AUDIO ENGINEERING

NOVEMBER
1949
Conlon
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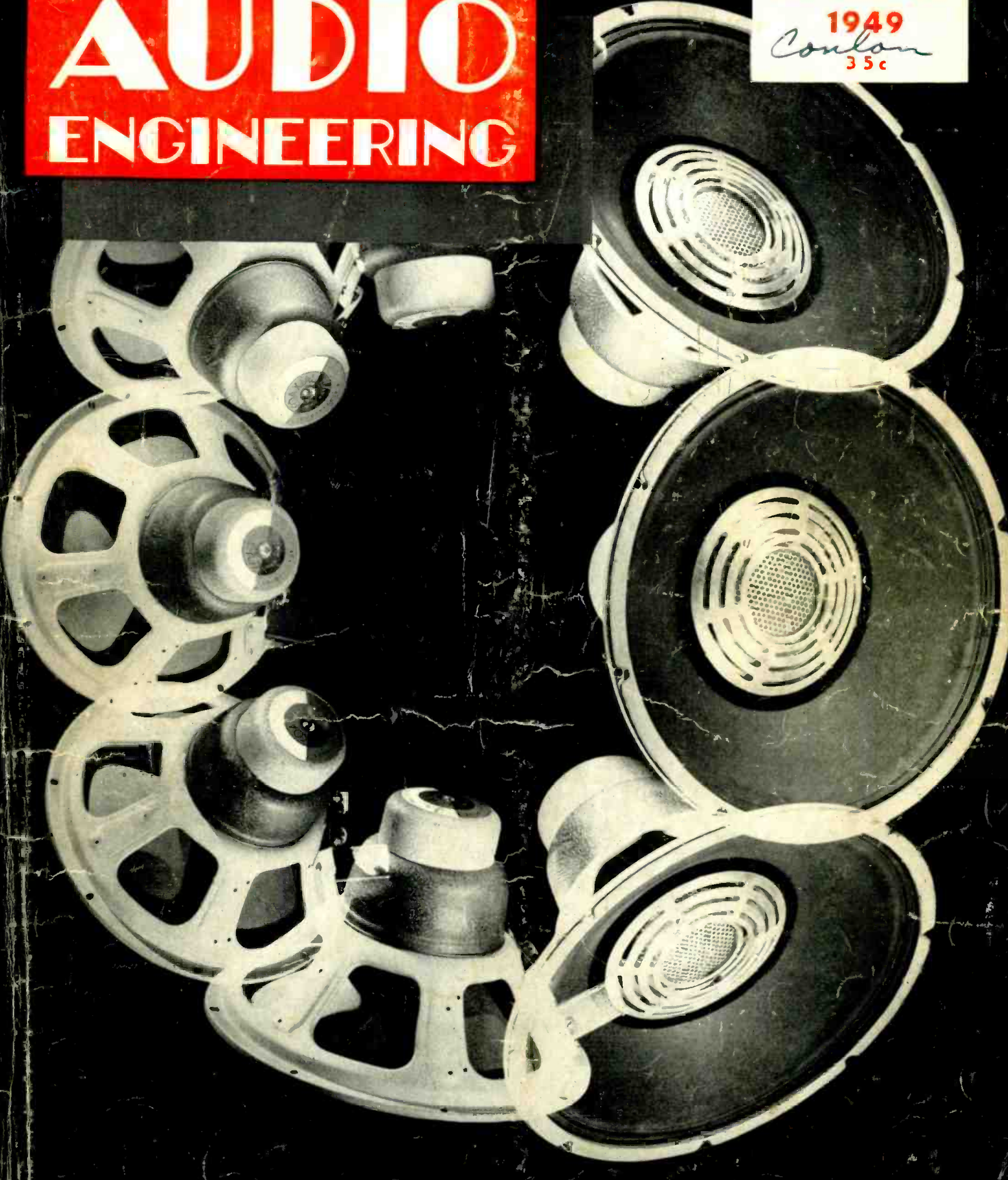

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NOVEMBER, 1949 — Vol. 33, No. 11

COVER

Montage of the new Jensen H-510 loudspeakers. This model employs a direct radiator cone for the low frequencies and a separate high-frequency horn and driver for the high channel. As in optics, the acoustic lens with the central opening and offset circumferential slots controls time delay by progressively increasing the acoustic ray path from the center to the edge of the lens. This use of an optical lens principle produces a polar pattern that is uniform over an unusually wide angle.

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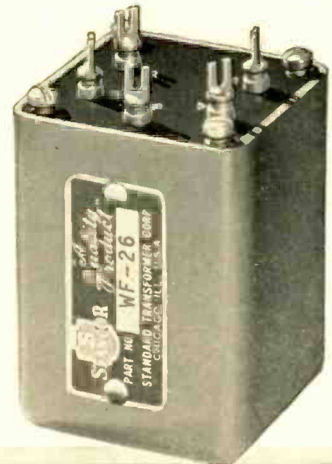
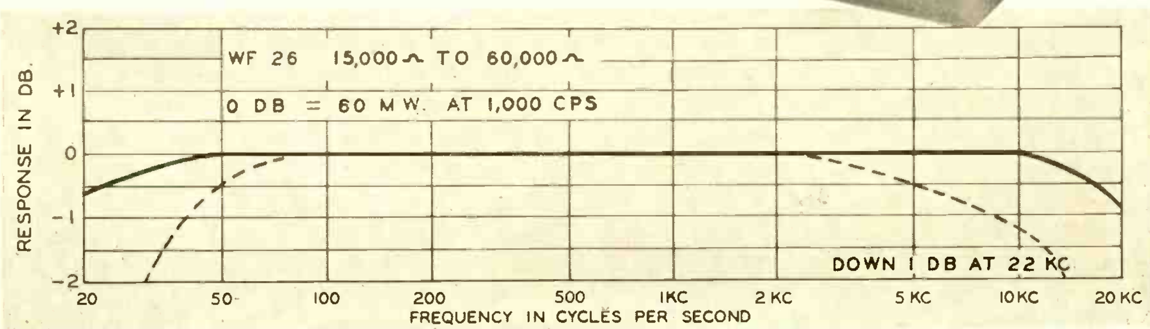
High Fidelity in small space



Companion series to the outstanding "HF" line, Stancor's compact "WF" transformers are designed for applications that demand the combination of high fidelity response with economy of space.

Superior construction including nickel alloy laminations results in a guaranteed response within ±2 db from 30-20,000 cycles. All units, except those carrying DC in the primary winding, employ a hum-balanced coil structure and/or internal, high permeability, magnetic shielding to minimize hum pickup from an external field. Cast cases, measuring only 1½" x 1½" x 2", provide adequate shielding together with an attractive finish that adds to the appearance of your apparatus. Cases are tapped for top or bottom mounting and lug terminals are provided on a permanently marked phenolic panel.



● The dotted line indicates the performance of a competitive brand equivalent unit tested under identical conditions.

STANCOR WF Series

Part Number	Application	Primary Impedance In Ohms	Secondary Impedance In Ohms	Response ±2 DB From
	INPUT			
WF-20	Low Impedance Microphone, Pickup or Multiple Line to Single Grid	50, 125/150, 200/250, 333, 500/600	50,000	30-20,000
WF-21	Low Impedance Microphone, Pickup or Multiple Line to Single or P.P. Grids	50, 200, 500	50,000	50-20,000 Multiple alloy shield for extremely low hum pickup
WF-22	Low Impedance Microphone, Pickup or Multiple Line to P.P. Grids	50, 125/150, 200/250, 333, 500/600	80,000 overall, in two sections	30-20,000
WF-24	Dynamic Microphone to Single or P.P. Grids	30 ohms	50,000 In two sections	30-20,000
	INTERSTAGE			
WF-26	Single Plate to Single Grid	15,000 ohms	60,000, 2:1 turns ratio	30-20,000
WF-28	Single Plate to P.P. Grids. Can use split pri. for P.P. Plates	15,000 ohms	80,000 overall. 2.3:1 turns ratio overall	30-20,000
	MIXING			
WF-30	Low Impedance Mixer, Microphone, Pickup or Multiple Line to Multiple Line	50, 125/150, 200/250, 333, 500/600	50, 125/150, 200/250, 333, 500/600	30-20,000
	LOW LEVEL OUTPUT			
WF-34	Single Plate to Multiple Line	15,000	50, 125/150, 200/250, 333, 500/600	30-20,000
WF-36	P.P. Low Level Plates to Multiple Line	30,000 Plate to Plate	50, 125/150, 200/250, 333, 500/600	30-20,000
WF-35	Single Plate to Multiple Line Primary DC 8.0 ma	15,000	50, 125/150, 200/250, 333, 500/600	50-20,000

WE WELCOME COMPARISON, under identical test conditions, of Stancor "WF" units with equivalent types of any other brand of high fidelity transformer, regardless of published claims. Frequency response curve charts sent on request.

STANCOR

For complete information on the Stancor "WF" series and the larger "HF" units, see your Stancor radio parts dealer or write for the 1949 Stancor catalog B, listing over 400 transformers and related components for sound, radio and television.

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Somerset Laboratories offer a new High Definition 12 watt AMPLIFIER with the SOMERSET Dynamic NOISE SUPPRESSOR — the last Link in High Fidelity Reproduction — a combination having unusual performance characteristics and giving the finest in High Fidelity Reproduction.

Claims of high quality audio amplifiers based only on a showing of frequency response beyond audible limits or low distortion and noise percentages evidence engineering skill, but do not guarantee High quality Reproduction.

Such an Amplifier may accentuate defects of the program source or distortions originating within the loudspeaker. The use of tone controls to offset these effects may degenerate performance and the High Fidelity characteristics are virtually unuseable.

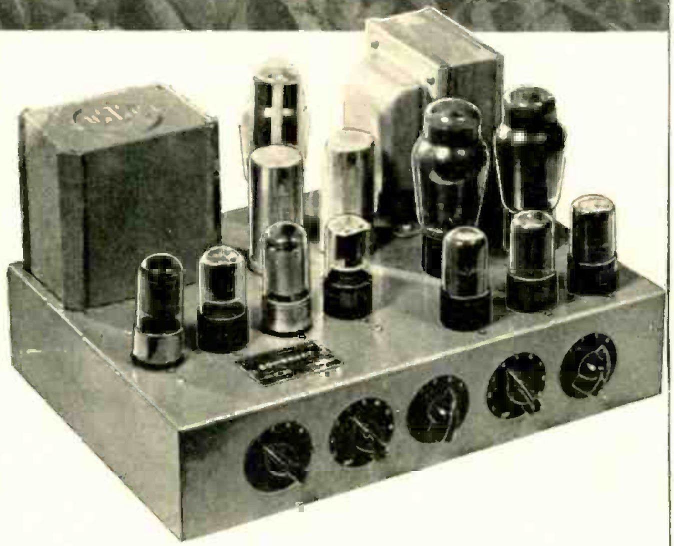
The SOMERSET FEEDBACK AMPLIFIER was designed not as a laboratory exhibit but as the controlling unit in the reproducing system. Its performance with respect to frequency response, and distortion is superb. In addition it has the ability,

First—To reject unwanted portions of the input signal,

Second—to subject the loudspeaker to a rigid discipline the consequence of which is Reproduction with perfect definition.

These outstanding qualities are produced by the SOMERSET DYNAMIC NOISE SUPPRESSOR and a UNIQUE MULTIPLE FEEDBACK CIRCUIT whereby the Amplifier acquires a more perfect control of the movements of the loudspeaker diaphram throughout the audible range.

In this CIRCUIT beam power tetrodes are used in a manner which greatly reduces output impedance. Extraordinarily effective loudspeaker damping and substantial improvement in bass tone response are obtained without distortion or intermodulation. Thus, even inexpensive loudspeakers become capable of high quality reproduction rarely equalled by the most costly equipment.



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EDITOR'S REPORT

EDITORIALS are accepted as a necessity in most magazines—for some obscure reason—and are usually regarded as an outlet for the ideas of the magazine's staff. This is not always so in our case, for no one can presume to know exactly all the needs of an industry, and many of the ideas presented herein are effectively "borrowed" from letters. Such was the case last month, with the original idea about furniture cabinets being gleaned from a letter by Milton J. Lichtenstein; such is the case again this month, with John van Heijenoort furnishing the motivation.

While some form of cabinet is necessary to house a residence radio system, and while myriads of amplifiers are described for home construction and many more are available commercially, the list of acceptable radio tuners is relatively small. And not all of those that are available commercially are ideally adaptable for home usage.

Among desirable features of tuners—either FM or AM—should be listed a self-contained filament supply. Sufficient plate current can usually be furnished by conventional amplifiers, but most of them will not provide the additional three to four amperes of filament current for a modern FM or combination FM-AM tuner.

Another desirable feature—available on some tuners—is the automatic frequency control circuit. Mistuning of an FM receiver can result in considerable distortion, and even though correctly tuned in the first place, warm-up drift may cause an increase in distortion. Since a control voltage is obtainable from the discriminator without the addition of any components of importance, the extra cost can usually be due only to a redesign of the oscillator circuit to include a reactance tube. These two features should be adequate to simplify residence radio installations immeasurably.

RECORDED MUSIC ENTHUSIASTS

Congratulations to the newly formed New York Society of Recorded Music which already has some fifty members who meet bi-weekly and listen to programs arranged from their individual record collections. Peter Hugh Reed, noted critic and publisher of the American Record Guide, was drafted as president and is active in promoting the organization. The first few meetings were held in the Music Room of the New York Public Library, but the need for more space and a later closing hour made it desirable to hold future meetings at St. John's Auditorium, 224 Waverly Place, in Greenwich Village. The next meeting is scheduled for the evening of November 17th, and all interested in recorded music are invited to attend.

James B. Lansing

A letter recently received from friend and contributor Ross H. Snyder of KJBS, San Francisco, brought sad news and a tribute which expresses the sentiment of many of us in words which need no improvement.

With the death on the 30th of September this year of James B. Lansing, the industry and those who knew and loved him have suffered an incalculable loss.

Jim was more than a brilliant engineer: he was an artist of the first order. That his field was the creation of fine machinery in no way diminishes the stature of his art. Impatient of mediocrity to the point that he threw aside personal gain time after time, Jim lived and died in the grip of a fierce ideal. His contributions to the art of re-creating sound were not confined to the inventive genius he applied to the developments of the 'thirties' nor to the products which bore his name, but were extended and multiplied by those whom he infected with his enthusiasms.

On the day before his death, Jim was laying plans for the writing and publication of a work which was to have incorporated the knowledge with which he implemented his art. He felt keenly the responsibility of communicating this to others, and deeply regretted that the pressures of active creation which drove him so relentlessly had prevented that communication, now lost.

The loss of the kind gray man whose devotion to an artistic and scientific ideal was matched only by the depth of his own warm humanity is a bitter tragedy.

— Letters —

Figures-of-Merit

Sir:

I have just noted Mr. Powell's suggestion for a driver figure-of-merit with interest. While there are many factors which govern the merit of tubes as adequate drivers for a given power amplifier, Mr. Powell is to be commended for suggesting the product of the grid bias and amplification factor. As Mr. Powell points out, his figure-of-merit is somewhat oversimplified and is therefore valid only when the "all-other-factors-the same" condition exists. It appears that a more reliable figure-of-merit for driver tubes might be the product of the grid bias and the transconductance rather than grid bias and amplification factor. Thus the plate resistance, which is a significant factor in a tube's ability to deliver adequate undistorted output, is also taken into consideration.

This can be illustrated by considering a tube such as a 6N7 for driver duty. One section of this tube may be used separately as a driver, or the two sections may be operated in parallel. In either case, the recommended grid bias as well as the amplification factor remain unaltered, indicating no change in the merit of the combination as a driver. However, the effective plate resistance of the two sections in parallel is only one-half of either section alone, which results in doubling the transconductance. The reduction in effective generator impedance therefore results in a larger output voltage for a given load resistance.

Since the dimension of the grid bias—transconductance figure-of-merit is that of a current, which represents the maximum possible signal current available in the plate circuit, it is necessary only to multiply this figure-of-merit by the effective load impedance offered to the tube to determine the maximum possible drive available to the power output stage.

The revised "figures-of-merit" for the tubes mentioned by Mr. Powell and his own "figures-of-merit" are tabulated below for purposes of comparison.

Tube Type	$E_c g_m$ (ma)	$E_c \mu$ (volts)
27	20.5	189
76 or 6P5	19.5	186
½-6SN7 or 6J5	20.8	160
½-6N7	15.5	210

It is observed that the table indicates that the 6SN7 is somewhat superior to the 6N7.

In conclusion, it appears that one must consider other factors in addition to the ones mentioned by Mr. Powell (non-linearity and hence intermodulation distortion, etc.) in choosing the most suitable tube for a driver. For example, a choice based on any figure-of-merit defined so far may lead to a tube exhibiting power-output capabilities far greater than the tubes chosen for the output stage. It is believed, however, that a figure-of-merit defined as the product of grid bias and transconductance may prove a more adequate index of a tube's ability as a driver for power output audio stages since it includes an additional factor—the plate resistance of the tube.

William J. Kessler,
Project Engineer,
Engrg. & Ind. Experiment Station
University of Florida,
Gainesville, Florida.

ANNOUNCEMENT

To users of Western Electric Microphones, Loudspeakers and Disc Reproducing Equipment

Effective October 1, 1949, the Western Electric Company has discontinued the sale, servicing and maintenance of sound system products, including the following major items:

Microphones

633 Type
639 Type

Loudspeakers

728B
755
757

Reproducing Equipment

109 Type Reproducer Group
9A Reproducers
9B Reproducers

To assure uninterrupted service and maintenance to owners of these products, we have entered into an agreement, effective Oct. 1, 1949, with the ALTEC LANSING CORPORATION of Hollywood, California. Under the terms of this agreement the Altec Lansing Corporation receives all necessary engineering information, as well as our inventory of the above equipments and their parts, and will make available service, maintenance, repair and replacement parts for the products listed.

The Graybar Electric Company will act as distributor for the Altec Lansing Corporation, as it has for Western Electric, in serving customers' needs on these equipments, under terms of an agreement recently concluded between the Graybar Electric Company and the Altec Lansing Corporation.

The leadership and integrity of the Altec Lansing Corporation make us completely confident that all users of the Western Electric equipments listed will continue to have available to them service of the very highest quality.

F. R. Lack
Vice President

Western Electric Company
INCORPORATED

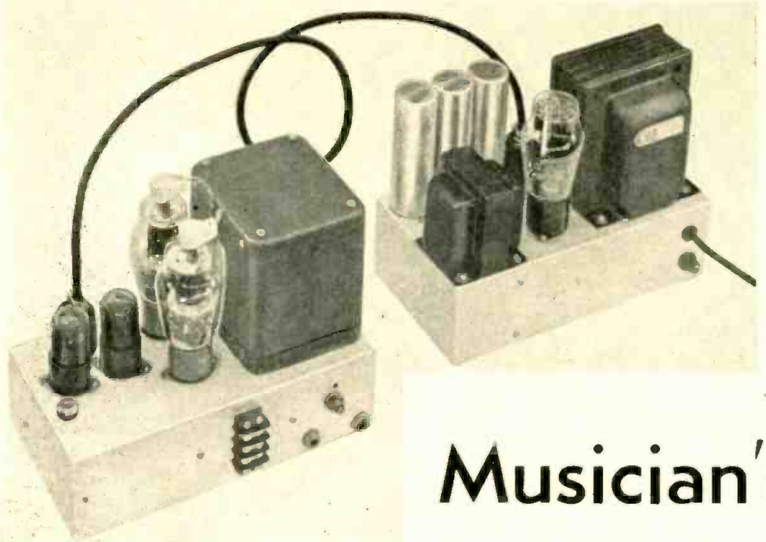

Fig. 1. The two chassis comprising the amplifier patterned after the "Williamson."

DAVID SARSER*

and

MELVIN C. SPRINKLE**

Musician's Amplifier

An adaptation of a famous English circuit which has already earned an enviable reputation for quality.

Amplifiers are something like women—there are a lot of 'em. And—like women—amplifiers come in all sizes, shapes, and degrees of appeal. The readers of radio magazines have seen dozens of different amplifier designs, and audio enthusiasts are as vociferous in praise of their pet circuits as Kentucky colonels about their pet way of making a mint julep.

The writers of this article—one a professional violinist in Toscanini's NBC Symphony, owner of the famous Lamoreux Stradivarius, and a builder of amplifiers, the other a professional electronic engineer whose avocation is serious music—have both made a baker's dozen of amplifiers, but have felt that most of these amplifiers in one way or another never completely recreated a satisfactory "studio sound."

The writers, then, have pooled their resources and have come to the conclusion that there should be a simple, easy-to-make, and thoroughly foolproof circuit which gives out with that intangible something called "presence effect." In doing so, we are going to duck controversies regarding beam-power tubes versus triodes, transformers versus resistance coupling, and all the other perennial areas of enthusiastic conflicts and ideologies. All we're really after—how simple it sounds!—is to reproduce music in the home which sounds the same way it does in the concert hall or broadcast studio.

Recently, we heard about the "Williamson" circuit which has been widely publicized in England and Australia as the absolute tops for obtaining natural reproduction. It was written up in *Wireless World* (an English publication) for April and May, 1947. This circuit has become so popular in England that it was reprinted with minor modifications in the August, 1949, issue of the *Wireless World*.

