IRE Transactions on AUDIO

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PGA NEWS

CONTRIBUTIONS

PUBLISHED BY THE

Professional Group on Audio

IRE PROFESSIONAL GROUP ON AUDIO

The Professional Group on Audio is an organization, within the framework of the IRE, of members with principal professional interest in Audio Technology. All members of the IRE are eligible for membership in the Group and will receive all Group publications upon payment of an annual fee of $2.00.

IRE TRANSACTIONS® on AUDIO

Published by the Institute of Radio Engineers, Inc., for the Professional Group on Audio at 1 East 79th Street, New York 21, New York. Responsibility for the contents rests upon the authors, and not upon the IRE, the Group, or its members. Individual copies available for sale to IRE-PGA members at $0.50; to IRE members at $0.75, and to nonmembers at $1.50.

PGA News

PHILIP B. WILLIAMS
ADMINISTRATIVE COMMITTEE
1957–1960

P. B. WILLIAMS

Philip B. Williams was born at Ancon, Canal Zone, in 1916. He received the B.A. degree in physics and mathematics in 1937 and subsequently did work in radio engineering at RCA Institutes and Illinois Institute of Technology.

He was at station KBTM from 1937 through 1938 and at Zenith FM Station from 1940 through 1941. Mr. Williams joined the Jensen Manufacturing Company in 1942, where he was engaged in audio and acoustic work.

In 1950 he became senior engineer, responsible for advanced development of commercial and military transducers. He was made chief engineer at Jensen in 1952 and directs transducer development and electroacoustics research.

Mr. Williams is a council member of the Chicago Audio and Acoustic Group, member of the Audio Engineering Society, the American Institute of Electrical Engineers, and Senior Member of the IRE. He is past chairman of the Chicago Chapter of the IRE-PGA, past News Editor of Scanfax, and is Chairman of the Chicago IRE Membership Committee. His industry activities include IRE Electroacoustics, EIA Speaker, and RETMA High Fidelity Committees. He has authored various presented or published papers on loudspeakers. Currently he is IRE-PGA Program Chairman and a member of the IRE-PGA Editorial and Administrative Committees.

CONSTITUTION FOR PROFESSIONAL GROUP ON AUDIO*

Article XI—Section I of this Constitution provides that "it goes into effect unless 10 per cent of the Group Members file objections with the Executive Secretary of the IRE within 30 days of publication."

ARTICLE I
Name and Objects

Section 1—The name of the organization constituted herein shall be The IRE Professional Group on Audio of The Institute of Radio Engineers, Incorporated.

Section 2—Its objects shall be scientific, literary, and educational in character. The Group shall strive for the advancement of the theory and practice of radio engineering and of the allied arts and sciences, and the maintenance of a high professional standing among its members and affiliates, all in consonance with the Constitution and Bylaws of the IRE and with special attention to such aims within the field of interest of the Group as are hereinafter defined.

Section 3—The Group shall aid in promoting close cooperation and exchange of technical information among its members and affiliates and to this end shall hold meetings for the presentation of papers and their discussion, and through its committees shall study and provide for the needs of its members and affiliates.

ARTICLE II
Membership

Section 1—The membership of this Group shall be limited to members of the IRE of any grade, including

* Original Constitution approved March 7, 1949; amended September 8, 1954; amended October 8, 1957.

students, who have an interest in any phase of the field of interest of the Group.

Section 2—The Administrative Committee of the Group may authorize and recognize Affiliates of the Group who are members in good standing of other accredited organizations.

Section 3—Each such accredited organization must be approved by the Administrative Committee of the Group, the Chairman of the Professional Groups Committee, and the IRE Executive Committee.

ARTICLE III

Field of Interest

Section 1—The Field of Interest of the Group shall be the technology of communication at audio frequencies and of the audio-frequency portion of radio-frequency systems, including the acoustic terminations and room acoustics of such systems, and the recording and reproduction from recordings at audio frequencies, and shall include scientific, technical, industrial, or other activities that contribute to this field, or utilize the techniques or products of this field, subject, as the art develops, to additions, subtractions, or other modifications directed or approved by the IRE Committee on Professional Groups.

Section 2—The Field of Interest of the Group may be enlarged, reduced, or shifted moderately as the needs of the occasion indicate with the provision, however, that if it overlaps the field of interest of another group to the extent that interference occurs, the Committee on Professional Groups may draw up more exact lines of demarcation, and that if some other Group wishes to enlarge their field to the disadvantage of this Group, that this Group will reasonably and in good faith consider the proposals and abide by any decision of the Committee on Professional Groups.

Section 3—A subgroup may be formed and operated on any plan not inconsistent with the powers of the Administrative Committee of this Group. A subgroup formed in a Section shall be known as a Chapter. A Chapter may assist the Administrative Committee of this Group in the management of a National Meeting, Conference, Lecture Series, Symposium, or Convention promoted by this Group in a Section. The Chapter shall be responsible for coordination of such meetings with the Section. A Chapter may promote meetings of the Section in the Field of Interest of this Group, under the control and supervision of the Officers of the Section in which the Chapter is located.

ARTICLE IV

Management and Election of Officers

Section 1—The Group shall be managed by an Administrative Committee of nine members of the Group.

Section 2—The terms of office of the members of the Administrative Committee shall be three years, one third of the members being elected each year by the Group membership.

Section 3—Election of the Members of the Administrative Committee shall be by a method detailed in the Bylaws, which method shall include a suitable provision for nominations by Group members who are not Members of the Administrative Committee, and shall include a provision for election by a mail ballot by the Group members.

Section 4—Within-term vacancies on the Administrative Committee shall be filled by appointments for the unexpired terms made by the remainder of the Administrative Committee.

Section 5—The Chairman and Vice-Chairman shall be elected from among the members of the Administrative Committee who are willing to run plus any other Group member nominated by the Administrative Committee, or by the Nominating Committee and approved by the Administrative Committee, or by petition of 25 members of the Group.

Section 6—Election of the Chairman and Vice-Chairman shall be by a method detailed in the Bylaws, and shall include a provision for election by a mail ballot by the Group members.

The terms of office for the Chairman and Vice-Chairman shall be approximately one year and may exceed this interval only in the case where the date of the Annual Meeting of the Administrative Committee is being changed and a continuation in office is necessary to effect the new schedule, or no successor has been elected or appointed.

Section 7—The Chairman and Vice-Chairman shall be voting members of the Administrative Committee.

Section 8—The Secretary-Treasurer shall be appointed by the Chairman of the Group, with the approval of the Administrative Committee, for a one-year term. and need not be a member of the Administrative Committee.

Section 9—Names of the elected Officers and the Members of the Administrative Committee shall be reported to the IRE Executive Secretary.

ARTICLE V

Powers, Privileges, and Duties

Section 1—It shall be the duty of each member of the Group to participate in the election of the Officers and Members of the Administrative Committee and to vote on such matters as require a referendum to the membership. Each member should keep the Administrative Committee informed concerning his views.

