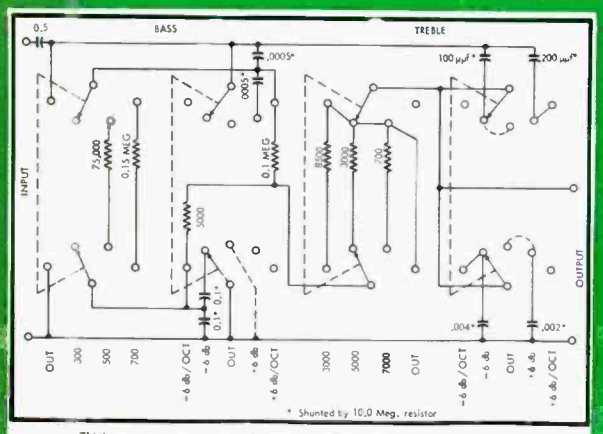
SEPTEMBER, 1956

50¢

AUDIO

ENGINEERING MUSIC SOUND REPRODUCTION

PREVIEW of N. Y. Hi-Fi SHOW



This new tone-control arrangement will provide either variable turnover, variable slope, or both. See page 17.

Details of the new Conn Electronic Organ are given by the author of "Electronic Musical Instruments." See page 40.

VERSATILE BASS-TREBLE TONE CONTROL

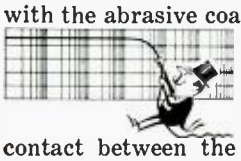
RECORD SPEED AND PLAYING TIME

SOUND EFFECTS CONSOLE FOR U. N. STUDIOS

OUTPUT TRANSFORMER DESIGN

The 7 Old-Fashioned Villains of Tape Recording

...and How irish BRAND FERRO-SHEEN Foiled Them All

Once upon a time, 7 Old-Fashioned Villains like this  were wreaking endless woe on Decent People with Tape Recorders. The 1st Villain was Oxenscheid the Oxide Shedder.  He scraped away at the crumbly oxide coating of old-fashioned tape and gummed up tape recorders with the shedding particles. The 2nd Villain was Wearhead the Head Wearer.  He filed down the magnetic heads with the abrasive coating of old-fashioned tape. The 3rd Villain was Frickenshaw the Frequency Discriminator.  He dragged down the high-frequency response of old-fashioned tape through inadequate contact between the "grainy" coating and the head. The 4th Villain was Noysenhiss the Noise Generator. He generated tape hiss and modulation noise  as a result of the random vibrations and irregular flux variations caused by the uneven magnetic coating of old-fashioned tape. The 5th and 6th Villains were Dropofsky the Drop-Out Artist and Pringlethorpe the Print-Through Bug.  They put nodules and agglomerates into the oxide emulsion of old-fashioned coated tape, causing "drop-outs" whenever these trouble spots lost contact with the record or playback head, and inducing "print-through" on the recorded tape when the extra flux at the trouble spots cut through adjacent layers on the reel. The 7th Villain was Brattleby the Embrittler. 

He dried out the plasticizers in old-fashioned coated tape and embrittled irreplaceable recordings. Then: OCTOBER, 1954! That's when a very un-old-fashioned little man by the name of F. R. O'Sheen  announced that he had developed the revolutionary new **irish FERRO-SHEEN** process of tape manufacture and presto!  the 7 Old-Fashioned Villains were sent a-scurrying with cries of "Confound it—Foiled again!" Yes, F. R. O'Sheen had made the new magnetic oxide lamination of **irish FERRO-SHEEN** tape so smooth-surfaced and non-abrasive, so firmly anchored and homogeneously bonded to the base, so free from nodules and agglomerates, that the 7 Villains were evicted—for good! **Moral:** Don't let Old-Fashioned Villains do you out of your hi-fi rights!  Just say "No, thanks" to ordinary coated tape and ask for F. R. O'Sheen **irish FERRO-SHEEN**, that is! ORRadio Industries, Inc., Opelika, Alabama.

THE BRITISH INDUSTRIES

Sounding Board

Good News

for those who asked for another Carnegie Hall Concert-Demonstration

by G. A. Briggs!

. . . It will be held Wednesday, October 3, 1956, at 8:30 P. M.!

You doubtless remember the reviews of last year's concert-demonstration, which appeared in national magazines, newspapers, and over the radio. We were extremely gratified to read the enthusiastic words of many well-known commentators. For example:

"Crowd Spellbound by Hi-Fi Discourse"

"Stupendous demonstration of how far hi-fi has traveled in achieving the illusion of live music."

— Louis Biancolli, New York World-Telegram

"Many were experiencing a new dimension in sound reproduction."

— John Briggs, New York Times

If last year's demonstration illustrated a "new dimension," this year's will surely open new avenues of great interest and value to those who enjoy high fidelity reproduction or who work with high fidelity equipment. A fascinating new program has been prepared, featuring artists and records entirely different from those in the first presentation. Even for those who know relatively little about technical matters — and certainly for all who understand the field — this is an opportunity to enjoy perhaps the most significant and interesting high fidelity event of the year.

When it comes to sound reproduction, it is not enough to see the results of technical progress. We all need to *hear* them as well. We have enlisted the personal participation of the leading record companies and some of their outstanding artists. You will see and hear

The Sounding Board

cut along dotted line and save

The Sound Board

E. Power Biggs, exclusive Columbia artist at the organ; Morton Gould, who records exclusively for RCA Victor, conducting a special percussion ensemble with tap dancer, performing some of his own compositions; and the renowned Ferrante and Teicher, exclusive Westminster recording artists, at two pianos.

Pre-recordings of some of the selections on the program have been made in Carnegie Hall by Columbia engineers, under the direction of Howard Scott, and will be compared with live performances of the same music by the same artists. You will also hear excerpts played from a wide selection of outstanding records of many labels. Mr. Briggs will act as moderator and commentator and we may look forward to his usual pertinent comments, illuminated by flashes of his inimitable wit and humor.

Equipment for the program will be operated by Mr. Harold J. Leak, the prominent designer of Leak amplifiers. Mr. Leak will have at his disposal Wharfedale Loudspeakers, Leak Amplifiers, and the Garrard 301 Transcription Turntable with the Leak Dynamic Pickup.

As you know, this is *not* special equipment designed for the demonstration. Not only is the equipment standard, but even the records played are readily available through any dealer. The only exceptions are the pre-recordings made on tape for the special purpose of comparison under identical auditory conditions.

The program is entirely devoted to promoting appreciation of the science and art of sound reproduction. It is not "commercial" in nature, no advertising of any sort will intrude, and I am sure you will find the evening most enjoyable and rewarding. I urge you to order tickets *early*. Last year's demonstration was sold out in advance, and this year's will certainly be.

Sincerely yours,

Leonard Carduner
President

For tickets, write or go to Carnegie Hall Box Office, 7th Avenue and 57th Street, New York.

For your convenience:

Date: Wednesday, October 3, 1956
Time: 8:30 P.M.
Prices: $3.30, $2.50, $2.00, $1.50

SEPTEMBER, 1956 VOL. 40, No. 9
Successor to RADIO, Est. 1917.

AUDIO

ENGINEERING MUSIC SOUND REPRODUCTION

CONTENTS

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

ABOUT MUSIC

HAROLD LAWRENCE*

Music, Musik, Musique

THE *Musical Times* recently printed an article by Hugo Schwarzschild which set out to prove that all is not right with Bach's *Well-Tempered Clavier*. The author arrives at the "inescapable conclusion that the preludes and fugues of the 'Forty-Eight' have been wrongly associated, and that what Bach actually planned was a set of twenty-four pairs of preludes and another of twenty-four pairs of fugues." He blames inept copyists, "improvers," and gullible music critics for the collection's sorry state. He then proceeds to expound the theory that each prelude "reflects in some measure man's sad lot on earth, and each fugue the life he may ultimately hope for." Example: "The rising chain of tetrachords depicts man's painful aspiration, the frequent inversion of the theme his discouragement (in the Fugue in B♭ Minor, Book II)." An examination of Bach's number symbolism, A = 1, B = 2, BACH = 14, and J. S. BACH = 41, etc., brings the article to a turgid mathematical conclusion.

The following month the editors admitted it was all in fun. There was no Hugo Schwarzschild, and no need to look askance at the *Well-Tempered Clavier*. The anonymous writer, who probably convinced more than a handful of his readers, executed his prank with great skill. Only close familiarity with German musical essays could have given it such an authentic ring. He had, of course, hundreds of models to work from. Johann Nepomuk David's study of Mozart's *Jupiter* Symphony, published in 1953, is a typical example. David, a Stuttgart composer, organist, and teacher of composition, maintains that the entire symphony is based on the first ten notes of the finale. In tracing the movements made by each of the ten notes throughout the work, the learned professor resembles nothing less than a sort of musicological private eye. He methodically builds up a case by means of figures, graphs and musical illustrations. The only trouble is, as Eric Blom who reviewed the book wrote: "it does not matter to him whether his notes come on strong beats or any beat at all, or in the most insignificant of unaccented places."

Like its language, history and cuisine, a nation is characterized by its own brand of musicology. We have seen how a German writes about music. Now let's cross the Rhine for a glimpse of the Gallic.

The French differ from their middle European neighbors in several respects. Number symbolism, an outgrowth of fugal development and classical form, is, of course, foreign to them. They do not share the Teuton's passion for research and are unimpressed by complicated architectural designs. In fact, the average French musical critique is a record of verbal impressions of an impromptu character. Facts and clear analysis are generally smothered in fumes of aromatic prose. On May 1, 1952, the Parisian weekly *Arts* devoted its entire music section to the golden anniversary of Debussy's *Pelléas et Mélisande*. It invited a number of prominent composers, conductors and critics to contribute a few words to the occasion. Henri Sauguet wrote: "Since the day I first heard Debussy's works, I have remained enchanted by their absolutely magical charm, and neither the passing years nor the evolution of my tastes, have altered the truly passionate love I feel for the music that has exerted such a profound and lasting influence upon me. *Pelléas et Mélisande* represents a high point in the history of French music, and indeed of all music. Its principal contribution to the lyric stage is that of an infinitely original, refined, moving, tender, captivating personality whose extraordinarily fresh tonal language bears forth a poetic language all its own."

Across the Channel, the speech is more precise, sentences are shorter, and emotions less vaporous. British writers, no longer paralyzed by European tradition, can examine the lives and works of Continental composers with greater objectivity, and deflate quite a few timeworn theories. Sometimes their remarks can be downright disrespectful. Take Vaughan Williams' discussion of the Bach purist, for example. "There is a tendency nowadays to 'put Bach in his place.' He is labelled as 'Baroque' (whatever that may mean) and according to the latest orders from Germany [these words were written in 1950 and could now apply to such things as the extensive Deutsche Grammophon Archive Production which features 'original' editions] he is to be performed as 'period music' in the precise periwig style. This is all part of a movement to 'play Bach as he wrote it.' To do this would be impossible even if we wanted to. Our violins are played on quite a different principle; our horns are soft and our trombones are loud. I should like to see Mr. Goosens confronted with one of those gross bagpipe instruments which in Bach's time stood for an oboe. The harpsichord, however it may sound in a small room—and to my mind it never has a pleasant sound—in a large concert room sounds just like the ticking of a sewing machine." (*Some Thoughts on Beethoven's Choral Symphony and writings on other musical subjects.* Oxford University Press)

Vaughan Williams' attack on "authentic" Bach performances is hardly the last

* *26 W. Ninth Street, New York 11, N.Y.*

"My interest is music—and I'm sensitive to distorted or uneven notes. I compared the sound, and then decided that the Garrard RC 121 gave better performance. The music comes over clean and clear . . . without wows, flutter, or rumble."

"We live on a budget—and want the best our money can buy. The RC 121 Garrard gives us the 'tops' in record changers at a price we can afford. It comes pre-wired, so easy to install that I did it myself."

"Radio service men have been waiting for the new Garrard RC 121. It's the first Garrard changer that fits into any cabinet. It will play for years, keep my customers satisfied. And parts are always available."

"I'm an engineer, and I can understand why the Garrard is called the world's finest record changer. It has heavy-duty steel construction, adjustable levers, a lot of quality playing features, and it is put together carefully."

"My friends at school all like the Garrard RC 121. When I'm alone and just listening, I play records one at a time, by hand. For dancing or background music while I'm studying, the changing and mixing features of the RC 121 are perfect."

"I'm an old hand at high fidelity. Being critical about sound, I like to experiment. I find that the new RC 121 won't hum with the most sensitive pickup, has the easiest adjustments for stylus pressure on any changer, and tracks without resonance or distortion."

There's something exciting for everyone in this entirely new GARRARD

World's Finest Record Changer

These features make the GARRARD RC 121 "Renown" your best buy in record changers . . . at $42.50

HEAVY STEEL PRECISION TURNTABLE: A full inch high. Eliminates magnetic hum by strengthening motor shielding. Fly-wheel action. **Silent, free-wheeling, ball-bearing turntable mount.**

GENUINE RUBBER TRACTION MAT: Exclusive raised tread—adapts itself to contours of your records; protects grooves.

TRUE-TURRET DRIVE: Eliminates vibration, plays records at perfect, constant speed. Single turret, direct operation without belts.

EXCLUSIVE SENSI-MATIC TRIP: Sure operation even with tone arm set at lowest tracking pressures. Quiet, safe, gentle to records.

EASIEST STYLUS PRESSURE ADJUSTMENT ON ANY CHANGER: Protects delicate record grooves! Stylus Pressure set with easily-accessible knob on tone arm.

Exclusive! **TRUE-TANGENT TONE ARM OF ALUMINUM:** Plays *better* by eliminating resonance, providing greater rigidity, low mass, and lightness.

INTERCHANGEABLE PLUG-IN HEADS: Accommodate your choice of pickups. Fit all cartridges — crystal, ceramic, or magnetic; turnover, twist or plug-in types.

READY FOR PLUG IN! 6-ft. U.L. approved electric cord and pickup cable, standard jack. No soldering, tools required.

FULL MANUAL POSITION: Fingertip control adds to your automatic changer the advantages of a manual record player. Professional-type finger lift.

STEEL MONO-BUILT UNIT PLATE: Years of trouble-free service. Exclusive SNAP MOUNT springs mount changer instantly; can be levelled from top!

SIMPLI-MIX OPERATION: You load records of any standard diameters in size order on fixed spindle. Automatic spindle for 45 rpm records optional.

4-POLE SHADED "INDUCTION SURGE" MOTOR: Constant in speed, with minimum vibration. Smoothest, quietest, most powerful type. No hum, even with sensitive pickups. Self-aligning Oilite bearings. **Exclusive dynamically-balanced rotor.**

The Garrard RC 121 "Renown" is everyone's quality record changer . . . engineered to bring you unmatched craftsmanship and features in a compact, economical unit. Whether you are assembling your first high fidelity system or rebuilding an old set, this fine Garrard changer meets every requirement. See it, test it — and you'll agree.

Now there's a GARRARD for every high fidelity system. Write for B.I.C. Plan Book.

301 Turntable $89.00

RC 98 Super Changer $67.50

RC 88 Deluxe Changer $54.50

RC 121 Mixer Changer $42.50

Model T Manual Player $32.50

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word on the subject, but it does represent a free-swinging, English outdoors approach to music criticism. Trevor Harvey's review in the February, 1956, issue of *The Gramophone* of a Pergolesi Concertino, attributed on the record label to Ricciotti, belongs to this company: "This Ricciotti *Concertino* business has become tiresome! The work here recorded is, as most will guess . . . to be found . . . under the name of Pergolesi. Nobody blames musicologists for trying to discover who did compose wrongly attributed works, and it is certainly unlikely, to say the least, that Pergolesi was the composer of these: but unless the experts can be sure who did write the music (and in this instance they can't), confusion is saved if everybody sticks meanwhile to one name—the old one. At least we shall all know what we are going to hear."

There are hundreds of questions that will never be answered regarding the correct authorship of certain works. But that will not prevent musicologists from turning out oceans of words on the subject of misattributed compositions. One English critic called this sport, "ento-musicology" because fragments of information or clues are "pursued in the same manner as an enthusiastic entomologist pursues butterflies, that is to say, in order that they may be 'bagged' as specimens, carefully ticketed and placed firmly in a pre-ordained and unalterable place in some vast private collection." (*Musical Opinion*, November 1954).

Contemporary Russian musical articles are easily identifiable, as readers of this column have already gathered from the past two months' articles on Soviet music and musicians. As for America, there is no predominantly outstanding trait or style, apart from a certain catholicity of taste.

National differences, however, melt away when confronted with the writer on twelve-tone music. Whether he be American, French, Spanish or Japanese, each dodecaphonist sounds monotonously like the next.

At this point, I should like to make it clear that the foregoing generalizations do not necessarily apply to the great names in music criticism, e.g., Berlioz, Schumann, Newman, Shaw, Einstein, Gray, etc., nor to the other levelheaded perceptive writers on music to whom we owe so much—we, that is, except for Sir Thomas Beecham who once said: "You critics are always talking about the meaning of music . . . The whole point of music is that it should *sound* well. Never mind what it signifies."

COMING EVENTS

Sept. 17–21—11th Annual International Instrument-Automation Conference & Exhibit, The Coliseum, New York City.

September 27–30—New York High Fidelity Show, New York Trade Show Building, New York. Presented by Institute of High Fidelity Manufacturers, Inc., with participation of Audio Engineering Society.

September 26–30—Eighth Annual Convention of the Audio Engineering Society, New York Trade Show Building, New York.

Oct. 1–3—National Electronic Conference, Hotel Sherman, Chicago. For information write J. S. Powers, Executive Secretary, 84 E. Randolph St., Chicago 1, Ill.

Oct. 7–12—80th Convention, Society of Motion Picture and Television Engineers, Ambassador Hotel, Los Angeles, Calif.

Oct. 9—Hartford Symphony in High Fidelity, Bushnell Memorial, Hartford, Conn. Sponsored by Audio Workshop of West Hartford and Gray Research & Development Co., Inc., Manchester, Conn.

Oct. 18–21—Second Mexican High Fidelity Fair, Hotel Regis, Mexico, D.F. For information, write Mario Aguilar, Lopez 43-301, Mexico 1, D.F.

Apr. 9–11, 1957—Fourteenth Annual British Radio Component Show, Great Hall, Grosvenor House, Park Lane, London, W.1, England. Admission by ticket only, obtainable from the Radio and Electronic Component Manufacturers' Federation, 21, Tothill Street, London, SW. 1.

Apr. 12–15, 1957—The London Audio Fair, 1957, Waldorf Hotel, Aldwych, London, W.C. 2.

Now...TV pictures magnetically recorded on tape!

Here's why magnetic tape is recommended by Ampex

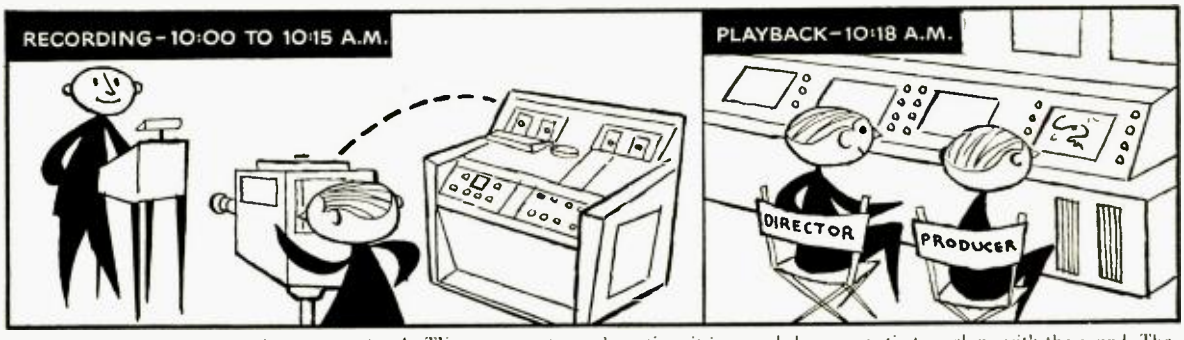
Tests by Ampex Corporation show tape made with Du Pont "Mylar" gives best all-around performance on new "Videotape" recorder

"In developing our 'Videotape' recorder, we made extensive tests on various types of magnetic tape," reports the Ampex Corporation. "We had to be sure the performance of the tape was commensurate with the quality and durability built into our equipment. We found that tape made with 'Mylar' met all our requirements—that's why we recommend it to people who will be using our 'Videotape' recorder."

THE first practical method for recording TV *sound* and *pictures* on magnetic tape has been announced by the Ampex Corporation, Redwood City, California.

The Ampex "Videotape" recorder uses tape made with Du Pont "Mylar"* for these important reasons: It's tape that can withstand unusual recording rigors without the risk of cracking or breaking—it can be stored indefinitely and played many times without any harm to either picture or sound quality.

Tape made with "Mylar" is strong, but thin enough to reproduce a whole hour's TV program on one 14-inch reel. It's virtually unbreakable—



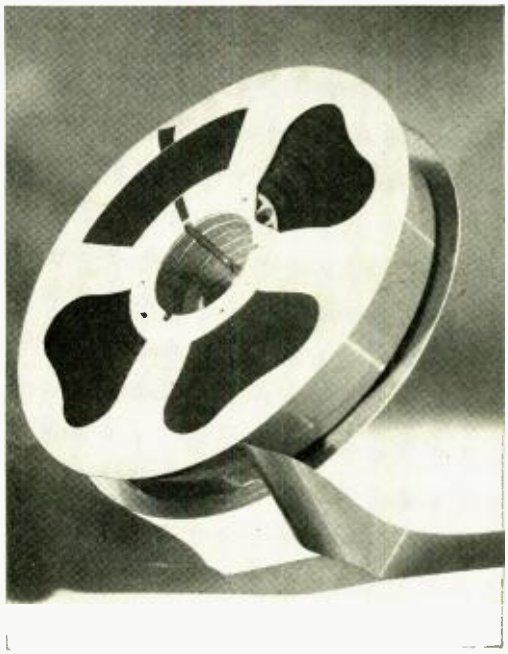
Here's how the new "Videotape" recorder works: As TV camera captures the action, it is recorded on magnetic tape along with the sound. The tape can then be played back *immediately*. This enables the producer and director to check the performance immediately without tying up costly talent and studio time.

made with Du Pont "Mylar" for "Videotape" recording

unaffected by changes in temperature and humidity. In short, the high tensile strength and dimensional stability of "Mylar" offer unlimited tape life under *all* conditions.

Basically, this tape is the same as conventional sound-recording tape made with "Mylar". All leading manufacturers are now featuring sound tape made with "Mylar" for home, educational, business, commercial and religious use. Next time you see your dealer, ask for a reel or two of your favorite brand now made with "Mylar". If you'd like a copy of our booklet on tapes made with "Mylar", just mail in the coupon below.

*"MYLAR" is Du Pont's registered trademark for its brand of polyester film.
Du Pont manufactures the base material, "Mylar"—not finished recording tape.
In Canada, "Mylar" is sold by Du Pont Company of Canada Limited, P. O. Box 660, Montreal, Quebec.



Reel of magnetic tape made with Du Pont "Mylar" is used in Ampex "Videotape" recorder. Because "Mylar" is extra-strong, even in thin gauges, a full hour's TV program can be recorded on a single 14-inch reel. Tapes assure faithful reproduction, even after repeated usage—can be stored indefinitely without becoming brittle or dry.

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Please send your booklet outlining advantages of magnetic recording tape made with "Mylar".

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LETTERS

REPORT BY BRIGGS

SIR:

In reference to the reaction to our concerts comparing live to reproduced sound, it must be admitted that the only time we have succeeded in changing over from live to recorded and back where it was impossible to detect any difference whatever was during one item in Carnegie Hall when the Philadelphia Wind Quartette were sitting immediately in front of the loudspeakers, in the same positions they had when the recording was made. Removed from the special environment, this record sounds no better than many others.

The question of how much power is required for distortion-free results still remains unsettled—at least in your country. I sent a copy of our recent R.F.H. programme to Mr. E. D. Nunn, of Audiophile Records, and it brought forth the following letter:

"Dear Mr. Briggs:

"I have just received the program of your concert of May 12. You certainly ought to be complimented on making these prodigious efforts—I can just imagine the time and energy required to produce one of these "shows."

"I take issue with you on just one comment, however—the amount of power required for home reproduction.

"Now immediately we must give a satisfactory answer to the question 'whose home?' This may be the basis for our difference of opinion. In my home I use twenty speakers—eight 12" woofers, properly baffled, four 6" mid-range speakers, and two Janszen electrostatic tweeters, each of which has four sections. Our room is 28 by 41, with a 16' beam. I use McIntosh 60-watt amplifiers, and I find that one is completely inadequate. Two hooked in parallel do a fair job, but it is only when three of them are used in parallel that the results are satisfactory."

My views on the question were outlined in my reply to Mr. Nunn, as follows:

Dear Mr. Nunn:

First of all, in reply to your letter, I should like to say that I envy you your listening room. Secondly that I do not doubt that you produce first-class sound; BUT as we have filled the Festival Hall with sound on three public occasions, with a total of 9000 pairs of ears listening critically to 60/80 watts going into FOUR 3-speaker systems, with real organ and orchestra for comparison, it is futile to say that it cannot be done. We have probed that it can.

"If you have to use 180 watts where we should require no more than 30 or 40 watts, there would seem to be only three possible explanations:

1) You are using grossly inefficient speakers.

2) You are not calculating watts on our usual RMS basis. In other words, our 60 watts would be 120 in America.

3) You like your reproduction two or three times larger than life."

I am still firmly of the opinion that the quickest and most reliable way to test loudspeakers is to listen to them in a concert hall. It was interesting to have confirmation of this view in the May, 1956, issue of *Wireless World* in an article on "Monitoring sound broadcast programmes," by T. Somerville of the BBC Research Department. The writer deals in a most interest-

ing way with the evolution of present methods of assessing quality, and has this to say about selection of loudspeakers:

"To check whether poor acoustics could indeed cause the difficulties experienced in selecting loudspeakers, the whole experiment was transferred to a good orchestral studio, where the consistent selection of loudspeakers was shown to be possible."

There can be little doubt that improved methods of monitoring records made for domestic use would result in better records; and this brings us naturally to the consideration of electrostatic speakers which have been so much in the news during the last year or two.

It is fairly obvious that the smooth response and low-distortion performance of the new types will find a useful application in professional as well as domestic sound systems. It is to be regretted that most of the articles which have been written about electrostatics to date have extolled their virtues and ignored their shortcomings. This is ridiculous, because the shortcomings always show up sooner or later—often sooner than fond designers expect. As I have always made a practice of exposing the shortcomings of moving-coil speakers, I propose to take this opportunity to redress the balance with electrostatics, without being rude to them because we hope to make them.

The main difficulties would appear to be as follows:

1) Being fundamentally high-impedance capacitative devices, performance is affected by temperature and humidity, unless ways and means are found to overcome the risk. (Our Mr. Cooke breathed on the first sample he made and it stopped working, but it was a very cold day and he is a bit of a fire-eater. I can see a nice publicity line here—"Listen to our new loudspeaker and hold your breath.") Modern designs appear to be quite satisfactory in this climate, but two or three years' experience will probably be necessary before shipments can safely be made to such countries as South Africa, Malaya, Australia, Hong Kong, etc.

2) The use of plastics is still a doubtful proposition because some of these materials alter their characteristics with changing temperature and with the passing of time. The position here strikes me as analagous to the use of grease in pickup damping, which has been a source of trouble in many designs.

3) The diaphragm does not move equally over its entire area. Being clamped at the edges, it obviously moves most in the centre, especially at resonance where damping is more essential than with moving coil speakers because the resonance is not absorbed by negative feedback.

4) The so-called rigid plates are not at all rigid, especially after many holes have been punched in them. Therefore they must resonate and colour the reproduction unless the resonances can be successfully dumped.

5) Some types of electrostatic speakers are very directional. This disadvantage can be overcome, but the necessarily more complex design increases the cost.

6) Being capacitive, the device will cause some amplifiers to go unstable.

7) Sensitivity is at least 3 db below good moving-coil units, and even 6 db below that of models with 180,000 lines of total flux. This means increasing the amplifier rating by two or three times. American makers of electrostatic tweeters always recommend a grossly inefficient bass speaker for this reason.

(*Continued on page 88*)

AUDIO engineering society

CONVENTION PROGRAM

The Eighth Annual Convention of the AES offers a fine and varied program of technical papers which cover the entire range of audio from design to testing of the completed product.

OFFERING SOME FORTY PAPERS on all aspects of audio—from the most technical presentations to practical discussions of the use of high-fidelity equipment in the home—the Annual Convention of the AES opens with a business meeting at 9:00 a.m. on Wednesday, September 26, followed at 9:30 by the first technical session. The concluding session is scheduled for Saturday afternoon.

Incoming officers will be inaugurated at the business meeting, and the usual committee reports will be made to the membership.

The technical sessions, which are to be held on in the second-floor auditorium of the New York Trade Show Building, 8th Avenue and 35th Street, New York, are open to the public at a nominal charge. The complete program of the Convention follows:

Wednesday, September 26.

9:00 a.m. Annual Business Meeting
Installation of Officers
Committee Reports

9:30 a.m. TECHNICAL SESSION: DISC RECORDING AND REPRODUCTION.

Donald J. Plunkett, Capitol Records, Inc., Chairman.

PRACTICAL ASPECTS OF HOT STYLUS.
Carlos E.R.A. Moura, RGE Records Ltd. (Paper given by Julius Postal)

Heating of stylus. Increasing the size of gem. Matching stylus with cutter head. Influence of burnishing facets on frequency response, distortion, and stylus wear. Feather edge stylus. Adjustment of optimum working temperature. Elimination of resonance effects of heating element. Interaction of stylus supply voltage on cutter head performance. Readjustment of cutting depth. The finished record.

A NEW RECORDING PLANT
J. W. Bayless, Capitol Records, Inc.

Capitol's new Tower Recording Studios in Hollywood have incorporated many new concepts of sound-recording studio design. Outstanding features are visual beauty; uniform illumination; complete mechanical isolation of the studios and reverberation chambers from the building proper; minimization and variable control of natural room tone; completely variable reverberation time and quality; other features minimize delays during the recording sessions.

HIGHLIGHTS IN THE MANUFACTURE OF REK-O-KUT TURNTABLE AND ARM
Avery Yudin, Rek-O-Kut Company, Long Island City, N.Y.

A collection of Kodachrome transparencies will be accompanied by an informal talk explaining the problems and processes developed and carried out in the manufacture of quality precision turntables and turntable arms.

A STEREO RECORDING STUDIO WITH UNUSUAL FACILITIES
Howard T. Souther, Electro-Voice, Inc. Buchanan, Mich.

An outline of desirable facilities for stereo-tape recording is presented. Arrangements involving minimal space and manpower requirements are discussed. The installation of Musicorders, Inc., of Chicago illustrates these points with stereo tape-recording and dubbing equipment, instantaneous disc recording, dubbing and sound effects assemblies, and a recording studio designed for stereo.

EXTRA FINE-GROOVE PHONOGRAPH SYSTEM
Peter C. Goldmark, CBS Laboratories

1:30 p.m. TECHNICAL SESSION: MAGNETIC RECORDING.

Thomas E. Mercin, A-V Recording Studios, Inc., Chairman.

A NEWLY DESIGNED IN-LINE TWO-CHANNEL MAGNETIC HEAD OF UNIVERSAL APPLICATION
Richard C. Sinnott, Melvin C. Sprinkle, et al., Ampex Corp., Redwood City, Calif. Given by: Melvin C. Sprinkle

Description of the high-crosstalk-rejection two-channel head for use as a stereo, full track, or half-track head. Basic design incorporates crosstalk rejection of 60 db in the mid audio frequency range which allows for half-track record and playback without spurious signals being recorded or reproduced on adjacent channels. A short discussion of geometric or wave length crosstalk as well as transformer crosstalk within the head.

TAPE STORAGE PROBLEMS
Frank Radocy, Audio Devices, Inc., New York

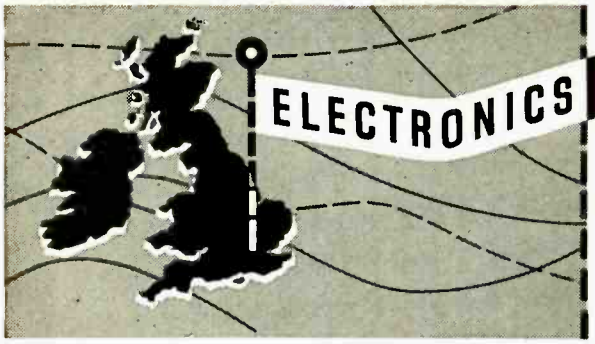
The changes in the performance characteristics of magnetic tape due to storage conditions are physical and magnetic. The factors that influence physical and magnetic characteristics include type of base material, formulation of magnetic coating, climatic conditions, winding tensions and time. Physical changes are easily controlled and magnetic characteristics can be controlled by the selection of available base materials and proper winding technique.

A PROGRAM DELAY SYSTEM FOR NETWORK BROADCAST USE
C. Robert Paulson, Ampex Corp., Calif. Emil Vincent, American Broadcasting Co.

The radio industry needs new operational techniques which offer the broadcaster more reliable and saleable programming at lowered costs. Mr. Paulson will detail the evolution of automatic programming systems, analyze the requirements of magnetic tape equipment and summarize the work of Ampex Corp. in this line. Mr. Vincent will describe the Ampex Automatic Program Delay System installed at A.B.C., New York.

E.M.I. STEREOSONIC RECORDING AND REPRODUCING SYSTEM
Dr. R. Dutton, E.M.I.

With the application of the magnetic tape recording medium to domestic tape records, the full possibilities of the Stereosonic system can now be realized. The



The British Electronics Industry is making giant strides with new developments in a variety of fields. Mullard tubes are an important contribution to this progress.

EF86

Another Mullard contribution to high fidelity

The Mullard EF86 audio frequency pentode is one of the most widely used high fidelity tubes in Britain today. It has been adopted by the leading British manufacturers whose sound reproducing equipment is enjoying increasing popularity in the United States and Canada.

The marked success of this tube stems from its high gain, low noise and low microphony characteristics.

By careful internal screening, and by the use of a bifilar heater, hum level has been reduced to less than 1.5μV. Over a bandwidth of 25 to 1,000c/s equivalent noise input approximates 2 μV.

When operated below 1,000c/s, internal resonances of the EF86 are virtually eliminated. Even at higher frequencies chassis and tube socket damping are usually sufficient to make vibration effects negligible.

Supplies of the EF86 are now available for replacement purposes from the companies mentioned here.

Principal Ratings

Heater	6.3V, 0.2A
Max. plate dissipation	1W
Max. screen dissipation	0.2W
Max. cathode current	6mA

Characteristics

Plate voltage		250V	
Screen voltage		140V	
Grid voltage		−2V	
Plate current		3mA	
Screen current	0.6mA	Transconductance	1800 μmhos

Base

Small button noval 9-pin

Supplies available from:—

In the U.S.A. International Electronics Corporation,
Dept. A9 81 Spring Street, N.Y.12.
New York, U.S.A.

In Canada Rogers Majestic Electronics Limited,
Dept. HL, 11-19 Brentcliffe Road,
Toronto 17, Ontario, Canada.

Mullard

ELECTRONIC TUBES

used throughout the world

MULLARD OVERSEAS LTD., CENTURY HOUSE, SHAFTESBURY AVE., LONDON, ENGLAND

Mullard is the Trade Mark of Mullard Ltd. and is registered in most of the principal countries of the world.

system aims to reproduce at the ears of the listener the same relative acoustic pressures and phases as would be experienced in the original sound field. Particular importance is laid on the attainment of these conditions in the middle- and low-frequency regions.

A TEN YEAR STUDY OF "MEMORY" PRINT THROUGH EFFECT IN MAGNETIC RECORDING TAPES

J. Herbert Orr, ORRadio Industries, Inc., Opelika, Alabama

Starting in 1946 and taking four samples per year of all manufacturers, a comparison analysis was made. Standards remained the same for all tapes, these standards being those accepted by the industry as of 1948, printing from layer to layer vs. time, with variable magnetic qualities.

SOLUTION TO SOME PROBLEMS IN MAKING MASTER TAPES

Russell J. Tinkham, Ampex Corp., Calif.

Failure to achieve satisfactory tape masters is often due to a variety of little understood relationships between the recording machine and the tape. The effects on the quality of recording as a result of tape variations and machine adjustments are discussed.

Thursday, September 27.

9:30 a.m. TECHNICAL SESSION: TRANSISTOR APPLICATION PROBLEMS

A. E. Harrison, Fairchild Guided Missiles Division, Wyandanche, N. Y., Chairman.

DESIGN OF NEGATIVE-FEEDBACK AMPLIFIERS FOR HI-FI EQUIPMENT

Hugh R. Lowry, Semiconductor Products, General Electric Company

This paper will describe the considerations necessary in the application of negative feedback to transistor amplifiers and discuss in detail how these principles are used in the design of a low-distortion transistor hi-fi amplifier incorporating pickup compensation, tone controls and loudness compensation. Relationships will be shown between the current, gain, voltage gain, and input and output impedance of typical transistor amplifiers.

TRANSISTOR AMPLIFIERS FOR AIRCRAFT INTERCOMMUNICATION SYSTEMS

T. Eugene Smith, Texas Instruments, Inc.

The presentation of design considerations involved in the development of audio amplifiers for aircraft intercommunication systems will include design of output, driver, and preamplifier stages. Particular emphasis will be placed on low distortion and low noise. The presentation will deal with the use of both silicon and germanium transistors and will include the effects of operation at temperature extremes.

DIRECT-COUPLED TRANSISTOR AUDIO-FREQUENCY AMPLIFIERS

William F. Palmer, Sylvania Electric Products Inc.

The operating characteristics of transistors are especially useful in the design of component-economical audio amplifiers. Complementary types in cascade or symmetrical stages offer particular advantages. Design considerations and advantages will be discussed.

HIGH-GAIN AMPLIFIER UTILIZING POSITIVE FEEDBACK

James M. Buchanan, Marvelco Electronics Div., National Aircraft Corp.

Application of positive feedback in an amplifier normally results in instability, oscillation, or a saturated state. These are exemplified in a high gain d.c. analog computor amplifier, in a high gain i.f. strip, or in a multivibrator. However, if various techniques are used to control the amount of feedback they will result in a boot-trap effect giving high gain.

(Continued on page 79)

GOODMANS LOUDSPEAKERS

for High Fidelity Systems

Goodmans loudspeakers owe their fame and reputation to one essential listening quality: they sound better. This, naturally, is the result of design and construction characteristics which have resulted in higher efficiency, improved transient response, lower distortion and smoother, overall performance.

Whether you plan a full range, single channel speaker, a 2-way or 3-way system, your choice of Goodmans reproducers will reward you with more performance quality than you can buy at double the price.