Having studied the Williamson circuit and having read the comments on its intermodulation distortion in Audio Engineering for September, 1948, we became interested in the possibilities of the amplifier.

Strictly from the technical point of view, the output tubes are 807's with triode connection. The 807 has much to recommend it as an audio tube. It is a standard type, available everywhere, and though it is usually considered to be a transmitting tube, its price makes it no more expensive than other tubes used by amplifier constructors. It has a fairly high plate dissipation, and draws enough plate current to provide adequate audio power. It is a cathode type, rather than direct heated and hence the completed amplifier has no hum even when used with efficient speakers with fine bass response such as the Altec Lansing 604B.

The output transformer presented somewhat of a problem as the original circuit called for a transformer not manufactured in this country. If it were specially made to Williamson's specifications the cost would be prohibitive. A careful survey and trial on various transformers available through jobbing channels disclosed that one transformer—the Peerless S-265Q—would best meet the rigid specifications for performance.

The resistance network in the cathode circuit of the 807 tubes contains a variable resistor P_1, which is set to give equal current in each tube. A closed circuit jack is provided in the cathode circuit of each 807 to permit insertion of a milliammeter when making this adjustment, and the plate current should be balanced by P_1 to exact equality, at 50 ma per tube.

The original Williamson diagram contained a series resistor to adjust the total plate current drain of both tubes. After building several of these amplifiers it was decided to omit this control and substitute a fixed resistor, since once it is set it is never changed.

The driver stage consists of a single 6SN7GT tube connected in push pull and resistance coupled to the 807's. Here one of the points of superiority of the 807 is evident. Most low-mu triodes such as the 2A3 and its six-volt counterpart, the 6B4G, have a high bias of the order of 60 volts and, hence, require a driver stage capable of putting out signals whose peak values are of this magnitude. As a result, resistance coupling to low-mu triodes is not practicable unless elaborate precautions are taken to supply adequate driving voltage with low distortion, a difficult task. The triode-connected 807 requires about 35 volts bias and thus the use of 6SN7 as a driver becomes practical. The first two stages are unique as they consist of a single 6SN7 tube using the first section as a voltage amplifier which is directly coupled to a "cathodyne" or split load type of

* 548 *Riverside Drive, New York 27, N. Y.*
** 5 *Melrose Ave., Bergenfield, N. J.*

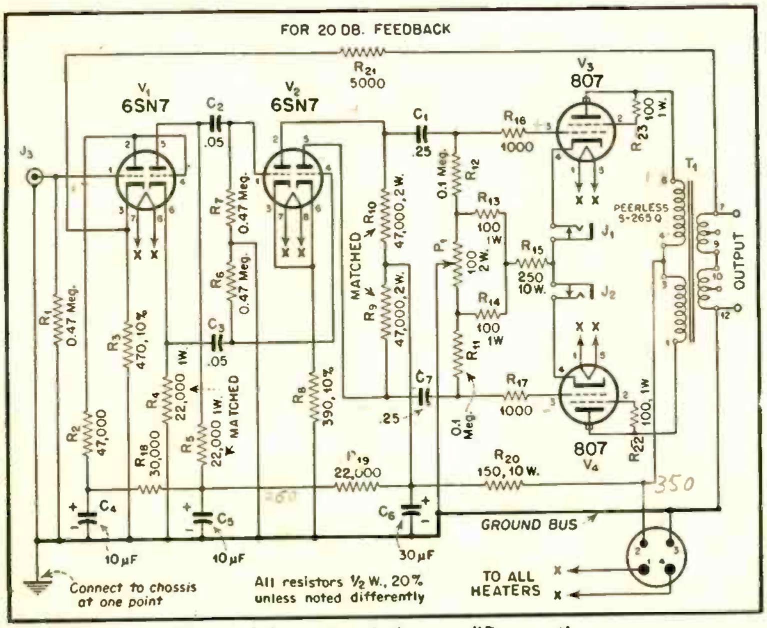

Fig. 2. Schematic of the amplifier section.

phase inverter. Use of this type of phase inverter permits direct coupling, as the positive voltage on the phase inverter grid is offset by the high positive voltage on its cathode. Direct coupling to the phase inverter permits the extension of the low-frequency response in this stage to d.c. and eliminates coupling networks which can cause phase shift and low-frequency attenuation. It will be seen from the schematic, *Fig*. 2, that there are only four coupling capacitors in the entire amplifier, two on each side of the push pull system. Thus the response of this amplifier at low frequencies is remarkably good.

Inverse Feedback

It will be noted that inverse feedback is used in this amplifier. Inverse feedback has been used with beam power amplifiers, but the circuit is not confined to this type of amplifier. Our amplifier incorporates approximately 20 db of feedback which is put around four stages and the output transformer. With this much feedback there is absolutely no trace of supersonic or subaudible oscillation, a tribute to the design of the output transformer. Feedback greatly improves the linearity and response of the amplifier and reduces the source impedance looking back into the output terminals to the unbelievably low figure of about ⅔ of an ohm on the 16-ohm output tap. When this amplifier is used with highly damped, high-efficiency speakers, the clarity of reproduction is more than satisfactory.

In connection with source impedance, there are two schools of thought. One group holds that the source impedance should be made as low as possible by using triode tubes, by the use of inverse feedback, or possibly both. The other group maintains that the source impedance should be low, but not necessarily as small as possible—their claims being based upon listening tests. This second group feels that a representative value of source impedance should be from 0.5 to 1.0 times the load impedance; thus on a 16-ohm tap the source impedance would be between 8 and 16 ohms. This amplifier has been constructed so that the source impedance is very low and those persons who prefer a slightly higher value may increase the feedback resistor (R-21) to approximately 22,000 ohms, or they may insert a resistor in series with the speaker voice coil should they prefer to retain the effects of the high feedback in this amplifier.

The power supply, *Fig*. 3, is built on a separate chassis to eliminate hum and also to provide a more compact construction, which simplifies installation. It is conventional with the exception that high grade 600-volt oil-filled capacitors are used in the filter. The recommended power transformer is designed for continuous operation with a drain of 200 ma in the plate supply. In practice it is found that after the amplifier has been on all day the transformer is just moderately warm.

Construction Details

Construction of this amplifier is simple. The amplifier and power supply are both placed on a 5 x 10 x 3 chassis; there is plenty of room for parts with complete accessibility for service should it be required. All resistors and capacitors are mounted on a terminal strip which is mounted on one side of the chassis as shown in *Fig*. 4. This type of construction, long used by professional amplifier builders, has been much neglected by amateur constructors and its use is encouraged to provide neatness as well as ease of construction and repair.

In order to reduce hum and undesired coupling between stages to a minimum, a grounding bus is used. This begins in the amplifier where the B— from the power supply enters the chassis, connects to the grounded side (terminal 12) of the output transformer secondary and then is carried along on the terminal strip toward the input, picking up cathode circuits and filter capacitor cans as it goes. It is grounded to the chassis at only one point near the input connector. Use of a grounding bus in amplifiers is also well known to professionals, and a large part of the difficulties encountered by amateur constructors is due to haphazard ground connections. The layout of parts is shown in *Fig*. 5.

At this point it might be well to review a few of the beliefs held by amateur constructors of amplifiers. Many amplifier designs which have appeared in magazines have had their virtues

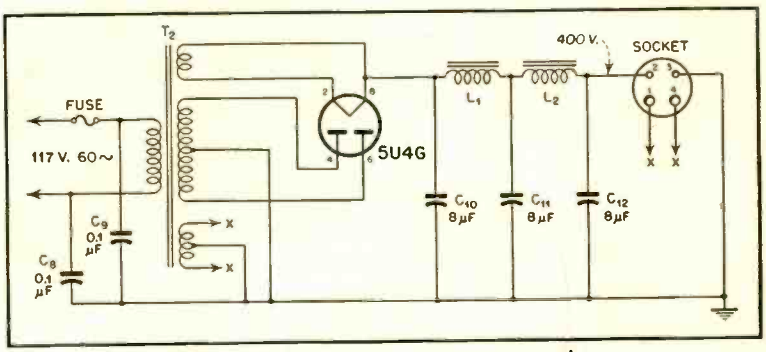

Fig. 3. Schematic of the power supply.

extolled solely on the basis of frequency measurements. The measurement of frequency response is an important property of an amplifier, but it is not the *only* property which contributes to naturalness in the reproduced sound. Frequency response is a measure of how the gain of the amplifier changes as a function of frequency. If, for example, the absolute gain is 75 db at 1,000 cps and 70 db at 10,000 cps, then the amplifier is said to be down 5 db at 10,000 cps. For this reason frequency response measurements are usually made at low output levels.

Power Output vs. Frequency

One important property of an amplifier which has long been neglected in the previous literature on the subject is power output at various frequencies. Magazine articles and manufacturers' literature will state that an amplifier will put out "10 watts." Sometimes they state the frequency and the degree of distortion that was present when this measurement was made. The importance of power output over the audible spectrum is so great that it cannot be over-emphasized, and it is this factor which is to a large degree responsible for naturalness of reproduction and freedom from distortion. Full power output over a wide band of frequencies is largely determined by the output transformer, the most important component in an audio amplifier.

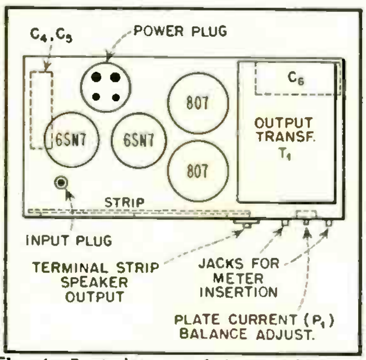

Fig. 4. Parts layout of the amplifier on a 5 x 10 chassis.

The manufacturers of output transformers more often than not fail to make any statement as to the power output of amplifiers using their transformers at various frequencies. Regarding the transformer we used, the manufacturer states that the output will be down no more than 3 db from midrange power at 20 cps and at 20,000 cps. Audio enthusiasts who make measurements of power at various frequencies from 20 to 20,000 cps would be amazed to see the very poor power characteristic of a favorite amplifier.

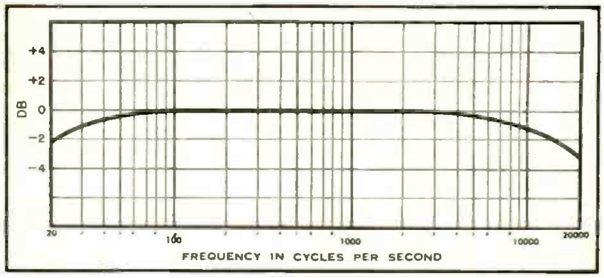

Fig. 6. Relative power output with respect to frequency.

Performance

The absolute gain of this amplifier, with about 20 db of feedback, is 70.8 db. The frequency response was measured by feeding in a signal at constant level from an audio oscillator, the signal being fed through a series resistor of 500,000 ohms which is equal to the input impedance of the amplifier. This is the customary way of measuring amplifiers professionally. The output was measured across a 16-ohm non-inductive resistor and high grade meters were used which had a minimum of frequency error. Under these conditions the amplifier is flat from 20 to 80,000 cps. There is a rise of 3.4 db at 96,000 cps and the output begins to fall at about 100,000 cps. In the revised article, Mr. Williamson states that his amplifier is flat from 20 to 100,000 cps, but he does not state the manner in which the response was measured.

The amplifier performs exceptionally well when tested with square waves. This test consists of feeding square waves into the input and observing the wave form on an oscilloscope at various points throughout the circuit. If the output waveforms have sharp corners and no tilt on top and bottom the following things can be said about the amplifier:

1. The frequency response is flat to at least 20 times the fundamental frequency of the square waves.
2. There is no time delay; i.e., the phase shift through the amplifier is proportional to frequency.
3. There is no spurious oscillation produced by steep-wave-front signals, such as the usual music and speech programs.

Square wave testing is a sensitive method of testing amplifiers, especially with regard to phase shift, and it was found that this amplifier passed without distortion square waves having fundamental frequencies from 20 cps to 5,000 cps. These signals were passed through the entire amplifier and not just one stage. This confirms the frequency-response measurements and showed that there is uniform time delay for all frequencies between 20 and 100,000 cps. It is entirely possible that the startling realism in reproduced music is due to the excellent phase characteristics of the amplifier, as a non-linear phase characteristic disturbs the arrangement of harmonics in complicated signals such as program material.

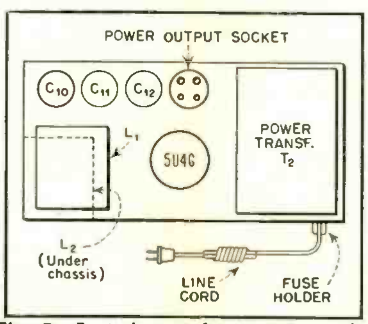

Fig. 5. Parts layout for power supply.

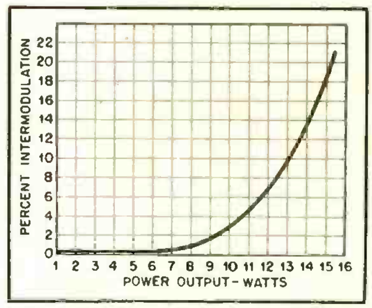

Fig. 7. Intermodulation distortion curve plotted against power output.

Mr. Williamson does not state the power characteristics of his amplifier, but does say that the power output is 15 watts. As our output tubes are not exactly the same as the KT66 valves originally used, we cannot make accurate comparison, but with 807 tubes and a 400-volt plate supply it will deliver 12.2 watts to the load resistor at 1,000 cps at 7 per cent intermodulation distortion. As may be seen from *Fig.* 6, the power begins falling off at low frequencies and is approximately 0.7 db down at 40 cps and 2.1 db down at 20 cps. It is down 2.1 db from full power at 15,000 cps and down 3 db at 20,000 cps. This power curve on the surface may appear to be excessive, but tests run by the authors on several well-known makes of audio amplifiers have shown the power to be down as much

[*Continued on page 53*]

An Instructional Broadcast Studio

EUGENE F. CORIELL*

Radio studios for instructional purposes may resemble professional installations, but must have special consideration in their design to be of greatest value.

When better military radio shows are built, better military writers, announcers and directors will build them. This briefly is the philosophy behind the installation of an instructional broadcasting studio at the Armed Forces Information School at Carlisle Barracks, Pennsylvania. Here, selected enlisted and commissioned personnel of all the armed services are trained in the techniques of public information. One of these techniques is radio, and the pupose of this article is to describe some of the audio and related features of this studio occasioned by its educational character.

To a radio man faced with the job of building a broadcasting studio for instructional purposes, it might seem that any conventional studio would do if it were big enough—and it is true that size has a lot to do with it. The studio proper at Carlisle Barracks is forty-seven by twenty feet and for demonstrations it can seat fifty students as observers. The control room is sixteen by twenty feet and seats up to twenty-five persons.

However, size is not the only difference between instructional and operational studios. Since the facilities are primarily for student use, they should be planned with student habits and limitations in mind. For example, students will sometimes blow into an expensive velocity microphone to see if it's working, after which, due to a ruptured ribbon, it works no more. When the script calls for a yell, the student generally puts his heart into the yell—and the yell right into the microphone. A careless sneeze "on mike" will sometimes finish off a ribbon microphone that has somehow weathered many a class session. That these things happen is generally not the fault of the students, who in most cases have never been under studio discipline before.

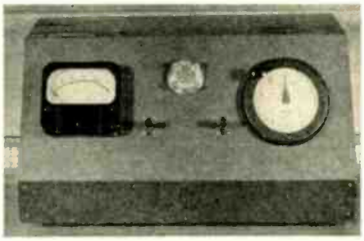

Fig. 1. Preliminary layout of director's turret. The keys control the talkback microphone and monitor speaker.

One solution — in addition to careful briefing — is to use comparatively rugged dynamic microphones until the students have become somewhat accustomed to the limitations of studio gear.

Another aid in acquiring microphone technique is a VU meter out in the studio where the student announcer can see it. The meter will give him some idea of the volume limitations of broadcast equipment, not so much in terms of volume units or decibels as in terms of the variations of his own voice. It might be argued, and with some merit, that this is an artificial prop and therefore unrealistic, since most stations do not have VU meters visible from the studio. One answer is that the meter is used only during the student's first few times at the microphone. Another answer is that after a few sessions with the meter, the embryo announcer rarely yells into the microphone any more.

VU meters also come in handy for the organist who is sometimes a student. It is often difficult for non-radio organists to accustom themselves to the restricted volume range the equipment can tolerate. A VU meter helps considerably in the early stages, if you can get the musician to look at it. One way to encourage him to look at it is to put the meter on top of the organ console as shown in *Fig.* 3, approximately in the organist's line of sight to the director in the control room. Since he has to watch the director for cues, he can hardly remain unaware of the meter seen at the same time out of the corner of his eye.

Director's Turret Facilities

Another use of the VU meter in an instructional set-up is on the producer's or director's turret in the control room, as seen in *Figs.* 1 and 2. This not only gives the student director a visual check on each actor's volume; it also shows him very graphically that the meter alone doesn't tell the whole story. Due to differences in harmonic content, some voices will sound too soft or too loud in comparison with others, even though the VU meter is peaking properly. With the meter apparently lying to his face, he is impelled to do something about this confusing anomaly, rather than leave it to the engineer. After a little practice with this set-up, the student director is in a much better position to listen critically in an operational control room where the only VU meter is in front of the engineer. The reason is that he has learned not to believe all he hears, volume-wise.

The director's turret has another gadget not usually needed in most control rooms — a key that switches a fixed pad into the monitor speaker circuit. This reduces the volume enough to allow the director or student director to comment to the student observers seated behind him regarding the performance of the cast.

The director's turret also contains the usual stop clock and the microphone and associated key switch for the familiar talkback to the studio. Some stations may tolerate poor speech quality from the talkback, with the idea that anything is good enough for what is essentially only a one-way intercom. However, this is highly questionable in an instructional studio. The student announcer or actor is likely to be a little on edge in the relatively strange surroundings of the studio, and

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Fig. 2. Control room equipment as seen from student observers' seats. Director's position is at right of turntables, with recording rack and disc recorders at far right. Power supplies, patch panel, and radio tuners are in rack to left of the console.

his nerves are not soothed by a gravelly voice barking at him through the talkback speaker. Good speech quality in the talkback is a good investment for this type of work.

While on the subject of the talkback, here is another feature that is unusual, although not original. It is customary to interlock the talkback with the on-the-air sign switch or the outgoing-line key to prevent accidental operation while on the air or while recording. However, when working with students, it is often desirable to maintain closer control over the cast than is possible with the usual hand signals. The reason is that students tend to concentrate so much on the script that they forget to keep an eye on the director in the control room. One way of getting around this is to have the output of the talkback amplifier automatically switched from the studio speaker to a pair of phones when the on-the-air sign switch is thrown. The phones are fed through a fixed-loss pad and are worn by the assistant director, usually a student, to whom the director can give instructions while the show is on the air. This arrangement is used sparingly because, as explained to the students, the announcers and actors in operational studios must keep an eye on the director, even while reading their lines, without benefit of a prompter.

The devices mentioned above are helpful, certainly, but it soon becomes apparent to the instructor that no amount of VU meters and other gadgets will prevent occasional heavy peaks from getting through to the recorder. The result is apt to be severe distortion and, in the case of disc recorders, the peak may cost "ghosting" in the adjacent groove. This points up the need for a limiting amplifier, adjusted for the usual maximum compression of 5 db. Compression in excess of this amount is, in itself, a likely cause of distortion.

Program Phones

Some stations provide program earphones in the studio so that the show may be monitored there if desired. These phones, which are not to be confused with the talkback phones mentioned earlier, are often used by the sound man and the organist. This arrangement is particularly helpful in training directors of military programs who, due to lack of radio personnel at their home commands, will often have to take part in shows they direct. Monitoring a program with earphones is not very satisfactory, due to the distortion introduced by the phones themselves. However, it is possible to get a fair idea of relative volumes, the effectiveness of fades, and so on. The program phones also allow the announcer-director to know when to cue in cast members who have speeches that follow music played on the control room turntables. This is important since the studio speaker is automatically turned off when the microphones are alive to prevent feedback. As there is little chance of feedback from the earphones, these need not be interlocked with the microphones and are fed by a separate amplifier bridged across the outgoing line.

Another item of instructional studio gear is the turntable equipment. Turntables intended for student use or for use with students should be rugged, and that applies to everything about them, including the pick-up. The light-weight variable reluctance type with permanent stylus has worked out very well, although the replaceable-stylus models probably would be a safer choice for this service. The light-weight heads have the additional advantage of low needle talk, which is important for instructional use, as students have not had enough experience to learn to ignore the annoying noise of the needle.

While on the subject of turntables, there is a seemingly simple improvement that would save considerable maintenance on this equipment. It has been our experience that sooner or later, in spite of warning, somebody puts a dictionary or other heavy object down on the platter of the turntable — or even leans on it. The result is often a sprung platter productive of plaintively wavering music. To correct this, somebody — usually somebody else — has to spring the platter just the right amount the other way, which is no fun. If the center shaft cannot be made heavier, some enterprising manufacturer might provide some deflection stops spaced around the circumference of the platter just under its rim. Then when some thoughtless individual leans on the table, the resulting deflection would be limited to the small clearance above the stop. If this clearance were within the elastic limit, no permanent set to the platter would result.

[*Continued on page 51*]

Fig. 3. To assist student organist in maintaining safe volume limits during rehearsals or broadcast, a standard VU meter is mounted on the organ console directly in his line of vision.