Section 2—The Chairman, under the direction of the Administrative Committee, shall have general supervision of the affairs of the Group. He shall call all regular and special meetings of the Administrative Committee, general meetings of the Group, and the Annual Meeting of the Group, and shall preside at all such meetings. He shall coordinate all activities of the Group and have such other powers and perform such other duties as may be provided in the Group Bylaws, or as may be delegated to him by vote of the Administrative Committee. It shall be his duty to see that the orders and resolutions of the Administrative Committee and of the Committee on Professional Groups are carried out. The Chairman shall be an ex-officio member of all Standing Committees except the Nominations Committee and of the Professional Groups Committee. He may vote in the Administrative Committee only to break a tie.

The Chairman, as an ex-officio member of the Committee on Professional Groups, shall represent the Group at meetings of this Committee. He may delegate such representation to another Officer or Member of the Administrative Committee by a letter to the Chairman of the Committee on Professional Groups.

Section 3—The Vice-Chairman shall assume the duties and have the powers, duties, privileges, and responsibilities of the Chairman during the latter's absence or incapacity and shall in general assist the Chairman in fulfilling his duties. He shall become Chairman upon the death, resignation, or permanent incapacity of the Chairman.

Section 4—The Secretary-Treasurer shall be responsible for all reports, petitions, and records concerning the Group. He shall keep true and faithful minutes of all meetings of the Administrative Committee and general meetings of the Group, and shall make such reports of his activities as may be required by the Administrative Committee, the Committee on Professional Groups, or the IRE. He shall be responsible for sending out notices according to plans delineated by the Administrative Committee or laid down in the Group Bylaws. He shall keep in his files copies of all meeting notices, minutes of meetings, letters and bulletins sent and received for at least seven years, except for those which may be specifically assigned to the custody of others. In the absence of the Chairman and Vice-Chairman, the Secretary-Treasurer shall perform the duties of the Chairman.

Section 5—The Secretary-Treasurer shall utilize the services of Headquarters as bursar. All funds shall be handled under the rules established by the Executive Secretary of the IRE. Disbursements shall be made only as ordered by the Administrative Committee, on the signature of the Chairman or the Secretary-Treasurer.

Section 6—The newly-elected Chairman, Vice-Chairman, and members of the Administrative Committee shall assume office at the end of the Annual Meeting of the Administrative Committee, or as soon thereafter as practicable, and shall be invited to attend this meeting. They shall continue in office until a new Chairman has been duly elected and has taken office.

Section 7—The Chairman, as soon as expedient after election, shall appoint the Chairman of each of the Standing Committees provided by the Bylaws.

Other Committees may be authorized by vote of the Administrative Committee and their Chairmen shall be appointed by the Chairman.

Chairmen appointed shall serve until their successors are appointed or the Committee is dissolved.

Section 8—The Administrative Committee shall fill vacancies of office which occur during the year.

Section 9—Moneys held by or for the Group legally belong to the IRE, and such moneys shall not be expended for purposes known to be inimical to the interests of IRE.

Section 10—No Officer or Member of the Administrative Committee shall have any authority to contract debts for, pledge the credit of, or in any way bind the IRE for any amount in excess of the funds allocated to the Group for normal operation and authorized by the Administrative Committee.

Section 11—No Officer of the Group or Member of the Administrative Committee shall receive, directly or indirectly, any salary, traveling expenses, compensation, or emolument from the Group, unless authorized by the Administrative Committee or by the Bylaws of the Group.

ARTICLE VI

Financial Support

Section 1—The Group shall not charge dues.

Section 2—The Group may make registration charges at its Group meetings, conferences, lecture series, symposia, or conventions. The registration fee for non-IRE members may be higher than for IRE members or Affiliates of the Group.

Section 3—The Group shall not make registration charges at a meeting, conference, or convention which it operates as part of a Sectional, Regional, or National meeting, conference, or convention.

Section 4—The Group may make assessments on its Members or Affiliates for publication and additional purposes.

Sections 5—The Group may raise revenues by other means, such as advertising, shows, requests for contributions, etc., provided such means do not conflict with policies and revenue means of the IRE, or encroach on revenue fields of prior established Groups or Sections. The Group must receive from the Executive Secretary of the IRE an opinion that a proposed method of raising revenue is nonconflicting and not against IRE policy before embarking on the proposed plans.

Section 6—The Group may, but only after approval of the IRE Executive Committee, make a charge for sending out meeting notices to IRE members who are not members of the Group, and to Group Affiliates, to cover the extra expense thereby entailed.

ARTICLE VII

Meetings

Section 1—The Group may hold Meetings, Conferences, Lecture Series, Symposia, or Conventions either alone or in cooperation with Sections, Regions, National Convention Committees of the IRE, or other technical organizations, but the approval of IRE Headquarters must be obtained in advance in order to prevent conflicts of dates. The Group shall sponsor at least one technical conference of national scope each year, which may be held during the National Convention, or during some other IRE meeting, or as a separate conference.

Section 2—Meetings, Conferences, Lecture Series, Symposia, or Conventions of the Group shall be open on an equal basis to all Members of the IRE and to Group Affiliates. Separate Meetings, Conferences, Lecture Series, Symposia, or Conventions of the Group shall not be held at a time or place which will conflict with a Sectional, Regional, or National Meeting, Conference, Lecture Series, Symposium, or Convention without approval of the Executive Committee of the IRE.

Section 3—Meetings of the Administrative Committee shall be held at such times as are found necessary. Meetings of the Administrative Committee may be called by the Chairman of the Group at his own discretion, or upon request by two other members of the Committee. The time and place shall be announced at least two weeks in advance of the meeting.

Section 4—The Administrative Committee shall have its Annual Meeting during the IRE Spring National Convention at the time and place designated by the Chairman.

Section 5—Four members of the Administrative Committee, exclusive of the presiding officer, shall constitute a quorum.

Section 6—A majority of the legal votes cast by those Members of the Administrative Committee attending a meeting shall be necessary in the conduct of its business except as otherwise provided in this Constitution or the Bylaws.

Section 7—Business of the Administrative Committee may be handled by correspondence, telephone, or telegraph where in the opinion of the Chairman matters requiring action can be adequately handled in that manner. A majority of the legal votes cast by the members of the Committee is necessary for approval of actions handled in that manner. Telephone acts are to be confirmed in writing.

ARTICLE VIII

Publications

Section 1—Publications, other than programs, notices, newsletters and the like may be entirely or partly the PROCEEDINGS OF THE IRE, or the CONVENTION RECORDS.

Section 2—Publication of any material may be by the IRE TRANSACTIONS ON AUDIO if the Group desires, and is limited only by good taste and established policies of the IRE. The Group shall utilize the IRE facilities in publishing the TRANSACTIONS. Publication shall be at the Group's risk and expense except when otherwise arranged with the IRE.

ARTICLE IX

Referendum

Section 1—A referendum may be initiated by the Administrative Committee or by a petition to the Chairman signed by at least ten per cent of the Group membership. More than one question may be included on any ballot.

ARTICLE X

Recall

Section 1—If for any reason the best interests of the Group seem to require a change in the Officers or the Administrative Committee during the year, the matter shall be duly and carefully considered by the Administrative Committee.

Upon not less than a two-thirds vote of the Administrative Committee, or upon receipt by the Administrative Committee of a petition signed by twenty members of the Group, the Administrative Committee shall meet for the special purpose of considering and voting upon the recommended change.

Section 2—An affirmative vote of two thirds of the legally cast votes of the Administrative Committee Members present shall be necessary to declare an office vacant.