FULL-RANGE LOUDSPEAKERS

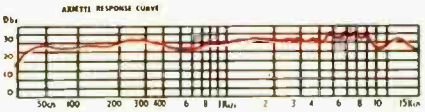
These speakers represent the most practical, low cost approach to true high fidelity sound reproduction. The ability of these speakers to provide an unusually smooth response over an exceptionally wide frequency range — with low distortion — is due to their unique cone structures and heavy magnet systems.

AXIETTE 8" Hyperbolic Cone $23.20

The ideal hi-fi speaker for restricted space applications. Handles up to 10 watts.

Range 40-15,000 cycles.

Note: An excellent 'tweeter' in combination with an Audiom 60 'woofer' with 750 cycle crossover.



AXIOM 80 10" twin-cone $68.50

The one speaker in the world with a free cone (strut) suspension and 20 cycle free air resonance. Single speaker handles 12 watts continuous program material (use 2 for 25 watts).

Frequency range 20-20,000 cycles.

AXIOM 22 12" twin-cone $72.95

Considered the finest full-range 12" speaker made. Extra-heavy magnet system.

Power rating 40 watts continuous program material.

Frequency range 30-15,000 cycle

AXIOM 150 12" twin-cone $53.50

Similar to Axiom 22 above except for power rating. Power rating 30 watts continuous program material.

Frequency range 30-15,000 cycles.

AXIOM 100 12" twin-cone $27.00

Perfect combination of economy and fidelity. Power rating 20 watts continuous program material.

Frequency range 40-15,000 cycles.

WOOFERS

Goodmans bass reproducers are designed for use in 2-way and 3-way systems. Heavy magnet systems and unique cone design provide smooth bass response down to 20 cycles in recommended enclosures.

AUDIOM 60 12" woofer $50.00

Economical woofer for two or three way home music systems. Power rating 30 watts continuous program material.

AUDIOM 70 12" woofer $69.40

Most powerful 12" woofer made. Very heavy magnet system, high compliance cone structure.

Power rating 40 watts continuous program material.

AUDIOM 80 15" woofer $95.50

Heavy magnet system and high compliance cone suspension make this unit ideal for high power hi-fi and sound movie installations.

Power rating 50 watts continuous program material.

AUDIOM 90 18" woofer $118.80

Giant woofer for high power high fidelity applications.

Power rating 100 watts continuous program material.

Made in England

MID-RANGE AND HIGH FREQUENCY REPRODUCERS

The Goodmans mid-range pressure driver coupled with its exponential horn provides a smooth, undistorted response in the mid-hi frequency range, designed for use in 3-way systems. The addition of a Goodmans high frequency 'tweeter' results in a 3-way system with response extending to the upper limits of audibility.

MIDAX MID-RANGE DRIVER with Exponential Horn

$58.80

For three way systems used with 750 and 5000 cycle crossovers. For use in systems up to 30 watts.

TREBAX TWEETER
High Frequency Driver with Horn

Designed for 5,000 cycle crossover. Response extends to 15,000 with smooth taper above. For use in systems up to 30 watts. **$27.00**

Prices slightly higher west of Rockies

CROSSOVER UNITS

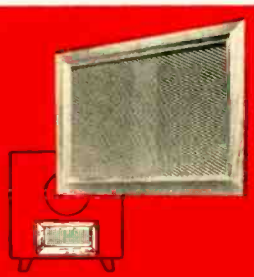
Designed for use with Goodmans 2-way and 3-way systems. Employ complete half-section L/C networks and provide 12db per octave roll-off beyond crossover frequencies. 15 ohms at all terminals to match Goodmans reproducers. Model numbers indicate crossover points.

Model X0750
for 2-way systems $25.00
Model X05000
for 2-way systems 8.50
Model X0750/5000
for 3-way systems 30.00

All Goodmans units are 15 ohms except the Audiom 90.

GOODMANS ARU

The Goodmans Acoustical Resistance Unit is a practical and acoustically correct application of the principle of friction loading. It permits the use of an enclosure only ⅔ the size required for a conventional bass reflex. Results in improved performance by providing optimum loading to zero cycles, lower distortion, bass response to 20 cycles and virtual elimination of all resonant peaks. Four types from $10.90.



NOTE: Prefabricated enclosure kits designed for the Goodmans ARU will be available shortly for all Goodmans speaker systems.

ROCKBAR CORPORATION 650 Halstead Avenue, Mamaroneck, N. Y.

In Canada: A. C. Simmonds and Sons, Ltd., Toronto, Ontario

EDITOR'S REPORT

THE NEW YORK HIGH FIDELITY SHOW

COMES AGAIN the Fall season, and with it the beginning of the audio show season—which seems to continue until well in the Spring—considering the two shows to be held early in 1957 on the West Coast, one in Los Angeles on one weekend and the other in San Francisco on the following weekend. Of these two, more later as the time approaches. In the meantime, there is a show in Chicago in early November, and there is one in Mexico in the middle of October. Of these also, more later.

The "show of the month" and most imminent on the hi-fi horizon is the first New York High Fidelity Show to be presented by the Institute of High Fidelity Manufacturers—and at the time of going to press it appears that this show is to be the greatest to date in the Big City. Certain it is that the facilities are considerably more comfortable than the usual site of such shows, because of the air conditioning—likely to be a most desirable addition to the show locale because of the somewhat earlier date this year than heretofore. Even if the weather itself did not make air conditioning worthwhile, the combined equipment of over a hundred exhibitors—which must average at least five hundred watts power input each, and even with the normally high output power levels which might average five watts each, leaving 495 watts to be dissipated as heat in each room, or a total of 49,500 watts—makes it almost a necessity. Maybe we should be thankful for the development of transistor products which might well result in cooler shows.

The show preview section of this issue indicates that there will be plenty of new items on display again this year, and we—as well as most of our readers—are looking forward to the four days of the show with the greatest of interest.

This section begins on page 44.

Will we see you there?

READERS' SERVICE CARDS

By way of explanation of some of the inconsistencies in the readers' service cards some months, let it be said that this particular portion of the magazine is regularly printed about two weeks before the remainder of the pages go to press, and there are many instances when there are changes in the number of New Products and New Literature releases and in the pages on which the various advertisements appear. Thus there have been mix-ups which have not been convenient for the readers nor for the department which processes the returned cards which we receive from you in thankfully large quantities. Our worst failure in this regard was in the June issue wherein the NL and NP codes were duplicated. Some of these "errors" are unavoidable because of last minute changes in the advertisers; some indicate less than perfect checking. In those instances where an advertisement is on a page which is not listed on the card, for example, or where there are some discrepancies in the coded listings for the New Products and New Literature columns, may we suggest that the reader write in the proper code.

On the other hand, we receive a few cards each month on which the reader has neglected to fill in his name and address. If the card should be postmarked Leavenworth, Kansas, for example, where we happen to have only one subscriber, we could reasonably well guess who it was from (unless the reader who sent the card happened to pick up the magazine from a newsstand). Obviously if it comes from a large city, we haven't the slightest chance of divining who sent it. Even fingerprints fail because so many people in the Post Office have handled the card on its way to us, even if we had access to the master file of fingerprints. Then, too, it is doubtful if *all* of AUDIO'S readers have their fingerprints on file.

This should explain why sometimes you don't receive the information you requested on the card you so carefully checked and sent—maybe you forgot the name. Incidentally, the new placement of the name and address lines at the top of the card is the result of a suggestion from a reader—he thought it would be easier to type on with this new arrangement. And so do we.

THE MONTHLY RECORD CONTEST

No, we haven't given it up, nor do we expect to. However, Mr. Canby—our mainstay on things musical—is in Europe with his nose to the audio and recording world to give him something to talk about in the coming months. And even though it doesn't take long for a letter to fly from New York to Paris and for a reply to fly from Paris to New York, it seems as though the activities of a reportorial vacation enforce a relatively long passage of time from when the letter is received in Paris and when the reply is started back. In any case, we seem to have lost touch with Mr. C slightly. The record for this month is therefore omitted; we have on file your replies with respect to the Tschaikowski 4th and the Siena Piano—we do not have the results of the judging. We assume we will have both by the time the October issue goes to press, together with a new record upon which you may whet your ears and pens. The same out-of-touchness has prevented us from running the regular AUDIO ETC column—both for August and for this month. The only reason we are able to keep up a continuity of the RECORD REVUE is that we cheated a little—we asked Mr. C for lots more copy for the few months preceding his hiatus and then didn't run it all, saving it up for these leaner months—a little trick we learned on his first overseas vacation from AUDIO several years ago.

MODEL 580, 1000-CYCLE CROSSOVER / MODEL 581, 400-CYCLE CROSSOVER

THE PICKERING ISOPHASE is a revolutionary new speaker with a single diaphragm that is curved and virtually massless. This diaphragm is moved or driven as a unit by an electrostatic field. It re-introduces an audio signal into the air at a low velocity to closely approximate the unit area energy of the sound at the microphone in a concert hall or studio, thereby creating a "window-on-the-studio" quality that is breathtakingly realistic. Conventional cone or dynamic type loudspeakers reproduce sound by moving only small amounts of air at high velocities. The ISOPHASE, with its large sound-generating surface, is a radical departure from the older concept.

The ISOPHASE is available in two models. Model 581 covers the musical range from 400 cycles per second up to well beyond the limits of human hearing. The response over this range is consistent and absolutely uniform—without the slightest bump, peak, or resonance of any kind. This in itself is an unprecedented characteristic for a loudspeaker.

Model 580 has the same uniform response and clarity starting at 1000 cycles per second and similarly going out to supersonic frequencies.

Using an ISOPHASE SPEAKER with a FLUXVALVE PICKUP, recorded sound is reproduced for the first time *without distortion caused by the frequency characteristics of the transducers* . . . the middle and higher frequencies are recreated with a smoothness, definition, and degree of balance never before achieved with any speaker.

PICKERING & CO., INC. OCEANSIDE, N. Y.

Professional Audio Components

"For those who can hear the difference"

. . Demonstrated and sold by Leading Radio Parts Distributors everywhere. For the one nearest you and for detailed literature, write Dept. A-11

EXPORT: AD. AURIEMA, INC., 89 BROAD ST., NEW YORK / CANADA: CHARLES W. POINTON LTD., 6 ALCINA AVE., TORONTO.

WARREN A. MARRISON. Tompion Gold Medal, Worshipful Company of Clockmakers of the City of London, for pioneer work on development of quartz crystal oscillators as precision standards of time.

W. G. PFANN. Mathewson Gold Medal, American Institute of Mining and Metallurgical Engineers, for discovery of and pioneering research in zone melting.

H. T. FRIIS. Medal of Honor, Institute of Radio Engineers and Valdemar Poulsen Gold Medal, Danish Academy of Technical Sciences; important work in application of short and ultra-short radio waves.

CLAUDE E. SHANNON. Stuart Ballantine Medal, Franklin Institute of the State of Pennsylvania, for contributions to a comprehensive theory of communication.

AXEL G. JENSEN. David Sarnoff Gold Medal, Society of Motion Picture and Television Engineers, for technical contributions to television; G.A. Hagemann Gold Medal for Industrial Research, Royal Technical College, Copenhagen.

H. F. DODGE. Shewhart Medal, American Society for Quality Control, for original contributions to the art of statistical quality control.

R. KOMPFNER. Duddell Medal, Physical Society of England, for his original work on the traveling wave tube.

WALTER H. BRATTAIN. Co-winner with Dr. John Bardeen of John Scott Medals, City of Philadelphia, for invention of the transistor.

PIONEERS OF PROGRESS

These are some of our recent medal winners at Bell Laboratories. The awards they have won symbolize recognition for outstanding achievement in the many sciences that bear on telephony. Bell Labs is extremely proud of them—and of the thousands of scientists and engineers who work with them to keep the American telephone system the greatest in the world.

BELL TELEPHONE LABORATORIES

WORLD CENTER OF COMMUNICATIONS RESEARCH AND DEVELOPMENT

A Versatile Bass-Treble Tone Control

CHARLES T. MORROW*

This bass-treble tone-control circuit, containing only resistors, capacitors, and switches, provides control not only over the amount of equalization but also over the frequency at which the response starts up or down.

BASS-TREBLE EQUALIZERS or tone controls are appropriately used in a high-fidelity amplifier to compensate for loudspeaker deficiencies, or, if a more specialized equalizer is not available, to compensate for recording characteristics. They are occasionally useful when a radio program is improperly equalized at the studio. They may be used as a substitute for loudness controls, although the author has never been tempted to try to compensate for ear characteristics.

In general, it is more important to control the frequency at which boost or attenuation begins than the maximum equalization at the high or low end of the spectrum. Most tone controls incorporated into commercial amplifiers control primarily the maximum equalization.

The circuit of *Fig.* 1 has been in use in the author's home amplifier for the past two years and provides both types of control. Four two-gang rotary switches are used—preferably of the shorting type. The circuit also uses fifteen resistors and eight capacitors exclusive of the input coupling capacitor. For simplicity, the diagram omits the 10 megohm resistors that are shunted across the eight capacitors to minimize switching transients. Two switches provide choices of nominal 3-db frequencies: OUT, 300, 500, or 700 cps for bass, and 3000, 5000, 7000, or OUT for treble. The other two switches provide corresponding choices of 6-db-per-octave droop, droop to a depressed 6-dh plateau, OUT, boost to a 6-db elevated plateau, or 6-db-per-octave boost. The insertion loss is approximately 26 db, which is made up by a preamplifier. Other 3-db frequencies could be chosen or added by connecting other resistors to the switch contacts, and other maximum equalizations could be obtained by connecting other capacitors.

The various equalization curves for the circuit of *Fig.* 1 are shown in *Fig.* 2, and it can be seen that enough choice is possible for most ordinary situations, although there might be some virtue in extra switch positions for elevated and depressed plateaus at 12 db, or a change to a plateau between 6 and 12 db. The reader may prefer to select his own 3-db frequencies. For this reason, after the operation of the specific equalizer circuit is discussed, formulas will be given, and non-dimensional curves for bass and treble separately. From these the reader should be able to design his own equalizer. A brief derivation involving complex algebra is given in Eq. (*6*), which the reader may ignore if he chooses.

Bass Equalization

Examination of the left half of the circuit of *Fig.* 1 shows that it consists of a resistive voltage divider with a loss of approximately 26 db, and a set of capacitors for bass boost. The 3-db points are varied by shunting the resistive voltage divider with resistors. In general, the diagram shows nominal values for commercial components.

For a selection of a 3-db frequency of 300 eps and a 6-db-per-octave bass droop, the bass equalizer reduces to the circuit of (A) in *Fig.* 3, where the total resistance $R_1 = 0.1$ megohms approximately, $k = 1/20$, and $f_1 = 300$ eps.

If a 6 db depressed plateau is chosen, the bass equalizer reduces instead to the circuit of (B) in *Fig.* 3b, which includes a capacitive voltage divider which starts to take over in the region of the nominal 3-db frequency and has 6 db more loss than the resistive divider.

If "out" or flat response is chosen, the circuit of (C) in *Fig.* 3 is applicable (or (D) if switch connections are made according to the dotted lines of *Fig.* 1). The capacitive divider in this case has the same loss as the resistive.

If an elevated 6 dh plateau is chosen, the circuit of (E) in *Fig.* 3 is applicable. A capacitive divider with 6 db less loss than the resistive begins to take over in the region of the nominal 3-db frequency.

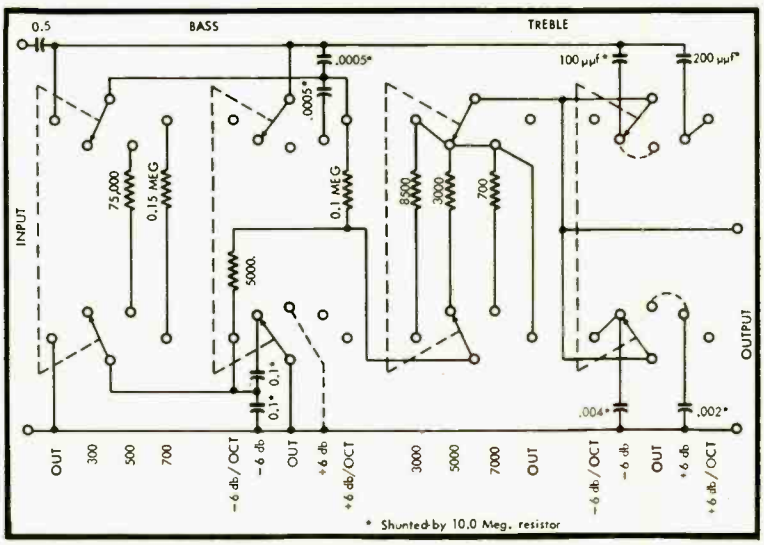


Fig. 1. Schematic of amplifier employing the tone correction circuits described in the accompanying text.

* *Ramo - Wooldridge Corporation, 8820 Bellanca Ave., Los Angeles 45, Calif.*

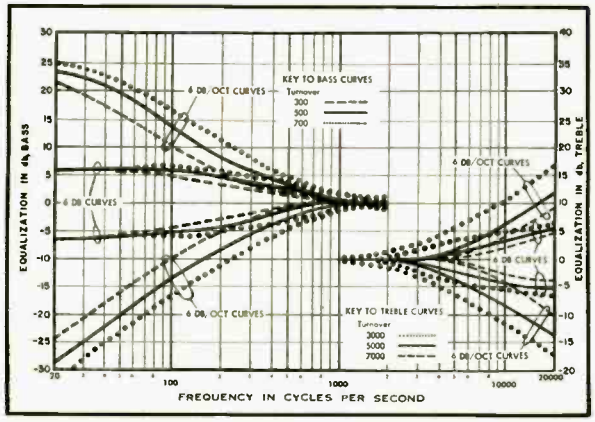


Fig. 2. Basic characteristics of the various equalization curves provided by the circuit of Fig. 1.

Finally, if a 6 db/octave boost is chosen, the circuit of (F) is applicable, in which the capacitive reactance is equal to kR_1 at the 3-db frequency and becomes the controlling load impedance at lower frequencies, decreasing the insertion loss.

Use of a resistive shunt on the resistive divider raises the 3 db frequency to 500 or 700 cps by effectively decreasing R_1 while C_1 remains constant. The effect at low frequencies is the same as if the individual resistors of the divider were divided by the same factor.

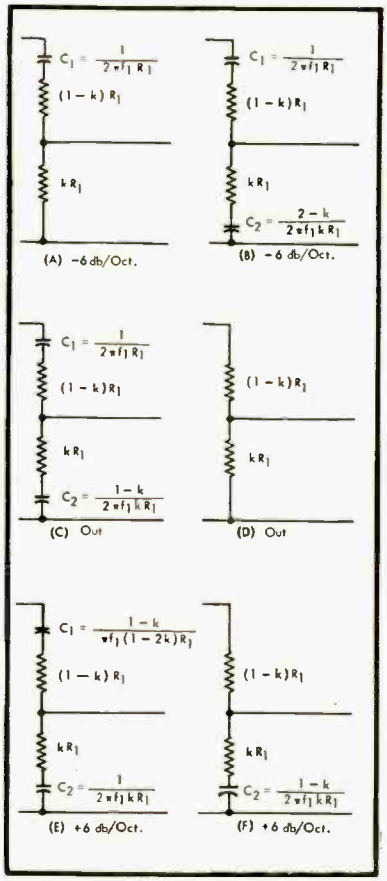


Fig. 3. Circuit configurations and formulas for bass equalizer section.

Treble Equalization

Operation of the treble equalizer is similar except that the capacitors are in shunt with the voltage divider resistors rather than in series, and the resistors used to control the 3-db frequency are in series with the output lead rather than in shunt with the voltage divider.

For example, if a 6-db-per-octave droop is chosen, the treble equalizer reduces to the circuit of (A) in *Fig.* 4, where R_1 is the total resistance of the unshunted resistive divider. This is merely a circuit with a mid-frequency transmission k and a high-frequency droop corresponding to that of a resistance R_2 working into a capacitive load C_2.

If a 6-db depressed high-frequency plateau is chosen, the circuit of (B) in *Fig.* 4 is applicable. In the region of the nominal 3-db frequency, a capacitive voltage divider with approximately 3 db more loss than that of the resistive divider begins to take over.

For "out" or flat response, the circuit of (C) is applicable [or (D) if switch connections are made according to the dotted lines of *Fig.* 1]. In the latter case, the capacitive divider has the same insertion loss as that of the resistive.

For a 6-db elevated plateau, the circuit of (E) in *Fig.* 4 is applicable, in which the capacitive voltage divider has approximately 6 db less insertion loss than that of the resistive divider.

For a 6-db-per-octave boost, the circuit of (F) is applicable. The voltage due to current through the capacitor C_2/k is closely equal to that due to current through the upper resistor at the 3-db frequency f_2.

Discussion

Approximate formulas for the gain of the simplified circuits as a function of frequency are given in Eqs. (*1*) through (*8*) in case the reader wishes to design his own equalizer. The gain (*1A*) is plotted as a function of f/f_1 and f/f_2 in *Figs.* 5 and 6, for the case of $k = 1/20$ and plateaus at 6 db.

It will be evident that the capacitors in *Figs.* 3 and 4 were chosen so that the 3-db points for *Figs.* 3A and 4A would be exactly f_1 and f_2, and so that the attenuations of the capacitive voltage dividers would be exactly $k/2$, k, or $2k$ as called for. For small values of k, the expressions for calculating the capacitances become quite simple.

Formulas for Bass Equalization

$$2A.\quad |A| = \frac{kR_1}{\sqrt{R_1^2 + R_1^2 f_1^2/f^2}} = k\frac{1}{\sqrt{1 + f_1^2/f^2}} \qquad (1)$$

Simplifying the remaining equations,

$$2B.\quad |A| \approx k\frac{\sqrt{1 + f_1^2/4f^2}}{\sqrt{1 + f_1^2/f^2}} \qquad (2)$$

$$2C.\quad |A| \approx k\frac{\sqrt{1 + f_1^2/f^2}}{\sqrt{1 + f_1^2/4f^2}} \qquad (3)$$

$$2F.\quad |1| \approx k\frac{\sqrt{1 + f_1^2/f^2}}{\sqrt{1 + k^2 f_1^2/f^2}} \qquad (4)$$

(*Continued on page 87*)

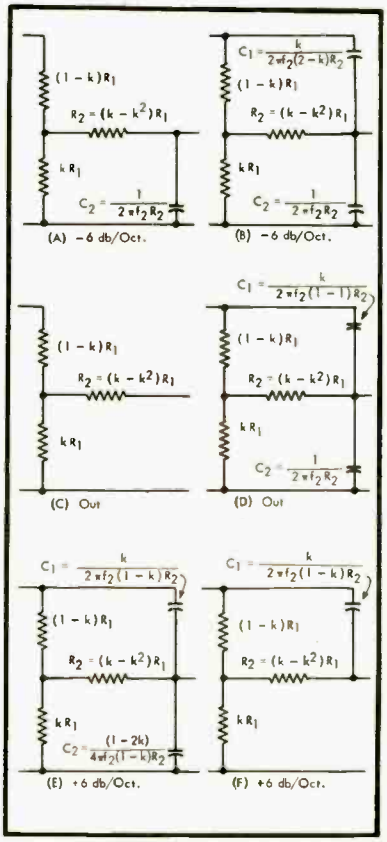


Fig. 4. Circuit configurations and formulas for treble equalizer section.

Record Speed and Playing Time

A tongue-in-cheek analysis of the possibilities of high-quality reproduction at 16 2/3 rpm in comparison with the present 33 1/3 and 45 rpm discs—but an analysis, nevertheless, which has a strong background in good engineering.

CHARLES P. BOEGLI*

SEVERAL YEARS AGO, lovers of recorded music went their way in a state of blissful misery (if it can be defined by a combination of such seemingly contradictory terms) with heavy and fragile shellac records of at best poor fidelity, and an occasional better-than-average vinyl disc to provide a sort of oasis. The 33 1/3-rpm LP record, the 45-rpm disc, new and better pickups and amplifiers, and so on, appeared almost overnight and at last the music lover could listen to sound as well as (and in some cases instead of) music.

But there is a law of compensation, and the price had to be paid for all this new enjoyment. Sometimes one wonders whether it was worth it, for beside the cost of new equipment there was a surtax, as it were, on the audio fan's peace of mind. Nowadays one has no sooner bought a speaker than a newer, better, cheaper one appears; and to purchase the latest pickup seems to insure the announcement of a superior one next month. Even turntables are vulnerable; ominous whisperings about 16 2/3-rpm records continue to be heard and will not be stilled.

Happily, mathematical laws sometimes aid the peace of mind of the audio fan. For example, consider 16 2/3-rpm records. Whether they will ever replace the "old" 33 1/3-rpm discs depends upon what sort of benefits can be realized from them, and what sort of expense must be endured to enjoy these rewards. Certainly, we cannot assume that by a simple halving of speed the amount of music on a record side can be doubled, for, as we shall see later, the picture is complicated by other factors. For example, there is the problem of pickups.

Even at the present state of the art, pickups for 33 1/3-rpm discs are not yet perfect, and cause much more record and stylus wear than they should. A great deal of work remains to be done; the one-mil tip should track with a force of around one gram and have a dynamic mass less than one milligram[1]. Admittedly these figures do not appear unreasonable, as they would have ten years ago, but they remain to be accomplished. The problem is multiplied by smaller styli and it doesn't appear that we will have thoroughly satisfactory pickups with ½-mil styli for some time to come. In view of the probable reluctance of music lovers to endure once again the rigamarole of replacing all their equipment, it seems reasonable that if 16 2/3-rpm discs are to make their appearance very soon, they will have to be cut for a one-mil stylus.

The question then comes down to whether much longer playing time can be realized with present equipment simply by reducing the speed at which the disc turns. Fortunately, a good answer to that problem is easily obtained. Suppose we let n equal the number of grooves per inch cut on the record. With newer methods of recording this quantity will of course vary across the disc but that will have no effect, as we shall see later. There is a tacit assumption, however, that the "average" n will be the same irrespective of the speed at which the record turns, and this is not a bad assumption if the same stylus is used for all the speeds. The total number of grooves on the disc is then $(R-r)n$, R being the outer radius and r the inner radius at which grooves are cut. This quantity, of course, is also the number of revolutions the disc must turn to be played, and if s is the rotational speed in rpm, the total playing time

$$t = \frac{(R-r)n}{s} \text{ minutes} \qquad (1)$$

Now, the inner radius is related to s; obviously, the lower the speed, the greater will r have to be to avoid excessive tracing distortion at the center of the disc, even with a perfect pickup. We may get an idea of the relationship from Roys,[2] where it is shown that for a one-mil stylus the intermodulation distortion reaches 10 per cent on a 45-rpm disc at an inner diameter of about 4.9 inches, and on a 33 1/3-rpm record at a corresponding measurement of around 6.8 inches. It seems logical that this distortion is attained approximately at a fixed linear speed, so that if we assume

$$r = \frac{4.9 \times 45}{2s} = \frac{110}{s}$$

we shall have the desired relationship. Putting $s = 45$ in this equation, we get $r = 2.45$ inches ($d = 4.90$ inches) and for $s = 33\ 1/3$, $r = 3.31$ inches ($d = 6.62$ inches), so the equation agrees pretty well with experiment.

On the other hand, Columbia has specified a minimum diameter of 4¾ inches for their discs ($r = 2.375$ inches) and we must assume they knew what they were doing, so we should modify the above equation to permit this smaller diameter. It turns out then that

$$r = \frac{79}{s} \qquad (2)$$

for commercial discs meeting the specifications of Columbia, and this is the equation we shall substitute into Eq. (1), yielding the result

$$t = \frac{(R - 79/s)n}{s} = \frac{nR}{s} - \frac{79n}{s^2} \qquad (3)$$

As a matter of interest, let us find the s at which t will be a maximum. We have

$$\frac{dt}{ds} = -\frac{nR}{s^2} + \frac{158n}{s^3}$$

which we set equal to zero to find the s for a maximum t. This gives

$$s = 158/R = 316/D \qquad (4)$$

for maximum playing time, where D is the maximum diameter of the record. Note that the quantity n has dropped out and does not appear in Eq. (4).

Now, for a 12-inch disc, $D = 11.5$ inches (allowing for the lead-in grooves) and $s = 316/11.5 = 26.6$ rpm.

For a 10-inch disc, $D = 9.5$ and $s = 32.2$ rpm.

For a 7-inch disc, $D = 6.5$ and $s = 47$ rpm.

These speeds agree surprisingly well

(*Continued on page 87*)

* *Cincinnati Research Company, 2209 Losantiville Road, Cincinnati 13, Ohio.*

[1] F. V. Hunt, "On stylus wear and surface noise in phonograph playback systems." J.A.E.S. January, 1955, p. 2.

[2] H. E. Roys, "recording and fine-groove technique." AUDIO ENGINEERING September, 1950, p. 11.

Output Transformer Design

NORMAN H. CROWHURST*

This article not only explains the "mystic" factors in output transformers, and tells how to design them, it makes important suggestions the author considers essential to continued progress in the industry.

THE OUTPUT TRANSFORMER is one of the more important components in any modern amplifier as regards its contribution both to cost and to performance. So the primary considerations in designing an output transformer must resolve into various aspects of the economic question, "How good, for how much?" Keeping "both feet on the ground," we will start by considering the various items that contribute to the over-all cost of an output transformer.

Costs

On the material side, there are two main groups of cost: the core and the winding. Two classes of core material enter the consideration: the fairly inexpensive silicon-iron alloys that come in stamped or punched laminations; and the much more expensive grain-oriented strip-wound material, ranking in the order of ten times the cost for the corresponding weight.

Compared to these costs the cost of winding material is relatively small. The principal economic question in relation to winding material concerns choice of the best wire *covering*, which is usually enamel, or a similar material. From the viewpoint of achieving the lowest cost, a more expensive covering is sometimes justified, because it enables the winding to be accomplished more readily without the risk of shorted turns. Associated with wire covering is the matter of a suitable impregnating compound, which can finalize the winding assembly and prevent its deteriorating due to atmospheric conditions in which the transformer will work.

On the labor side of the question there are again two major operations: the winding and the complete assembly. In determining the lowest cost for a given performance, one has to take all of these elements and see which one adds up to the lowest figure. For example, concerning the winding labor: it may be possible to save material in the core and winding, but the result of this saving will be that a more complicated method of mixing is necessary, which will put up the cost of labor for winding the coil.

Similarly with the assembly part of the story: the more expensive grain-oriented, or C-type core, does have the advantage that the assembly labor costs are reduced; with the older lamination type core, although the material is much cheaper, assembly takes longer and hence is more costly; the C-type core is very quickly and easily assembled with simple tools.

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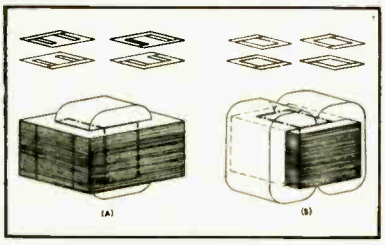


Fig. 1. The two types of construction employing punched laminations. Above each is shown, reduced in size, the lamination configuration used to build it up. At (A) the shell type, using a single coil assembly, with E and I, or T and U laminations. At (B) the core type, using two coil assemblies, with U and I, or L laminations. In each case, the heavy dashed line outlines the magnetic path area of the core, while the heavy dot-and-dash line outlines the winding window area.

Choice of Core Type

All of these costs have to be weighed against various performance considerations that may be laid down in the transformer specifications. The first major question to decide now is the kind of core to be used: whether to employ a C-type core or one of the laminated varieties. So we will start by giving some approximate comparative figures relating the two kinds of material.

Of course, these will provide only a guide, because the final answer to the question depends upon the precise costs of labor and materials, which are factors that vary widely from place to place and over a period of time: the most economic solution at one place and time may be the least economic solution at some other place or time. The purpose here is to give some performance comparisons. Then the cost figures can be put in and the various other relevant details, to help make the decision.

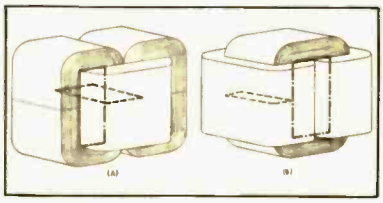


Fig. 2. The same two types of construction employing prefabricated C cores wound from grain oriented strip.

The first thing to notice is that the relative dimensions change between the two kinds of core. For a good transformer using a built up laminated core, the usual proportions constitute a larger volume of core than of winding. These laminations are relatively cheap and, even if they were a little more expensive in comparison with winding material, the large core section would still be the most economic proposition because it makes for a simpler type of winding and assembly.

Changing over to the C-type or strip-wound core, the trend is towards a much more conservative core cross section and a larger winding window. The reason for this is the very much greater relative cost of the C-core materials. By making this change, the over-all cost of a transformer with similar performance can be kept in the same region—it may be more or less according to the precise features involved and the relative cost of materials involved. However, it would become exceedingly complicated to make a direct comparison between cores of one material in one kind of proportions, and cores of a different material in different proportions. So we shall make the comparison on a step-by-step basis.

At this point however, an important point should be stressed. Recently the author encountered a case where transition from laminations to C core had been made, simply by removing the laminated

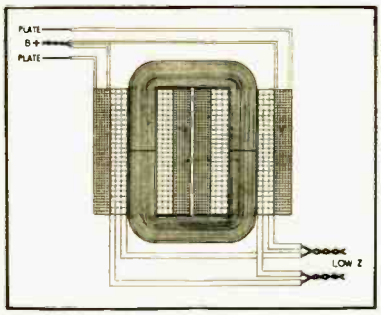


Fig. 3. Section through a transformer using a single C core, relying on electrical interconnection for low leakage: each limb of the core is virtually a separate transformer, one for each plate circuit, and the secondary low-impedance windings must be paralleled; to maintain high core inductance, the winding connections should be such that the core magnetizing effects are in phase.

core and inserting a pair of C cores that happened to fit conveniently over the same bobbin. *This change is never an economic proposition.* To the uninitiated, it would seem that the principal difference is a relatively large air space in the winding window of the C core, and air does not cost anything! Of course, there is a little more core material, due to the increased length necessary to "go round" the air space. But make a quick comparison this way:

With E and I laminations, the transformer had been about 94 per cent efficient; the change had improved the efficiency to about 96 per cent and increased the power at the low end about three times. But had the coil been redesigned and rewound to fill out the same pair of C cores, the efficiency would have jumped to almost 99 per cent and the low-frequency power rating about eight or ten times.

This improvement is probably much more than the customer needed. So a smaller C core could have been used for the design. That change raised the cost from $14 to $16. In all probability a change tailored to suit the customer's needs would cost not more than the original transformer. This brings us to the first basis for comparison.

Power Rating and Efficiency

First we assume that the build-up of the strip-wound C core is such as to produce a transformer identical in dimensions with one using a laminated core. Under these conditions, using the same winding, that is, number of turns and wire gauge, the working impedance of the winding for maximum energy transfer efficiency can be pushed up by a ratio approximately 1.55. This is because of the very much reduced shunt losses in the core.

This change in working impedance means that the losses will be reduced in this same ratio. If the laminated core produced a transformer of 90 per cent efficiency (i.e. 10 per cent losses), the C core using identical dimensions would produce a transformer of 93.5 per cent efficiency (i.e. 10 per cent ÷ 1.55 losses). However if both types work at maximum energy transfer efficiency, in all probability, due to the change in relative dimensions, the full advantage of this improved efficiency will not be gained. On the other hand, the laminated type core often does not work at optimum efficiency due to other considerations, so it may be that the C core will gain an even greater improvement in power transfer efficiency.

Taking an alternative assumption—that we will be content with the same efficiency in the two kinds of transformer (of the same size and shape)—the power rating can be pushed up at the low-frequency end due to the reduction of losses and the change in nominal impedance that can be achieved for a given winding. Due to reduced losses, the working impedance of a given winding can also be reduced by a factor of 1.5 for the same efficiency, so the power rating can be increased by a ratio of 1.5. Further than this, due to the increased permissible flux density before saturation is reached, the power rating can be increased approximately 7 times.

Thus the over-all increase in power rating for a given size of transformer can be more than 10 times. This means that, if the transformer using regular laminations gives maximum power down to a frequency of 60 cps, one using the C-core construction would give ten times the power at 60 cps, or approximately the same amount of power down to 20 cps.

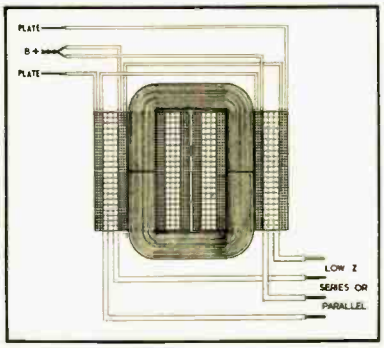


Fig. 4. Section through a C core transformer relying on distributed transformer action for low leakage: each limb carries half of each plate winding and half of the secondary; as a result there is no leakage flux potential between limbs, and the windings may be connected in series or in parallel to suit impedance requirements.

Frequency Response

The figures just given relating to maximum power at the low-frequency end are not *directly* related to the matter of frequency response—a fact that often does not seem to be appreciated. Maximum power at the low-frequency end is controlled by saturation flux density, whereas the *response* at the low-frequency end is controlled by the effective inductance produced by the core *below* saturation flux density, using the same winding as a reference.

A comparison between the C-core materials and the older lamination type materials, shows that the effective permeability below saturation is increased by an average figure of 3.5 times. This means that the primary inductance of a given winding, on a core of the same proportions, would be increased by 3.5 times. As the operating impedance of this winding will probably be increased also, this means that some of the benefit will be transferred to the upper end by reducing the leakage inductance referred to the specific impedance used.

The exact distribution of the improvement in frequency response will depend upon the relative distribution of other losses. The best way to express

SIZE DESIGNATION	MATERIAL	QUANTITIES REFERRED TO 1000-TURN WINDING OCCUPYING HALF OF AVAILABLE SPACE						MAX. POWER 60 cps	ROLLOFF	
		Winding Resistance (total referred)	Core Losses (K) R_e	Core Losses (K) Rh_{60}	Minimum Inductance	Leakage Inductance	Maximum Efficiency	Optimum Impedance	LOW	HIGH
					Hys.	mH	%	ohms	W	cps	cps
EI-12 x 1½"	High Silicon	70	120	20	35	30	95.2	2900	7.5	18	15,000
EI-12 x 3"	"	100	240	40	70	43	95.9	4900	15	12	18,000
EI-13 x 2"	"	28	160	27	47	50	97.3	2100	25	8.5	6,800
EI-13 x 4"	"	39	320	54	94	70	97.7	3500	60	6	8,000
50/18/13	C-core	17	190	28	70	40	98	1800	65	4	7,000
50/32/13	"	21	340	50	125	49	98.4	2700	135	3.5	9,000

Fig. 5. Method of tabulating data to facilitate output transformer design. Optimum impedance is that for maximum efficiency. Maximum power and the frequency response roll-offs are based on the optimum impedance given. Power rating can be increased, and low-frequency response extended, by using an impedance lower than optimum (or more turns for a given impedance). In the opposite direction, high frequency response can be extended by using an impedance higher than optimum (or less turns for a given impedance). Where requirements conflict, high-frequency response can alternatively be extended by sectionalizing.