Simplified Preamplifier Design

HOWARD T. STERLING*

Unnecessary complication in phono preamplifiers may be avoided by making practical compromises in the performance requirements.

THE PREAMPLIFIER has been a bone of argument and contention for so long that editors will shortly look to some other subject for material, but there are a number of considerations which have not as yet been thoroughly brought to light, and it is the intention in this paper to discuss their application to the development of a new plug-in preamplifier.

This unit is shown in *Fig.* 1, both open and with the shield in place. It measures approximately 1½ x 2 inches and its seated height is 3 inches. Inspection of the open view will show that particular effort has been made to assure good mechanical construction. This is in direct contrast to some recent plug-in preamplifier designs, where tube sockets have been secured only by their leads, and electrical connections left floating, rather than tied down, on the apparent theory that since they are hidden by the shield, good practice is unnecessary.

The plug-in feature has a number of advantages, including interchangeability with preamplifiers of other equalization characteristics, and with crystal equalizers; independent shielding; and the fact that since it is not an integral part of the equipment with which it is to be used, it may be added when and if desired, with a significant improvement in the simplicity and economy of the amplifier system.

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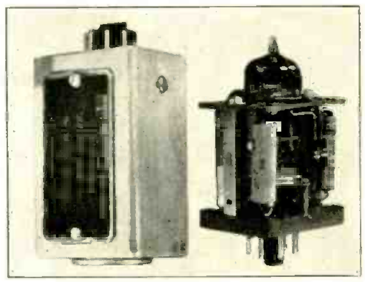


Fig. 1. External and internal appearance of plug-in phonograph preamplifier.

While these preamplifiers may, of course, be equalized for the NAB transcription recording characteristic, their immediate application was to be for playing standard records in the home.

Equalization

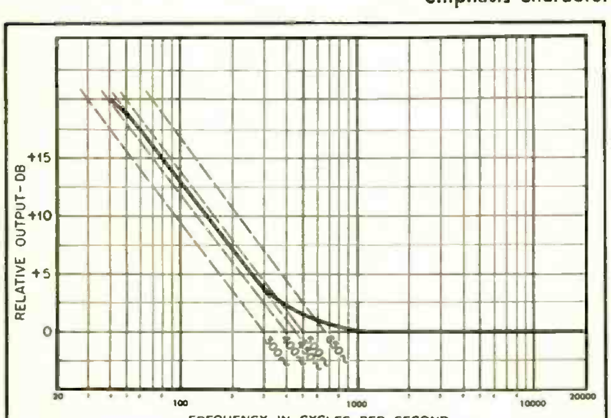
There has been considerable attention recently to equalization of the preamplifier for the various recording characteristics now in use. St. George and Drisko[1] have performed a valuable service in providing as exact information as can be obtained as to these characteristics and have gone to some pains to equalize for each of them. Such complication is not wholly desirable in many applications, and there is some question as to whether it is necessary. Actually, it is possible to equalize for all these characteristics, with a maximum error of 3 db, using a single low-frequency turnover and the simplest type of high-frequency shunt tone control.

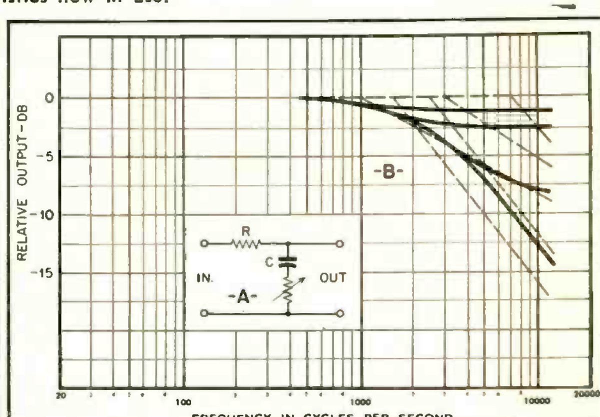
Figure 2 shows the response curve of the plug-in preamplifier, together with the ideal equalization characteristics for the various turnover frequencies in use. It will be seen immediately that the maximum deviation from these ideals is a little over 3 db, while actually, as will be shown later, it is less than that.

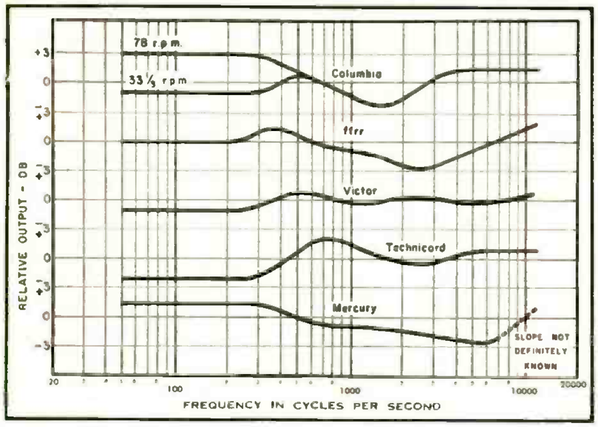
Figure 3(A) shows the familiar high-frequency shunt type of tone control, and if C is chosen so that X_c equals R at 2500 cps, the resulting characteristics will be those of the solid lines at (B) for various settings of the control. The dash lines again indicate ideal correction for the different types of preemphasis, and the approximation is better than 3 db at all points.

Combining the low- and high-frequency characteristics now, and adjusting the base line for reasonable symmetry, the curves of *Fig.* 4 are obtained. Here the maximum error is still less than 3 db, and is actually in a desirable direction for Victor and Columbia. The most frequent complaint about the

Fig. 2 (left). Response of plug-in preamplifier compared with ideal curves for turnover characteristics now in use. Fig. 3 (right). (A) Simple high-frequency shunt tone control will give curves of *B* if R = X_c at 2500 cps. (B) Characteristics of high-frequency shunt tone control for different settings, together with ideal compensation (shown in dotted lines) for preemphasis characteristics now in use.







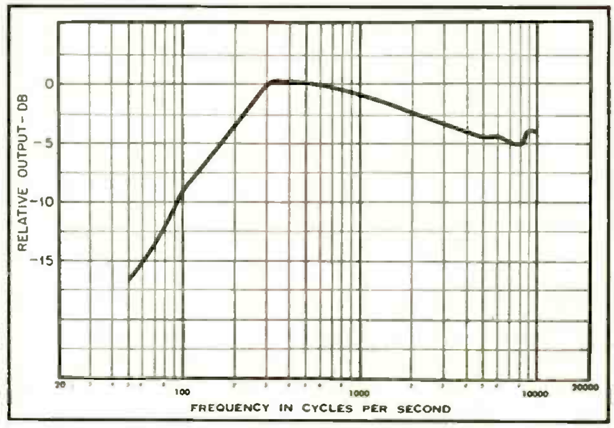


Fig. 4 (left). Composite of *Figs.* 2 and 3B showing approximation of ideal characteristics possible with single low-frequency turnover point and simple high-frequency tone control. Fig. 6 (right). Characteristic of Columbia 10003-M test record.

Columbia 78-rpm records is that they are "thin," so we have about 3 db of bass boost; the LP's have, if anything, an uncomfortable amount of bass, and the 1-db drop will not be a serious loss. Both types are inclined toward excessive brilliance in the middle highs which will neatly complement the dip at 1500 cps. Victor is also likely to be a little heavy in the bass, and the loss of one and a half db will be all to the good. Actually these deviations are significantly less than may be expected from other parts of the system, and there is every reason to believe that the records themselves show an even wider variation.

It is not necessary, of course, to use the precise circuit of *Fig.* 3 (A). A treble boost-cut circuit[2] may be modified to give the same characteristics in addition to the flexibility of treble boost.

With regard to the LP's, incidentally, there has been a wide divergence of opinion—some saying that they are distortion and noise free, and some saying that they are very poor in these respects. Experimental work with one of the better recordings (Scheherazade, with Ormandy) has indicated that there is a serious amount of both noise and distortion, but that it seems to occur only above about 10,000 cps. Since most "wide range" speaker systems roll off at about this point, it was audible only on the RCA LC1A and the James Lansing D1000 of the speakers checked. In these cases a 10-kc low-pass filter with a slope of about 36 db/octave, critically damped, was found to be the solution. Statements with regard to the fidelity of these records seem to be justified, incidentally, since this filter noticeably altered the quality of high-frequency recorded sounds.

Circuit Design

A number of circuit configurations, such as shown in *Fig.* 5, were considered before that shown at (C)—a modified Pickering circuit—was finally decided upon. The familiar circuit of (A), popularized in the G.E. preamplifier, was rejected because it can be overdriven easily and because it has a fairly high output impedance for use where the capacitance of long shielded lines may be encountered. The circuit of Burwen[3], shown at (B), is also easy to overdrive, and it is difficult to obtain flat high-frequency response due to the loading of the feedback network by the Miller effect in the second stage.

There has been some criticism of Pickering's circuit as a result of hum pickup between the heater and the unbypassed first cathode of the 6SL7, but this is not a serious consideration with the 12AY7, a tube recently made available by General Electric, and designed particularly for low noise, hum, and microphonics. Actually, the 12AT7 or the 12AX7 may also be used in the preamplifier, since the feedback effectively equalizes gain, and the only difference will be in the noise level. The circuit as used here will take an input signal as high as 0.8 volts without overload at 1000 cps, and hence will accommodate any of the low-level magnetic cartridges without adjustment. The internal impedance at high frequencies is 2500 ohms, which is sufficiently low to drive a line capacitance of .005 μf without frequency discrimination.

It was found that some noise was being produced by current flow in the plate resistor for the first stage. Care-

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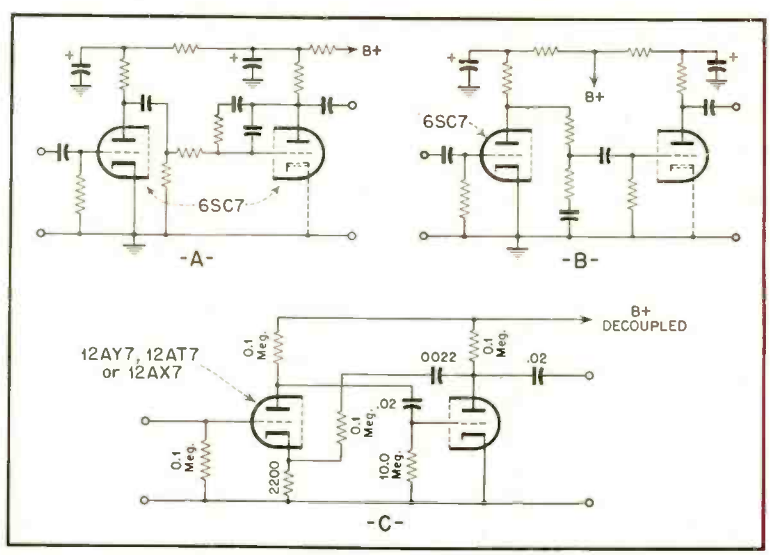

Fig. 5. Preamplifier circuits: (A) Burwen; (B) General Electric; (C) Modified Pickering circuit used in plug-in preamplifier (see text).

Audio Frequency Measurements

W. L. BLACK* and H. H. SCOTT**

Part II: Design, development, and maintenance all depend on the measuring procedures employed. The author discusses these methods thoroughly, and presents reasons for every step.

WAVE ANALYZER DETERMINATION of harmonic distortion at the output of the equipment under test involves separate measurement of the individual harmonics and the calculation of the square root of the sum of their squares. The wave analyzer is connected as shown in *Fig.* 2 and *Fig.* 11. The percentages of the harmonic components with respect to the fundamental are determined by calibrating the wave analyzer by tuning to the fundamental and setting the meter to 100 per cent, and then reading the other components referred to this calibration. The total harmonic distortion in per cent is then the ratio of square root of the sum of the squares of the voltages of the individual components to the voltage of the fundamental frequency. The wave analyzer can be used to check the signal source for harmonic content. Such a check should be made to insure that measurements are being made of harmonics generated in the equipment under test as indicated in *Fig.* 11.

For such tests on balanced equipment the same precautions must be observed as outlined in the section on

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This paper was originally presented at the joint IRE-RMA Meeting at Syracuse, New York, on April 28, 1948, and is presented in its entirety in AUDIO ENGINEERING *by authorization of The Institute of Radio Engineers.*

response and gain measurements. However, in the case of wave analyzer measurements it probably will not be possible to connect directly to the output terminals of the equipment under test without producing unbalance since the usual wave analyzer has one terminal at ground potential. In this case it will be necessary to insert an isolating transformer in the input leads to the wave analyzer. To check that such a transformer does not introduce appreciable distortion, the arrangement for checking distortion in test equipment indicated in *Fig.* 11 should be used.

The measurement of distortion with a wave analyzer tends to be more precise than measurements with a noise and distortion meter under some conditions, as discussed later. However, it has the disadvantages that the actual observations are more time consuming and that calculations are necessary to determine the total distortion percentages.

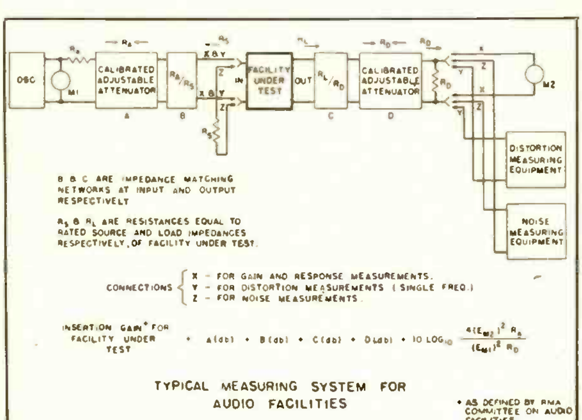


Figure 2

In making distortion measurements, the same absolute gain as well as the same relative distribution of gains and losses in the equipment under test as were used for the gain and frequency response measurements must be used to insure correlation of results.

It is also advisable to make a check at the output of the equipment under test with the signal removed to see if actual components of the signal are causing the indication or if it is due to noise or hum generated in the equipment. If noise causes a reading approaching the order of magnitude of the expected distortion readings, the selective method of measuring the harmonics with a wave analyzer will ordinarily result in more accurate determination of distortion than a nonselective method.

A distortion factor meter,[11] when used for distortion measurements, attenuates the fundamental of the test signal output of the equipment under test and passes the remaining signal, which is composed of harmonics and noise. The rejection of the fundamental is achieved either by the use of a high-pass filter or by the use of a sharply selective circuit. Comparative measurements may thus be difficult to correlate, particularly if the amplitude of the remaining noise approximates that of the harmonics being measured. Such meters are sometimes so arranged that the frequency-selective circuits may be disconnected for use in measuring noise as discussed later. Such a device is ordinarily termed a distortion and noise meter.

The harmonic and noise content at the output of the equipment under test is indicated as a percentage of the total value of these components with respect to the value of the entire output signal. As is the case in all harmonic-distortion measurements, the signal source and any isolating transformer used must not introduce appreciable distortion.

A distortion factor meter may be substituted for the output meter as shown in *Figs.* 2 and 11. It will be necessary to preserve the desired grounding condition of the circuit under test and to terminate the output attenuator properly. This termination can be in part or in whole the input of the distortion and noise meter. For example, suppose that the latter has a 500-ohm resistive input and the proper termination required is 600 ohms. It will then be necessary to add 100 ohms of series resistance, properly arranged to maintain the desired grounding relations.

In addition to the errors caused by noise as already mentioned, this method of distortion measurement may be subject to other errors. The readings may be accentuated or reduced by phase relationships between different harmonics or between the same harmonics introduced by each of several elements in the equipment under test. Furthermore, when the magnitude of the harmonics exceeds a few per cent there is a metering error as the distortion factor meter indicates the ratio of the harmonics to the fundamental plus the harmonics rather than to the fundamental only.

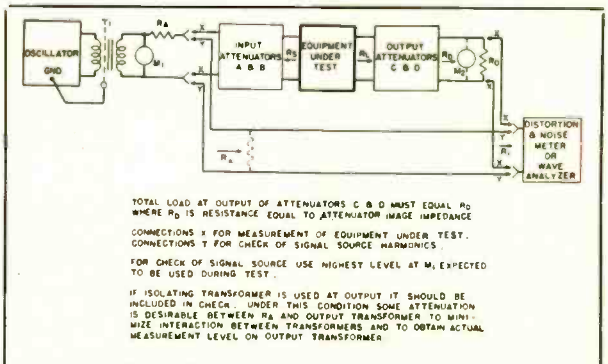
Intermodulation Measurements

By substituting two signal sources at the input, two signals can be simultaneously applied to the equipment under test and, by means of an analyzer connected at the output, the intermodulation between the two signals can be measured. Different methods of making such measurements have been discussed in the literature [12, 13, 14, 18]. In general such tests require that the maximum possible peak voltage value of the composite signal does not exceed the peak test voltage which would be applied to the equipment under test in making single-frequency harmonic measurements. The magnitudes of sum and difference frequencies resulting from modulation within the equipment under test are then determined at the output.

The results of such intermodulation measurements on a system composed of amplifiers and related components such as attenuators can ordinarily be correlated with measurements of single-frequency harmonic distortion on the same equipment. However, in connection with the interpretation of such results in terms of minimum standards and associated methods of measurement the Committee on Audio Facilities of the Transmitter Section of RMA has taken the position that "there is not sufficient data available at this time based on subjective observation to establish recommended conditions for test for intermodulation measurement."

Noise Measurements

The measurement of electrical noise in a complex audio system such as the complete audio facilities for an elaborate broadcasting studio is very simple in theory. The reference output power at the reference frequency is first determined. The signal is then removed, the input is terminated with a resistance equal to the rated source impedance and the residual output level is measured. The ratio of the two levels expressed in decibels is then the signal-to-noise ratio. In actuality there are two major complications in measuring the noise, as well as questions which arise in defining the signal and its measurement. These complications are the nature of the noise and the characteristics of the noise meter.



CONNECTIONS FOR DISTORTION MEASUREMENTS

Figure 11

The nature of the noise is important basically even though it is measured as electric energy, in the actual application of the equipment under test it is ultimately converted to acoustical energy and as such is a disturbance on a subjective basis to the listener. The noise energy present in audio facilities for radio broadcasting is ordinarily composed mainly of two types. The first is random energy distributed substantially uniformly over the frequency spectrum and of relatively uniform amplitude. This is primarily caused by thermal noise in resistances. Vacuum tube disturbances such as "shot effect" may also be contributing. The second is energy concentrated at one or more frequencies. A typical cause of such noise is operation of equipment from an alternating-current power source. In addition to these two types ordinarily present, peaks of relatively high amplitude but of short duration may be experienced. Such peaks may occur at random intervals or may recur at repetitive time intervals.

The characteristics of the noise meter become a problem because of the possible variations in the nature of the noise energy. If all noises had the same wave-shape, then any meter capable of indicating steady state electrical energy and having the requisite sensitivity could be used. However, when noises have different frequency make-ups, either due to various mixtures of single-frequency and random noise or due to various mixtures of different single frequencies, then if the noise meter is to give equal readings on noises which are equally disturbing to a listener, the frequency response characteristic of the noise meter is important and should not be flat. Finally the possible presence of random pulses emphasizes the time of integration of the meter and the ballistic properties of the indicating instrument.

As a temporary arrangement for measuring the noise on audio facilities for radio broadcasting (not including studio-transmitter loops), the Committee on Audio Facilities has agreed upon making noise measurements with a device having a frequency response flat within plus or minus two decibels from 50 to 15,000 cps and having the ballistic characteristics of the "standard VU meter" but reading (responsive to) the rms value of a complex wave approximating a steady state condition. The Committee also notes that measurement of pulse noise conditions has not been included because of lack of definition and equipment.

The results of the measurement of noise with a meter having a substantially flat frequency response are ordinarily reasonably adequate for comparative use in the field outlined herein, particularly on like equipment. For example, in audio facilities for radio broadcasting, the noise problem frequently simplifies to that of the control of hum from power supply when power is supplied as alternating current to the heaters of indirectly heated cathodes and as rectified and filtered alternating current for the other elements. Where a diversity of conditions exists, it may be necessary to qualify the results of noise measurements to insure proper interpretation: this results largely from employing flat response measurement of electrical noise, as generally the ultimate criterion is disturbance on an acoustical basis. For this reason, frequency weighting in the meter has been generally resorted to in noise tests on telephone systems and in acoustical measurements, to simulate human ears at representative listening levels. Examples of this are the Bell System program noise measuring equipment and the American Standard Sound Level Meter. [15, 16, 17] There are incorporated in the latter device two frequency weightings, corresponding to ear characteristics for 40 db and 70 db acoustical levels. Re-

[Continued on page 48]

Audio Transformer Applications

A. J. AVIS*

Impedance calculations for transformers are encountered regularly in audio work. The author clarifies relations between impedances in tapped and multi-winding coils.

Audio transformers are essential elements of high quality audio systems. The broadcast engineer, to whom quality performance is a prime consideration, uses audio transformers in practically every phase of his work. Modern design, high quality materials, and up-to-date manufacturing processes contribute to the superb performance of present day transformers.

In this connection, the writer recalls some experiences with transformers in the humid climate of the Netherlands East Indies in the early 1930's. Transformers were difficult to obtain and demanded highly developed protective techniques to combat the onslaughts of humidity, termites, fungi and many other threats to the delicate life of the fragile and valuable components.