Section 3—Upon an affirmative vote of two thirds of the legally cast votes of the Administrative Committee Members present, the vacant office may be filled for the unexpired term, upon nominations from the floor.

ARTICLE XI

Amendments

Section 1—Amendments to this Constitution may be initiated by petition submitted by twenty-five members of the Group, or by the Administrative Committee, such petition being submitted to the Committee on Professional Groups, and to the Executive Committee of the IRE for approval.

After such approval, the proposed amendment shall be publicized in the Group TRANSACTIONS or Newsletter, with notice that it goes into effect unless ten per cent of the Group Members file objections with the Executive Secretary of the IRE within 30 days of publication. If such objections are received, a copy of the proposed amendment shall be mailed with a ballot to all members of the Group at least 30 days before the date appointed for return of the ballots, and the ballots shall carry a statement of the time limit for their return to the IRE office. Approval of the amendment by at least two-thirds of the legal votes cast shall be necessary for its enactment.

Section 2—Bylaws to this Constitution may be adopted or changed by a two-thirds vote of the votes legally cast by the Administrative Committee at a regular or special meeting, provided that notice of the proposed Bylaw change has been sent to each member of the Administrative Committee at least one week prior to such meeting, or a Bylaw may be changed by an affirmative vote of two-thirds of the legally cast votes of the Members of the Administrative Committee by communication from the Chairman to each member and vote received by mail.

Section 3—All amendments to the Constitution or Bylaws shall become effective immediately after the affirmative vote, or as soon as a notice of the change has been mailed to the Executive Secretary of the IRE, unless a later date has been specified at the time the vote is taken.

CHAPTER NEWS

Baltimore, Md.

At the June 19 meeting the Baltimore Chapter combined a technical meeting with the election of officers.

The technical portion of the meeting consisted of a talk on "Speaker Systems for High Fidelity" presented by H. Peter Meisinger, Chief Engineer of Audio Design at Lee, Inc. Washington, D. C. Mr. Meisinger discussed various types of speaker enclosures for high fidelity systems developed by his company and marketed by the National Company as part of their line of hi-fi components. The discussion included the "Catenoid" system which is a horn loaded enclosure whose expansion follows the hyperbolic cosine law. The technical discussion was followed by a demonstration.

The election results follow:

Chairman, Kenneth W. Betsh, Bendix Radio Corp.
Secretary and Vice-Chairman, J. L. Markwalter, Jr., Aircraft Armaments
Membership, G. N. Webb, Johns Hopkins University
Local Papers, W. A. Visher, Bendix Radio Corp.

Cleveland, Ohio

The following report on the October 3 meeting has been furnished by Jack Goldfarb: At this meeting W. W. Dean, manager of High Fidelity Components Engineering at the General Electric Co. gave a talk on "Testing High Fidelity Amplifiers in the Home." Mr. Dean's talk described methods that electronic engineers might use for testing high fidelity amplifiers in their own home. It described the type of test equipment needed and the tests that are most revealing. The talk covered the measurement of gain, noise, distortion, and frequency response.

Milwaukee, Wis.

William Alpert reports a meeting on June 18 at the ESM Building. At this meeting Marvin Camras, Senior Physicist at the Armour Research Foundation and Chairman of the Committee on Chapters of the PGA, gave a talk on "Recent Developments in Stereo and Magnetic Recording." The talk was accompanied by a demonstration of both high and low price equipment available for home use. There was an excellent attendance at the meeting and a lively discussion followed the demonstration.

San Francisco, Calif.

A meeting was held on September 17 at the St. Mark's Episcopal Church in Palo Alto. A paper on the "History, Tonal Design, and Acoustical Environment of the Modern Pipe Organ" was presented. The following account of the meeting, entitled, "Long Way Bach" was written by Lambert Dolphin and is reprinted from the San Francisco Section *Grid*.

"Three talks and a demonstration of the new three-manual Casavant pipe organ were featured at the September meeting of the Professional Group on Audio. . . .

"Canon E. E. West, rector of the parish, welcomed the group and recalled some of the interesting problems with building contractor and architect in building a church with good acoustical properties and organ placement. Only the choir division of the organ is located in the chamber originally intended by the architect to house the entire organ. The majority of the voices are located behind the high altar in a chamber formed by increasing the over-all length of the church. Ideal egress of sound is provided from this chamber since the front is entirely open and covered only with plastic grille cloth.

"Lambert Dolphin gave a brief historical background of the modern church pipe organ following the opening musical selection played by C. Thomas Rhoads, organist of the church, which was Purvis' Marche Grotesque. Dolphin pointed out that the modern organ, to be capable of satisfactorily performing music of many composers and many times, must embody tonal principles and sounds from many schools and periods of organ building. Just as it is impossible to perform music of Bach on a Wurlitzer theater pipe organ, so also is it impossible to perform music of Cesar Franck on an instrument typical of Bach's time.

"Dolphin gave a short elementary physics discussion of the manner in which organ pipes produce sound. Open flue pipes can produce only those frequencies which are an integral number of half wavelengths of the pipe length, and closed pipes only those frequencies such that the wavelength is an odd integral number of quarter wavelengths of the pipe length.

"Reed pipes are closely coupled systems with two separate natural frequencies, that of the vibrating reed, and that of the pipe attached. Reed sound is very rich in harmonics, some of which may even be stronger than the fundamental. Two separate adjustments, reed length and pipe length, make it possible to adjust the intensity and tone color of a given reed pipe over a wide range.

"Richard Stenger, Jr., northern California representative of the Casavant Organ Co. of St. Hyacinthe, Quebec, has just completed the installation of the new organ at St. Mark's. Stenger's broad background and experience in the pipe organ field was evident from his complete and thorough explanation of the factors affecting the sound and speech of organ pipes. He outlined the important variables which the pipe maker fixes when the pipe is made, and those factors which are adjustable after the pipe is completed, such as the position of the various parts of the mouth of the pipe. Pipe diameter, or scale, and mouth cut-up, which is the ratio of mouth height to width, are especially important factors in determining the harmonic structure of flue pipes.

"With the assistance of Rhoads, Stenger selected examples of various organ sounds and illustrated how choruses of sound are constructed and how combinations of various ranks of pipes make the tone color possibilities almost unlimited.

"Ray Long, well known in audio circles, is especially at home when discussing acoustics. His talk on the acoustical characteristics of St. Mark's Church was especially interesting. Since no other instrument depends for its sound so vitally on the acoustical environment in which it is placed, it is especially important to give some consideration to those factors which will improve the sound of the organ.

"The very long reverberation time of St. Mark's (over four seconds) is excellent for organ, although the highest recommended reverberation time, according to acoustical engineers, is only two seconds. While long reverberation times tend to obscure speech, this effect can be minimized by providing desirable reflections which arrive at the listener's ear shortly after the direct sound itself.

"Placement of the organ at St. Mark's is close to ideal since the ratio of direct to reverberant sound is very good for every person in the congregation.

"A short organ recital played by Mr. Rhoads concluded the program. During the second part of this recital the lights in the organ chambers were turned on so the group could see the layout and construction of the organ. Mr. Rhoads performed the following selections: Now Thank We All Our God, Bach; Zu Bethlehem Geboren; Walcha; La Nativite, Langlais; Fugue in G Minor, Bach; Minuet from Fireworks Music, Handel; Cantabile, Franck; and Fugue in C Minor, Bach."