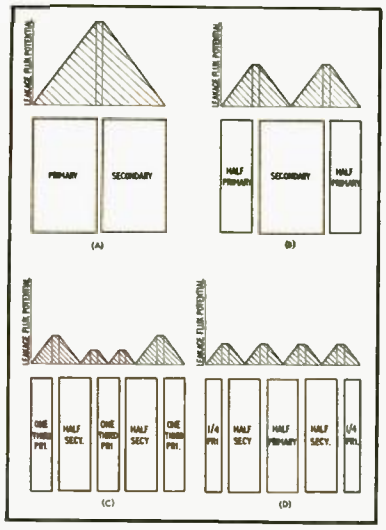


Fig. 6. How sectionalizing influences leakage inductance. The significance of leakage flux potential, and the relative advantage of the arrangements shown, are discussed in the text.

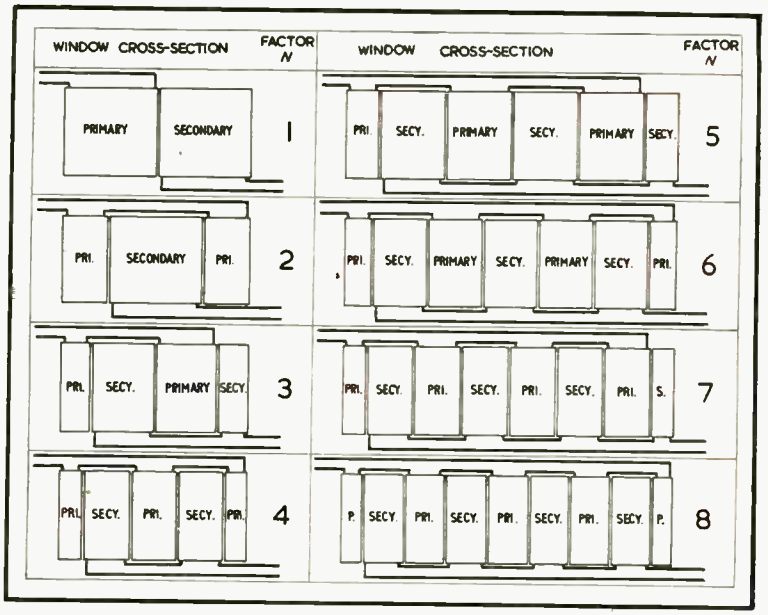


Fig. 7. Table of sectionalizing arrangements with the values of factor N to be used with the chart of Fig. 9 in computing leakage inductance.

the matter is that the over-all frequency response will cover a band width increased in *ratio* by approximately 3.5 times, using a coil and core of the same dimensions and proportions.

In practice, as the C-core construction employs a relatively larger window for the size of the transformer, it is easier to employ a greater amount of mixing in the construction of the winding. Also as the core is more costly it is more economic to spend a little more on winding than to go to a larger core size to achieve a given improvement.

The net result, then, is that change from the old laminated core to the newer C-type cores promises an improvement in frequency response band of *at least* a ratio of 3.5.

Size and Weight

For some applications the big problem is size and weight: how small can we make an amplifier to deliver a given power? The easiest way to arrive at a comparison on this basis is to consider how the relevant quantities vary as size is changed, maintaining the same shape. Under this condition, the same number of turns will represent the same operating impedance, for maximum energy transfer efficiency, and both core losses and winding resistance will vary directly in inverse proportion to the linear dimensions.

This means that, when energy transfer efficiency is the controlling factor and, due to the change in material, we have reduced the losses by a ratio of 1.55 for the same size, we can in turn reduce the size, to bring the losses back to the original figure, in linear dimensions by a factor of 1.55. This represents a reduction in weight or volume to less than 1/3 of the previous value—not much more than 1/4.

It may be that the limiting factor is the power handling capacity at the low-frequency end, in which case the power handling capacity of a given number of turns on a particular core *shape* will vary approximately as the fourth power of the linear dimension. As for a given size, we had an improvement of 10 times, this means that linear dimension can be reduced by the fourth root of 10, or the volume and weight by the 3/4 power of 10. This represents a possibility in size and weight reduction of better than 5 to 1 by using the C-core material.

As this shows a better reduction than the one based on consideration of energy transfer efficiency, it means that the efficiency will be probably somewhat reduced by using this greater reduction.

To get some kind of cost comparison we need to have a means of considering how change in the relative quantities of core and winding volume will affect the situation. As a general principle we can make the assumption that a constant performance can be achieved by having a constant *product* of core and winding volume. This means that if we halve the core volume we need to double the winding volume to maintain a compatible performance. This is approximately a sound foundation for comparison, but of course there are many other factors that must be considered in completing out a design.

Using this as a basis of pricing both kinds of transformer in *dollars per pound,* exclusive of case, impregnation, or filling, we find that the C-core variety shows an increase over the old laminated type in the region of twice. This means that if we utilize a C-core construction of approximately half the total volume of the previous laminated core construction, we shall land up with a transformer of approximately the same price.

The foregoing discussion has shown that, whichever criterion is considered as a basis for performance comparison, a transformer of half the volume on C-core construction should achieve better performance than its prototype in the laminated core construction.

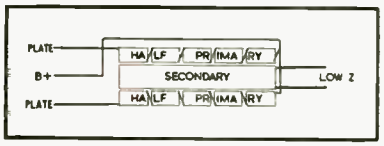


Fig. 8. A cross section through a simple winding arrangement where both leakage inductance and primary capacitance have to be minimized. This is only likely to be required with the higher plate circuit impedance values.

Choice of Core Size

Closely associated with deciding what material the core should be made of, comes the question of the size and shape. Laminated cores are built up, from stampings of specific dimensions, to a desired stack thickness as shown at *Fig.* 1. There are two basic shapes, one of which may be built up with laminations of E and I, or T and U configuration,

while the other shape may be built up with L's, or U's and I's. The former group requires only one coil assembly, while the latter group uses two coil assemblies.

From the viewpoint of energy transfer efficiency, the two arrangements are in dual relationship one to the other: the former uses a single loop of winding with a double loop of core; while the second uses a double loop of winding with a single loop of core. This is more evident when the assembly is produced by C-core elements instead of laminations.

In this case the equivalent of the lamination dimensions is produced by the size and shape of former on which the strip core is wound and the build-up or number of turns of strip core wound on the former. The equivalent of stack thickness in the lamination arrangement is produced by the width of strip wound in the C-core arrangement. This is illustrated in *Fig.* 2.

From the viewpoint of energy transfer efficiency, the arrangement shown at (A) in both *Figs.* 1 and 2 requires a maximum of core with a small amount of winding, while the arrangement at (B) requires a maximum of winding with a minimum of core material. Consequently, *on the basis of the energy transfer efficiency* consideration, the second variety is the best for C-core construction because of the much greater cost of the core material.

When we turn to frequency response, the story is not quite the same: for maximum frequency response both varieties require a fairly hefty core section with a small winding cross section. However, there is still some economic advantage to the single C-core construction of (B) in *Fig.* 2. It should be noted, however, that the single-C-core uses a different build-up than that regarded as optimum for a double-C-core construction, so it is not a simple matter of deciding whether to use a single pair of C cores or a double pair of the same specification number.

One requires to select a pair of C cores designed for operation as a *single* pair and with double winding.

An important point to remember in designing the winding layout for this type of construction is that there will be a very large leakage inductance between the two winding assemblies, so one of two alternative methods of overcoming this must be adopted: either electrical interconnection must be employed to provide close coupling between sections which otherwise would be separated by a large leakage inductance, or the sections of winding must be so distributed between the two limbs that the leakage inductance is non-effective in the over-all transfer. The latter method means that every possible transformer action must be equally distributed between the two limbs. Figures 3 and 4 show typical methods adopting each of these principles.

If electrical interconnection is relied upon, as in *Fig.* 3, then it is important that the windings be connected in parallel as shown, so as to equalize the magnetic field in both limbs. On the other hand, the second method, of *Fig.* 4, provides uniform distribution of transformation and eliminates the effect of leakage inductance between the two halves. So in this case it is unimportant whether the windings on each limb are connected in series or parallel. This gives the advantage that series/parallel connection can be utilized for providing a variety of different impedances.

Power transfer efficiency can be calculated by completing a suitable design and evaluating the series and shunt losses. While the foregoing discussion will provide a useful guide in selecting the suitable core material and size for the particular purpose, it may be necessary to carry out a number of preliminary designs to ascertain just which is the final best economic choice for the purpose in hand.

As described in a previous article[1]

(*Continued on page 89*)

[1] N. H. Crowhurst, "Input transformer design." AUDIO, June, 1956.

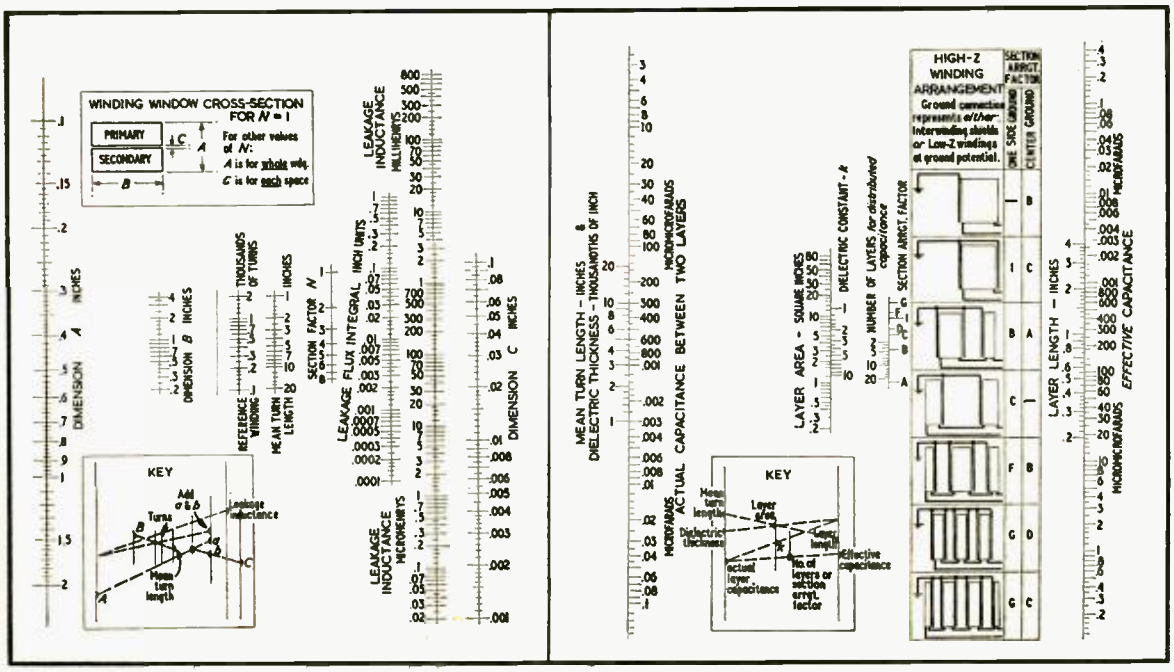


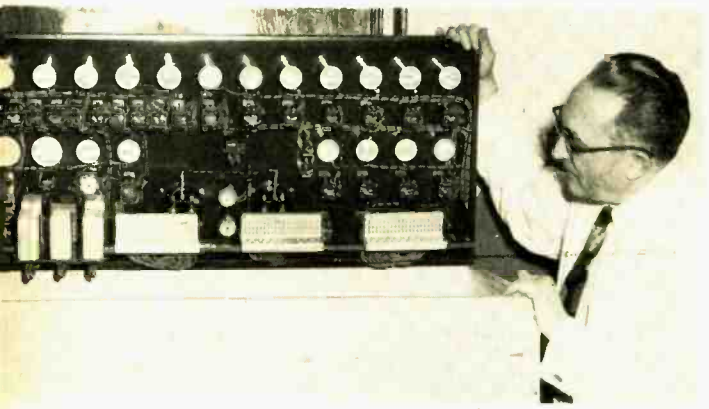
Fig. 9. (left). Chart for the computation of leakage inductance. The section factor for any given arrangement of winding cross section can be obtained from Fig. 7. Fig. 10. (right). Chart for the computation of various winding capacitances. The value of dielectric constant k used must take into account the material used to provide interlayer or interwinding insulation, and also the effect of impregnation if employed. The number-of-layers scale is used for finding the effective terminal capacitance due to distributed interlayer capacitance. The section factors, obtained from the table inset, are used to find the total terminal capacitance due to spaces between the high-impedance winding and either shields or low-impedance winding sections, as shown in the table.

Special Audio Console Meets WSB-TV Needs

BERT ENNIS

Combining old-world Southern charm with the most modern of audio control facilities, WSB-TV provides improved sound quality, increased flexibility, and simplified operation to its engineers with a console designed especially for its studios.

Within this strikingly different structure that could pass as a mansion for Scarlett O'Hara is the most complete and functionally efficient radio-television broadcasting facility in the South. Designed and built by The Austin Company to harmonize with Atlanta's traditions the authentically Georgian structure has an estate-like setting on an historic hilltop. (Courtesy The Austin Company)



The new control console, hinged to permit ready access to pots and switches, shows neatness and efficiency which combine to minimize crosstalk. All amplifier equipment is in an adjacent rack.
Color coding of knobs and switches facilitates quick handling by the engineer, while the four-inch elevation of the back provides maximum visibility of the studio below.

WAY DOWN SOUTH, in the land of cotton, corn and drive-ins, structures of striking architectural beauty continue to enhance the natural charm of the southern landscape. The economic resurgence so evident to a traveler through the South is particularly manifest in new buildings designed to house various activities in the entertainment world. Magnificent new coliseums have been erected in Charlotte and Winston-Salem, North Carolina. New buildings in the television industry are keeping pace with this trend, and while this story is devoted to a rather remarkable piece of audio equipment in NBC-affiliated station WSB-TV, Atlanta, Georgia, we feel constrained to mention briefly, at least, the architectural impressiveness of the exterior and interior of this structure.

Located on West Peachtree Street, in the northeast section of Atlanta's outskirts, WSB-TV presents a facade completely symbolic of the charm of the old south, with towering white columns fronting an exterior reminiscent of the heroine's home in the unforgettable "Gone With the Wind," the continued screen presentation of which adds a new measure of fame to the capital city of Georgia. The accompanying photographs of the exterior and the reception room lack only the fragrance of jasmine and magnolias to transport the reader back a century to antebellum days.

In strict contrast to an atmosphere engendered by the architect's magic is the modernity of the offices, studios, control rooms and equipment of WSB-TV. Owned by Atlanta Newspapers, Inc., a corporate name embracing the Atlanta Constitution and the Atlanta Journal, its executive director is J. Leonard Reinsch. John M. Outler, Jr., is general manager, and R. A. Holbrook, chief engineer. Assigned to Channel 2, WSB-TV operates well over 100 hours weekly, under 100 KW power.

When the necessity for certain audio equipment specifically designed to meet the requirements of WSB-TV became apparent, Robert A. Holbrook, chief engineer of the NBC Atlanta outlet, together with other officials of the station, submitted a basic design of an audio control console to members of the engineering department of Altec at the company's New York headquarters. Station requirements called for an audio instrument which would

afford control of two studios—the larger 50 feet by 70 feet—with specific demand for maximum studio visibility on the part of the audio engineers, limitations concerning space, and uninterrupted facile operation, for use in monitoring remote shows and local live productions.

The entrance hall of the new studio center literally lays out the red carpet for visitors who ascend the elegant open staircase leading to the main production floor. The cherry-red carpeting and the red velvet drapes contrast vividly with the off-white of the carved woodwork.

Equipment Details

Following protracted study of the basic design, project engineer Mike Revzin decided that the requirements set forth could best be met by a combination of split-mixers. The console consists of a 9-position mike split-mixer feeding into the main split-mixer, which also has a separate announce mike input, and five line input. Input switching to the line mixers allows selection of any of ten inputs. All lines are isolated by repeat coils, allowing the use of either balanced or single-ended inputs.

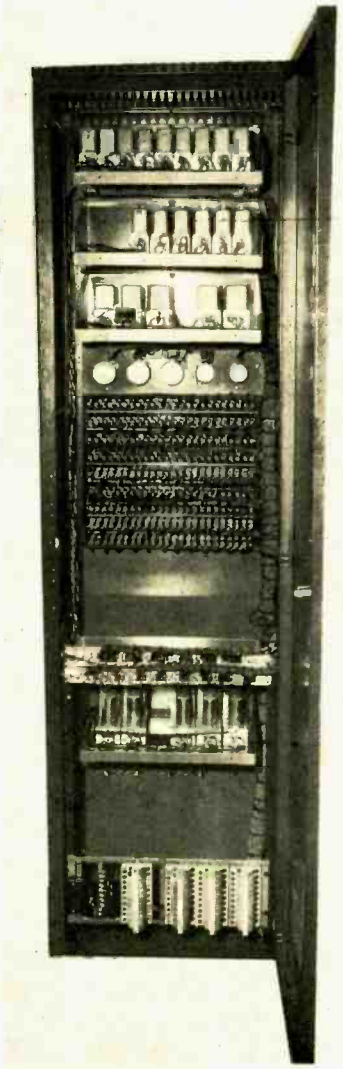
Continuous metering is provided for both channels, together with the ability to preview any of the line inputs, off-air signal, either line input, or the cue channel. To provide facility of operation and service, control equipment only is installed in the custom-designed console. All amplifiers, relays and power supplies are mounted in a specially designed separate rack. Requirement limiting the size of the console to occupy a pre-determined amount of space has been met by confining the over-all proportions to 37 by 19½ inches.

The important problem of permitting maximum visibility on the part of the audio engineer during rehearsal and show periods has been solved by a height dimension of four and one-half inches, with the console fitting snugly a trifle above the lower margin of the glass which separates the studio from the control room.

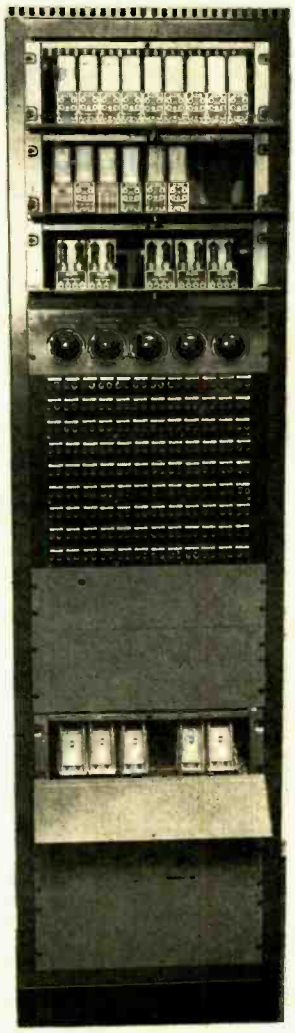
Plug-in amplifiers and power supplies specified by WSB-TV chief engineer Holbrook facilitate maintenance. For example, line and monitor amplifiers may be directly interchanged, all necessary power supply changes being made automatically at the connectors. Five separate power supplies are used, each having its own fuse, switch, and pilot light. All equipment is brought up on jacks, permitting any desired combination to be used.

Another feature of the control console is the switching facilities which permit talk-back, while muting the studio speakers, but permit the muting to be over-ridden by either the control room microphones, or the phono. Inasmuch as this console is used in con-

(*Continued on page 88*)



Equipment rack with doors open to show compactness of plug-in amplifiers.



Rear of equipment rack shows same neatness as the console, with adequate space remaining for sound-effects filters.

* *Altec Lansing Corporation, 161 Sixth Ave., New York 13, N. Y.*

Sound Effects Console for U. N. Studios

D. D. JONES*

Adding effects to broadcast programs is considerably simplified with a properly designed sound-effects console. The author describes one model briefly, and discusses the requirements for reverberation systems with special emphasis on the combining of two signals of differing levels.

OF ALL THE SPECIAL EFFECTS paraphernalia which is usually found in any well-equipped sound effects department, the sound effects console is perhaps the most generally useful.

Realism from sound effects apparatus can be produced in the studio in many ways. These range from the archaic but still effective dried-peas-on-a-drum-head technique for the simulation of pouring rain all the way to modern techniques for the simulation of gun shots by means of the electronically triggered synthesizer.[1]

With few exceptions however, a well-designed "effects" console using sound-effects records can satisfy many programming needs and it can do so at relatively low cost.

Whether or not a given "effect" should be produced by recordings through a console or by other means probably depends upon the precision of timing necessary. For example the sound of gun fire, a sudden explosion, or the slamming of a gate can be recorded and reproduced very realistically, but if split-second timing is needed for the best dramatic effect, sounds of this kind are probably best produced by acting them out with electronic or mechanical synthesizers designed for the purpose.

Any sound is of course much more manageable in the recorded form, and when timing accuracies are not too stringent a versatile sound effects console is usually the best expedient.

The sound effects console described here is now in use at United Nations Headquarters in New York. Since 1948 the Department of Public Information of the UN has produced many documentary programs for global distribution. These are produced on both film and disc, and the need to authenticate script sequences by means of sound effects arises quite frequently.

The design was strongly influenced in several respects by its successful counterparts in use by the networks. Also, to conform with needs of the Radio Division of the UN it includes certain newer features to ensure flexibility of operation over a widening range of production requirements. Special attention has been given to the mechanical design to facilitate speedy operation and simplify assembly and maintenance.

The Audio System

Front and top views of the console are shown in *Fig.* 1 and the simplified audio block diagram appears in *Fig.* 2. Provisions have been made so that the console may be connected directly to the studio control room through a six-pair cable (CBL2) which connects to bulkhead connectors on the studio wall. These cable pairs, which terminate at the control room jack field, may be used to set up: (1), direct line feeds to the control room; (2), director's cue from control room; and (3), reverberation facilities, about which full details will be given in the following.

Four crystal pickups and three variable-speed turntables are provided. With this arrangement two pickups may be used on one turntable—a very useful feature. With two pickups, the output of each under separate mixer control, any two parts of a given recording may be reproduced simultaneously.

Each of the reproducer arms is provided with a removable long-shank stylus which is brightly illuminated with a prefocused "inspection lamp." Long-shank styli are essential as they facilitate rapid spotting and cueing of records. A previous paper by Monroe and Fish[2] explains the necessity for these features in greater detail.

The equalization characteristic in each reproducer channel is fixed. A

* *B. Eichwald and Company, New York*

[1] J. L. Hathaway and R. E. Lafferty, "Gun shot reinforcers and synthesizers." *JAES*, January, 1953.

[2] R. B. Monroe and P. E. Fish, "CBS–TV sound effects console." AUDIO ENGINEERING, March, 1950.

Fig. 1. Two views of the sound-effects console. Left, from the front to show the general arrangement, and in use, at the right, indicating the convenient placement of controls and pickup arms.

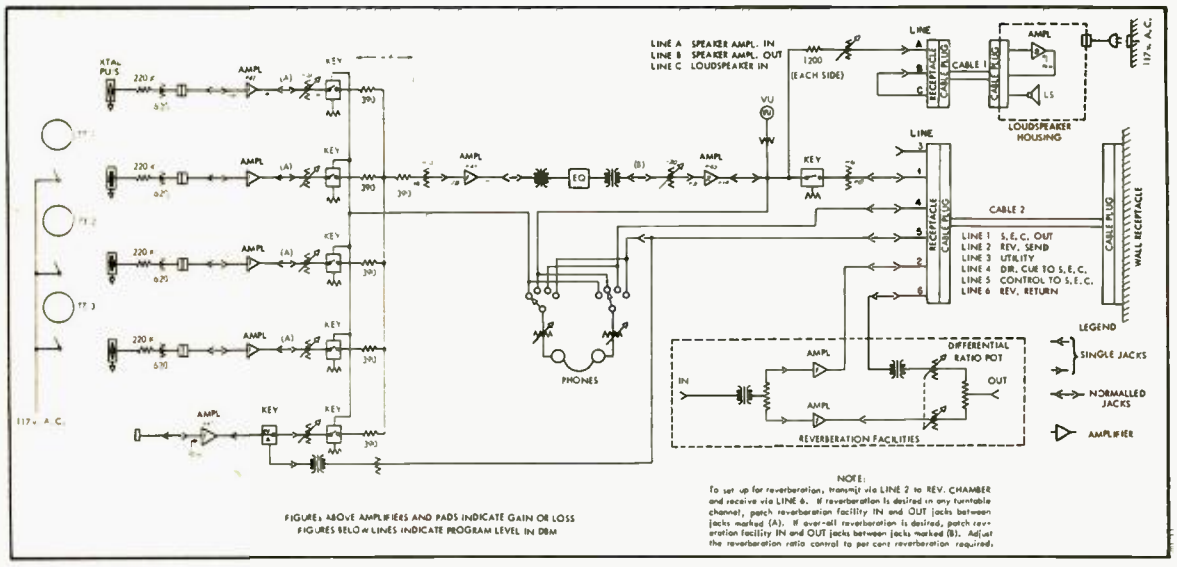


Fig. 2. Simplified block schematic of the audio circuits.

high- and low-end variable equalizer is provided and is connected between booster and line amplifiers. This provides a maximum range of from 16 db attenuation to 12 db of accentuation at two frequencies, 40 or 100 eps. It also provides for a similar high-frequency equalization range at three upper frequencies—3000, 5000, and 10,000 eps. In the event that some unusual frequency characteristic lying beyond the normal ranges is encountered in any individual reproducer channel, it is a simple matter to patch in an accessory filter. All important circuits are provided with standard twin-type telephone jacks, and the jack field and the left end of the console, *Fig* 2, facilitates special set-ups and simplifies maintenance.

The complement of amplifier equipment is as follows: for the four reproducer channels (*A1.1* through *A1.4*), the utility channel (*A1.8*), the booster amplifier (*A1.6*) and the reverberation facility (*A1.6* and *A1.7*), Langevin 111 preamplifiers are used. The line-level amplifier *A2* is Langevin type 102, and the loudspeaker amplifier *A3* (located in the loudspeaker enclosure) is Langevin 130. Nominal levels of impedance and power are indicated at all junctions on the over-all block diagram as are the insertion gain and loss figures for circuit elements.

As with some of its predecessors, split headphone cue is provided so that the sound effects operator may cue successive record bands while listening in one ear and have uninterrupted "over-all program" or "director" cue line in the other. Independent switches *SW1.1* and *SW1.2* provide for this. These are located on the small inset panel on the front of the console. It will be apparent from inspection of the diagram that either left or right headphone may be switched to any one of four positions: sound effects console out, incoming director's cue, over-all program from control room, and the console cueing bus which is commonly connected to all five mixer keys *K1.1* through *K1.5*.

By means of a reverberant chamber, located in a remote part of the UN Conference Building, and the facilities included in the console, a reverberation signal may be mixed with over-all audio output or, if desired, selectivity with any individual mixer channel. This feature increases the versatility of the console as it makes possible an endless variety of effects which would otherwise be difficult or time-consuming to set up.

A simplified diagram of the reverberation facility is shown in *Fig.* 3 and will be recognized as contemporary practice.[3] To obtain reverberation the reverberation chain (IN, OUT, *Fig.* 1) is "inserted" into any channel and the reverberation ratio control *Vc2* is adjusted for the desired effect.

Design of the reverberation ratio control

Conventional procedures were followed in the design of the audio circuits. These are so well treated in available periodicals that any review would be redundant. The design of the reverberation ratio control, however, required special attention and the criteria will probably be of interest.

Referring to *Fig.* 3 it will be noted that for any given signal appearing across the input of dividing pad *P2.1*, the ratio of the direct and reverberant path signals can be continuously adjusted with the dual attenuator *VC2*. This is accomplished without appreciable change to the program power level in the load. This control must be designed around a constant power concept or variations of net output from 0 to 3 db over reference volume level can occur with changes in ratio settings. The attenuator used is a differential type consisting of

(*Continued on page 60*)

[3] J. D. Colvin, "Audio systems for FM broadcasting." AUDIO ENGINEERING, May, 1947.

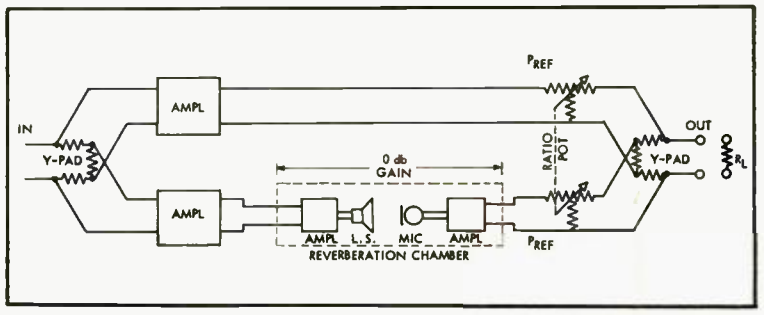


Fig. 3. Block diagram of the reverberation circuits.

The Conn Electronic Organ

The "Artist" model described was heard on radio and TV from the Convention in Chicago, played through an elaborate Jensen speaker system

IN TWO PARTS—PART 1

RICHARD H. DORF*

New instruments cover a complete line from concert to spinet models and are prime examples of the separate-oscillator school of design.

C. G. Conn Ltd. of Elkhart, Ind., perhaps justifies the slight aura of pretentiousness the "Ltd." gives its name by its many decades of outstanding work in the production of band instruments. For a fewer number of years it has also been in the electronic organ business producing a line of instruments called Connsonatas. For a reason which escapes this writer, it has recently abandoned the pleasant and rather clever elision of "Conn," "consonant," and "sonata" which resulted in the name of the Connsonata, and the new line of instruments comprises three principal models of what is known simply as the Conn Organ. The loss of euphony on the nameplate, however, is more than made up by the gain in nearly every musical and electronic element consonant with organ design; the new models make beautiful music and may be had at prices well in line with industry norms despite the inherently greater expense of the design approach.

The most elaborate of the new models is the Classic or 800 Series pictured in *Fig.* 1. This one has three complete sets of generators for Great, Swell, and Pedal, 19 stops, 14 couplers, and a 32-note pedal clavier. The Minuet or Series 500 model is shown in *Fig.* 3. It is a spinet along the lines of the current trend, with two 44-note offset manuals, 13 stops, 7 couplers, and a 13-note pedal clavier. Even this small model has independent generators for the two manuals and a monophonic generator for the pedals, a welcome relief from the discontinued models of not very long ago which used a single generator set for everything.

The middle unit, which is described in detail herewith, is the Artist or 700 Series organ which appears in *Fig.* 2. The Artist model, which has two full manuals, 25 pedal notes, 16 voices, and 9 couplers, is very similar in function to the others. It has two complete sets of tone generators for the manuals and a monophonic generator for the pedals.

Design Principles

There are two principal schools of thought concerning organ design. One, typified by Hammond, says that there should be separate generators for the notes and that tone colors should be obtained by harmonic synthesis—using the generated tones above the fundamental in use at the moment as harmonics of the fundamental to build up harmonic structures as desired. The other, of which Baldwin is presently the major exponent, employs locked frequency dividers to produce tones rich in harmonics, then passes them through filters which remove the harmonics not wanted to achieve a particular tone color. Both have certain advantages, although there is no doubt that the latter system, known as the formant principle, yields tone colors which are much more closely imitative of acoustical instruments like the pipe organ and others.

The Conn Organ, like the Allen, employs a combination of the two principles (with emphasis on formants), but is much simpler schematically and physically than the Allen while achieving about the same results. It contains a separate oscillator for every note (and for each manual); every oscillator yields not only a sine wave but also a sharply pulsed wave which is passed through formant circuits. In addition, the inter- and intra-manual couplers operate like those on a unified pipe organ to give octaves and mutations which may to a certain extent be used like the harmonics obtained with Hammond's drawbars. The actual number of formant voices and couplers on the Conn does not represent the maximum available with this company's design

Fig. 1. The Conn "Classic" model, Series 800.

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

approach any more than the actual specification of any of the major organs represents the maximums available with their own peculiar approaches. Specifications are the result of educated guesses which attempt to balance musical versatility with cost in an effort to purvey the largest possible number of organs to the largest possible number of as satisfied as possible customers.

Figure 4 is a block diagram showing the principal functional components of the Conn Artist model. Seventy-three oscillators are available for the swell manual, comprising notes 13 through 85. The note numbering system is based on the unison pitches for a 5-octave manual, with a 16-foot octave below and an 8-foot octave above. Thus the unison manual notes are 13 through 73 (remembering that there is an extra top C on the manual), with the 4-foot octave 73 through 85. There is no 16-foot octave 1 through 12. This becomes clearer if the reader is looking at an organ manual or has a copy of the writer's book, "Electronic Musical Instruments."[1]

The swell oscillators are keyed by special under-key switches, of which more later, which control plate voltage, and also by couplers, which control sounding of the note at unison pitch and/or in other registers or with mutations. Oscillator outputs are sent to

[1] *Radio Magazines, Inc., P.O. Box 629, Mineola, N. Y., $7.50.*

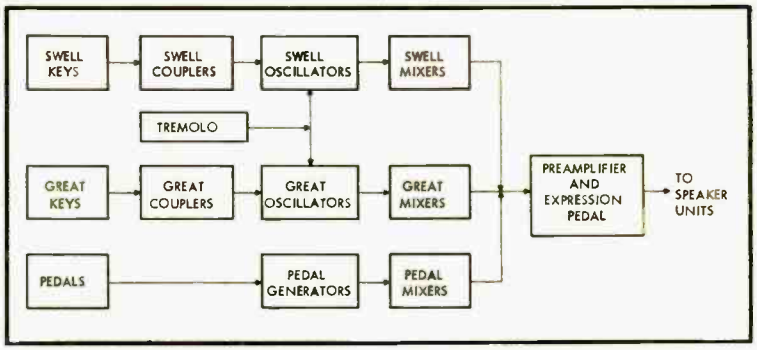


Fig. 4. Simplified block diagram of the Series 700 organ.

an output bus which passes the tones to so-called mixer circuits. These are actually triode amplifiers equipped with filters for the formant circuits and attenuators for the flute tones, with the filters and attenuators controlled by stop-tab switches. Outputs of the mixers are summed and led to a preamplifier containing a swell-shoe circuit, thence to an output connector from which a cable leads tone to the amplifiers mounted in the speaker units (or tone cabinets, as most makers call them).

The setup is the same for the Great except that the notes generated are 13 through 73. The pedal circuitry employs a solo-type generator consisting of only two actual oscillators. Each is used for one of the two octaves covered in the pedals and has variable frequency so that only one note can be played at a time in each octave.

Tone Generators

The tone generators are individual oscillators of the grounded-plate Hartley type, as diagrammed in *Fig.* 5, each using half of a 12AU7. The cathode is grounded through low-value summing resistors in the string-bus circuit; R_3 and R_4 are merely scaling resistors whose values vary—R_3 from note to note and R_4 from octave to octave. The tone appearing at the cathode tap of the coil is nearly sine in shape and it is used for flute-type stops; that appearing between the lower terminal of the tuning coil and ground (across the terminating resistor shown in a later circuit) is sharply pulsed and is called

Fig. 2 (left). The Conn "Artist" model, Series 700, is the subject of the technical description. Fig. 3 (right). The "Minuet" model, Series 500 is designed for the smaller home.

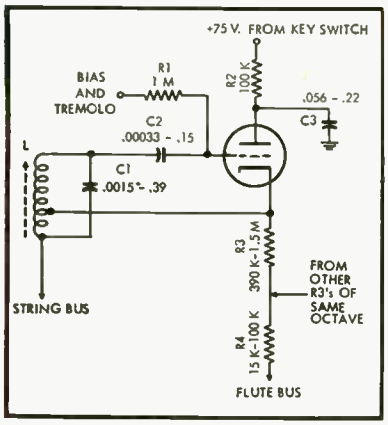


Fig. 5. Schematic of one tone generator; a separate generator is used for each note of each manual in the organ.

string tone. Each oscillator is keyed by applying 75 volts positive to the plate through a 100,000-ohm time-constant resistor R_z which operates in conjunction with time-constant and bypass capacitor C_z. Limit values are shown in *Fig.* 5 for those which vary. The note is tuned by varying the position of the iron core in L with a screw and spring arrangement.

Twelve notes — one octave — are mounted on each chassis. *Figure* 6 shows the rear of the organ with all the electrical components except the key switches in view. At the lower right are the first four Great generator chassis, with the fifth left of the swell shoe. Above are the six Swell chassis.

Preamplifiers And Tremolo

The chassis to the left of the great generators in *Fig.* 6 holds the pedal generators, flute and string preamplifiers for the great division, and the great tremolo generator.

Figure 7 shows the division preamplifiers. String tone from the string bus shown in *Fig.* 5 is fed to a 27-ohm resistor and a 100-ohm potentiometer in parallel. The potentiometer adjusts the over-all string level by shunting the resistor. This resistance is what completes the cathode-ground circuit for d.c. in *Fig.* 5. The string tone is low in level and is fed through two cascade amplifier stages, thence through a shielded line to the voicing or mixer circuits. Flute tone is fed directly to the grid of a single amplifier stage, thence from the plate to the mixers. No blocking capacitor is necessary between oscillator cathode resistors and preamplifier grid since the cathode d.c. voltage is very low due to the shunt of less than 27 ohms to ground afforded by the string-bus circuit. A similar set of preamplifiers appears on the chassis to the left of the swell generators in *Fig.* 6 and is used for the swell flute and string buses.

The great vibrato generator, shown in *Fig.* 8, employs a 12AU7. The two triodes are cross-coupled by the 1-megohm resistors and 0.1-μf capacitors between the plate of each and the grid of the other, so that positive feedback is produced around a loop composed of the two triodes. A tuned transformer is connected between the plates, and this smoothes out the waveform. The secondary feeds vibrato signal to a series resistor network to which the bias-input R_1 of each tone oscillator of *Fig.* 5 is connected. This apportions the vibrato signal so that each oscillator "vibrates" the optimum amount for best musical results despite differences in tuned-circuit Q's due to differences in component values and operating frequencies. Since neither end of the transformer secondary is grounded, the tone oscillator grid-ground circuit for vibrato is completed by the string-bus connection shown. The network resistors, in conjunction with the 56,000- and 2700-ohm resistors coming from the 75-volt line, divide the B-voltage properly to afford some positive bias for the generator tubes.

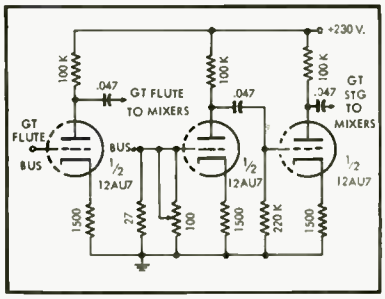


Fig. 7. Schematic of the Great bus preamplifiers.