Radio amateurs spent many evenings comparing, arguing, and defending their latest developed protective techniques, which they claimed were guaranteed to allow a tranformer to remain unattended for fully two months. Regularly removing transformers from the sets and drying them slowly in hot boxes was old stuff—it took more courage to dip the pride of one's collection in a hot bubbling mixture of rosin and beeswax, praying that the latest treatment would not again result in a horribly sticky mess that eventually would seep through the entire set. Reliability was a touchy characteristic then, and not many makes of transformers were able to take both the climate and the protective practices to which they were subjected by the zealous amateurs.

Most readers, however, living in less trying climates, may feel assured that their investment in high quality audio transformers is a safe one, without having to resort to any maintenance program. An investment it will be, however, for good quality transformers are not cheap, and mediocre ones are not worth wasting time and money on if the utmost in performance is your goal.

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Specific Uses

Sometimes a transformer is needed that must operate satisfactorily over a wide range of operating levels and over a wide frequency band. An example of such an application is the matching transformer used in certain audio signal generators equipped with an output meter and variable attenuator with 110-db range in 1-db steps. The output of the attenuator is fed into this matching transformer, which provides various output impedances while handling a power range from −60 to +35 dbm over a frequency band from 20 to 20,000 cps and with less than 1 per cent harmonic distortion. The fact that such transformers are produced in commercial quantities at reasonable cost is a good example of the high standards of design and manufacture in the transformer industry.

The application of audio transformers as a rule requires a certain amount of impedance matching. In most cases, little difficulty is encountered with interstage transformers, which normally are selected to operate with a specific set of tubes and therefore are not subject to a change in conditions. With care, good resistance-capacitance coupled circuits may be designed to replace interstage transformers, but it is not so simple to find a substitute for input or output transformers, which are often called upon to accomodate a wide variety of impedances.

Microphones and pickups require a wide range of input values, and loudspeaker voice coils vary with speaker size, type, and manufacturer. Telephone

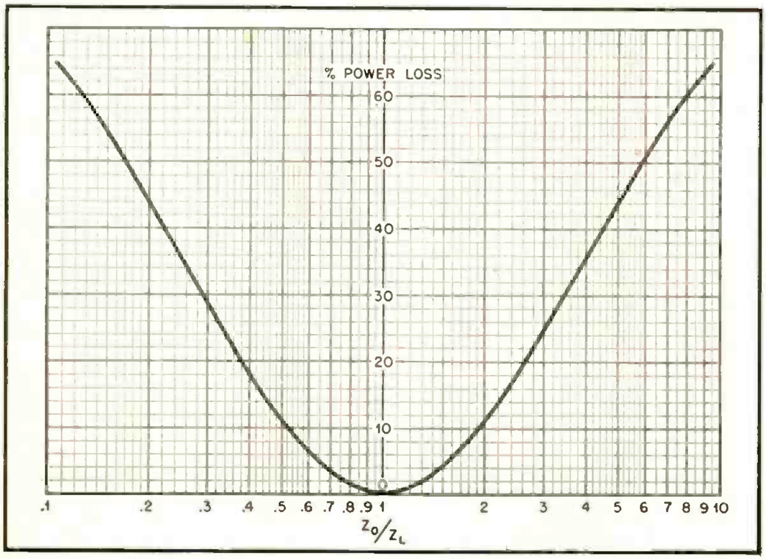
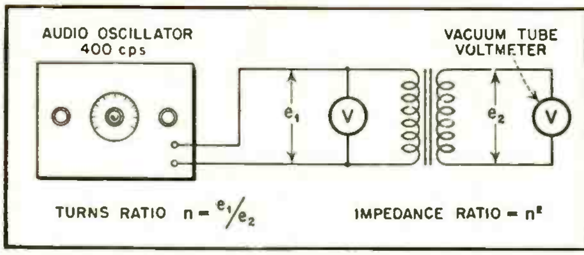


Fig. 1. Curve showing power loss due to impedance mismatch between circuits.



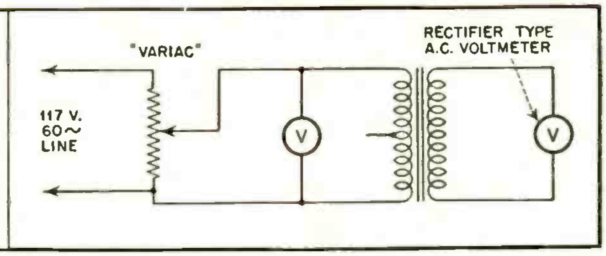


Fig. 2 (left). Simple method of measuring turns ratio of transformers when v-t voltmeter is available. This arrangement is suitable for all types of transformers. Fig. 3 (right). Method of measuring turns ratio of output or speaker coupling transformers.

lines and multiple-speaker installations complicate the picture even more and emphasize the importance of suitable input and output transformers.

Transformer Selection

The selection and application of each type require special considerations, which often are not obvious to the non-

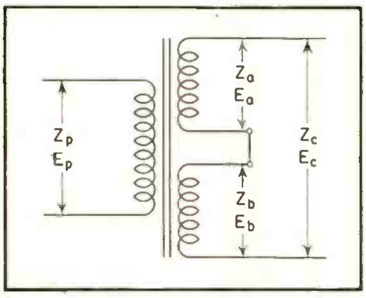


Fig. 4. Coil arrangement using two separate windings connected in series.

professional designer. Transformers are usually designed for a definite application, and optimum performance is obtained only under specified operating conditions. The performance of a unit when applied under different circumstances may differ appreciably from that which is expected. Furthermore, the frequency characteristic of input and output transformers and the available output from the amplifier are definitely affected by incorrect impedance matching. A few cases are described to illustrate some of these effects. 1. A 500-ohm to 8-ohm voice coil matching transformer with a power handling capacity of 20 watts may perform superbly with low losses when driving a heavy duty speaker. However, when used as an input transformer to match an 8-ohm dynamic microphone to a 500-ohm line, unsatisfactory operation may result. The low-level signal may be inadequate to provide sufficient flux excitation in the large core, since the minimum signal level depends on the grade of lamination iron used. Inasmuch as operations under these conditions have not been anticipated in the design, no provision has been made to utilize special costly core materials which are capable of developing adequate flux densities at exceedingly low signal levels. On the other hand, a transformer designed for dynamic microphone matching purposes would transmit the low signal levels efficiently in that service, but would be unable to handle a speaker power level because of core saturation and limited current-carrying ability in its fine wire. 2. When a transformer is used at a different impedance level than the rated value, the frequency response may be affected to a marked degree. Consider for example an output transformer designed to match an 8000-ohm plate-to-plate load to a 500-ohm line, and having a frequency response within 0.5 db from 30 to 15,000 cps. It is desired to use this transformer to match a 5000-ohm plate-to-plate load by reducing the secondary load in the same proportion to about 313 ohms.

The inductance of the primary is sufficient to maintain only 0.5 db loss at 30 cps when shunting a 8000-ohm generator. The effect of reduced generator impedance by a ratio of 8:5 is such that the primary inductance is now sufficient to maintain 0.5 db loss at only 20 cps. On the other hand, the effect of leakage reactance, which controls the high-frequency response, is increased by the ratio 8:5 and the response of the transformer will be down 0.5 db at 10,000 cps. The reverse holds when the transformer is used in a higher impedance level circuit. Similar conditions exist in input transformers. 3. The effect of power loss due to mismatching is shown in *Fig.* 1, where power loss is plotted in per cent against the ratio of optimum output impedance Z_o to actual load impedance Z_L. The following example illustrates an application of the graph. An amplifier is available with 8- and 16-ohm taps, and it is desired to determine which one to use to connect a 12-ohm voice coil. The 8-ohm connection gives a ratio of Z_o/Z_l of 8/12 or 0.667 and from *Fig.* 1 a loss of 4 per cent. The 16-ohm connection results in a ratio of 16/12 or 1.33 and a loss of only 2.5 per cent, indicating the more desirable connection.*

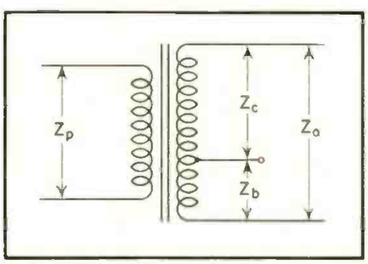


Fig. 5. Coil arrangement for single tapped secondary.

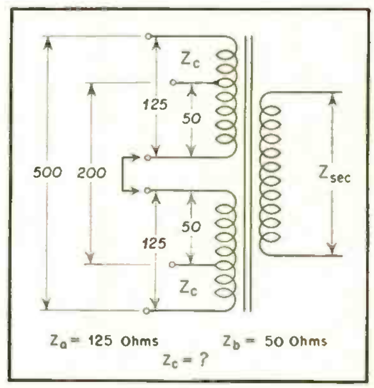


Fig. 6. Typical input transformer connections. Two 125-ohm windings connected in series provide a 500-ohm winding; similarly, two 50-ohm windings in series equal a 200-ohm winding.

In the first part of this acticle, transformer applications involving known impedance values have been considered. Most designers and experimenters are limited in selecting suitable transformers to commercially available lines, which include a great many with tapped or multiple windings. The values available at the taps may not always provide as close a match as would be desirable, and one may won-

(Continued on page 45)

(*Note that this applies only when maximum power output is the primary consideration. Ed.)

Practical Aspects of

Logarithmic Amplifiers

C. J. LeBEL*

Amplifiers having wide-range linear db scales have wide use in audio measurement work. Various design problems are discussed, together with their solutions.

METHODS OF CONVERTING an audio signal to an output voltage which would be proportional to level in decibels were discussed by the writer last month.[1] In the following paragraphs some phases of the practical application of logarithmic circuits will be discussed, including their application in a high sensitivity voltmeter for measuring surface noise on recordings. An easy-to-make experimental log circuit will be shown, and a scale-expansion meter circuit will be covered.

*Audio Instrument Co., 1947 Broadway, New York 23, N. Y.

[1]"New Developments in Logarithmic Amplifiers," C. J. LeBel, AUDIO ENGINEERING, Vol. 33, No. 9, Sept. 1949.

Recording Speed

Oscillograph recordings of radio program level and of acoustical decay in a room were shown in last month's article. These curves present a number of examples of recording speeds between 1000 and 1500 db per second, showing that the old high-speed level-recorder with its limit of 600 db per second was too slow for many applications, and that a speed of at least 1500 to 2000 db per second should be available. The modern direct-writing oscillograph with a logarithmic amplifier preceding it should replace the level-recorder in any careful analysis. The oscillograph having no tapped attenuator, one can be sure that any detail in the curve is not the result of step-by-step motion over a tapped attenuator, nor of erratic action of servo-system clutches.

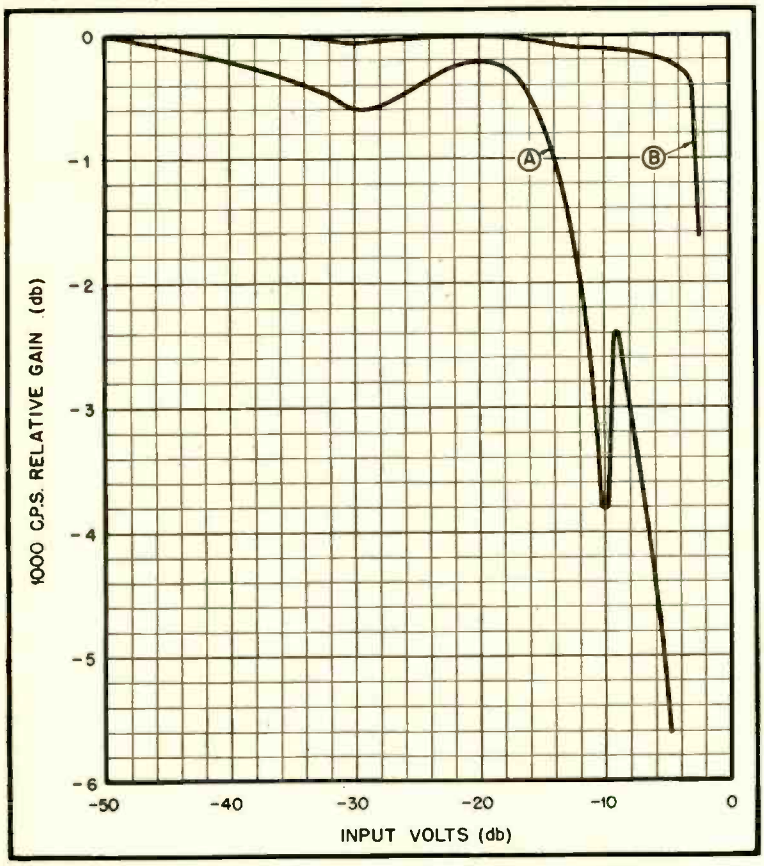


Fig. 1. Gain variation with output voltage for an ordinary single stage amplifier (A) and for an instrument amplifier of different design (B) using 20 db of negative feedback. Both amplifiers have same nominal gain.

Some Practical Matters

Judging from recent discussions with a number of ordinarily well-informed engineers, there is little general realization of the variation of gain of an ordinary amplifier with input level, and the need of instrument-quality amplifiers for the input and output elements of a logarithmic system. In *Fig.* 1 the gain variation of an ordinary single-stage amplifier has been compared with that of a section of an instrument amplifier (of equal gain) employing a large amount of negative feedback. In a complete amplifier system, the overall gain variation would be three to four times the value given for a single stage or section. It is desirable to use at least 20 db of negative feedback if a highly stable amplifier is to be produced or the accuracy of the logarithmic relation is not to be injured.

Regardless of which logarithmic material is employed, the correct value of series resistance must be employed. The amount required depends on the material chosen and on its physical dimensions. As in so many other audio problems, the quickest method is the experimental. *Figure* 2 shows how an increase in series resistance increases the linearly logarithmic range by improving the linearity at the lower end of the curve. This is done at the expense of sensitivity. If carried too far, the driving voltage requirement becomes prohibitive. Stray capacitance across the series resistance also begins to affect the frequency response. This tends to limit the resistance to 50,000

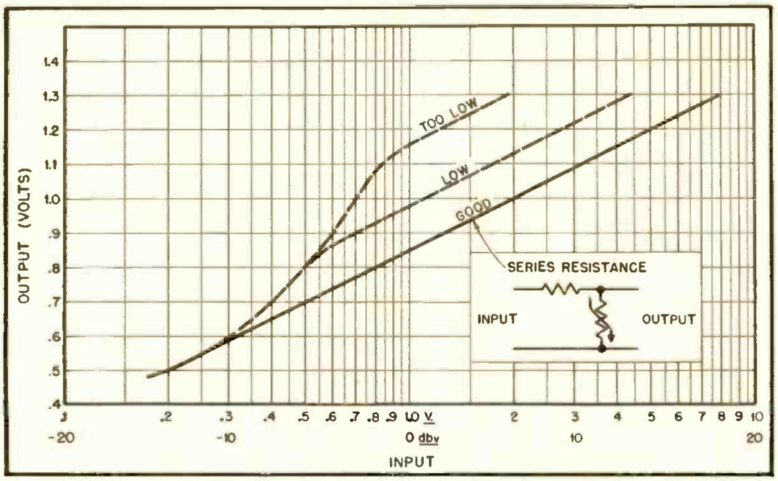


Fig. 2. Effect of varying resistance in series with logarithmic resistor.

or 100,000 ohms for work up to 100 kc, and 10,000 or 20,000 ohms for frequencies above that.

After the resistance has been increased to its maximum value, it will often be found that the accurately logarithmic range is still not great enough. A further extension of the linear range, by 10 or 15 db at the lower level limit, can be achieved by adding bias, by means of the circuit shown in the previous article. The polarity of the bias will depend on the particular material used, and must be determined by experiment. An example of the variation in linearity with bias is given in *Fig.* 3. It is desirable to stabilize the bias voltage, and a convenient circuit for the purpose is shown in *Fig.* 4. This utilizes the negative voltage-current relationship of an ordinary half-wave selenium rectifier junction. For closest regulation, a two-stage stabilizer circuit is desirable, as shown.

There are a large number of logarithmic materials, and the main difference between them lies in the range of accurately logarithmic effect. For the engineer who would like to do a little experimenting, the most convenient material is copper oxide in the form of a meter rectifier. A circuit for using a bridge-type unit without bias is shown in *Fig.* 5. If the range is to be extended by using bias, half-wave copper oxide rectifiers are obtainable from some manufacturers. Two should be used in a full-wave circuit, as shown in the previous article. Since a copper oxide junction itself rectifies, the rectifiers in that circuit can be omitted.

Scale Spreading

It is often found that a 50- or 60-db scale is too big, and that a 20- or 30-db range would be desirable. If the sensitivity of the vacuum-tube voltmeter fed from the log element is varied, it will be found that the top limit of the db scale is shifted on the meter, but the effective logarithmic range is unchanged. The way to get the desired result is to spread the scale by using a suppressed zero type of meter. The lower, undesired, part of the db range is thereby shifted off the lower part of the scale and suppressed.

Two methods of zero suppression are available — mechanical and electrical. The mechanical method has been widely used, but it has the disadvantage that the pointer is drawn against the left hand stop whenever the meter is not in use. The spring is under constant tension, and fatigue and permanent set will result eventually.

The answer to this is to use electrical zero suppression, as shown in *Fig.* 6. An adjustable bias current is passed through the meter, of such polarity as to draw the pointer to the left hand stop. When the level rises above the bias value, the meter will indicate. The method can be used with virtually any vacuum-tube voltmeter circuit. To line up the meter scale with the log element, both VTVM sensitivity and meter suppression current should be adjustable. First set the desired maximum level into the log element, then adjust VTVM sensitivity until the pointer comes to the top of the scale. Decrease the input to the log element by the range of the meter scale (for example, 30 db for a 0 to 30 meter scale) and adjust the suppression current until the pointer is on the lowest line of the scale. If the range chosen calls for a great deal of suppression, such as a 20-db scale, then the two controls interact and two or three adjustments will be necessary to

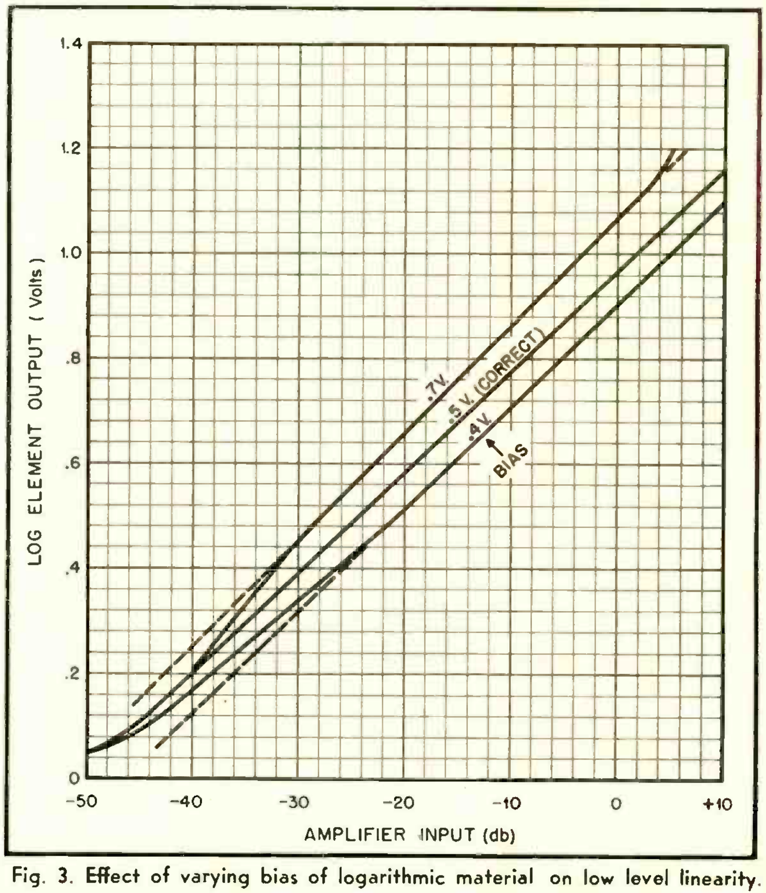


Fig. 3. Effect of varying bias of logarithmic material on low level linearity.

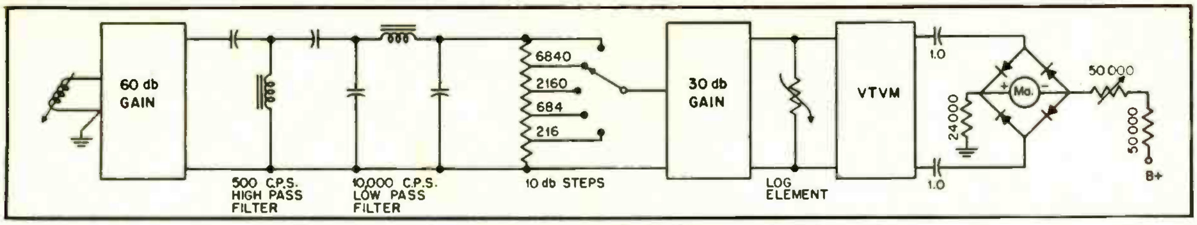


Fig. 7. Disc-noise meter using methods discussed in this article.