New Chapters

Reports reach us that interest is being shown in many areas toward the formation of new chapters.

Mark W. Bullock is surveying the Dallas area. Mr. MacVeety believes there are good possibilities in the northern New Jersey section which already has over 168 PGA members at large. Ed Harding has more than 53 members at large to work with in the Twin Cities area. H. H. Schwartz reports considerable interest in Montreal area. Robert S. Kirby is working hard in the Denver area.

For those interested, a Professional Groups Manual is available from IRE Headquarters with rules, suggestions, and procedures. Please write L. G. Cumming if your Chapter does not have one.

PGA ADMINISTRATIVE COMMITTEE MEETING MINUTES

Members Present

B. B. Bauer
A. B. Bereskin
M. S. Corrington
H. F. Olson, *Chairman*
F. H. Slaymaker

Members Absent

S. J. Begun
A. B. Jacobsen
W. E. Kock
W. T. Selsted
P. Williams

Committee Chairmen Present

M. Copel
M. S. Corrington
F. H. Slaymaker

Committee Chairmen Absent

S. J. Begun
M. Camras
W. E. Kock
P. Williams
W. T. Selsted

The meeting was held at the IRE Headquarters, New York, N. Y., on Tuesday, October 8, 1957 and was called to order at 10:00 A.M.

Financial Information

The following financial information was made available by Headquarters:

PGA membership as of September 30, 1957:

Paid	3724
Paid Students	511
Unpaid	20
Affiliates	2
Total	4257

Balance in the Treasury as of September 30, 1957—$16,931.38.

Affiliate Membership

To promote the affiliate membership plan, the Secretary was directed to send information about this plan to the *Journal of the Acoustical Society of America*, AIEE, SMPTE, and AES, for publication.

Committee Reports

1) Editor Bereskin suggested the publication of the PGA membership list. By motion of Slaymaker and seconded by Corrington, it was decided unanimously to publish a membership list, by regions and sections, with the names in alphabetical order within sections. The addresses will not be given.

Editor Bereskin informed the Committee that M. Camras is willing to become Editor-in-Chief at the expiration of Bereskin's term. It was agreed that Chairman Olson will communicate with the appropriate parties to endorse this appointment.

The number of copies of TRANSACTIONS sent to the members of the Administrative Committee was reviewed by the Editor.

Professor Bereskin requested the list of PGA Committee membership from the Secretary.

2) *Award Committee:* F. H. Slaymaker gave a report on the recommendations of the PGA Awards Committee to the IRE Awards Committee for the W. R. G. Baker and Browder Thompson Awards.

3) *Program Committee:* M. Corrington confirmed his acceptance of Chairmanship of the PGA-Sponsored Audio Sessions for the 1958 IRE National Convention.

4) The Secretary was directed to send a telegram to the Chairman of the Nominating Committee, urging him to hasten the work of his Committee.

5) M. Copel reported about the progress of the Institutional Listings, since the PGA raised the fee for the Listings.

Request from Philadelphia Chapter

This Chapter has requested funds to help sponsor an Acoustic Demonstration to be held at the Philadelphia Academy of Music for the PGA Program of May 7, 1958. The Chairman is Mr. Nels Johnson, Philco Corporation, 4700 Wissahickon Ave., Philadelphia, Pa. The Secretary was requested to communicate with Mr. Johnson about the details of the proposed budget, sponsorship, program, and publicity.

The meeting adjourned for luncheon and reconvened after luncheon to consider changes in the Constitution and by-laws. (These were received by the Secretary and forwarded to Headquarters for action on October 17, 1957.)

B. B. BAUER,
Secretary-Treasurer

WESCON PAPERS DEADLINE SET FOR MAY 1, 1958

Authors wishing to present papers at the 1958 IRE WESCON Convention to be held in Los Angeles, Calif., August 19–22, should send 100-word abstracts and either the complete text or a detailed summary to the Technical Program Committee Chairman:

Dr. Robert C. Hansen
Microwave Laboratory
Hughes Aircraft Co.
Culver City, Calif.

There will again be an IRE WESCON CONVENTION RECORD. Authors will be notified of acceptance or rejection by June 1, 1958.

WITH OTHER ACOUSTICAL AND AUDIO SOCIETIES

The August, 1957 issue of the *Journal of the Acoustical Society of America* contains thirteen papers, three of which will be of special interest to members of the IRE Professional Group on Audio.

In a unique approach to architectural acoustics, Cesare Codegone writes on the subject of "Orthonophonic Surfaces in Auditorium Design." A study is made, in a particular case, of the shape to be given to the ceiling of a large auditorium such that the sum of the direct intensity and the intensity reflected by the ceiling is constant. It is assumed that the source is an arc of a circle in a horizontal plane with a uniform intensity distribution. The shape of the reflecting ceiling, which in this case is a surface of revolution, is given by a graphical construction founded upon mathematical conditions. The results may also be applied to both optical and thermal fields.

A new audiometric test covering a large number of people is reported by J. C. Webster and P. O. Thompson of the U. S. Navy Electronics Laboratory, San Diego, Calif., under the title, "Recorded Group Audiometer Test Comparisons." At the 1956 Southern California Exposition, recorded series of 4000-cps absolute threshold tests were administered over earphones to 1919 people in groups of eight or less. The results suggest that left ears tend to show greater HL. The results of this survey for HL as a function of age agree reasonably well with results of other recorded-test hearing surveys, but not so well with survey results obtained with clinical audiometers.

It is seldom these days that one comes across a relatively unknown phenomenon such as described by W. W. Fain, S. L. Brown, and D. E. Lockenvitz of the Physics Department, University of Texas; "U-Effect, II, an Electrokinetic Phenomenon." When a glass capillary tube filled with a column of alternate layers of mercury and an electrolytic solution is forced to vibrate mechanically, an ac voltage is generated across the ends of the column. Certain aspects of this electrokinetic phenomenon have been investigated both experimentally and theoretically. Data are presented for 1) the tube output voltage vs amplitude of vibration at fixed frequencies of vibration, 2) the tube output voltage vs frequency of vibration at fixed amplitudes of vibration, and 3) output impedance during vibration for constant unloaded tube output voltage vs frequency of vibration.

The issue contains its usual section on current publications on acoustics, including "The Review of Acoustical Patents" by Robert W. Young.

The *Journal of the Audio Engineering Society* has just issued its January, 1957 issue which contains several articles, all of them of interest to the audio technologist. Among them is a description by Harold Gallina of the "Audio-visual Requirements of the Overseas Missionary," which is especially timely in this era of international stress. Mr. Gallina is technical consultant to the National Council of the Churches of Christ in the U.S.A. He points out that the ever-increasing use of audio-visual aids by overseas missions' personnel emphasizes the need for equipment which will meet the vagaries of foreign operations, such as a range of voltages from below 100 volts to 250 volts, both ac and dc, unstabilized, as well as frequencies of 25, 40, 42, 45, 50 and 60 cps! A well-equipped modern missionary will do well to carry a 35-mm slide projector capable of operating on kerosene, and he must not neglect to fungusproof his equipment. The author describes adaptations of commercial devices and several new developments in this field.