Both speed and amplitude of tremolo (actually it is vibrato or frequency swing) are controlled by the three tab switches shown in the cathode circuit. Tremolo generators for Great and Swell are identical (there is none for the pedal as pedal vibrato is undesirable) though the tone-generator resistor networks are somewhat different in detail. Lines from the paired cathodes of each generator go to the tab switches as shown in *Fig.* 8. When the TREMOLO F (meaning full) switch is closed both sets of cathodes are grounded through 2200-ohm resistors. With the TREMOLO M (medium) switch closed, another 10,000 ohms of resistance is placed between cathodes and ground, lowering the plate current and reducing the tremolo-voltage output of the transformer secondary. When TREMOLO L (low) is closed another 4700 ohms in the cathode circuits reduces tremolo still further. With all switches open over 1 megohm is in the circuit, effectively causing oscillation to stop. With more than one switch closed, the tremolo will be that given by the more potent switch.

This tremolo or vibrato system obviously lends itself well to separate use of tremolo on the two manuals, and indeed the larger Classic model has GREAT TREMOLO OFF and SWELL TREMOLO OFF switches. While a single tremolo generator could have been used for both manuals, the designers wished to carry through the advantages of separate

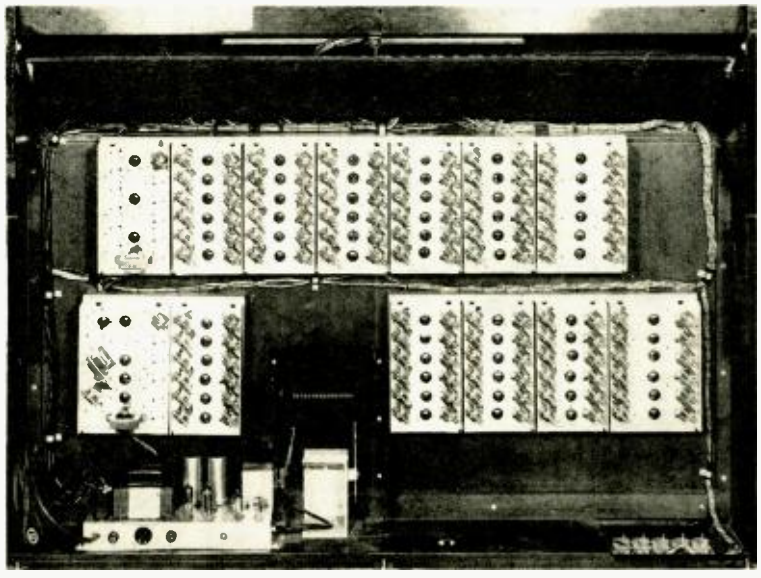


Fig. 6. Rear view of the organ to show the placement of the tone generator chassis —twelve notes being accommodated on each.

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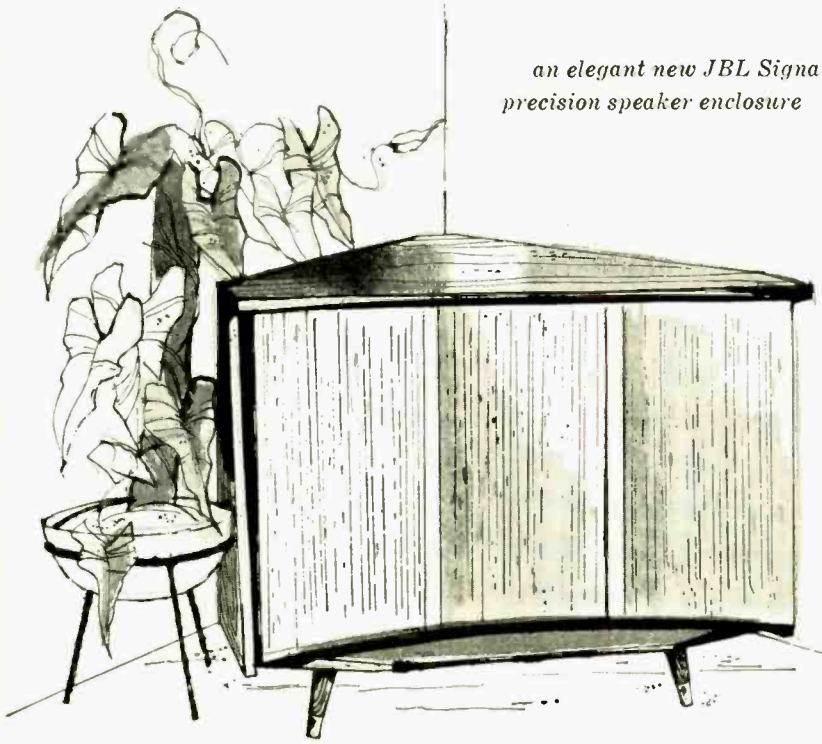

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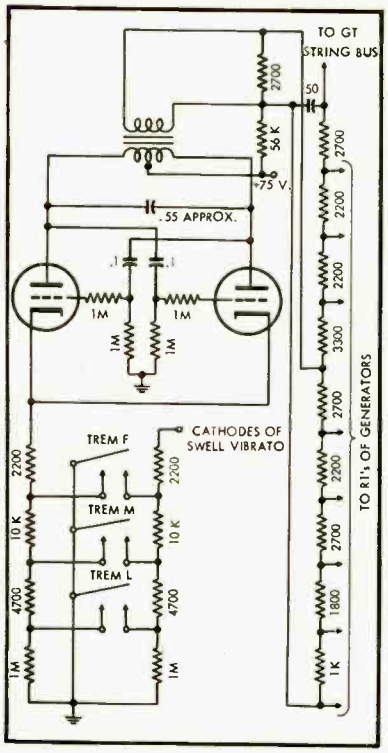

Fig. 8. Schematic of the Great tremolo circuit. A similar unit is required for the Swell manual.

oscillator ranks as far as independence and resulting "chorus" or "ensemble" effects are concerned by keeping the tremolos of the two manuals independent and random as well.

Pedal Generators

The complete pedal generator circuit appears in *Fig.* 10 but *Fig.* 9, which should be examined first, is a simplification showing the oscillator itself. It is a grounded-plate Hartley, and like the manual generators, a string tone is taken from across a resistor in series with the tank circuit. No flute tone is taken from the pedal division. A positive bias is placed on the grid with the aid of a voltage divider and isolating resistor. The oscillator is tuned over the 12 or 13-note range required by using an inductor with taps. In parallel with the tapped inductor is a trimming inductor which has variable inductance. In effect, using the pedals causes the appropriate tap to be used for each note so that the remaining inductance tunes the oscillator correctly.

Figure 10 is a schematic of the complete pedal division. Each pedal operates a switch like those shown in such a manner that the plunger is pushed in and the contactor connects the center contact with that shown as the upper one in the drawing. Tracing the circuit from the grid of the left triode, there is first C_2, the grid-leak capacitor shown in *Fig.* 9, then the tuning capacitor C_1, which goes to the bottom of the coil. The junction of these two is switched, as can be seen from *Fig.* 9. Following the lead from this junction, it goes to the center contact of the B_1 switch. If this pedal is not pressed, the connection continues through the bottom B_1 contact to the center $C\#_1$ contact. If the $C\#_1$ pedal is not pushed, connection continues through its bottom contact to the center contact of C_1. If we assume that pedal C_1 is pushed, the connection is made to the top contact of the C_1 switch, thence to the top of the coil. This places the entire coil in the circuit and causes the lowest note—C_1—to sound. If no pedal is pushed, connection is made through the bottom contact of the C_1 switch to the top of the coil through a 27,000-ohm resistor which destroys the Q of the tuned circuit and prevents any oscillation.

Only three pedal key switches of octave 1 are shown, but there are, of course, twelve, all connected in the same way, with the top contact of each going to a tap on the coil. Therefore, when any pedal is pushed, the connection from the junction of C_1 and C_2 is made to the appropriate coil tap and the right note is heard. If two pedals are pushed simultaneously, only the higher note will be heard since the line from switch to switch is broken at the higher-note point.

Exactly the same arrangement is used for the second pedal octave with separate coil L_2 and triode, etc., except that since the pedal clavier has 25 notes, the L_2 coil has provision for 13 notes rather than 12. The pulsed pedal output goes through a triode preamplifier like the manual output buses and thence to the mixers.

(To be continued)

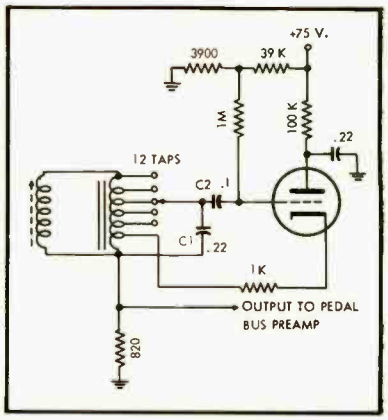

Fig. 9. The pedal generator is monophonic and requires only two triode sections for 25 notes.

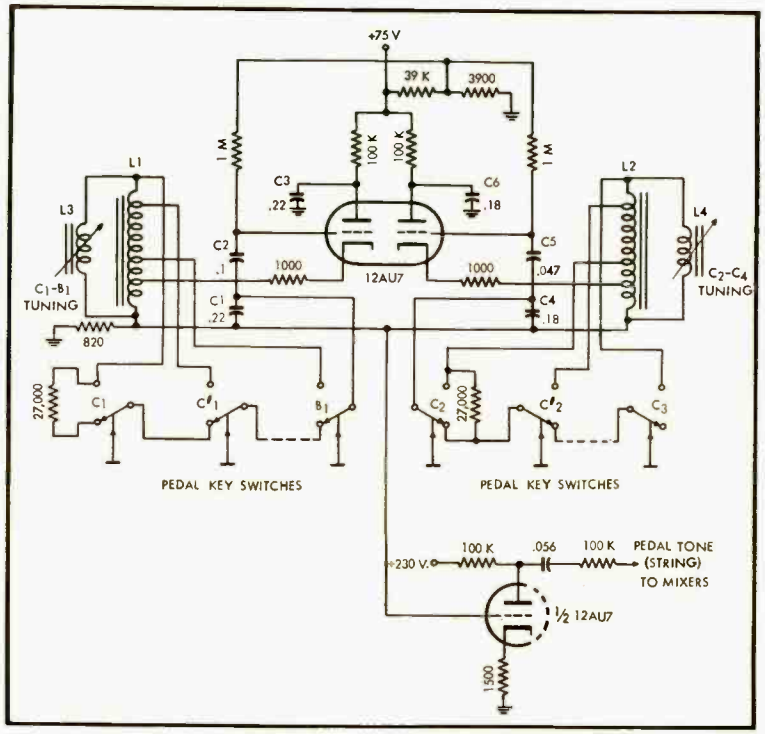

Fig. 10. Simplified schematic of the keying and the connections of the pedal generator.

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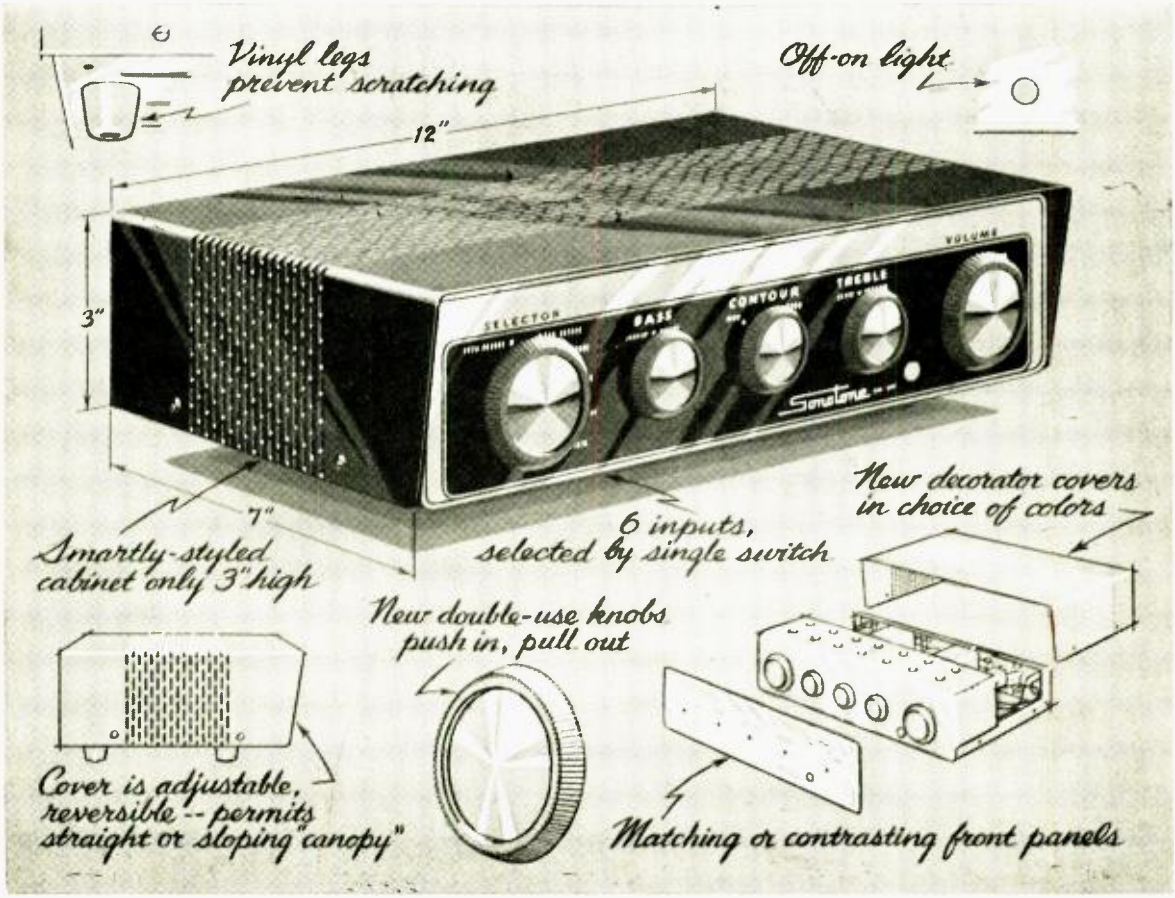

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Part 2. Concluding the presentation of a thorough treatise on the performance of loudspeakers in different types of mountings, from the flat baffle to the most elaborate enclosures. This installment commences with a discussion of the reflex cabinet.

THE REFLEX CABINET is a special case of the vented box where the area of the vent is fixed and normally equals the piston area of the cone, and the resonant frequency of the enclosure is made to coincide with that of the cone. The term "reflex" is based on the fact that at its resonant frequency the radiation from the back of the cone appears at the vent inverted due to the resonator action described previously. The design of the reflex cabinet is greatly simplified since now we know the frequency to which we are going to tune the enclosure and we can use previous formulas for its dimensions.

In order to keep the dimensions as economic as possible a duct is often employed so that a smaller cabinet can be used for a given resonant frequency. The duct length is limited by two factors:

(1) It is convenient to have the duct extending into the enclosure (*Fig.* 13), so the volume of the duct must be added to the volume of the enclosure; consequently if the duct length is increased a point will be reached when the decrease in the required cavity volume is being equalled or even exceeded by the increase in the volume of the duct. The optimum duct length for a minimum volume occurs when the length of the duct $l = \frac{2160}{f} - 1.7R$ where both dimensions are in inches.

(2) It is necessary for the duct to be short compared with a wavelength at frequencies around resonance, and should not exceed $\frac{1130}{f_s}$ inches.

The total volume with the duct is given by:

$$v = \pi R^2 \left[\frac{4.66 \times 10^6}{f^2 (1 + 1.7R)} + 1 \right]$$

where all dimensions are expressed in inches.

The advantage of the coincident resonances in a reflex cabinet is that the loudspeaker cone receives maximum damping at its resonance which results in

(1) Reduction of cone velocity at resonance but an increased radiation efficiency around the frequency due to vent radiation.
(2) Increased power handling capacity.
(3) Improved transient response due to increased damping at resonance.
(4) Reduced distortion due to reduced cone amplitude.

The resonances f_1 and f_2 are spaced either side of the cone resonance and are equal in amplitude. Impedance curves comparing similar speakers (*A*) on an infinite baffle and (*B*) in a reflex cabinet are shown in *Fig.* 14.

* *Goodmans Industries, Ltd., Axiom Works, Wembley, Middlesex, England.*

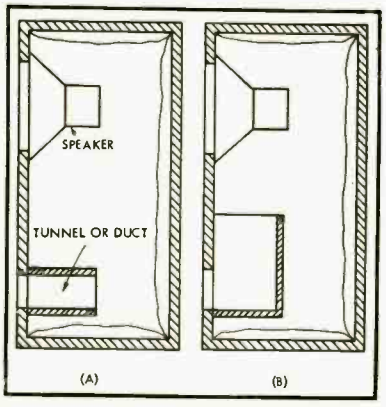

Fig. 13. Cross section of reflex cabinets. (B) shows how the tunnel may be folded.

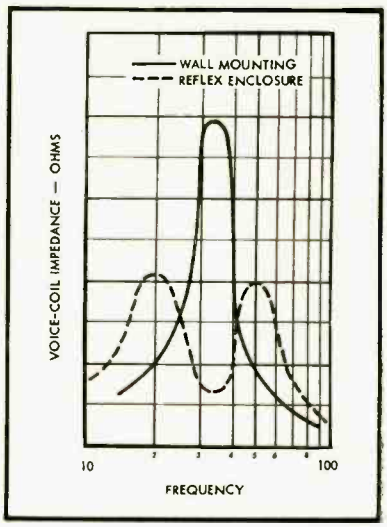

Fig. 14. Impedance curves of reflex enclosure vs. infinite baffle.

Further Types of Vented Enclosures

The Acoustical Corner Ribbon Enclosure. This is an enclosure of the double reflex type as shown in *Fig.* 15. The analogous circuit is also shown. A system of this nature will exhibit three impedance resonances alternating with two anti-resonances. A sketch showing comparison as stated is shown in *Fig.* 16. The progressive increase towards a flatter and more extended bass is noticed.

The BBC Enclosure. An enclosure based on a similar principle was introduced by the BBC in 1935 except that the mass M_1 was formed by a blanket of felt as shown in *Fig.* 17.

The RJ Enclosure. Recently introduced in the U.S.A. was an enclosure known as the RJ. This was another form of vented enclosure of very small dimensions in which a low resonant frequency was achieved by using a long duct of very small cross-section. Due to the very resistive nature of such a duct, the lower-frequency resonance normal with this type of enclosure had a greatly reduced amplitude. Normally, as we have seen, this would result in the higher-frequency resonance having prominence approaching closed box conditions. This, however, was overcome by reducing the loudspeaker aperture take the form of a narrow slot. A number of designers have used a slot in this manner so we will consider it a little more closely.

Slot Diffusion. This involves mounting the loudspeaker not facing into a circular hole as is normally done, but into a narrow vertical slot. The initial advantage claimed for this was an improved treble distribution. A second advantage of using a slot is that the reduced area in which the cone is radiating increases the mass and friction loading on the cone and thereby lowers the resonance both in frequency and amplitude. The analogous circuit of the RJ enclosure circuit is shown in *Fig.* 18

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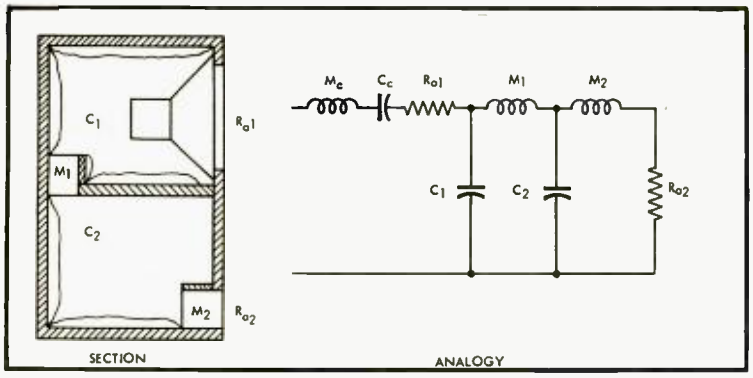

Fig. 15. Cross section ond onology of Acousticol Monufocturing Co's. corner ribbon enclosure.

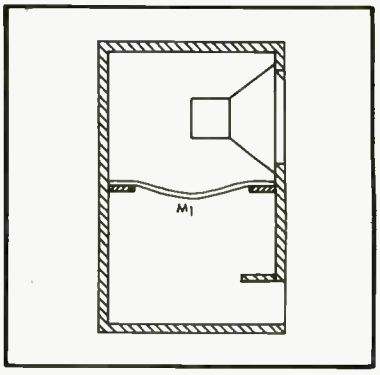

Fig. 17. Cross section of British Broodcosting Corporotion enclosure.

where R_s and M_s are the slot components.

Arguing as before, the lower resonant frequency f_1 will be substantially that of R_c, M_c, C_c, R_a, R_s, M_s, M_c, R_{a_2} in series. The upper resonant frequency f_2 will be R_c, M_c, C_c, R_a, R_s, M_s, C_e in series.

Since the combined impedance of M_e and R_{a_2} is much higher than that of M_s and R_s, the latter will have a greater effect on f_2 than f_1. Thus the use of slot loading tends to overcome the excessive prominence of f_2 when f_1 is heavily damped by using small resistive ducts.

The great disadvantage of slot loading is in the fact that the cavity formed between the cone and the faces of the slot together with the slot itself, form a Helmholtz resonator which, depending upon dimensions, will be highly active in the middle registers. In addition, serious irregularities in this range will occur due to standing waves existing between the surface of the cone and the inside surface of the slot face. Consequently the use of a slot at frequencies above 200 to 300 cps is rather unsatisfactory.

Various alternative methods of applying the series mass and friction components have been used in this country. A simple yet very effective system patented by Murphy Radio Ltd. was to apply the loading to the rear of the loudspeaker, in the form of a corrugated cardboard drum (*Fig.* 19) where the "tubes" formed by the corrugations provided the required loading. The disadvantage of this arrangement was that the drum tended to exhibit resonances normally encountered in a tube whose dimensions equalled those of the drum.

Mass Resistive Enclosure. This enclosure, developed more recently by Goodmans Industries Ltd., whilst following in the broad principle the above systems, had, however, several refinements. Consisting basically of an enclosure with a small vent, the dimensions of these were so chosen in conjunction with the constants of the cone to be used therein that the lower resonance f_1 was made to occur at 20 cps, this being considered the lowest frequency that would be required. This meant that the resonance of the enclosure occurred at some higher frequency, the value of which was of no consequence, and so for the upper resonance f_2 where the only concern was its amplitude.

The dynamic impedance of the enclosure was also considered with its relationship to that of the loudspeaker. This is necessary since if this impedance is too high attenuation will occur at some bass frequencies, and if too low the cone velocity may become excessive and introduce distortion.

A rigid cowl of certain dimensions was introduced to the rear of the loudspeaker as shown in *Fig.* 20. Since the sides of the cowl were not parallel with the sides of the cone standing waves were avoided, and by making the area of the outlet (formed by the annulus between the magnet and the cowl) large

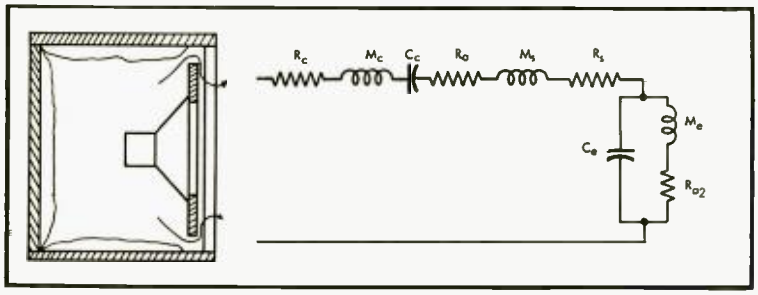

Fig. 18. Cross section and onology of RJ enclosure.

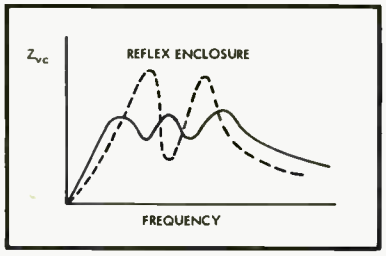

Fig. 16. Response curve (solid line) of enclosure of Fig. 15 compared with reflex cabinet.

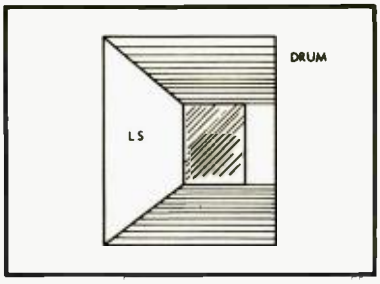

Fig. 19. Arrangement of corrugated cardboard drum surrounding loudspeaker to increase resistive loading.

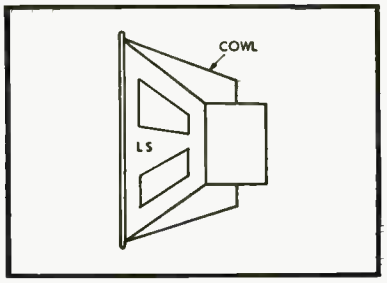

Fig. 20. Another loading device involves the use of a cowl around the loudspeaker mechanism.

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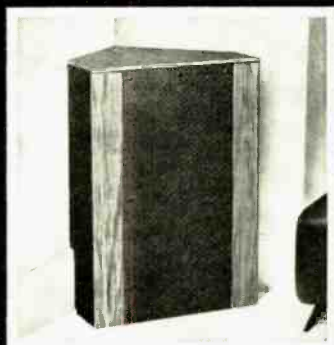

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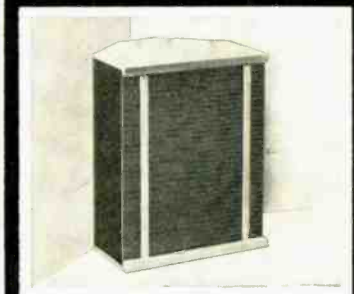

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compared to the volume existing between the cowl and the cone, its efficiency as a Helmholtz resonator was low. Also since almost the entire length of the cowl was filled by the cone and chassis assembly there was insufficient uninterrupted length to maintain pronounced tube resonance. The additional cone loading was determined by the area of the annulus.

The principal advantage of these types of enclosure over the reflex cabinet are

1. Great reduction in size
2. Better loading down to lower frequencies, although this type of enclosure is not tuned to the cone resonance of the loudspeaker, better damping is obtained by the highly frictional nature of the small vents used.
3. Upper resonance f_2 is not so prominent.

The disadvantage was that although middle- and upper-frequency coloration could be greatly reduced, it could not be entirely removed, and when such an enclosure was used with a really high-quality loudspeaker having a very smooth frequency characteristic, the coloration due to the cowling could be detected. In addition to this, at frequencies immediately above the lower resonance f_1 the output falls due to the restraint imposed on the cone by the cowling.

We have now discussed a few of the types of enclosure used for mounting loudspeakers, and at this stage a brief summary of our findings so far might be considered.

1. *The True Infinite Baffle* consisting of a loudspeaker mounted in a wall is capable of providing excellent reproduction down to the bass resonant frequency of the cone. There are no additional resonances or coloration above this frequency; there is no appreciable radiation below this frequency due to the mechanical reactance of the cone changing from mass to stiffness. There is no additional air loading at the cone resonance, and excessive cone velocity at this frequency may cause distortion.

2. *The Finite Flat Baffle* possesses the same characteristics as the wall mounting when the dimensions are sufficiently large. Otherwise a loss in bass radiation occurs below a frequency determined by the dimensions.

3. *The Open-Backed Cabinet,* although the most convenient form of enclosure, is acoustically unsound due to inherent resonances, although these may be used to augment a falling bass characteristic due to insufficient baffle area.

4. *The Enclosed Box* is very good provided the loudspeaker cone has a sufficiently low resonance; otherwise, added stiffness due to the enclosed air causes excessive rise in this resonance.

5. *The Vented Box* overcomes the inherent disadvantage of the closed box and will extend the bass response of almost any loudspeaker quite appreciably. In the case of loudspeakers having very low cone resonances, i.e. between 20–25 cps, this extension is rather pointless. The upper resonance f_2 is present in this type of enclosure and is usually pronounced when using normal loudspeakers.

6. *The Reflex Enclosure* has the very great advantage over all previous types by providing the loudspeaker cone with maximum air damping at resonance. The concomitant advantages are outlined in the description. It loses some of this advantage when compared with wall mounting at frequencies above the cone resonance due to the upper resonance f_2, although this may not be sufficiently serious to turn the scale. The reflex enclosure is usually more practical to construct.

7. *The systems* involving additional mass loading on the cone, when carefully designed, hold all the advantages over the previous systems, but fall down by having irregular middle and upper frequency characteristics, and it is very doubtful whether it is better to have very smooth bass response if reproduction above 200 cps is colored.

PIPES—FOLDED AND TAPERED; LABYRINTHS AND HORNS

As before, we are concerned with what happens to the back radiation of a cone. So far we have pushed it into the next room, shut it up in boxes and squeezed it out through vents. We shall now consider a few further modes of attack.

The Infinite Pipe

If the rear of a loudspeaker were connected to an infinitely long pipe all the back radiation would disappear to infinity or be absorbed on the way, as was the case for the true infinite flat baffle. The pipe, however, would provide a much greater air loading on the loudspeaker cone. The infinite baffle could very approximately be replaced by a pipe whose length was very much greater than a wavelength of the frequency being considered.

An example of such a pipe has been met where the loudspeaker was mounted on a baffle fitting flush with the fire grate, so that the back radiation went up the chimney. (The extension of this story which says that a bird's nest in the chimney provided the correct resistance termination is discounted.) Pipes of this nature may be regarded as alternate air masses and air compliances and if the pipe were of constant cross section, these would be distributed evenly along its length. The analogous circuit for this is given in *Fig.* 21.

The Absorbing Pipe or Labyrinth

Usually it is impracticable to make the pipe long compared to the wavelengths of the lowest frequencies involved, and problems of pipe resonance are encountered. As will be seen later, an open pipe will exhibit resonances, due to reflections from the open end, at all frequencies where the length of the pipe approximates to any whole number of half wavelengths, i.e., if the length of the pipe is equal to half the wavelength of frequency f_o then the pipe will resonate at f_o, $2f_o$, $3f_o$—nf_o where n is any whole number. In order to reduce these resonances, the walls of the pipe are arranged to have a high coefficient of absorption and to present as much friction to the air movement as possible.

Again considering the analogous circuit, at frequencies where the pipe is short compared to a wave length, C_p vanishes and the circuit may be redrawn as at (A) in *Fig.* 22. The total impedance, Z_p, of the pipe components is almost entirely resistive. This is demonstrated by the impedance curves where the loading due to the pipe has reduced the amplitude of the cone resonance, but its frequency is unchanged, as shown at (B) of *Fig.* 22. Once again there is little to be gained from evaluation of component values since there are too many factors normally unknown to the constructor. We will say, however, that a folded labyrinth will be effective down to that frequency where

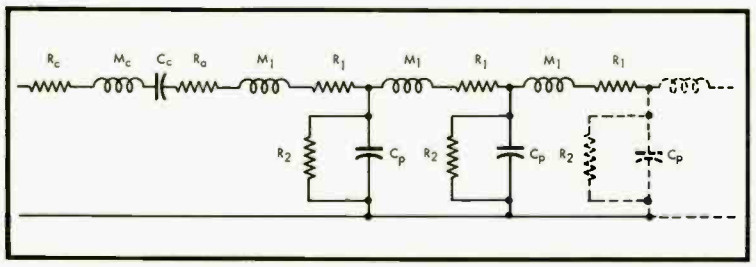

Fig. 21. Analogy of infinite pipe loading on loudspeaker. R_c, M_c, C_c, and R_a are loudspeaker components; M_1 is distributed mass, C_1 is distributed compliance, R_1 is friction at walls of pipe, and R_2 is absorption at walls of pipe.

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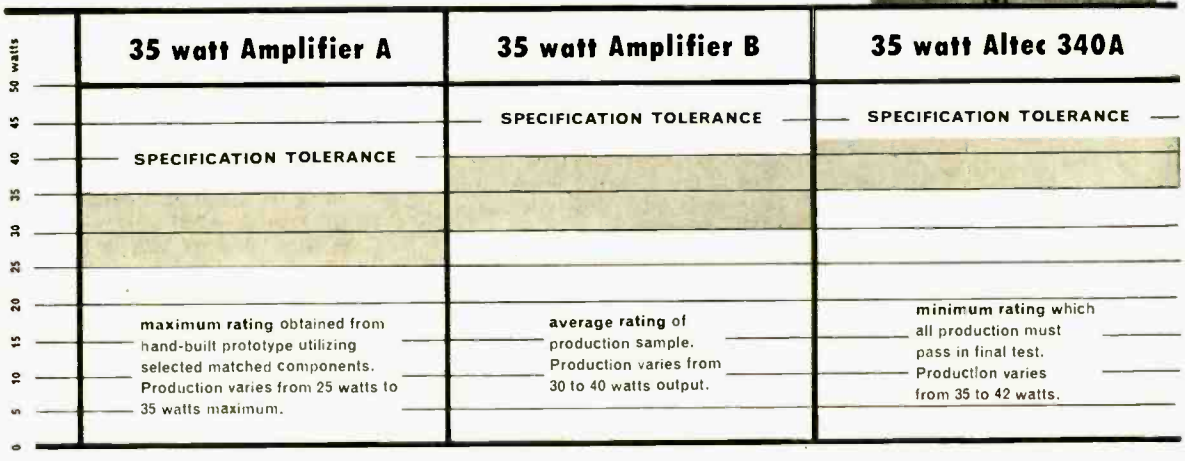

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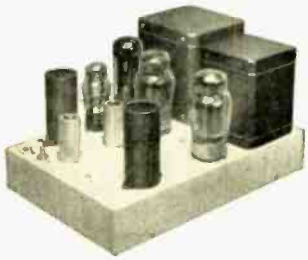

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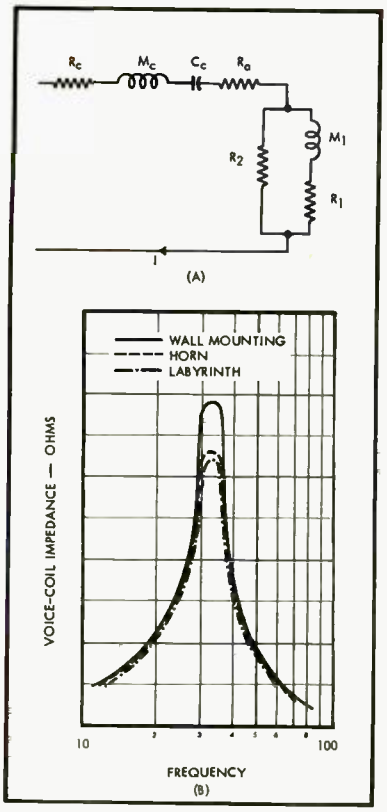

Fig. 22. Analogy and response curve for absorbing pipe.

the length of the pipe is one quarter of the wavelength. The cross-sectional area of the pipe should be equal to the piston area of the cone.

The advantage of the labyrinth, over the infinite baffle, provided it is sufficiently long, is that it provides an increased air load on the cone. In addition, it provides complete absorption of the back radiation without the introduction of any resonances of its own and without modification of the speaker resonance. This resistive loading is also responsible for the principal disadvantage of the labyrinth, i.e. its low efficiency. From the analogy it will be seen that the cone velocity (I) is limited to a large extent by the friction component (R_l). The absorption factor is too low (R_g is too high) to have very much effect at very low frequencies. However, the excellent air loading at very low frequencies makes possible the use of sufficient bass boost in the amplifier to compensate for the fall in efficiency without the danger of undue distortion.

As was indicated previously, this is only true if the length of the labyrinth is not less than one-quarter wave length of the lowest frequency that will be fed into the speaker. The cone resonant frequency should not be considered as the limiting frequency, since by use of the above methods and with suitable bass lift good reproduction may be had from the speaker at frequencies well below its resonance.

The Tuned Pipe

We have mentioned on several occasions that a pipe will exhibit resonances when its length approaches a quarter wave length. We will now examine this more closely. Consider *Fig.* 23.

Assume that one end of each pipe is connected to a piston vibrating at frequency f. Assume further that the piston has just moved forward to produce a pressure corresponding to point A on the curve. The distribution of pressure in pipes of various lengths is indicated by the curve.

Pipe P_1 is short compared to the wave length at frequency f and therefore the pressure difference along its length is small. If the far end of P_1 is open, the contained air will behave as a mass at this frequency, and if P_1 is closed at the far end the enclosed air will behave as a stiffness, either case providing an impedance to the motion of the piston.

Pipe P_2 is a quarter wave length of the frequency f, and at the instant shown the pressure varies from maximum to zero along its length; a quarter of a cycle later than this instant the point of maximum pressure would have

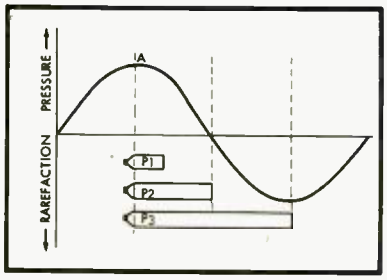

Fig. 23. Distribution of pressure in pipes of various lengths.

reached the far end of the pipe. If this end were open the pressure would be expelled and a rarefaction would be reflected back to arrive at the piston just as this had moved outwards, thus adding to the partial vacuum against which the piston was already working. Thus at this frequency the load on the piston would be increased, in other words an anti-resonance occurs.

If, however, the far end of the pipe were closed, the pressure wave arriving there could not be expelled and, therefore, would be reflected back to arrive at the piston as the latter moved outwards. This would tend to cancel the partial vacuum against which the piston was working, and the load on the piston would be decreased, i.e. a resonance occurs.

In the case of the open pipe, resonances will occur at all even numbers of quarter wave lengths, and anti-resonances will occur at all odd numbers of quarter wave lengths. For the closed pipe the reverse is true.

We shall now see how these actions are applied to loudspeaker enclosures. One system is to use an open pipe whose anti-resonance is made to coincide with the cone resonance. If this frequency is f, then the length of the pipe is:

$$l = \frac{1130}{4f} - 1.7\ R \text{ ft.}$$

With l expressed in inches,

$$l = \frac{3390}{f} - 1.7\ R$$

Where R = the radius of the pipe or $\sqrt{A/\pi}$ when A is the cross sectional area.

This enclosure then exhibits a very similar impedance characteristic to the reflex cabinet described earlier. It has the advantage of being rather more simple to construct. The disadvantage of tuned open enclosures is that, as we have seen, they exhibit resonances at all the harmonic frequencies. These may be reduced by the use of an absorbent lining as we have described previously.

An alternative to this is to use a closed pipe tuned to a frequency a little lower than the cone resonance and thus use the resonance of the pipe to overcome the stiffness reactance of the cone at this frequency, thereby extending the bass response. The formula is that given previously. A satisfactory value for f in this case would be about 20 per cent lower than the cone resonant frequency. An enclosure of this type exhibits resonances at all the odd harmonics of its resonant frequency.

