due to last-stage power-supply ripple is reduced by secondary (or tertiary) feedback. In contrast, hum at the load terminals due to this source is worse with primary feedback than with no feedback at all.

4. Feedback to single-ended (unbalanced) input stages from a push-pull output stage is more simply accomplished with secondary feedback than with primary feedback of satisfactory form for high-quality application.

5. For given gain reduction, amplifier internal output impedance is lower with secondary feedback than by other simple feedback methods, because as far as regulation is concerned, winding resistances are lumped in with the tube plate resistances, and effectively reduced by the feedback action.

Problems in Development of Secondary-Feedback Amplifiers

Difficulty far greater than mere loss of amplification with application of feedback

(Continued on page 45)

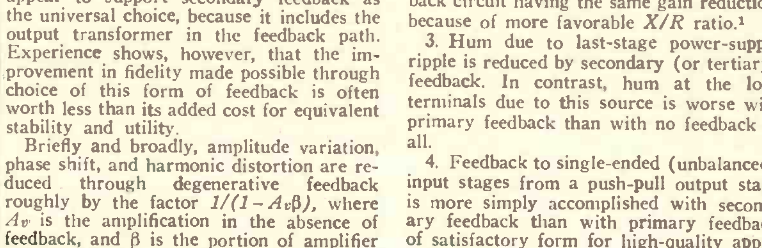

Fig. 1 (left). Simple equivalent circuit of transformer. Fig. 2 (right). Expanded circuit to represent impedances at frequency extremes, referred to the transformer primary.

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* *311 W. Oakland Ave., Oaklyn 6, N. J.*

[1] *Audiology*, "Output transformer design consideration," AUDIO ENGINEERING, April 1953.

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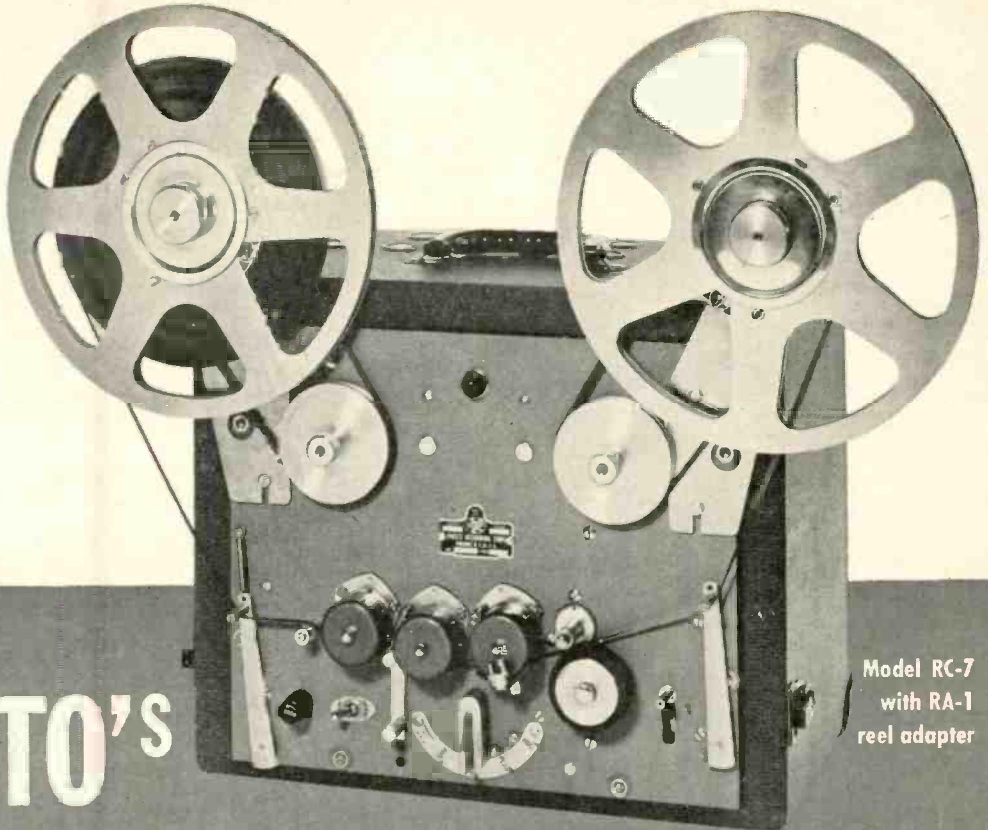

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The PRESTO RC-7 has already been acclaimed "the finest tape recorder of its size available." Although portable in size, the RC-7 embodies features and heavy duty construction found only in larger, more expensive, studio-type machines.

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EDITOR'S REPORT

NEW RECORDING CHARACTERISTIC

A GOOD TWENTY-FIVE per cent of the correspondence received each month deals with recording characteristics—the principal question in the minds of the writers being "What characteristic is the Doakes Recording Company using at the present time?" Our regular answer to questions of this type is that it does not make any difference what characteristic is being used—simply provide enough flexibility in the reproducing system for *all* characteristics and then adjust the controls so the reproduction sounds good.

This answer—we will admit frankly—is not just what the correspondent wants. He would usually prefer that we would state the turnover frequency in cps, the rolloff in db at 10,000 cps, and the bass pre-emphasis, if any. We have endeavored to state on every occasion where the question comes up that such information is not only unobtainable—as it apparently isn't in most instances—but that the movement of a microphone by as little as three feet will make more difference than the few-db changes in the recording characteristic that occur as the art of recording is advanced.

Part of this misunderstanding stems from the definition of "recording characteristic," but we believe firmly that Bob Moyer has answered all the questions at once, at least with respect to RCA Victor records, and has at the same time explained just what is meant by the term. We commend for careful reading by every user of records the article commencing on page 19.

In considering the recording characteristic, it should be pointed out that the AES *playback* curve endeavored to clarify the requirements at the time it was first introduced. The fundamental premise behind the AES curve was that a fixed basic reproducing characteristic should be employed by every manufacturer in his monitoring circuits, and that the records should be so recorded that they would sound right (to the producer) with a system equalized in this manner. Variations to suit the individual listener could then be introduced by means of the bass and treble tone controls, and, if desired, by sharp cutoff filters. While the AES playback curve received considerable support from many of the record manufacturers, it is admitted that not all of the manufacturers went along, and for several valid reasons.

The vast majority of phonograph records are reproduced on equipment which is not entirely free from rumble. With the AES curve, low-frequency equalization continued to increase, reaching 26 db at 20 cps, and still more as the frequency lowered. Furthermore, due to circumstances beyond anybody's control, low-frequency response from crystal pickups began to drop off somewhere below 100 cps when used with practical values of grid resistors. Therefore, improved low-frequency response could be obtained if a small amount of low-frequency pre-emphasis were introduced. This would result in less hum and rumble with even the highest quality equipment, and in better bass response with crystal pickups—which everyone knows outnumber the magnetics by a factor of at least 10 to 1.

The old NAB recording characteristic has come in for its share of criticism during the last few years—the main objection being excessive high-frequency pre-emphasis. However, a new recommendation has been circulated by NARTB and it seems probable that this recommendation will become a standard within a short time, eliminating the AES playback curve and the old NAB curve. The proposed NARTB standard is identical with the New Orthophonic curve now in use by RCA Victor and fully described by Mr. Moyer. Maybe this will end forever the difference in recording characteristics and simplify equipment design and operation.

TRANSISTOR CONTEST

To encourage development and experimentation in the use of transistors, the Receiving Tube Division of Raytheon Manufacturing Company has announced a contest with a first prize of $5000 and sixteen other prizes ranging downwards to $100. Contest rules may be obtained from any of Raytheon's Special Purpose Tube Distributors, but the requirements are, briefly, that a contestant must obtain a CK722 transistor and design and build a piece of electronic equipment which employs one or more of these devices. Further requirements are that the contestant must then mail a photograph of the unit and a short constructional article, together with a completed official entry blank to Raytheon. The contest closes at midnight of August 31, 1953—almost two months to go.

The transistor is unquestionably a fascinating device, and Æ is also interested in equipment which employs one or more. We would be pleased to receive short stories about audio applications—either independently from those entered in the contest or perhaps such articles as may possibly have been entered without winning a prize. We do not wish to detract in the slightest from Raytheon's contest—so perhaps we should be content to wait until it is over. However, this is a continuing offer, with no closing date.

GIVEAWAYS

Many of the giveaways distributed at the various shows have varying degrees of usefulness, but few have come into our hands that were more useful to the audioman than The Ballentine Rule which was first distributed at the IRE show in March. On one side, this item—a form of slide rule—shows decibel differences between 0.1 mv and 100 volts, levels with respect to 1 and 6 mw in 600 ohms and with respect to 6 mw in 500 ohms. The other side indicates decibel conversions for gains and losses referred to both current and voltage ratios. The Ballentine Rule is available free upon request to Ballentine Laboratories, Inc., Boonton, N. J. and is an extremely useful addition to the "tools" of the audio engineer or experimenter.

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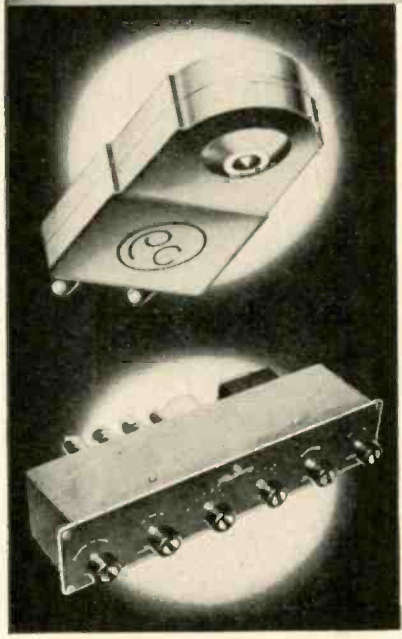


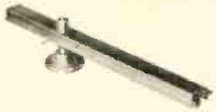
PICKERING CARTRIDGES . . .

are the choice of audio engineers throughout the world. They are universally acclaimed because of their high output, wide range performance and low distortion. They are used wherever a fine cartridge is required in radio stations, recording studios and for purposes of quality control by leading record manufacturers.

• •

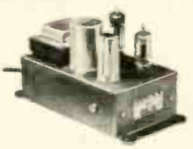
MODEL 410 AUDIO INPUT SYSTEM . . .

is designed to provide a complete audio control center. Model 410 may be used in any high quality playback system. Three input channels are provided—one for magnetic cartridges and 2 "flat" channels for other audio circuits. A 3-position equalizer network is built into the magnetic cartridge channel and provides accurate equalization for LP, AES and 78 rpm recording characteristics. Separate bass and treble controls are also provided. These are of the step-type and permit bass and treble adjustments in 2 db increments. The tone control circuits are intended to compensate for record characteristics and for listener-environment acoustical conditions. *They are not intended to compensate for amplifier and/or loudspeaker deficiencies.* Model 410 is intended for use with the highest quality professional type playback equipment. The output of the Model 410 is fed from a cathode-follower circuit and will work into any high quality audio or line amplifier having a high impedance input. It may also be used with a transformer for the purpose of feeding a 500 ohm line. Because of its flexibility, low noise and low distortion level, it is ideally suited for bridging and monitoring purposes and for critical listening applications.



THE MODEL 190 ARM . . .

is designed primarily for use with microgroove records. Its design has been recognized by leading audio engineers as that which incorporates all of the desirable tracking characteristics. Analysis has shown that for maximum performance with LP records the vertical mass of the moving arm element must be held to a minimum and further, that the arm must be counterbalanced about the vertical axis. This permits minimum stylus or tracking force and provides maximum record life. The Model 190 Arm embodies these all important features necessary for proper microgroove record playback.



MODEL 230H EQUALIZER-PREAMPLIFIER . .

is unique in its accuracy of equalization and frequency response. The intermodulation distortion is .2 per cent at normal output level. It is intended for use with high quality amplifiers having gain and tone controls. When used with the Pickering Model 132E Record Compensator the 230H is ideal for radio station and recording studio use and for applications requiring accurate low noise and distortion free playback.

MODEL 132E RECORD COMPENSATOR . . .

is designed to be used in conjunction with a magnetic cartridge preamplifier such as the Pickering 230H or any preamplifier which provides 6 db per octave bass boost. Six playback positions are incorporated:

1—European 78 rpm Records
2—Victor 45 rpm and Decca 78 rpm Records
3—No high frequency roll-off, 500 cycle turnover
4—All Capitol Records, new Victor 33⅓, Audio Engineering Society Curve
5—Columbia, London and most LP Records
6—To remove the hiss from old noisy records

Precision elements are used in its construction to give accurate compensation. The 132E is inherently a low distortion R-C device.

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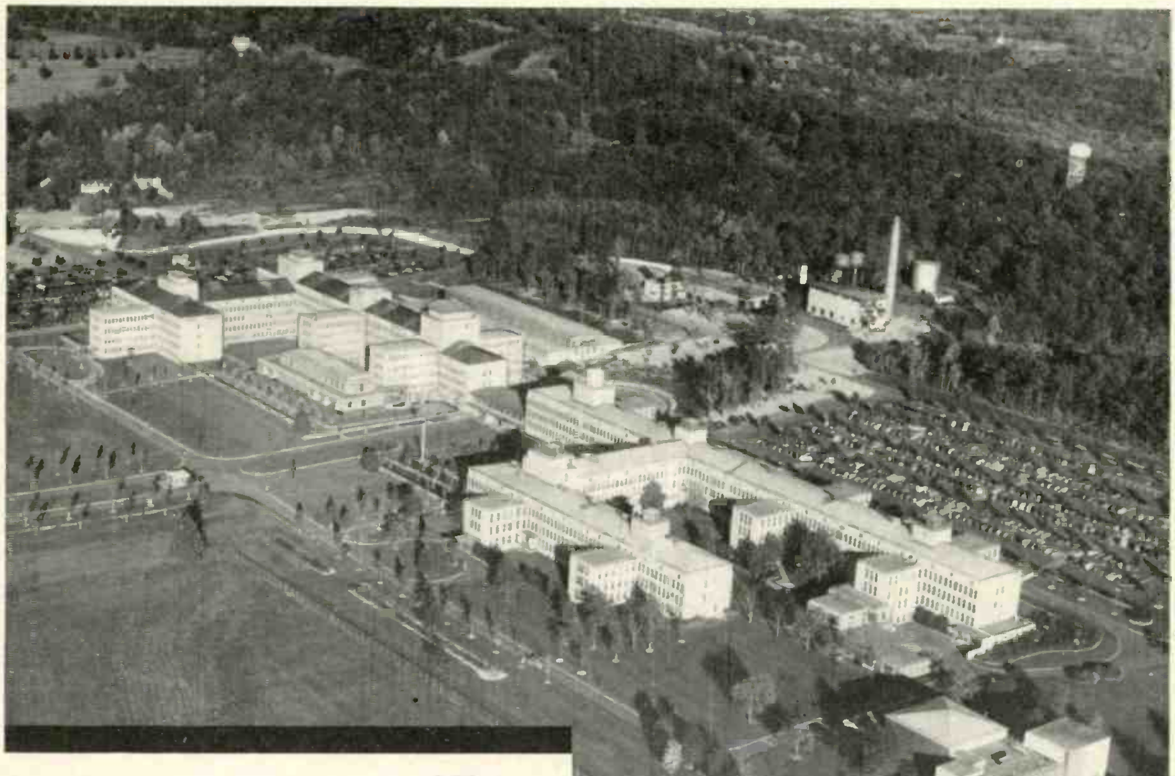
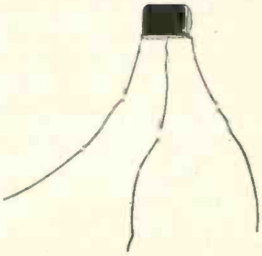


Bell Telephone Laboratories at Murray Hill, N. J. Other laboratories are in New York City and at Whippany and Holmdel, N. J.

Birthplace of the Transistor



The ***Transistor***, that revolutionary new electronics device, is a product of *telephone* research. It was conceived, invented and developed at Bell Telephone Laboratories by men in search of ways to improve telephone service. It was announced just five years ago.

The ***Transistor*** can do most of the things that vacuum tubes can do—and others, too—but it is not a vacuum tube. It works on entirely new physical principles. Rugged, simple and tiny, the Transistor uses incredibly small amounts of power—and then only when actually operating.

Transistors promise smaller and cheaper electronic equipment and the spread of electronics where other equipment has not been able to do the job as economically. They are already at work in the Bell System, generating the signals that carry dialed numbers between cities, and selecting the best route for calls through complex switching systems. Engineers see many other possibilities: for example, as voice amplifiers in telephone sets to aid the hard of hearing, and as switches.

Recognizing the tremendous possibilities of the ***Transistor*** in every phase of the electronics industry, the Bell System has made the invention available to 40 other companies. Thus, again, basic research to improve telephony contributes importantly to many other fields of technology as well.

TRANSISTOR SUMMARY

Basically, a ***Transistor*** is a tiny wafer of germanium with three electrodes, over-all about the size of a coffee bean.

It can amplify signals 100,000 times on much less power than a pocket flashlight requires. This opens the door to its use in smaller telephone exchanges where vacuum tube equipment would be too costly to operate.

Unlike a vacuum tube, the ***Transistor*** has no vacuum and no filament to keep hot. It operates instantly, without "warm-up" delay. The Transistor can also be used as an electric eye and to count electrical pulses.

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Evolution of a Recording Curve

R. C. MOYER*

A discussion of the reasons for the existence of "recording curves" and a presentation of the official specifications for the "New Orthophonic" curve currently used for RCA Victor records and well on the way to universal adoption by all record manufacturers.

The primary function of any home phonograph record is to provide entertainment for the consumer. That this entertainment may be provided in its best possible form has been one of the prime objectives of every record manufacturer since the start of the business at the turn of the century. The degree of success attained in this direction is judged largely by the sound of the finished record as reproduced on a typical or standard reproducer. The quality and balance of this sound is determined by the characteristics of the reproducer, the recording system, and to a very large extent, microphone placement, orchestra seating, and studio acoustics. Thus there are in effect three areas, any one or all of which may be made variable, to change the sound heard by the listener. It is the first two of these three areas, namely the over-all reproducing and recording characteristics, with which we are primarily interested.

During the period from approximately 1900 to 1925 when acoustical recording was used, both of these areas were relatively fixed; that is, balance, separation, etc., were being accomplished as well as possible by placement of the artists in relation to the horn of the recorder. With the advent of electrical recording equipment, great flexibility which had hitherto been impossible was provided for the recording director in making records. Flexibility in reproducing records was also provided with the introduction of the electric phonograph with tone and volume controls.

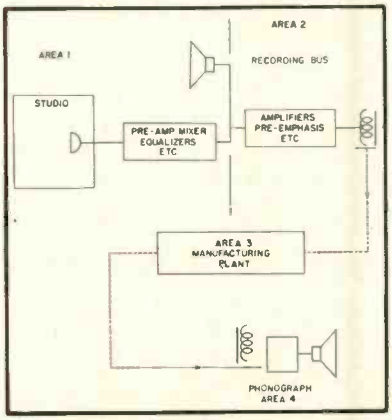

Fig. 1. The actual disc recording characteristic is defined as the characteristic of Area 2 alone. It includes the fixed high- and low-frequency pre-emphasis and crossover curve. All variable components are grouped in Area 1 and are used to obtain desired musical effects.

Hints for playing RCA VICTOR records

Use of the "New Orthophonic" curve is recommended for all RCA Victor records and records released by RCA Victor since August, 1952. With a few exceptions in the early 6000, 7000, and 9000 series, this applies to all LM, WDM, and DM records or albums above 1701, and LCT and WCT above 1112. It also includes all LHMV, WHMV, LBC, WBC, and Extended Play 45's. Records issued prior to that date should be played with the same crossover and high-frequency characteristic, but without the roll-off at low frequencies. A 4- to 5-db increase in response at 50 cps, usually obtainable with a low-frequency tone control, is suggested for these records.

Although the improvements in general quality and frequency range obtained with the new equipment were outstanding, this added flexibility led to a period of confusion for the disc manufacturer, the phonograph manufacturer, and the consumer. The difficulty was that the record companies tried to make discs sound right on what they considered the best phonographs of the day, while the phonograph manufacturers were bringing out new models which, in their opinions, sounded best with all types of records. Whether or not this was a healthy condition is questionable. However, eventually a certain degree of standardization resulted largely because all companies had a common objective, namely, to bring the customer the best possible sound from the available reproducers.

The recent increasing interest of the audio engineer and owners of wide-range phonographs in the subject of disc recording and reproducing characteristics, and the many conflicting opinions now prevalent on the subject make it desirable that the past and present practices of one of the oldest record manufacturers be presented. Traditionally, the exact recording characteristic in use has been a closely guarded secret of each company; just as in the early days of disc recording a particular sound box was often the personal property and secret of success of a recording technician. While these ideas of the past have been changed materially through the efforts of RTMA, AES, and the record companies themselves, there still exists in the mind of the public considerable confusion on the subject.

Definitions

Much of the past confusion in the record and phonograph industry has risen from the lack of satisfactory and generally accepted definitions of expressions commonly used by the recording engineer; and still complicating the problem (both nationally and internationally) is the difficulty in making absolute measurements.

If a recording-reproducing system is divided into sections according to function, four general areas will result as shown in *Fig*. 1. Area 1 includes the studio, microphones, orchestra seating, mixers, variable equalizers, and amplifiers feeding the recording bus and monitor speaker. Area 2 contains tape or disc recorders and their associated amplifiers which produce certain magnetization *vs.* frequency characteristics on tape or velocity *vs.* frequency characteristics on disc with constant voltage input applied to the recording bus. Area 3, the manufacturing operation, may be disregarded in this discussion—its function, of course, is to provide finished records which duplicate the quality and frequency range recorded on the original lacquer master. Area 4 includes the finished record and the reproducer.

The fidelity of a recording is often judged in terms of the naturalness of the reproduced sound and the degree that it recreates the sound heard in the studio or the concert hall. The objective in modern phonograph recording is not always in that direction, however. Special acoustic effects, changes in normal balance among instruments and soloists, and in some cases—especially in "pop"

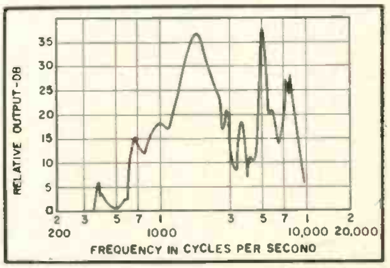

Fig. 2. Relative frequency response of an early Victor acoustic phonograph based on an ideal frequency record with 500 cps crossover.

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recordings—unusual electronic sound effects are often used as devices to create a particular over-all effect desired by the conductor, artist, or musical director. In these cases, all of the variable items included in Area 1 are used as tools to obtain the desired result on the monitor speaker. The criterion, then, for judging recording fidelity is the degree that the reproduced sound matches the sound heard in the monitor speaker at the recording session rather than the sound that was heard in the studio itself.

From the foregoing discussion it can be seen that two definite advantages result from a grouping of recording components as shown in *Fig.* 1. First, all variable effects of studio, mixers, equalizers, etc. may be evaluated at the monitoring point and adjusted at will to obtain the desired sound. Secondly, the disc recorder and reproducer, although physically separated, may be considered as a unit whose sole function is to bring the same sound heard in the monitor speaker into the home of the listener through the medium of the record.

Unfortunately, the situation has not always been that simple and straightforward. In many early recording installations fixed and variable components were, of necessity, often intermixed throughout the system. An example of this in the early Victor electrical recording systems may serve to illustrate the point. Condenser microphones used at that time are known to have a sharply rising response characteristic at high frequencies. The point has never been completely resolved, but presumably due to speaker deficiencies, the high-frequency balance was satisfactory with these microphones. Later when ribbon-type velocity microphones replaced the condenser types, high-frequency pre-emphasis was added to in the preamplifier to preserve the former balance. Finally, when wide-range monitor speakers were installed, the pre-emphasis was removed from the preamplifiers and placed after the recording bus. Thus, at different times we have had the same fixed pre-emphasis in three different parts of the channel: in the microphone itself; after the microphone, but ahead of the monitor speaker; and finally after the monitor speaker. In each case it contributed the same effect to the over-all characteristic on the record. In other words, it was always part of the effective recording characteristic.