Mr. Abraham Cohen, Engineering Manager of University Loudspeakers, Inc., White Plains, N. Y. writes on "Mechanical Crossover Characteristics in Dual Diaphragm Loudspeakers." He points out the importance of mechanical and acoustical crossovers in loudspeaker systems. He discusses the role of diaphragm shape and material in controlling the mechanical crossover characteristic. The principles set forth are applied to an analysis of the behavior of a typical commercial dual-diaphragm type loudspeaker, in which mechanical separation of low and high frequencies is obtained by the use of apex-mounted diffuser-type radiating elements.

Any time a new transducing means is described the audio technologist will do well to prick up his ears. From England comes the description of a new method of controlling the wind produced by a corona discharge which provides the basis for a new loudspeaker design having no moving parts. The inventor is Dr. David M. Tombs, and the article is written by Gerald Shirley, President of the Televex Co., Yonkers, N. Y. The author describes the construction of a corona triode in which a ring mounted coaxially about one electrode and given suitable potentials is found to control the discharge and hence the magnitude of the wind. Characteristic curves indicating triode-like behavior for various electrode spacings are presented.

Frank Radocy, Director of Quality Control of the Audio Devices, Inc., New York, N. Y., writes about "Tape Storage Problems." When magnetic recording tape is stored, its subsequent performance is determined by the physical and magnetic characteristic of the tape material, as well as by its storage environment. Care must be exercised in selecting the proper type and thickness of the base material and in the choice of magnetic coating formulation. Close control over climatic condition during storage, an even wind without excessive tension, and adequate reel packaging reduce physical damage.

An excellent tutorial paper on magnetic recording entitled, " A Survey of Factors Limiting the Performance of Magnetic Recording Systems," appears in this issue. It is written by E. D. Daniel, P. E. Axon, and W. T. Frost, all three originally with the BBC. Mr. Daniel recently joined our National Bureau of Standards. In a ucid and fundamental fashion the authors survey the fundamental properties, hf bias, response as a function of wavelength, head factors, effects of gap misalignment, separation of head and tape, tape thickness, self-demagnetization, effect of the rate of extinction of the recording field, effect of amplitude fluctuations and its causes, effects of speed fluctuations, losses in the head core, etc.

A copious bibliography follows the article. This article (which originally appeared in the *Proceedings of the IEE* in March, 1957, pp. 158–168) will prove most valuable to anyone desiring to grasp some of the fundamental problems in magnetic recording.

B. B. Bauer

A Magnetic Recording Pickup Head with Crossed Cores for Hum Balance*

MARVIN CAMRAS†

Summary—**This paper describes a simple means of hum balance for a magnetic recording pickup head. Hum level improvements of approximately 20 db are obtained in both single and double coil pickup heads by the method described in this paper.**

A PICKUP head sensitive enough for signals from magnetic tape is also sensitive to fields of power transformers, motors, and similar parts required in a magnetic recorder. Tape signals are normally in the order of 0.1 maxwell, so that for a signal to hum ratio of 60 db, the hum flux should not exceed 0.0001 maxwell.

To reduce hum pickup, the head is usually encased in a high permeability shield as shown in Fig. 1(a). A shielding top cover, with openings to pass the tape, is effective. Sometimes the shield is made of nested cans, with alternate layers of copper and permalloy. Elaborate shielding is expensive, so that additional means are generally used to achieve the required degree of hum reduction.

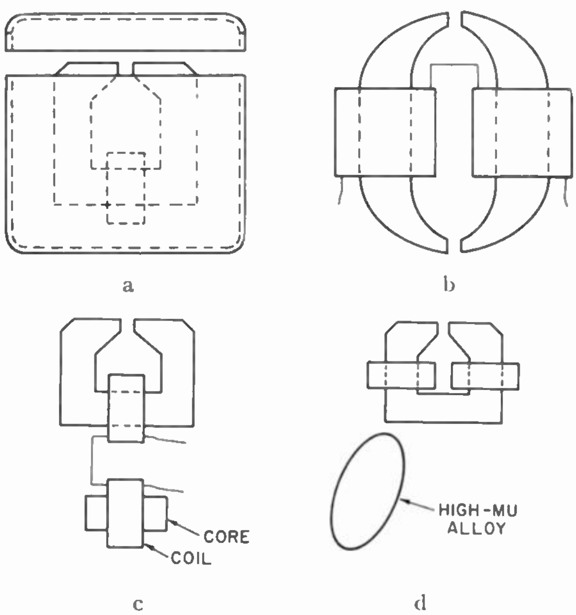

Fig. 1—Methods commonly used for hum reduction: (a) shield can, (b) balanced construction, (c) hum-bucking coil, (d) field orienting piece.

The balanced construction of Fig. 1(b) is very popular. A uniform external hum flux produces equal and opposite voltages in the two coils; while the internal signal flux gives additive voltages. Unfortunately, the hum flux is seldom uniform, so cancellation is incomplete.

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Magnetic heads are mounted in a fixed position for alignment with the tape drive. They cannot be moved to adjust for minimum hum. But an adjustment is possible by the use of a separate hum-bucking coil and core as in Fig. 1(c). The auxiliary coil is mounted close to the head, and is proportioned to pick up a hum voltage which cancels that picked up by the head. Fine balance is made by moving or turning the hum-bucking coil or its core-piece.

Another possibility for adjustment is the field orienting piece of Fig. 1(d). A strip of high permeability material is located near the head to distort the external hum field, and changes the field in direction or uniformity in such a manner that cancellation in the head is more complete. The arrangement of Fig. 1(d) is useful in connection with a balanced construction to minimize the last traces of hum.

Fig. 2 shows a novel construction where a single coil head is made "hum-bucking." The main core of Fig. 2 sends a maximum of hum flux through the voice coil when the hum field direction is as indicated by the dashed lines. To balance out the effects of this hum flux, an additional core is made from a long piece of high-permeability flat stock, and threaded through the coil in crossed fashion as shown. The hum flux picked up by the auxiliary core links the coil in a direction opposite to hum flux in the main core. If the two are equal, the induced emf cancels out.

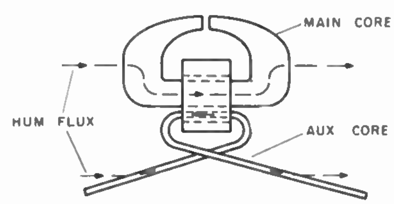

Fig. 2—Single coil hum balanced head.

An experimental head was built along the lines of Fig. 2. Without the auxiliary core-piece, the head was oriented for maximum flux in a standardized 60-cycle field and gave a relative reading of 35 db. The auxiliary polepiece was inserted and adjusted for best balance. When the head was then oriented for maximum pickup, it read 16.5 db. The net improvement was thus 18.5 db. Even better results were obtained when the head and field were kept fixed in position, to simulate the usual condition in a magnetic recorder.

Instead of making the auxiliary core-pieces long as in Fig. 2, shorter wider ones can be used to pick up the same flux, and they can be bent so as to "shade" the main core, as well as their own crossover path.

A two coil head is shown in Fig. 3. If we disregard the extra core, we can see that in spite of apparent symmetry, a hum flux in the horizontal direction follows a path in the main core which induces additive voltages in the coils. By means of the extra core, we send opposite flux through the coils to balance that of the main core. An experimental head of this type gave 26 db of hum in the same field as the previous one. The auxiliary core reduced it to 6 db. The improvement was 20 db.