The analogous electrical circuit for this type of enclosure is the same as that for the infinite pipe shown earlier in *Fig.* 21 except in the case of the tuned pipe the value of R_l is much lower and R_g is very high.

Many attempts have been made to prevent the troublesome reflection oc-

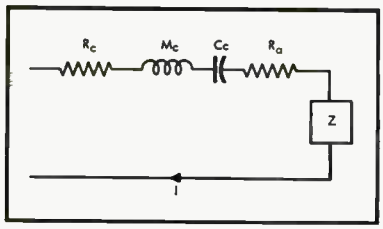

Fig. 24. Equivalent circuit for horn loading on a loudspeaker. Z is the impedance of the enclosure.

* accurate speeds

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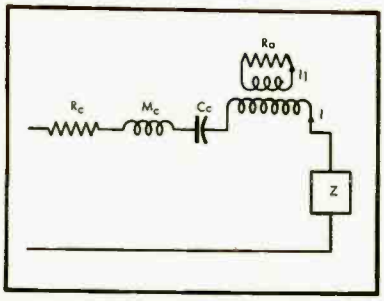


Fig. 25. Analogy of horn loading to show matching of generator to load by means of a transformer.

curring in a short open pipe by the addition of some friction materials to the open end. It is well known in electrical terminology that a circuit of the form shown in *Fig.* 21 is a transmission line which will present a certain characteristic impedance to the input circuit. If, however, the line is very short but its far end is terminated in an impedance equal to the characteristic impedance, the line will possess identical characteristics to a transmission line that is infinitely long. The line is then said to be correctly terminated.

This being so, it was not unnatural to imagine that the open end of the tube could be correctly terminated. The difficulty here, however, was that unless the tube was either completely open or completely closed, it would tend to resonate on the Helmholtz principle making its performance as a tube difficult to determine.

The various systems described in the section on vented enclosures for reducing the upper resonance may be applied to the tuned pipe. Any system increasing the mass loading on the one will decrease the harmonic resonances with respect to the fundamental. Once again, of course, the problem of middle and upper frequency coloration is introduced.

One further system that has found favour is the reduction of one of the harmonic resonances by virtue of the speaker position; for example the third harmonic resonance which is the most prominent in a closed quarter wave tube may be removed by positioning the speaker one-third of the length from the closed end. The speaker is then at a node of the third harmonic resonance and this is then not excited. This principle is used by the Decca Record Company in their corner enclosure and gives excellent results. A further feature of this enclosure is that the pipe is tapered. This serves to lower the efficiency of the resonance and extend it over a wider band of frequencies and is a principle incorporated in the Voigt corner horn.

Incidentally, it is interesting to note that since the speaker is nearer the closed end of this enclosure the motion of the air in the pipe will, at resonance, be in anti-phase with that of the cone. The formula given will not apply in this case since the speaker opening in this position will modify the characteristics of the tube.

Horn Loading

At frequencies where the dimensions of the loudspeaker cone become very small compared with a wave length, the radiation resistance falls. Above the cone resonance, however, the laws governing the velocity of the cone are such as to compensate for this to some extent, but nevertheless the efficiency of the speaker is considerably reduced at these frequencies. All this may be seen by considering the equivalent circuit (*Fig.* 24).

At very low frequencies R_a becomes small compared with the impedance of the remaining components and consequently V and the power in R_a is decreased although above resonance the increase in I due to the falling impedance of the inductive elements partially compensates for this. It is well known that the maximum power delivered from a generator to a load occurs when that load equals the impedance of the generator. If necessary, the load can be matched to the generator by a transformer. Applying this to the analogy we have *Fig.* 25.

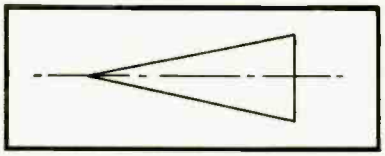


Fig. 26. Cross section of conical horn from throat to mouth.

The higher impedance of the transformer primary matches more accurately that of the remaining components so V is increased. In the secondary, I_1 is much higher than I in the previous condition, so that the power in R_a is increased.

Acoustically, such a transformer is analogous to a horn (*Fig.* 26). The pressure build-up due to the limited radiating area at the throat of the horn will present a high impedance to the cone of the loudspeaker and reduce its velocity in exactly the same way as it does in a tube.

At the mouth of the horn due to its larger area, the impedance to the sound wave will be much lower; the pressure will therefore be lower and the velocity high. This ties up with our pressure-voltage, current velocity, analogy.

There are two factors which determine the lowest frequency at which a horn will maintain its efficiency. These are (1) the rate of flare; (2) the diameter of the mouth.

(1) There is no formula showing an optimum rate of flare for a conical horn for a given low-frequency extension. Since the efficiency falls steadily over a wide band of frequencies one can only state that the lower the rate of flare, the better.
Most horn designs are based, not on the conical, but on the exponential horn and here it is possible to arrive at an optimum value, as we shall see.

(2) The mouth diameter of any horn must be equal to at least one quarter of the wavelength of the lowest frequency it is required to radiate, otherwise standing waves will be set up due to reflections from the open end in the manner we have shown for tuned pipes.

The Exponential Horn

It has been found that for a given low-frequency extension, size for size, the exponential horn is very much more efficient than a conical horn. Its use, therefore, is almost universal.

An exponential horn is one whose cross-sectional area increases exponentially with the distance from the throat (*Fig.* 27), and the cross-sectional area A at any distance d from the throat is given by

$$A = a\varepsilon^{md}$$

where a = throat area

$\varepsilon = 2.713$

$$m = \frac{4\pi f}{c} = \frac{f}{927}$$

if all dimensions are in inches. The very great disadvantage of the horn is its size. In order to demonstrate this, let us design a horn suitable to load a 12 in. loudspeaker down to, say, 30 cps which is, after all, quite a modest figure.

Mouth Diameter $D = \frac{c}{4f} =$

$$\frac{13{,}560}{4 \times 30} = 113 \text{ in.}$$

$$= 9.5 \text{ ft.}$$

Area of Mouth $A = \frac{D^2}{4} =$

$$\frac{113^2}{4} = 10{,}020$$

Area of Throat $a =$

$$\text{piston area of 12-in. cone} = 78.5 \text{ sq. ins.}$$

$A = a\varepsilon^{md}$ (d is the unknown)

$$\frac{A}{a} = \varepsilon^{md} \quad m = \frac{f}{927} = \frac{30}{927}$$

$$\text{Log}_\varepsilon A - \text{Log}_\varepsilon a = md$$

$$d = \frac{\text{Log}_\varepsilon - \text{Log}_{\varepsilon a}}{m}$$

$$= (\text{Log}_\varepsilon 10{,}020 - \text{Log}_\varepsilon 78.5)\,927$$

$$= \frac{(9.2122 - 4.3631)\,927}{30}$$

$$= 150 \text{ in.}$$

$$= 12 \text{ ft.} 6 \text{ ins.}$$

Needless to say, these dimensions are

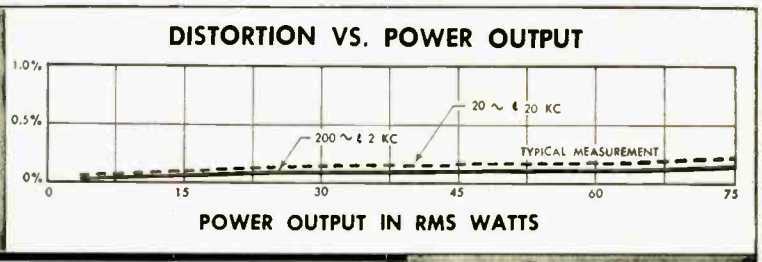
(*Continued on page 82*)

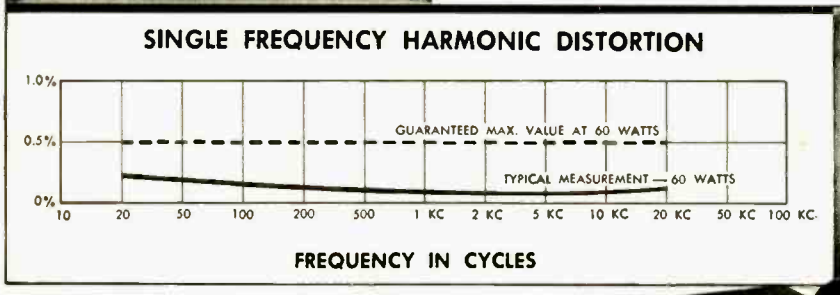
Here's Proof of McIntosh superior performance!

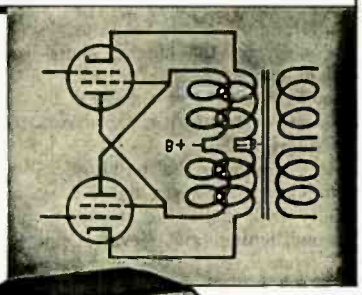
For *clean amplification, low distortion* and *abundant power* no other amplifier compares with the McIntosh—long the standard of high fidelity excellence. The fundamentally-different McIntosh circuit delivers amplification within 0.4% of theoretical perfection. Nothing is added to or taken from the input signal. The result: a realism, clarity and listening quality without "fatigue" caused when tones are lost, distorted or intermixed within an amplifier. There are more *plus* values with the McIntosh. Hear it at your dealer's.

Distortion: 1/3% Harmonic and 1/2% IM, even at full rated output, from 20 to 20,000 c.p.s. *Power:* 30 watts continuous, 60 watts peak (for Model MC-30); 60 watts continuous, 120 watts peak (for Model MC-60).
Frequency Response: 20 to 20,000 c.p.s. ±0.1 db at full rated output. 10 to 100,000 c.p.s. ±1.0 db at one-half rated output. High efficiency of the McIntosh circuit means longer life, less heat dissipation and less power consumption for greater output.

The exclusive, patented McIntosh Bifilar Circuit, first with Unity Coupling, is inherently superior by design, laboratory measurement and listening test. Wave-form distortion, due to switching transients between each half of the class "B" amplifier is eliminated at all frequencies. The result is the purest amplification possible.







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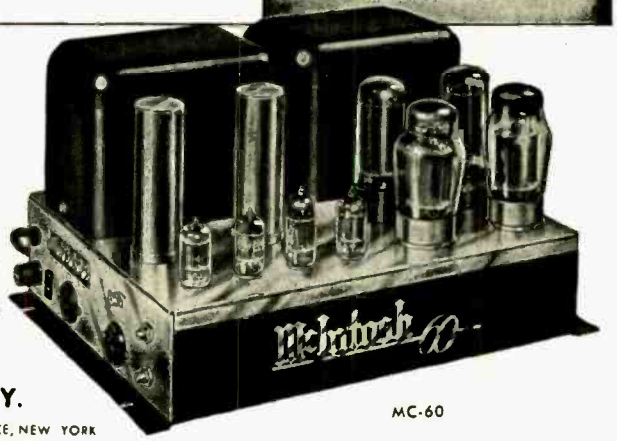

MC-60

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Preview of Exhibits

A brief description of dozens of the new items and hundreds of the more familiar products that will be on view at the New York High Fidelity Show this month—whetting our appetites for more and better equipment, greater flexibility, and expanded facilities.

AT TWO O'CLOCK on the afternoon of September 27 the greatest of all audio exhibitions will open in New York. It is the first New York High Fidelity Show sponsored by the Institute of High Fidelity Manufacturers. Continuing for four days, with hours from two to ten p.m. daily, the Show will occupy four floors of the New York Trade Show Building, and will present the most impressive array of audio gear ever assembled for public display. Admission charge will be 50 cents until six p.m., 75 cents in the evenings.

For those who are not acquainted with the New York Trade Show Building it should be noted here that if a structure should be built with nothing but the housing of audio shows in mind, it might well resemble the NYTSB in many respects. For example, there are acoustically-treated ceilings, an amenity which has been sadly needed but distinctly lacking in all of this country's previous audio shows. How much this will mean to the High Fidelity Show was clearly evidenced at the July meeting of the National Association of Music Merchants held in the Trade Show Building, where home music systems made up the biggest single segment of exhibitors. Performance of the various systems was enhanced by the acoustical correctness of the demonstration quarters.

Other features the building affords are modern fluorescent lighting, exceptionally wide halls and doorways, full air conditioning, and elevator capacity great enough to prevent congestion of large crowds. It is located almost in the center of Manhattan's Show Area, occupying the block between 35th and 36th streets on Eighth Avenue.

So much for physical facilities.

Speaking as one who has attended many audio exhibitions with more-than-casual interest, it is the suggestion of the reporter that the problem of loudness in exhibits be solved before it arises.

The day of the audio "nut" is no longer here, and with him has departed the era of *loud* sound at the expense of *good* sound. All of us can recall those audio exhibitions where one of two participants were allowed to spoil the entire show, not only for themselves but for other exhibitors as well, by operating at excessive volume.

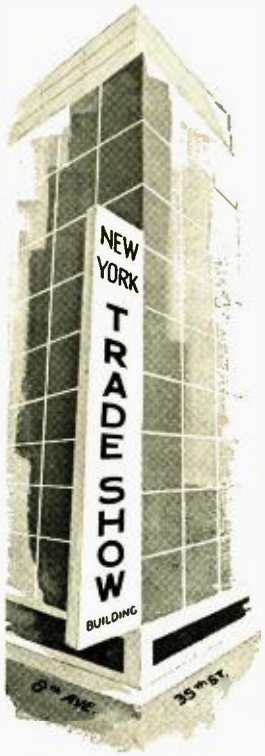
The average visitor to today's audio show is thinking in terms of fine music in his living room, and doesn't give a solitary hoot about how loud his system will play, so long as it sounds good at comfortable listening levels.

There's nothing to be gained by driving a speaker to distortion when, at the same time, you are driving listeners to distraction.

It is not within the province of this observer to formulate an answer to the problem. But solved it must be, and in its solution will be found a distinct advance in the success of all audio shows.

The staff of AUDIO will attend the New York High Fidelity Show en masse, ostensibly to serve well the dignity of professional calling, but in reality to revel in all the gadgets like a bunch of kids with a new toy.

The following is a preview of what will be shown by the many exhibitors—some of it completely new, some with typical yearly improvements, and some the old standby items that we have learned to expect from year to year—hoping that some of these excellent items will still be around until we have saved enough out of our lunch money to buy them.



Possibly no piece of sound equipment developed within the last year has created such a stir as the AR-1 speaker system, which will be demonstrated by **Acoustic Research, Inc.** Unbelievably small when compared with average sys-

tems, the AR-1 is capable of bass response which rivals even the largest conventional enclosure. Those who missed the AR-1 at the 1955 show will find the experience of hearing it pleasantly surprising.

Acro Products Company will display amplifiers using the firm's Ultra-Linear output transformers. Also, various models of the transformers themselves will be on hand for inspection. Acrosound transformers are designed for bandwidth considerably wider than the audio band, thus permitting exceptionally stable feedback and excellent transient response.

Altec Lansing Corporation, along with displaying its complete line of high-fidelity speakers and amplifiers, has chosen the show for the unveiling of its new FM-AM tuner. Designated as Type 306A, the tuner features outstanding sensitivity and a tuning meter for easy visual tuning. Many advanced circuit changes have been incorporated in its design.

American Electronics, Inc. will make its initial bow at an Eastern high-fidelity show as the new manufacturer of Berlant Deluxe and Concertone Custom tape recorders and accessories. Of more than casual interest to the serious audio hobbyist is the Concertone Custom Model 23-2, a complete stereo recorder in two

HIGH-FIDELITY TURNTABLES

the **PRESTO** *Pirouette*

Professional performance standards combined with maximum simplicity of operation. Beautifully machined 12" or 16" cast aluminum turntables for super-smooth, rumble-free operation. Choice of heavy-duty four-pole motor or hysteresis synchronous motor to meet all requirements in speed accuracy. Three-idler drive system with interchangeable idler wheels minimizes wear. Single-flick shift, operated in one plane, selects 33⅓, 45 or 78.26 r.p.m. speeds and shuts off motor.

Model T-18, 12" turntable, four-pole motor	$ 66.00
Model T-18H, 12" turntable, hysteresis motor	117.00
Model T-68, 16" turntable, four-pole motor	87.00
Model T-68H, 16" turntable, hysteresis motor	147.00

DISC RECORDING EQUIPMENT

New **PRESTO K-11**

Three-Speed Disc Recorder

Ideal for home or semi-professional use. Three-speed operation without adapters. PRESTO cutter head for both standard groove (110-line pitch) and microgroove (220-line pitch). Records discs up to 13¼" diameter. Comprises the popular T-18 Turntable, recording and playback amplifiers, high-fidelity pickup with turnover cartridge, and two speakers (woofer and tweeter) mounted in cover of carrying case. Separate microphone and radio inputs, monitor jack, level indicating meter and recording equalizer also featured.

Model K-11, complete with hysteresis motor $445.00
Recorder mechanism only, with hysteresis motor 259.50

RECORDING DISCS

PRESTO Green, Brown, White and Orange Labels for Instantaneous Recording. Single and Double-Sided Masters.

The perfect disc for every recording need. Optimum performance combined with highest permanence. Made to conform with rigid PRESTO standards and quality-controlled at every step.

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TAPE RECORDING and PLAYBACK EQUIPMENT

PRESTO R-11 Series
Professional Tape Recorders

The ultimate in recorder-reproducer units. Three full-track heads. Tape speeds 15 and 7½ ips, with others on special order. Reels sizes 10½" or 7". Exclusive capstan drive with hysteresis motor. Torque-type reel motors. Solenoid-operated, self-adjusting brakes. Variable fast-speed control. Wired for remote control.

Model R-11 tape transport mechanism (chassis only)	$ 775.00
Model R-11 in carrying case	827.00
Model SR-11 recording console (includes R-11 mechanism, A-901 amplifier and CC-2 studio console)	1250.00
Model SA-5 remote control switch	40.00

PRESTO SR-27 Tape Recorder

A moderately priced tape recorder for professional and home use. Consists of R-27 tape transport mechanism and A-920B amplifier. Three separate heads. Three-motor drive, including hysteresis capstan motor. Tape speeds 15 and 7½ ips, plus fast forward and rewind. Reel sizes up to 8". 10-watt amplifier has two built-in speakers and controls.

Model SR-27 complete in two portable carrying cases $588.00

PRESTO Long-Playing Tape Reproducer for Background Music

8 hours continuous playback from 14" reels with dual-track operation at 3¾ ips. Fool-proof, trouble-free, economical. Complete assembly includes PB-17A tape playback mechanism, A-904 preamplifier and CC-4 (horizontal) cabinet*. **Complete** $996.00

**Cabinets for vertical mounting available*

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Functionally designed without mechanical or electronic "gingerbread"... precision-engineered without compromise...massively constructed without economizing on components and machined parts . . . custom-built without short-cuts . . . quality-controlled without fail . . . THAT'S the Presto Look – result of a quarter century's experience as America's leading manufacturer of tape and disc recording equipment.

TAPE RECORDER AMPLIFIERS

PRESTO A-900-5, A-901 and A-920 Amplifiers

Designed to complement PRESTO tape recorders. A-900-5 has separate record and playback channels, three-microphone input, 250-ohm low-level mixer, illuminated VU meter, and 500-ohm output with +20 db maximum power. A-901 is similar to A-900 except for single 500-ohm transformer input instead of mike inputs. A-920 is more compact, has both microphone and playback preamplifiers, single 250-ohm mike input, 10 watts power output into 15 ohms with provision for 500-ohm output at 0 db, plus two small, built-in speakers.

Model A-900-5, for rack mounting	$388.00
Model A-901, for rack mounting	350.00
Model A-920, for rack mounting	309.00

(Each supplied in carrying case for $15.00 extra.)

Export Division:
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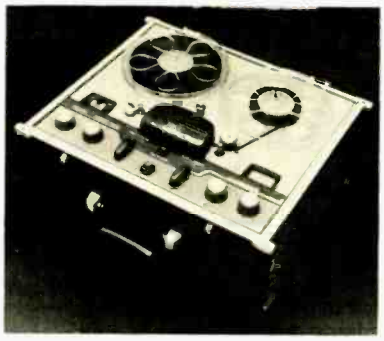
PRESTO RECORDING CORPORATION
PARAMUS, NEW JERSEY

portable cases. Unveiled for the first time will be a new Concertone broadcast-quality microphone.

Those music lovers who can't enjoy listening to a music system unless it looks good, and who are offended by poor appearance even though the system approaches perfection in sound, will find both of their esthetic tastes satisfied beyond measure when they visit the exhibit of **AMI Incorporated.** In both sight and sound, the AMI home music systems which will be shown reflect the years of experience which AMI has devoted to the development and manufacture of fine sound-reproducing equipment. The ladies, particularly, will enjoy this display.

The new "A" series of tape recorders is to be shown for the first time to a hi-fi audience by **Ampex Corporation.** Both monaural and stereophonic models are available, and in either portable cases or table-top housings of fine wood. In addi-



tion, a complete console music system will be on view—a system which includes a stereophonic recorder, two amplifier-speaker combinations, record changer, equalization controls, and (optionally) an AM-FM tuner. This could well be a dream system all packaged up neatly and ready to play.

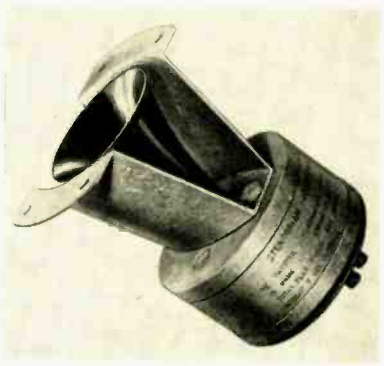
The hearty trend toward FM listening will be accelerated by the introduction of broad-band yagi antenna systems designed especially for high-fidelity reception of FM programs, displayed by **Apparatus Development Company** of Wethersfield, Conn. Two high-gain antennas

will be shown, the "FM/Q" Sr., a multi-element double-driven yagi featuring high front-to-back ratio and directivity for fringe installation, and the "FM/Q" Jr. for better-than-normal reception at average distances.

An expanded line of five different types of magnetic recording tape will be featured in the exhibit of **Audio Devices, Inc.,** makers of Audiotape. Packaged in colorful new boxes for quick identification, tapes range from standard Audiotape on 1½-mil acetate base to super-thin Audiotape on ½-mil Mylar. Newest of the Audiotapes is that found in the blue box—a low-cost longer-playing tape on 1-mil acetate.

For those record collectors who prefer a single-stylus cartridge over the triple-play type, **Audiogersh Corporation** will introduce the new Miratwin Model MST-1. Similar in construction to either half of the well-known MST-2, the MST-1 is available with diamond or sapphire stylus for microgroove or 78-rpm records, and permits stylus change without the use of tools. Audiogersh will also introduce the re-designed Audette, a compact two-way high-fidelity speaker system which is ideally suited for stereophonic music systems.

A complete showing of the extensive line of W/B Stentorian speakers, and the well-known QUAD II amplifier and matching QC II control unit will make up the exhibit of **Barker Sales Company** of Ridgefield, N. J. Included in the Sten-



torian line is a new super tweeter, Model T-12, with a frequency range of 3000 to 20,000 cps and a power rating of 15 watts. The new QUAD QC II audio control unit has provision for tape input, output, and simultaneous monitoring. If you are the critical type, a visit to the Barker exhibit will be most satisfying.

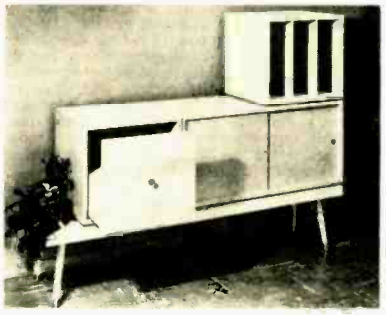
Stereo equipment will be emphasized by **Bell Sound Systems, Inc.,** which will introduce a new two-channel amplifier that is truly remarkable in its flexibility of control. Output power of each channel is 10 watts. Inputs are provided for stereo tape and FM-AM stereo tuner. In addition to containing level and tone controls for each channel, the 3-DT amplifier includes a switch for channel reversal. Bell also will introduce a low-priced stereo kit for conversion of the standard RT-75 tape recorder for stereo playback.

A sure-fire hit of the High Fidelity Show is certain to be the new line of public-address amplifiers shown by **David Bogen Company, Inc.** Entirely striking, both in appearance and in performance, the new Bogen amplifiers represent a distinct advance in the field of p.a. equipment. Sharing the spotlight with them will be the new Bogen Model RR501C hi-fi AM-FM receiver, a complete home music system on a single compact chassis, which will be shown publicly for the first time and the newly-styled line of Bogen hi-fi tuners and am-

plifiers. Also receiving its public introduction will be the Model ST10 unit for stereophonic tape playback. The ST10 incorporates dual preamplifiers and a 10-watt power amplifier in a single compact enclosure.

Styled with an eye to modern low-ceiling environments, the new B-400 speaker system to be shown by **R. T. Bozak, Inc.** contains the same components as the Bozak B-130, in a low-boy infinite-baffle enclosure. The driver complement includes four B-199A woofers, one B-209 mid-range speaker, and one B-200XA 8-element tweeter array. With 50 watts input, the clean range of the B-400 extends from below 28 to beyond 20,000 cps.

Known for the eventful quality of its audio show displays, **British Industries Corporation** will perpetuate its reputation with a handsome showing of the latest achievements in Garrard record changers and turntables, Wharfedale speakers, River Edge cabinetry, Leak amplifiers, RJ speaker enclosures, and



Genalex audio tubes. Sharing honors for the spotlight will be the new Garrard changers and the Series 100 River Edge kits, both of which will be shown to the New York public for the first time. Both the variety and the quality of the equipment on exhibit should make a visit to the BIC quarters one of the show's more satisfying experiences.

Along with a number of speaker systems of impeccable quality, **Brociner Electronics Corporation** will exhibit its Mark 10 and Mark 20 integrated audio amplifiers, the Mark 30C audio control center, and the Mark 30A power amplifier. All of these units incorporate printed circuitry, which was pioneered by Brociner in the high fidelity field, and as a

(Continued on page 66)

UNUSUAL RECORDINGS for the Discriminating Hi-Fi Record Collector

AUDIO FIDELITY RECORDS presents *Studies in* **HIGH FIDELITY** *sound*

NEW ! ! ! on AUDIO FIDELITY RECORDS for the FIRST TIME ! !
BACH TRANSCRIBED FOR PERCUSSION
The most exciting, original and powerful percussion work yet.
- Toccata and Fugue in D Minor
- "Great" Fugue in G Minor
- Toccata in F Major
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AUDIO FIDELITY AFLP 1812
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The exciting, throbbing rhythms of the Steel Band, trademark of the West Indies, in a modern high fidelity tropical treatment. Oil Drums in Hi-Fi, a 20th Century phenomenon.
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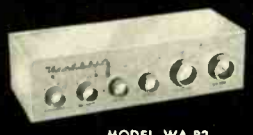

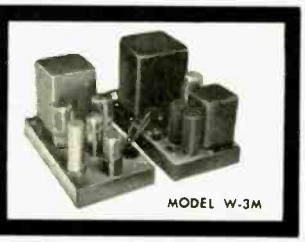

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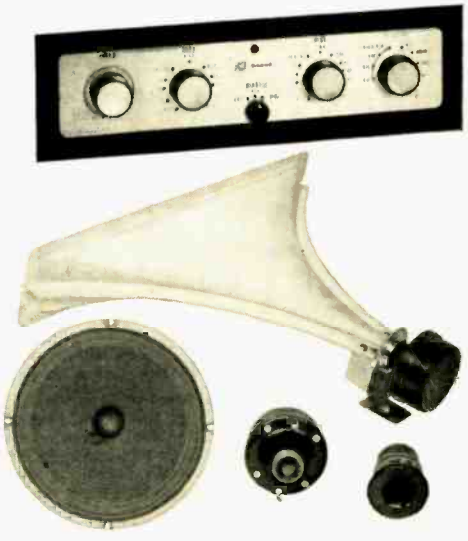

New York High Fidelity Show
Directory of Exhibitors

These are the companies whose products will be seen at the year's biggest Hi-Fi show this month. The list was complete at the time of going to press, but it is likely that there will be others before the opening day. The Show Preview, starting on page 44, describes the products that are being stressed by these exhibitors.

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25 Thorndike St., Cambridge 41, Mass.

ACRO PRODUCTS COMPANY 326
369 Shurs La., Philadelphia 28, Pa.

ALTEC LANSING CORP. 502, 524
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AMI INC. 529, 530
1500 Union Ave., S.E., Grand Rapids, Mich.

AMPEX CORPORATION 433, 439
934 Charter St., Redwood City, Calif.

APPARATUS DEVELOPMENT CO. 322
Drawer 86, Wethersfield 9, Conn.

AUDAK COMPANY 330
500 Fifth Ave., New York 36, N. Y.

AUDIOCOM, INC. 537
The Publishing House, Great Barrington, Mass.

AUDIO DEVICES, INC. 418
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AUDIOGERSH CORP. 401
514 Broadway, New York 13, N. Y.

AUDIO MAGAZINE 403, 404
204 Front St., Mineola, N. Y.

BARKER SALES CO. 304
996-8 Edgewater Ave., Ridgefield, N. J.

BELL SOUND SYSTEMS, INC. 436, 435
Columbus 7, Ohio

BERLANT-CONCERTONE 548
655 West Washington Blvd., Los Angeles 15, Calif.

DAVID BOGEN CO., INC. 349
29 Ninth Ave., New York 14, N. Y.

THE R. T. BOZAK SALES CO. 506, 508
P. O. Box 966, Darien, Conn.

BRITISH INDUSTRIES CORP. 447, 407
80 Shore Rd., Port Washington, N. Y.

BROCINER ELECTRONICS LAB. 532
344 E. 32 St., New York 16, N. Y.

CABINART 348
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COLBERT LABORATORY 505
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DAUNTLESS INTERNATIONAL 504
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DeJUR-AMSCO CORP. 307
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THE DUOTONE COMPANY 403
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DYNA COMPANY 403
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ELECTRO-SONIC LABORATORIES 545
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ELECTRO-VOICE CORP. 333, 335
Buchanan, Michigan

EMC RECORDINGS 317
806 E. Seventh St., St. Paul 6, Minn.

EMI, INC. 308, 311
151 W. 46 St., New York, N. Y.

ERCONA CORP. 315
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FAIRCHILD RECORDING EQUIPMENT CO. 540, 542
Whitestone, N. Y.

FENTON COMPANY 301
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FISHER RADIO CORP. 424, 428
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GENERAL ELECTRIC COMPANY 629, 630
Syracuse, N. Y.

GOODMANS INDUSTRIES LTD. 651, 652
Axiom Works, Wembley, Mdsx, England

GRAY RESEARCH & DEVELOPMENT CO. 526
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GROMMES (Precision Electronics Inc.) 343
9101 King St., Franklin Park, Ill.

HARMON-KARDON, INC. 438, 441
520 Main St., Westbury, L. I.

INTERNATIONAL ELECTRONICS CORP. 425
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JAYVEE WOOD PRODUCTS 539
Lansdale, Penna.

JENSEN MANUFACTURING CO. 527, 528
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MARANTZ COMPANY 547
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MOTOROLA 647, 650
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61 Sherman St., Malden 48, Mass.

NESHAMINY ELECTRONIC CORP. 507
Neshaminy, Pa.

NORELCO (North American Philips Co., Inc.) 534
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ORRADIO INDUSTRIES, INC. 443
Shamrock Circle, Opelika, Alabama

ORTHO-SONIC INSTRUMENTS INC. 420
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PENTRON CORP. 347
777 S. Tripp Ave., Chicago 24, Ill.

PICKERING AND COMPANY, INC. 339
Oceanside, N. Y.

PILOT RADIO CORP. 444, 445
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PRESTO RECORDING CORP. 437
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THE TETRAD COMPANY, INC. 408, 410
62 St. Mary St., Yonkers 2, N. Y.

THORENS COMPANY 323
New Hyde Park, N. Y.

UNITED AUDIO PRODUCTS 303
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UNITED SPEAKER SYSTEMS 531
462 Broad St., Bloomfield, N. J.

UNIVERSITY LOUDSPEAKERS, INC. 325, 328
80 S. Kensico Ave., White Plains, N. Y.

V-M CORPORATION 601
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STAN WHITE, INC. 431, 432
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AUDIOCLINIC??

JOSEPH GIOVANELLI*

Pops During Warm-up

Q. *Some very annoying pops come from my amplifier while it is warming up. What can I do to stop this from happening? S. F. Saiya, Brooklyn, N. Y.*

A. This condition probably arises from the fact that the high voltage rectifier warms up faster than do the other tubes, since the rectifier is a filamentary cathode while most of the others are heater-cathode types. Since little current is drawn from the high voltage supply until the majority of the tubes come up to operating temperature, the voltage is higher than normal. Perhaps this voltage causes a slight arc somewhere in the circuit, or perhaps there is some leakage in a filter at this time. There are many reasons why this might occur, and it is likely that nothing is happening which will damage your amplifier. If your unit is not one of high power output, it might be a good idea to change the rectifier to a heater-cathode type, such as a 5V4. To do this, move the filament lead of your present rectifier (the lead which is now on pin 8) to pin 7. Leave all other connections to pin 8 undisturbed. This is all that need be done. Before making this substitution, consult a tube manual and see whether the 5V4 can be expected to handle the current taken from the remaiuing tubes in your amplifier.

Internal Impedance

Q. *How is the internal impedance of an amplifier determined? Edward J. Mulvey, Bedford, Mass.*

A. The equivalent circuit for the output of any amplifier, whether it be ultra-linear, with or without feedback, or whatever, would be a generator whose output feeds directly into a resistance (which is the internal impedance of the amplifier). When an external load, such as a resistance or loudspeaker, is placed across the output terminals of the amplifier, the generator voltage divides up according to Kirchoff's law. By means of this law and some algebraic manipulations, the following formula may be derived: $R_s = (E/V - 1)R_L$, where R_s is the internal impedance in ohms, E is the voltage at the output terminals with no external load connected, V is the voltage at the output terminals with the external load connected, and R_L is the value of the external load resistor in ohms.

When making this measurement, pure resistances should be used as the external load. Feed the output from an audio oscillator into the input of the amplifier to be measured. Adjust the oscillator frequency control so as to produce an output of 400 cps. Measure the voltage at the output terminals of the amplifier with a vacuum tube voltmeter, and with no external load resistor connected. Next, measure the voltage with the external load connected across the output terminals. If the output terminals used are intended to work into an 8-ohm speaker, use an 8-ohm resistor as R_L. Substitute all known values in the formula, and solve the equation. You will then have determined the amplifier's internal impedance.

Now, vary the load resistor over a wide range of values to see how much change there is in the internal impedance. In most amplifiers there should be very little change, although there will be some, intentionally introduced to compensate for the varying impedances offered by loudspeakers at different frequencies.

Next, vary the frequency to see what happens to R_s. This, again, should have little effect with most amplifiers.

Sometimes the impedance will be found to change even though such changes were not intended by the builder of the equipment under check. This change occurs because the negative feedback is taken from the same winding on the output transformer as that used for connecting the loudspeaker. It would be best to use a tertiary winding to derive the feedback, although some effect on it will be observed because of inductive coupling between all transformer windings.

Hum

Q. *Why is a high impedance circuit subject to more hum than a low impedance circuit? Storrs Bigelow, Idaho Falls, Idaho*

A. We will consider this from two angles: 1) with an inductance of many turns (high impedance) in the grid circuit of an amplifier and 2) with a high resistance in the grid circuit of an amplifier.

1) To understand this, we must go to the laws governing the generation of electricity by magnetism. The amount of voltage developed at the output terminals of a generator is determined by three factors: (a) the speed with which magnetic lines pass through the turns of a coil (the greater the speed, the higher the voltage); (b) the strength of said magnetic field (the greater its strength, the higher the voltage); and (c) the number of turns on the coil (the greater the number, the higher the voltage). When hum is presented to the grid circuit via such an inductance, we have, in effect, a generator. A stray a.c. voltage acts as the magnet of the generator passing through the turns of the coil at a rate dependent upon the supply frequency. Because of the large number of turns comprising the inductance referred to above, a large voltage can be expected at the grid of the amplifier. An inductance of low impedance has considerably fewer turns wherefore the voltage produced would be lower for the same amount of stray a.c.

2) First, some stray a.c. introduces a current into the grid lead by capacitive coupling. Ohm's law tells us that when a current flows through a resistor, a voltage appears across it. The higher the value of the resistor, the greater will be the voltage. In this instance, we have specified a high resistance. It is self-evident that in a high impedance circuit there will be a higher hum voltage presented to the input of the amplifier than would be true of one having a low resistance in its grid circuit.

μv/db of Quieting

Q. *What is meant by μv/db of quieting? Storrs Bigelow, Idaho Falls, Idaho*

A. The statement of μv/db of quieting is used in discussions of the performance of FM receivers. The symbol μv means microvolt, one-millionth of one volt. Thus, 2μv/20db of quieting means that when a 2-microvolt signal is fed into the antenna terminals of an FM receiver having this characteristic, the average background noise is 20 db below the full rated output of the receiver, i.e., when the broadcast transmitter is modulated 100 per cent. If the background noise is 20 db below the full rated output of the receiver, it is the same as saying that the signal is 100 times stronger than the noise output. This ratio of 100 to 1 will mean that some background noise can sometimes be heard.

Fletcher-Munson Effect

Q. *What is the Fletcher-Munson effect? Kenneth Eckman, Memphis, Tenn.*

A. The human ear is non-linear. In other words, when we listen to music or other wide-range program material at high volumes, we hear all the frequencies reasonably well. As the volume of reproduction is reduced, the high and low frequencies appear to be attenuated more than the mid-range. Therefore, the general effect upon the listener is that of a reproduction lacking in highs and lows whereas at the higher volume no such lack was felt. It must be understood that at the lower volumes the amplifier continues to deliver high, low, and mid-range frequencies in the same proportion as it did at the higher volume. The difference is in the way the ear hears the sounds. This characteristic of the ear is the Fletcher-Munson effect. Many amplifiers have loudness controls whose action works conversely to the Fletcher-Munson effect, so that as the volume of such an amplifier is reduced, the bass and treble are attenuated less than the mid-range.

Variable Damping Control

Q. *I have an amplifier with a variable damping control and I don't know what it is for. Will you please tell me how to use it? Evelyn Maher, Canton, Ohio*

A. It is practically impossible to remove all resonant frequencies from a speaker system, especially at the low end. Because resonant frequencies tend to be more outstanding than others, a form of distortion has obviously been introduced. The effect of such resonant points may be lessened if the amplifier can present the proper load to the speaker. This is accomplished by rotating the variable damping control. The setting on the control which does present this proper load to the speaker is known as the critical damping point. Above this point, the speaker is said to be over-damped, causing it to he less efficient at low frequencies and to produce a "colder" tone. Below the critical damping point, the speaker will be under-damped, causing it to boom. Under-damping exaggerated to the point of becoming negative usually produces an undesirable hangover effect, wherein each sound is followed by a ghost. The overall effect is that of muddiness.