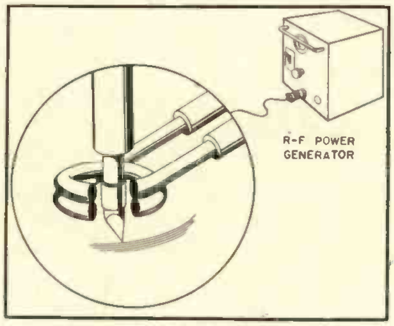

Fig. 5. R.f. induction heating applied to sapphire recording stylus. A small iron band slipped over the sapphire supplies the heat to the cutting tip by conduction.

Recording Curve

In discussing a recording curve it is important to keep in mind the elements which are combined to form any conventional disc recording characteristic. First, we have the electromagnetic cutter response which ideally produces a constant-amplitude cut at low frequencies, changing gradually to a constant-velocity cut (decreasing amplitude) at high frequencies. The primary reason for maintaining constant-amplitude recording at low frequencies is to limit the modulation amplitudes (lateral groove excursions) to some practical value which can be successfully recorded and reproduced. The crossover (the transition point between constant-amplitude and constant-velocity recording) is defined as the intersection of the asymptotes to the two straight-line portions of this curve. Secondly, we have the high-frequency pre-emphasis and in some cases a moderate low-frequency pre-emphasis which are both added electrically in the recording amplifier. High-frequency pre-emphasis in recording is added in order to obtain a reduction of record noise by using a corresponding high-frequency attenuation in the reproducer. This pre-emphasis in recording is possible because the high frequencies in actual music and speech are attenuated with respect to the lower frequencies. Low-frequency pre-emphasis in recording, also possible because of actual attenuation of very low frequencies in music, permits the use of a corresponding low-frequency attenuation in the reproducer, thereby reducing hum and rumble.

When these two or three curves are added together the resulting curve gives what was generally considered to be the recording characteristic. This was true for all practical purposes when recording on wax discs, but is not necessarily true at high frequencies for lacquer discs due to recording losses which will be discussed later. It is largely due to the existence of these recording losses that the term "recording characteristic" is now defined as the actual velocity *vs.* frequency characteristic recorded on a disc with constant voltage input applied to the recording bus. Specifically, it is the over-all characteristic of Area 2 in *Fig.* 1 which involves the response-frequency characteristic of the recording amplifier after the bus, any fixed recording equalizers, the recorder itself, and the cutting properties of the stylus and disc material.

It is important to realize that for any given recording, the type of music, variations in microphone placement, studio acoustics, and recording equalizers will affect the actual velocity-frequency characteristic recorded on the final disc. However, if the consumer desires to reproduce the sound as originally heard from the monitor speaker, the recording characteristic and the reproducing characteristic must remain fixed and complementary.

One might conclude then that, provided they are matched, these characteristics in themselves are unimportant, serving only as a means to an end. This, in fact, would be true, were it not for the mechanical limitations of disc recording and reproducing and the question of record and system noise. These then become the real contributing factors in selecting a specific recording characteristic. Gradually as techniques and equipment have improved, the range of recorded and reproduced frequencies has been increased, making certain changes in the basic recording characteristic desirable for best over-all results.

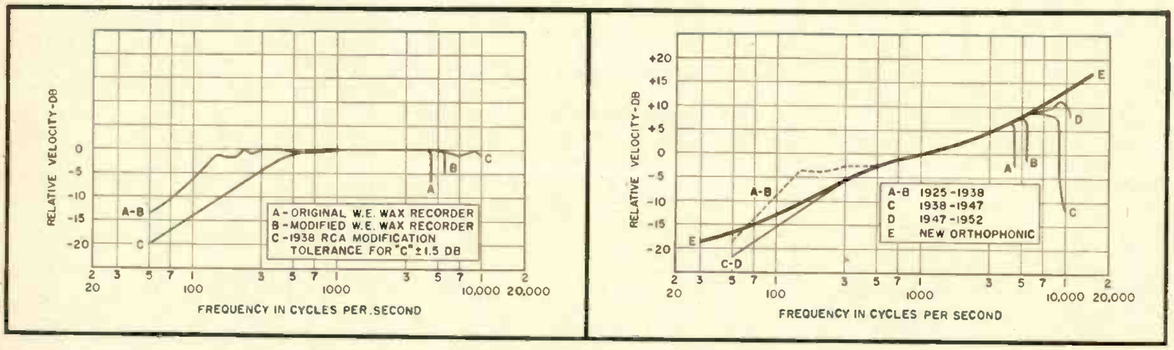

Fig. 3 (left). Relative frequency response of Western Electric "Wax Recorder" in original form and as modified by Western Electric and later by RCA Victor. Fig. 4 (right). Recording characteristics used on Victor records from 1925 to present. Dashed part of Curves A and B represent cutter characteristic. Filters were generally used to remove bass when using these cutters.

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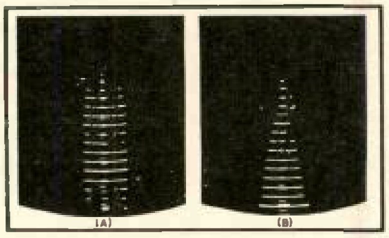


Fig. 6. The recording loss at 10,000 cps across a 12-in. LP record using a burnishing-type stylus is illustrated in (A). Use of a heated wax-type stylus eliminates this loss as shown by the light pattern in (B). The outer and inner bands are 1,000 cps tones recorded for reference purposes.

Early Victor Characteristics

As previously stated, with early mechanical recording techniques, playing the record on a phonograph offered the only satisfactory method of judging record quality, since monitoring at the recording session was impossible. Continuous experimentation with sound boxes, horns, recording and reproducing styli, etc. resulted in gradual improvements in clarity of tone and increased volume. In each case, however, the result of a change in equipment or in studio setup was evaluated in terms of playback results; the objective, of course, being to provide the consumer with the best possible sound.

Specific information concerning the characteristics of the various acoustical recorders used for the early Victor recordings is limited. Recent measurements of the frequency response of an early Victor acoustic phonograph shown in *Fig.* 2 give some idea of the over-all results obtained in those days. Actually the recorded range was somewhat greater than indicated by these reproducer curves. On December 29, 1924 the last Victor acoustic recordings were made, and on May 5, 1925 the first recording session with electrical recording equipment was held.

The electromagnetic recorder used was developed by Bell Telephone Laboratories. It is usually referred to as the "wax recorder" or "rubber-line recorder." It had a cross-over frequency of about 200 cps and a high-frequency cut-off of about 4,500 cps, as shown in *Fig.* 3, Curve A. Subsequent modifications by Bell Telephone Laboratories resulted in an extension of the high-frequency range to about 5,500 cps as shown in Curve B. During the early and middle '30's further development by RCA Victor engineers resulted in an extension of the high-frequency range to 10,000 cps or better and a smoothing out of the low-frequency range as shown in Curve C. The fact that intermodulation distortion at full 78-r.p.m. level is in the order of 2 to 3 per cent gives ample proof of the excellent design and performance of these recorders.

The over-all recording characteristic using the wax recorder and condenser microphone are shown in *Fig.* 4, Curves A and B. The actual effective low end of these curves is subject to some question, however, since it was common practice to use a rather elaborate "bass filter" to reduce the low-frequency response in order to obtain the best sound on average reproducers.

The change from condenser microphones to ribbon-type velocity microphones and new preamplifiers with high-frequency pre-emphasis built in was accomplished during 1932. The resulting over-all curve remained essentially unchanged.

In 1938 the improved RCA version of the wax recorder and completely new and improved recording channels were placed in operation. At that time the adjustable bass filter was discarded, pre-emphasis was removed from the preamplifier and added after the recording bus, and an 8,500-cps low-pass filter was added primarily to reduce noise and distortion effects resulting from playback turntable flutter, pickup tracking, and manufacturing methods. The recording characteristic then became that of Curve C, *Fig.* 4. With the introduction of improved reproducers and manufacturing techniques after the war, the 8,500-cps filter was removed from the channel, resulting in Curve D. Finally, after the installation of feedback recorders with further improved high-frequency response, the "New Orthophonic" characteristic has been adopted. Examination of the curves of *Fig.* 4 will show that—except for the questionable low-frequency portion used in the early days of electrical recording—characteristic changes introduced throughout the years has been essentially extensions of range, the general curve throughout the middle range of frequencies being held constant. Furthermore, it may be assumed that the early electrical recordings (Curves A and B) also had approximately a 500-cps crossover point, since the change to the new equipment in 1938 was accomplished with no loss of bass on the finished records. Recent studio experience in rerecording many of these older records for the Collectors and Treasury series reissues has shown that a 500-cps crossover frequency represents about the best average characteristic for satisfactory reproduction of these records.

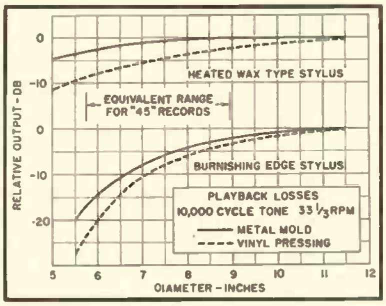
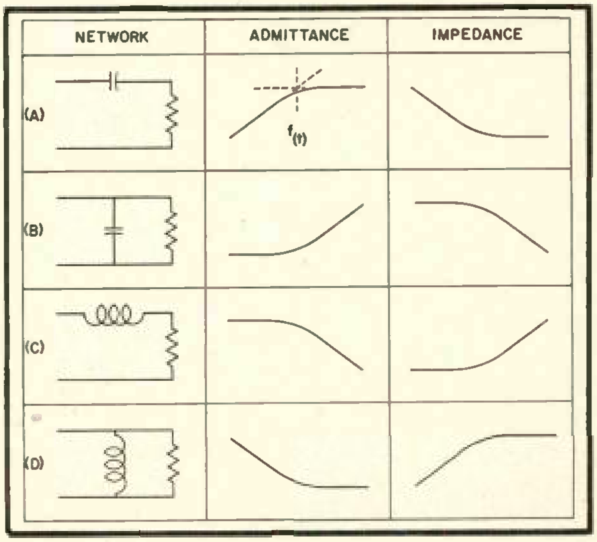


Fig. 7. At the lower recorded velocities, playback from the metal mold and light pattern measurements are in good agreement. At 5.5-cm/sec. level obtained with the heated stylus, playback output falls slightly below the indicated velocity due to curvature limitations toward the inside of the disc. Playback losses due to deformation of the record material exist in either case and are overcome by diameter equalization when recording music or speech.

Hot-Stylus Recording

With the introduction of lacquer recordings for instantaneous playbacks and rerecording purposes, it became apparent that high-frequency recording losses existed which were not present when recording on wax. These losses are due largely to the elastic properties of lacquer recording materials and to the burnishing edges of lacquer recording styli which are required to obtain quiet cuts. Once again modifications were made to the wax recorder which largely overcame these recording losses on lacquer at 78 r.p.m. However, at the lower groove velocities encountered in 33-1/3 r.p.m. recordings it was found that the desired high-frequnecy equalization could be maintained on the disc

Fig. 8. Impedance or admittance either rise or fall at the rate of 6 db per octave. The asymptotes to the two straight-line portions of these curves intersect at a frequency $f_{(t)}$, often referred to as the turnover or crossover frequency. The exact frequency is determined by the time constant of the network.



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only with additional electrical high-frequency pre-emphasis in the recording channel. The amount of additional pre-emphasis varied with styli and, of course, increased considerably with decreasing groove velocity. Since the recording amplifiers were capable of more than adequate power, no harmful distortion effects could be detected from the use of what appeared to be more than normal pre-emphasis at high frequencies. Due to the recording losses, this pre-emphasis did not appear on the disc.

During 1950 recording on lacquer with an electronically heated wax-type stylus was introduced. R.f. induction heating is used as shown in *Fig.* 5 where the work coil, sapphire stylus, and thin surrounding band are illustrated. One of the outstanding advantages of the heated wax-type stylus over the burnishing-type stylus is that high-frequency recording losses when cutting lacquer at low groove velocities are completely eliminated as can be seen from the light pattern photographs in *Fig.* 6. The upper part of this figure shows a heated stylus recording of a 10,000-cps tone recorded in bands across the entire playing surface of a typical twelve inch 33-1/3 r.p.m. LP record. The photograph in the lower part shows a similar recording made with a cold burnishing-type stylus. It can readily be seen that the width of the reflected light bands remains constant in the first case, while in the second photograph the width decreases toward the center of the record, indicating recording losses at the lower groove velocities.

Playback losses, of course, still exist and are compensated for by the addition of sufficient diameter equalization in recording to maintain constant high-frequency response across the playing surface of the record. These playback losses are a function of pickup construction, stylus size, and record material. The output voltages obtained from a modern high-quality pickup when playing the metal mold (sometimes called "mother") and vinyl pressing are shown in *Fig.* 7. The equivalent groove velocities and losses for 45 r.p.m. records are also indicated in this figure. It can readily be seen that the playback loss obtained from the rigid metal record is negligible, whereas the loss due to compound deformation amounts to some 5 or 6 db from the outside to the inside of the record.

Among the other advantages of heated stylus recording are:

1. Elimination of horns at the top edges of the grooves which are characteristic of recordings made with burnishing-edge styli. This improvement makes possible the use of slightly higher recording levels without damage to adjacent grooves and also results in finished pressings somewhat less susceptible to scuffing.
2. Reduced cutting noise, especially at the low groove velocities encountered toward the inside of fine-groove recordings. This reduction in cutting noise, of course, results in reduced surface noise on the final product.

TABLE I

Relative Velocity vs. Frequency "New Orthophonic" Curve

fcps	Vdb	fcps	Vdb
15000	+17.2	3000	+ 4.8
14000	+16.6	2000	+ 2.6
13000	+16.0	1000	± 0.0
12000	+15.3		
11000	+14.5	700	− 1.2
10000	+13.7	400	− 3.8
9000	+12.9	300	− 5.5
8000	+11.9	200	− 8.2
7000	+10.8	100	−13.1
6000	+ 9.6	70	−15.3
5000	+ 8.2	50	−17.0
4000	+ 6.6	30	−18.6

New Orthophonic Characteristic

It has been customary to refer to recording curves in terms of crossover frequency and amount of pre-emphasis at 10,000 cps relative to 1,000 cps. Unfortunately, these two factors alone do not adequately define a recording characteristic. When more information about a curve is required, a graph showing relative velocity *vs.* frequency is usually supplied. The obvious difficulty with a curve alone is that the true crossover frequency and pre-emphasis are usually obscured, making the design of suitable equalizers possible only by the cut and try method. To overcome these difficulties, recording curves now are often defined as conforming to the impedance or admittance of one or more electrical networks.

The impedance or admittance curves of simple two-element networks consisting of a resistor and capacitor or a resistor and inductor are all similar in shape when plotted with frequency on a logarithmic scale and impedance or admittance in decibels on a linear scale. These curves approach a 6-db-per-octave slope at one end and a limiting or fixed value at the other end, as shown in *Fig.* 8. The transition frequency or point of intersection of the two asymptotes to the curve is determined by the time constant of the circuit as follows:

$$f_{(T)} = \frac{1}{2\pi T};\ T = RC \text{ or } LR$$

Where f_T = Transition frequency in cps
T = Time constant in microseconds
R = Resistance in ohms
C = Capacitance in microfarads
L = Inductance in microhenries

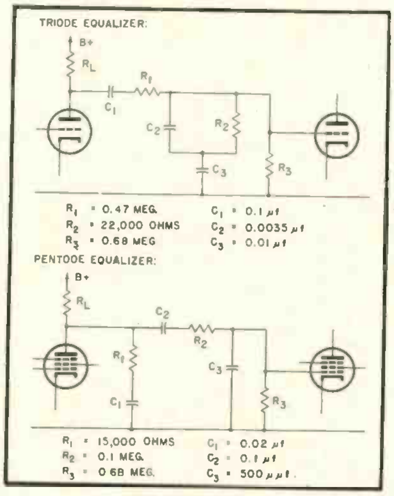

Fig. 9. When using magnetic pickups, simple RC equalizer circuits may be incorporated in a voltage amplifier stage to obtain the "New Orthophonic" characteristic. Additional adjustment of high- and low-frequency tone controls should be made to correct for pickup and tone arm characteristics.

At the frequency f_T the magnitude of the reactance of the capacitor or inductor is equal to the magnitude of the resistor. Also at this frequency the absolute value of the impedance or admittance is either 0.707 or 1.414 times its constant-impedance value, i.e. 3 db above or below the "flat" portion of the curve.

These curves have a general shape that fits the requirements of disc recording and reproducing characteristics. They are also curves that are easily obtained in amplifier designs either separately or in combination. It follows then that impedance or admittance curves provide an ideal method of expressing or defining a recording or reproducing characteristic.

To illustrate their use, three specific examples are cited here. These examples when combined form the "New Orthophonic" recording characteristic.

The expression "75-microsecond pre-emphasis" indicates that high frequencies are pre-emphasized according to a curve which conforms to the admittance of a parallel resistor and capacitor network, (B) of *Fig.* 8, with a time constant of 75 microseconds. The curve is +3 db at 2,120 cps and +13.7 db at 10,000 cps relative to low frequencies.

An ideal cutter characteristic as defined earlier may be represented by a curve which conforms to the admittance of a series RC network, (A) of *Fig.* 8, where the time constant defines the crossover frequency. For a 500-cps crossover point T = 318 microseconds. In a similar manner, low-frequency pre-emphasis may be expressed as a curve conforming to the admittance of a parallel resistor-inductor combination, as in (D) of *Fig.* 8. For 3-db rise at 50 cps, for example, the time constant of the network is 3,180 microseconds.

Any of the above curves may just as well be expressed as conforming to the impedance of suitable two-element networks, although use of the admittance curves is more generally accepted.

By algebraically adding the ordinates of these three curves, an over-all curve will be obtained which accurately defines the "New Orthophonic" recording characteristic. The relative velocity values for the over-all curve arbitrarily referenced to "0" db at 1,000 cycles are shown in Table I.

In making comparisons between the former RCA Victor curve and the "New Orthophonic" characteristic, sev-

(*Continued on page 53*)

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The Lateral Mechanical Impedance of Phonograph Pickups

J. G. WOODWARD* AND J. B. HALTER*

Part 2. Using the equipment and methods described in Part 1, the authors present a series of typical measurements on pickups made during the years from 1901 to 1951.

INSTRUMENTATION and techniques for measuring the lateral mechanical impedance of phonograph pickups were described in the first part of this paper.[7] We shall now present the results of measurements made on a number of pickups. These pickups are representative of certain stages of phonograph development over the period between 1901 and 1951. The data will be presented chronologically and will give a systematic, quantitative description of progress in phonograph pickup design. In order to limit the presentation to a reasonable length we have chosen (with one exception to be noted later) to give data only for pickups representative of those used in quantity for home phonograph systems, and which were sold as part of complete home-phonograph systems or record players. This means that the particular type of pickup tested is not necessarily the best available in the year in which it was first marketed, since transcription pickups and many of the pickups used in custom installations are excluded on this basis. While data will be presented for pickups made by several manufacturers, we cannot designate the pickups by model or manufacturer, the only exceptions being two or three obsolete types.

The data for mechanical impedance will be shown as curves of resistance and reactance *vs.* frequency. In the same figure with the impedance characteristic, the measured response-frequency characteristic will be given. This is the response which the pickup would have when playing a test record having constant amplitude below 500 cps and constant velocity above 500 cps with a smooth transition between the two ranges. As an aid in evaluating the pickup response characteristics, an idealized response curve has been indicated along with each characteristic. The response characteristics were measured with the pickups (except acoustical types) connected to an effectively infinite electrical impedance.

Since the general aspects of the mechanical-impedance characteristics have been discussed previously, the characteristics of the various pickups can be given here with a minimum of comment. In comparing the impedance characteristics of different pickups it is important to note the ordinate scale used in plotting the impedance. The ordinate scale factors differ by 20 to 1 between certain earlier and more recent pickups.

Fig. 6. One of the earliest "talking machines," made in 1901. The characteristics of its reproducer are shown in Fig. 7.

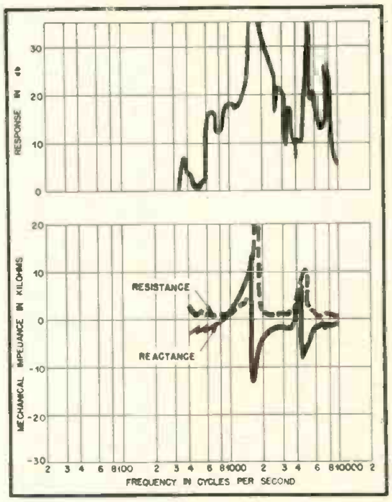

Fig. 7. Frequency response curve (above), and resistance and reactance curves (below) for the reproducer used on the instrument of Fig. 6.

1901

The oldest phonograph tested was manufactured by the Victor Talking Machine Company in 1901. This machine is pictured in *Fig.* 6. The impedance and response characteristics are shown in *Fig.* 7. This machine is a museum piece and was in a damaged condition when received for testing. Because of this condition the impedance data below about 400 cps are not considered to be valid and, therefore, are not shown in *Fig.* 7. There is reason to believe that above 400 cps the impedance and response data shown give a reasonably accurate picture of the performance of the machine when new.

1918

A more recent type of acoustic phonograph is shown in *Fig.* 8. This instrument was manufactured in 1918. Its response and impedance characteristics are given in *Fig.* 9. It is reassuring to find that our measured response curve is in good agreement with that published by Maxfield and Harrison[8] in 1926

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* *RCA Laboratories, Princeton, N. J.*

[7] J. G. Woodward and J. B. Halter, "The lateral mechanical impedance of phonograph pickups. Part I," AUDIO ENGINEERING, June 1953.

[8] J. P. Maxfield and H. C. Harrison, "High-quality recording and reproducing of music and speech," *Bell Sys. Tech. J.*, 5, 493–523; July, 1926.

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Fig. 8. A high-quality acoustic phonograph made in 1918. Its characteristics are shown in Fig. 9.

(compare with the dashed curve of their *Fig.* 20.)

In the neighborhood of the antiresonance at 60 cps the mechanical impedance becomes very large. However, it does not become infinite as the curves suggest. In this instance, as in a number of others, the magnitude and phase angle of the voltages measured with the test equipment changed so rapidly with frequency near antiresonances that it was not feasible to obtain data sufficiently accurate to close the curves. The general form of the impedance characteristic at an antiresonance is always like that depicted between 1000 and 2000 cps in *Fig.* 7.

1929

One of the earliest types of electrical phonograph reproducer is shown in *Fig.* 10. The pickup is an electromagnetic type having a balanced armature. It was first incorporated in home phonographs in 1929. Its response and impedance characteristics are given in *Fig.* 11. A thorough analysis of the electrical and mechanical behavior of this pickup has been made by Kellogg,[9] and the response characteristics of *Fig.* 11 is in close agreement with his data.

1939

The characteristics of an early type of crystal pickup are given in *Fig.* 12. This pickup used a twister-type crystal configuration and employed a replaceable steel needle. It was first marketed in 1939. The measurements were made with the pickup mounted in the pickup arm of a record player with which this type of pickup was originally sold.

1944

A rather similar type of crystal pickup, but the product of another manufacturer and first offered for sale about 1944, was mounted in the pickup arm of an automatic record changer with which the pickup was frequently used. The results of tests of this system are given in *Fig.* 13. This pickup, like the previous one, used a replaceable steel needle.

1945

The response and impedance characteristics of a crystal pickup first marketed in 1945 are shown in *Fig.* 14. This pickup was among the first to use a permanent sapphire stylus and to provide vertical compliance in the stylus arm. During the tests the pickup was mounted in the arm from a record changer with which this type of pickup was originally sold. A description of the construction and performance of this type of pickup has been published by A. D. Burt.[10]

1949

The characteristics of a crystal pickup with a sapphire stylus for microgroove reproduction were given in *Fig.* 3 and will not be repeated here. This pickup was first marketed in 1949. As pointed out, the pickup was tested in two different arms. Pickup arm "A" is the arm of a record player in which the pickup was customarily used. Pickup arm "B" was a special laboratory model.

(*Continued on page 42*)

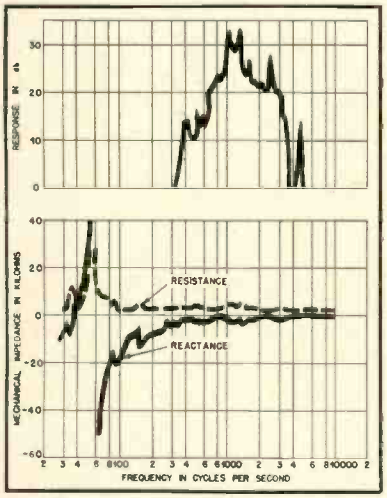

Fig. 9. Frequency response and impedance curves for the instrument of Fig. 8.