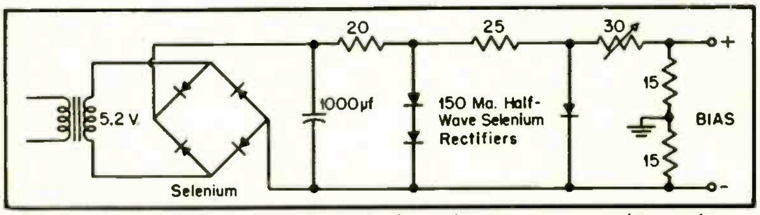


Fig. 4. Stabilizer for bias voltage. Adjust rheostat to exact bias voltage.

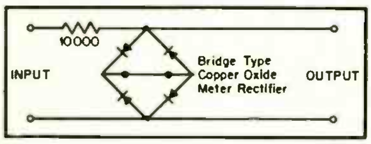


Fig. 5. Full-wave copper-oxide meter rectifier used as logarithmic element.

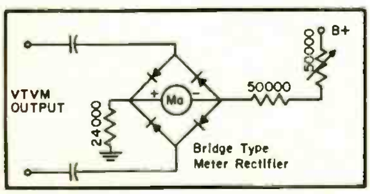


Fig. 6. Electrical zero suppression circuit.

put both ends of the scale in simultaneous alignment. Electrical zero suppression is so convenient that it is a pity it has been so little used.

The circuit design is very straightforward, and it is only necessary to make the resistors in the suppression circuit of such value that they do not disturb the linearity of the VTVM, for they form a load across its output.

Disc-Noise Meter

For years it has been customary for well-run recording studios to measure the noise level of every lacquer master and mother cut and every test pressing as a means of checking the operation of equipment and personnel. The meters used have generally been built up from a combination of standard amplifiers, a VU meter, and occasionally a limiter of some sort. Not being an instrument amplifier, the gain has generally drifted with time and use. Furthermore, there has been some question as to how the results compared with the ear's judgment when different materials, such as different pressing stocks, were used for comparison.

There is a sound theoretical basis for such doubt. Whereas the human ear measures logarithmically, then integrates the result, ordinary rectifier meters, such as the VU meter, do the reverse. They integrate the energy of a noise wave and then translate the integrated average logarithmically by means of a VU scale.

An objection may also be raised to the use of a limiter or clipper for meter protection, an objection which is peculiar to noise measurement—the peak factor of noise is at least five or ten to one. If clipping is to start just above the full-scale meter indication, on a sine wave basis, the accuracy on noise of the top half of the meter scale is destroyed. If clipping starts 25 db above full scale, also on a sine wave basis, the initial meter accuracy will not be affected, but the meter will receive occasional 20:1 overloads. It will not burn out, but the cumulative effect of mechanical mistreatment will eventually damage it enough to require its repair.

The solution to both of these problems is to have the logarithmic action *precede* the meter movement. Then the meter operates as the ear does and yet is protected from overload. The overload protection results from the fact that the meter receives the *logarithm* of the current, not the current itself. A 40-db overload will give twice normal meter current, not 100 times normal.

A disc-noise meter may be put together from what has already been discussed. It is necessary only to add filters to limit the frequency range to that specified in the NAB disc-noise standard—a 500-cps high-pass section and a 10,000-cps low-pass section, both of the constant-K type. *Figure* 7 shows such a circuit, and *Fig.* 8 the frequency response.

There may be some question as to the need for such large amounts of gain. However, this design contemplates measuring the noise of the quietest lacquer at the center of a 20-db meter scale.

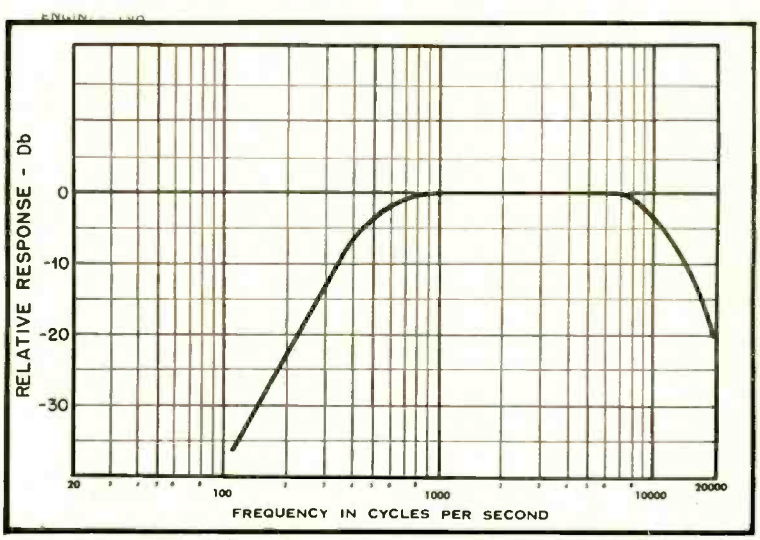
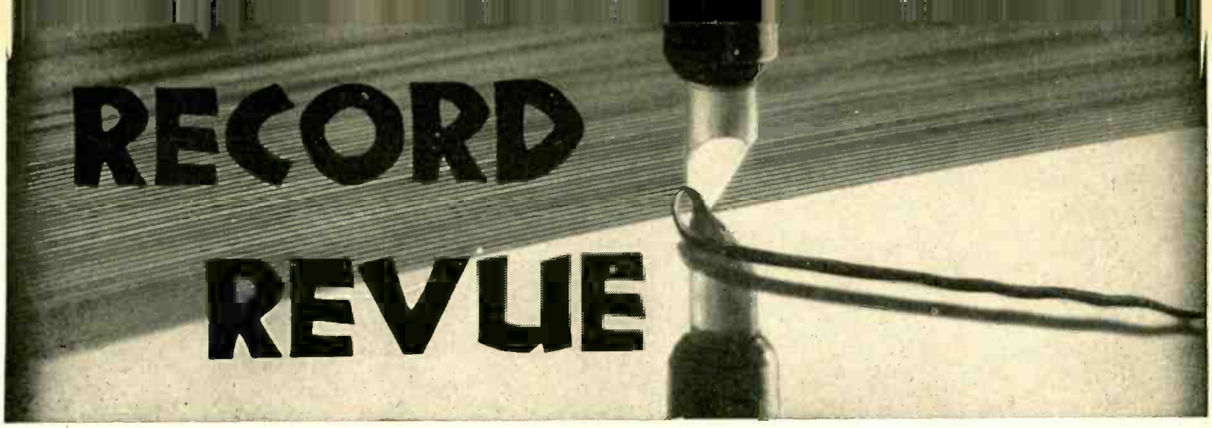


Fig. 8. Frequency response of disc-noise meter.



Those Fuzzy (?) LP's

EDWARD TATNALL CANBY*

SPECULATION is the stock in trade of this department, but this month's speculations are going to have even more if's and but's than usual—for this is the account of a decidedly unfinished bit of continuing questioning. The subject is familiar—the LP record. The questioning involves (1) is there unwarranted distortion in some (or many) LP's and if so, how come? (2) Is the magnetic pickup the best for LP playing, as most engineers automatically assume?

After a year and a quarter of LP history the confusions over LP quality continue unabated and at all levels, and this I find most remarkable. It's OK for us non-engineers to disagree, what with a million and one amateurish mistakes liable to gum up the issue—blaming the records, for instance, for "too much bass" or "too little bass" when quite clearly the trouble is equalization, about which few record owners know anything—rather than anything wrong in the records themselves.

But when, after all this time, the engineers disagree still, and disagree mightily, there's something that needs clarifying somewhere along the line. And worse, when the very results themselves seem—as has been happening to me—to contradict themselves, then something has got to be done.

Let's take a few of the symptoms. Working with a GE cartridge, I have in the last few months consistently found that many LP's from Columbia produce on my machine a varying amount of "buzziness" and distortion in the highest range, particularly in the louder parts. The first and obvious explanation was a bad stylus. No such thing—that has been eliminated long since. Buzzings continued. Well, then something else in the equipment must be wrong. Perhaps a matter of tracking? Don't think so, for I have encountered the same effects quite uniformly with a player that, being semi-portable and used in many places, is bound not to sit at exactly the same tilt, if any, for each situation. I have arbitrarily tipped the machine this way and that, changed the stylus weight, without materially changing the buzzy distortion. Trouble in the amplifier or elsewhere along the electrical line? Sounds as though it must be there, since after all, Columbia is unwilling to admit to any pronounced distortion in the LP product okayed by them for release. Every engineering calculation would suggest that the trouble is with me and my equipment, not with the records.

I am always willing to accede to that sort of argument and assuredly would here—*except* for one nasty little thing that keeps coming up to bother me. Ever so often, along comes an LP that does not—but definitely does *not* distort, and that under identical conditions. I have a half dozen or so of these at least, and results are unfailing. Put on one of them at a loud part—the sound is clean. Slip one of the other LP's on, and there is that fuzziness again. No one has yet been able to explain this one for me, but I can demonstrate it. I have, only too obviously, in some semi-public "concerts" during this summer. I had to pick and choose. Certain LP's I could play. Others I could not, unless with a cut-off of 8000 or lower.

So far so good. To double-check I customarily listen to as many of my doubtful cases as I can on other people's equipment. From what I have heard on various engineer's outfits, my impression is that many an LP, played on a GE pickup, gives on other's equipment results more or less like mine, if anything with more unsatisfactory sound. Magnetic variants such as Pickering and Clarkstan give similar results but even more unpleasant (probably because of wider frequency range). I have heard it said that there are "no good LP's at all" when it comes to the really high tonal ranges. Though I violently disagree, I have heard some demonstrations that were most unhappy in the sound. How to explain them?

But this is far from the end. I am fortunate in having as a good friend the man who developed the LP in the first place, Dr. Peter Goldmark. When LP-itis begins to hit me badly and things just sound terrible, I go to him for consolation. And I am baffled. In Dr. Goldmark's office the very records which have buzzed and rattled for me play without a trace of audible distortion! It has happened over and over again. I have even taken a disc from his player that sounded perfectly clean and found when I got home that it was buzzy and seemingly overcut; nor could any juggling I do, including a large dose of roll-off in the highs, really clean it up. Two of the seven-inchers were particularly strange in this respect. One was the Welitch recording of a soprano aria from Weber's "Freischutz," the other a violin and piano piece called "Tsigane" by Ravel. Both were unbearable as I had heard them at home. Both were flawless as Goldmark played them. Why?

Lest you think this is an amateur argument, read further. Of course there were differences in the playing conditions. Let us leave aside acoustics in the listening rooms. The most vital item is that Dr. Goldmark uses his own *crystal* cartridge, not a magnetic, the LP-33 (now superseded by the Astatic U model, with replaceable needle, that fits both the Astatic FL arms and the old Philco player arm). It plays into an RCA amplifier and speaker system. It is, of course, equalized to the LP curve by the man who designed that curve. He ought to know. Dr. Goldmark apparently feels that crystals are here to stay, for he has designed a series of them for LP playing and has not, that I know of, done any work with magnetics. The crystals are recommended without reservation—for professional as well as amateur work—or so I have gathered. What's more, as begins to become clear, the things seem to work. At any rate, I have the evidence of my own ears corroborated by some crystal playing at home that the LP's do play with a great deal less apparent gross distortion when the crystals are used than when the theoretically superior magnetics are employed. At this point I'm willing to make that generalization, based on a lot of hearing.

I can hear some engineers snickering at my naivete. Let me throw in a few more arguments. Yes, it would seem obvious that the distortion (assuming it's there) shows up on the magnetics because of their better response in the high range; the crystals just don't get up in the distorted range. Now this is a weighty argument, but not, in my present opinion, quite weighty enough. The several crystal models that Columbia has recommended are good easily to 10,000 cps with a downward slope that is plenty flat enough to be managed. The "buzziness" that I complain of is high-up, but I would question seriously whether it is all of it *above* 10,000. An 8000-cps cut-off, tuned sharply at 10,000, still lets through some of it in most cases. Any such distortion should, everything else being equal, come through on the crystals more or less as it does on the magnetics, with equivalent equalization. It does *not*, to the best of my experience. Why?

Yes, the good LP's (the ones I have found good, if you wish) are to my ear better sounding via any magnetic than with any crystal. Doubtless because, after all, no crystal pickup has quite the even response that a fine magnetic pickup can give. Naturally, al-

[*Continued on page 36*]

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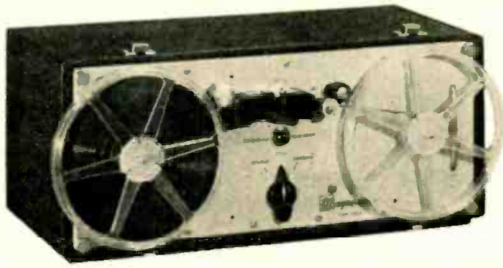

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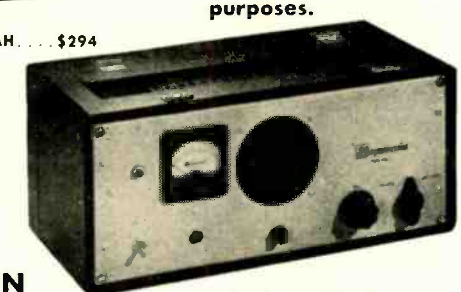

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CONVENTION PROGRAM

Presenting a total of twenty-two subjects in four sessions, the First Annual Convention of the Audio Engineering Society opens on Thursday, October 27, at the Hotel New Yorker. This is a greater number of audio papers than have ever been presented in any one calendar year heretofore by all other societies combined.

In addition to the technical sessions, the Society will hold its annual business meeting, the installation of officers, and the first banquet. The newly created John H. Potts Memorial Award and the Society's annual award will be bestowed at the banquet, together with a number of Honorary Memberships.

The Audio Fair, the first exhibit ever devoted entirely to audio equipment, will be held during the three days on the sixth floor of the hotel.

Thursday, October 27, 1949

11:00 a.m. Registration.
Advance Sale of Banquet Tickets—Sixth Floor

Exhibits open.

1:30 to 2:30 p.m. Business Meeting—Installation of Officers—Grand Ballroom

2:30 to 5:00 p.m. Magnetic Recording Session—Grand Ballroom

Chairman...................C. J. Le Bel
Audio Instrument Company

1. Operating Problems & Experiences ....R. H. Barnaby—National Broadcasting Company
2. General Problem ....W. O. Summerlin Audio & Video Products Corp.
3. Standards—Present Status ....R. M. Morris—American Broadcasting Company
4. Improving Uniformity ....E. W. Franck—Consultant
5. Distortion Measurements .... G. L. Dimmick—Radio Corporation of America
6. Speed Regulation Problems ....P. Brubaker—Rangertone
7. Duplication by Contact Printing ....Robert Herr and J. E. Johnston—Minnesota Mining & Mfg. Corp.

Friday, October 28, 1949

9:30 a.m. Registration. Advance Sale of Banquet Tickets. Sixth Floor

Exhibits Open

9:30 a.m. to Noon **Papers** —North Ballroom

Chairman........Theodore Lindenberg—Fairchild Recording Equipment Corp.

1. "Automatic Audio Gain Controls" ....J. L. Hathaway—National Broadcasting Company

The development and application of automatic audio gain controls at the National Broadcasting Company is reviewed from the simple filament type compressors of 1929 through the present day studio units.

General characteristics are described, such as attack and recovery times, gain reduction, and thump. Practical units are illustrated for various applications; for controlling or limiting in broadcast studios, transmitters, portable equipment, and recording system.

A complete description is given of the latest type of studio control unit incorporating an adjustable control characteristic, a double-time constant-gain recovery circuit, and a circuit which permits transmission of pistol shots at abnormally high peak levels in order to create realistic sound effects.

2. "A New Development in Directional Microphones" ....Dr. Harry F. Olson and John Preston — Radio Corporation of America Laboratories

The directional microphone is a second order gradient system exhibiting a uniform and narrow directivity pattern and a smooth response frequency characteristic over the frequency range of 50 to 15,000 cycles. The directional efficiency—that is, the energy response to random sounds—is one-tenth. This order of directivity makes it possible to use a pickup distance up to 12 feet with speech in conventional studios. The use of several of these microphones, fixed in position and each microphone covering a section of the total action, together with a monitoring console makes it possible to cover rapidly changing and larger areas of action with smaller variations in the output level than is possible with the conventional microphone and boom arrangement.

3. "Microphone Placement in AM & TV".......................H. M. Gurin—National Broadcasting Company

The factors involved with sound in bringing intelligent information to the listener or viewer are analyzed, particularly with respect to the characteristics of the equipment, studio acoustics, and pickup techniques.

A number of variations of microphone placement in regular broadcasts, for different types of programs, will be demonstrated with an explanation of the methods employed. The differences in these techniques have been carefully studied and basic general methods are recommended.

The problems in television sound will also be indicated and the methods of handling some of these difficulties suggested. The differences between regular broadcasting or motion picture sound recording techniques will be discussed as well. The information of the type of program on the placement of microphones has been scrutinized and examples of current practices will be demonstrated.

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 AES Editor before the tenth of the month preceding the date of issue. Address replies to AES Editor, Audio Engineering, 342 Madison Ave., New York 17, N. Y.

- **Audio Technician.** 12 yrs laboratory, mfg, and field experience. 1st phone, competent trouble-shooter and constructor with design background. Pleasing, effective personality. Desire responsible position with BC station or equipment manufacturer. Box 101.
- **Research and Development Engineer.** Ph. D., specialized in electronics, circuit design, electro-mechanical devices, acoustics, precision-mechanics, nuclear physics equipment. Would like to be your consultant or part-time adviser. Box 102.
- **Electrical Engineer,** over 20 yrs electronic, acoustic, dynamic audio devices, systems. Accomplishments in development, design, manufacture, for commercial, marine, govt equipment. Exp. supervision, planning, estimating. Early radio background. Residence NY area. Box 103.
- **RCA Institute** graduate wishes position with audio company or recording studio. Box 104.
- **Communications Engineer** (MIT) 22, single, with good theoretical background and some experience; interested in research, development, or teaching in audio, acoustics, electric circuits, and vacuum-tube circuits. Box 111.
- **Audio Engineer:** Three years experience in magnetic tape development including pigment research, coating formulation, coating techniques, pilot plant operation, manufacturing control equipment and techniques. Broad background in all phases of film and disc recording. Box 112.
- **Graduate Student** of radio and television desires Junior Engineering position in audio or recording industry. Age 23, married, child. Willing to travel occasionally. Prefer midwest or south. Box 113.

4. "Longitudinal Noise in Audio Circuits" .... H. W. Augustadt—Bell Telephone Laboratories

This paper discusses the general effect of the presence of longitudinal noise on a circuit. The difference between metallic circuit noise and longitudinal noise is indicated both by definition of terms and representative circuit illustration. Test circuits for identification of type are described and discussed. Representative conditions by means of which longitudinal noise is introduced into a circuit are illustrated and discussed. Practical means and other limitations for reducing the disturbing effect of longitudinal noise on a circuit are described. The paper closes with an illustration of the application of the principles discussed to the design of a quiet AC-DC amplifier.

5. "Control of Sound in the Theater" ....Professor Harold Burris-Meyer—

Electronic control of sound for theatrical purposes was undertaken in the early Thirties as a continuing research project at Stevens Institute of Technology, supported by several organizations and individuals. When the war started, electronic sound control equipment had been completed and in use experimentally in the Metropolitan Opera House for two seasons. The control of sound for all theatrical purposes was substantially completed. Since the war, the project has been devoted to the development of a modular system of sound control equipment which should conform to theatrical operating practices and provide for varying demands. It includes basic equipment with which small tasks may be accomplished and provisions for adding standard items to other equipment as needs increase, without revision of design or the use of tools. The design of this system and its capabilities will be described.

6. "Logic in Relay Switching Circuits" .... William Keister—Bell Telephone Laboratories

Four basic control paths for an electromagnetic relay are the operate, lock-up, shunt and lock-down paths. Contacts on switches or other relays are connected in one or more of these paths to control the actions of relays in automatic control circuits. These relays respond to particular combinations of control events and may "remember" certain events in order to influence later stages of the circuit action. The arrangement of contacts in a control path is determined by logical analysis of the combinations of events which must cause the relay to act. A concise statement of conditions for closing a path corresponds to a series parallel circuit configuration where the words and and or relating control events correspond respectively to series and parallel connection of electrical contacts representing these events. The circuit may be written in symbolic form and the configuration rearranged and simplified by elementary theorems of Boolean algebra.

2:00 to 4:30 p.m. Papers —East Room

1. "A New Coupling Circuit for Audio Amplifiers" .... F. M. McIntosh, Consulting Engineer

After three years of laboratory work directed towards producing a sound amplifier which would fully meet the band width, waveform distortion, transient distortion, and phase shift requirement for completely realistic reproduction, it was found that such an amplifier probably cannot employ conventional push-pull circuits, (the desirability of the push-pull circuit being presumed to be self-evident). The core of the impending problem is the apparent impossibility of manufacturing a transformer having a ratio of leakage inductance referred from one-half of the primary to the second half, to open circuit inductance to one-half of the primary in excess of 80,000.

Leakage inductance in a push-pull transformer from one-half of the primary to the second half is primarily responsible in a Class AB or B amplifier for the production of a repetitive transient which occurs at the instant of current switching. The new circuit described herein offers a complete solution to the problem and, in addition, possesses many other excelling features. The design of an amplifier embodying this circuit will also be discussed.