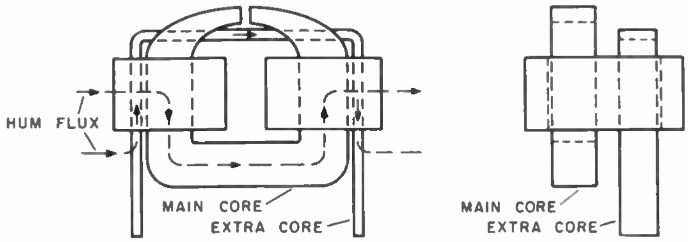

Fig. 3—Double coil hum balanced head.

We should note that the two coil head had a total of twice as many turns as the single coil head. For a fair comparison of these designs, the output of the two coil head was reduced by 6 db in each case. The results are summarized in Table I.

TABLE I

Head	Aux. Core	Hum-DB	Improvement-DB
Single coil	Out	35	
Single coil	In	16.5	18.5
Two coil	Out	20	
Two coil	In	0	20

We note that by use of the auxiliary core on an inexpensive single coil head, a better hum rating is obtained than with a standard two-coil type. Also, the two-coil type can itself be improved 20 db. In practice the advantage is even greater because the auxiliary core can be adjusted for balance in the exact location where the head is used on a recorder.

From the foregoing, it appears that the auxiliary crossed core-piece provides a simple method for reducing hum by 18 to 20 db. This may eliminate the need for shield cans on inexpensive head designs, and it gives a worthwhile reduction in hum factor of more elaborate heads.

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Application of Acoustical Engineering Principles to Home Music Rooms*

WILLIAM B. SNOW†

Summary—**This paper describes the important factors to be considered in the construction of a *home music room*. The effects of reverberation, room resonances, sound diffusion, and noise are considered. Special consideration is given to the control of acoustical conditions, and a room in which many of these factors have been taken into account, is described.**

Introduction

A STUDIO, a sound stage, or an auditorium usually has a well-defined purpose for which the best acoustical conditions can be provided by proper design. But even in a home elabo ate enough to include a room entirely devoted to music there will be more complicated requirements, and it will be difficult to specify and attain "best" acoustical conditions. For the usual home where the "music room" must also serve additional purposes and where its cost is a very important consideration, the problem becomes diffuse and the detailed plan of an individual room necessarily represents a compromise between a number of divergent factors depending upon the owner's particular tastes and needs. It would be impossible to apply all of the acoustical design techniques described in this paper to such a music room. Nevertheless, a selection from them can be used to benefit any room, not only for music, but also for general living.

It would be convenient if all the necessary considerations could be listed and discussed independently and in logical order. This condition seldom is found in complex physical situations, and home music room acoustics offer no exception. The factors are interdependent to a large degree. In the following discussion they are separated to the extent of the author's ability, but numerous crosscurrents will be evident.

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Fundamental Acoustical Factors

The fundamental conditions which result in a good acoustical environment for music are described first. Later, methods of obtaining these conditions in homes are suggested.

Reverberation

A factor which can be discussed in a quantitative way, and measured in numbers, is reverberation. If a musical instrument starts sounding out-of-doors, the sound radiates away in all directions, there is only a direct path between instrument and listener, and the intensity of this direct sound falls continuously as the distance to a listener increases. If the same instrument starts sounding in a room, for an instant the same condition prevails. But in every direction the sound shortly encounters a wall, floor, or ceiling which is not a perfect sound absorber, and the part which the surface does not absorb is reflected back into the room in a new direction. Here it again strikes a surface, again has the unabsorbed part reflected in a new direction, and so on. The room soon has sound energy bouncing around in it in a prodigious number of directions, and the sound level heard by an auditor builds up until the total energy represented by absorption at the boundaries for all reflections just equals the energy being put into the room by the instrument.

The buildup of sound energy is illustrated at the left of Fig. 1. The bouncing energy constitutes the reverberant sound field, which is essentially the same throughout the room. In contrast with conditions out-of-doors, inside a room the sound level does not decrease continuously with distance from the source. As illustrated by Fig. 2, close to the source where direct sound predominates the situation is the same. But at distances of more than a few feet in home-sized rooms the sound consists primarily of the constant reverberant field. This also is shown by Fig. 2. Reverberation thus raises the sound intensity at practical distances by confining the total amount of sound to the volume of the room, and the principal sound heard is reverberant.

The direct sound has an extremely important role, however. It contributes to the appreciation of short transient sounds. But more than that, it alone carries the information giving the sense of direction, by allowing the listener to observe initial transients clearly during the short time interval before the many-directioned reflections begin to arrive at his ears.

At the right of Fig. 1, the decay of sound in the room, after the instrument has stopped sounding, is depicted. Sound level decreases with numerous fluctuations, but at an average rate, as shown, which can be expressed in db per second. However, the more common expression is the time in seconds for the sound level to fall 60 db. This is known as reverberation time. Although it is an arbitrary number, through long usage it has become the standard for expressing the amount of reverberation in a room.

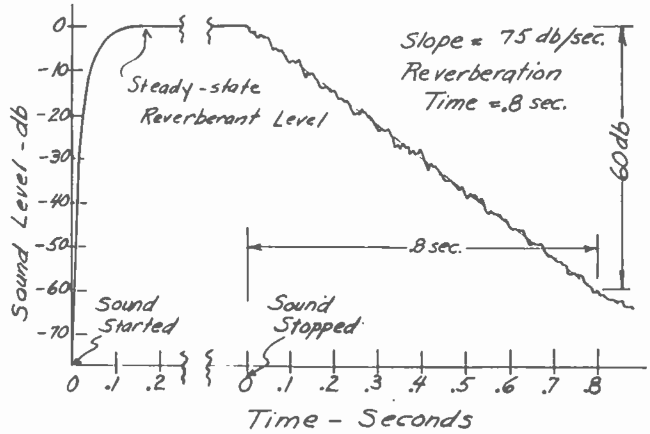

Fig. 1—Growth and decay of sound in a room. The sound level builds up rapidly (left) to a steady-state condition where the absorption of walls, ceiling, floor, and openings just equals the rate of energy emission of the source. When the source is stopped (right), the sound level decays logarithmically at a rate determined by the room volume and total sound absorption.

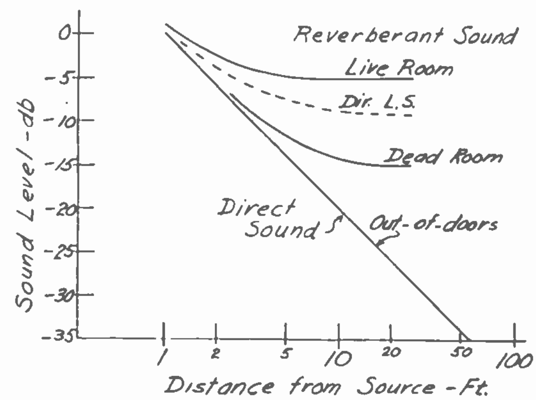

Fig. 2—Variation of sound level with distance from a nondirectional source. With no sound reflections (out-of-doors) only direct sound is heard, falling at the rate of 6 db per doubled distance. In a room at short distances the direct sound predominates, but at ordinary listening distances the reverberant or reflected sound level, predominates for continuous sounds. The reverberant level is greater for a live room with little sound absorption. Since a directional loudspeaker (dashed line) does not radiate equally in all directions, it gives the effect of a less reverberant room, for constant sound level *on axis*.