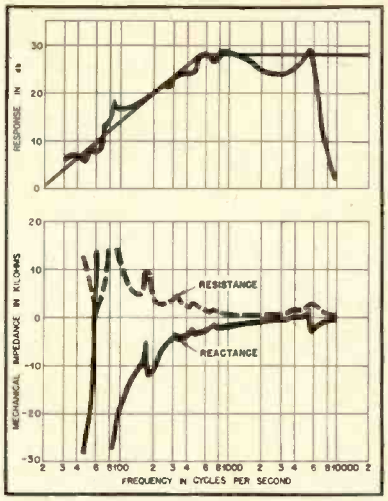

Fig. 11. Characteristics of the pickup used on the electric phonograph shown in Fig. 10.

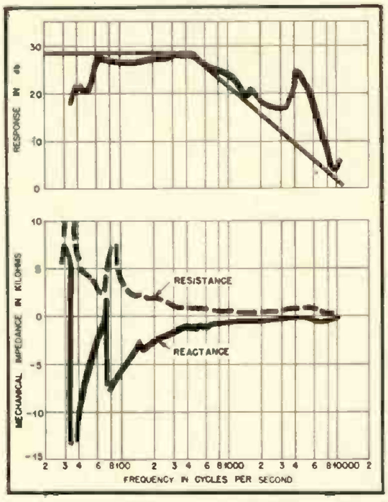

Fig. 12. Characteristics of an early twister-type crystal pickup.

Fig. 10. One of the early electric phonographs—1929.

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[9] E. W. Kellogg, "Electrical reproduction from phonograph records," *Trans. A.I.E.E.*, 46, 903–912; Oct. 1927.

[10] A. D. Burt, "The reduction of record noise by pickup design," Electronics 16, 90–93 Jan. 1943.

Audio for Leisure Hours

Suggestions for a few possible methods for increasing enjoyment of a hi-fi installation by transporting the loudspeaker to the listener.

SUMMERTIME is often considered the time when one's usual interests in the home change to outdoor activities, but there are some hours when one can't swim, play golf, go fishing, or engage in usual summer sports. Occasionally one just wants to relax in a cool patio or garden, enjoying the evening breezes. During such times, it is possible—nay, even probable—that many of Æ's readers would also enjoy listening to their favorite symphony, radio program, or dance band while relaxing. And for those areas where the evenings are suitable for outdoor sitting for a greater part of the year, the advantages of an outdoor loudspeaker may be still more important.

For the occasional time when such entertainment is desired, the obvious method is simply to move the entire speaker enclosure somewhere convenient to the leisure area—connecting extension cords from the regular location to the new one. This can be done easily when the loudspeaker is small, so long as it is a separate unit, but when it gets up to the size often used by the serious listener this can be somewhat of a problem. If the speaker is simply to be rolled out onto a porch, it is suggested that casters be affixed to the bottom—or possibly that a small dolly be constructed upon which the unit may be placed.

For garden parties, for example, the speaker can be transported anywhere in the yard—as shown in the photo. Such a solution is certain to be temporary, since few of us would subject a valuable speaker to the weather, even overnight. Still other solutions involve the use of a built-in arrangement such as that shown in the drawing. This involves a simple weatherproof housing in which a speaker can be mounted and left permanently—or at least during the season when it is to be used most. Similar ideas would occur to anyone who really wanted to have his music where he wanted to be. Of course, one could simply open the windows and turn the volume up higher, but this is not the most desirable solution.

One of the simpler installations involves the mounting of a conventional sloping-front speaker baffle in a protected location close up under the eaves. This will usually be considered adequate if the principal use is for following a ballgame on the radio, or even for most of the whodunits and dramatic presentations. Most critical listeners would not be satisfied with this type of speaker for music reproduction, however, and would probably be just as content with small portable radio sets adjacent to their easy chairs.

In those locations where it is possible to gain access to the attic or to a closet—or even to the garage—the speaker can be installed in the wall, making sure to provide sufficient protection against the weather. It has been suggested by some readers that a speaker could be installed in the ceiling over a covered porch provided there was space available to make the installation. This type of mounting might entail suitable acoustic treatment behind the speaker.

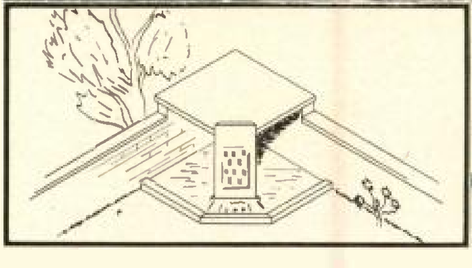
Electrical Preparations

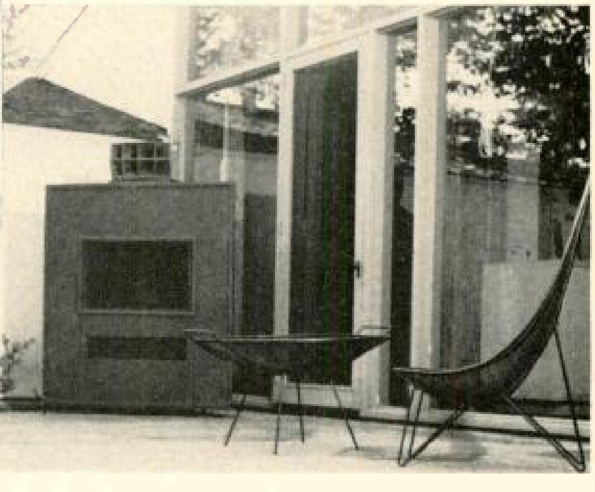
A few simple suggestions relative to the method of making an outdoor installation may be of interest. Considering the current in the voice-coil circuit, it is important that wire of sufficiently large cross section be employed. For short temporary runs, ordinary zip cord is satisfactory, and the use of either 14 or 16 ga. is recommended. When the installation is to be permanent, 14-ga. solid wire is preferred—the type used in house wiring. For a neat installation, conduit can be laid across the yard from under the house near the normal speaker location, terminating in a weatherproof outlet box with a suitable receptacle. If the speaker is to be installed in a housing that can be left out the year around, a similar method should be allowed, though it is not necessary to provide for easy detachment.

At the indoor speaker location, a heavy-duty d.p.d.t. switch should be installed, so that the circuit can be transferred readily to the outdoor speaker when it is to be used. If both speakers are to be used at the same time, it will be necessary to provide for impedance matching.

Like most changes or improvements in a home music system, this type of installation entails some work, but when completed it will provide many hours of pleasurable listening in surroundings which are best suited for "music under the stars."

Left: For temporary use, a standard loudspeaker cabinet can be moved to a suitable location in the garden, although better-grade furniture is not well adapted for continuous outdoor use. Below: If the listening area is close to the house, it may be sufficient simply to move the speaker cabinet out onto a covered porch. Lower left: The drawing originally suggested by George Augspurger, shows a permanent installation in a corner of a garden wall. Photographs furnished by Philip Kelsey.





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Handbook of Sound Reproduction

EDGAR M. VILLCHUR*

Chapter 12—The Power Amplifier. Part I.

An amplifier, as the name implies, is a device to make things bigger —more precisely, to increase the size of energy-patterns. In common with the other components of sound reproducing systems it is an energy transmission device, the general name for which is *transducer*. But while the speakers and mounting devices that have so far been discussed always release energy in an amount that is somewhat short of that contained by the input stimulus (giving them the designation of *passive* transducer), an amplifier performs a sort of engineering sleight-of-hand; its output—seemingly the same in identity to the received stimulus—contains more energy than its input. For this reason amplifiers are called *active* transducers.

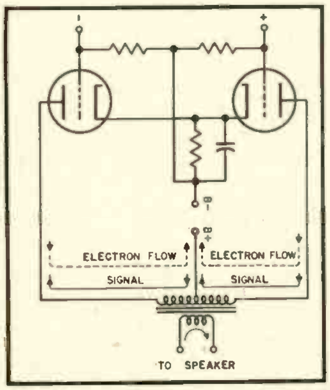

Fig. 12—1. Push-pull output circuit. Currents in the two halves of the transformer are opposite in both phase and direction, effectively putting them in phase across the whole primary.

Passive transducers—mechanical levers, electrical transformers, or acoustical horns—are designed to shape a given amount of power[1] to the form most suitable for the job at hand. They increase the efficiency with which a source of power can be harnessed, but add nothing of their own. When modern technology became concerned with the transmission and reproduction of vibratory energy, there came a point when the most efficient passive transducers that could be designed were inadequate. The human voice mechanism, the vibrating phonograph stylus, or the radio transmitter's spark oscillator did not possess enough driving power for the desired results, even with the improved horns and antennas that reduced energy waste. The solution to the problem was to inject additional outside energy into the systems: to amplify.

The need for amplification arises when vibratory power must be increased without disturbing the time sequence and pattern of its oscillations. As in the case of the passive transducer, the amount of amplifier output energy is always less than the total energy supplied—losses due to friction, viscosity, or electrical resistance are inevitable—but a small input stimulus is able to borrow and direct power from an independent second source, shaping this independent power to its own pattern. The outside source with which we are almost exclusively concerned here, of course, consists of the electric company's generators.

Modern amplifiers may be designed for mechanical, acoustical, or electrical applications, but the input energy is always converted to electrical form before it is amplified. The vacuum-tube has been the heart of almost all amplifying devices until recently, when transitor, magnetic, dielectric and other types of amplifying devices have been developed and used. All of these devices, however, work on the same basic principle; a relatively weak signal voltage or current controls another current, drawn from a source capable of releasing much greater power. This control is exerted at some point or area astride the path of output current flow.

It will be seen from the above that all amplifiers are power amplifiers. The technical term "power" amplifier, however, is reserved for those stages in which the amount of power that is regimented to the input pattern is appreciable—when the output is used, for example, to drive a loudspeaker, recording cutter or radiating antenna. When the amplifying stage is designed for the primary purpose of increasing signal voltage, without the corresponding decrease of current that must be sacrificed with a transformer, it is called a "voltage" amplifier.

All of the stages of a complete audio amplifier are normally voltage amplifiers except for the final or output stage. The input signal is subjected to tone control, voltage amplification, and phase splitting, all for the purpose of being made suitable and of sufficient voltage to drive the relatively insensitive power amplifier.

The Push-Pull Output Stage

The output or power amplifier stage is usually the greatest danger point in the amplifier from the point of view of degradation of quality. One of the measures taken to decrease distortion in this stage is the universal use, in quality units, of the "push-pull" circuit. The most common form of this circuit appears in *Fig.* 12—1.

If the two grids are fed out of phase (that is, if one grid is stimulated by the negative half of the signal cycle at the same time that the other grid receives the positive half) the current flowing in one tube will be increased while the current in the other is decreased. This effect may also be described in terms of signal current, by which is meant the *change* in the flow of electrons, ignoring the magnitude and direction of actual flow. From the point of view of

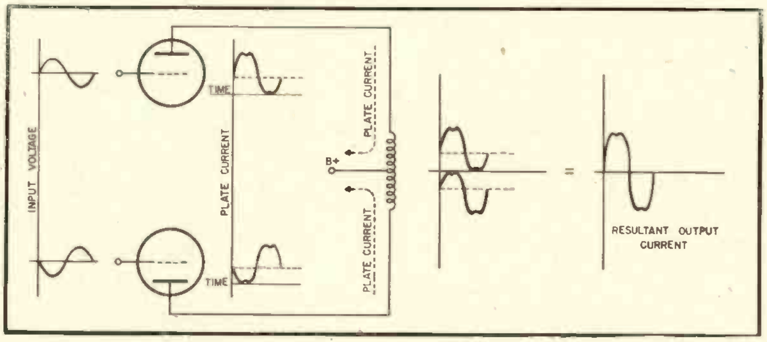

Fig. 12—2. Cancellation of even-harmonic (asymmetrical) distortion generated within a push-pull stage. Since the plate currents are in opposite directions in the transformer primary, a current decrease in the lower half is plotted with the same upward slope as a current increase in the upper half.

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* *Contributing Editor,* Audio Engineering.

[1] The term *power* refers to energy per unit of time.

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the tubes the two signal currents, represented by the solid arrows, are out of phase; from the point of view of the output transformer the signal currents are in phase across the whole of the primary winding. A decrease of electron flow through the lower half of the primary has the same a.c. effect as an increase of electron flow into the upper plate. Currents induced in the secondary are thus additive, and the two signals are recombined in phase into a single output current.

The use of more than one tube in the output circuit increases power capability, but there are special advantages when the tubes are connected in push-pull rather than in parallel. If the two halves of the circuit, including tubes, are balanced so that they are operating identically, the even-harmonic distortion generated in one tube is cancelled by that generated in the other. The signals from the two halves are recombined in such a way that any distortion components introduced into one signal half-cycle must be symmetrical to those introduced into the other half-cycle, a condition in which we have seen (Chapter 9) even-harmonic orders cannot be present.

Figure 12—2 illustrates graphically this cancellation of even harmonic distortion. It will be seen that the even-harmonic or asymmetrical distortion impressed on one particular half of the input signal is the same in form but alternate in time for each tube, creating distortion symmetry in the final output. It will also be seen that the odd-harmonic distortion, symmetrical to begin with, is unaffected. The cancellation, besides reducing distortion under given conditions, makes possible the use of operating conditions for higher power which would create intolerable distortion in a single-ended stage.

In addition to the cancellation of even-harmonic distortion the push-pull circuit cancels hum generated in each half (assuming the two tubes each generate the identical kind of hum). It is also apparent that the d.c. component of the output current flow, represented by the dotted arrows in *Fig.* 12—1, is out of phase as far as the transformer is concerned, and the core-saturating effect of the d.c. current in one half of the primary winding is opposed by that of the other. The d.c. current rating of the transformer primary must cover only half of the total plate current flowing, unlike the case of the transformer used for single-ended or parallel connections.

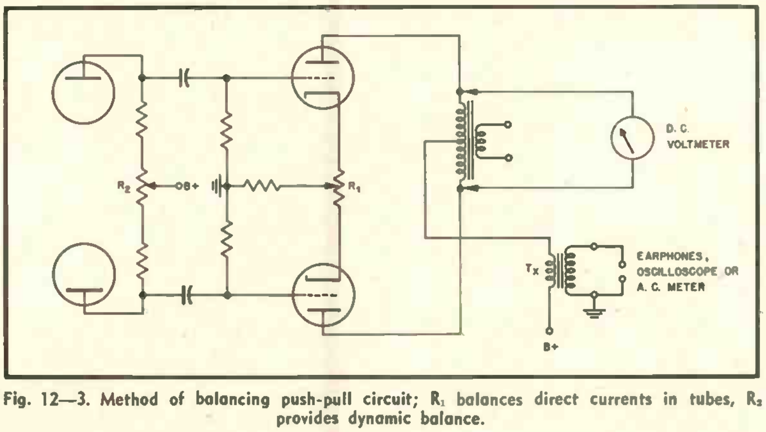

Fig. 12—3. Method of balancing push-pull circuit; R_1 balances direct currents in tubes, R_2 provides dynamic balance.

The push-pull circuit has no effect on distortion or hum generated elsewhere in the amplifier, and has no direct effect on odd-harmonic distortion generated within its own tubes. Operating conditions may be chosen, however, which place the major part of the generated distortion in the even-harmonic orders. Tube manuals normally list two sets of operating conditions for an output tube, one for minimum total distortion in single-ended use, and the other for minimum odd-harmonic distortion (often with higher total distortion in the single tube) in push-pull use.

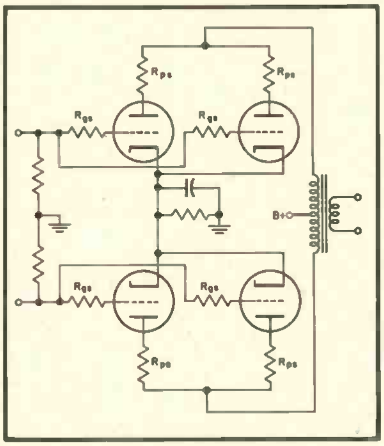

Fig. 12—4. Push-pull-parallel circuit, including grid and plate stopping resistors R_{GS} and R_{PS} respectively.

Balancing the Push-Pull Stage

Actual realization of the advantages listed above is dependent on the degree of balance that can be achieved in practice between the two halves of the push-pull circuit. Such balance may be secured by adjustment of circuit values under operating conditions.

There are two types of adjustment that can be made; balance of d.c. in the two halves of the transformer primary under quiescent conditions, and balance of the output signals of each tube. *Figure* 12—3 illustrates methods of making these adjustments.[2] The relative bias voltage on each tube is adjusted first, by the slider of R_1. This is for d.c. balance with no signal on the tube grids. When the currents through the top and bottom of the transformer primary are equal, the d.c. voltage drop across the whole of the primary will be zero. The adjustment is made under the assumption that the d.c. resistances of the wire in each half of the primary are substantially equal, an assumption which can, in any case, be easily checked with an ohmmeter.

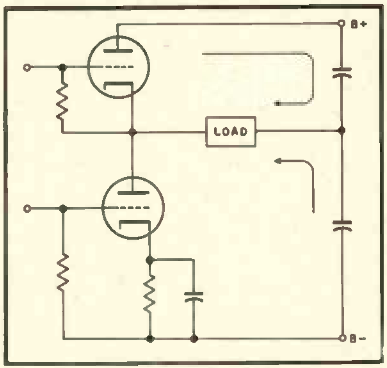

Fig. 12—5. Basic circuit of "single-ended" push-pull output stage. The arrows indicate the relative phase of the signal in each half of the circuit.

Dynamic balance is achieved next. This procedure involves control of the amplitude of one or both of the input signals; in *Fig.* 12—3, R_2 varies the relative input to each grid. The adjustment is made for equal signal strength in each half of the output circuit rather than for equal stimuli at each grid, so that inequalities in output tube amplification are compensated for. The index of optimum operation is minimum signal in the secondary of T_x (an ordinary cheap output transformer reversed), since the signal currents combine out of phase when they enter the common B+ line.

Occasionally there will be a very bad match between the two tubes themselves. In such a case the substitution of a tube with characteristics closer to those of its mate will facilitate the task of balancing.

Load Impedance for a Push-Pull Stage

The value of the load impedance presented to the output stage determines the amount of power that will be absorbed by the load. The load which will accept maximum power from a generator has an impedance which is equal in value to the source impedance of the generator (in this case the plate resistance of the tubes), but such a value of load impedance for an output tube is not necessarily the proper one from the point of view of minimum distortion. Tube manuals list optimum load impedances

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[2] D. T. N. Williamson, "High-quality amplifier: new version." *Wireless World,* v. 55 p. 282 August, 1949.

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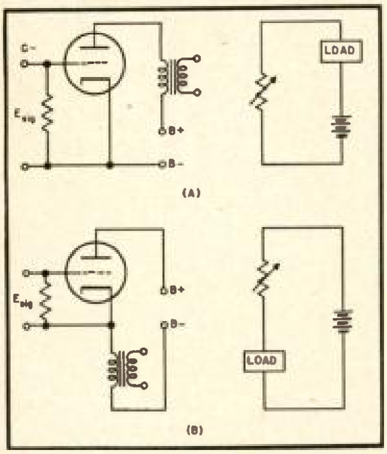

Fig. 12—6. (A) Plate-loaded stage, and analogous circuit. (B) Cathode-loaded circuit (not a cathode follower) and analogous circuit showing basic identity to (A).

for given output tubes used under varying operating conditions. Since the low-impedance loudspeaker that constitutes the load of the power amplifier stage is not suitable for direct insertion in the plate circuit, an output transformer is used. This steps up the effective impedance presented by the speaker to the output tubes, or, looking at the transformer from the opposite direction, it steps down the effective value of the generator source impedance to which the load is matched. The transformer also keeps d.c. out of the speaker voice coil.

Output transformers are rated for given primary and secondary impedances. Transformer specifications, for example, may list a "plate-to-plate" primary impedance of 5000 ohms and a secondary impedance of 8 ohms. This does *not* imply that the impedance of the primary winding is 5000 ohms or that the impedance of the secondary is 8 ohms. It does mean that if an 8-ohm load is connected across the secondary winding, the plates connected to the primary will "see" a 5000-ohm load, which we say is reflected into the primary.

The two halves of the load presented to a push-pull circuit of the type shown in *Fig.* 12—1 are in series, each half to one tube. The total load must therefore have an impedance with twice the value of the correct single-tube load under the same operating conditions. A parallel connection of two output tubes, on the other hand, requires a load impedance with half the value of the single-tube load.

The selection of a load impedance for a given output stage is based on the above principles. For example, a single 25L6 calls for a load impedance of 2000 ohms for optimum single-ended operation. Two 25L6's in push-pull, operating under the same conditions, will thus require a 4000-ohm load. However, if the load impedance per tube is reduced to 1500 ohms the major part of the distortion generated is shifted from odd to even orders, at the price of a slight rise in total single-ended distortion. These conditions are more favorable for push-pull operation, and the optimum push-pull load for 25L6's becomes 3000 ohms.

Push-Pull-Parallel Circuits

The power capability of a given push-pull stage may be doubled by connecting additional tubes in parallel with the original output tubes, as in *Fig.* 12—4. This connection halves the required value of the load impedance and of the cathode bias resistor, if the latter is used. The output voltage remains the same, as in the case of batteries connected in parallel, but since the load impedance is halved the output power is doubled. It will be seen later that when the output requirement is increased signal voltage, additional stages are connected in cascade rather than in parallel, like the series connections of batteries designed for higher voltage.

Push-pull-parallel circuits are especially susceptible to a type of instability called parasitic oscillation. These oscillations may occur at high audible frequencies or in the supersonic range, and may be either steady or erratic. When they break out during signal peaks only, they often create an effect very similar to speaker rattle. Measures taken to prevent parasitic oscillation include:

1. The use of "stopping" resistors in the grid and plate circuits, as shown in *Fig.* 12—4, wired close to the socket pins. Typical values are 500 ohms for the grid resistors, and 50 ohms for the plate resistors.
2. Careful layout of the circuit to prevent coupling between the output circuit of one half of the push-pull stage and the input circuit of the other half.
3. Shielding of input and/or output signal leads.

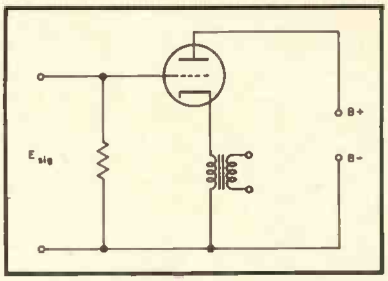

Fig. 12—7. Cathode follower circuit. Unlike the circuit of (B) in Fig. 12—6, the load in the cathode is common to both grid-cathode and plate-cathode circuits.

The "Single-ended" Push-Pull Stage

A new circuit configuration for the push-pull output stage has been developed recently,[3] which presents certain advantages from the point of view of operation at power levels in excess of those ordinarily drawn from the tubes, and from the point of view of direct (transformerless) coupling to the loud-

(*Continued on page 50*)

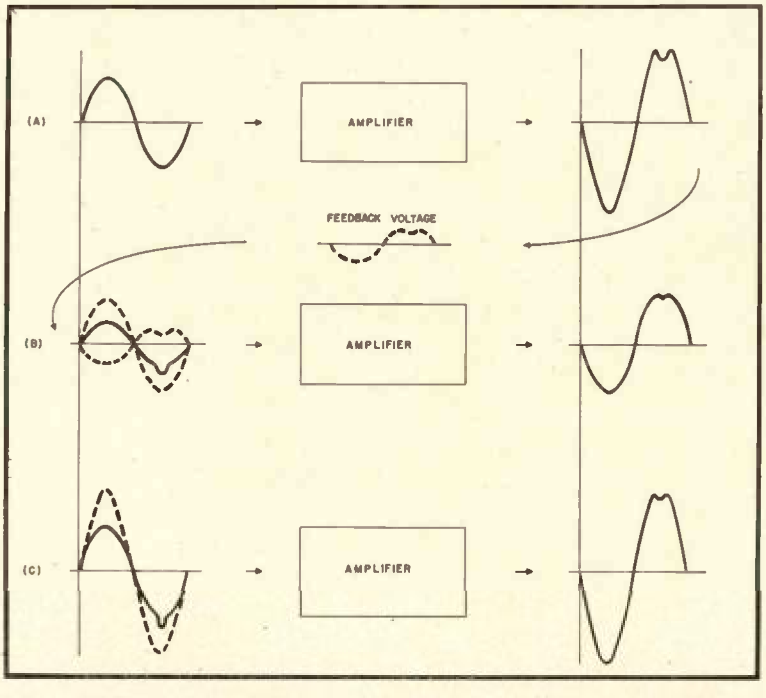

Fig. 12—8. Reduction of distortion by negative feedback. A fraction of the distorted output of (A) is re-introduced out-of-phase at the input. This produces a new input signal, shown at (B) in solid line, which is partially pre-compensated for the distorting influences that it will encounter in the amplifier.