2. "Standards—A General Discussion" .... Cyril Ainsworth—American Standards Association

3. "Audio Techniques in TV broadcasting" .... S. R. Patremio—DuMont Television Network

The audio in television broadcasting is similar in many respects to the audio in AM or FM broadcasting. It deals with the pick-up of sound in the form of voice or music, both live and recorded. However, television differs slightly in the fact that the microphones must be out of view of the cameras. This alone is one of the most difficult problems to cope with.

Another problem is that the talent plays to the cameras and not the microphones. This makes it necessary to follow the talent with microphone booms to keep them within range of the microphones. In the case of an orchestra, the microphones must be concealed and still produce the desired balance. Therefore, new techniques must be used.

In order to fully cover the problems in television broadcasting, they will be separated into the following categories: studio and theatre, films, teletranscriptions, field transmitter, and master control, and will be discussed separately.

4. "Audio Consoles for TV" .... R. W. Byloff—National Broadcasting Company

The problems encountered in making good sound pickups for a television stage and controlling several sound channels satisfactorily have troubled sound engineers since the beginning of television broadcasting. In this talk the author will describe some of these problems, and compare them with the problems met in motion pictures, radio, and recording. Equipments now used in motion pictures and recording for original takes and re-recording, and equipment used for sound broadcasting and television will be described and compared. The features of a proposed audio console for television use will be described in detail.

5. "Sound Reinforcing System" .... A. W. Schneider—Commercial Radio-Sound Corp.

Basic principles for theoretically perfect results; relation of fidelity, loudness and illusion to practical problems and compromises required will be discussed. Several large basic sound reinforcing systems, illustrating applications of various types of apparatus and compromises that have to be effected, will be described. Discussion of sound reinforcing requirements for broadcast and television studios.

7:00 p.m. Audio Engineering Society Banquet —North Ballroom
Norman C. Pickering, Toastmaster
Presentation of Awards and Honorary Memberships
Special Feature:

A comparison test, behind screens, of loudspeakers of leading manufacturers, with identification at close of Banquet.

Saturday, October 29, 1949

9:30 a.m. Registration —Sixth Floor
Exhibits Open

9:30 a.m. to 12 Noon. Audio Measurements Session—North Ballroom
Chairman .... W. L. Black—Bell Telephone Laboratories

1. The General Problem .... W. L. Black—Bell Telephone Laboratories
2. Intermodulation ....
   A. P. G. Peterson—General Radio
   H. E. Roys—Radio Corporation of America
   J. K. Hilliard—Altec-Lansing
   N. C. Pickering—Pickering & Company
3. Transient Methods .... M. S. Corrington—Radio Corporation of America
4. Operating Problems.... J. D. Colvin—American Broadcasting Company

Exhibits open until 4:00 p.m.

THE AUDIO FAIR

Directory of Exhibitors

ALTEC-LANSING CORP. 625
(Peerless Electrical Products Division)
161 Sixth Avenue, New York 13, N. Y.
Power transformers, filter chokes, input, interstage, output, modulation, and replacement transformers. "A transformer for every audio application."
IN ATTENDANCE:
H. S. Morris, Dave Sonkin, Mel Sprinkle, Marty Wolf

AUDIO & VIDEO PRODUCTS CORP. 614-615
1650 Broadway, New York 19, N. Y.
Ampex Tape Recorders; Minnesota Mining & Mfg. "Scotch" Tape; Altec-Lansing equipment.
IN ATTENDANCE:
Charles E. Rynd, Russell O. Hudson, W. O. Summerlin

AMPEX ELECTRIC CORP. 614-615
San Carlos, California.
Ampex tape recorders
IN ATTENDANCE:
Charles E. Rynd, Russell O. Hudson, W. O. Summerlin

AUDAK COMPANY, Inc. 642
500 Fifth Avenue, New York 18, N. Y.
Electronic-acoustical apparatus.
IN ATTENDANCE:
Maximilian Weil, George V. Sullivan, Alf Weberg

AUDIO DEVELOPMENT CO. 635
2833 13th Ave. So., Minneapolis 7, Minn.
Audio and power transformers, filters, amplifiers, jacks, and plugs.
IN ATTENDANCE:
Walter E. Lehnert, Eric R. Slayton

AUDIO DEVICES, Inc. 651
444 Madison Avenue, New York 22, N. Y.
Audiodiscs, Audiopoints, Audiotape.
IN ATTENDANCE:
Wm. C. Speed, C. J. LeBel, Bryce Haynes, Herman Karnbrodt

AUDIO FACILITIES CORP. 646
608 Fifth Avenue, New York 20, N. Y.
Specialized audio and electronic apparatus, theatre sound systems, artificial reverberation equipment.
IN ATTENDANCE:
John H. Beaumont, Lewis S. Goodfriend

AUDIO INSTRUMENT COMPANY 637
1947 Broadway, New York 23, N. Y.
Bridger, Logarithmic amplifier, logarithmic voltmeter, intermodulation analyzer, artificial ears, hearing aid test equipment, preamplifiers for condenser microphones, disc-noise meters, custom built audio measuring instruments.
IN ATTENDANCE:
C. J. LeBel

BALLANTINE LABORATORIES, Inc. 622
Boonton, New Jersey.
Electronic Voltmeters
IN ATTENDANCE:
Chas. L. Gawler, Walter A. Knoop, Harry C. Gawler, Allyn W. James

BURLINGAME ASSOCIATES, Ltd. 647-648
11 Park Place, New York 7, N. Y.
Manufacturers' Representatives
IN ATTENDANCE:
B. O. Burlingame, Robert Asen, G. C. Engel, Milton Lichtenstein, Charles Sargeant

Audio Fair Exhibitors

BROCINER SOUND LABORATORIES 647-648
(Burlingame Associates, Ltd., 11 Park Place, New York 7, N. Y.)
Klipsch System loudspeakers
IN ATTENDANCE:
Victor Brociner, B. O. Burlingame

BRUSH DEVELOPMENT CO. 647-648
(Burlingame Associates, Ltd., 11 Park Place, New York 7, N. Y.)
"Soundmirror" magnetic tape recorders
IN ATTENDANCE:
J. H. Munchausen, B. O. Burlingame

FRANK L. CAPPS & Co., Inc. 636
244 W. 49th Street, New York 19, N. Y.
Recording and reproducing styli, advance balls, shaving knives.
IN ATTENDANCE:
Isabel M. Capps, Wally Rose, Bill Clifford, Rom Marcucci, Dick Marcucci, Sal Gualtieri

CLOUGH-BRENGLE CO. 622
(Gawler-Knoop Company, 1060 Broad St., Newark 2, N. J.)
Sweep Frequency generators.
IN ATTENDANCE:
Chas L. Gawler, Walter A. Knoop, Harry C. Gawler, Allyn W. Janes

COOK LABORATORIES 636
139 Gordon Blvd., Floral Park, N. Y.
Feedback recording heads, Q-C recording equipment, Audioid synthetic damping. Series 10—20,000-cps frequency record.
IN ATTENDANCE:
Emory Cook, Joe Kuhn

THE DAVEN COMPANY 616
191 Central Ave., Newark, N. J.
Attenuators, potentiometers, rotary selector switches, precision wire-wound fixed and variable resistors, transmission measuring sets, decade resistances, volume level indicators, and all types of test and measuring equipment.
IN ATTENDANCE:
Lewis Newman, E. L. Grayson, J. P. Smith, Jr., R. J. Newman, C. F. Scott

ALLEN B. DuMONT LABORATORIES, Inc 622
(Gawler-Knoop Company, 1060 Broad St., Newark 4, N. J.)
Cathode-ray oscillographs, voltage and time calibrators.
IN ATTENDANCE:
Chas. L. Gawler, Walter A. Knoop, Harry C. Gawler, Allen W. Janes

ELECTRIC INDICATOR CO. 649
Parker Avenue, Stamford, Conn.
Electric motors and generators.
IN ATTENDANCE:
Ralph Kricker, Joseph Marcus, Alfred Debona

THE ELECTRONIC WORKSHOP, Inc. 634
351 Bleecker St., New York 14, N. Y.
High fidelity audio components and systems, audio amplifiers and control units, and instruments for audio or special applications.
IN ATTENDANCE:
Frank Ganci, Leonard Sherry, Howard T. Sterling, Byron St. Clair, Ben Bell, Jan Syrjala, Alan Sobel, Alice Fee

ELECTRO-VOICE, Inc. 618
Buchanan, Michigan.
Broadcast and public address microphones; crystal magnetic, and ceramic phonograph cartridges and arms; microphone stands, transformers, and accessories.
IN ATTENDANCE:
Jack E. Willson, A. R. Kahn

Audio Fair Exhibitors

FAIRCHILD RECORDING EQUIPMENT CORPORATION 653
154th St. and 7th Ave., Whitestone, L. I., New York.
Tape recorders, synchronous disk recorders synchronous transcription turntables, transcription pickup, magnetic playback cartridges, cutterhead, equalizers, amplifiers, VU panels, mixer panels, complete unitized amplifier systems. Complete recording installations built to specifications.
IN ATTENDANCE:
Jay H. Quinn — Avery Lockner
Leon A. Wortman — C. V. Kettering
Wm. Hazlett

GAWLER-KNOOP COMPANY 622
1060 Broad Street, Newark 2, N. J.
Manufacturers Representatives.
IN ATTENDANCE:
Chas. L. Gawler — Walter A. Knoop
Harry C. Gawler — Allyn W. Janes

GENERAL ELECTRIC COMPANY 619
Electronics Park, Syracuse, N. Y.
Speakers, tone arms, pickups, preamplifiers.
IN ATTENDANCE:
R. S. Fenton — J. W. Duffield
T. J. Nicholson

JAMES B. LANSING SOUND, Inc. 611-612
2439 Fletcher Drive, Los Angeles 26, California.
Loudspeakers.
IN ATTENDANCE:
C. G. Barker — John S. Boyers

H. J. LEAK & CO. LTD. 650
Brunel Road, Westway Factory Estate, Acton, London W.3, England.
"Point One" audio frequency amplifiers; Leak dynamic pickup; Leak "550" loudspeaker system
IN ATTENDANCE:
H. J. Leak, Esq., M. Brit. I.R.E.

LIVINGSTON ELECTRONIC CORP. 646
Livingston, New Jersey.
Phonograph pickup arms, "MB" Loudness controls, Stylus pressure gages.
IN ATTENDANCE:
C. O. Smiley — John Gardner

MAGNECESSORIES 609
Box 6960, Washington 20, D. C.
Carson Tape Splicer — Visi-Mag
IN ATTENDANCE:
Robert H. Carson

MAGNECORD, Inc. 611-612
360 N. Michigan Blvd., Chicago 1, Ill.
Tape recording equipment.
IN ATTENDANCE:
C. G. Barker — John S. Boyers

J. A. MAURER, Inc. 631
37-01 31st Street, Long Island City 1, N. Y.
Maurer 16-mm professional motion picture cameras, Maurer 16-mm sound-on-film recording system, Maurer 16-mm film phonograph.
IN ATTENDANCE:
L. A. Root

McINTOSH ENGINEERING LABORATORY 611-612
710 14th St., N. W., Washington 5, D. C.
Amplifiers.
IN ATTENDANCE:
Frank McIntosh

THE MIGEL DISTRIBUTING CORP. 601
118 East 25th Street, New York 10, N. Y.
The Bolsey Portable Microfilmer and Reader.
IN ATTENDANCE:
Morton R. Shapley — John Migel
Ralph DeSola — William Nichols

Audio Fair Exhibitors

THE MINNESOTA ELECTRONICS CORP. 622
(Gawler-Knoop Company, 1060 Broad St. Newark 2, N. J.)
Amplifiers, filters, Noiseraers.
IN ATTENDANCE:
J. H. Munchausen

NEWARK ELECTRIC CO., Inc. 602
242 W. 55th St., New York 19, N. Y.
Wharfdale speakers, Du Mont scopes for audio measurements. Audiodiscs, Audiotape, Altec-Lansing sound equipment. Daven attenuator pads.
IN ATTENDANCE:
Herman Holstein — Samuel Weisbroth

PANORAMIC RADIO PRODUCTS Inc. 626
10 South Second Ave., Mount Vernon, N. Y.
Panadaptor, Panalyzor, Panoramic Sonic Analyzer, Panoramic Ultrasonic Analyzer.
IN ATTENDANCE:
Bernard Schlessel — Joseph F. McClean
Ben H. Tongue — Ralph Segel

PEERLESS ELECTRICAL PRODUCTS DIVISION 625
(Altec-Lansing Corporation)
161 Sixth Avenue, New York 13, N. Y.
Power transformers, filter chokes, input, interstage, output, modulation, and replacement transformers. "A transformer for every audio application."
IN ATTENDANCE:
H. S. Morris — Dave Sonkin
Mel Sprinkle — Marty Wolf

PERMOFLUX CORPORATION 641
4900 West Grand Ave., Chicago 39, Ill.
Speakers, baffles, headphones, microphones, tape recorders and amplifiers.
IN ATTENDANCE:
L. M. Heineman — T. Trzyna
C. C. Fisher

PICKERING AND COMPANY, Inc. 624
309 Woods Avenue, Oceanside, N. Y.
Phonograph pickups; pre-amplifiers; equalizers; amplifiers; audio equipment; solenoids; transformers; magnetic devices; I-M distortion measuring instruments.
IN ATTENDANCE:
Walter O. Stanton — Norman C. Pickering

PRESTO RECORDING CORP. 623
(Mail) P.O. Box 500, Hackensack, N. J.
(Plant) Paramus, New Jersey.
Recording and transcription turntables, studio and portable tape recorders, recording amplifiers.
IN ATTENDANCE:
Thomas B. Aldrich — Irving Rosenblatt
Fred Jorysz — John Strampfer

PRESTOSEAL MANUFACTURING CO. 647-648
(Burlingame Associates, Ltd., 11 Park Place New York 7, N. Y.
Magnetic tape (plastic) splicers, film splicers.
IN ATTENDANCE:
Leonard Herzig

PROCTOR SOUNDEX CORP. 639
133 N. Sixth St., Mt. Vernon, New York.
Turntables and pickup arms; audio sound equipment.
IN ATTENDANCE:
B. A. Proctor — J. J. McCann
B. A. Proctor, Jr. — Emil B. Kurkowski
M. A. Peckham

RACON ELECTRIC CO., Inc. 617
52 E. 19th St., New York 3, N. Y.
Loudspeakers for public address systems, re-entrant trumpets, driver units, paging speakers, marine speakers, tweeters.
IN ATTENDANCE:
A. I. Abrahams
Edward Maged

Audio Fair Exhibitors

RADIO CORPORATION OF AMERICA 632-633
Camden and Harrison, New Jersey.
Tubes, Sound Products and Broadcast Audio Equipment as follows: Rack-Mounted Tape Recorders, 70-D turntable with 45 rpm modification, LC1A speakers, and microphones.
IN ATTENDANCE:

W. O. Hadlock	Julius Haber
Harold Becker	A. R. Hopkins
C. M. Lewis	E. Miller
J. E. Hill	M. A. Trainer
W. T. Babcock	H. W. Rhodes
A. K. Ward	A. Lof
H. C. Elwes	H. C. Somerville
R. von de Linde	Kenneth Shaffer
Lawrence Le Kashman	Nick Carter

RANGERTONE, Inc. 621
73 Winthrop St., Newark 4, N. J.
Magnetic tape recorders and magnetic recording.
IN ATTENDANCE:

R. H. Ranger	F. Whitehouse
S. L. Ackerman	P. Brubaker
A. Colabella	

RECOGRAM RECORDERS CO. 610
11338 Burbank Blvd., North Hollywood, Calif.
Magnagram magnetic film recorder; Centogrip splicers.
IN ATTENDANCE:

D. J. White	Wm. H. Stutz

REK-O-KUT COMPANY, Inc. 652
38-01 Queens Blvd., Long Island City 1, N. Y.
Cutting units, transcription turntables, recording mechanisms, playback units, recording amplifiers.
IN ATTENDANCE:

George Silber	Frank Scannell
Sydney Simonson	

SOMERSET LABORATORIES, Inc. 628
1701 Palisade Ave., Union City, New Jersey.
Amplifier, dynamic noise suppressor pre-amplifier.
IN ATTENDANCE:

Carl E. Ring	James Evans
John T. Loomis	Besse Auerbach

SONAR RADIO CORPORATION 644
59 Myrtle Ave., Brooklyn, N. Y.
Tape recorders; amateur equipment.
IN ATTENDANCE:

Jack Babkes	Ray Morehouse
Edward A. Babkes	Adolph Schwartz
John Yinaga	Jos. Abrams

STANCIL-HOFFMAN CORP. 645
1016 N. Highland Ave., Hollywood 38, Calif.
Stancil-Hoffman magnetic transcription recorders and reproducers, magnetic communications recorders, the "Minitape" miniature magnetic recorder, the Elken automatic tape splicer.
IN ATTENDANCE:
Henry J. Geist and Associates

STEPHENS MANUFACTURING CORPORATION 620
8538 Warner Drive, Culver City, California.
Loudspeakers and Microphones.
IN ATTENDANCE:

Robert Lee Stephens	Art Cerf
Henry Hold	Dick Mittl

SUN RADIO & ELECTRONICS CO., Inc. 640
122 Duane St., New York 7, N. Y.
Distributor of sound products.
IN ATTENDANCE:

Samuel N. Gerard	Irving Green
Sy Bosworth	Joseph Greenfield
Burt Zimit	Al Goldberg
Walt Zuckerman	Lionel Phillips
Sanford Herman	Bob Smith

Audio Fair Exhibitors

TECH LABORATORIES, Inc. 638

Bergen & Edsall Blvd, Palisades Park, N. J.

Attenuators, potentiometers, tap switches, fixed pads, matching pads, gain sets, viscosity meters, resistance measuring equipment.

IN ATTENDANCE:

M. Bjorndal, A. L. Budd, G. Van Baaren

UNIVERSITY LOUDSPEAKERS, Inc. 643

80 S. Kensico Ave., White Plains, N. Y.

Commercial and industrial loudspeakers, driver units, tweeters and accessory equipment, Powrmike systems.

IN ATTENDANCE:

Seymour Blumenfeld, Irving Golin, Saul White, Lawrence Epstein, Haskell Blair

U. S. RECORDING CO. 611-612

1121 Vermont Ave., N.W., Washington 5, D.C.

Consolette.

IN ATTENDANCE:

H. P. Meisinger

RECORD REVUE

[*from page 26*]

most every engineer uses magnetics as a matter of course for this reason. But how about the many LP's that don't come through well via the magnetic treatment? Well, they do come through via the crystal.

Which leads on to a bit more. It is at once evident to me in listening to Dr. Goldmark's office machine that there is a decided difference in tonal balance between what he is getting and what I am accustomed to as the average sound from engineers' equipment. The highs seem far less pronounced—so much so that at first my impression was the "tone control" effect of severe roll-off, until, after a bit, I begin to hear the triangles and what-not that indicate the presence of high highs. I am sure that most engineers, reacting earwise, would be struck at once, as I am, by this seeming lack of highs. Aha! Of course you don't hear any distortion; you can kill any distortion if you roll down those highs enough, you are saying. Just a moment. *Who said they were rolled off?* To the best of my knowledge the CBS player and the RCA amplifier are equalized to match the LP record's curve. There is no *extra* roll-off.

Then what. . . .? Well, one conclusion I am forced to, in the face of this, is that most engineers are *not* equalizing their equipment to match the LP curve. Tin ears—we all have 'em. I begin to suspect that most engineers have been listening to hi-fi equipment for so long that the stuff has crept up on 'em. Equalize correctly and it sounds dull, so quick boost up those highs and get some *real* hi-fi! We all know the notorious love of J. Q. Public for the exaggerated juke-box type of bass: hadn't we better look at that beam in our own little eye and check up on our highs?

If you don't agree, then you explain it. Because I have one final argument that may clinch this last, and that is an ingenious new crystal soon to be put out by Columbia and Astatic, of which I have an early sample. It embodies a new slant to the problem of equalization, for this is a "pre-equalized" crystal which has been doctored up *to match in itself the curve of the Columbia LP record almost exactly*, and that to beyond 10,000. (It is housed in the same case as the just-available model CQ-J, now being used in the new Columbia player, but differs internally and will go by another code name, C-AC.)

Now here is a crystal pickup that is a natural for experiment. No equalization at all; it is designed to be fed directly into a flat amplifier. When so fed, it gives automatically the curve required to reproduce the LP record. And this on the authority of the designer of both.

What happens when it is put to work? (1) The music comes out sounding like the sound I have heard in Dr. Goldmark's office. A bit "rolled off" on the high end. You may point your own moral for that. My own conclusion, again, is that a lot of us have been overindulging in highs. What sounded to me on the dull side sounded to others quite natural and brilliant. (2) The records that have been buzzing away merrily these many months on my magnetic pickups again come out definitely minus the buzz, or whatever other name the unpleasantness can be given. This crystal, automatically equalized, acts as does the original LP crystal, the LP-33. In some unexplained manner it "matches" the LP record better than existing magnetics. Records that sound distorted on the magnetic come clean on this. What have these crystals got that avoids the trouble which crops up in the magnetics? It is possible that the difference is not electrical. Keep in mind that this new crystal is equalized definitely to the LP curve up to 10,000 and continues on out "to 12,000."