Each individual speaker system will have its own particular critical damping setting on the control which is why no setting can be marked "critical damping." To determine the critical damping point for a particular speaker system and amplifier would require a laboratory adjustment. Since the sound supplied by the individual reproducing system is in existence for the pleasure of its listeners, it is entirely up to them to select by ear the setting which presents to them the most satisfactory listening experience.

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Should any Lifetime Driver Unit become inoperative at anytime under these conditions, it will be repaired or replaced at our option entirely free from any service charge.

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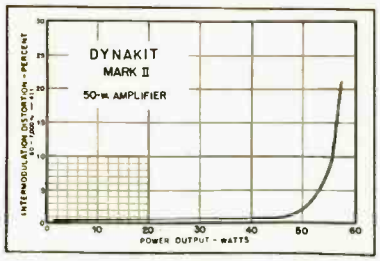

Fig. 1. Intermodulation distortion curve for the Dynakit 50-watt amplifier.

Equipment Report

Dynakit "build-it-yourself" 50-watt amplifier—AMI music system amplifier, model R-1250—United Speaker Systems' "Premiere"—Racon 15HTX "high-compliance" loudspeaker.

WITH MOST SERIOUS AUDIO HOBBYISTS aware that there are some advantages to higher power for their home systems, particularly when they may be driving speakers in several locations at the same time, the availability of a 50-watt amplifier in kit form should be interesting.

Further, when the kit amplifier exhibits really excellent quality throughout, is quite simple to construct, and because it is a kit somewhat less costly than a comparable factory-built amplifier, it is likely to excite the serious hobbyist.

Fig. 2. The Dynakit, amplifier with its protective cover.

The Dynakit amplifier, shown in *Fig.* 2, is attractive in appearance, carefully prepared so that all parts go together without any mechanical work being required by the constructor, and can be assembled easily in less than three hours, even by the least experienced amateur. The more complicated wiring of the input and driver stages is already completed in the form of a printed circuit board, and requires only mounting on the chassis and the connecting of seven wires into pretinned eyelets. The remainder of the construction is straightforward, and requires only the use of screwdriver, diagonal cutters, pliers, and a soldering iron.

The circuit, *Fig.* 3, is a new development by Dave Hafler, and employs two 6CA7/EL84's in the Ultra-Linear output stage, working with fixed bias, and a single 6AN8 in the input and phase-splitter stages. Since these two stages are direct coupled, there is only one RC network between input and output, which reduces problems of phase shift in relation to the feedback circuitry. The input stage consists of the pentode section of the 6AN8, and it is direct coupled to the triode section which serves as a cathodyne phase splitter, and thence driving the output grids directly. Fixed bias is supplied from a tap on the power transformer secondary and a separate selenium rectifier.

Since it is hardly necessary to show the frequency response of a simple power amplifier of modern design—practically all of them are within a fraction of a db from 20 to 20,000 cps—the only curve shown, *Fig.* 1, is that of intermodulation distortion, indicating that the unit is slightly under two per cent at 50 watts, measured into a resistance load. For comparison purposes, an output of 1 watt is obtained from an input signal of 0.198 volts, and an input of 2.78 volts will provide the full 50-watt output. As a matter of interest, the IM distortion at outputs of less than 35 watts is well under 0.5 per cent. The amplifier will furnish 1 amp. at 6.3 volts and 20 ma at 200 to 400 volts for an external preamplifier. Output impedances of 8 and 16 ohms are regularly supplied, with an additional 4-ohm output being available at extra cost. Measured output impedance across the 16-ohm tap is 1.1 ohms, corresponding to a damping factor of 15.

The crucial test of any amplifier is, of course, how it sounds in actual use, and the Dynakit serves to show the advantage of thoroughly adequate power. With 50 watts available, there is a definite difference in the way the system handles music peaks, and a direct comparison between this unit and a 5-watt unit, for example, will indicate that oftentimes the distortion we attribute to pickup, record, or what not might better be attributed to the power amplifier. With 50 watts, one is not likely ever to hear an overloaded signal—that is, not in the average speaker system.

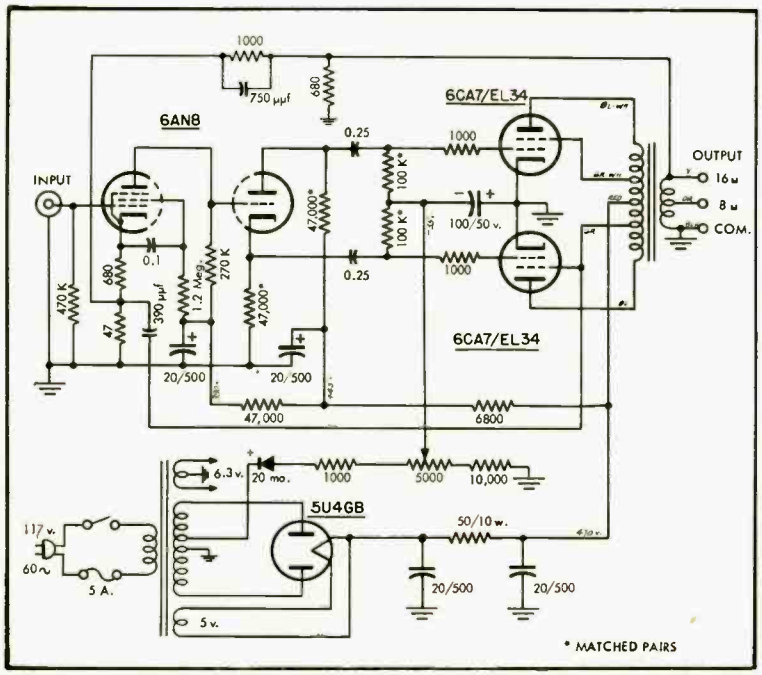

Fig. 3. Complete schematic of the Dynakit. The suppressor grids of the output stage are not shown, but are connected to the cathodes and thence to ground at the tube socket.

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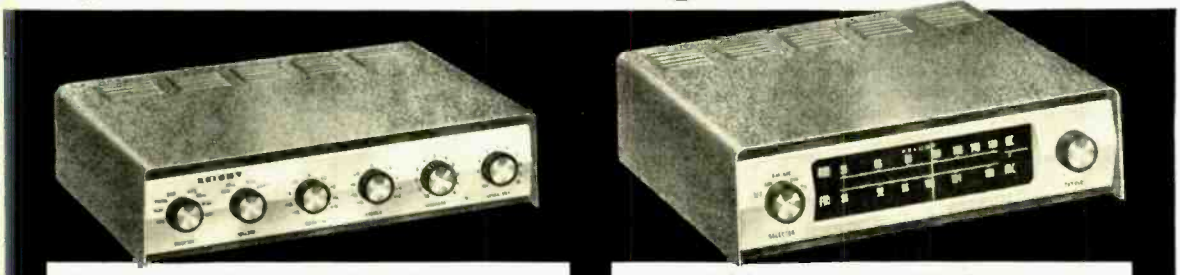

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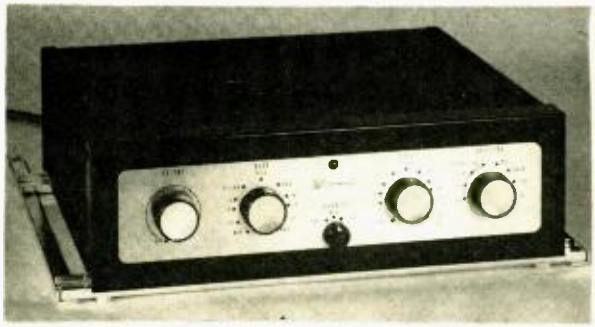


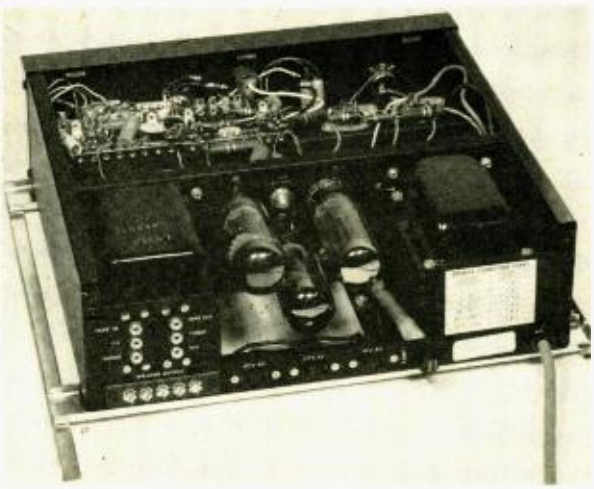


Fig. 4 (above). AMI R-1250 Amplifier is attractively housed and of conservative yet modern design. Fig. 5 (right) The interior of the R-1250 is neat and compact, and would be easy to service when necessary.

AMI Incorporated R-1250 AMPLIFIER

Intended for incorporation into their high-fidelity phonograph consoles, all of which employ dual-horn speaker systems, the R-1250 amplifier gives the impression of having been designed with ease of operation as one of the important features. Foremost of the features in this direction is the selector-switch nomenclature—PHONO, TUNER, TAPE, TV, MIC—indicating that there is only one phono equalizing position. Actually there are four phono positions, none of them effecting a change in the basic equalization for magnetic cartridges, but instead introducing high-frequency cutoffs. Therefore, instead of having to choose the proper phono curve, the user simply switches to PHONO, giving there is too much noise or scratch the conwhat is essentially an RIAA curve, and if

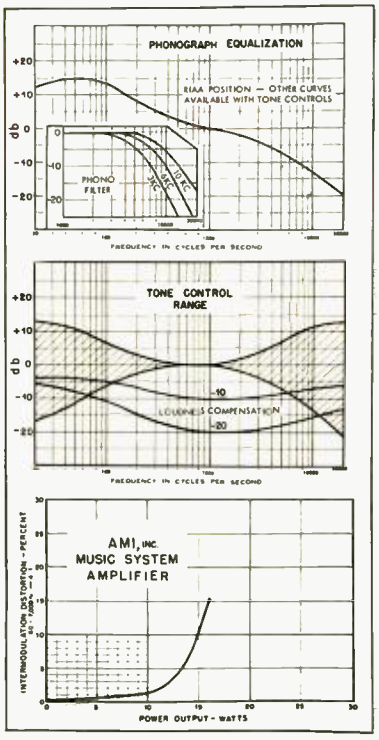


Fig. 6. Performance curves for the AMI R-1250 amplifier.

trol may be turned to any of the PHONO positions with a cutoff frequency shown, as 10 kc, 6 kc, or 3 kc. The curves in the upper section of *Fig.* 6 show the effect of the cutoff switch, which is designed with the proper constants to accommodate a G.E. cartridge. Actually, these constants will work quite close to the indicated curves with some other pickups—notably the Audak, Goldring, Miratwin, and Tannoy which have inductances in the same range as the G.E. Simple changes in the constants of the cutoff circuit would make it possible to obtain similar response with any cartridge.

The external appearance of the amplifier, *Fig.* 4, is in keeping with the high standard of appearance of the AMI cabinets. The framework of the housing is of black lacquer, while the panel is satin gold in finish, as is the perforated cover which is held in place by two sheet-metal screws at the back. When these are removed, the cover may be slid out to provide access to the interior of the amplifier, as shown in *Fig.* 5. The output stage consists of a pair of 6L6GB's in an Ultra-Linear circuit, and these tubes and the 5U4G rectifier may be reached from the back of the amplifier without removing the cover. Similarly, the three other tubes, all miniature, may be reached from the bottom of the unit, being located in a channel in the chassis.

The preamplifier stage employs a 12AD7, which is a low-hum, high-gain dual triode designed by Sylvania for preamp use. This stage is used only for phono and microphone.

The built-in RIAA equalization will accommodate most present-day records, with any required "touching up" of the curves being done with the tone controls, which are calibrated in db as well as with the names of the other curves that may be obtained. However, as we have often said, unless the user has a large collection of records which includes 78's over a number of years and LP's since their introduction, the RIAA curve should be the best compromise, since it will play practically any LP within limits, with minor changes made by the tone controls.

The output transformer secondary is connected somewhat differently from conventional amplifiers in that it will accommodate any speaker impedance from 2 ohms to 500, or practically any combination of speakers. A chart on the back of the unit indicates the impedances available. One of the outputs is labeled "70.7-volt line" and is especially useful to feed a number of speakers throughout the house, for example, each being provided with a matching transformer by means of which it is possible to preselect the wattage of signal that is supplied to that particular speaker.

The loudness contour selector consists of a three-position switch marked LOUD, MEDIUM, and SOFT. In the two latter positions, both low and high frequencies are boosted to compensate for the Fletcher-Munson effect, as shown in the center section of *Fig.* 6, along with the effect of the tone controls. A rumble filter built into the phonograph preamp has a slope of 18 db per octave, and is designed for greatest attenuation of the rumble frequencies resulting from a 4-pole phono motor.

Among the other conveniences are three switched a.c. outlets and a hum-balance control which is a center-tapped potentiometer across the heater winding.

A 1-watt output signal is obtained from an input of 0.13 volts on any of the high-level inputs, when the volume control is set at maximum. A like signal voltage is available at the tape output jack and is not affected by the volume or tone controls, which we believe is the proper arrangement for a tape-recorder feed. The same 1-watt output signal is obtained from an input of slightly under 1 mv from the PHONO input, and from a signal of 3 mv from the MIC input.

Subjectively, the amplifier performs smoothly, sounds good from either phono or radio tuner inputs, and is of most attractive appearance. Its neatness and styling would be appreciated by many homemakers—that means wives—over some other and more professional-appearing equipment. When incorporated in a complete "package" it consistently gives a good account of itself.

UNITED SPEAKER SYSTEMS' "PREMIERE"

Combining speaker mechanisms of recognized high quality with a good design of cabinet and high-class workmanship, the "Premiere" speaker system offered by United Speaker Systems has been put through its paces from a subjective standpoint and comes through with flying colors. This unit, shown in *Fig.* 7, is a corner speaker and consists of a back-loaded-folded-horn type of cabinet mounted integrally with a housing for a high-frequency horn and driver unit and which

Fig. 7. The "Premiere" speaker system.

also accommodates the dividing network in the same space. The woofer is a 15-inch Altec 803A, and the high-frequency speaker is an Altec 802A driver on an H-811B horn.

With complete systems, we have consistently made tests by direct comparison with the design presented in these pages in January and February, 1949—a unit consisting of a Stephens 103LX woofer an Altec 802A driver mounted on a 2×4 multicellular horn for the midrange, and a Jensen "Super Tweeter" for the top end. Using a Shure 300 broadcast microphone, we have been able to obtain a measureable output up to 22,000 cps, although we have no calibration on the microphone and it wouldn't be expected to be flat in that range. For the determination of the low-frequency limit, we have found that the King of Instruments record, Vol. I, produced by Aerolian-Skinner Organ Company, will give an accurate qualitative measure of the lowest frequency at which the speaker stops acting like a loudspeaker and begins to "flap in the breeze." One section of this record consists of a scale played on the organ in Symphony Hall, Boston, and ranges from 16 cps up to 8000 as fundamentals, with considerable harmonic content, of course. As the scale is played, the lowest notes seem to be composed principally of noise, with no musical sequence. However, at some point in the scale, the notes become musical tones, and progress up the scale in the normal manner. By observing the note—counting from C up the scale—it is easy to determine at which point the tone becomes music, and by consulting a chart the frequency may be found.

With the "standard" system, the tone at which the musical scale appears to begin is G in the first octave, or a frequency of 24 cps. The Premiere commences at A, which is 27.5 cps. In general, the Premiere has the same sound quality as our "standard" with only a slight difference in the "cleanness" in the extreme low region, and with slightly less brightness in the extreme high end—probably because of the use of the Super Tweeter on the standard.

On the whole, however, we consider this to be one of the very few that we have heard that compares so closely to the comparison speaker. Measured in the same room and using the "10-point average" method, we find that both are within ±3 db from 30 to 10,000 cps, and differ only 7 db at 15,000 cps.

This is the first speaker system we have tested that we would consider as an acceptable substitute for our "standard," although it must be admitted that there have been one or two others which—if tested on direct comparison—would probably be equivalent. This model is, however, of a design that would be acceptable in any top-quality installation.

RACON MODEL 15HTX LOUDSPEAKER

The testing of loudspeakers is fraught with more pitfalls than with any other single component, in our opinion, because of the difficulties involved. In the first place, to make tests that are anything like accurate, it is practically necessary to employ an anechoic chamber, since reflections of sound in a room—particularly in the higher frequencies—cause reinforcement and cancellation of the sound output with a resulting curve which would be completely meaningless, and any room in a normal home or laboratory is likely to have walls which would cause reflections. This can be observed by the ear alone, and without any instruments, simply by reproducing a frequency of, say, 8000 cps, and listening. Movement of the ear amounting by only a fraction of an inch will often cause a great difference in the audible level, and when using a microphone and a meter the differences are much more noticeable.

The "10-point average" method referred to in the preceding review consists of making a frequency run with the loudspeaker being fed a constant level. The acoustic output is measured with good-quality microphone for ten separate runs—each made with the mike in a different location in the room. The levels measured are then averaged. This results in measurements which are quite reproducible, and we normally use this method for making measurements on complete loudspeaker systems. Admittedly, however, this is a long and tedious process, and in spite of its repeatability still leaves something to be desired.

Still another method is to feed a "warble-frequency" tone to the speaker, holding the level constant at the speaker terminals, and measuring the output, again using a microphone. The warble-frequency signal effectively prevents building up any standing waves in the room, and gives reasonably repeatable results.

However, with speaker mechanisms which are loaned to us without a recommended enclosure, we feel that the difference in the performance in the low-frequency end particularly would depend so much on the type of enclosure employed that the results would be meaningless. On the other hand, considerable information about the low-frequency performance of a speaker may be gleaned from an inspection of the voice-coil impedance, and we have chosen to make accurate measurements of this parameter to cover the low end. At the higher frequencies, we have employed a warble-frequency record covering the range from 1000 to 10,000 cps to give a comparative measure of the smoothness of the response in this region.

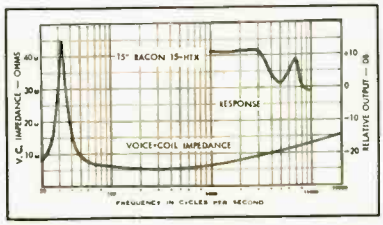


Fig. 9. Curves of voice-coil impedance and sound output from 1000 to 10,000 cps, as measured with a warble-frequency sound source.

Fig. 8. The Racon 15-HTX two-way speoker mechanism.

Figure 8 shows the Racon 15HTX loudspeaker, a two-way system with the heavy-duty cone and a coaxially mounted high-frequency unit. The cone is mounted with a high-compliance surround that consists of a cellular formulation of plastic which resembles foam rubber. This type of mounting permits an extremely wide range of cone motion at the low frequencies. To prevent cone breakup, the entire cone is stiffened with Styrofoam "splints" cemented to the back, and the resulting low-frequency performance is smooth and free from doubling down to 30 cps.

Reproduction in the midrange derives from a separate cone attached to the voice coil at the apex of the large cone, and gives a separate sound source, in effect, for this range. From 5000 cps up, the reproduction comes from a small stiff-paper cone speaker which is loaded by a sealed chamber behind it to increase the resonant frequency, the entire unit being mounted in the center of the large cone.

The voice coil impedance of the speaker in free air is shown in *Fig.* 9, with measurements being made with an applied signal of one-half watt. The high-frequency performance of the unit from 1000 cps upward is shown in the same figure, measurements being made by the warble-frequency method, and no corrections are indicated for the microphone characteristics. Thus the curve is not particularly revealing unless compared with others made in the same manner. (Such curves will be shown during succeeding months.)

Since the low-frequency performance of any speaker depends more upon the housing than it does on the speaker itself, full-range measurements were not made, but with the unit mounted on an infinite baffle there was audible output up to 16,000 cps (about the upper limit of this observer's hearing).

U. N. CONSOLE

(*from page 27*)

ganged "T" networks each having opposing attenuation-*vs.*-rotation characteristics.

When the direct and the reverberant path signals are combined, the resultant power level across the load R_L is determined by the sum of the respective components of power. If these components are of equal magnitude (i.e., their difference equals zero), the combined level on a power basis is 3 db higher than for either one alone. This is so because doubling any power is the same as multiplying by 2, which by the formula,

$$db = 10 \log_{10} \frac{2p}{p} = 3 \, db \qquad (1)$$

When the difference between two component powers exceeds 20 db, the increment over reference power (which in this instance is the unattenuated signal in either branch, P_{ref}) is very small, less than 0.1 db, and may be neglected.

Also, when the reverberation and direct power components are equal, this state may be conveniently (but arbitrarily) referred to as 50 per cent reverberation and is made to correspond to the mid-point of rotation for the differential attenuator.

We found by experiment that the presence of reverberation component is just barely discernable when the reverberation component is attenuated about 20 db (1.0 per cent power) below direct signal as a reference; the effect of adding the direct signal is just about detectable when it comes in at 20 db below reference. These observations helped to establish the range of attenuation required in each side of the attenuator for full control of the reverberation ratio over the limits 0 to 100 per cent. Therefore, each section of the ganged attenuator provides for 20 db of attenuation over half of its mechanical rotation in increments of 1.5 db, and zero loss over the balance of rotation.

According to Van Wynen[1] the mathematical procedure used to find the increment in db when adding components of power is to find the power ratio for each component, add them and then reconvert to db above reference power. If P_{ref} is unity, and the sum of the power ratios of two components is also unity, the db increment is zero. It does not matter what the actual powers are.

From the definitions of power and voltage ratios given in Table I, it will be noted that the output/input power from any setting of the attenuators may be expressed as a decimal fraction in the form:

$$P_{out}/P_{in} = (1/k)^2 \qquad (2)$$

By equating the reference power P_{ref} to 1, the increment for any pair of complementary taps on the ganged attenuator may be expressed as:

$$db = 10 \log \frac{(1/k)_a^2 + (1/k)_b^2}{P_{ref}} \qquad (3)$$

An ideal dual attenuator for this purpose would develop constant output power for any ratio setting, e.g., the sum of the power ratios $(1/k)_a^2 + (1/k)_b^2$ for complementary steps would always be equal to 1 (or P_{ref}) and the increment for each step would be zero.

But this condition, which is easily met when linear changes in power are desired, cannot be worked out in a two-unit attenuator when the steps are scaled logarithmically unless some departures are made from the usual 1.5 or 2 db steps.

However, by careful alignment of the paired attenuator sections using 1.5 db steps the maximum increment can be held to less than 1 db. Since this easily satisfies the operating requirements, the cost of a more unconventional network was avoided.

Table I gives the data for the reverberation ratio control, *VC2*. 600-ohm bridged "T" networks are used, but the table is applicable to any impedance level.

TABLE I

DIFFERENTIAL ATTENUATOR FOR CONTROL OF REVERBERATION RATIO

STEP	SECTION 1 LOSS	SECTION 1 $(1/k)_a^2$	SECTION 2 LOSS	SECTION 2 $(1/k)_b^2$	INCREMENT in DB
1	0	1.0	Inf.	0.0000	0.00
2	0	1.0	24.0	0.0039	0.01
3	0	1.0	22.5	0.0056	0.02
4	0	1.0	21.0	0.0079	0.03
5	0	1.0	19.5	0.0112	0.04
6	0	1.0	18.0	0.0158	0.06
7	0	1.0	16.5	0.0223	0.09
8	0	1.0	15.0	0.0316	0.13
9	0	1.0	13.5	0.0446	0.19
10	0	1.0	12.0	0.0631	0.26
11	0	1.0	10.5	0.0891	0.37
12	0	1.0	9.0	0.1259	0.51
13	0	1.0	7.5	0.1778	0.71
14	0	1.0	6.0	0.2512	0.97
15	1.5	0.7079	4.5	0.3548	0.26
16	3.0	0.5012	3.0	0.5012	0.008
17	4.5	0.3548	1.5	0.7079	0.26
18	6.0	0.2512	0	1.0	0.97
19	7.5	0.1778	0	1.0	0.71
20	9.0	0.1259	0	1.0	0.51
21	10.5	0.0891	0	1.0	0.37
22	12.0	0.0631	0	1.0	0.26
23	13.5	0.0446	0	1.0	0.19
24	15.0	0.0316	0	1.0	0.13
25	16.5	0.0223	0	1.0	0.09
26	18.0	0.0158	0	1.0	0.06
27	19.5	0.0112	0	1.0	0.04
28	21.0	0.0079	0	1.0	0.03
29	22.5	0.0056	0	1.0	0.02
30	24.0	0.0039	0	1.0	0.01
31	Inf.	0.0000	0	1.0	0.00

DEFINITIONS: (for the voltage and power ratios)

$E_{in}/E_{out} = k$

$E_{out}/E_{in} = 1/k$

$P_{in}/P_{out} = k^2$

$P_{out}/P_{in} = (1/k)^2$

All for the case when $Z_S/Z_L = 1$

Mechanical Design

Several mechanical features represent departures from the usual construction methods, for example, all amplifiers and jacks are rack mounted on a heavily constructed and hinged swing-out door at the left side of the console, as shown in *Figs.* 4 and 5. The entire motor-board unit is isolation-mounted on seven Lord vertical snubbing plates. Local storage is provided for a limited number of sound effects records in a pneumatically damped tilt bin in the right side. The separate loudspeaker assembly slides into the bottom cavity when the console is moved about.

Acknowledgment

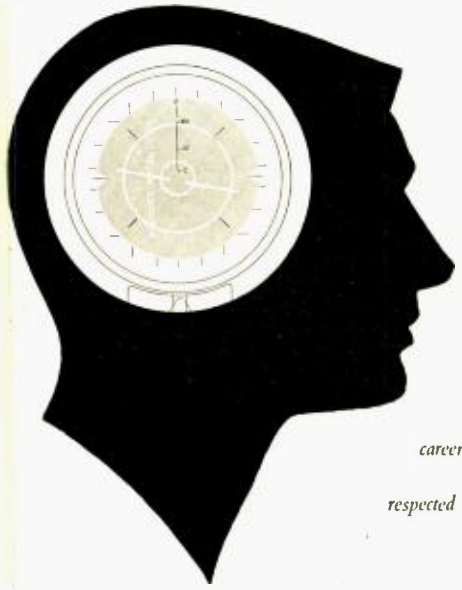
Mr. Colin J. M. Kinnish on the staff of B. Eichwald and Company assisted the writer with the electrical and mechanical design. Mr. Hendrick Roskam, Jr., of the UN Buildings Management Staff did the excellent cabinet work. The project was under the supervision of Mr. R. Chestnutt, Telecommunications Supervisor for the United Nations.

Fig. 4. Left end of the console with the access door open for servicing.

Fig. 5. Second section of the left end opens to permit access to amplifiers.

[1] K. G. Van Wynen, "Devices for combining DB levels." *Bell Lab Record*, December, 1940.

Systems Career: a laboratory for learning



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EDWARD TATNALL CANBY*

STEREO TAPES

Stereo Rating. Mr. Canby has rated these tapes on a scale from 1 to 5 (5 being the highest value) as to specific stereo effectiveness, over and above the general values of recording and performance as heard in comparable monaural reproduction.

The rating is personal, includes both musical and technical factors that contribute to stereo value, and represents a fair measure of the stereo worth of the tape in terms of the extra cost of stereo recordings and playback equipment.

All tapes were reviewed in the stacked (in-line) head form. Tapes marked with an asterisk are listed as also available in staggered head form.

Vivaldi: Concerto Grosso in D Minor. Mozart; Eine Kleine Nachtmusik. Bach-Stoessel: Prelude in E Major. Sorkin Sinphonette.

Concertape Stereo 23-3A

Stereo Ratings: 4, 2, 5 respectively.

This is an interesting kind of stereo and of a special type among those I have listened to. The music is chamber-orchestral. That is, it falls midway between chamber music, of the quartet and sonata type, and music for orchestra, from Mozart-Symphony-size on up in size. There are clear solo instruments here, and small groupings, two or three strings apiece. There is an over-all sound that is orchestral when all play together, but predominantly the sound is of close-up solo players—chamber music. This is a vital and important class of music, both for much 18th century music of Bach, Handel, Vivaldi, Mozart *et al* and for much newer and lots of contemporary music. Half and half.

Actually, this means a tricky recording problem. Get the music to sound fairly close, make the spacing-out of the solo instruments clear, from right to left, but don't lose the over-all sense of orchestral fullness. Not easily solved, and every piece offers a different special problem of balance, depending on what instruments are playing, which are solos, which "tutti" or group-performing. I've rated them accordingly.

The Vivaldi Concerto has two solo violins and a solo cello. The volume balance is good, and very natural; but the spacing of these three individual players is tricky. The first violin is the best real solo, the others quasi-solos. At times they play solo all three together. At others the first solo violin alone plays with orchestra accompaniment.

Concertape (Webcor) has put all three solos on one side, together, as I hear it, and this is probably the best solution. They are a bit closer to us than the body of strings around them.

The Mozart has no solo, but the group of first violins does most of the talking, so to speak. There is no real need for separation in this piece and the only notable advantage is the increased realism of the room-sound.

But the Bach—very short and a transcription—is a terrific stereo piece. Reason: The main work is a dialogue of complex counterpoint between first and second violin sections which are here clearly spaced as two opposed groups on each side, but with enough room liveness to join the two together into one room. Their brilliance and the effect of the side-to-side counterpoint is terrific! Best demonstration stereo I know.

Smetana; Dance of the Comedians Grieg: Peer Gynt Suite. Sinfonietta, L. Sorkin.

Concertape Stereo 502 (5")

Stereo Rating: 5

This is a first rate short stereo, light-music style, in which the miking has hit the spot perfectly—not too far away, not too close. In this one there is no distracting sense of the side instruments being in the speaker rather than out in space around and behind it. Here the whole orchestra (as in the Strauss recordings of Reiner) spreads out and fills a huge space before you, with all elements naturally balanced, from one side to the other. And the big-hall sense of presence is about as good as stereo can ever do—it hits you even in the soft passages, and the shock when you shift to one-track listening is quite surprising.

Music of Johann Strauss. Sinfonietta, Sorkin.

Concertape 101-A

Stereo Rating: 5

Another excellent and well balanced orchestral stereo, well played too. The big-hall effect is there, but only a medium-big liveness—it's the reality of the sense of being right in a hall that is good, whether very live or not so live.

No trouble here with too-strong side-instrument recording; the two ends blend smoothly into the middle of the space, between the speakers, and the roundness of the whole orchestra is complete, without distracting exaggeration.

Clearly enough, the sharp, in-side-the-speaker stereo separation must be reserved strictly for music where there are in truth independent solo sounds that should logically be close to the speaker and from a point, rather than an area. The more sharp side-to-side effect, the less filling-out of the middle, the less over-all effect of being in a hall. Y'takes yr chree. . . .

Mendelssohn: Scherzo; Borodin: Nocturne; Schubert: Moment Musicale, etc. Fine Arts Quartet.

Concertape Stereo 22-3

Stereo Rating: 2

Dittersdorf: Quartet in E Flat; Turina; Prayer of Toreador: Wolf: Italian Serenade. Fine Arts Quartet.

Concertape Stereo 22-4

Stereo Rating: 3½

Quartet playing is a special stereo problem, since the four instruments normally play in a lump—and the bigger the hall, the less separation there is. In a small room, in a home, there is close-up separation but no big liveness. In the concert hall there is often liveness, distance—but no side-to-side separation at all.

The first of these tapes (curiously halfway between background music and serious listening music) is, if I'm right, a bit unbalanced in the tracks, one being stronger. Hard to tell exactly. And there is a certain ambiguity of placement, an odd feeling that the cello, for instance, is now here, now there. This might be faulty synchronization, tape stretching or the like, or simply an odd effect of the hall echo, which is rather large and full. Anyhow, it bothered me a bit, on two hearings, and so I give it a lowish stereo rating.

The second tape, which I played only in part, seems better, the quartet players are more firmly anchored down. Elusive, and I'm frankly not sure what the difference might be. So take it or leave it, but this one gets a higher rating, pro tem.

Both tapes are recorded in a rather live hall, which definitely takes them out of the living room and gives them a concert hall sound. Hence, logically, they should be on a distant stage, *without sidewise separation.* But instead they are actually quite close, and there is a clear separation.

To cope with this inconsistency of the literal effect, I had to pull the two speakers closer together—they were further apart than the physical width of a living string quartet! With this live, big-hall sound, they were blown up sidewise into an oversized orchestra at the wider spacing. Lovely effect, but utterly unnatural for the discriminating quartet enthusiast, to put it mildly.

Well, most listeners won't be too scrupulous about such things. If you aren't, just jack my ratings up, since the stereo effect is very definite here, as compared to the monaural effect. Interesting problem in recording, decidedly.

Incidentally—the playing of this group is first rate. I enjoy them more each time I hear them.

"The Hi-Lo's in Hi-Fi." ("Surrey with the Fringe on Top," etc.)

Omegatape Stereo ST 7006*

Stereo Rating: 2

This set of popular arrangements for band

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with close-up choral and solo group is recorded with fabulous fidelity—technically. The singing is ultra-clear, every breath can be heard. The band is in a live background, the singers very close in the foreground, in standard recording style. A fine record of its musical type.

But as to stereo, it's nothing much. In fact I found it easier to listen on only one track. The reason, I think, is that this is miked more or less in standard monaural style, with the voices greatly magnified over their "natural" volume level and recorded at close range. In stereo recording this won't do. It only makes for confusion, for unexpected grotesqueness—as if a group of giants were hovering in the air before you, singing.

I don't know the answer, but clearly stereo is going to have to develop new techniques for popular-type recording. This won't be easy, for popular music has long since become wholly dependent on the artificial balances of sound obtained by solo miking and trick liveness, and a "natural" positioning in space just doesn't exist for it.

Lenny Herman—Music in Motion.
1: Livingston T-1088-BN
2: Livingston T-1089-BN

Stereo Rating: (2)

It all depends on what you want. To my way of thinking this isn't stereo (or even binaural) at all. It's simply two-point recording. In one speaker you hear a piano, in the other an accordion. No liveness, no sense of space, either behind them or between them. Just the two points.

Interesting, and maybe it's a good idea for the series of salonish arrangements offered on these two tapes. That's why I rate it (2), with parentheses. It isn't stereo, but maybe it's good two-channel listening just the same, for those who are after this music. A legitimate, if limited effect.

Beethoven: Symphony #5. Boston Symphony, Munch.
RCA Victor Stereo ECS-7*

Stereo Rating: 4½

Mozart: Symphony #41 ("Jupiter"). Chicago Symphony, Reiner.
RCA Victor Stereo DCS-10*

Stereo Rating: 4

These two make an interesting comparison—the two great classic symphonists and two notable performing teams to go with them. In this music the stereo advantage is inherently less sensational than in the case of the colorful Richard Strauss and Bartok music, but the effect is musically helpful nonetheless, especially in the Beethoven.

The Fifth Symphony, in fact, is quite remarkable under stereo treatment—you hear for the first time things that clearly old Beethoven intended you to hear, notably the wonderful bounce of the hall echo, after his numerous short, violent chords. They are superb in stereo.

Moreover, the brass punctuation, very pronounced in this recording, is wonderful to hear; the pizzicato strings, the oboe solo, the tympani, all gain by the stereo spacing, within the great concert hall. (If ever music was concert hall music, this is it!)

As in other RCA Boston stereo recordings, the brass is here favored and loud, the strings somewhat dark colored and indistinct. In the Tchaikowsky "Pathétique" this has unfortunate effects on the musical continuity; but Beethoven's brass is the more effective for it. The transition, pianissimo, from the third to the last movement and the re-transition back to the last movement's main theme are particularly wonderful in stereo. Altogether a highly worthwhile stereo and I like the Munch straightforward interpretation.

Reiner's Mozart is more mannered and I'm not nearly as enthusiastic musically about it as his Strauss, which is unbeatable. The Mozart symphony, at Chicago, seems to be recorded with the front strings somewhat closer; they are shinier, sharper, more posi-

tively to left and right. The big-hall sound is less than in the Beethoven. Physically speaking, the stereo effect here is very pronounced, more so than in the Beethoven; but oddly, I don't feel that it makes as much *musical* difference. Beethoven really can use it. Mozart takes it or leaves it.

It's clear we're going to be living and learning with stereo, and I'm all for it.

Falla: El Amor Brujo. (No performers listed.)

Concert Hall Stereo—advance test.

Stereo Rating: 4

This was an advance test tape but should be available, along with others from Concert Hall Society, by press time. The test label forgot to mention the performers but the playing is excellent and so are the brief solos by the unknown lady singer.

Falla, like most moderns, is a good subject for stereo—lots of pin-point solo sounds, in the larger ensemble. This recording has a fine, big-hall sound, but I'd say it was miked a bit too close on both sides; there is more music definitely at each speaker than in the wide space in between. This exaggerates the stereo separation, and some will like it the more, but I feel that better musical realism comes when the over-all impression is more positive, the two speakers still less in evidence. Matter of taste, and this is a fine tape.

The solo voice is definitely at the left speaker, and quite close to the mike (in standard recording style) though her volume level is in reasonable proportion to the total sound, I'd like to hear her further away, on stage, and even less loud.

Stravinsky: The Fire Bird Suite. (No performers listed.)

Concert Hall Stereo—advance test.

Stereo Rating: 4½

Another Concert Hall Society test tape, from the first release on that label, which should be available by press time. This one, in spite of some trouble with too-near sides, is a musical whiz—because Stravinsky of this sort is terrific for stereo.

In this tape the sense of the hall and of the instruments spread out between the speakers is never lost, though there is a very sharp right and left separation—too sharp—of some of the end instruments. In this Stravinsky music the solo effects are so constant, so well spaced out, so transparently merged, that the sense of realism is hardly impaired at all by the over-emphasis of the two ends. Instruments, groups of instruments, are constantly being heard in the area between the speakers. The bass drum is particularly good.

A brisk, expressive performance, very showy and very businesslike. The dynamic range on the tape is tremendous—the opening notes are so faint as to be almost inaudible.

(Palestrina: Mass "Assumpta est Maria.") Palestrina: Magnificat; Stabat Mater.) Dessoff Choirs, Boepple.

(Concert Hall experimental stereo)

Stereo Rating: 5

These works, already available on LP disc, were also recorded in stereo and I was allowed to make a stereo copy—I was present and singing in the performance. I mention them here to express the hope that maybe they'll eventually be released on stereo tape; for the stereo effect of the large chorus is superb to my ear and the music without equal. There's nothing else quite like it in stereo form.

Here, too, the expanse of the performers spreads out, in a large, live hall, to seemingly huge dimensions, ultra-natural. Here, too, there are solo-like groupings coming from various areas, blending and merging; here, too, the hall itself and your feeling of being right in it, the chorus very much life-size before you, is really extraordinary. The music, for single and for double chorus, is sung with joy and musicianship, on pitch and in tune, the words shaped intelligibly and expressively. A fine sound, and so here's hoping. . . .