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[3] Arnold Peterson and Donald B. Sinclair, "A single-ended push-pull audio amplifier," *Proc. I. R. E.*, v. 40, No. 1, p. 7, January 1952.

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Correction of
Frequency Response Variations Caused by Magnetic Head Wear

KURT SINGER* and MICHAEL RETTINGER*

Increased gap reluctance due to wear causes a lowering of head inductance and a consequent variation in performance which can be restored to normal by an adjustment of bias current.

IT HAS BEEN NOTICED in the past that wear on a magnetic recording head results in a decrease of high-frequency response of the over-all magnetic recording/reproducing system and also in a change of head sensitivity. The information and data contained in this article explain the reasons for the change in frequency characteristic and offer a simple expedient for correcting the losses and thereby extending the useful life of magnetic heads.

While the benefits of a high-frequency bias current employed in magnetic recordings have been described in numerous publications, it is not frequently noted that the use of too much bias entails the loss of recorded high frequencies. This is due to an erase action produced by the bias flux at the front gap of the recording head. As the recording medium moves past the gap, it is subjected to a rapidly alternating magnetic field, which tends to restore the medium to its neutral or virginal state, wherein the magnetic dipoles are oriented heterogeneously. This effect is more pronounced for the high frequencies than for the lows and appears to be associated with the recorded wave length.

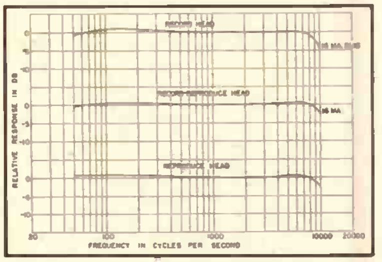

Fig. 1. Frequency characteristic at initial bias current with a head inductance of 4.9 mh; 45 ft. per minute

Wear on a magnetic recording head reduces the front-gap pole-face depth and thereby produces an increase of the gap reluctance. This in turn produces a higher effective bias flux which has, as noted above, an erase action and thus tends to attenuate the high frequencies as they are being recorded on the recording medium. It should be noted that this higher front-gap reluctance is due only to the decrease in front-gap pole-face depth and not to any widening of the gap, which with our type of magnetic head construction remains constant.

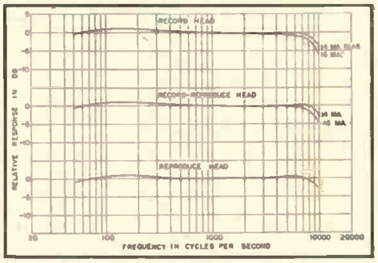

Fig. 2. Frequency characteristic vs. initial and optimum bias current for a head inductance of 4.5 mh at 45 ft./min.

It is the purpose of the following to present these performance variations as a function of the lowered inductance associated with head wear and to show how, simply through a correction of bias current, proper performance can be restored.

To permit a ready evaluation of the test results, it is desirable to describe the method of testing. First, a frequency recording was made with an MI-10795-1 Head hereinafter called the test head. The film speed was 45 ft. per minute (9 in. per sec.) and the initial bias current 16 ma at 68 kc. The recording was then reproduced on a similar head and the properly equalized output from it was taken as an indication of the performance of the test head as a record head. Next, the recording was reproduced on the test head and the output from it was taken as an indication of the performance of the test head as a combination record-reproduce head.

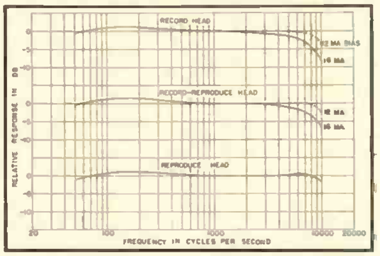

Fig. 3. Frequency characteristic vs. initial and optimum bias current for a head inductance of 4.2 mh at 45 ft./min.

A frequency film which had been made previously was then reproduced on the test head and the output from it was considered an indication of the performance of the test head as a reproduce head. The three frequency characteristics thus obtained are shown on the curves of *Fig.* 1. The top, center, and bottom curves show the initial test head performance as a record, record-reproduce, and reproduce head respectively.

The test head was then removed from the recorder, lapped until its inductance was lowered by 0.4 mh, that is, reduced from an initial 4.9 mh to 4.5 mh. The entire test was then repeated, thereby obtaining a new set of performance data on the test head as a record, record-reproduce, and reproduce head. It was noticed that the change in frequency response (loss of highs) resulting from the lowered inductance was greater when the head was used as a record head than when it was used as a reproduce head. To restore the frequency response of the record head to normal, the bias current had to be reduced to 14 ma. The frequency characteristics obtained from the test head with its inductance reduced to 4.5 mh are shown on the curves of *Fig.* 2. The upper and center curves show head performance as a record and record-reproduce head with the initial bias of 16 ma and the reduced bias of 14 ma (dashed line). The test head was then removed again from its mount, lapped so that its inductance was lowered again by a certain amount—in this case from 4.5 to 4.2 mh—and the tests were repeated. The frequency characteristics obtained from this series of tests are shown on the curves of *Fig.* 3. Again it should be noted that the reduction of bias current to 12 ma for

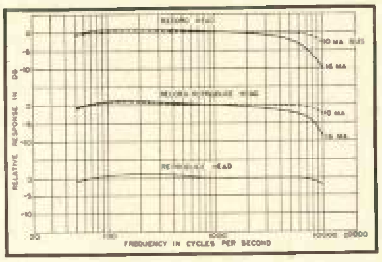

Fig. 4. Frequency characteristic vs. initial and optimum bias current for a head inductance of 3.85 mh at 45 ft./min.

(*Continued on page 46*)

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* *RCA Victor Division, Radio Corporation of America, Hollywood, California.*

Presented on May 1, 1953 at the SMPTE Convention in Los Angeles, California. This article will also appear in the SMPTE Journal.

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Equipment Report

CONCERTONE MODEL 1501-S TAPE RECORDER

DESIGNED to be readily installed in the system of a serious audio experimenter or music lover who wants good recording quality, the Concertone 1501-S is one of the simplest machines available. While this instrument can be obtained in several forms for various applications, the basic chassis is ideally suited for a high-quality home music system.

There are many instances where the user wants to be able to record a full hour at 7½ in. per sec. or even to record for a half hour at 15 ips, and this requires the ability to handle 10-in. reels. While most recorders in the medium-price class are satisfactory from the standpoint of frequency response, few are able to accommodate the standard NAB tape reels.

From the illustration of *Fig.* 1 it will be seen that this unit is built on a cast aluminum chassis which mounts all of the necessary switches for its operation. It is 14 by 22 in. and requires a 5 in. space below the panel and a clearance of only 3 in. above. It may be had simply as a chassis, as shown, which may be installed in an existing cabinet or built into a suitable piece of furniture, or with a console tray which protects the mechanism and amplifier while offering mounting facilities. For those who wish a portable model, a carrying case is available, either with or without a monitoring amplifier and speaker; a metal console cabinet is also obtainable which provides space for amplifiers or for convenient tape storage.

The chassis employs three motors—a two-speed model to drive the capstan, and torque-type motors to drive each of the reels. By a simple switching arrangement, the two reel motors are connected in series across the a.c. line during recording, with a resistor across the supply motor (see *Fig.* 2). This provides suitable torque for take-up and somewhat less to hold back the supply reel, thus eliminating the need for friction clutches of any kind. The brakes are employed only for stopping. A pressure roller holds the tape against the capstan during recording, the tape being free-running during rewind or fast forward. One three-position switch controls the a.c. and selects the desired tape speed—7½ or 15 ips. The lever-type knob on the housing at the front of the panel actuates the pressure roller, and when in the record position, the rewind control knob is mechanically interlocked to prevent operation. Similarly, during rewind or fast-forward, the capstan lever cannot be operated.

Measured rewind or fast-forward time was 64 seconds in either direction for a 2500-ft. reel, and brake operation is so arranged that no tape spill occurred at any time when the machine was stopped, even though the tape was being wound at high speed; loading is simple, the tape being simply dropped into a slot on the housing. Heads are readily interchangeable, so the user could shift from single-track to dual-track recording with a minimum of trouble.

Electronic Circuits

The Concertone is a three-head machine—thus recording and playing back simultaneously so as to provide a check of the material being recorded. This requires two separate amplifiers, as shown in *Fig.* 2, both being on a chassis mounted under the main panel. Record and playback levels are independently adjustable, and the recording amplifier has sufficient gain to provide full recording level with an input signal of .004 v. The output signal is approximately 1.0 v. Measured IM distortion through both amplifiers and the recorded tape was 4.2 per cent at the normal recording level.

The amplifiers are so arranged that the recorder may be connected permanently between a tuner and the control amplifier of a home system. When the selector switch is in the STANDBY position, the circuit between tuner and control amplifier is normalled through; in the RECORD position, the incoming signal is recorded on the tape, and played back through the output circuit—giving a continuous check on recorded quality. The selector switch is prevented from being turned to the RECORD position unless a safety button is depressed, a feature which reduces the possibility of inadvertently erasing a recorded tape.

Because of its excellent listening quality, its ease of operation, and the practical method of connecting into a music system, this recorder is considered a desirable adjunct to any high-quality installation.

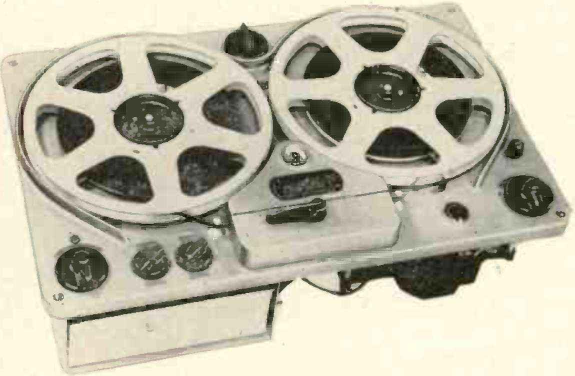

Fig. 1. The Concertone 1501-S Tape Recorder, unmounted.

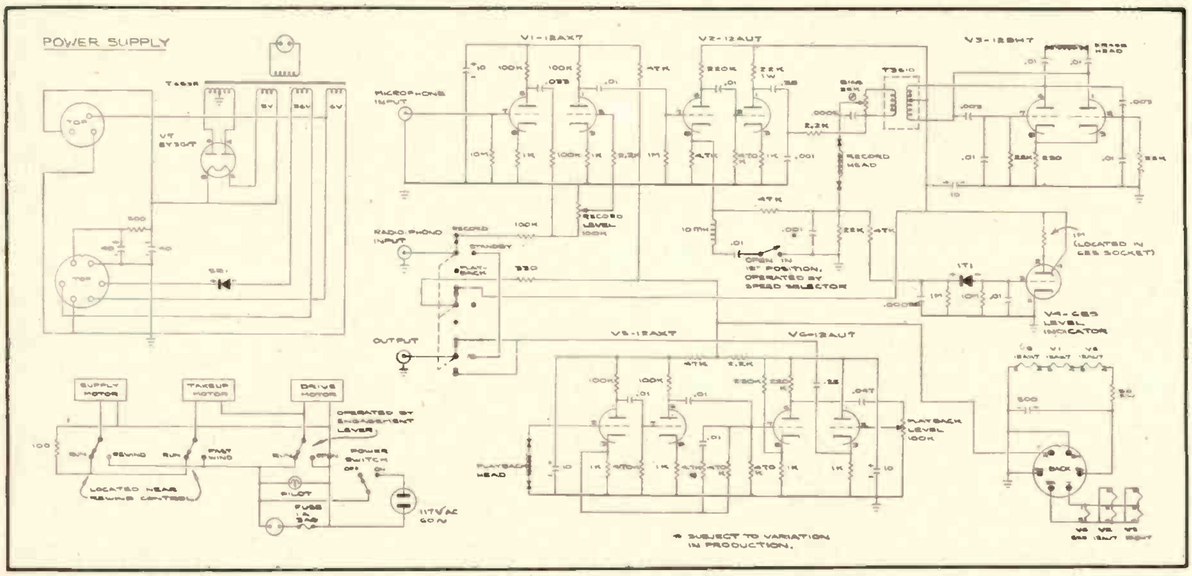

Fig. 2. Schematic of Concertone tape recorder. The power supply is shown at the upper left, the a.c. wiring at the lower left, and the amplifiers at the right. Note that d.c. is employed on the low-level amplifier stage heaters.

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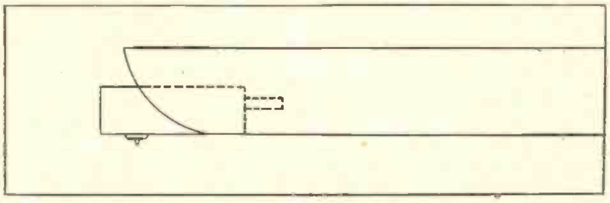
AN OPEN LETTER TO THE AUDIO INDUSTRY

The advent of the LP record and jewel stylus, along with their acknowledged blessings, has greatly accentuated a problem which is now very serious for home-music lovers -- i.e., needless deterioration of fine records through causes of which the average layman is naturally uninformed.

In the "Crystal Age," remember...when HOW MUCH was almost all that mattered...the pickup was cased inside the arm itself, eliminating the expense of a presentable housing. This was an economic need in the mid-30's...but NOT SO TODAY!

Today's LP stylus is sharp as a sewing needle -- a very angel of good or evil. Stylus ALIGNMENT is tremendously important -- yet in more than 40% of cases recently observed, the stylus was found to be misaligned, riding the delicate groove walls at an angle, to the right or to the left -- ruining the performance of these records -- and the users are unaware of the situation, because the stylus is concealed from view.

The Audio Industry, of course, wants to do the right thing by its trusting public. There are arms on the market with the usual crystal-type mounting holes and covered sides -- but with an open front. Such an arm should be sufficient to aid the owner in keeping the stylus aligned. This letter, however, calls specific attention to arms still on the market that are enclosed on all sides, completely concealing the stylus from view. It is this type which the writer feels should be corrected.



There are several simple solutions which engineers will readily recognize. The above sketch is one of these solutions.

Maximilian Weil
President

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Equipment Report (Cont'd)

SARGENT-RAYMENT SR68 AM-FM TUNER

INCORPORATING quality of sound reproduction with excellent workmanship and a new type of AM detector, the Sargent-Rayment SR68 AM-FM tuner offers an interesting study in design, in addition to being an excellent tuner.

Not since the early days of "high fidelity"—when the term was created to apply to sets which could reproduce up to 7500 cps—has there been available a manufactured radio receiver which provided AM quality which approached FM. Undoubtedly it was FM itself that caused this, because for those listeners in metropolitan centers the FM receiver gave better quality than most super-heterodynes, and for those in outlying areas, the interstation squeal was usually sufficient to preclude the use of wide-range AM receivers. Furthermore, unless the designer resorted to relatively expensive circuitry, detector distortion was high. However, in the SR68 most of these objections have been overcome in the AM section and in addition a high-quality FM receiver has been added. While the Sargent-Rayment line includes the SR58 AM tuner and the more modest SR51-B AM-FM tuner and with tone controls, the SR68 is the one tested and the leader in the group. There are also a preamplifier-tone control unit, two power amplifiers, and a simple one-tube preamp.

The principal limitation to good quality in AM receivers is usually one of atmospherics—for everyone knows that with a wide-range t.r.f. tuner the quality of reproduction approximates that of a good FM tuner. However, as the bandwidth increases the susceptibility to atmospheric noise also increases, and monkey chatter and interstation whistle (10,000 cps) become objectionable, especially if the tuner is used at any appreciable distance from the transmitter.

With the SR68, most of this trouble has been eliminated because two bandwidths are available—10 and 18 kc. In the SHARP position, therefore, the audio signal extends only to about 4000 cps, while in the BROAD position, the response is essentially flat to 9000 cps. This increase in bandwidth is obtained by detuning four circuits in the two-stage i.f. amplifier.

Fig. 1. Sargent-Rayment Model SR68 AM-FM tuner.

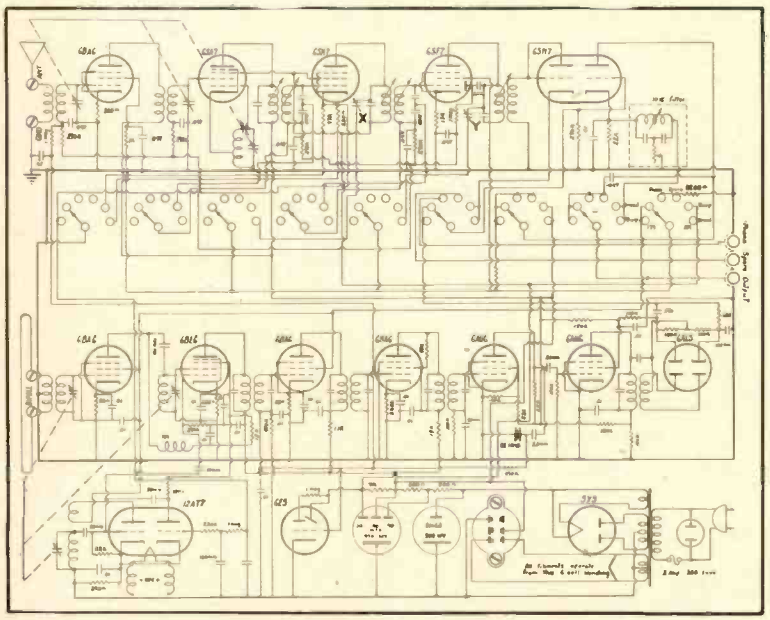

Fig. 2. Complete schematic of SR68 AM-FM tuner. The AM section is at the top, with the FM section below. The power supply is shown at the lower right.

With an increased bandwidth, the effect of detector distortion becomes more objectionable unless steps are taken to lower this distortion at the source. The two-tube circuit employed in this tuner shows a distortion of less than 0.5 per cent at 100 per cent modulation. Essentially the circuit consists of a diode which is direct coupled to a cathode follower. This arrangement presents a minimum loading across the diode resistor, which results in the very low distortion shown. The output of the cathode follower is then fed through a 10-kc filter which consists of an inductance, two capacitors, and a balancing resistance which is adjustable for maximum suppression at the resonant frequency. The listening quality of the AM receiver in the BROAD position compares favorably with the FM section on the same program material.

The FM section of the tuner—an entirely independent circuit—except for the tuning capacitor, tuning indicator, and power supply is equally well built. The selector switch indicates BROAD and SHARP for the FM circuit, inspection indicating that in the BROAD position the a.f.c. circuit is operative. The i.f. amplifier employs the Armstrong circuit, using two limiters and a discriminator. Additional a.v.c. voltage is obtained from a crystal diode rectifier deriving its signal from the junction between the two limiters.

The SR68 is self contained, and provides power for the preamplifier-tone control unit, or for the simpler preamp previously mentioned. The power circuit switching is convenient when the entire S-R line is employed. The incoming a.c. line feeds into the preamplifier-tone control unit in which is located the ON-OFF switch. A socket on this chassis feeds the tuner, and a socket on the tuner chassis feeds the main amplifier which also has a socket to feed a record changer. Thus one switch operates the entire system without any effort being required to connect it up.

The selector switch on the tuner includes a PHONO position and a SPARE position, which may be used for other inputs. In normal use the output of the preamplifier is fed to the PHONO input on the tuner; the output of the tuner chassis is fed back to the preamp-tone control chassis to provide for bass, treble, and volume controls, and the output from this chassis is then fed to the power amplifier. This again provides for a simple interconnecting process.

The SR68 chassis is 15 in. wide, 12 in. deep, and 6¼ in. high, and is provided with a brushed brass panel. Only two knobs are used—the selector switch and the tuning control, the latter having a heavy flywheel to give the "velvet" touch in tuning. The entire chassis is finished in a dark brown enamel, and is provided with mounting brackets for attaching to a panel or to a shelf, or to both. A power supply socket provides 6 volts a.c. and 200 volts of well filtered d.c. for a preamplifier.

FM sensitivity is somewhat better than 5 microvolts for 30 db of quieting and equivalent full output from the discriminator.

Although relatively high priced, this tuner will be considered particularly desirable for the listener who may be limited to AM reception but who wants better quality of reproduction than is usually available with more conventional AM tuners.


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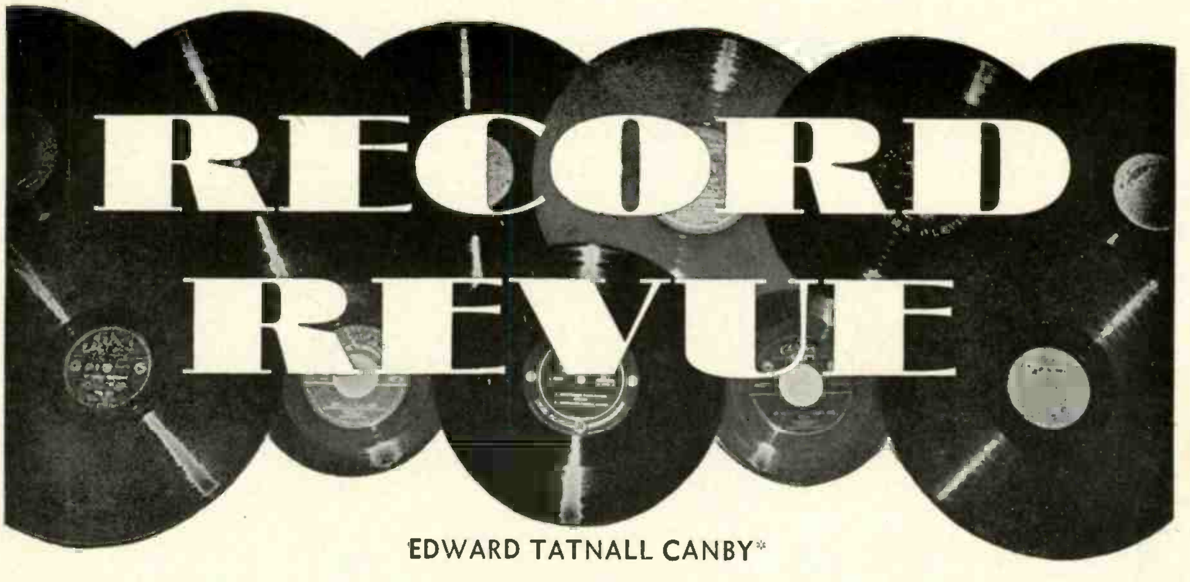
RECORD REVUE



EDWARD TATNALL CANBY*

Keeping the Score II. Rhythm

HEREWITH a continuation of last month's remarks on musical notation and score-following for the audio fan and the lover of recorded music. Let me remind you that in this discussion I'm taking the somewhat novel viewpoint that there are now two co-equal methods of preserving the musical art, complementary to each other and equally important for all of us—first, the written note and second, the recorded sound.

Written music has the awesome sanction of a thousand-odd years of history. For that time and longer it has been the officially acceptable means for passing along the evanescent musical art from one generation to the next; its prestige among musicians, historians, librarians, musicologists, is enormous. Electrical recording, as a new-fangled kind of music preserver, is still in a horse and buggy stage of acceptance among those who are the powers in the musical world. Librarians and musicologists have a huge amount of work to do in the near future merely to set up a system that can even remotely compare to the vast organization of the printed musical note, through world libraries, publishers, collectors, music dealers and in the hands of actual performers. We have hardly made a beginning here—but before we can do much better a lot of musicians, librarians and the rest must come to accept the recorded form of music as something more than an ingenious plaything or a low-caste interloper! That is why I insist that, as of right now, the two forms of preservation are of equal importance and of equal dignity.

On the other hand, the new generations of musical people who have acquired their knowledge and their love of music entirely through records and radio—and this is the great musical force today—must reciprocate, from the other side of the fence. They will do well to discover for themselves (as the ads say) the usefulness of printed music as an adjunct to listening, the timeless values inherent in the score that, by their very nature as rather specialized generalities, can never be found in any recorded performance.