Could there be some subtle mechanical factor or factors that have been overlooked in the designing of the magnetic LP cartridges and in the setting up of arm-and-cartridge combinations? It is notable that whereas engineers using magnetic LP cartridges invariably use the long and bulky professional-type arms, CBS crystal LP-playing equipment just as invariably employs smaller and shorter arms. The demands of home players could not, I'd say, entirely account for this. It is already obvious enough to me that there is a lot more tracking trouble with the fancy long-arm set-ups than with the very short and light arms used for crystals. Passages that will not track on an expensive long arm (blame the record!) will track with no trouble at all on the Astatic FL short arm. These are factors. What else? I leave that to you to suggest, since I am fast getting out of my depth in this area.

* * *

So there you have it—as fine an example of inconclusive writing as this magazine has so far sported. My conclusion is mainly that there are things that need explaining, and my intention is to stir up comment and perhaps argument so that in the end they will be explained to everyone's satisfaction. I want to know what causes the unpleasant distortions I have heard from magnetic LP pickups. I want to know why a few LP's are astonishingly free from them, played on identical equipment—especially since CBS is not admitting any difference between those that sound good to me and those that don't. I want to know why the CBS-designed crystal LP cartridges do not show up this distortion, why the LP records seem so much less temperamental as played thus crystal-wise. Just what has CBS got there, and why can't the magnetics do the same?

Comments of any sort are invited from interested parties, especially accounts of your experiences with LP's and your explanation of same, all in the interest of good, clean fun. We all, naturally, beg the indulgence of Columbia Records, Inc., as the largest producer of the LP type of disc and hence automatically the butt of our inquiry. Since in these matters Columbia, advocating crystal, seems to stand against many professionals who advocate magnetic, I suggest you experiment with the new crystals yourself. Approved cartridges to date are the LP-33, now being withdrawn, and its successor the model U-J; the small standard-mounting CQ-J, just now becoming available; the C-AC, to come later, all designed under CBS supervision. Other crystals may or may not give comparable results.

LP records that are strikingly free of the buzzy-style distortion—at least as I hear 'em on magnetic cartridges—are:

Beethoven, Symphony #1 (Bruno Walter)
Rimsky-Korsakov, "Scheherezade."
Enesco, Roumanian Rhapsody #1.
Hindemith, Metamorphoses on Themes of Weber.
Saint-Saens, Symphony #3, with Organ.
Walton-Sitwell, "Facade."

As for me—I'm playing my LP's on magnetics, at home. But my FM-AM New York broadcast of LP's weekly will be done exclusively via crystals. Fair test.

Schubert, "Trout" Quintet in A, opus 114
Franz Rupp, piano; Stross Quartet.
Capitol EDL 8019 (4)

• This recording, on 78 and 45 but not so far scheduled for LP, is not only one of the most delightful of all Schubert's instrumental works, but it happens to be an excellent test recording for the bass range, since the quintet of instruments is one of the very few in all classical literature (maybe it's the only one?) that includes a string bass or "double-bass." The instrumentation is for piano, violin, viola, cello and bass. The bass here serves just as it does in a small jazz ensemble, to put body and depth into the music, to hit off the rhythm and the harmony, almost drum-wise. It is beautifully recorded, close-to and loud but never too loud. On a table phonograph it is completely inaudible (the overtone that ordinarily give us a sense of bass are here rather weak, and the notes are mostly too short for very much to register, anyway) but play these records with an extended range outfit and presto—the double-bass practically stands right up in front of you. A very nice check on low-frequency resonances, since this massive instrument plays its way all over the lower tonal range and with considerable power, at that.

Schubert has a very special piano technique that he used when that instrument was playing "ensemble"—that is, playing along with other instruments: he writes high octaves near the extreme top end of the keyboard, and the sound is almost like a xylophone or marimba, a sort of bell-like melodic line. In the "Trout" Quintet this highly ornamental piano writing is set off particularly nicely by the fat and tubby sound of the double bass at the other frequency extreme.

The title is explained by the 4th movement, a set of variations on the melody of one of Schubert's best known songs, "the Trout."

Stravinsky, Concerto for Two Pianos
Vronsky and Babin, duo-pianists.
Columbia MM 837 (3)
LP: ML 157

Stravinsky, Suite Italienne ("Pulcinella")
Raya Garbousova, cello; Erich Itor Kahn, piano.
Concert Hall C5 (2)

• Two interesting Stravinsky items. The concerto is a major work and a difficult one for two pianos alone minus orchestra. It was issued last year in a Vox recording by Appelton and Field (with "program notes" by Canby); now it gets its second trial, on LP as well as 78, with another team (and Columbia has done me the honor of "borrowing" the substance of the Vox program notes for its description. Both versions are miracles of piano teamwork, for this is an incredibly difficult work, written as though the two instruments were one, the players a single four-handed superman. Both are flawless in the performance and convincingly tremendous in massive effect. But I like the Appleton-Field version better. It seems to me warmer, more musical, better phrased, and I think the music comes through in more easily digestible form, too. The advantages of LP, however, weigh on the other side. Both recordings are models of what two-piano recording can be, the Vox version a bit erratic but fundamentally excellent, the Columbia sharper and more "pingy" in the percussive passages, smoother in the over-all. If you like big, dissonant, brilliant piano noises and you have a big outfit that will take all you can feed it, maybe this concerto wouldn't be such a bad bet. Worth a try. It's potent music.

The "Pulcinella" suite is a strange and interesting hybrid. The original was for orchestra (1920), music for a ballet. The stuff has not one but two composers, nor do I mean one composer and one arranger. The ballet music was written by Stravinsky "after" Pergolesi (the brilliant young Italian composer of the early 1700's who wrote the famed Stabat Mater and the operetta "La Serva Padrone"), by which Stravinsky means that he wrote new and original music of his own that incorporated actual thematic material of Pergolesi and, even more, the "feeling" of the older music. It may be hard to figure this one out, but I can only suggest that, for an engineer, this is equivalent perhaps to the creation of a new electronic circuit in which certain basic and characteristic elements from an older one are made use of and given due credit. Engineers of course do it all the time, and so do musicians, but most musicians aren't as definite about it as Stravinsky, who has also written a ballet "after" Tchaikowsky. In such cases, as might be expected, one hears some of each composer—and if you think the mix-

ture of Stravinsky and Tchaikowsky sounds incredible (or S—Pergolesi), just listen to it. It works! (P.S.—See last month's review of Hindemith's "Metamorphosis on Themes of Carl Maria von Weber"—same kind of thing—and note the unexpected results of the mixture of Hindemith and the early 19th century Weber.)

Brahms, Serenade #1 in D, opus 11
Concert Hall Society Orchestra, Swoboda.
Concert Hall C4 (4)

• If it didn't make good reading there wouldn't be much point in reviewing this for engineers, since it is available only to subscribers for the Limited Edition. Still, it's well for all of us to know what's going on, if only second-hand. This recording is for me the answer to a fifteen years' wish. For that long I've had a single record of two short movements from this rarely heard work and have wished all that time, some day, to hear the rest of it. This is its first complete recording as far as I know, and why it isn't played more often I cannot say, for if you like Brahms at all, this is bound to please. It's a very early work, and, as such, a product of genius, without question. The rich combination here of horns, woodwinds and strings is orchestra-like, yet with the fullness and nearness of a smaller group of virtuoso soloists; the music is equally rich, harmonically and melodically. Recording is excellent and on good vinylite. Concert Hall's usual (apparent) high turnover, big pre-emphasis in the highs. If you ever have access to it, try the third movement or the last.

Haydn, Symphony #94 ("Surprise")
Berlin Philharmonic, Schmidt-Isserfeldt.
Capitol ECL 8021 (3)
LP: P 8038

• This is perhaps the most familiar of all Haydn symphonies, but there has never been a performance like this one on records. Haydn is the so-called "father of the symphony"—by which is meant that this benign and wonderful man, one of the simplest and yet most profound minds in all of music, developed a type of music for a considerable ensemble of players from earlier styles that involved music for solo players with an occasional background framework for larger groups. "Considerable," however, indicates not the huge 100-piece symphony orchestra of later days, but a group of about 30 or 40 players at the most—plenty to make a big noise in a small hall for selected audiences. Most performances of Haydn today are done with a much larger orchestra and in a heavy-weight style, borrowed from later music, that only succeeds in making Haydn sound cute and silly. Especially on records, where as any engineer knows the bigger an orchestra is, the muddier the general effect, without of course the slightest gain in volume, since volume nowadays is a function of electrical "level," not of instrument power.

Moreover, because of the physical characteristics of musical instruments, a large orchestra has an utterly different balance from a small one. Strings can play together in large groups, hence your big orchestra has many more strings than your small one. But woodwinds, flutes, oboes, etc., do not blend well and must remain pretty much solo instruments. Hence, in the larger orchestra they are far weaker in proportion to the strings. Later writers, taking this into account, fix their music to match. But when Haydn (and Mozart) are played as written but with an over-sized orchestra, the woodwinds are lost in a huge mass of string tone, the balance thrown off. The larger mass of strings, too, simply cannot play the rapid, clean-cut notes originally designed for a small, close-working group of string players.

The Berlin Philharmonic recording of the "Surprise" is done with a small orchestra, and the players are almost soloists, as it should be. Nor is there any striving for "big" effects, no cuteness; the music is played accurately and seriously, and you'll find it a lot more powerful in effect than the numerous recordings made with "modern" orchestras.

Enesco, Roumanian Rhapsody #1
Liszt, Mephisto Waltz
New York Philharmonic. Rodzinski.
Columbia LP: ML 2057

• Here are two reissue jobs, one of which rates as the best LP of the month—the Roumanian Rhapsody. This (see article above) is one of those LP's that on my magnetic pickups comes through crystal-clean and without a buzz. As already stated, I am in a state of infinite confusion right now as to what this indicates. But whether all LP's or few sound good on your machine, I'm sure that this recording of a rather silly show piece will delight you with a top-ranking sound. Put it next to "Scheherezade" on your LP shelf. The Liszt (also inexplicably) is not as clean, not as clear, even though it involves the same orchestra, same conductor. It's OK, but not super.

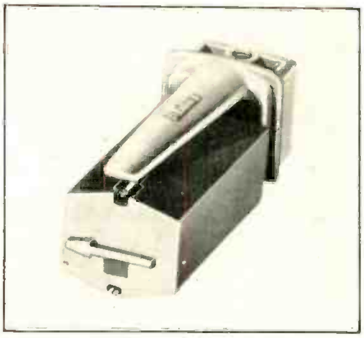
Britten, Young Person's Guide to the Orchestra
Handel, Royal Fireworks Music (arr. Harty)
Columbia LP: ML 4197

• Aha! Here's that super test record that most engineers have long since discovered in its 78 version, complete on LP, and my report is that it's good on LP, too. You can have that famous pistol shot to your heart's content. I'd say that, somehow or other, the low-turnover, heavy-bottomed characteristic of the English records has been preserved in the LP. (Does Columbia try to equalize for the known difference between English and U.S. recordings?) The highs here are fairly modest in strength as compared to some domestic Columbia LP's, but the stuff is there all right. There is some noticeable change in quality (so I detect, at least) between beginnings and ends of the 78 rpm sides, especially when a side ends loud.

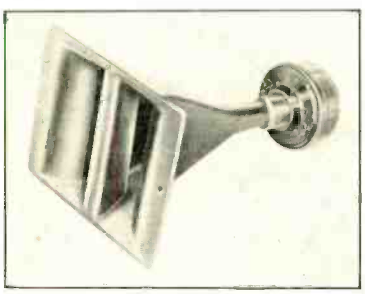
The Handel "Fireworks" supersedes the famous album played with Harty himself conducting (Columbia X 51). That album still is tops musically, but this is a fair approximation in the playing. As an LP this is fairly clean, but the loud strings are just a bit mealy. (A kind of unclarity that might, I'd hazard a guess, be a matter of resonances in the cutting assembly, or intermodulation of some sort; it's a sound that's very familiar on older records, as some would put it, a "phonograph" sound as distinguished from the clean sound of natural strings. Very slight here.)

NEW PRODUCTS

• **The Polyphase Reproducer**—a high-quality magnetic unit that solves the problem of playing the various types of discs now in use—has just been an-



nounced by Audak Company, 500 Fifth Avenue, New York 18. It permits ten different combinations of removable styli, is easily mounted on most arms, and has excellent "ear-quality." The Polyphase provides wide-range performance at exceptionally low cost.



• **A new tweeter,** of aluminum, has been introduced by University Loudspeakers, Inc., 80 S. Kensico Ave., White Plains, N. Y. This model is designed for 600-cps crossover, and may be had for either 20- or 40- watt systems. The coverage extends to 80 deg. horizontally, and makes possible the economical assembly of a two-way speaker system. Further information may be obtained from the manufacturer.

• **Audiotape**—heretofore available only with paper base—may now be had with plastic base, thus making the line complete with all types of magnetic recording tape. Two coatings are being offered, both the high-coercive black oxide and the medium-coercive red oxide, and both may be had on either paper or plastic. New low prices on the entire line of Audiotape will be furnished by Audio Devices, Inc., 444 Madison Ave., New York 22, N. Y.

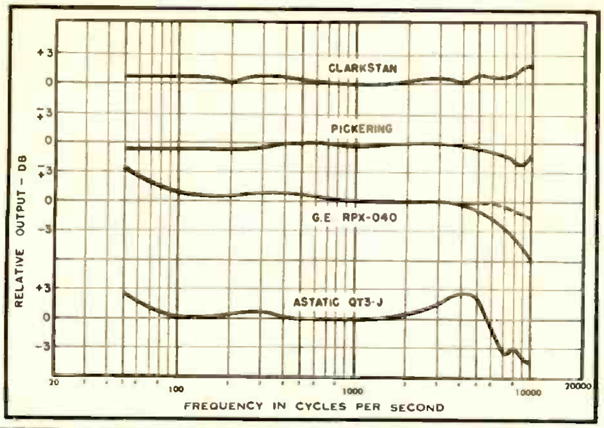


Fig. 7. Equalized response characteristic of popular pickups.

PREAMPLIFIER DESIGN

[*from page 17*]

ful selection and handling would be necessary with standard resistors in this position, so special low-noise English resistors now being made available in this country are used instead.

Pickup Response

This design has led to some related research on the matter of pickup response and comparison, which seems to be of considerable interest. Since both the Pickering and Clarkstan cartridges are guaranteed to be flat within 2 db (once the roll-off resistor is removed from the Clarkstan) it was considered safe to assume the mean between the two as essentially flat response.

On this basis the curve of *Fig.* 6 was determined for the Columbia 10003-M test record. This indicates a significant drop in the high frequencies over the published characteristic, and this drop is confirmed by the light pattern of the record.

The comparative curves of *Fig.* . were plotted for the Clarkstan, G.E. RPX-040, and the Pickering, as well as the Astatic QT-3J.

Performance of the G. E. is very critical with respect to loading, both resistive and capacitive. The curve of *Fig.* 7 was run with a load of 0.5 megohm and 500 μμf. Loading of the order of 0.1 megohm may cause the response to be down 3 db at about 7500 cps. Where the plug-in preamp. is to be used with G. E. cartridges, the input resistor should be raised to 0.5 a megohm.

The QT-3J, although a crystal, shows relatively little distortion, and is comparable to the magnetic cartridges in this respect, although, as might be expected from the curve, its transient performance is not as good. It has not received the attention it deserves,

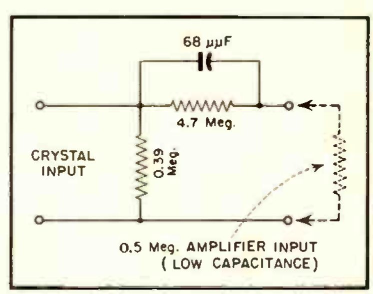


Fig. 8. Equalizer for QT3-J cartridge to give response of *Fig.* 7

however, largely because few people have taken the trouble to equalize it properly. *Figure* 8 shows the equalizer used to obtain the curve for the QT-3J in *Fig.* 7. This may be built into an octal base and substituted for the plug-in preamplifier when desired.

Biography

1 "Versatile Phonograph Preamplifier," Paul W. St. George and Benjamin B. Drisko, Audio Engineering, March, 1949.
2 "Flexible Dual Control System," Howard T. Sterling. Audio Engineering, Feb. 1949.
3 "Feedback Preamplifier For Magnetic Pickups," Richard S. Burwen, Audio Engineering, February, 1948.

TRANSFORMER APPLICATIONS

[from page 21]

der how to determine the impedance values between taps, and the impedance of unequal windings in series. This would be a simple matter were the actual number of turns known, but this is usually not the case.

There are two methods by which the impedances that are available from a given transformer may be determined. If an audio oscillator and a vacuum-tube voltmeter are available, the turns ratio may be measured directly. Apply a known voltage from the oscillator to one winding and measure the voltage with the high-impedance vacuum-tube voltmeter at the desired terminals, as in *Fig.* 2. The impedance ratio is then the square of the voltage ratio.

By measuring and recording the values at various taps, a convenient set of data on that particular unit may be obtained.

With output transformers, a rough check may even be made using only a multirange rectifier-type meter with 1000-ohm-per-volt sensitivity and the regular 117-volt 60-cps line, as shown in *Fig.* 3. This method is not recommended for input transformers because of the load presented by the voltmeter.

If the impedance values are known at several taps or of separate windings, a simple calculation may give the desired answer more quickly. A few formulas have been derived which are fairly easy to remember, and values are obtained without reference to the primary impedance. To illustrate this, the following simplified derivation is presented. Note that the primary impedance is used as a common factor, and subsequently drops out.

Assume a transformer having three windings, *p*, *a*, and *b*, corresponding voltages E_p, E_a, and E_b, and impedances Z_p, Z_a, and Z_b, with the arrangement shown in *Fig.* 4. It is desired to derive an equation for Z_c representing Z_a and Z_b wired in series, observing "aiding" polarities.

$$E_a/E_p = \sqrt{Z_a/Z_p}$$

$$E_a = Z_p\sqrt{Z_a/Z_p}$$

$$= E_p\sqrt{Z_a} \,/\, \sqrt{Z_p}$$

Similarly

$$E_b = E_p\sqrt{Z_b} \,/\, \sqrt{Z_p}$$

and

$$E_c = E_p\sqrt{Z_c} \,/\, \sqrt{Z_p}$$

$$E_c^2 = E_p^2\, Z_c \,/\, Z_p$$

$$Z_c = E_c^2\, Z_p \,/\, E_p^2$$

Now

$$E_c = E_a + E_b$$

$$= E_p\ (\sqrt{Z_a} + \sqrt{Z_b}) \,/\, Z_p$$

From above

$$Z_c = E_c^2 + Z_p \,/\, E_p^2$$

Substituting and solving

$$Z_c = (\sqrt{Z_a} + \sqrt{Z_b})^2$$

$$Z_c = Z_a + Z_b + 2\sqrt{Z_a\, Z_b} \qquad (1)$$

Similar derivation for the value between taps of a winding as shown in the diagram of *Fig.* 5 yields the following formula:

$$Z_c = Z_a + Z_b - 2\sqrt{Z_a\, Z_b} \qquad (2)$$

These formulas have been of great use to the writer and it is hoped that they may serve the reader equally well.

The following examples are given to illustrate their application:

1. An amplifier has to be matched to a 600-ohm load. The output transformer has a 500-ohm winding and a winding tapped at 2, 4, 6 and 8 ohms. The 500-ohm winding in series with the 4-ohm section will give, using formula (*1*):

$$Z_c = 500 + 4 + 2\sqrt{500 \times 4}$$

$$= 504 + 2\sqrt{2000}$$

$$= 504 + 89.44 = 593.44 \text{ ohms}$$

The 6-ohm section together with the 500-ohm winding will yield:

$$Z_c = 500 + 6 + 2\sqrt{500 \times 6}$$

$$= 506 + 2\sqrt{3000}$$

$$= 506 + 109.6 = 615.6 \text{ ohms}$$

The 4-ohm section apparently would be the better choice.

2. The 20-ohm dynamic microphone has to be matched to an amplifier while the input transformer has two tapped windings as shown in *Fig.* 6. The known values would result in considerable mismatch and the value of the unknown section is investigated:

$$Z_c = 125 + 50 - 2\sqrt{50 \times 125}$$

$$= 175 - 2\sqrt{6250}$$

$$= 175 - 158 = 17 \text{ ohms}$$

This match is obviously closer than would be possible using only the known values and best results are obtained by using both Z_c sections in parallel.

In closing, the writer wishes to call attention to the fact that two equal impedances in series will give a value four times that of the single winding and that one half of a winding presents an impedance of one-fourth of the total winding.

STATEMENT OF THE OWNERSHIP, MANAGEMENT, CIRCULATION, ETC., REQUIRED BY THE ACT OF CONGRESS OF AUGUST 24, 1912, AS AMENDED BY THE ACTS OF MARCH 3, 1933, AND JULY 2, 1946.

of AUDIO ENGINEERING, published monthly at New York, N. Y., for October 1, 1949.

State of New York ss.:
County of New York

Before me, a Notary Public in and for the State and county aforesaid, personally appeared Dorothy S. Potts, who, having been duly sworn according to law, deposes and says that she is the publisher of AUDIO ENGINEERING, and that the following is, to the best of her knowledge and belief, a true statement of the ownership, management, etc., of the aforesaid publication for the date shown in the above caption, required by the Act of August 24, 1912, as amended by the Act of March 3, 1933 and July 2, 1946 embodied in section 537, Postal Laws and Regulations, to wit:

1. That the names and addresses of the publisher, editor, managing editor and business manager are: Publisher: Dorothy S. Potts, 1737 York Avenue, New York 28, N. Y.; Editor: Charles G. McProud, 7 Peter Cooper Road, New York 10, N. Y.; Managing Editor: None; Business Manager: Sanford L. Cahn, Westmoreland Gardens, Little Neck, N. Y.