PREVIEW OF EXHIBITS

(from page 46)

result are remarkably compact. Despite their small size, however, their performance is without compromise. The Mark 30C, for example, has less than 0.1 per cent intermodulation even when operating at full output.

A fresh concept in the field of high-fidelity cabinetry will make its appearance in the **Cabinart** exhibit of **G & H Wood Products Co., Inc.** Cabinart will introduce a pre-finished kit version of many of its most popular models, including the Rebel series. All pre-finished kits

are provided with a hand-rubbed finish in a choice of Korina or mahogany. Also to be shown is the greatly expanded Cabinart line of standard kits, as well as the extensive assortment of finished Cabinart enclosures. Typical is Model 35, illustrated, a drop-front equipment cabinet with speaker enclosure.

Under the banner of **Capitol Records, Inc.,** division of **Electrical & Musical Industries, Ltd.** a demonstration of tape records and a tape-record reproducer will be shown. The equipment is part of the recently-introduced E.M.I. Stereosonic recording and reproducing system, a system which stems from research and developmental work by E.M.I. engineers going back to 1931. Dr. G. F. Sutton of the Record Division of E.M.I. will be in charge of the demonstration which bids fair to be one of the show's highlights.

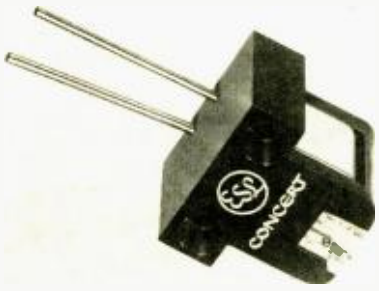
The new Colbert Model 3-CFD electronic frequency divider is certain to attract the attention of audio perfectionists who visit the exhibit of **Colbert Laboratory, Inc.** The divider affords complete range controls for three frequency bands, provides a h-f channel amplifier, eliminates impedance mismatch, and permits optimum damping for individual loudspeakers. It may be used with cone-type of electrostatic speakers, or combinations where both types are employed.

Collectors of sound, both usual and unusual, will have a field day in the exhibit of **Dauntless International,** record distributors. Specializing in unique records with excellent fidelity, Dauntless will have on demonstration literally hundreds of records representing the *Replica* and *Audio Fidelity* labels. Some of the more intriguing titles are: *The Brave Bulls*, recorded in Mexico, a hi-fi presentation of the complete musical background of an afternoon at the bullfights; *Bach for Percussion*, regarded by many collectors as the most exciting and original percussion work yet to be recorded; *Bawdy Songs and Backroom Ballads* in which Oscar Brand, noted folk singer, sings for people with lusty appetites and strong musical tastes.

Visitors to the show will see the first New York showing of the Dynakit 50-watt power amplifier kit manufactured by **Dyna Company** of Philadelphia. As most audio hobbyists know, because of

its remarkable performance the Dynakit has achieved an acceptance seldom accorded equipment so soon after its being placed on the market. The kit, reviewed on page 54, includes a pre-wired printed-circuit board on which most of the wiring is complete, thus permitting complete assembly by a novice in less than three hours. Dyna will also introduce a new preamplifier kit with exceptional performance characteristics.

Superb reproduction of records will be keynoted in the exhibit of **Electro-Sonic Laboratories** whose celebrated ESL cartridges are characterized by extremely low dynamic mass, high compliance, and very little distortion. Various models of



the ESL cartridge will be on demonstration, ranging from the modestly priced "Soloist" which can be used with most high fidelity equipment, to the "Professional" which must be teamed with the ESL Model 310 transcription arm in order to realize its superb potential.

A raft of pleasant surprises is in store for the engineer and the hobbyist alike when they visit the **Electro-Voice, Inc.** exhibit. The new E-V Model 3303 stereophonic AM-FM tuner incorporates virtually every feature which could be desired in an audio control center. Highlighting the latest E-V developments in hi-fi cabinetry will be the new Model EV881 equipment console which will receive its first public showing. This is the first in a number of console designs which will be forthcoming in the near

future. Broadcast and recording engineers will find all of the newest E-V microphones on display. Completing the exhibit will be the extensive line of E-V speakers and the new "80" series ultra-linear ceramic cartridge.

Ercona Corporation of New York, American representative for a number of British-made high-fidelity products, will introduce the new Connoisseur three-speed hysteresis-motor turntable, the

Mark II pickup cartridge with diamond armature, and the complementary lightweight balanced arm. Versions of special equipment for use with Ferrograph tape decks will be introduced in four different series. Also slated for display are some high-quality FM tuners and a complete line of hi-fi speakers.

Bearing out the synonymity which has long existed between the words "Fairchild" and "moving coil," **Fairchild Recording Equipment Company** will intro-

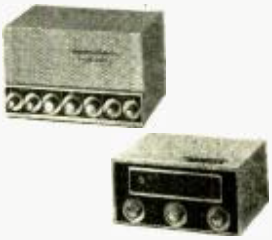
duce its new "Micradjust" moving-coil pickup cartridge. Construction of the Micradjust permits extremely fine adjustment of damping after final assembly and test. As a result each individual cartridge is hand adjusted for optimum performance. Sharing honors with the car-

HARVEY Reports on HI-FI

September-October, 1956

The woofs and tweets of the New York audio show season will be echoing in thousands of ears, golden and tin, by the time most of you read this — and HARVEY'S, New York's traditional rendezvous for audiophiles, will be buzzing with "Have you heard . . ." and "Is it better than . . ." and "How soon will you have it . . ." and all the other queries about the debut-making new components. But HARVEY'S veteran audio consultants are not given to crystal-gazing — they believe in a "let's wait and see" period before going all-out for any new development. They are certainly all-out for the time-proven equipment we are reporting on this month — it's the kind that can weather years of audio shows without obsolescence.

Take the wonderful **Garrard 301** transcription turntable, for example. It's not the newest on the market, but many top-ranking experts still prefer it to any other. G. A. Briggs, for one, has been using it in all of his celebrated concert-hall demonstrations. The Audio Instrument Company, Inc., an independent laboratory, recently tested three random samples of it and came up with sensationally low wow and rumble figures, far exceeding the most stringent professional requirements. The Model 301 is made with typical British attention to fine details — such as ball bearings where others use only bushings. It is one of the very few top-flight turntables with variable + or — fine adjustment on each of the 3 speeds — indispensable for playing with perfect pitch those off-pitch records that have been so much discussed lately. Best of all, it costs only $89.00.



Then consider the **Stromberg-Carlson AR-420** *amplifier and* **SR-402** *tuner. Nothing flashy about them — just straightforward, proven circuitry . . . careful physical design . . . solid workmanship . . . a sure bet for the discriminating audiophile! The AR-420 is a 25-watt job with a pair of 6L6G's for output. It incorporates on the same chassis a highly versatile preamplifier with continuously variable turnover and roll-off controls for phono equalization — the only off-beat touch, but an impressive one . . . The SR-402 is a deluxe AM-FM tuner featuring an exclusive dynamic cascade noise limiter and a temperature-compensated driftless oscillator. Sensitivity is rated at 1.5 μv for 20 db quieting. Prices are eminently reasonable in view of the obviously high quality — $109.95 for the AR-420 amplifier, $159.50 for the SR-402 tuner.*

Another obsolescence-proof, gilt-edged audio security is the **Ampex 601** tape recorder. This is the new, improved version of the Ampex 600, the epoch-making little 7½ ips portable tape recorder that sounded just like the big Ampex professional 15 ips console jobs. Can't ask much more than that from any tape machine . . . The improvements incorporated in the 601 are not in overall design, which could hardly be improved, but in minor details important to a number of users. Both input and output have been changed to low impedance to suit all professional requirements . . . the safety button for "record" is now illuminated . . . the Samsonite case is a new and very handsome shade of tan . . . a few additional small physical changes make for added convenience. Price is still $545.00 and worth the dent in anyone's hi-fi budget . . .

When it comes to loudspeakers, new designs may come and go, but **Jim Lansing Signature** *speakers outlive (and outsound) most of them. The extra care that goes into the design and construction of these beautiful units has been proverbial since the dawn of hi-fi. Here's a recipe for a Jim Lansing combination that's hard to beat at the price: Take the Model D123 12-inch extended range speaker ($54.50). This is the recent and much-admired Jim Lansing design with the 3⅝" depth (!), 3" voice coil and 35 cps cone resonance. Put it into the Model C36 reflex enclosure ($51.30, blond or mahogany). Add to it the Model 075 high-frequency unit ($54.50), the unique ring-type radiator developed by James B. Lansing Sound. Cross over at 2500 cps by means of the Model N2500 dividing network ($15.00). Sit back and enjoy superb sound for a total of only $175.30!*

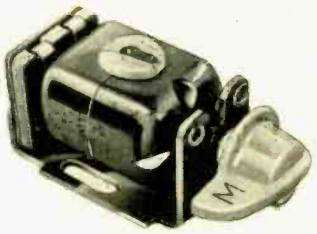
To mention just one relative newcomer, let's look at the **Fisher FM-40** FM tuner. It's already in the "old-reliable" category, anyway, being simply one of the newer units in a thoroughly field-tested line of high-quality Fisher tuners. This one is compact and outstandingly stable and drift-free — as well as quite moderately priced. It has simplified controls and a very neat little meter for accurate center-of-channel tuning. Sensitivity is stated to be 3μv for 20 db quieting. An unusual feature is the provision of three different outputs: cathode follower, detector and multiplex. All this comes for just $99.50, plus $14.95 extra for mahogany or blond cabinet.

Again, a reminder that you can order by mail from HARVEY'S just as easily as "come and get it." Many of our best customers wouldn't do it any other way. They just add some extra money for postage and let HARVEY'S and the U.S. Post Office Department do all the hard work. Excess postage is promptly refunded, and HARVEY'S money-back guarantee covers any subsequent complaints, which are about as rare as people with 22,000 cps hearing . . .

HARVEY RADIO CO., INC. 1123 Avenue of the Americas (6th Ave. at 43rd St.), New York 36, N.Y. JUdson 2-1500

tridge will be a new amplifier, currently under wraps, which is described as "unlike any previously commercially available."

Fenton Company, New York, will cover many audio interests in an exhibit which will feature the new Motek Type K7 tape deck, the Fen-tone P-7000 reversible magnetic cartridge, and an improved professional-quality multi-impedance velocity microphone. The K7 tape deck includes three independent a.c. motors. It incorporates such other features as positive interlock of all switching and braking mechanisms, including automatic pinch-roller and pressure-pad assembly. The P-7000 cartridge numbers among its features remarkably low distortion, frequency response from 20 to 18,000 cps, ±2 db, and a tracking force of 5 to 9 grams. The microphone to be introduced



is the B&O Model 53, similar in most respects to the well-known Model 50 except for the multi-impedance feature.

Of all equipment displayed at the IHFM show, there is every reason to believe that none will excite more approbation than the Model TR-1 all-transistor preamplifier-equalizer to be exhibited by **Fisher Radio Corporation.** Equipped with both phono and microphone inputs, the TR-1 is the first all-transistor high-fidelity preamplifier, and is characterized by ab-

solutely zero hum and microphonism. Other new Fisher products which are certain to come in for a great share of attention are the new Model CA-40 master control amplifier, a 25-watt amplifier and preamp on a single chassis, and the Model 55-A 55-watt laboratory-standard power amplifier.

General Electric Company will feature its new Model A1-401 "Golden Co-Ax" 12-in. coaxial speaker. Introduced as the finest speaker GE manufactures, the A1-401 is an advanced high-fidelity reproducer combining a 12-in. woofer, a 2¾-in. tweeter, and a built-in electrical-mechanical crossover network. It is remarkably

free of distortion over its entire frequency range of 40 to 15,000 cps. Power handling capacity of 25 watts and a most moderate price are other features which mark the "Golden Co-Ax" as an outstanding high fidelity value. Amplifiers, pickups, record-playing accessories, and custom cabinetry will emphasize the extent to which GE is moving forward in the high fidelity field.

Operating stability never before realized is claimed for the new 50-watt high-fidelity amplifier which will be featured in the exhibit of **Gray Research & Development Company.** Full power output with less

than 1 per cent intermodulation, and linear frequency response from 6 to 100,000 cps are among its features. Another new Gray development which will be on display is a custom-built sound reproducing system for use in hotels, churches, concert halls, etc. Demonstrations will include use of the well-known Gray viscous-damped tone arm as a means of preventing damage to recordings and pickup cartridges in audio-visual classes where children are permitted to play records.

Harman-Kardon, Inc., whose pioneering in the use of printed circuits for tuners and amplifiers has led to reduced size without sacrifice of quality, will give first public showing to the new Theme II AM-

FM tuner and the Festival II complete high fidelity system. Although mounted on a single chassis only 4 inches high, the Festival II incorporates a high quality AM-FM tuner, a hi-fi preamplifier complete with full control facilities, and a 40-watt power amplifier.

British-made Mullard tubes, particularly of the audio-frequency variety, will

be the center of attention in the exhibit of **International Electronics Corporation**, Mullard distributors in the United States. In addition to the EL-34, already well-known in this country, there will be introduced the EF-86, a pentode which is one of the most widely used high-fidelity tubes in Britain today. Another inviting feature of this exhibit will be a demonstration two new Mullard amplifier circuits used in conjunction with the new Mullard Alto Bass 12-in. coaxial speaker.

Jensen Manufacturing Company has chosen the IHFM show for the first public display of its new Contemporary speaker systems. Slanted toward the medium-priced market, the Contemporary reproducers are available as both two- and three-way systems. The Model CN-82 two-way system makes an excellent "starter," which can easily be converted to a three-way system with the KTX-1 Range-Extender Kit without cabinet modifications. In addition, the exhibit will include the entire current line of Jensen high-fidelity speakers.

A new Klipsch corner-horn loudspeaker system will be shown for the first time by **Klipsch & Associates.** Designed so that it may be used as a television base, the unit is equipped with a Klipsch 3-way drive system and has a frequency range of 40 to above 22,000 cps. One of the new systems will be given to the visitor to the Klipsch space who wins a name-choosing contest. Identified temporarily as the Model T, it will be christened after the winning name is selected.

Three new additions to the Signature line of speakers and accessories will be introduced by **James B. Lansing Sound, Inc.** The Model 075 high-frequency radiator has a non-resonant frequency response from 2500 cps to beyond the range

of audibility. When used with the new Type N2500 dividing network, it is ideal for complementing the performance of Signature extended-range speakers, such as the well-known Models D-130 and D-31. The third new item to be featured in the Lansing exhibit is the "Harlan" enclosure for multiple speaker systems.

Those who seek perfection in speaker performance will do well to strike a beeline for the exhibit of **L.E.E. Incorporated**, where the new LEE Super Catenoid will be on demonstration. The Catenoid is a three-way speaker system using a folded catenoidal corner horn for the bass end of the spectrum. Also on display will be the LEE Trio, a modestly-priced three-way system consisting of a woofer and two tweeters.

A new tape recorder engineered to meet every requirement of the most exacting professional application will be unveiled for the first time publicly by **Magnecord, Inc.** Designated Model PT-6P-AC'X, the new machine is powered by three motors, including a two-speed hysteresis-synchronous drive motor, and is

push-button controlled. Editing and cueing have been simplified to the ultimate on his newest Magnecord which is available either for rack mounting or in a portable carrying case.

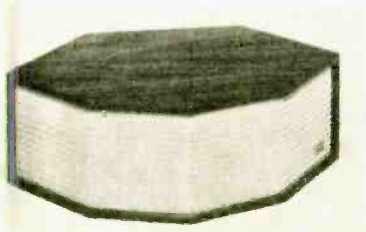
Those who seek both beauty of design and perfection in performance will approach the goal of their quest in a visit to the exhibit of **Marantz Company.** Here they will find an advanced version of the Marantz audio consolette which was one of the highlights of the 1954 Audio Fair, and a production model of the new

Marantz power amplifier which was shown in prototype form in 1955. Together, the Marantz combination represents music reproduction in its highest form.

National Company, Inc., along with showing its complete line of tuners, amplifiers, and speakers, will introduce its new spectacular-performing little "Synfonette" speaker system. Although only 8"d x 14"w x 9"h, the Synfonette rivals

many units much larger and more costly. It is especially well suited for use with stereo systems where space is limited. If you are a Manhattan cliff dweller, and just haven't the room for a large speaker system, you will find a visit to the National exhibit completely rewarding.

Skepticism about the durability of electrostatic speakers should be reduced by a visit to the exhibit of **Neshaminy Electronic Corporation**, whose JansZen Model 1-30 now carries a two-year warranty on the electrostatic radiators. The JansZen, while not an entirely new product, in re-



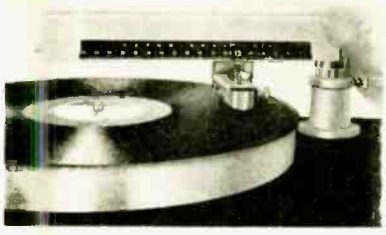
cent months has gained nation-wide attention in keeping with current enthusiasm over electrostatic reproducers. Its patented push-pull constant-charge design permits high power output, high efficiency, and extremely low distortion. Total harmonic distortion is less than 0.5 per cent at 50 watts input between 500 and 10,000 cps.

The Norelco automatic record changer, and a comprehensive group of Norelco speakers with recommended matching enclosures will be featured in the exhibit of **North American Philips Company, Inc.** Made in Holland, Norelco speakers are characterized by their unique "twin cone" construction, in which the smaller of two cones acts as an acoustical generator for frequencies above 10,000 cps and as a diffuser for lower tones. The larger cone acts as a generator below 10,000 cps and as a reflector for notes above this frequency.

Inanimate though magnetic recording tape may be, there will be no lack of animation in the manner of its display by **ORRadio Industries, Inc.**, of Opelika, Ala., makers of tape bearing the "Irish" trade name. For the professional fraternity, Irish will introduce its new VTR

(Video Tape Recording) tape, capable of recording a one-hour TV show, both video and audio, on a single 12-in. reel. Amateurs and pros alike will find interest in the new Irish Green-Band Tape No. 211, now produced by the company's exclusive Ferro-Sheen process, and in the new Irish "No-Spill" reel which alleviates the tape-spillage problem.

A new model of the Ortho-Sonic V/4 tone arm, priced lower than the present model, will be starred by **Ortho-Sonic Instruments, Inc.** Designated Type 100, the new unit retains all features except that it will not play transcription-size rec-



ords, being limited to records up to 12-inch. The current Model 200 will be continued. Another new Ortho-Sonic product to be introduced will be a variable-speed 12-in. manual turntable in the top quality bracket.

The trend toward stereophonic tape recordings will be forwarded by **Pentron Corporation** with the introduction of its new Model PS-1 stereophonic tape player. The PS-1 plays either stacked- or stag-

gered-head stereo, as well as full- or half-track conventional recordings. Also on display in the Pentron exhibit will be the Pentape recorded library, the complete line of Pentron tape recorders, and the Model MM-4 4-position electronic mixer which greatly enhances the flexibility of any tape recorder.

Along with the superb Fluxvalve pickup cartridge, **Pickering and Company, Inc.,** will feature an impressive demonstration of its Models 580 and 581 "Isophase" balanced push-pull electrostatic speakers. The two units differ only in size and frequency range, the 581 going

down to 400 cps and the 580 to 1000 cps, with both flat to well above 30,000 cps. Unlike conventional cone speakers which drive small amounts of air at high velocity, the Isophase speaker introduces sound into the air at low velocity, closely approximating the unit-area energy of the original sound entering the concert hall or studio microphone.

Along with introducing a new, comprehensive group of tuners and amplifiers, **Pilot Radio Corporation** will unveil its new line of Component-Console music systems. Within handsomely-styled enclosures, Pilot has assembled and installed famous identifiable high-fidelity components, thereby originating a new concept in high fidelity—"component quality with console convenience." Highlighting the Component-Console models

is the Pantheon series, a magnificent group of music systems styled to gratify the most discerning taste.

A new high-fidelity AM-FM tuner, designed as a matching unit for Grommes amplifiers, will be introduced in the exhibit of **Precision Electronics, Inc.** Also spotlighted will be a modified kit version

of the Grommes Model 61PG 20-watt hi-fi amplifier. The Model GRT-3 tuner affords FM sensitivity of 2 microvolts for 20 db quieting, 200 kc bandwidth at 6 db down, and frequency response of 20 to 20,000 cps within ±0.5 db. A tuning meter is in-

corporated which operates on both AM and FM. The 61PG kit is a complete single-unit amplifier with built-in pre-amplifier and all controls. It offers exceptional performance and is very modest in price.

Presto Recording Corporation, one of the oldest companies in the recording equipment field, will be featuring its high-fidelity Pirouette turntables, including both 12- and 16-in. models. New in

the Pirouette line is a two-speed model (33-1/3 and 45 rpm) in the low-price range. Also being shown is the improved Presto Model K-11 portable disc recorder. Professional disc and tape equipment will be in abundance.

A new principle in cone suspension which permits extremely large motion, lowers resonant frequency, and introduces "pneumatic damping," will be seen in the exhibit of **Racon Electric Co., Inc.** Racon high-fidelity speakers use the HI-C (high compliance) suspension with the result that there is practically a "free edge" cone having great flexibility without mechanical restraints or magnetic non-linearity. Illustrated is the Model 12 HTX, a tri-cone three-way unit. Other items to be shown will be the entire line of Racon industrial speakers, also a variety of tweeters, horns, woofers, and crossover networks.

Among the many striking cabinets at the show, none is likely to excite more favorable comment than the "Styled-in-California" series of complete home music

systems introduced by **Radio Craftsmen, Inc.** Also to be shown is an entirely new line of Craftsmen tuners and amplifiers, a compact high-fidelity table model record player for use with an external speaker, and a matching three-way speaker system. Be sure and get a look at those gorgeous enclosures.

Beauty of design and a high standard of audio performance are combined in the representative line of tuners and amplifiers which will be demonstrated by **Rauland-Borg Corporation.** Of particular

interest to music lovers is the Model TV 55 television sound tuner, which permits the enjoyment of TV sound with the same wide-range quality you experience when listening to hi-fi FM. It also permits full-fidelity recording of your favorite TV programs.

New to the American audio scene is the Tandberg tape recorder which will be featured in the exhibit of **Reeves Equipment Corp.** of New York. Manufactured in Sweden, the Tandberg will be shown in several models including a 3-speed dual-track machine whose frequency response is stated to be 30 to 15,000 cps at 7½ ips. Also of distinct interest is the Model 2F, a two-speed recorder which incorporates solenoid relays to permit remote operation by a foot-pedal switch. The operating pedal governs start, stop, rewind, record and erasure. Reeves also will exhibit Grampian-Gotham professional recording equipment and some imported hi-fi speakers.

Reeves Soundcraft Corporation will accent professional equipment in a display which will include such commercial items as magnetic recording film, recording discs, and a new cueing disc which has been designed to help the radio disc jockey with his cueing and change-over problems. For both home recordists and professional recording engineers Reeves will have on hand its entire line of magnetic recording tape.

Although the **Rek-O-Kut Company** exhibit will include a wide variety of precision record-playing equipment, the spotlight will beam on the new Rondine Series turntable and turntable arm, both mounted on the handsome Rondine base. Truly a pioneer in turntable manufacture, Rek-O-Kut this year is introducing its first tone arm designed primarily for home use. The Rek-O-Kut arm is preci-

sion-built throughout, though moderately-priced. Among its features is an adjustable counterweight which may be used to alter stylus pressure, the change in pressure being at the rate of one gram per one-and-a-quarter turns of the weight.

Two new additions to the Goodmans line of high fidelity speakers will be shown by **Rockbar Corporation,** distributors in the United States for the British firm. The Trebax is a high-frequency reproducer with a built-in horn. Frequency response extends to 15,000 cps and crossover is at 5000 cps. The Midax, pictured, is a mid-range reproducer consisting of a pressure driver and horn unit designed to cover 400 to 8000 cps.

Ronette Sales Corporation intends to exhibit the complete line of Ronette microphones, with particular emphasis placed on the new Slim Ronomike which is illustrated. Flat frequency response of the Slim Ronomike is 30 to 10,000 cps, and distortion is stated to be so low that it defies measurement. Also on exhibit will be some radically new Ronette die-cast tone arms and the well known Fonofluid 12 and 16-in. transcription arms. The display will be completed with a showing of the entire line of Ronette high quality pickup cartridges.

Unique in the sense that it will be the only instrument of its type on display, the Schober electronic organ kit, exhibited by **The Schober Organ Corporation,** is certain to duplicate the sensation it created when it was first shown publicly at the 1955 audio show. Designed primarily for home construction, the Schober kit offers an instrument of superb quality at a price which places it within reach of modest incomes. A completed organ will be on demonstration throughout the show, and various parts of the kit will be available for examination.

A newly-designed AM section affords reception entirely comparable to FM in the new Type 330-B AM-FM stereo tuner which will be featured in the exhibit of **Hermon Hosmer Scott, Inc.** The 331-B tuner is identical except that it includes a complete equalizer and preamplifier.

Another new Scott product which is certain to excite great interest is the Type 210-E Dynaural amplifier. The improved Dynaural noise suppressor has provision for rumble suppression only, scratch suppression only, or for both rumble and scratch suppression.

A new FM tuner, and a low-boy version of the Forester speaker with matching equipment cabinet, will be introduced by **Sherwood Electronic Laboratories, Inc.** The Model S-3000 tuner is outstanding in its sensitivity of 1.2 microvolts for 20 db quieting, a degree of performance

stemming from use of the new 6BS8 low-noise cascode input tube. The Sherwood cabinetry is handsomely finished in natural walnut, and is designed to meet the demand for lower furniture which can be located conveniently beneath a window in the popular ranch-type home.

For the budget-minded hi-fi fan **Mark Simpson Manufacturing Co., Inc.**, will introduce the Masco Model AFR, a decorator-styled single-chassis FM-AM tuner and 10-watt amplifier priced under one hundred dollars. Included in the AFR is a quality preamplifier permitting the use of any top-grade phono pickup. It is fully equalized for all microgroove records, including RIAA as well as 78's, and has separate bass and treble controls. Smartly faced with a front panel finished in gold, and encased in a telephone-black enclosure, the AFR has an illuminated tuning scale with flywheel control.

Transducers, electro-mechanical and electro-acoustic, might well be regarded as the governing theme of the **Sonotone Corporation** exhibit, which will feature pickups and speakers. The pickups are various models of the Sonotone "3" series of ceramic cartridges whose remarkable performance at high output makes preamplification unnecessary. The Sonotone Linear Standard speaker system utilizes true acoustical damping to achieve exceptional sound reproduction.

Stromberg-Carlson Company, in addition to showing an entirely new line of high-fidelity components, will introduce a group of complete home music systems housed in cabinetry which is a decorator's dream. The various systems are made up of the same amplifiers, tuners and speakers which can be bought as separate components. Seeing and hearing these instruments will be a thoroughly rewarding experience.

The reputation for building fine sound equipment which the company has established in previous audio exhibits, will be well evidenced by **Tannoy (America), Ltd.,** in a display which features, in addition to the well-known Tannoy dual-concentric speaker systems, a new preamplifier-amplifier combination. The preamp is known as the "Autograph" and contains virtually every desirable facility for music reproduction. The amplifier is a complementing 30-watt unit built to high standards of precision. A number of improved Tannoy woofers and tweeters will also be shown.

Record playing equipment and accessories along with a new line of high-

(Continued on page 88)

CONVENTION PROGRAM

(*from page 12*)

TRANSISTOR INPUT STAGE FOR PHONOGRAPH PICKUPS

H. C. Lin, CBS-Hytron, Semiconductor Operations

Transistor input stages of different configurations for either inductive- or capacitive-type phonograph pickups are considered from the standpoint of signal-to-noise ratio, frequency response, distort on and sensitivity.

1:30 p.m. TECHNICAL SESSION: AUDIO SYSTEMS AND COMPONENTS.

Clair D. Krepps, MGM Records, Inc., Chairman.

BASIC REQUIREMENTS FOR A STEREOPHONIC SYSTEM

Norman H. Crowhurst, Audio engineering consultant

The exact reproduction of a three-dimensional sound field is impossible so perfect stereophony cannot be realized. The success of any practical system must depend upon the degree to which it achieves an illusion of realism. The so-called "true" stereophonic is not so effective as artificially improved versions. The basic requirements for an economic stereophonic system using single channel recording are deduced and demonstrated.

AUDIO IN SALMON RESEARCH—A FISH DETECTION SYSTEM AT BONNEVILLE DAM

Richard H. van Haagen, U.S. Dept. of Interior, Bureau of Fisheries

A master-oscillator multiple-detector system for following the movement of adult salmon through a series of underwater orifices is described. A sinusoidal audio-frequency oscillator supplies individual conductivity bridges; the unbalance due to fish passage, amplified, operates a relay; the make-break differential of the relay supplies an annunciator action, which switches lights at a central control rack and discovers each fish.

MODERN CONSTRUCTION OF VELOCITY MICROPHONES AND THEIR APPLICABILITY FOR BINAURAL RECORDING AND AS ACOUSTICAL MEASURING INSTRUMENTS

E. Rorbaek Madsen, Bang & Olufsen A/S, Denmark.

This paper will describe the B&O-53 ribbon microphone and the principles and practical possibilities of obtaining stereophonic effects with two loudspeakers, making use of the intensity principle. The applicability of the B&O mike for this purpose will be shown, and the importance of the acoustical separator will be explained. A special use of the B&O mike which has been of considerable use when measuring reverberation time in cinemas and concert halls will be mentioned.

THE LIBRARY OF NATURAL SOUNDS AT CORNELL UNIVERSITY

Peter Paul Kellogg, Laboratory of Ornithology at Cornell University.

This paper describes the unique library in which there are over 10,000 recordings of natural acoustic phenomena, mostly the voices of birds, available to scholars for scientific study. Methods of editing, cataloging and handling are discussed.

SHIPBOARD ENTERTAINMENT SYSTEM

R. T. Van Niman, Bureau of Ships, Department of the Navy, Washington 25, D. C.

AUDIO AUTOMATIC GAIN CONTROL DEVICES

F. J. Bias, Studio Facilities Engineering, Broadcast Equipment, General Electric Co.

Automatic audio gain control devices manufactured by the General Electric Co. will be discussed.

7:00 p.m. EIGHTH ANNUAL BANQUET.

Mitch Miller, guest speaker.

Presentation of the Society's Annual Award, John H. Potts Memorial Award, Emile Berliner Award, Honorary Memberships, and Society Fellowships.

Friday, September 28.
9:30 a.m. TECHNICAL SESSION: HOME MUSIC SYSTEM DESIGN.

R. D. Darrell, Stone Ridge, N. Y., Chairman.

A PRACTICAL COMMERCIAL OTL POWER AMPLIFIER

Julius Futterman, Harvard Electronics Co.

An OTL power amplifier isolated from the a.c. line and so constructed as to have UL approval is described in this paper. It is capable of supplying 60 peak watts of program material into a conventional high-fidelity loudspeaker system. The IM distortion is phenomenally low and the transient response unequalled by conventional power amplifiers. It can be driven to maximum output with conventional preamplifiers.

REQUIREMENTS FOR AN INTEGRATED HIGH FIDELITY SYSTEM

Chester A. Snow, Jr., Gray Research & Development Co., Manchester, Conn.

A general discussion of the problems to be considered in the design and manufacture of a quality integrated high-fidelity system for the home. Such a system as developed by the Gray Research and Development Co. is described in detail. Reasons for selection of various major components and their operating features are given. Cabinetry which is both functional and stylish will be outlined.

EVOLUTION OF THE PHONOGRAPH

Oliver Reed, Publisher, "Radio and Television News" and "Popular Electronics"

The development of the transducers of Edison, Berliner, and Johnson will be discussed. The paper will describe and illustrate techniques which emphasize the significance of the original acoustical devices and their contributions to the development of the audio art and to the hi-fi industry of today. The author will also display and describe Phonographs, Gramophones and Talking Machines from his historical collection.

A NEW APPROACH TO PICKUP-ARM DESIGN

Walter O. Stanton, Pickering and Co., Oceanside, N.Y.

Recent engineering studies have disclosed that pickup-arm design can be improved by more attention to hitherto overlooked factors, with particular respect to current lightweight pickup development trends.

NEW TRENDS IN HIGH FIDELITY TUNER DESIGN

Robert E. Furst, Harmon-Kardon, Inc., Westbury, N.Y.

Progress in AM-FM tuner design is centered more around the adoption of new assembly techniques. The etched wiring board is revolutionizing electronic mass production methods. The use of component inserting machines, conveyor lines, mechanized inspection and test will be explored. A major problem is the reduction of incidental oscillator radiation in compliance with new FCC regulations. Design criteria and test methods will be discussed.

A PROFESSIONAL APPROACH TO HOME RECORDING SYSTEMS.
Philip Erhorn, Audiofax Associates, New York, N. Y.
Integration of studio-type equipment into rack mounted home monaural and stereo installations.

Friday, September 28.

1:30 p.m. TECHNICAL SESSION: LOUDSPEAKERS.

Philip Erhorn, Audiofax Associates, N. Y. C., Chairman.

ACOUSTIC HORN STRUCTURAL MECHANICS AND RELATED PERFORMANCE
Abraham B. Cohen, University Loudspeakers, Inc., White Plains, N.Y.

A HIGH-FREQUENCY UNIT
Charles D. Lindridge

This paper will describe a unit with associated loudspeaker for producing sound of high frequencies. The basis upon which the unit has been constructed will be described, the author's belief being that a specific frequency is important only when it is within the range in which listeners have pitch discrimination.

PROBLEMS OF BASS REPRODUCTION IN LOUDSPEAKERS
Edgar M. Villchur, Acoustic Research, Inc., Cambridge, Mass.

The special problems of speaker bass performance, harmonic distortion, frequency range, and uniformity of response will be discussed. The author will give different approaches to their solution and outline some misconceptions about speaker damping.

MIDRANGE SPEAKERS
Paul W. Klipsch, Klipsch & Associates, Hope, Arkansas

Some response curves explain why certain midrange and "top end" speakers sound as they do. One straight axis midrange unit has constituted part of a sys-

tem whose output is audibly indistinguishable from the original sound. In contrast, a reflexed horn with a series of peaks and deep troughs gives an "empty house" effect. The middle range is what we are most sensitive to and which, if wrong, is more irritating than in the extremes.

THE USE OF ANALOGS IN OPTIMIZING LOUDSPEAKER PERFORMANCE
George W. Sioles, University Loudspeakers, White Plains, N.Y.

FLIGHT DECK LOUDSPEAKERS
Purcell J. Dansberger, Bureau of Ships, Department of the Navy, Washington 25, D. C.

A description of the technical problems, both electrical and mechanical, leading to the design of 6000-watt sound distribution systems for flight-deck coverage for the new Forrestal-Class of super aircraft carriers.

Saturday, September 29.

9:30 a.m. TECHNICAL SESSION: STANDARDS AND MEASUREMENTS.

Walter O. Stanton, Pickering & Co. Inc., Chairman.

THE CONSUMER LOOKS AT STANDARDS
Donald M. Berk, Consumers' Research, Inc.

A brief discussion of the need for standards for home reproduction components. Recommendations for minimum standards on certain items used by the non-expert consumer of hi-fi equipment will be offered.

INDUSTRY BENEFITS FROM STANDARDIZED MEASUREMENT PROCEDURES
Julian D. Hirsch, The Audio League

Many readers of competitive advertising have been confused because manufacturers of most types of high-fidelity components have not fully standardized their measurement techniques. This ambiguity is more severe in connection with phono pickups and loudspeakers. It is therefore desirable that each manufacturer state the conditions under which his claimed results were obtained.

PROPOSED STANDARDS FOR LOUDSPEAKER MEASUREMENTS
John E. Karlson, Robert Hutchison, Karlson Associates, Inc., Brooklyn, N.Y.

The author points up the needs of the Audio industry for standards of measurements, particularly as they apply to tranducers. He outlines a procedure for evaluating loudspeakers.

"EQUIPMENT REPORT" TESTING METHODS
C. G. McProud, Editor and Publisher, AUDIO Magazine, Mineola, N.Y.

The author will describe the measuring equipment and test methods used in evaluating audio components for AUDIO magazine's "Equipment Report." Since there are no accepted standards for audio measurement which apply to consumer-type equipment, it has been necessary to establish procedures which are duplicable from unit to unit. Basically, the "Equipment Report" serves to substantiate the manufacturer's claims of performance.

1:30 p.m. TECHNICAL SESSION: LOUDSPEAKERS II.

Richard B. Olmsted, Olmsted Sound Studios, N. Y. C., Chairman.

A HIGH QUALITY HIGH POWER LOUDSPEAKER SYSTEM
R. T. Bozak, The R. T. Bozak Mfg. Co., Darien, Conn.

This paper covers the review of design considerations for and illustrates the exceptional reproducing system for use in a theatre.

A NEW FULL RANGE LOUDSPEAKER
Theodore Lindenberg, Pickering and Company, Inc., Oceanside, N.Y.

Circle 81A→

BAFFLES UNBAFFLED

(*from page 42*)

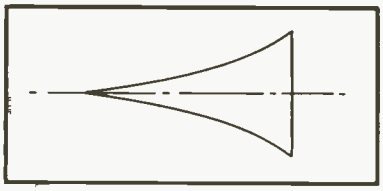


Fig. 27. Cross section of exponential horn from throat to mouth.

quite impracticable for most people.

One way of overcoming this is to flick through the pages of some of the magazines devoted to this subject, and one will find designs and advertisements for horns fully capable of maintaining a high radiation efficiency down to 20 cps constructed within a space of about five cubic feet.

We have no comments to offer.

Commercial Folded and Corner Horns

Horns of this nature have come into prominence in recent years, particularly in the U.S.A. and they are a compromise between performance and size. The Klipsh corner horn is accepted universally as one example of this. First introduced by Klipsh, the corner horn, as its name implies, is a folded horn with the final fold formed by the corner and the walls of the room (*Fig.* 28).

Using this artifice, a horn may be made to radiate down to 40 cps without being excessively big. On average, however, the lower frequency limit of these horns is about 60 cps, and one should beware of claims setting this frequency at a much lower figure. Above this frequency, of course, these horns are very efficient indeed and are capable of very impressive reproduction. Indeed, so great is the radiation at these frequencies compared with the middle and upper frequencies that in some designs the bass may be excessive.

There are many different designs of these horns. Usually the rear of the cone is horn loaded and the upper frequencies are radiated from the front in the usual way. In this case, the bass radiation from the front of the cone is small compared with that from the mouth of the horn so the question of cancellation does not arise.

An alternative system is to enclose the rear of the speaker in a small bass chamber and use the mass reactance of the horn loading in the front face to overcome the stiffness reactance of the chamber.