Unpindownable

We must keep always in mind the paradox that written notation is the ultimate source for correct information on a work of music mainly because it is *imprecise* in many respects, because it defines not the exact, mechanical form of a piece of music but, rather, the inexact and flexible area of variation within which every good performance of the music will lie. Remember that music is a uniquely transitory art, sounded forth in the medium of time. A work of music is an abstract conception, a highly flexible entity, defined by no one actual performance but relating to all performances.

Musical composition is, I suppose, most nearly paralleled by ballet choreography. Neither of these arts can be pinned down, on paper or any other way, to an exact formula reproduceable at will. Both depend very largely for their practical existence on the performers who do the re-creating from the abstract pattern. The fact that ballet is only beginning to find practical notation merely dramatizes what is essentially the same situation in music.

As I suggested last month, even such recent and well known music as that of Beethoven is perhaps 85 per cent literal in the paper form, and that includes a vast amount of oral tradition that helps us to know how Beethoven's music should sound. For earlier music the percentage of mechanical accuracy goes down fast—I hazarded a rough 20 per cent or so for the great music of the Renaissance and I'd put the accuracy of the surviving music of Ancient Greece (only a few fragments) as perhaps 5 per cent if that. Not even a piece of music written yesterday and played today under the composer's direction is 100 per cent encompassed in the printed or written notation.

Isn't this self-evident? Who ever said notation was exact? No musician of a practical turn of mind ever had such a silly idea, but I feel that the point must be pushed hard, to answer that persistent urge among audio men and engineers that I run into again and again, to reduce music in all its aspects to a scientific formulation. Analyze a piece of music, or a hundred pieces, take the essence of same and work out a formula of scientific precision for the manufacturing of music by rule! With persistence, these optimistic souls think, we should be able to by-pass the composer and make music by push-button. Similarly, we should be accurate enough in our notation system so that a composer should be able to write his music once and for all, in terms of such extreme exactness that duplicate performances would be available as like as so many musical peas.

A fine conception and it is merely the natural result of our scientific training of the mind. But it won't work in music because music isn't that sort of stuff. No work of musical art can ever be pinned down to such exact terms, nor ever will be. It's in the nature of music to be to some extent abstract, universal. The entity which we speak of when we refer to a "piece of music" or a "work" has an existence independent of any performance; it is itself a sort of prototype for all the performances, yet not any one of them; it is both an abstract ideal towards which every performance aims and at the same time a practical guide which determines the very sound of those performances—none of which are "it" but merely individual interpretations of this strange super-music, the unattainable "original." When we speak of "Beethoven's Fifth Symphony," then, we speak in the last analysis of the abstraction that exists within the written limitations of the printed score—*not* of the sound of this or that performance. The performance is not *the* symphony but an interpretation of *the* symphony, which remains inviolably abstract. How's that for an engineering concept?

So let's get this straight for good: a recording may preserve a single performance with very great faithfulness, in far greater and more specific detail than any conceivable score could do—indeed, except for the problem of monaural reproduction, it *is* that performance. But the preserved performance is never the work itself, which is necessarily an abstraction,

---

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

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now YOU can tell when to change stylus

Pointer No. 39 in Weil's "ELECTRONIC PHONO FACTS"* reads: "No jewel-point is permanent, be it diamond or sapphire. Therefore, periodic checking is necessary if good reproduction and the record disks themselves are to be preserved. . . ." The variation in durability of jewel-points (any jewel point) gives extreme importance to the ever present question:

WHEN TO CHANGE STYLUS !

A microscope will show a flat on any diamond (much sooner on sapphire) after 40 or so hours of play, yet the jewel is in good playing condition. Hence, in diagnosing wear, it is the presence of actual cutting edges that is important. This makes a microscope ($15.00 to over $100.00)—almost useless to an untrained observer. He can see, but he can't judge. (See April issue of HIGH FIDELITY) The Audak Company has developed the STYLUS-DISK which makes home-analysis of *any* jewel-point very simple. This AUDAX-DISK is made of a special soft material. One side is made for LP, whereas the other side is for standard grooves.

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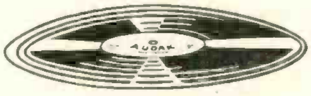

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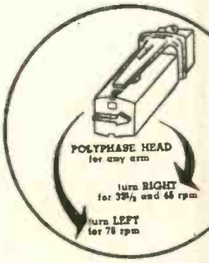

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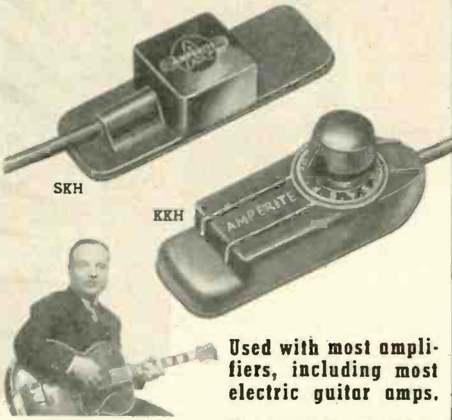

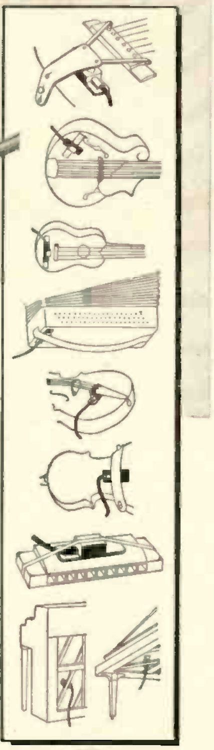

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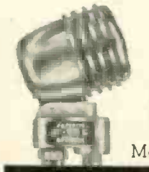

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indeterminate in detail, adjustable and adaptable.

The printed notation system is not only un-precise, inexact, but is that way of necessity and by its very nature. Not all the King's men nor all the mathematicians and engineers and gadgeteers and inventors together ever will endow it with the objective accuracy of a recording. Yet in the printed score *is always the music itself,* specifically in its very indefiniteness as well as in those few aspects that can be rigidly defined. The score is the algebraic n, where n equals any and all performances that come within its rather wide tolerances.

Kilomiles and Quarter-notes

With that idea under our skulls, let us proceed to some of the fine specific abstractions that constitute this abstract musical notation. As described last month, the two major aspects of musical sound that are represented on paper are both proportions. *Pitch,* a system of audio-frequency proportions, is represented by the vertical dimension on paper. (Pitch is pinned down fairly exactly—never absolutely—for reasons that are external, mainly the characteristics of instruments which are tied to fixed pitches. Folk dances, popular song tunes, etc. are heard at any and every pitch which convenience dictates.) *Rhythm,* a system of time proportions, is represented by the left-to-right dimension. Of these two elements the system of notating rhythm is the most flexible and perhaps a shade easier to grasp at the beginning.

Engineers are in a nice position to appreciate the peculiar abstractions that we in music use for rhythm writing. In America and Germany the terminology is strictly fractional and the "unit" time value is, moreover, very seldom in evidence at all; nor has it—or any of its fractions—any concrete existence whatsoever; the whole thing is an abstract relationship expressed by the fractional numbers.

This is simple enough, from an engineering viewpoint. There exists an arbitrary term, without value, which is called unity, the "whole"-note, as we call it. In terms of this x, other time values take on fractional values—half-notes, quarter-notes, and the rest. The whole-note is virtually never the practical unit for operating purposes; it merely sets up the system, mentally speaking, so that the rest can fall into a proportionate pattern. The fractionality, at least, is no different from that found in the audio or electronic fields. The bel is a unit, but the decibel is the practical "unit" for general use in spite of its name. We have μf, $\mu\mu f$, mm, even such pleasant terms as the kilomile, the kind of mile that rockets and jets and high powered sports cars use.

In musical notation, as in these scientific terms, the "unit" of practicality is almost always a fractional one, a pure abstraction that merely sets up a good, clean relationship of proportion. Our most common time "unit" today is the quarter-note, which isn't a quarter of anything in practice—especially in waltz time, (¾) where it is a third, or in jig time (6/8), where it is two thirds of a half!

Fractions are for convenience, then, and we can forget about unity except in terms stated clearly at the beginning of every musical score, that define the rhythmic unity for that particular music. But beyond mere fractionality we must further understand the extreme flexibility which can make in actual practice, a sixteenth-note in one Beethoven movement roughly equal to a half-note in another! We not

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only must set down the unit-of-the-moment, but we must give it a rough time value for performance purposes—and that value is *never* precise, in any score. More often than not it is extremely vague.

Actual time values, for performance, are incredibly casual in notation. They may be indicated very loosely by the written time signature, if any—*allegro, andante, Sehr rasch, deep blues,* etc. or, failing that (and most older music has no indication at all), by the position of a movement in a work, its style or content, the sense of the harmony or the kind of melody, demanding a certain general speed or slowness; these values, expressed or merely implied, very further from composer to composer, from period to period, from performance to performance (often as greatly as 2:1) and from concert hall to concert hall—acoustics having much to do with the optimum speed at which a piece may be played. Moreover they *must* vary, for that is the nature of music. It's up to the performer's good judgment in a given situation.

In very few cases is an exact or even approximately exact tempo (speed) ever indicated and agreed to by all, for a given piece. The Metronome? An ingenious and precise gadget—and for that very reason virtually never taken literally. (If composers occasionally do, then performers do not. They feel, rightly, that music cannot be pinned down by any such diabolically accurate device.) Metronome readings are occasionally indicated by the composer (more often by well meaning editors whose authority is unacceptable) but nobody with sense would take these as more than preliminary guides as a working basis for experiment.

The value of a given rhythm-term, say a quarter-note, may vary according to this system over a vast range, perhaps 20:1, and so with the entire system of rhythm notation. Luckily, common sense, common traditions and general understanding of the musical art makes the musical rhythm system fairly practical. But I'd hate to try to read our music from scratch, like the archeologists, along about 2400 A.D.

We'll finish this discussion on musical notation next month—space is rapidly drawing to an end, so on to the new records.

RECORDING-OF-THE-SEASON

Haydn: The Seasons. RIAS Symphony Orch., RIAS Choir and Choir of St. Hedwig's Cathedral, Soloists, Ferenc Fricsay.
Decca DX-123 (3)

"Best" recordings, so designated by Committees, individuals, publicity agents, magazines like Æ, or even by a sort of general surge of feeling among the customers, have a peculiar fascination for us, akin to that engendered by the well known public opinion polls. Nobody really can say for keeps which is "the" best recording, or the best TV show, or the best toothpaste, but there is something legitimate about the desire we all seem to have for a spotlighting of values.

"The Seasons," then, is my current selection as Best, and will remain so until something else challenges it in my experience. Best, because it is a superb performance of music that hasn't previously had even a good job done on it. Best, because it is a fine technical job of recording. Best, because it is one of the most all-satisfying great works of music you can imagine, combining ineffable heights of musical beauty with a delightfully earthy humor. This last is the key to this performance—humor, in the midst of great musical expression. We have absurdly pompous ideas of "oratorio," and earlier versions have fallen for the malarkey that great music on a big scale must be stuffy and solemn and heavy; not this performance, and not this music.

More specifically, "The Seasons," Haydn's last big work, is actually a non-religious oratorio,

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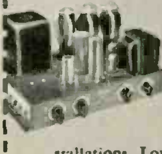

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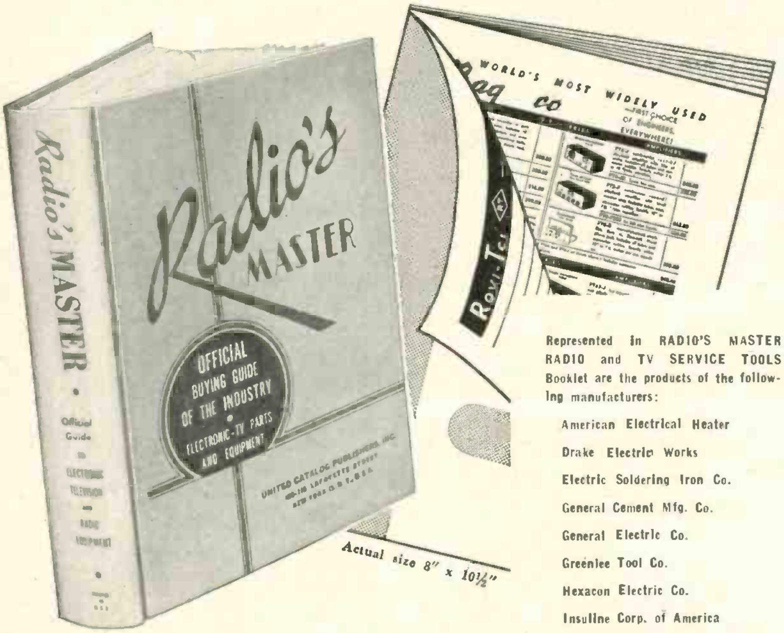

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celebrating the four periods of the year and the parallel ages of man's life—youth, maturity, old age, and the eternal Hereafter, a second and permanent youth. But the work, while full of the earthiness of country living, the drinking and lovemaking, the sowing and the harvesting, is at the same time profoundly reverent and deeply religious. Here I'd say, is just about the ultimate expression of the truly civilized man. We could do with a lot more of the same. Listen to this at leisure, on good equipment and with the text in hand. It'll be a hard-boiled man-creature who won't be moved by it, by the end of a couple of sides.

BLUEBIRD

The Basic Library discussed as a principle by Irving Kolodin on the backsides of the latest batch of Bluebird records (RCA's low-priced line) is presumably illustrated by the records themselves. If so, then this particular Library is merely a pot-pourri of glorified dinner music, background audio, operatic tid-bits and familiar concert pieces that reminds me rather strongly of my dentist music—the stuff I have to listen to on my dentist's permanently tuned radio while the drilling goes merrily on. (His radio operates 12 hours a day on one station and he never hears a single trace of what it plays, as far as I can see. Sheer background torture music.)

Seriously, if this is the sort of Basic Library considered proper for us morons, then we'd better revert to Basic English as our most likely speech. The parallel isn't too far-fetched. This music is serviceable enough and plenty of it is basically sound; but its promoters have made sure that either it is very, very familiar or very, very easy, or both. Baby food, for us supposed grown-ups.

No offense intended to the individual items, taken as a non-basic non-library. Herewith a few:

Schumann: Carnaval Ballet Suite (arr. orch.). Philharmonia, Irving. **Delibes: Sylvia Ballet Music.** Paris Opera orch., Fourestier. **Bluebird LBC 1025**

Mendelssohn: Violin Concerto. Borries; Berlin Philh., Celibidache. **"Italian" Symphony.** Hallé Orch., Barbirolli. **Bluebird LBS 1049**

Most record buyers have long since found out that a cheap record today isn't necessarily a poor one (and vice versa), just as a small company isn't necessarily a punk one. The two caveats that should apply to cheap-label buying are, first, as to content and performance they will tend to range wildly from the very good to the very bad—quality control is somewhat less than strict; and, second, in regard to technical quality the very same thing applies—you may expect anything from superb to terrible. Indeed, it's safe to say that, musical politics and legal complexities aside, the low-priced label is simply one that allows a wider over-all tolerance, from best to worst. The average remains pretty high.

It's amusing to hear the solid, personal Germanic expression of Schumann's famed piano piece, Carnaval, turned into typical ballet music of the Franco-Russian school! It works, but those who know Schumann for himself will be flabbergasted at the easy transformation. You can almost see the ballet itself onstage, so typically is this performance in ballet style. A fine hi-fi record, Bluebird or no; it has on the Schumann side a full-bottomed, brassy and clean sound, somewhat metallic, on the Delibes side (Paris Opera) a typically French liveness—just a bit too dead and close for average U.S. tastes. A fine disc.

The Mendelssohn disc illustrates the hazards of low-priced buying. The Violin Concerto is fine, the quality excellent, the performance good enough; but the "Italian", with Barbirolli, has a dismal 5000-cps cutoff, or equivalent, and a thin, screetchy sound that reminds me strangely of the early Columbia Barbirollis of around 1940. No good.

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Tchaikowsky: Piano Concerto #1. Ciccolini; Paris Conservatory, Cluytens.
Bluebird LBC 1020

The old war horse in an odd Italo-French performance that seems to me rather dry and rattly—might as well make this piece thunder in earnest, or let it pass. Dryish recording, excellent quality, not unlike the Delibes above.

Chopin: Preludes; Scherzi. Moiséiwitsch (piano).
Bluebird LBC 1038

This pianist with the unspellable name is a wizard and turns out a high powered mixture of Rubinstein (for the muscle work) and Cortot (for the delicate fire) that makes for exciting Chopin, above average in musicality. Piano is clean, rather distant and without much bass—but it signally lacks the hard edge of some earlier RCA piano discs and is much the better for it. Why is this a Bluebird and not a Red Seal? Not for any reason that matters to you and me.

Orchestral Music from Grand Opera. (Rossini, Saint-Saens, Spontini.) Asstd. Orchestras.
Bluebird LBC 1039

You may be sure that the Red Seal never sported such a pot-pourri as this on one disc! Here's the center-piece of my dentist music (above), perfectly fit for Wired Music or background to you-know-what. Only piece I find titillating to the intelligence is the Spontini overture to La Vestale; probably because I'd never happened to have heard it, and liked its Beethoven-period sincerity and melody. The rest are old favorites.

SCOTCH

Mendelssohn: Scotch Symphony, #3.
A. Pittsburgh Symphony, Steinberg.
Capitol S-8192
B. London Symphony, Solti.
London LL-708

Strange—having discussed these two once elsewhere, after much playing of both, I now come back to them a few weeks later with a different audio "system" in a different room, and find the balance upset. Previously I had preferred the London version because of the closeness of its typically ffrr strings, a recording technique beautifully adapted to Mendelssohn, who wrote a very special kind of string music full of wonderful detail work that is lost in a big, distance liveness such as you'll find on the Capitol version. London's is close-up in a golden liveness; Capitol's is evidently one-mike, at an unusually great distance and with a monumental blur.

I then called the Steinberg (Capitol) performance "furious"—I agree with myself now, except that I must add, on this re-hearing, that it is not only furious but tremendously effective in putting over the serious and beautiful content of this unusual Mendelssohn—his last symphony. True, the detail work is considerably blurred, not only by the acoustics but by some rapid tempi. But the over-all impression—at least in my current listening room—makes up for the lost detail work.

However—the London performance still holds up on the former grounds: the intimate and incredibly smooth inner gear-workings of this complex score are clear as crystal and by their very presence in such clarity a pleasure to hear. If the long string melodies of the slow movement sound a bit ragged, we can blame the close-by mikes, which have a habit of unblending an ensemble of sound that at concert hall distance might come to the ear as smoothly balanced as mayonnaise.

Which is the "best"? What a preposterous question! The best performance, assuming that both were somehow heard under neutral and similar acoustical conditions? The Steinberg-Capitol without any doubt. But these are two phonograph records, not two concert performances, and we must take all factors into judgment including the musical effect of the engineering technique. For some, then, London's clarity will count most of all. I should worry; I'm lucky enough to own both. (For the affluent: by all means buy both for yourself. Well worth it.)

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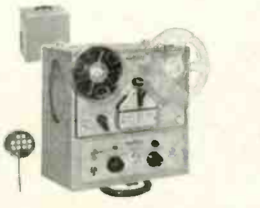

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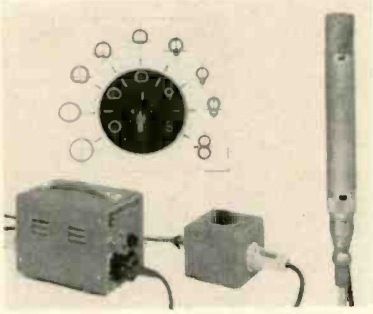
NEW PRODUCTS

● **High-Fidelity AM-FM Tuner.** Many professional features are included in the new Fisher Model 50-R AM-FM tuner, which incorporates a two-band superheterodyne circuit with completely independent r-f channels for AM and FM. FM sensitivity affords 30 db of quieting for 2½-microvolt signal input with 72-ohm antenna. AFC may be disabled at will. Frequency response is 20 to 20,000 cps within ±1 db. Distortion is less than 0.04 per cent for 1 volt output. Heterodyne interference on AM is minimized with 10-kc whistle filter. Hum level is down 90 db with volume control on full. Cathode-follower output permits operation up to 200 feet from amplifier. Circuit of the 50-R contains 14 tubes, including tuning eye and rectifier. The unit is self-powered and features shielded construction throughout, with components fully shock-mounted. Size is 14¾" wide × 8½" high × 9¼" deep, and weight is 17 lbs. Fisher Radio Corporation, 41 E. 47th St., New York 17, N. Y.

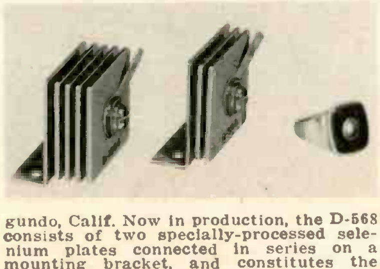
● **New Recording VU Meter.** A new VU meter for easy visual recording control of any recorder has just been introduced by TapeMaster, Inc. This instrument permits the operator to adjust the recording level accurately to the optimum value, thus reducing the possibility of overload on the tape with attendant increase in distortion or, conversely, ensuring that the recording level does not ever go below a satisfactory minimum. The ballistic characteristics of the instrument differ from the standard VU meter, but are claimed to be more easily read, particularly by the unskilled recordist. The scale and sensitivity are equivalent to that of the standard meter, and the instrument is available with or without internal illumination. For further information, write for Bulletin No. 110 to TapeMaster, Inc., 13 W. Hubbard St., Chicago 10, Ill.

● **Endless-Tape-Loop Recorder-Reproducer.** Designed primarily as an automatic station break announcer, the Magneloop recorder-reproducer may be used wherever there is need for repeating recorded messages. The unit meets NARTB secondary standards, and will handle messages up to 60 seconds in length with frequency response 50 to 7500 cps at 7½-ins./sec. tape speed. Equipped with remote-control start and automatic stop, the Magneloop operates from an endless loop of standard quarter-inch magnetic tape housed in a removable cartridge. It is equipped with high-impedance microphone input and ungrounded bridging input which is disconnected automatically when microphone plug is inserted. Shock-mounted preamplifier includes 60-kc bias and erase oscillator. For commercial usage, such as industrial exhibits and advertising displays, there is a model which operates at 3¾ ins./sec. and has a maximum playing time of two minutes with frequency response to 5000 cps. For complete technical specifications and prices write to Magneloop Division, Amplifier Corp. of America, 398 Broadway, New York 13, N. Y.

● **Polydirectional Condenser Microphone.** Many new possibilities in recording and broadcast technique are opened by the new Type C-12 microphone, whose directional characteristics may be altered by remote control even while the unit is in operation. The microphone proper consists of the electrostatic transmitter head, a Type 12AU6 tube, and an output transformer, all of which are contained in a metal housing 15 in. long by 1⅝ in. in diameter. Interconnection cable to the power supply unit may be up to 600 ft. long. There is a separate cable connecting the power supply with the remote directional control unit. By means of this unit the polar curve may be varied from omnidirectional to unidirectional to bidirectional (with all intermediate positions) during recording. Frequency range is 20 to 15,000 cps. Output level is minus 42 db. Output impedances are 30, 250, and 500 ohms. Power requirements are 117 volts, 60-cycle a.c. Further information will be supplied by the manufacturer, Akustische und Kino-Geräte Ges.m.b.H., Nobilegasse 50, Vienna XV, Austria.

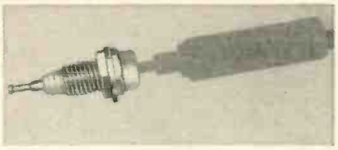


● **Selenium Regulators.** Recommended for the regulation of d. c. voltages of the order of 1.5, the new Type D-568 selenium regulator is the first in a series to be developed recently by International Rectifier Corporation, 1521 E. Grand Ave., El Segundo, Calif. Now in production, the D-568 consists of two specially-processed selenium plates connected in series on a mounting bracket, and constitutes the basic design of similar units for various low-voltage regulation requirements.