2. That the owners are: Radio Magazines, Inc., 342 Madison Ave., New York 17, N. Y.; Dorothy S. Potts, 1737 York Avenue, New York 28, N. Y.

3. That the known bondholders, mortgagees, and other security holders owning or holding 1 per cent or more of total amount of bonds, mortgages, or other securities, are: None.

4. That the two paragraphs next above, giving the names of the owners, stockholders and security holders, if any, contain not only the list of stockholders or security holders as they appear upon the books of the company, but also, in cases where the stockholder or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting, is given; also that the said two paragraphs contain statements embracing affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock, and securities in a capacity other than that of a bona fide owner; and this affiant has no reason to believe that any other person, association, or corporation has any interest direct or indirect in the said stock, bonds, or other securities than as so stated by him.

(Signed) DOROTHY S. POTTS, Publisher.

Sworn to and subscribed before me, this 7th day of september, 1949.

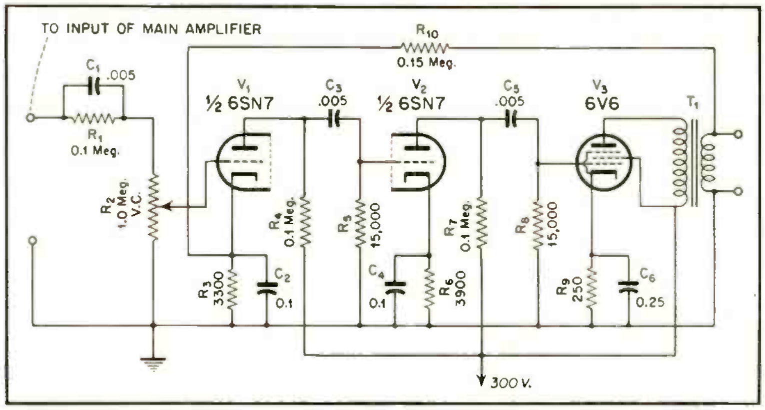
(Seal). HARRY N. REIZES, Notary Public.

State of New York, No. 24-3249550, Qualified in Kings County, Certs filed with Kings & N. Y. Co. Clk. Off. & Kings Co. Reg. Off. Commission expires March 30, 1951.

Techni-Briefs

Tweeter Amplifier

Fig. 1



At first consideration, the idea of building a separate amplifier to operate a tweeter may seem like a lot of trouble to achieve results that can be attained adequately by the use of cross-over networks. However, there are several advantages to the use of this system that may be worth taking advantage of. One, strangely enough, is its economy. The parts that are required for this amplifier can be purchased for less than ten dollars, whereas a coaxial speaker will cost from two to fifteen times that amount.

The amplifier, *Fig.* 1, is straightforward and easy to construct. The *RC* coupling is designed to filter frequencies below 10,000 cps, and although some lower harmonics are present, they are not noticeable except at a much higher gain than would ever be necessary in operation. Practically any output transformer designed for single-ended 6V6 operation will serve, the secondary impedance being uncritical at the frequencies amplified. With a nylon or multicellular tweeter it will be found that the amplifier is highly efficient, since the rigid tweeter diaphragm is not loaded down with unwanted lows. Another advantage of this system is that the cross-over is at the input stage rather than at the power output, and few of the usual problems of cross-over networks are present.

The subjective effect is quite interesting. When a live FM program is being amplified, a turn of five or ten degrees on the tweeter-amplifier gain control will give an edge and a clarity to the sound which may not have been missed previously, but that is appreciated when it is heard. If the main amplifier is then turned off, it will be found that the output from the tweeter that caused a marked change in timbre is scarcely audible by itself.

David Hancock
510 Lexington Ave.
New York

Amplifier designed by
Peter Hancock,
Federal Telephone and Radio.

AUDIO FREQUENCY MEASUREMENTS

[from page 19]

sults of acoustical measurements with such a meter would of necessity require supplementary data for coordination with previous results of flat resonse measurements of the electrical noise in amplifiers intended as components of an electro-acoustical system. However, generally available data corelated with weighted electrical measurements made on amplifying systems do not appear to exist in sufficient volume to warrant abandonment at the present time of the existing use of flat weighting for electrical noise measuremeets on the audio systems under discussion. This decision is an expedient and is subject to review in the light of more adequate information which may become available later.

As noted above, the Committee on Audio Facilities has specified that the noise measuring device have the ballistic characteristics of a standard VU meter but that it read the rms value of a steady complex wave. Since the standard VU meter does not read this rms value, it is of interest to inquire what discrepancies would arise if a standard VU meter (with suitable gain) were used as the noise measuring device. This meter has a characteristic

$i = Ke^x$, where

i = numerical magnitude of instantaneous value of current fed to indicating instrument.

e = numerical magnitude of instantaneous value of input voltage.

$x = 1.2 \pm 0.2$

K = a constant

For an rms device, x = 2. With an rms device, if two equal-amplitude sine-waves of frequencies, not harmonically related, are fed to it, the output indication is 3 db greater than that for either sine-wave component alone. For the VU meter, tests indicate that the increase in this case is about 2.1 instead of 3 db. From the above formula it is seen that the VU meter rectifier does not differ greatly from a full-wave linear rectifier. Computations on the linear rectifier indicate that on a wave consisting of fundamental and 50 per cent third harmonic it would differ from the rms device by from —2 to +0.3 db, depending on the relative phase of the fundamental and harmonic. and that on a wave consisting of fundamental and 50 per cent high harmonics the linear device would read about 0.3 db below the rms device.[8] It seems likely that on ordinary steady noises found in audio systems the difference between a VU meter reading and an rms reading would not exceed about 1 db. For noises of markedly peaked wave shapes, the difference would be greater; but these are not ordinarily originated in audio facilities.

The Committee on Audio Facilities has not specified the frequency response of the noise measuring equipment above 15,000 cps. It would seem desirable that this response cut off frequencies above 15,000 cps, since the broadcast receiver and listener would ordinarily be insensitive to them. If measuring instruments of differing frequency response above 15,000 cps are used to measure a noise having components above 15,000 cps, different readings will be obtained, particularly if the equipment under test has a substantial frequency response above 15,000 cps. However, the difference between the readings of a standard volume indicator and an ordinary noise and distortion meter, contributed by the differences between their frequency-response characteristics, will usually amount to only a few tenths of a db, though in particular cases (e.g. where the apparatus under test picks up the field from a long-wave radio-telegraph station) larger differences may be found.

Noise Measurement Using a Distortion and Noise Meter

To make noise measurements with the distortion and noise meter of the general type already described its calibration is first adjusted so that it indicates 0 db with a test signal at a medium frequency such as 1000 cps after the input level is established at the normal or operating level. The gain and control settings of the equipment under test should again be the same as for previous measurements. The output of the equipment under test should be terminated by resistance equal to the rated load impedance. Noise measurement is then made by removing the input to the equipment under test and substituting a resistor equal to the rated input source impedance across the terminals. The resistor should be non-inductive and of a type, such as a wire-wound resistor, which will not in itself generate appreciable noise. In high-impedance, low-level circuits it may be necessary to shield it carefully to avoid hum pickup trouble.

If the noise set is substituted directly for the output meter M_2 of *Fig. 2*, the noise and distortion meter will indicate the number of decibels which the noise is below the level indicated by M_2. To obtain adequate meter deflection under some conditions, it may be necessary to connect the distortion and noise meter directly to the output of the equipment under test. The meter will then indicate the noise level in decibels below the predetermined signal level at that point.

The frequency-response characteristic of the distortion and noise meter used may be a factor in obtaining comparative results particularly if a relatively flat response of the equipment under test is maintained appreciably beyond the audible frequency range as already mentioned.

Acknowledgments

The authors wish to ackowledge the assistance of Mr. W. F. Byers of the General Radio Company for his help in the preparation of a preliminary draft. In addition, thanks are due to those who offered constructive comments to this presentation in manuscript form and to the many persons who, over the years, have published results of their work and thus made this compilation possible. The footnote references and the appended bibliography are not intended to be all-inclusive but they do indicate some of the sources of information available which bear on the subject matter.

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INSTRUCTIONAL BROADCAST STUDIO

[*from page 15*]

Getting back to existing equipment, turntables with self-contained amplifiers are sometimes operated by the students, and it is difficult to keep the hum level down, particularly when teaching schedules conflict with maintenance schedules. It sometimes helps to ground the amplifier chassis, and the same is true of tape recorder chassis and any other instructional equipment — provided, of course, that they are not of the a.c.-d.c. type To facilitate grounding, a bare copper wire is strung around the studio under the chair rail and connected to one of the building water pipes. Fahnestock clips are spaced every ten feet along this wire, permitting the grounding of apparatus anywhere in the studio without the hazard of long wires trailing across the floor. In this connection, every effort is made to keep the floor clear, not only of grounding wires, but also of microphone and other audio cables, a.c. power cables, and so on. All these circuits are carried in separate wall conduit runs that girdle the studio, with outlets at ten-foot intervals.

Echo Device

Another audio facility is the echo device. This arrangement, which did not originate at Carlisle Barracks, consists principally of the reverberation attachment and associated preamplifier from the studio Hammond organ. The attachment is a delay-producing arrangement in which a loudspeaker driver unit is mechanically coupled to a crystal pickup through long, helical springs that slow down the signal appreciably. Since this device is in parallel with the microphone circuit between any two convenient low-level points, the main or program amplifier receives both the "on-time" and the delayed portions of the signal, and the phase difference provides the echo effect. The degree of echo can be varied by the tap switch, which is part of the reverberation preamplifier.

Then there are some electrical power items to be considered. The first is a master switch and pilot light at the door of both the studio and the control room. Students — and experienced personnel too — sometimes leave the building without turning off all equipment. The master switch permits the instructor to kill all a.c. power on the baseboard outlets as he leaves for the day. The pilot light, visible through observation windows in the door, will remind him if he forgets.

The on-the-air warning light outside

the studio door is another power item. Originally, this was a red bulb over the door frame, but no one paid much attention to the light, nor to the associated large warning sign on the door itself. A flasher button was inserted in the bulb socket to make the light blink, on the theory that a blinking light was more noticeable — but it didn't work out that way. Finally, a red lumiline tube was mounted vertically at eye level on each side of the door frame, complete with flasher, and that did the trick. The seemingly obvious solution of a bolt on the inside of the studio door would be a safety hazard, especially since the studio door opens inward.

The devices described in this article are the result of considerable experience in teaching the basic of announceing and production in a very limited number of instructional hours. They are based on the assumptions that the student knows nothing of the broadcasting field and that almost any device is legitimate as a training aid to emphasize and perhaps dramatize the points made by the instructor. The corollary to this latter principle is that the training gadget should not develop habits in the student which must be unlearned when he finally steps into an operational studio.

New Literature

• **Wire Markers:** New 12-page illustrated Western Lithograph catalog entited "The Most Effective Wire Marker Ever Devised" shows latest methods of marking wire, pipe, cable, conduit, etc., with die-cut, self-adhesive EZ Code markers. Western Lithograph Co., 600 E. Second St., Los Angeles 54, Calif.

• **Film production and TV Equipment:** S. O. S. Cinema Supply Corp., 602 W. 52nd St., New York 19, offers an 88-page catalog listing approximately 1600 items covering 16mm and 35mm studio cameras, accessories and lenses, as well as recorders, projection equipment, and most other items required in this work. The catalog—entitled "Sturelab 8A" celebrates nearly a quarter of a century as an industry leader.

• **Radio and Television:** So comprehensive in content and clear in presentation that it is a veritable handbook, the new catalog offered by Lafayette Radio, 100 Sixth Ave., New York 13, lists a number of "packaged" high-fidelity radio-phonograph equipments in addition to the entire line carried in stock in the many Lafayette stores.

• **Relays:** Colorful New Catalog D120A illustrates and describes various types of relays, gives contact ratings, coil specifications, sizes, prices, and other helpful data. Ward Leonard Electric Co., Electronic distributor Division, 53 W. Jackson Blvd., Chicago, Ill.

• **16-mm equipment:** New catalog of post-war models provides rather detailed information about the major units of Maurer equipment. Free copy may be obtained from J. A. Maurer, Inc., 37-01 31st St., Long Island City 1, N. Y.

MUSICIAN'S AMPLIFIER

[*from page 13*]

as 20 db at 20 and 20,000 cps. The overall intermodulation distortion curve is presented in *Fig.* 7.

On the surface it may appear that 12.2 watts is rather poor output from two 807 tubes, but it must be remembered that the 807's are triode-connected and the efficiency of triodes is much less than that of tetrodes. Moreover, the power output compares very favorably with that from type 2A3 or 6-volt equivalent triodes. The power ratings given in the tube manual for these types are the power developed in a load resistor connected plate to plate, while our power measurement was of *useful* secondary power. Those who have built "10 watt amplifiers" using 2A3 or equivalent tubes might find it very enlightening to measure the undistorted power in a resistor connected in place of their speaker. We have found that the power of 12 useful watts is more than enough for home volume, even when operating with a 10 db safety factor.

The intermodulation distortion in this amplifier was checked on Altec Lansing intermodulation equipment, using frequencies of 40 and 2,000 cps. It was found to be extremely low at powers up to about 8 watts. As a matter of fact, the IM distortion for ordinary room volume powers was less than .2% which is entirely negligible. As pointed out in AUDIO ENGINEERING for September 1948, the power read on the IM equipment may be converted to equivalent single-frequency power, the usual way of rating an amplifier, by multiplying the IM meter power by the factor 1.47. This has been done in the published curve and it will be noted that the amplifier does not begin to exhibit serious distortion until sine wave power of 12.5 to 13 watts is reached. Thus the power curve for various frequencies, as reproduced in this article, is for substantially distortionless reproduction. If the reader wishes to be conservative in his amplifier performance, the power output as read from the curve should be divided by the factor 1.47 in order to get the IM *meter* power for a given amount of distortion.

When this amplifier is connected to a wide range speaker system and fed with good program material (e.g., local, live FM transmission) the resulting realism is so startling that it must be heard to be appreciated. The intermodulation distortion is so low that when a full symphony orchestra is playing, the various instruments are easily detected. The thud of the bass drum and the tinkle of the triangle are reproduced naturally at low levels, together with other sounds, even the squeaking of chairs and shuffling of feet. One very prominent musician, who is a composer, arranger and conductor and in whose home one of these amplifiers has been installed, said: "You not only can hear the difference between the flute and clarinet, but you can also separate the first and second clarinets when they play together".

Controls

It will be noted that the circuit diagram does not show any gain control. It is the authors' contention that an ideal amplifier should be one which can be tucked in some corner and forgotten while gain control and equalization should be accomplished in a separate control unit. The equalization and gain controls together with a phonograph preamplifier may well be a part of an FM tuner. If it is desired, however, to incorporate a gain control, the 0.5 meg grid resistor of the input stage may be replaced with a 0.5 meg left hand taper volume control. No equalization (tone controls) should be added to this amplifier, as the feedback loop goes from the output transformer to the first stage, and the large amount of feedback will negate any equalization introduced within the feedback loop. If equalization is desired it must be incorporated before the volume control. There is such power available at both the bass and treble end so that when the bass and/or treble boost is used, the results are positive and free from distortion at all comfortable levels. When bass boost is added the foundation music is solid and free from thuds.

To a couple of fiddlers—one who fiddles all day on a Stradivarius, the other who fiddles all day with amplifiers, *this* amplifier is the best that we have yet heard. We suggest that you build one and judge for yourself.

PARTS LIST

C_1, C_7—0.25 μf. 400 v. paper.
C_2, C_3—.05 μf, 600 v. paper.
C_4, C_5—10 μf, 450 v. electrolytic.
C_6—30 μf, 500 v. electrolytic.
J_1, J_2—Closed circuit jack. Mallory A-2 (*Must* be insulated from chassis).
J_3—Input connector. Amphenol 75-PC1M (R_1 is mounted inside this connector).
J_4—Power cable connector, Amphenol 86-RCP4 (4-pin male chassis plug).
P_1—100 ohm, 2W. wire wound potentiometer.
R_1, R_6, R_7—0.47 meg. ½ W.
R_2—47,000 ohms.
R_3—470 ohms, ½ W. 10%.
R_4, R_5—22,000 ohms. 10%. (matched).
R_8—390 ohms. ½ W. 10%.
R_9, R_{10}—47,000 ohms, 2 W. 10% (matched)
R_{11}, R_{12}—0.1 meg, ½ W.
$R_{13, 14}$, R_{22}, R_{23}—100 ohms.

R_{15}—250 ohms, 10 W. wire wound.
R_{16}, $_{17}$—1000 ohms, ½ W.
R_{18}—27,000 ohms.
R_{19}—22.000 ohms.
R_{20}—150 ohms, 10 W. wire wound.
R_{21}—5000 ohms. 10%.
T_1—Peerless S-265-Q.

Power Supply

C_8, C_9—0.1 µf, 600 v. paper.
C_{10}, C_{11}, C_{12}—8 µf, 600 v. oil filled.
F_1—Littelfuse 342001 fuse extractor post with 3AG fuse, 2 amps.
J_5—Power cord socket, Amphenol 77MIP4 (4-hole socket).
L_1, L_2—Peerless C-325-A. 10 H, 120 ma. d.c. resistance 240 ohms.
T_2—Peerless R-560-A. 800 v. CT at 200 ma; 5 v at 3 a; 6.3 v at 6 a.

Power Cable

1—Female connector, Amphenol 78-PF4.
1—Male connector. Amphenol 86-PM4.
4-wire cable, of required length.

All resistors are 1-watt, 20% tolerance, unless otherwise specified.

Additional Test Records

In order to complete the catalog of test records which appeared in the September issue, the following types are described — having been released after the original list was prepared.

CLARKSTAN

102M 12-inch, 33-1/3 rpm. Vinylite. SF. Microgroove audio sweep-frequency record, similar to 1000A but for long-playing microgroove records, covering range from 70 to 10,000 cps and recorded with NAB characteristic. Sweep repetition rate. 20 per second.

2000S 12-inch, 78.26 rpm. Vinylite, SF. Steady-state frequency record; recorded CV above 500 cps, constant amplitude below. Frequencies: 500 cps, 10, 9, 8, 7, 6, break. 5, 4, 3, 2, and 1 kc; 700, break, 500, 300, 200, break, 100, 70, and 50 cps, followed by 1000 and 500 cps.

2001S/2002S 12-inch, 33-1/3 rpm. Vinylite, DF. Microgroove steady-state frequency record. Frequencies: 1 kc: 10, 9, 8, 7, 6, break. 5, 4, 3, 2, 1.5, and 1 kc: 700, break, 500, 400, 300, 200, 150, break, 100, 70, 50, and 1000 cps. One side recorded with NAB modified characteristic; other side recorded CV above 500 cps, constant amplitude below.

101 12-inch, 33-1/3 rpm. Vinylite, SF. Intermodulation test record, 1:4 ratio, 7 kc and 100 cps recorded with NAB characteristic.

Clarkstan frequency records may be obtained from most radio jobbers, or from the Clarkstan Corporation, 11927 West Pico Blvd., Los Angeles 34, Calif.

ADVERTISING INDEX

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Daven Volume Level Indicators are designed to indicate audio levels in broadcasting, sound recording and allied fields where visual indication of volume is desired. Extremely sensitive, they are sturdily constructed and correctly damped for precise monitoring. Preferred by leading sound and electronic engineers throughout the world, these units incorporate all the latest DAVEN mechanical & electrical features.

Type 920
Rack model, low-level bridging type. Meter multiplier range: —20 VU to +20 VU. Power supply, 100—130 V. 60 cycle AC, with voltage regulator for normal variations. Reference level: 1 mv into 600 ohms. Special ranges on request.

GENERAL SPECIFICATIONS:

Imput Impedance	Type 910 and 911 — 7500 ohms. Type 915 — 7500 ohms bridging and 600 ohms terminating. Type 920 — 12,500 ohms.
Frequency Range	Less than 0.2 db variation from 30 to 17,000 cycles.
Meter Scale	—20 VU to +3 VU and 0 to 100%. Type A has VU reading on upper scale. Type B has percentage reading on upper scale. Scale is large, clearly marked and carefully designed to minimize eye fatigue.
Indicating Meter	NAB Standard; 4 inch square, rectifier type possessing ideal characteristics for monitoring purposes.
Mounting	Rack models 19" long for standard relay rack; portable models available in walnut cabinets.
Finish	Standard, black alumilite panel. Other colors available upon request.

Type 915
Rack model, terminating and bridging type. Meter multiplier ranges: Terminating, —6 VU to +32 VU; bridging +4 VU to +42 VU; or terminating, —6 VU to +16 VU; bridging, +4 VU to +26 VU. 2 VU steps. Reference level; 1 mv into 600 ohms

Type 910
Rack model has same characteristics as Type 911. Available with illuminated scale, if desired.

Type 911
Portable model, bridging type. Meter multiplier is a constant impedance "T" network which extends the range of the instrument in steps of 2 VU from +4 VU to +42 VU or +4 VU to +26 VU. Reference level: 1 mv into 600 ohms.

Write to Dept. A-6 for additional information.

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