Reverberation is both good and bad, like inertia and friction. Inertia keeps the automobile engine running and friction is undesirable, whereas inertia would soon smash the car if it were not for friction in the brakes. Similarly, reverberation raises the sound level and adds a quality to music which people enjoy, in addition to helping musicians play by allowing them to hear themselves and each other. But if it is excessive it destroys definition, because old sounds persist and interfere with the proper perception of new sounds. As in the case of so many engineering problems, proper control must be exercised to gain the benefits while minimizing the detrimental aspects.

Room Resonances

At certain frequencies, where the sound wavelength correlates with room dimensions, resonant conditions cause unusually high sound pressures which appear as audible peaks in response. A familiar example is the boom in bathrooms which leads to the popularity of bathroom singing. This phenomenon is illustrated in Fig. 3 which shows the sound level in a room from a "representative" loudspeaker with constant amplifier input. The peaks are most prominent at low frequencies, because at higher frequencies they crowd so close together that they are not appreciated by the ear as distinct. As long as there are reflections at the room boundaries, this effect will persist and there will be differences in response at various parts of the room. It should not be considered a fault—people like to listen to music in rooms, and this is a normal characteristic of that kind of listening. As with reverberation, the proper proceedure is to control the effect, and this is done primarily with room shape as is seen later.

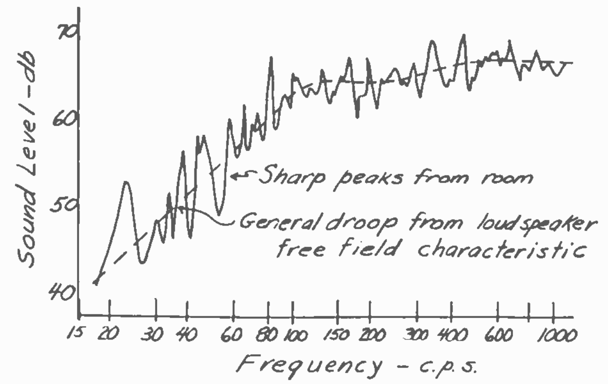

Fig. 3—Frequency response of hypothetical loudspeaker in a room. A loudspeaker with smooth response in a free field (dashed line) will have a response as shown in a room, because of room resonances and sound reflections. This is *characteristic* of indoor listening, and is not objectionable when acoustical conditions are properly controlled.

Sound Diffusion

The ideal reverberation concept assumes that sound is thoroughly dispersed or diffused about the room. And it has been observed that music sounds best in rooms where diffusion is good—that is, where the reflected sound arrives relatively uniformly from all directions. Such an effect is obtained when the direction of travel is distinctly altered at each reflection, either by geometrical factors or by nonuniform absorption patches. When diffusion is good, the decay of sound is smooth as illustrated in Fig. 4 by the solid line, whereas a poor distribution of reflected sound results in an irregular decay curve such as the dashed line.

A particularly objectionable lack of diffusion results from pairs of hard parallel walls, or floor and ceiling. Here the sound becomes "trapped" in paths perpendicular to the surfaces and travels back and forth with little absorption. This gives a rough quality; and distinct multiple echoes can be perceived from a hand clap between such surfaces. This effect is known as flutter echo and will not be present if the surfaces are nonparallel or irregular, or if one of them has good sound absorption.

When the sound absorption is largely concentrated in one area, the double decay slope shown in Fig. 4 often results. The sound impinging on the absorption is rapidly removed, giving the high initial slope, whereas that which remains primarily in the unabsorbent region decays much more slowly. This same effect can be produced by a coupled space—frequently a long, reverberant hallway.

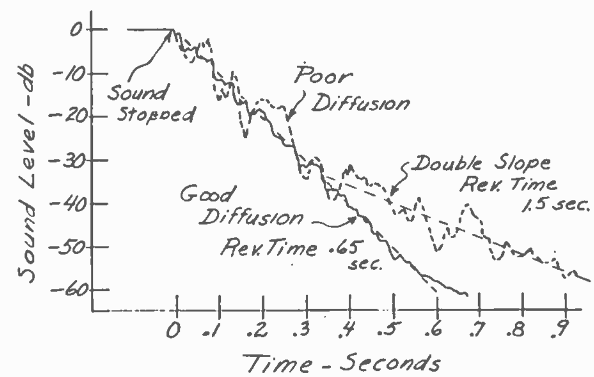

Fig. 4—Types of sound decay in rooms. Good sound diffusion, obtained by proper room shape and placement of absorption, yields smooth, uniform decay (solid line). Poor diffusion results in a rough decay pattern (dashed line) and frequently in more than one decay rate.

Noise

A most important consideration is noise. Noise coming from outside is an unwelcome intruder and interferes with the pleasure of listening to music and the ease of playing. Also, the music, no matter how gratifying to performer and willing listener, is just noise or interference to unwilling auditors; for example, someone trying to sleep or study. Consequently, a music room should be isolated as much as possible from other rooms. Probably this is the most difficult aspect of all in a music room, as it is in other rooms of a modern residence. Almost all trends seem exactly away from providing quiet and sound isolation; nevertheless, efforts in this direction will be repaid in more pleasant listening and living.

Control of Acoustical Conditions

In this section methods of obtaining the various desirable conditions for music rooms are set forth, but it is up to the individual to decide how many of them he can adapt to his own room. Of course, it is not necessary to listen in an ideal environment to enjoy music. Indeed, the "ideal" room is something of a myth, since its characteristics would vary with the type of music, and the so-called optimum conditions represent only the average judgment. The methods outlined below show the direction to take and what to avoid if possible.

Plan

The place to begin, in the case of a new home, is with the building plan and plot plan. Locate the room on the side of the house away from the street, or any other source of consistent noise. Sound is reduced in passing around a corner; therefore it is good to have music room windows in walls at an angle from bedroom or study windows. Large windows transmit more sound, so that from the noise standpoint the windows should be kept small unless they are double.

The music room preferably has outside walls, or common walls with kitchen, dining room, garage, etc., rather than with bedrooms. It is best if the bedroom-study section can be isolated from the other parts of the home. An aid in this direction is to provide a passage, heavily sound absorbent, with a door at each end.

Room Shape

It was mentioned that sound diffusion is obtained partly by irregularity of outline, but this is only true of frequencies where the irregularities are comparable to or larger than the sound wavelength. At low frequencies with wavelengths of 5 to 20 feet or more, this is impossible in home-sized rooms. The room resonances in this region must be accepted, but should be spaced by choosing the dimensions properly. The main dimensions should bear noncommensurate ratios to one another. For example, $8\times16\times24$ would not be a fortunate choice, but $8\times14.5\times26$ would be better, or $9\times16\times23$.

Flutter echoes are eliminated by making walls nonparallel, either by placing them on a slant or by securing irregularity of outline by the use of steps, alcoves, bay windows, zig-zags, etc. Convex curved surfaces are good, but avoid large concave ones which tend to focus sound in spots. The popular slanted ceiling with exposed beams is excellent, but is not needed to eliminate flutter echo over a carpeted floor. Where nonparallel surfaces are used, employ a slant of $\frac{3}{4}$ inch per foot, or more, relative to the opposite surface.