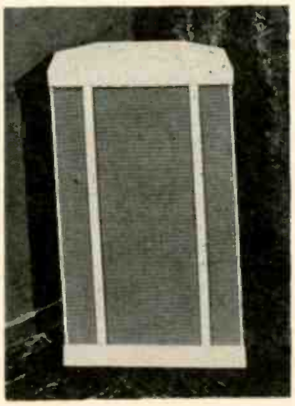


● **Improved 25-Watt General-Purpose Amplifier.** Although similar electrically to its predecessor, the new Bell Model 3725-B amplifier contains several new design features, including an additional microphone input. A newly-designed all-steel case is trimmed in chrome, with a sloping, lighted control panel. Plastic dial pointers glow when the unit is in operation, and are directly driven from six control knobs located beneath the panel. Separate controls are provided for treble and bass, as well as for three microphones and one phono. A wide range of output impedances, including 70-volt constant-voltage tap, permits matching to any speaker load. Frequency response is 30 to 18,000 cps within ± 2 db and output power rating is based on less than 5 per cent distortion. For additional information write Bell Sound Systems, Inc., 555 Marion Road, Columbus 7, Ohio.

● **Test-Point Jacks.** Color-coded insulators for circuit identification are featured in a new line of test-point jacks recently introduced as the 45-E Series by Cannon Electric, 3209 Humboldt St., Los Angeles 31, Calif. Designed to accommodate standard 0.081-in. diameter phone tips, the new jacks have extended Nylon insulation at the rear of the fitting to afford high flashover values. Capacitance is 5 to 7 μμf. and contact resistance is 6 to 8 mv/amp.



● **Klipsch "Rebel" Corner Enclosure.** Available both as a finished unit and as a kit, this Klipsch-designed enclosure is suitable for all standard 12- and 15-in. speakers. Manufactured by G & H Wood Products Company, 75 N. 11th St., Brooklyn 11, N. Y., the cabinet is known as the Klipsch Rebel IV by Cabinart. Attractively styled to blend with any interior decor, the enclosure may be purchased in a variety of wood finishes.



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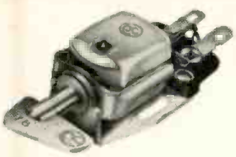

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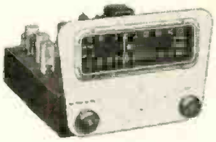

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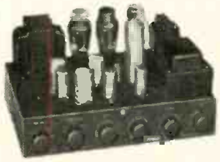

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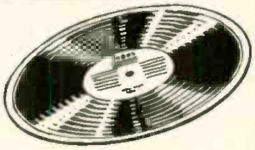

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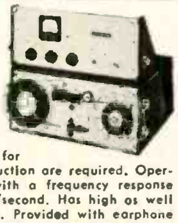

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LATERAL MECHANICAL IMPEDANCE

(*from page 24*)

1950

Figure 15 gives the response and impedance characteristics of a variable-reluctance pickup fitted with a microgroove sapphire stylus, and marketed in 1950. During the measurements the pickup was mounted on a special arm which was superior to those usually found in home phonographs. Consequently, the pickup-arm resonances occur at somewhat lower frequencies than was the case in many of the preceding examples.

1951

Figure 16 gives the response and impedance characteristics of a frequency-modulation type of pickup which was first offered for sale in 1951. During tests this pickup was mounted on the same special arm as was used for the variable-reluctance pickup of *Fig.* 15. This FM pickup is actually not in the same class with the other pickups tested since it has never been incorporated in production-model home phonographs, and has been used only in custom installations. However, we include it here as a matter of interest since it represents another type of pickup and one in which more than ordinary steps were taken to reduce the mechanical impedance to a low value.

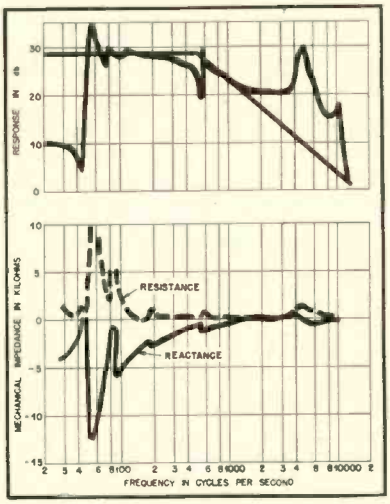


Fig. 13. Characteristics of another pickup similar to that of Fig. 12, but made by a different manufacturer.

Conclusions

We have presented the results of measurements of the lateral mechanical impedance of a group of phonograph pickups which we believe to be representative by type of pickups widely used in home phonographs. These pickups represent different stages of development in the period from 1901 to 1951. One feature made readily apparent by many of the impedance characteristics is the very large values of mechanical impedance occurring in the neigh-

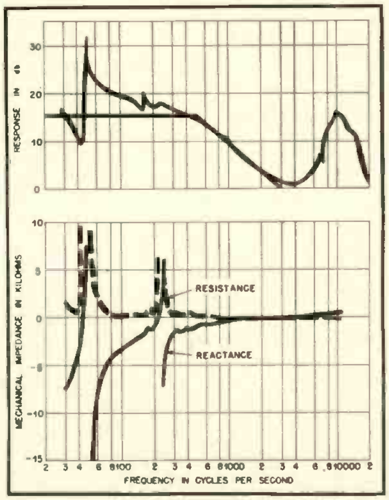
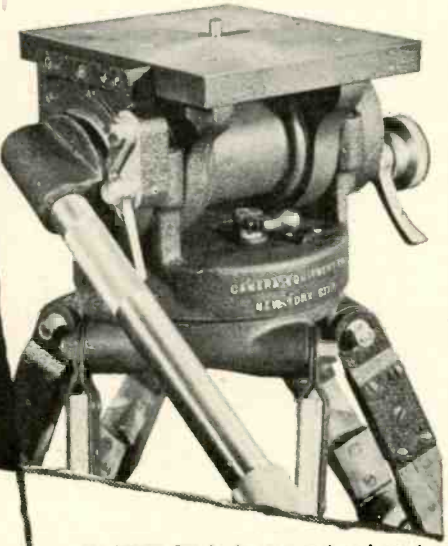


Fig. 14. Characteristics of a permanent-sapphire-stylus crystal pickup of 1945.



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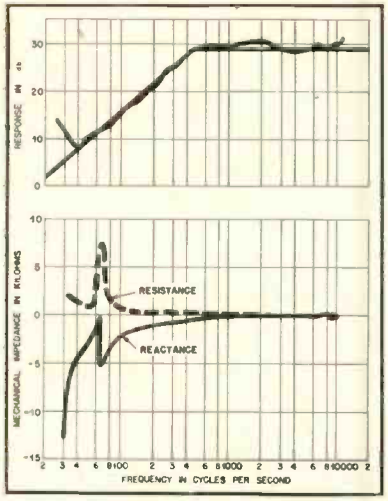

Fig. 15. Characteristics of a variable-reluctance pickup with a microgroove sapphire stylus. This model was first marketed in 1950.

borhood of pickup-arm resonances. This indicates the desirability of a complementary design of pickup and pickup arm to remove or reduce such resonances in the audio-frequency range.

It is clear that the lateral mechanical impedance of a phonograph pickup mounted in a pickup arm cannot be adequately described in terms of a simple compliance. However, if the pickup is mounted on an arm for which no resonances occur within the audio-frequency range, the mechanical impedance of the pickup itself can often be characterized as a simple compliance over a considerable range of low frequencies, i.e., until the stylus-arm resonance is approached. At this resonance the reactance passes from negative through zero to positive values. In modern pickups this usually occurs between 1000 and 3000 cps.

An examination of the impedance characteristics shown herein reveals that in every case the region near 400 cps is free of major resonances and antiresonances. It is therefore tempting to make a direct comparison of the pickups on the basis of their compliances at 400 cps. The compliance in each instance is obtained by taking the reciprocal of the 400-cps reactance as read from the impedance characteristic, and dividing by $2\pi \times 400$. When the compliance so obtained is plotted as a function of the year in which the pickup was first sold, the curve given in *Fig.* 17 results.

Figure 17 shows in a rather striking manner the trend of progress in the design of phonograph pickups. It makes almost inevitable the question, "Where do we go from here—and how soon?"

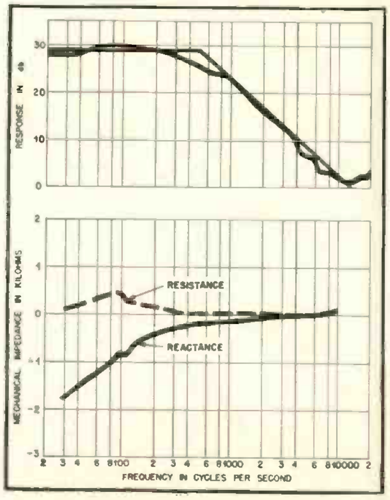

Fig. 16. Characteristics of a frequency-modulation type of pickup made in 1951.

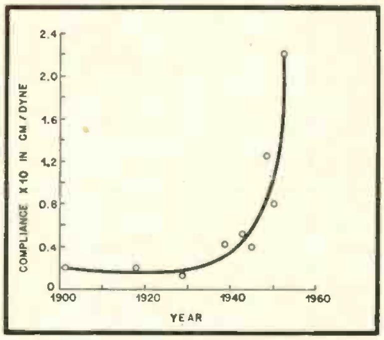

Fig. 17. Curve showing the trend in phonograph-pickup compliance over a 50-year period.

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PATENTS

(from page 6)

Obviously, each half-cycle of audio causes a reversal in the polarity of the charge on C_1. The voltage across C_1 is converted to unidirectional pulsations by the full-wave rectifier V_3–V_4, the load for which is R_3. Across R_3 there exist unidirectional pulsations whose recurrence rate is twice the frequency of the original voice currents in transformer *T*. All these pulsations have the same peak values. L_1–L_2–C_4 is a 50-cps low-pass filter which smoothes the pulsations. Since the pulsations are always at a rate much higher than 50 per second, the 50-cps filter output is a d.c. voltage whose level is in proportion to the pulse (and therefore the voice) frequency—the higher the pulse rate the higher the d.c. voltage, because of the filter's averaging or integrating function. The frequency of 50 cps was chosen because it was found that the fundamental frequency of the human voice in speech does not change at a rate equivalent to more than 50 cps. The d.c. output voltage, therefore, cannot change at a rate greater than this and can be transmitted further by any means having a bandwidth of 50 cps.

Referring again to *Fig.* 2, the output of F_1 is also fed to a rectifier whose purpose is to supply a d.c. voltage proportional to the relative volume level of the fundamental-frequency voice component. This rectifier is diagrammed in *Fig.* 4. It is a conventional full-wave circuit with a 50-cps ripple filter, again selected because it was determined that in speech the volume level of the fundamental does not vary faster than a 50-cps rate.

Note that up to here we have shown means for transmitting a signal representing voice frequencies as high as 400 cps over a path with only 50-cps bandwidth, and a means for sending a signal representing its volume over a similar 50-cps path—a total necessary bandwidth of only 100 cps instead of the original 320.

In ordinary speech transmission the remainder of the usual bandwidth is needed to transmit the formant characteristics so that the speech will be intelligible. In Steinberg's invention formants are transmitted in the same way as the fundamental.

In *Fig.* 2 the microphone output is also fed to F_2, which is a 300-to-800-cps band-pass filter. While several harmonics of the voice fundamental may be in this range, the strongest harmonic is caused by the formant in the range and this will be the strongest frequency component emerging from the filter. It is fed to the first formant frequency counter, a circuit identical to that used for the fundamental and diagrammed in *Fig.* 3. This produces a d.c. voltage whose value indicates the frequency of the first formant. The filter output also goes to the first formant rectifier, similar to that of *Fig.* 4, to produce a d.c. voltage proportional to the relative level of the first formant. In a similar manner second and third formants produce d.c. frequency- and level-indicating voltages through their own filters, frequency counters, and rectifiers. The end result is eight d.c. voltages, each changing at a rate not exceeding 50 cps (in terms of angular velocities). These signals may be combined by any of a number of known means into a continuous signal occupying only slightly more than 50 × 8 or 400 cycles of bandwidth, and transmitted by an ordinary r.f. transmitter or land line.

Receiving Apparatus

The receiving equipment is blocked out in *Fig.* 5. The signal from the transmitter is received and is separated again into its eight components, each a varying d.c. voltage. That representing the fundamental frequency is fed to a sawtooth oscillator whose frequency can be d.c. controlled. The values are so adjusted that the output of the sawtooth oscillator is of the same frequency as was the fundame tal voice frequency at the transmitter. The oscillator output is fed through a relay (see below) to a filter *F* whose transmission characteristic is the same as that of F_1 in *Fig.* 2. From here it goes to a vario-losser. The vario-losser, which can be one of several types, is simply an amplifier whose gain can be controlled by a d.c. control voltage. This one is controlled by the fundamental level signal. The losser output, consisting of fundamental voice frequency and level corresponding with the original, goes to an amplifier.

The 2nd formant frequency d.c. signal goes to a variable filter which contains a tuned circuit using a saturable reactor. The resonant frequency of the filter is determined by the d.c. value so that it is identical to the frequency of the second formant as it went through F_3 in *Fig.* 2. The second formant filter's audio input (*Fig.* 5) is taken from the sawtooth oscillator, so its output is principally that harmonic of the speech fundamental which falls at or near the second formant frequency; this is because that harmonic has been emphasized by the variable tuned circuit. The level at which the second formant is fed to its amplifier and the common output is determined by a vario-losser similar to that used for the fundamental, controlled by the d.c. second-formant-level voltage. The first and third formant filters are similarly controlled as to frequency by the d.c. first- and third-formant-frequency voltages, and their levels are set in their own vario-lossers by the level-control voltages.

The common output, therefore, contains a certain mixture of fundamental and harmonics, with those harmonics at and near the three formant frequencies emphasized to the correct degree. The Q's of the three filters are chosen so that they will closely reproduce the resonance patterns of the normal human voice cavities in their respective ranges. The result is intelligible reproduction by synthesis of the original speaker's voiced sounds.

The noise generator produces a random noise signal in imitation of the air rush present in unvoiced sounds. The relay is a polarized unit with the arm normally at center. When the d.c. signal representing the level of the third formant (2300 cps and above) is stronger than that representing the level of the fundamental (below 400 cps), as is the case when unvoiced sounds are transmitted, the relay arm is attracted by the upper coil and passes the noise generator output through the formant filters. When the fundamental level signal is stronger, as it is when sounds are voiced, the arm is pulled down and connects the sawtooth oscillator as the sound source.

This month's article is a bit longer and more detailed than usual, as you will notice. But not only is the invention we have described interesting because of its applicability to present problems and its ingenuity; the formant principle on which it was made is one that audio people should know about, for it is equally applicable to the timbre of musical instruments and gives us a better idea of why musical instrument sounds are dependent on the frequency range and linearity of sound equipment.

AUDIOLOGY

(from page 14)

is that of maintaining the amplifier nonoscillatory under all conditions of signal and loading. Stated simply, amplification around the feedback loop must be less than unity at the frequency or frequencies at which phase relations are correct for oscillation. (Exceptions to this rule are of relatively little practical interest.) Generally satisfactory stability margins are 6 db in amplitude and 30 deg. in phase. That is, with phase relations correct for oscillation, the loop gain should be no more than one half; and for all frequencies at which the gain around the feedback loop is greater than unity, phase shift should be at least 30 deg. different from that correct for oscillation. An amplifier may pass resistive load tests with flying colors and fail miserably with reactive loads. Some practical details of stability measurement are planned for a future installment.

Nature of the secondary feedback problem, as presently compared with primary feedback, may be more clearly understood with reference to the drawings, shown single-ended for simplicity. The diagrammatic arrangement of *Fig.* 1 is expanded in *Fig.* 2 to more nearly represent the transformer effects at extreme frequencies, with all impedances referred to the primary side.

Series resistances and inductances shown represent winding copper losses and leakage inductances, respectively. Central shunt elements represent core losses and winding self-inductances, and are effective at low frequencies only. Terminating and bridging capacitances represent the more significant distributed and coupling capacities. Magnitudes of some of the principal circuit elements vary greatly with different secondary taps in use. Also, complex winding designs with numerous interleavings may exhibit spurious resonances not described with this assumed equivalent circuit. Inclusion of this maze in the feedback loop is usually the greatest claim and yet the greatest weakness of the secondary feedback method.

When the feedback voltage sample is taken from the vacuum-tube plate (primary feedback), the complex transformer situation at high frequencies affects the feedback loop only as an element in shunt with the point of low impedance as established by negative voltage feedback, and loop phase shift due to the transformer alone cannot possibly exceed 90 deg. But with secondary feedback, circuit complexity comprised by the transformer is within the loop, with source impedance usually equal to the unaltered plate resistance of the power amplifier stage; compared with phase relations at mid-frequencies, phase shift at high frequencies easily exceeds 180 deg. right in this portion of the feedback loop alone, and the system becomes regenerative instead of degenerative.

To permit operation at all, the important transformer high-frequency resonances must far outside the audio band. Assuming attention confined to high-quality equipment having extensive feedback, it follows that the transformer must be faultless in the audio band (within simple compensation limits) before feedback is applied. Including the transformer in the loop thus can afford little improvement in the useful band, even if by some means the stability problem is satisfactorily solved. What was promising in principle tends to be of little value in practice.

The Case Against Secondary Feedback

1. For general distortion reduction and gain stabilization, considerably less feedback can be applied with secondary feedback than with that of primary form, without serious sacrifice of stability margins.

2. In circuits requiring extensive feedback, need for reasonably low plate resistance as source impedance for the transformer imposes the restriction of using triodes, or multiple feedback loops.

3. General success of the amplifier design is dependent upon output transformer characteristics which are difficult to control in design and manufacture, as compared with those characteristics important in the stability of primary feedback systems.

These are related and severe disadvantages of secondary feedback, all due to inclusion of the complex high-frequency output transformer structure within the loop. To meet rigid requirements on margins of stability in both amplitude and phase, under any and all load conditions, the secondary feedback method is not readily applicable, unless only a small amount of feedback is needed to fulfill performance specifications.

Principal labor in including the transformer within the loop is directed more toward preventing oscillation outside the audio band than toward improvement of performance within the desired band. The price of secondary feedback can be a bit high compared with the added value of specification advantages resulting from its use. Spectacular results may be obtained by other feedback means, without sacrifice of stability.

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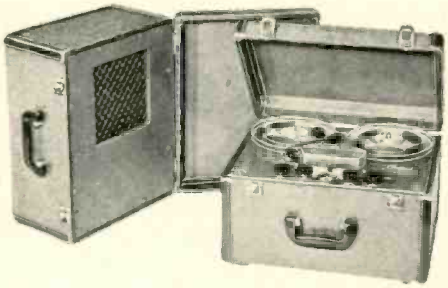

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MAGNETIC HEAD WEAR

(*from page 29*)

this head inductance of 4.2 mh restored the head performance to normal. The curves of *Figs.* 4, 5, and 6 depict the head performance for inductances of 3.85, 3.5, and 3.1 mh. These curves also show the change in bias current required to regain proper frequency characteristics.

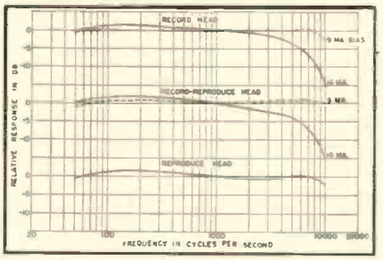

Fig. 5. Frequency characteristic vs. initial and optimum bias current for a head inductance of 3.5 mh at 45 ft./min.

Figure 7 shows the gradual loss in high frequencies as the recording head inductance drops from 4.9 to 3.1 mh at a constant bias current of 16 ma.

Exploring the region of maximum sensitivity bias of the record head over the range of inductances from 4.9 to 3.1 mh, it was noticed that the initial bias current of 16 ma and the reduced optimal bias currents in all cases represented bias currents corresponding to a value either equal to or slightly lower than maximum sensitivity bias. However, this statement should not be construed to mean that it is only necessary to adjust the bias current to maximum sensitivity bias to recover the lost high frequencies. This procedure would only result in an approximately normal performance. In order to compensate for

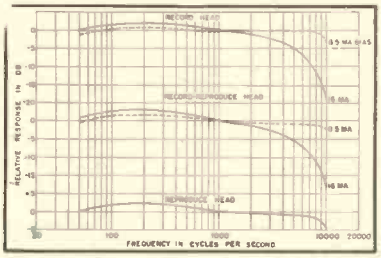

Fig. 6. Frequency characteristic vs. initial and optimum bias current for a head inductance of 3.1 mh at 45 ft./min.

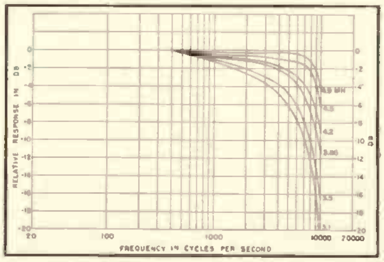

Fig. 7. Frequency response vs. inductance of recording head measured at a constant bias of 16 ma at 45 ft./min.

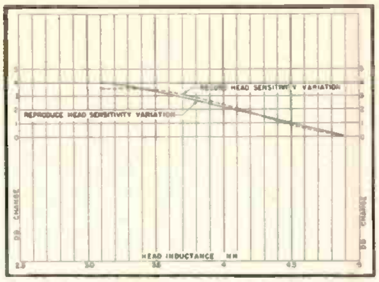

Fig. 8. Head inductance vs. sensitivity change, 45 ft./min., 400 cps.

head wear accurately, it is necessary to reduce the bias current experimentally to a value which will produce the initial frequency characteristic.

During these tests it was also noticed that a sensitivity change occurred in the test head. The sensitivity variations are shown on the curves of *Fig.* 8. Zero sensitivity of the test head as a record head corresponds to the sensitivity of the head with its full inductance of 4.9 mh operating at a bias current of 16 ma. It should be noted that as the head inductance is decreased and the head sensitivity increased it is necessary, in order to obtain 100 per cent modulation (approximately 2.5 per cent distortion at 400 cps), that the signal input to the head (signal current) be reduced by the amount shown on this curve. In exploring the performance of the test head as a reproduce head, zero sensitivity was assumed as the sensitivity of the head with an inductance of 4.9 mh. As the head inductance was lowered, the output from the head increased by the amount shown on this curve.

The curve of *Fig.* 9 shows the change in the 100 per cent modulation level that was noted as the head inductance was decreased and the bias current readjusted for satisfactory high-frequency performance.

Figure 10 has been included to show approximate values of optimum bias currents which can be used in an initial attempt at correcting for high-frequency loss by the record head when the head inductance has been reduced due to head wear. It must be understood that this curve can only be offered as an approximation toward the desired optimal bias current. Minor deviations from it may exist in individual cases.

All the above-described tests were made at a film speed of 45 ft. per min., or 9 in. per sec. The attenuation of recorded high frequencies due to magnetic

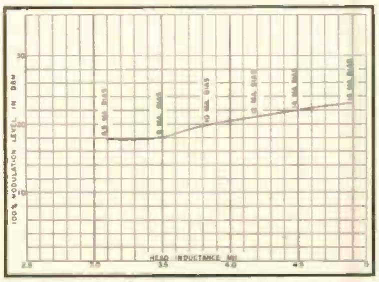

Fig. 9. Head inductance vs. optimum bias current vs. 100 per cent modulation level at 400 cps, 45 ft./min.

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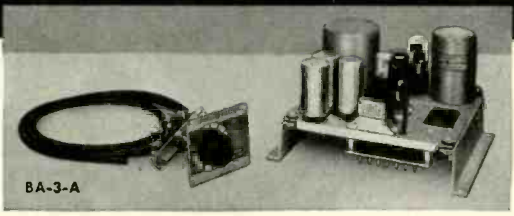

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head wear at other film or tape speeds will have the same trend, although it does not necessarily follow that the same pattern obtained with a 45 ft. per min. film speed will result. However, practice has shown that in all cases it has been possible to regain lost high frequencies through a reduction of bias current.

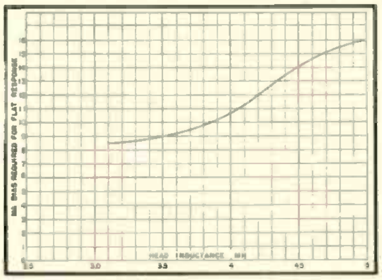

Fig. 10. Head inductance vs. optimum bias current, 45 ft./min.

We would like to inject a note of caution: Each change in bias current necessitates the re-establishment of the 100 per cent modulation recording level to avoid overloads and resultant increase in distortion.