In the well known Voigt corner horn the rear of the loudspeaker is loaded by a tuned tapered pipe, and the position of the loudspeaker in the pipe is so chosen that the acoustic impedance presented to the cone over a wide bond of bass frequencies provides optimum loading for the voice coil. A good radiation efficiency is secured by means of the pipe resonance, which is distributed over a wider range of frequencies by virtue of the taper.

The front of the cone is loaded by a small flare which increases the high frequency efficiency and improves distribution. A schematic diagram of the enclosure is shown in *Fig.* 29.

Summary

1. The Labyrinth is designed to absorb all the back radiation from the cone without introducing any resonance

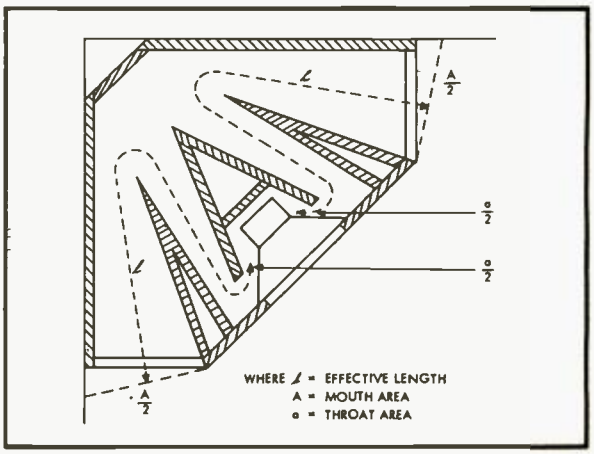


Fig. 28. Back-loaded folded horn in horizontal cross section.

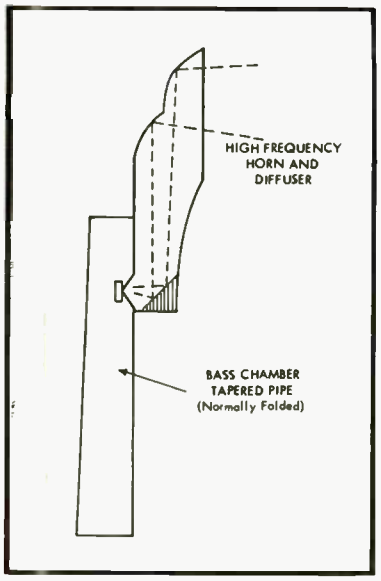


Fig. 29. Schematic diagram of Voigt Corner Horn.

effects. Excellent for maintaining air load on cone down to very low frequencies resulting in a very smooth extended bass response. Its efficiency is low but resistive control of cone velocity allows bass boosting to be used without distress.

2. The Tuned Pipe extends bass response and can provide similar loading conditions to the reflex cabinets on the loudspeaker cone at resonance. It has the advantage of simple construction, but the bass response is not as smooth due to harmonically related resonances.

3. The Horn. The full size horn is without any doubt the ideal method of cone loading, combining high radiation efficiency with very low distortion due to low cone velocity. The only disadvantage is the immense size required to reproduce really low frequencies.

4. Commercial Folded Horns. These are very efficient in their working range. Pros and cons vary from model to model but in general the middle bass may tend to be excessive, and the extreme bass poor, nevertheless capable of impressive results.

FRICTION LOADED ENCLOSURE

We have now covered fairly fully the features of performance and design of most of the recognised methods of mounting a loudspeaker, and we are now able to view these as a whole, pick out the better systems and review their respective advantages and disadvantages on the basis of our foregoing discussions.

The Full Horn. Acoustically this is the ideal method of loudspeaker mounting, it provides excellent air loading on the cone, is devoid of self-resonance and possesses a high radiation efficiency down to any desired frequency, being limited only by the horn dimensions. The disadvantage of the horn is the very great size required to be effective down to very low frequencies.

The Absorbing Labyrinth. This again presents excellent resonance free air loading on the loudspeaker cone, and in this respect is comparable to the horn. It is effective down to any desired frequency, being limited, like the horn, by its dimensions. Unlike the horn, however, the disadvantage of mounting a loudspeaker in a labyrinth is the low efficiency of the system; although this may be partially compensated for in the amplifier. A labyrinth capable of good absorption down to very low frequencies is still rather big.

The Reflex Cabinet. The advantage of the reflex cabinet is that an improvement in the radiation efficiency is maintained at very low frequencies by resonant phenomena. At the same time, excellent damping is applied to the loudspeaker cone at its resonance where it is most required. A further point in its favour is that it is relatively simple to construct.

The bass response from a reflex enclosure will have an efficiency somewhat higher than that from a labyrinth, and for a given bass extension, will be smaller, although it still makes a rather dominating piece of furniture in the drawing-room.

The response will not be so smooth as for a labyrinth due principally to the upper of the two resonances common to this type of mounting. If very much bass boost is applied the reflex enclosure will tend to sound boomy.

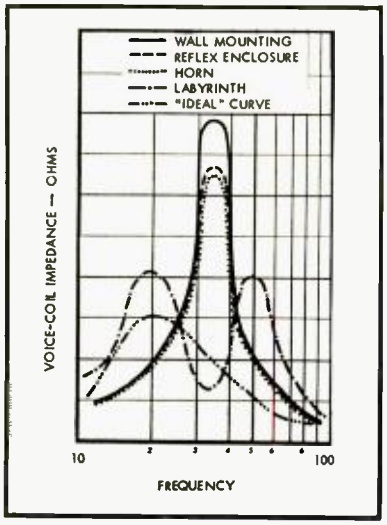


Fig. 30. Impedance curves of identical speakers mounted in various ways.

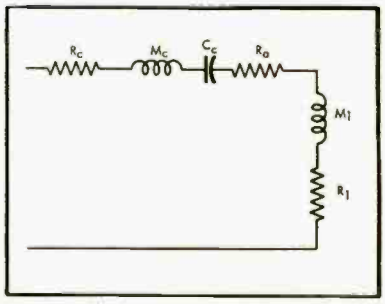


Fig. 31. First analogy of friction loaded enclosure.

The Wall Mounting or Infinite Baffle. The main virtue of this is the absence of resonances above the loudspeaker resonance, the damping due to air loading is low at resonance, and although this makes for higher efficiency, excessive cone movement at resonance may cause distortion. Typical impedance curves for identical speakers mounted in these four types of enclosure are given in *Fig.* 30.

With the exception of the efficiency attributable to a full-size horn, it was considered, after a great deal of research into the design of all types of enclosure that it should be possible to design an enclosure possessing all the advantages and none of the disadvantages of the various systems. Such an enclosure must have the following qualities:

(1) Resistance controlled mass loading down to 20 cps.

(2) Complete absence of resonances above this frequency.

(3) A general efficiency at least as high as a reflex cabinet and fully maintained down to 20 cps.

(4) Small size.

Such enclosures have now been developed and in order to understand the principle upon which they work, we will develop the argument that led to their design.

In order to satisfy requirements (2) and (3) the cone velocity must increase progressively as the frequency is lowered to 20 cps. Therefore, the enclosure must load the cone in such a way as to bring the effective cone resonance down to this frequency. There must also be a high resistive component in order to satisfy requirement (1).

In the analogy, these conditions are fulfilled by the velocity curve shown dotted in *Fig.* 30 and the corresponding analogous circuit shown in *Fig.* 31 where series inductive and resistive elements are added to the cone circuit.

If we are to apply the impedance

M_1R_1 to the cone, it is imperative that we also include a shunt capacitance to prevent this impedance from reducing the cone velocity excessively at the higher frequencies, in other words, to decouple the impedance at these frequencies. (*Fig.* 32).

It will now be seen that this is analogous to a special case of the vented box in which the dimension must be considered in conjunction with the mass and stiffness of the loudspeaker cone so that the lower impedance peak f_1 is of a predetermined frequency and magnitude. The approach to our ideal curve is now limited by the upper resonance f_2 and the anti-resonance f_o.

Considering first the latter, we know that this is due to the rise in impedance of the parallel circuit C_c, M_1R_1 at resonance, and since we are now only concerned with the lower resonance f_1, the anti-resonance f_o (not being tuned to the loudspeaker) serves only to introduce a trough at some frequency above f_o.

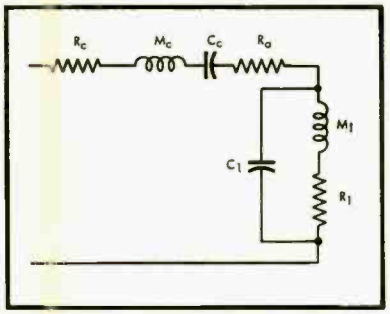


Fig. 32. Second analogy of friction loaded enclosure.

In order to reduce the magnitude of this trough a shunt resistance may be included in the circuit which will have the effects of reducing the "Q" of the parallel section and providing a limiting value for its impedance at resonance. This is shown in *Fig.* 33.

This resistance will also reduce the magnitude of the remaining resonances and it would be possible, by a suitable choice of components, to make the entire circuit almost completely aperiodic. In practice it was found, however, that an increase in the radiation efficiency of the system at extremely low frequencies was an advantage which could be had if the lower resonance was not completely damped, but was controlled by a sufficiently high frictional component in order to prevent excessive cone excursion.

In the final design this was achieved by carefully determined component values which, in addition, are such as to prevent an optimum acoustic impedance to the face of the cone. This is very important since if this impedance is too low then the cone velocity will be excessive resulting in undue distortion. Alternatively too high an impedance will cause a loss of bass radiation when the acoustic impedance of the enclosure is at its optimum, good radiation is secured with a cone velocity well inside the limits of the speaker. For these conditions it has been found that the dimensions are considerably smaller than those of vented or reflex enclosures. The optimum port area is considerably less than that of cone piston so radiation from the port may be neglected. The friction component R_f is relatively high.

The resistance R_f is analogous to a highly frictional air leak in the enclosure. A convenient way of forming this is to have a number of very narrow slits in one or more of the enclosure walls.

The choice of narrow slits will be appreciated when it is realized that any aperture will have both frictional-resistive and mass-reactive components, and it is very important in our case to ensure that the resistance is high compared to the reactance. The expression for the impedance of a narrow slit is given by

$$Z = \frac{2.23 \times 10.^{-3} d}{w^3 l} + j\frac{6\delta\omega}{5lw}$$

Where d = depth of slit
w = width of slit
l = length of slit
δ = density of air
$\omega = 2\pi \times$ frequency

From this it can be seen that as the width of the slit is reduced its resistance increases as the cube of the reactance.

An Axiom 150 Mk II was used in conjunction with this enclosure and the impedance curves are shown for this compared with those of the reflex cabinet and a true infinite baffle when housing speakers identical to the above. The evidence is fairly conclusive. The effect of closing the slits removing R_f is also shown in *Fig.* 34.

Listening tests comparing this enclosure with other types was also encour-

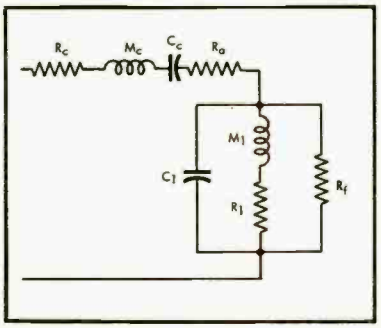


Fig. 33. Third analogy of friction loaded enclosure.

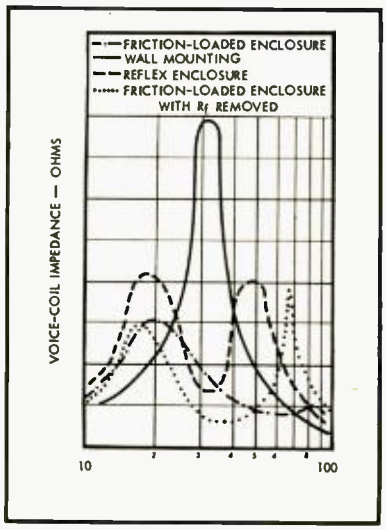


Fig. 34. Impedance curves of friction loaded enclosure in comparison with other types of mounting.

aging. It proved to have a firm bass response without any trace of resonance or coloration. The bass radiation was somewhat better than that from the reflex cabinet at middle bass frequencies and considerably better at the very low frequencies, thereby imparting a warm, well-balanced quality to the reproduction. Tests with an oscillator showed that a strong, pure 20 cps fundamental note could be radiated without excessive cone movement. Transient curves taken showed a very short clear time characteristic of non-resonant conditions. This is more interesting when one realizes that the volume of this enclosure is about half that of a correctly designed reflex cabinet for the same speaker.

In addition to the qualities mentioned this type of enclosure has the following advantages.

1. It is simple and cheap to construct.
2. The dimensions of the enclosure (corresponding to c_1 in the analogous circuit) are not extremely critical and may be varied up to ±10 per cent if necessary for styling. The dimension of the port and slits, however, are critical.
3. The enclosure can be of any shape and the port and slits can be placed in any position relative to each other and to the speaker provided they do not approach the latter too closely so as to produce some degree of back to front cancellation.
4. The resonant frequency of the loudspeaker is not critical provided it is not higher than 50 cps.

Many of these enclosures have been constructed for various speaker systems, and all exhibit the same excellent bass characteristics.

There are of course many different ways of forming the friction resistance R_f. A convenient method adopted was to make an enlarged port and cover part of it with closely spaced wooden slats having previously determined the required dimensions. Again the slits could be replaced by an aperture covered with a material of suitable porosity such as silk or felt supported between two layers of a ridged metal grid. It was important to prevent the material vibrating with sound pressure.

Further investigation along this line has resulted in the development of an Acoustical Resistance Unit which may be installed directly in a rectangular aperture of the proper size to provide the correct loading with a minimum of constructional work. Such a unit is shown in *Fig.* 35. It consists of a frame on which is mounted a decorative expanded metal grille, backed by a screen which is flocked to a closely controlled pattern so as to provide the proper acoustical loading.

Since this enclosure is capable of reproducing down to 20 cps and is free of resonances above this frequency the bass response is unaccentuated and perfectly natural. If, however, some accentuation is required this may be applied by means of the bass boast control on the amplifier, in which case the excellent air loading applied to the diaphragm will keep distortion to a minimum. This is considered more desirable than producing accentuation in the enclosure itself since with the exception of a full-size horn the latter cannot possibly provide the same carefully controlled accentuation as can an amplifier having a well designed boss lift control working in conjunction with a loudspeaker system with a high degree of aperiodic control down to zero frequency.

From its mode of operation this enclosure was named the Friction Loaded Enclosure, and we do feel that it represents a notable advance on previous types.

Fig. 35. Commercial form of Acoustical Resistance Unit designed to mount directly into rectangular opening in cabinet of specified dimensions.

RECORD SPEED

(*from page 19*)

with those in commercial use. For 10- and 12-inch discs 33 1/3 rpm is a good speed, particularly since it was standardized long before LP discs made their appearance. For 7-inch discs, 45 rpm is not far from the ideal value.

With an "average" n of 225 lines per inch, a 12-inch record which will play 22.8 minutes at 33 1/3 rpm will be good for only 13.5 minutes at 16 2/3 rpm, before distortion becomes too great. And the situation for the 10-inch disc is even worse, for here the comparison is between 16 minutes at 33 1/3 rpm and no time at all for 16 2/3 rpm! What this means, of course, is that if it is permissible to record to a minimum inside radius of 2.375 inches for a 33 1/3-rpm disc, the corresponding dimension for a 16 2/3-rpm record is 4.75 inches, equal to the outer radius of a 10-inch recording. The distortion is too great as soon as the playing starts.

So it looks as though before the 16 2/3 rpm disc becomes much of a threat to higher speeds, smaller styli will have to be developed and this in turn will require a great deal of work on pickup design in general.

It doesn't seem likely to happen for a number of years, anyway.

TONE CONTROL

(*from page 18*)

Formulas for Treble Equalization

3A. $$|A| = k\frac{1}{\sqrt{1+f^2/f_2^2}} \qquad (5)$$

3B. $$|A| \approx k\frac{\sqrt{1+f^2/f_2^2}}{\sqrt{1+4f^2/f_2^2}} \qquad (6)$$

3C. $$|A| \approx k\frac{\sqrt{1+f^2/f_2^2}}{\sqrt{1+f^2/4f_2^2}} \qquad (7)$$

3D. $$|A| \approx k\frac{\sqrt{1+f^2/f_2^2}}{\sqrt{1+k^2f^2/f_2^2}} \qquad (8)$$

If something other than a 6-db plateau is desired, the appropriate formulas may be obtained from (2), (3), (6) and (7) by changing the factor 4 under the square root. The ratio of capacitances should be changed in proportion to the square root of this number.

The bass and treble equalizations are very nearly independent. Thus, if f_1 and f_2 are close together, the corresponding deviations from the attenuation k—as obtained, for example, from *Figs.* 5 and 6—are directly additive on a decibel basis.

LETTERS

(*from page 9*)

8) As the frequency range is extended downwards, higher polarisation voltages become necessary and may reach a few thousand volts d.c. As this is supplied from a high impedance source it is not lethal, but precautions are necessary to avoid unpleasant shocks. The signal voltages applied to the plates also run to several hundred volts, and can be felt as well as heard.

I have seen it stated several times, especially in American journals, that the quality from electrostatic treble units is of such special nature that only specially selected bass speakers can be used with them. This is, if course, unadulterated piffle. When sound waves have bounced off walls and windows, and been absorbed by carpets and chairs, they become so dizzy that they cannot remember whether they were propagated by electrostatic diaphragms, moving-coil diaphragms, ribbon diaphragms, horn-loaded tweeters, or Ionophones. The problem of balancing the output of such speakers is precisely the same in each case, and mainly depends on equal sensitivity. Nobody need to hesitate to install an electrostatic treble unit because of any imaginary incompatibility with reasonably good bass systems. It will probably be found that there is a deficiency of treble, and this means padding down the bass output. To do this I would strongly recommend a constant-impedance volume control, rather than a potentiometer or series resistor, so that the maximum benefit of the damping factor of the amplifier is retained.

My object in stating the facts, as I see them, is simply to remind readers that producing perfect loudspeakers is no easy proposition. It is not implied that the difficulties are insurmountable.

I have suggested to Mr. P. J. Walker that a large-scale test in the Festival Hall would easily establish the relative merits of the two systems; the old and the new.—and I believe he is going into training for the event, but will not be ready until next year.

GILBERT A. BRIGGS
Wharfedale Wireless Works,
Idle, Bradford, Yorkshire, England

WSB-TV CONSOLE

(*from page 25*)

junction with an Altec 250A control console, provision has been made to transfer control to either console, from both positions. Signal lights indicate which console has control. Other switching facilities permit introduction of either of two sound-effect filters, or two utility inputs. The monitor may be switched to either channel, and its volume controlled at the console.

To assure speed and ease of console operation, color coding of knobs and switches is employed. All titles and scales are engraved for permanence and attractive appearance. In the fabrication of a broadcast console, a neat wiring layout is extremely essential to prevent cross-talk and undiscovered interaction between signal and speech circuits. This is accomplished in the manner shown in one of the photographs illustrating this article. No evidence of cross-talk is measurable, although ladder-type control is used throughout.

An interesting feature of this custom-designed equipment is the operation of the mixer output key, which actuates the "on-air" or "rehearsal" lights, in addition to its normal function. The announce booth signalling and speech circuit may be activated from either the booth, or the console.

WSB-TV engineers and officials have expressed satisfaction at the continuing efficient performance for the increased listening pleasure of the station's audience, numbering several hundred thousand.

In the interests of AUDIO readers, through the cooperation of chief engineer R. A. Holbrook, and John Kluttz, manager of electronic sales in Graybar Electric Company's Atlanta office, Altec was permitted to make a pictorial tour of the WSB-TV control room, with the resultant photographs accompanying this article.

EXHIBIT PREVIEW

(*from page 78*)

fidelity speakers, will be highlighted in the display of **United Audio Products** Division of United Optical Manufacturing Corp. The Dual automatic changer intermixes all records from 7 to 12-ins., and affords one-button control for 14-step operation. The Dual Micro Pianissimo record cleaner cleans both sides of a record simultaneously, at the same time removing static charges. Wigo speakers, which will be shown at an American audio show for the first time, are imported from Western Germany and represent precision manufacture at its finest.

United Speaker Systems will build its display around the Premiere and the Marquee, two multiple-speaker systems which are receiving great acceptance among members of the hi-fi fraternity. The Premiere, reviewed on page 56, is a high quality corner speaker system which employs horn loading on both low and high frequencies. The Marquee is a moderately-priced system which employs horn loading on the low end only. Cabinets are of the low-boy design and will be available in both traditional and modern exteriors.

University Loudspeakers, Inc., will display a number of new speakers, including the Diffaxial line and two new woofers with unusual characteristics. The Model C15W is equipped with an exclusive dual-impedance voice coil assembly which permits the driver's use in any system of 4 to 20 ohms. The Model C12W is an adjustable-response woofer with facilities for adjusting the high-frequency cutoff to 700, 2500, or 5000 cps, suiting the requirements of most tweeters.

TRANSFORMER DESIGN

(*from page 23*)

it is advantageous to tabulate information so that the power rating and other data about given core sizes may be seen at a glance, enabling suitable designs to be considerably expedited. Such a tabulation is illustrated at *Fig.* 5.

For a relatively simple and inexpensive amplifier a simple design of transformer with a minimum of mixing between the windings will prove adequate but for really high quality amplifiers with wide-band frequency response between close limits, a larger amount of sectionalizing and mixing becomes necessary. However, it is not profitable to just keep on dividing each winding into a greater number of sections indiscriminately. There are economic and uneconomic ways of sectionalizing, according to the purpose for which the sectionalizing is required.

It should go with saying that dividing the winding into sections will not effect any improvement at the low-frequency end. Primary inductance and saturation density are purely a matter of core dimensions and the number of turns provided on the windings. It is immaterial at these frequencies how the turns are arranged, so sectionalizing is only of importance at the high-frequency end.

But there are two ways in which sectionalizing can affect the electrical properties of the transformer. These are to reduce the winding capacitance and leakage inductance respectively. In earlier days, when tube load impedances tended to be much higher than the modern values, winding capacitance could be quite a problem. It can still be a considerable problem in drive and interstage transformers, but for output transformers it does not usually prove to be too serious a problem.

The major purpose of sectionalizing in an output transformer is usually to reduce leakage inductance. The extent to which either of these components requires to be reduced depends somewhat on the purpose for which the amplifier is required. If the amplifier is for laboratory purposes and will work into a resistance load primarily, then both leakage inductance and winding capacitance share an important relationship which must be considered in detail.

For the more common condition where the amplifier is intended to feed a loudspeaker load, the leakage inductance will usually be swamped by the voice-coil inductance of the loudspeaker which the amplifier feeds. However, if feedback is taken from the secondary of the transformer to some earlier stage in the amplifier, the leakage inductance comes

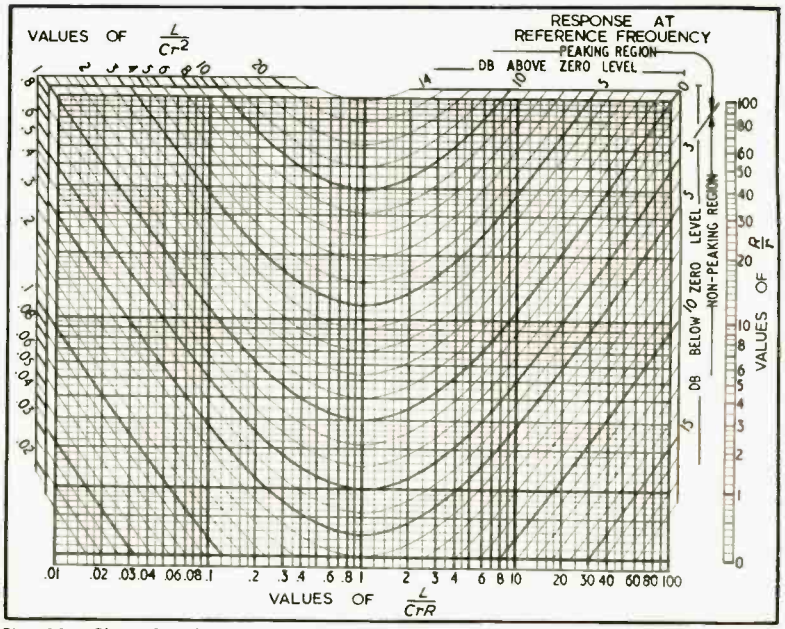


Fig. 11. Chart for determining the response shaping produced by various circuit element combinations. Values of L/CrR are calculated from the equivalent circuit of Fig. 13. The response shaping identified is given, normalized to the reference frequency obtained from Fig. 12, in Fig. 14.

within the feedback loop and hence must be considered in the over-all design.

The easiest way to consider how leakage inductance gets reduced by different sectionalizing arrangements is to draw a pattern for the leakage flux potential distribution through the winding. For a simple double winding arrangement this is shown at (A) in *Fig.* 6. Dividing one of these windings into two and disposing the two halves on either side of the other winding rearranges the pattern to (B).

Here it is clear that the portion of potential area contained in each triangular section, representing distribution of flux through the winding, is reduced to a quarter its previous value. The leakage inductance due to each of these sections is divided by eight. This is due to the fact that the leakage poten-

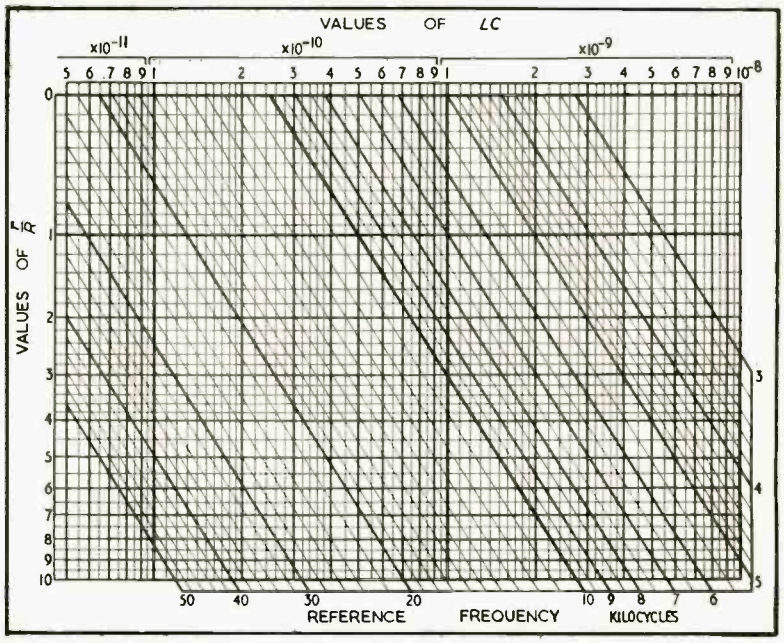


Fig. 12. Chart for determining the reference frequency for the response shaping identified by Fig. 11 and shown in Fig. 14.

tial produced is the product of the leakage flux at that point into the number of turns of the winding which that flux intersects. As each leakage flux potential area only acts on half the total number of turns in that winding, the integrated leakage potential due to leakage inductance in each section of the winding is ⅛ of that due to the whole winding in the arrangement of (A) in *Fig.* 6. So the leakage inductance due to the whole winding of (B) in *Fig.* 6 is one quarter of that at (A).

This is ignoring the leakage flux in the space between the windings which acts at a uniform leakage flux potential. Using a section factor of two, which is the comparison between (A) and (B) of *Fig.* 6, the leakage-flux potential at each of these spaces is divided by two. But the number of turns in which this induces a leakage potential is also halved. This means that the components of leakage inductance due to each space are divided by four, but because that there are now two spaces instead of one, the total contributed element of leakage inductance due to space between windings is one half of that in the single arrangement, assuming that each space in the second method of sectionalizing is of the same thickness as the original.

The leakage flux areas for two windings divided into three and two equal sections respectively are shown at (C)

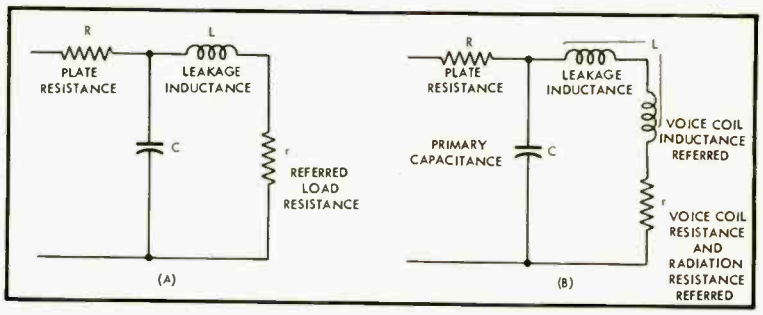


Fig. 13. Equivalent circuits for output transformer high-frequency response computation. (A) is the equivalent using a resistance load, and (B) is the equivalent using a loudspeaker load. The primary capacitance value used must include all effective capacitance across the primary, due to winding capacitance, distributed and lumped, tube plate-to-ground capacitance, wiring capacitance, and an additional capacitor, if used. Leakage inductance and load resistance must both be referred to the primary winding. The response predicted for (B) will be the current delivered to the loudspeaker at high frequencies. To obtain the voltage response, this can be combined with the impedance characteristic of r and the voice-coil inductance.

in *Fig.* 6. Here the succession of areas is not uniform and the leakage flux potential at different spaces between windings also differs, so a different series of factors will have to be used.

Comparison of this arrangement with that at (D) in *Fig.* 6 which still uses three sections of one winding and two of the other, shows that the latter arrangement results in much better reduction in overall leakage inductance. The relative dimensions and the factor they play on the over-all leakage inductance are shown in this figure for each of the cases.

On this basis *Fig.* 7 shows the factors for the number of sections used for the sectionalizing arrangements producing a maximum reduction of leakage inductance. In this schematic, the windings are in each case shown connected in series. This is unimportant—the referred leakage inductance will be of the same magnitude to the impedance to which it is referred, regardless of whether windings are connected in series or in par-

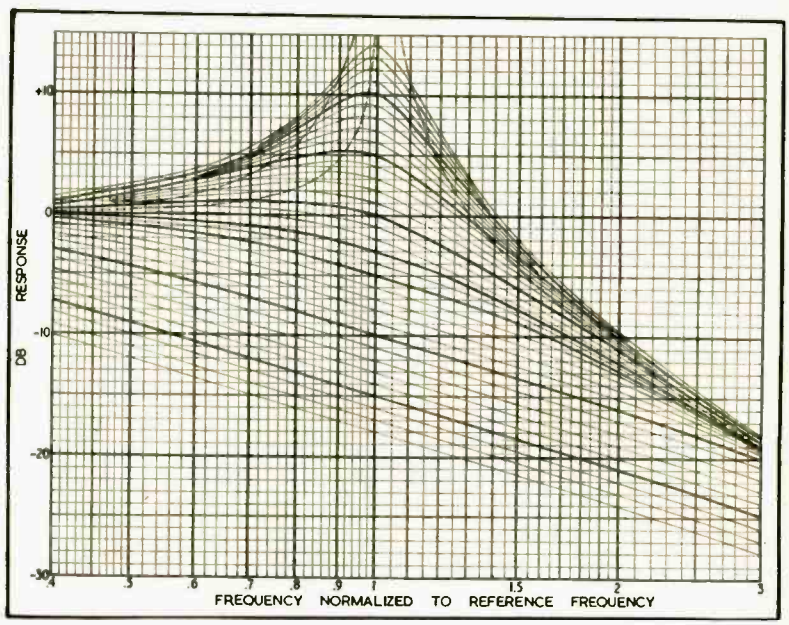


Fig. 14. Response shapings selected by the chart of Fig. 11. Actual frequencies can be calculated from the reference frequency given by Fig. 12. The dotted lines indicate the points of maximum slope on the curves (the outside ones) while the middle one indicates the point of the peak, which is useful in over-all response computation, particularly when the peak is not very high.

allel. In each case both the leakage inductance and the working impedance will be multiplied by the square of the number of sections used in transferring from parallel to series connections.

The best construction for producing a minimum leakage inductance uses windings with relatively long layer length and a few layers. To produce a low winding capacitance the layer length should be short and a large number of layers employed. In this way the interlayer capacitance consists of a larger number of smaller capacitances in series. But this arrangement is much less advantageous for reducing leakage inductance. So the best method, where both quantities have to be reduced, is to modify the method of winding, using a vertical sectioning in addition to the horizontal sectioning. A section of a complete winding suitable for this purpose is shown at *Fig.* 8. Here only the high-impedance winding employs vertical sectioning to reduce the capacitance.

In designing a transformer where both factors are important, it is best to keep the number of horizontal sections down, because each intermixing, although it reduces leakage inductance, also makes it more difficult to reduce winding capacitance. The charts of *Figs.* 9 and 10 will prove useful in calculating the over-all leakage inductance of different winding arrangements and also in computing capacitance effects.

Over-all Performance

The data so far given can be utilized to calculate the electrical quantities of a transformer. But its performance is usually specified in terms of power handling, efficiency, frequency response, distortion, and so on, which does not specifically state the electrical quantities we have so far discussed. *These details can only be successfully evaluated on the basis of a complete amplifier design.*

Power-transfer efficiency is the only feature of a transformer which is inherent to the transformer at certain operating impedances, regardless of the circuit in which it is used. The frequency response and distortion characteristics are almost entirely dependent upon the tube circuits, and upon the feedback arrangements, where feedback is used.

Frequency Response

To facilitate calculation of frequency-response characteristics under these conditions, *Figs.* 11 and 12 help evaluate the high-frequency response in terms of the known circuit values: the source resistance due to tube a.c. resistance, the winding capacitance plus any primary capacitance due to wiring and tubes, and the leakage inductance, together with the load resistance; (A) in *Fig.* 13 shows the fundamental high frequency

response circuit on which these calculations are based.

In practice the circuit with which the transformer is used is more likely to be that of (B) in *Fig.* 13 where the load also includes an inductance. If feedback is employed from the secondary of the transformer this will be taken from the junction between the inductance in the transformer due to its leakage and the inductance which forms part of the load.

Distortion

The distortion in output stages is due to (a) the transformer saturation at low frequencies, and (b) the effect of reactances in the transformer at other frequencies—sometimes also at low frequencies. These may cause the tube load line to open out into an ellipse, which produces an unfavorable loading condition for the tubes, causing an appreciable degree of distortion.

Stability

The transformer elements, leakage inductance, primary capacitance, and so on, also enter into the stability criterion for an over-all feedback amplifier. Also of course, any reactances in the load such as that due to voice-coil inductance, will also contribute to the stability criterion.

In designing an over-all amplifier all these factors should be taken into account and the writer suggests that the design department of a progressive transformer manufacturer should include facilities for advising amplifier manufacturers concerning the over-all design of equipment incorporating specific transformers; or, in reverse order, they should be capable of producing a transformer to suit a specified design and at the same time be prepared to give advice on the limitations of the design, with regard to loading conditions, etc.

This form of liaison, which for some reason seems to be unheard of, would result in considerable improvement in competitive amplifier design, in fact it would seem to be vital to further progress in this field.

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PROFESSIONAL DIRECTORY

NEW LITERATURE

• **Jensen Manufacturing Company,** 6601 S. Laramie Ave., Chicago 38, Ill., has released a new catalog, No. 1070, on its new line of Professional Series loudspeakers designed for commercial, industrial, institutional and public-address applications. Catalog 1070 contains 24 pages of definitive information on all equipment in the new Professional Series, including Hypex projectors, new Lifetime drivers, rectangular horns, transformers, and the Speech Master, Weather Master, and Viking lines. **S-1**

• **A. Lawrence Karp,** 16 Putnam Park, Greenwich, Conn., offers at no charge a newly-enlarged template catalog in which is listed more than 100 templates for use by draftsmen and others engaged in drawing electronic symbols and circuitry. Critical testing has shown that use of Karp templates can be expected to slice at least 50 per cent from everyday drafting procedures related to radio, computing and control devices, and general electronic gear. **S-2**

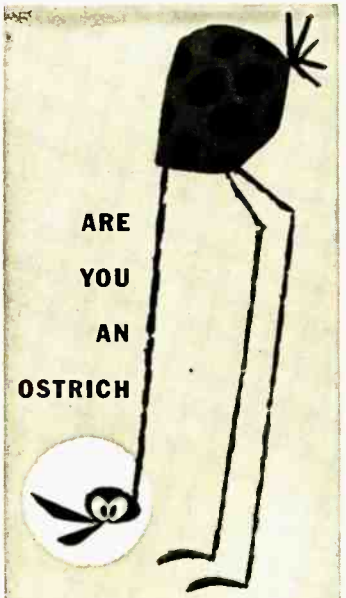
• **Rek-O-Kut Company,** 38-01 Queens Blvd., Long Island City, N. Y., has developed a disc record timing chart for professional studios and high fidelity fans who cut their own records. Presented in easy-to-read time-table form, the chart gives the playing time in minutes for cuts of various diameters in 7-, 10-, 12-, and 16-in. records, using either a standard 3-mil or microgroove 1-mil stylus. For standard stylus the chart has readings for 33-1/3- and 78.26-rpm speeds cutting 120 or 150 lines per inch. Readings for microgroove stylus are for 33-1/3 and 45 rpm cutting 210, 216, 240 and 270 lines per inch. The timing chart is printed on 8½" × 9¾" varnished stock. Requests for copies must be accompanied by a remittance of 20 cents to cover mailing costs. **S-3**

• **Shure Brothers, Inc.,** 222 Hartrey Ave., Evanston, Ill., is re-issuing its Reactance Slide Rule, a time-saving means for simplifying calculations of resonant frequency, capacitive and inductance reactance, coil "Q," and dissipation factor problems covering a frequency range from 5 cps to 10,000 megacycles. Anyone dealing with calculations of this type will find the slide rule a useful tool in his work. The slide rule is priced at 50 cents. **S-4**

• **Soundolier, Inc.,** P. O. Box 3848, St. Louis 23, Mo., has prepared and will mail free of charge two technical bulletins on the placement and selection of architectural loudspeaker baffles. Recognizing the fact that proper distribution of sound is dependent upon the baffle, the speaker, and the architectural acoustics of the room, Technical Bulletin No. 101 describes how to determine the proper baffle placement for any particular environment. Technical Bulletin No. 102 was prepared to aid the architect or consulting engineer in selecting the ideal baffle for his specific need. **S-5**

• **Centralab Division of Globe Union, Inc.,** 900 E. Keefe Ave., Milwaukee 1, Wis., announces availability of its Pocket Control Guide No. 4. This handy cross-referenced control guide is published semi-annually to keep up-to-date replacement control information available to servicemen. The 96-page guide is sized to fit neatly into a pocket or repair kit. The guide is priced at 20 cents. **S-6**

• **Simpson Electric Company,** 5200 W. Kinzie St., Chicago 44, Ill., is distributing a comprehensive two-color flyer describing the firm's line of 2- and 3-in. meter relays. Included is information on construction, terminals, weight, dial and scale arc. Details of calibration, movement, contacts, insulation breakdown, and temperature range are also given. Copies will be mailed on request. **S-7**



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