Employment Register

POSITIONS OPEN and AVAILABLE PERSONNEL may be listed here at no charge to industry or to members of the Society. For insertion in this column, brief announcements should be in the hands of the Secretary, Audio Engineering Society, P. O. Box 12, Old Chelsea Station, N. Y. 11, N. Y., before the fifth of the month preceding the date of issue.

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COMING EVENTS

July 13–16—MUSIC INDUSTRY TRADE SHOW. Palmer House, Chicago, Ill.

August 19–21—1953 WESCON (Western Electronic Show and Convention), Civic Auditorium, San Francisco, California.

September 1–3—INTERNATIONAL SIGHT AND SOUND EXPOSITION, combined with the CHICAGO AUDIO FAIR. Palmer House, Chicago, Ill.

October 14–17—Fifth Annual Convention of the AUDIO ENGINEERING SOCIETY, and THE AUDIO FAIR. Hotel New Yorker, New York City.

NEW LITERATURE

• **Triad Transformer Corporation,** 4055 Redwood Ave., Venice, Calif. lists more than 500 items in a new 28-page illustrated catalog which has just been released. Featured is an expanded line of TV components and industrial transformers, including toroids, transistor transformers, and miniatures for use in small audio amplifiers. The catalog also contains a geophysical section. Request for copy should specify Catalog TR-53.

• **Electro-Voice, Inc.,** Buchanan, Mich., in Bulletin No. 197, gives full details of the Compound Diffraction Projector, a new EV-designed p. a. loudspeaker system. Illustrated and described are the audio diffraction principles on which the CDP is designed. Also shown are curves for comparing the polar pattern and frequency response of the CDP with those of existing re-entrant-type horns. Copy will be mailed free on request.

• **Audio & Video Products Corp.,** 730 Fifth Ave., New York 19, N. Y. is distributing a 4-page illustrated catalog which presents detailed specifications and prices on the complete line of Ampex tape recording equipment and accessories. Featured is the new Ampex unit which permits up to eight hours continuous play with automatic reversal.

• **Wells Sales, Inc.,** 333 W. Chicago Ave., Chicago 22, Ill. devotes a new 16-page catalog to more than 150 types of small switches, including toggle and leaf types, miniatures such as Micro and Switchette, plungers, roller and wafer models, timers, and circuit breakers. In addition to illustrations, there are specs and prices.

• **Transvision, Inc.,** New Rochelle, N. Y., illustrates and describes a new, improved line of television kits in a pocket-size folder which will be mailed free on request. Prepared by the company's educational department, the folder stresses the ease and economy with which Transvision kits can be assembled, as well as the value of the experience thus obtained.

• **Simpson Elctric Company,** 5200 W. Kinzie St., Chicago 44, Ill. is distributing free a special publication titled "1001 Uses for the Model 260." In its 50 well-illustrated pages the booklet offers detailed data on technical features of the Simpson Model 260 volt-ohm-milliammeter, as well as specific information on its use on various types of radio and electrical applications.

• **Heinemann Electric Co.,** 340 Plum St., Trenton 2, N. J., offers a new manual explaining operating principles of basic circuit breaker designs and providing engineering data on factors of application. Included in the manual are simplified diagrams showing the three basic types of circuit breakers in general use, together with brief descriptions. Through colored charts and diagrams, explanations of temperature factors, inrush current effects, tripping and reset time, and time delay curves are provided. This booklet should be of informative value to anyone concerned with circuit breaker application, and is available upon request for Manual 101.

• **Photocircuits Corporation,** Glen Cove, N. Y., has just published a new 8-page brochure in which printed circuits, their function, fabrication, and application are comprehensively outlined and described. This modern method of "wiring" offers reduced assembly time, circuit reproducibility, lower wiring costs, improved reliability, and miniaturization, and is particularly suitable for radio and TV chassis, i.f. strips, antenna filters, terminal boards, wiping switches, flush commutators, and other uses where cost is an important factor. The booklet includes information on methods of application, materials, electrical characteristics with tables of values, components such as capacitors, resistors, tube sockets, switches, etc. Assembly methods are described and costs are suggested. Copy may be had upon request.

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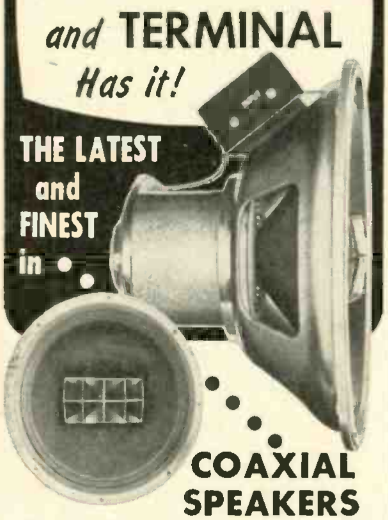

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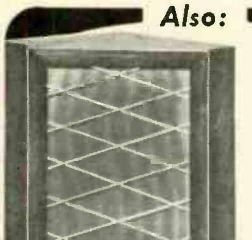

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SOUND HANDBOOK

(from page 28)

speaker. The basic design of this circuit appears in *Fig.* 12—5. Although at first glance the stage may seem quite different from a push-pull arrangement, an analysis of the flow of signal currents will indicate that the signals from each out-of-phase half of the circuit combine in-phase in the load. As in the case of the conventional push-pull circuit, the two signals are out of phase from the point of view of direction of flow from each tube, but in phase from the point of view of the load.

The a.c. loads for each tube in the conventional push-pull circuit are in series. In *Fig.* 12—5 the single, untapped load impedance is equivalent to two separate loads in parallel. The operational results are: 1) Distortion that occurs at high-power operation (class AB) due to imperfect coupling between the two halves of the transformer primary is eliminated. 2) The required value of load impedance is half of, rather than double the single-tube value, due to the parallel load connection. This brings the optimum load value down to a reasonable figure for high-impedance speaker voice coils (for example, the two triodes of the 6AS7-G require a load of only 280 ohms with this circuit). 3) Direct current is kept from the speaker voice coil without an output transformer, or, if an output transformer is used for matching purposes, its characteristics are not as critical. The need for transformer design that provides very close coupling between the two primary halves is eliminated by the equivalent of perfect coupling, and the effects of d.c. in the primary winding do not have to be considered. The untapped load is also a convenient feature for direct coupling to the speaker.

The disadvantage of this circuit is that the normal requirement for plate voltage is doubled, although the power drawn from the B supply remains the same. This disadvantage may be overcome by a circuit configuration that keeps the basic load design while placing the output tubes in parallel for the d.c. supply,[4] but d.c. must then flow through the transformer primary.

Cathode-Loaded Output Stages

The primary of the output transformer constitutes a load which is placed in series with a source of electrical power (the B supply) and a variable resistance (the tube). Other factors being equal, it makes no difference in what order the elements of this series circuit appear. In *Fig.* 12—6, (A) and (B) compare a plate-loaded circuit and a cathode-loaded circuit, both of which have grid circuits that operate independently of cathode current. These two stages will have the same operating characteristics and will require the same value of load impedance.

The circuit of *Fig.* 12—7 is different in that the cathode load is common to both the grid and plate circuits. All of the output voltage reappears, out of phase, at the input, since it is applied between the cathode and grid return. This results in a voltage loss rather than gain, referred to as a "gain" of less than one, although power gain is still possible. Such a circuit is called a *cathode follower,* because the voltage from cathode to ground follows the grid voltage exactly and in phase.

The cathode-follower stage will be discussed in greater detail in the section on voltage amplifiers. Its characteristics include extremely low distortion and lowered internal output impedance. Used in the power amplifier, however, it renders the stage so insensitive as to require input signal voltages of inconveniently high and sometimes unreasonable magnitude, and drastically reduces efficiency. Although the effective plate resistance of the tubes is greatly reduced by the 100 per cent out-of-phase feedback, the optimum load impedance is calculated on the basis of the original plate resistance values, (as is the case with more conventional feedback circuits) and thus remains unchanged from the value used with standard circuits.

Negative Feedback

Negative, inverse, or *degenerative* feedback[5] refers to a system in which a fraction of the amplifier output signal is fed back to the input terminals out-of-phase. This reduces the gain of the amplifier, but in effect pre-compensates the input signal characteristics for the distortion that will be encountered in *Fig.* 12—8 (A), illustrates the amplification of a stage without feedback, in which the generated distortion is indicated by the notch in the output sine wave. In (B), part of this distorted signal is fed back to the input and mixed with the undistorted input signal, creating a new input signal of reduced amplitude, but with an anticipatory hump where the notch is to be introduced. The result is to partially cancel the notch that would normally have been present in the output. If the input signal is now increased, as in (C), the output signal is restored to its original amplitude, but at the lower percentage of distortion.

Negative current feedback is produced when the feedback signal is proportional to the output current. Feedback obtained from the voltage drop across a small resistor in series with the load, or from an un-bypassed cathode bias resistor (which is in series with both input and output circuits simultaneously) provides such an arrangement. Negative voltage feedback, the type normally employed

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[4] *Ibid.*

[5] H. S. Black, "Stablized feedback amplifiers," *Bell Sys. Tech. J.*, v. 13 p. 1, January 1934.

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in power output circuits, furnishes a feedback signal proportional to the output voltage.

It is especially important that negative feedback be taken over the output stage of the audio amplifier. A common feedback circuit is shown in *Fig.* 12—9, in which the signal voltage developed across the transformer secondary and speaker is applied to the voltage divider consisting of R_k, and un-bypassed cathode resistor, and R_f, usually called the feedback resistor. All of the stages within the feedback loop benefit. The polarity of the feedback leads is determined experimentally—if they are reversed the amplifier will tend to oscillate rather than suffer a reduction in gain.

Although feedback is most important for the power output stage, there is a definite advantage in including in the feedback loop voltage amplifier stages prior to the power amplifier. If feedback is taken over the power amplifier alone, the required signal driving voltage—usually between 20 and 70 volts to begin with—is raised to the point where distortion in the preceding voltage amplifier may become a serious danger. On the other hand, with feedback taken back over several stages, (consistent with stability) no such heavy burden is placed on the voltage amplifier preceeding the feedback loop. It is vitally important that no control or signal switching facilities exist within the loop.

The percentage of total output signal that is fed back to the input does not have an absolute significance; its effect depends upon the amount of amplification within the feedback loop. A small fraction of output voltage may all but cancel the input signal at a low-level stage, while a much larger fraction of this same output voltage may have a relatively minor effect if applied just prior to the stage from which it is taken. The amount of feedback in an amplifier is described quantitatively as the decibel ratio of amplifier gain without feedback to the gain with feedback.

The number of db of negative feedback in an amplifier can be measured without much difficulty. With a given input signal amplitude the output voltage of a feedback amplifier is noted on an oscilloscope or an a.c. meter connected across the output at some convenient point such as the speaker voice coil. The ratio of this output voltage to the increased voltage that appears when the feedback resistor is removed, converted to db by the voltage formula, is the amount of feedback. For example, if feedback reduces the output voltage by a factor of 10 the amplifier has 20 db of feedback.

The feedback taken over an amplifier stage or group of stages is equal to:

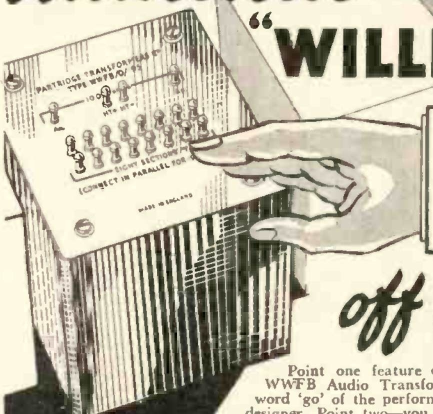
$$(\textit{db of feedback}) = 20 \log (1 - A\beta)$$

where A = original voltage gain within feedback loop

β = fraction of output voltage fed back

$A\beta$ = "feedback factor" (always negative when the feedback is negative)

The loop gain of a feedback amplifier is



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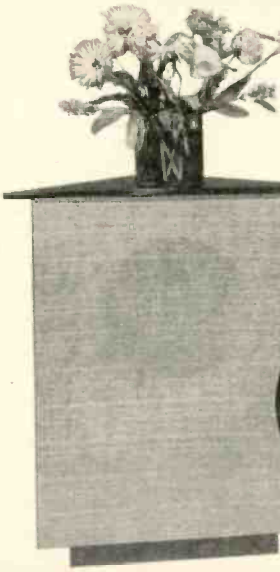

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reduced by the ratio $\frac{1}{1-A\beta}$ and is equal to:

$$(\textit{Gain with feedback}) = \frac{A}{1-A\beta} = \frac{1}{1/A-\beta}$$

It may be seen from this last expression that as A is increased for a given β the final gain of the amplifier becomes more and more dependent on the constant β, (approaching the value $1/\beta$) and less dependent on the imperfect physical factors that determine A. The sacrifice in gain, therefore, permits increased stability and increased freedom from distortion, frequency discrimination, and noise produced within the feedback loop.

It may also be seen that if the feedback factor $A\beta$ becomes positive at any frequency the gain and distortion are increased. The feedback is then positive or regenerative rather than negative, and after a certain point the amplifier will be self-oscillatory.

The benefits of feedback are not confined to reducing amplitude distortion; any changes of or additions to the signal by the amplifying stages are opposed. Harmonic distortion over a reasonable range of plate current variation, noise, and effective source impedance are all reduced by the same factor $\left(\frac{1}{1-A\beta}\right)$ as gain, and the allowable input signal amplitude is correspondingly increased.

There is a difference, however, between the effects of negative feedback on harmonic distortion and on noise. Distortion voltage appears as a percentage of output amplitude.[6] The distortion voltage in the output of the feedback amplifier shown at (B) in *Fig.* 12—8 is reduced, by the factor $\frac{1}{1-A\beta}$, from what it would have been without feedback *at the reduced amplitude*, and the percentage of distortion at all levels is therefore lowered by this same factor. Noise generated in the amplifier, on the other hand, is normally independent of signal amplitude. The output noise voltage is also reduced by $\frac{1}{1-A\beta}$ from what it would have been at the decreased output signal level, but the absolute value of the noise voltage generated is just as great at the reduced level as at the original level. Noise is therefore reduced no more than the signal, and the signal-to-noise ratio at first remains the same.

In order to achieve the same degree of improvement in signal-to-noise ratio as in distortion it is necessary to take the additional step shown at (C) in *Fig.* 12—8, that of increasing the input signal to the point where the output again assumes its original amplitude. This procedure does not affect the amount of noise generated in the amplifier or the amount fed back, so that the full reduction of noise voltage remains in effect at the increased output.

Negative feedback also creates a secondary advantage when used in conjunction with push-pull amplifier stages. The characteristics of all of the stages within the loop are stabilized and made more independent of variable factors such as power-supply voltage and tube condition, and the maintenance of push-pull balance is thus aided.

Inverse feedback cannot, however, help all situations indiscriminately. Severely deficient frequency response is a case in point. Signal frequencies at which amplification is reduced will automatically feed back less of a cancelling voltage, and frequency discrimination will be compensated for, but this same process may in certain cases increase rather than decrease amplitude distortion. If the original frequency discrimination is great enough (as might be the case in a poor-quality output transformer) the feedback factor in the deficient frequency range will be quite small, while signal input to the stages within the feedback loop will have been greatly increased to restore the original output signal amplitude. The result, with a large amount of total feedback, is to overdrive the amplifier in a frequency range virtually unprotected by feedback, and frequency compensation is secured at the expense of the much greater evil of higher distortion.

All of the above discussion has been based upon the assumption that the output signal is returned to the input 180 deg. out-of-phase. This assumption can never be entirely true, as some phase shift will always occur due to the reactive elements in amplifiers. As signal phase is shifted within the feedback loop the cancelling effect of the feedback voltage is reduced, and there is a transition from negative to positive feedback.

The same circuit conditions that produce frequency discrimination produce phase shift. Specifically, coupling capacitors will have higher reactances and produce greater phase shifts at very low frequencies; shunt capacitances affecting the higher frequencies will be present in amplifier networks; and the output transformer will create both inductive and capacitive effects.

The phase shift becomes progressively greater at the frequency extremes. As the total amount of feedback is increased there is the danger of oscillation at extreme bass or treble frequencies, usually in the subsonic or supersonic range. Subsonic oscillation is not difficult to detect, as it can be heard as "motor-boating" or actually seen as a slow back-and-forth movement of the speaker cone. It is easier for supersonic oscillation to go unnoticed. This may be guarded against, when building an amplifier, by checking with an oscilloscope across the amplifier output terminals. The inaudible but troublesome oscillations will show clearly on the screen, although they may require excitation before they occur. In both the subsonic and supersonic checks the amplifier should be observed under conditions of shock excitation—touching a screw driver to an

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[6] The percentage of distortion normally varies with output amplitude, but this fact does not have to be taken into account to explain the effect of feedback on distortion.

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input grid may provide the test signal. A borderline case will not oscillate, but will exhibit peaking at the frequency extremes where the gain has been increased, and a tendency towards low-frequency hangover or high-frequency ringing. The following are countermeasures against regeneration in the feedback loop:

1. Increase of the size of coupling capacitors within the loop, to reduce low-frequency phase shift. Coupling capacitors may also be completely eliminated by the use of direct-coupled circuits.

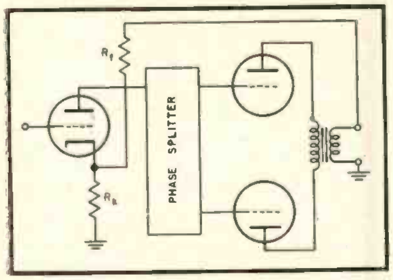

Fig. 12—9. Common circuit providing feedback over output stage, phase splitter, and preceding voltage amplifier. β is equal to $R_K/(R_K + R_F)$.

2. Use of a superior output transformer.

3. Decrease of the amount of feedback, by an increase in the size of the feedback resistor.

4. Reduction of the number of stages within the feedback loop.

5. Distribution of the output stage feedback between major and minor loops.

6. Introduction of a shorter, frequency discriminative feedback circuit within the loop proper, embracing fewer stages, which reduces over-all loop gain at the regenerative frequencies.

While it has previously been pointed out that low phase shift and good supersonic- and subsonic-frequency response offer no advantages in a sound reproducing system as a whole, such characteristics are not only desirable but up to a point necessary within the feedback loop. Beyond certain frequency limits, however, the danger of oscillation disappears because of poor transmission through the amplifier stages. The conditions for oscillation involve not only the absolute phase shift within the feedback loop, but the amount of this shift relative to attenuation in the frequency range concerned.

Part II of Chapter 12 will appear next month.

RECORDING CURVE

(from page 22)

eral points should be kept in mind:

1. The basic crossover point of 500 cps has been maintained, although the exact shape of the curve has been altered slightly, due to the differences in characteristics of the rubber-line recorder and the new feedback recorder.
2. Over the range from 300 cps to about 7,500 cps there is less than 1 db difference between the old and the new curve.
3. Below 300 cps the new curve has a rising characteristic introduced by the low-frequency pre-emphasis not used in the former curve.
4. Above 7,500 cps the new curve rises at a rate of approximately 6 db per octave while the former curve gradually flattened off to about 10,000 cps.

Reproducer equalization for the "New Orthophonic" characteristic may be obtained in a number of different ways, depending upon the type of pickup and circuit used. Two suggestions are offered in *Fig.* 9 where the use of a high-quality magnetic pickup is contemplated. These circuits are designed to give overall compensation, complementing the recording curve with a minimum of insertion loss. In actual practice minor adjustments to compensate for tone arm resonance and for high-frequency pickup characteristics may become necessary.

Other conventional amplifier circuits may be used equally well, provided the crossover frequency and tone control circuits are suitably adjustable.

In order to compensate accurately for both pickup and tone arm characteristics, it is necessary to check the over-all system with a suitable calibrated frequency record. If a conventional frequency record with constant-amplitude low end and constant-velocity high end is used, corrections must be applied which take into account the differences in relative velocity between the record and the recording characteristic at each frequency. A simpler approach for the non-technical person is to use a test record made with the recording characteristic for which correct equalization is desired. With a test record of this type the over-all output of a correctly adjusted reproducer will be essentially constant for all frequencies within the useful range of the system. RCA Victor now offers "New Orthophonic" 45 r.p.m. (12-5-51) and 33-1/3 r.p.m. LP (12-5-49) test records of this type which are available through RCA Victor record dealers and distributors.

Comments and Conclusions

In conclusion, it can be seen that, while maintaining the same general shape, the RCA Victor recording curve has been gradually extended in the high-frequency range as both recording and reproducing equipments have been improved. The effective low-frequency characteristic remained essentially unchanged since the start of electrical recording. However, it is impossible to give an exact low-frequency curve before 1938 because of the extensive use of adjustable bass filters and microphone placement to obtain the desired balance. Since 1938 the low end of the curve has had essentially constant amplitude below the 500-cps crossover point until the introduction of the "New

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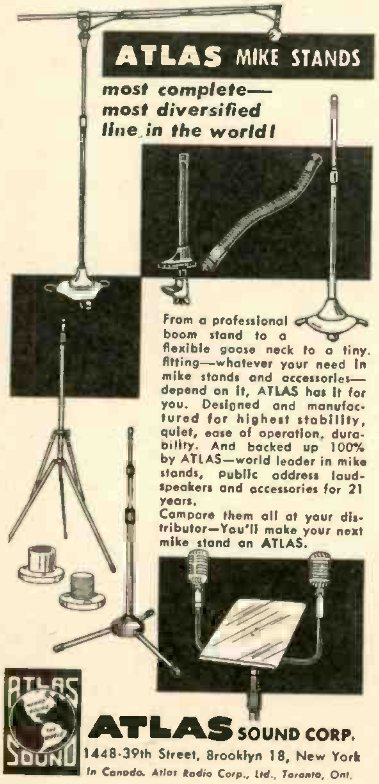

for every application...

ATLAS MIKE STANDS

most complete— most diversified line in the world!

From a professional boom stand to a flexible goose neck to a tiny fitting—whatever your need in mike stands and accessories—depend on it, ATLAS has it for you. Designed and manufactured for highest stability, quiet, ease of operation, durability. And backed up 100% by ATLAS—world leader in mike stands, public address loudspeakers and accessories for 21 years.
Compare them all at your distributor—You'll make your next mike stand an ATLAS.

ATLAS SOUND CORP.
1448-39th Street, Brooklyn 18, New York
In Canada, Atlas Radio Corp., Ltd., Toronto, Ont.

Orthophonic" curve with low-frequency pre-emphasis and extended high- and low-frequency ranges.

In adopting the new curve it has been the hope of RCA Victor engineers that a greater degree of standardization may follow in both the phonograph and the record industry. The departure from the former characteristic is not drastic. It does, however, permit a reduction of reproducer hum and turntable rumble with proper low-frequency compensation. With the extended low-frequency range of many modern wide-range speaker systems, this reduction of hum and rumble is now more important than with home phonograph equipment. Furthermore, it is felt that the high-frequency pre-emphasis is set at the optimum value for high-quality reproduction.

Radio's MASTER REPORTS

A MONTHLY SUMMARY of product developments and price changes of radio electronic-television parts and equipment, supplied by United Catalog Publishers, Inc., 110 Lafayette Street, New York City, publishers of Radio's Master.
These REPORTS will keep you up-to-date in this ever-changing industry. They will also help you to buy and specify to best advantage. A complete description of most products will be found in the Official Buying Guide, Radio's Master—available through local radio parts wholesalers.

Recording Equipment, Speakers, Amplifiers, Needles, Tape, etc.

BEAM INSTRUMENTS—Added Tannoy "Westminster" wall-type enclosure; Tannoy "Parliament" corner-type enclosure. (Mahogany cabinet at $125.00 net; Blonde cabinet at $130.00 net.)
BERLANT ASSOCIATES—Added model 1503-D dual-track recorder at $345.00 net; model 1503-S single track recorder at $345.00 net.
ELECTROVOX—Discontinued No. W-8A Replacement Needle for Webster Electric.
FISHER RADIO—Discontinued model 50-C control chassis.
GARRARD SALES—Added WB(Wood Base) for model T 3-Speed manual player at $5.25 net.
LOUIS BROS.—Added model 515 sloping wall speaker baffle for 15-in. speaker at $6.75 net; model 715 corner wall speaker baffle for 15-in speaker at $9.30 net.
QUAM-NICHOLS—Added new series of intercom speakers and new series of outdoor theater speakers.
RADIO APPARATUS CORP.—Discontinued AM receivers models AR-2, AR-3; FM receivers models M-51, M-101; squelch adapter model MS-119.
RECORDISC CORP.—Discontinued record preserver; turntable lubricant; 1-hour recording wire spool.
RECOTON CORP.—Discontinued variable reluctance pickups models 155C, 155X, 165X, 175X; acoustic tone arms models 51, 61. Increased prices on replacement Phoneedle Kits No. 150 to $21.75 net; No. 550 to $165.78 net; No. 650 to $188.70 net.
TURNER CO.—Added model ADA 95D dynamic microphone at $21.00 net.

ADDITIONAL CLASSIFIED

LICENSED 630 R.C.A. TV Chassis with or without AGC, Standard Coil TV-201 Tuner, suitable for use with 16-in. or 21-in. Kinescope. Single units $100, quantity discounts. Ansley Radio & Television, Inc., 85 Tremont St., Meriden, Conn.

ADVERTISING ARTIST with top agency will service audio companies with modern creative brochures, ads. Freelance. E. Gilbert, SLocum 6-9617, Brooklyn, N. Y.

FOR SALE: Disc recording system: Rek-O-Kut M5 overhead lathe mechanism with 120 L.P.I. feedscrew and Brush RC-80 cutter; 16-in. heavy-duty Rek-O-Kut recording turntable in excellent condition with cabinet ready to mount and use; all for $180. McIntosh 50W2 power amplifier with AE2A preamplifier and equalizer; nets for $325, sale price $190. Jac Holzman, 189 W. 10th St., New York 14, N. Y. OR 5-7137.

CLASSIFIED

Rates: 10¢ per word per insertion for noncommercial advertisements; 25¢ per word for commercial advertisements. Rates are net, and no discounts will be allowed. Copy must be accompanied by remittance in full, and must reach the New York office by the first of the month preceding the date of issue.

THE AUDIO EXCHANGE, INC. buys and sells quality high-fidelity sound systems and components. Guaranteed used and new equipment. Catalogue. Dept. AE, 159-19 Hillside Ave., Jamaica 32, N. Y. Telephone OL 8-0445.

WANTED: Western Electric 728-B or 754-A speakers. Send particulars to E. K. Goff, Route #1, Winston-Salem, N. C.

FOR SALE: Custom Hi-Fi cabinet. Beautiful, modern, excellent condition. Very reasonable. Dr. Millstein, LOrraine 9-1400, New York City.

ALLIED overhead lathe and turntable, perfect condition with new oversize G.E. synchronous motor and mercury switches, Fairchild 542 arm with 2.5-mil diamond cartridge mounted in exceptionally sturdy custom plywood console cabinet. Used less than 1 year, $525. Ampex 401, used 7 months, with RCA 77D mike, in perfect condition, checked by distributor, $750. MUST SELL, original owner leaving country. New York area only. BE 3-6587. Box CL-1, AUDIO ENGINEERING.

WANTED: Bound volumes AUDIO ENGINEERING, 1947–1952 inclusive. State price and condition. Box CL-3, AUDIO ENGINEERING.

ALTEC 800 horn, $45; Miller TRF tuner, $10; two new diamonds Pickering LP, Std, $40; Garrard changer 78, $10; collection 200 records, 25¢ each. Box CL-2, AUDIO ENGINEERING.

SELLING: Altec 604C in original carton, $125; Browning RJ-12 with power supply, $75; McIntosh C104A, $40. All prepaid. Jensen ST-877 cabinet, $80, local only. Chet Parkinson, 431 N. Encinitas, Monrovia, Calif.

PRESTO TL-10, new, $85. Makes your disc recorder double as a tape player. 2728 Greenfield Ave., Los Angeles 64, Calif.

SELL: ELECTRO-VOICE SP12B speaker, near new, $18. Carl Derossett, 10 Hamilton Way, Columbia, Missouri.

SELL: Radio Craftsmen RC-101 television tuner, less picture tube. Perfect condition, $185, express collect. Ray Kline, Bigelow Apartments, Pittsburgh 19, Pa.

30% DISCOUNT on factory-fresh, guaranteed LP records. Send for free catalog and literature. SOUTHWEST RECORD SALES, Dept. AE, 4710 Caroline, Houston 4, Texas.

FOR SALE: Altec Lansing 800 speaker, bass 803A, treble 802B; H. H. Scott 210-A amplifier; two Livingston Universal arms; Pickering Cartridges, diamond stylus, 1 LP, 1 Std; Rek-O-Kut T-12 table; all mounted; hardly used. Military service transfer forces sale at 92 Cliff Road, Wellesley Hills, Mass. Telephone WE 5-2689.

SALE or TRADE—Fairchild 541A1 cutter, equalizer, microgroove thermostylus attachments—for Hickok 288X, 292X. Box 101, St. Albans, N. Y.

ESSEX COUNTY & NORTHERN NEW JERSEY—BINAURAL is here to stay and we have it! Bring your two ears to our Audio shop for the musical experience of your life. COOK BINAURAL LP's in stock and others. Write for catalog. Audio construction to your specifications. CUSTOM MUSIC SYSTEMS, 225 N. 18th St., East Orange, N. J. ORange 3-3779.

WANTED by collector: Old radio library transcriptions. Premium price for World and Associated library discs. Bob Nicholas, 1012 45th Way, Long Beach 7, Calif.

FOR SALE: Klipsch l.f. horn, $60; Stephens 103LX2 woofer, $45; McProud 15-in. horn, $35; Stephens 824 horn, $20; Stephens Hyson 107 with network, $25; Wharfedale W10CSB, $22; Lansing 208, $15; Partridge WWFB trans., $15; Acrosound 300 trans., $15. All perfect. FOB. Hovland, 151 Hartford Tnpk., Hamden, Conn.

www.americanradiohistory.com

RECORDING TAPE
(PLASTIC BASE)
at NET PRICES
in Cartons of 12

WASHINGTON, D. C.: WHERE ELSE WOULD THERE BE MORE RED *Magnetic* TAPE?

•1200 ft. plastic tape with plastic reel included. Each reel individually boxed. Choice of nationally famous top quality brands such as: Reeves (SPN-12) 3.20; Webcor (2906) 3.20; Audio (1251) 3.23; Scotch (111-A) 3.25; Scotch H.O. (120A) 3.89; Irish, Professional grade (211 RPA) 3.30.

FOR AN INTERESTING HOBBY AND A CHANCE TO EXCHANGE TAPES WITH PEOPLE FROM ALL OVER THE WORLD JOIN:

A. Tape-Respondence International
3488 - 22 St., San Francisco, Calif.
(Fred Gootz, Secretary)
B. Voicespondence Club
1614 N. Mango Ave., Chicago, Illinois
(John Schirmer, Secretary

★★★★★★★★★★★★★★★★★★★★★★★★★★

USED RECORDING TAPE (PLASTIC BASE)

1.99 for 7"—1200 foot
.99 for 5"— 600 foot
.59 for 4"— 300 foot
.29 for 3"— 150 foot
Plastic reels included with all above sizes.

Money cheerfully refunded if you do not find this tape cleanly erased and as good as new. (If you are skeptical and from Missouri send us 12¢ in stamps and we'll roll you a sample.)

New empty plastic reels in boxes for easy labeling, 3" 10¢; 4" 22¢; 5" 24¢; 7" 30¢; 7" Professional reel (2¾" hub) 75¢ ea. EMPTY BOXES: 3" 3¢; 4" 5¢; 5" 5¢; 7" 10¢ ea.

We carry new recorders, recording blanks, tape, tape recorders, etc. at large savings. PLEASE INCLUDE SUFFICIENT POSTAGE.

COMMISSIONED ELECTRONICS CO.
2503 Champlain St. N.W., Washington 9, D. C.

PROFESSIONAL DIRECTORY

Custom-Built Equipment
U. S. Recording Co.
1121 Vermont Ave., Washington 5, D. C.
LIncoln 3-2705

"EVERYTHING IN HIGH FIDELITY"
From Primary Components
to Completed Custom Audio Equipment
KIERULFF
Sound Corp.
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Richmond 7-0271 ZEnith 0271

"WE HAVE IT"
HI-FI COMPONENTS EXCLUSIVELY
HOLLYWOOD ELECTRONICS
7460 MELROSE AVE.
HOLLYWOOD 46
CALIFORNIA
WEBSTER 3-8208

Industry People...

Dr. Pascal Vetterlein, chief engineer of Monske & Co., Hanover, Germany, and designer of the Minifon recorder, in New York for three-week visit. . . . Al Travis, designer of the Tapak portable tape recorder, reports increased business resulting from expanded sales distribution. . . . **A. B. Young, C. C. Bradbury,** and **W. E. Brown** have been appointed district credit managers for Graybar Electric Company in Los Angeles, Seattle, and Minneapolis, respectively.

Dr. Constantin S. Szegho, director of research since 1942, has been appointed vice-president of The Rauland Corporation, Chicago. . . . Entire electronics industry mourning the untimely passing of **Edwin I. Guthman,** coil manufacturing pioneer. . . . **Michael Boris,** formerly with Cline Electric Company, is new assistant factory manager of Simpson Electric Company, both Chicago. . . . **Louis Hausman** has switched from administrative vice-president of CBS Radio to vice-presidency of CBS-Columbia, Inc., where he will be in charge of sales and advertising.

Lawrence J. Cervone has been promoted to general sales manager of Gates Radio Company, Quincy, Ill.—replaced by **John M. Haerle** as head of Gates' New York office—other Gates personnel changes include addition of **Urlin F. Whitman** and **William Wallace Warren** as sales engineers. . . . **Lloyd A. Hammarlund,** president, The Hammarlund Manufacturing Co., Inc., New York, has been elected to the executive board of the Electronic Manufacturers Association, which comprises most of the electronic manufacturers in the New York–New Jersey area.

Otto H. Schade, internationally-known electronics engineer in RCA's tube department, honored with engineering doctorate by Rensselaer Polytechnic Institute—presentation made at commencement exercises during which his son, Otto Jr., was graduated with bachelor of science degree. . . . **Calvin Hugy** is new ad manager in charge of branch operations for The Hallicrafters Company. . . . **Walter M. Jonas** has been elected vice-president in charge of production of Radio City Products Company of Pennsylvania. . . . **Dr. Ralph L. Power** has retired from editorship of "The Transmitter" house organ of Hoffman Radio Corporation—plans to hang out his own public relations shingle after extended South American vacation.

Industry Notes...

Chicago Transformer Division of Essex Wire Corporation announces consolidation with **Standard Transformer Corporation**—new company to be known as **Chicago Standard Transformer Corporation.** Officers are: president, Addison Holton; vice-presidents, Arni Helgason, L. S. Racine, and Jerome J. Kahn, former **Stancor** president; secretary, W. F. Probst, and treasurer, M. A. Roesler. . . . **Ampex Electric Corporation** has organized a new research division under the direction of Dr. Carl Becker, prominent German physicist and audio engineer—developmental work will emphasize stereophonic sound.

Pentron Corporation has leased sales and display space along what is known as the "Fabulous Mile" of Chicago's Michigan Boulevard. . . . **Stephens Manufacturing Corporation** has been signed by **Natural Sound Corporation** to supply all speakers used in the **Kinevox** stereo sound system currently being installed in theaters throughout the country. . . . New York's **Harrison Radio Corporation** has moved Jamaica branch store into larger quarters—new address is 144-24 Hillside Ave. . . . **Freed Radio Corporation,** long known for its famous **Freed-Eisemann** trademark, has changed its corporate title to **Freed Electronics and Controls Corporation.**

FREE CATALOG of TV KITS
LEARN TV
Assemble a TRANSVISION TV KIT in easy stages. Pay as you wire—only $39 for Starting Package #1. Learn while building a superb 17" to 21" screen TV Set with latest features. Ideal for Fringe Areas, adaptable to UHF.
No technical knowledge required.
Catalog describes 6 great TV KITS
Write today to Educational Dept. at:—
TRANSVISION, INC., Dept.AE, NEW ROCHELLE, N. Y.

NOW! output uniformity
with SOUNDCRAFT PROFESSIONAL RECORDING TAPE
it's micro-polished*

Perfect reproduction — *that's the reason* you'll want to use Soundcraft Professional Recording Tape. Every high is crisp, clean —every low clear, full-bodied. Soundcraft Tape is *Micro-Polished;* polished, buffed and re-polished to a glossy smoothness, to produce greater output uniformity, lower distortion, improved high frequency response, better head contact and longer head life.

If you want quality second to none, be sure to ask for Soundcraft Professional Tape . . . the one and only Micro-Polished tape!

REEVES
SOUNDCRAFT
CORP.
Dept. B-7
10 East 52nd Street
New York 22, N. Y.
*PAT. APPLIED FOR

GROMMES
AMPLIFIERS
Model 50 PG
A high fidelity single unit amplifier with [illegible] performance. Power output, 10 watts, 20 watts peak. Distortion at 10 watts, 1% harmonic and 2% intermodulation. Frequency response ± .5 DB, [illegible] 20,000 CPS (± 1 DB, [illegible] 30,000 CPS at 10 watt level
$55.00
Model
215BA
15 Watt
ALL TRIODE BASIC AMPLIFIER
Response 10 to 60,000 CPS. Peak power 24 watts. Distortions at 15 watts, .07% H. and .2% I.M. 25 DB feedback from 3 loops, 2 direct coupled stages, cathode to lower drivers.
$99.50
WRITE FOR CATALOG
PRECISION ELECTRONICS, Inc.
9101 King Avenue, Franklin Park, Ill.

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Thousands Now Enjoy

The **HARTLEY 215** *Loudspeaker*

After Buying Sight Unseen and Sound Unheard

So spectacular was the performance of the Hartley 215, that its reputation soon reached American shores. Inquiries and orders began to pour in from engineers and audio enthusiasts. Wherever the 215 went, it evoked praise. It had everything that was claimed for it . . . and more. The clean crispness of its low frequencies, the natural smoothness over the entire audible spectrum, the freedom from strident 'highs', all added up to a thrilling new experience in listening enjoyment.

So rapidly did the story of the Hartley 215 get around, that within a very short time several thousands of orders were filled to American users . . . without the benefit of a single American outlet through which the British Hartley Company could show or demonstrate its speaker.

To meet this growing demand, an American Company has now been organized, and it will not be very long before Hartley products will be available through franchised dealers throughout the entire United States.
Net price $57.50

For complete information regarding the Hartley 215, and the new Boffle Speaker Enclosure, Preamplifier, and Main Amplifier, write to Department AE-f

Prices slightly higher West of the Rockies

HT

H. A. HARTLEY CO., INC.
521 East 162nd Street, Bronx 51, N. Y.

Now ready for immediate shipment

The 2nd Audio Anthology

No bigger, no better than the original Audio Anthology—in fact, it's just the same size and a perfect companion to the most authoritative book you now have on the subject of home music systems. But it contains all new material—reprints of over forty of the valuable articles which have most interested Æ's readers during the past two and a half years.

Features—
- Amplifiers
- Preamplifiers
- Tone Controls
- Phonograph Equipment
- Loudspeakers
- Speaker Enclosures
- Tape Recorder Amplifiers

Customary discounts to distributors.

Board Cover . . . . **$3.00** **Paper Cover** . . . **$2.00**

————————————CUT OUT—MAIL TODAY————————————

Book Division,
Radio Magazines, Inc.,
P. O. Box 629, Mineola, N. Y.

Sirs: Enclosed is my ☐ check ☐ money order for . . . . copies of the **2nd Audio Anthology.**

(Please check one) ☐ Board Cover ☐ Paper Cover

Name (print carefully) . . . .

Address . . . .

City . . . . Zone . . . . . State . . . .

ADVERTISING INDEX

AT LAST!

no more unscheduled program breaks!

irish SOUND-PLATE

AN ENTIRELY NEW MAGNETIC RECORDING TAPE

It's break-proof . . . just what you've been wanting

(Produced and Sold Under the IRISH Label as 220RPA Red Band ORRadio Magnetic Tape)

No Other Tape Matches These Sound-Plate Features:

- **SOUND-PLATE** has two times the tensile strength of acetate
- **SOUND-PLATE** will not tear or break
- **SOUND-PLATE** eliminates timing problems —programs on the nose
- **SOUND-PLATE** is unaffected by moisture or temperature change
- **SOUND-PLATE** is engineered for high speed operation, 15 to 500" per sec
- **SOUND-PLATE** is not affected by static
- **SOUND-PLATE** has a greater surface slip

Another Reason WHY SOUND-PLATE is Best For Professional Use!

There are differences in magnetic oxides. ORRadio molecular lubricated oxides are more stable in coating conditions and turn out more uniform dispersions, thus assuring you of the finest recordings possible. SOUND-PLATE is made in the ORRadio tradition.

Here, at last, the sum total of everything you have ever wanted in a professional magnetic recording tape. ORRadio IRISH 220RPA SOUND-PLATE eliminates your physical problems in magnetic tape recordings. It won't tear or break. It has all the excellent qualities that have made ORRadio IRISH 211RPA the most popular tape among professional engineers.

Yes, SOUND-PLATE costs a little more . . . but, in the long run, it will prove to be not only the most satisfactory, but the most economical magnetic recording tape you can use.

Try SOUND-PLATE at our expense! Buy a reel of SOUND-PLATE at your favorite Radio Parts Distributor. If you are not completely satisfied, return it to your distributor who has been authorized to refund your money.

1200 Ft. SOUND-PLATE on Plastic Reel .... **$15.50 List**

2400 Ft. SOUND-PLATE on Metal Reel **$33.85**

SOUND RECORDING
REG. U. S. PAT. OFF.

ORRADIO INDUSTRIES, INC. OPELIKA, ALABAMA

World's Largest Exclusive Magnetic Tape Manufacturer

Export Division: MORHAN EXPORTING CORP., 458 B'WAY., N. Y. 13, N. Y.

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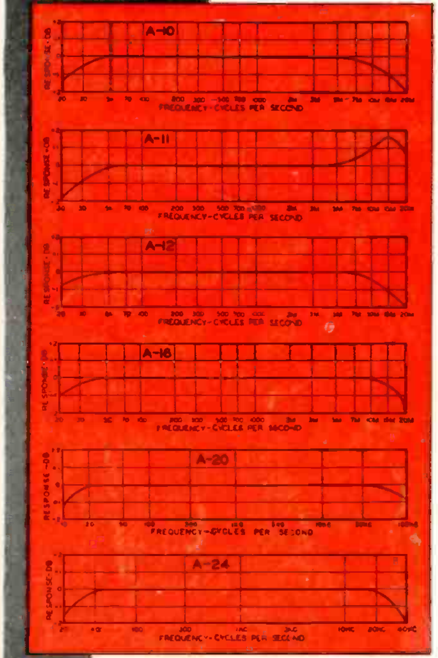
ULTRA COMPACT UNITS...OUNCER UNITS

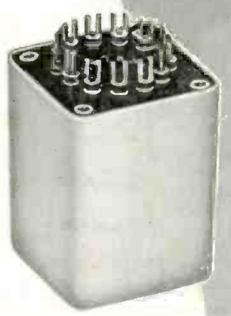
HIGH FIDELITY . . . . SMALL SIZE . . . . FROM STOCK

UTC Ultra compact audio units are small and light in weight, ideally suited to remote amplifier and similar compact equipment. High fidelity is obtainable in all individual units, the frequency response being ± 2 DB from 30 to 20,000 cycles.

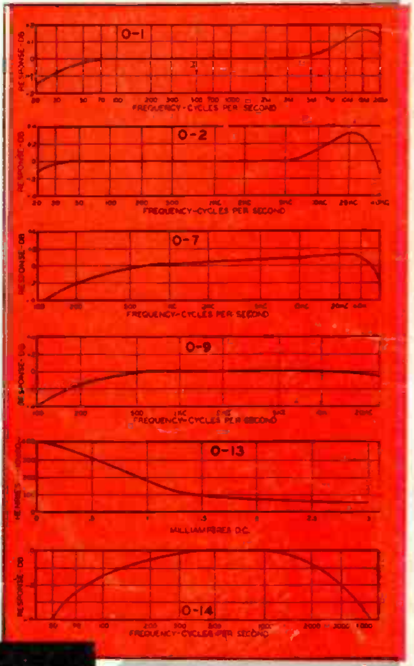
True hum balancing coil structure combined with a high conductivity die cast outer case, effects good inductive shielding.



Type No.	Application	Primary Impedance	Secondary Impedance	List Price
A-10	Low impedance mike, pickup, or multiple line to grid	50, 125/150, 200/250, 333, 500/600 ohms	50 ohms	$16.00
A-11	Low impedance mike pickup, or line to 1 or 2 grids (multiple alloy shields for low hum pickup)	50, 200, 500	50,000 ohms	18.00
A-12	Low impedance mike pickup, or multiple line to grids	50, 125/150, 200/250, 333, 500/600 ohms	80,000 ohms overall, in two sections	16.00
A-14	Dynamic microphone to one or two grids	30 ohms	50,000 ohms overall, in two sections	17.00
A-20	Mixing, mike, pickup, or multiple line to line	50, 125/150, 200/250, 333, 500/600 ohms	50, 125/150, 200/250, 333, 500/600 ohms	16.00
A-21	Mixing, low impedance mike, pickup, or line to line (multiple alloy shields for low hum pickup)	50, 200/250, 500/600	200/250, 500/600	18.00
A-16	Single plate to single grid	15,000 ohms	60,000 ohms, 2:1 ratio	15.00
A-17	Single plate to single grid 8 MA unbalanced D.C.	As above	As above	17.00
A-18	Single plate to two grids. Split primary.	15,000 ohms	80,000 ohms overall, 2.3:1 turn ratio	16.00
A-19	Single plate to two grids. 8 MA unbalanced D.C.	15,000 ohms	80,000 ohms overall, 2.3:1 turn ratio	19.00
A-24	Single plate to multiple line	15,000 ohms	50, 125/150, 200/250, 333, 500/600 ohms	16.00
A-25	Single plate to multiple line 8 MA unbalanced D.C.	15,000 ohms	50, 125/150, 200/250, 333, 500/600 ohms	17.00
A-26	Push pull low level plates to multiple line	30,000 ohms plate to plate	50, 125/150, 200/250, 333, 500/600 ohms	16.00
A-27	Crystal microphone to multiple line	100,000 ohms	50, 125/150, 200/250, 333, 500/600 ohms	16.00
A-30	Audio choke, 250 henrys @ 5 MA 6000 ohms D.C., 65 henrys @ 10 MA 1500 ohms D.C.			12.00
A-32	Filter choke 60 henrys @ 15 MA 2000 ohms D.C., 15 henrys @ 30 MA 500 ohms D.C.			10.00



TYPE A CASE
1½" x 1½" x 2" high



UTC OUNCER components represent the acme in compact quality transformers. These units, which weigh one ounce, are fully impregnated and sealed in a drawn aluminum housing ⅞" diameter... mounting opposite terminal board. High fidelity characteristics are provided, uniform from 40 to 15,000 cycles, except for 0-14, 0-15, and units carrying DC which are intended for voice frequencies from 150 to 4,000 cycles. Maximum level 0 DB.

OUNCER CASE
⅞" Dia. x 1⅛" high

Type No.	Application	Pri. Imp.	Sec. Imp.	List Price
0-1	Mike, pickup or line to 1 grid	50, 200/250 500/600	50,000	$14.00
0-2	Mike, pickup or line to 2 grids	50, 200/250 500/600	50,000	14.00
0-3	Dynamic mike to 1 grid	7.5/30	50,000	13.00
0-4	Single plate to 1 grid	15,000	60,000	11.00
0-5	Plate to grid, D.C. in Pri.	15,000	60,000	11.00
0-6	Single plate to 2 grids	15,000	95,000	13.00
0-7	Plate to 2 grids, D.C. in Pri.	15,000	95,000	13.00
0-8	Single plate to line	15,000	50, 200/250, 500/600	14.00
0-9	Plate to line, D.C. in Pri.	15,000	50, 200/250, 500/600	14.00
0-10	Push pull plates to line	30,000 ohms plate to plate	50, 200/250, 500/600	14.00
0-11	Crystal mike to line	50,000	50, 200/250, 500/600	14.00
0-12	Mixing and matching	50, 200/250	50, 200/250, 500/600	13.00
0-13	Reactor, 300 Hys.—no D.C.; 50 Hys.—3 MA. D.C.,		6000 ohms	10.00
0-14	50:1 mike or line to grid	200	½ megohm	14.00
0-15	10:1 single plate to grid	15,000	1 megohm	14.00

United Transformer Co.

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

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