It is desirable to use basic architectural features to achieve these effects, as contrasted to surface treatment, because this allows more freedom in the furnishing and decoration of the room, still obtaining a favorable reverberation time.

Construction Methods

Isolation

If the music room is to be quiet, and not a source of annoyance to others, detailed attention will have to be paid to construction methods both during the planning and building stages. The subject is too complex to treat in any detail here and study of the references is recommended. The following outline discussion shows what must be considered.

Wall construction must be substantial to yield good sound isolation. It is imperative to recognize the difference between a sound absorber and a sound isolator. The absorber is a porous structure, or a membrane which vibrates easily, and sound easily passes into it and through it. The sound isolator, on the other hand, is solid and accepts very little sound, reflecting most of it back into the room and transmitting little through to the opposite side. The same construction cannot serve both purposes, but must be properly combined with the other to achieve a complete acoustical design. An example will illustrate the point. It is popular now to construct buildings with a large common "attic" space in which services can be run without interference. The room ceilings are of acoustical absorbing materials such as glass-fiber board. The room walls are of solid construction, but run only to the absorbent ceiling. This type of construction leads to disappointment, because, while the sound absorption of the ceilings is high, the isolation is low and sound travels from one room to another over the top of the walls right through the porous absorbing panels. The walls must run clear to the roof, or the absorbent ceiling panels must be backed up by impervious panels.

The sound isolation value of a wall is primarily related to its weight per square foot, but increases only about 5 db for a doubling of that weight. Masonry walls are heavy and have medium sound isolation, *provided all pores are well sealed.* Lath and plaster walls are also fairly heavy, but many modern partitions are too light to give acceptable sound insulation.

If a double wall is used, with airspace between sections, the isolation is better. Ideally, twice the isolation of a single wall should be attained, but this would only occur with long airspace and negligible physical connections between walls at the periphery. In practice 10 to 15 db can be realized with careful design. The airspace should be at least 5 inches (studs can be in the space) and there should be no bridging connections between walls, except at the periphery. When double walls are used, it is an advantage to have a discontinuous floor construction at the walls.

Similar considerations apply to isolation between floors. There are double constructions for floors and ceilings that have the same advantages as double wall constructions.

A most important consideration is the elimination of all leaks or holes. Even electrical outlet boxes back-to-back with a through-hole, or heating system pipes through a loose-fitting opening, will cause trouble. The most serious "hole," however, is a door. Doors are lighter in weight than the walls, and are difficult to seal around the edges. Sound attenuating doors and special frames are available which may be used where direct access between rooms is necessary. They are expensive and must be carefully installed, but they are effective. If possible, bedrooms, bathrooms, and studies should not open directly from a music room, but should be isolated by a hallway which is treated with sound-absorbent material (acoustic tile, or carpet and drapes). This provides two doors with an absorbent chamber between—a "sound lock" which is effective.

Plumbing noise is a frequent source of annoyance in homes. Plumbing fixtures should not be mounted on walls contiguous to the music room, and wherever possible pipes should be resiliently mounted on the structure. It is unfortunate that little attention has been paid to this subject and no standard noise-reducing methods exist for home construction.

TABLE I

REVERBERATION TIME CALCULATIONS

ROOM 15×25.5×9 FEET = 3500 CUBIC FEET

Surface	Area Square Feet	100 cps Absorption Coefficient	100 cps Sabins	1000 cps Absorption Coefficient	1000 cps Sabins	4000 cps Absorption Coefficient	4000 cps Sabins
Floor							
$\frac{2}{3}$ carpet	255	0.15	40	0.5	130	0.7	180
$\frac{1}{3}$ wood	130	0.1	15	0.08	10	0.07	10
Ceiling							
Plaster	385	0.15	60	0.07	25	0.04	15
Windows							
$\frac{1}{4}$ wall area	180	0.2	35	0.1	20	0.05	5
Walls							
$\frac{1}{2}$ Plaster	360	0.15	55	0.07	25	0.04	15
$\frac{1}{4}$ Plywood	180	0.35	60	0.15	25	0.07	15
Drapes	145	0.03*	5	0.5*	70	0.6*	90
Furniture							
Padded	200	0.4	80	0.5	100	0.5	100
Air							
30 per cent relative humid			negligible		negligible		50
Total Sabins			350		405		480
Reverberation Time = $\frac{0.05 \times \text{volume}}{\text{Sabins}}$			0.5 second		0.43 second		0.36 second
Sabins less furniture			270		305		380
Reverberation Time			0.65 second		0.57 second		0.45 second

* Excess over bare wall.

Doubtless this all sounds complicated, expensive, and at variance with other objectives in home planning. No refutation is offered for such opinions, because ideal acoustical conditions are never attained easily. However, they are worthy of careful attention.

Room Surfaces

Reverberation is controlled by the absorption of the room surfaces and furnishings. Diffusion is also affected by the surface absorption. The average reverberation decay slope is independent of the location of the absorption, but experience has shown that placement is in fact important. To obtain a smooth decay and good diffusion, the absorption should be distributed. A hard-walled room with all absorption concentrated at one spot is not as good as one with absorption spread over the surface. For example, for many years wood-paneled rooms have been popular. The paneling gives a moderate absorption over the whole room surface, especially at low frequencies.

It is not necessary to have complete distribution of absorption for good acoustics; a good admixture of reflective and absorbent areas is satisfactory and more practical. What reverberation time should a home music room have? A time of 0.8 second above 500 cps, rising to 1.2 seconds at 60 cps, is an average recommendation. This represents a rather bare room, as will be shown. Reverberation time in a completed room can be measured, with specialized equipment. For design purposes it is calculated. A representative calculation is shown in Table I, where for each element of surface there is given an area, an estimated absorption coefficient for each frequency, and the corresponding total absorption. The latter is area times coefficient, and is expressed in sabins; one sabin being one square foot of total absorption. The coefficients may be deduced from experience or from tables in the references.

The room chosen here is considered a representative one, and shows what usually turns out to be the case—that a living room furnished primarily for comfort tends to be too dead for best reproduction of music. Even without any upholstered furniture the times would still be shorter than optimum. Note that the ceiling is hard plaster. In a dining room or bedroom where quiet is the principal acoustical consideration, an acoustically treated ceiling would be in order. It is not desirable in a music room.

In selecting surface treatments and furnishings the following observations serve as a guide.

1) Drapes, rugs and carpets, furniture in general give principal absorption at high frequencies.
2) Acoustic tiles and commercial absorbers have very high absorption between 500 and 2000 cps, with decreasing absorption above and below. The low-frequency absorption depends a great deal on the mounting used.
3) Plywood paneling, large glass areas have medium absorption at low frequencies, little at high frequencies. They give good balance with drapes, etc.
4) Walls, floors, and ceilings in frame construction give 10 to 15 per cent absorption at low frequencies, a few per cent at high frequencies.
5) Solid masonry, and slab floors, have very low absorption at all frequencies.
6) Block walls unfinished and unsealed may have absorptions as high as 30 to 50 per cent. This varies greatly with the blocks, installation, and finishing. If the blocks are good absorbers, they will also

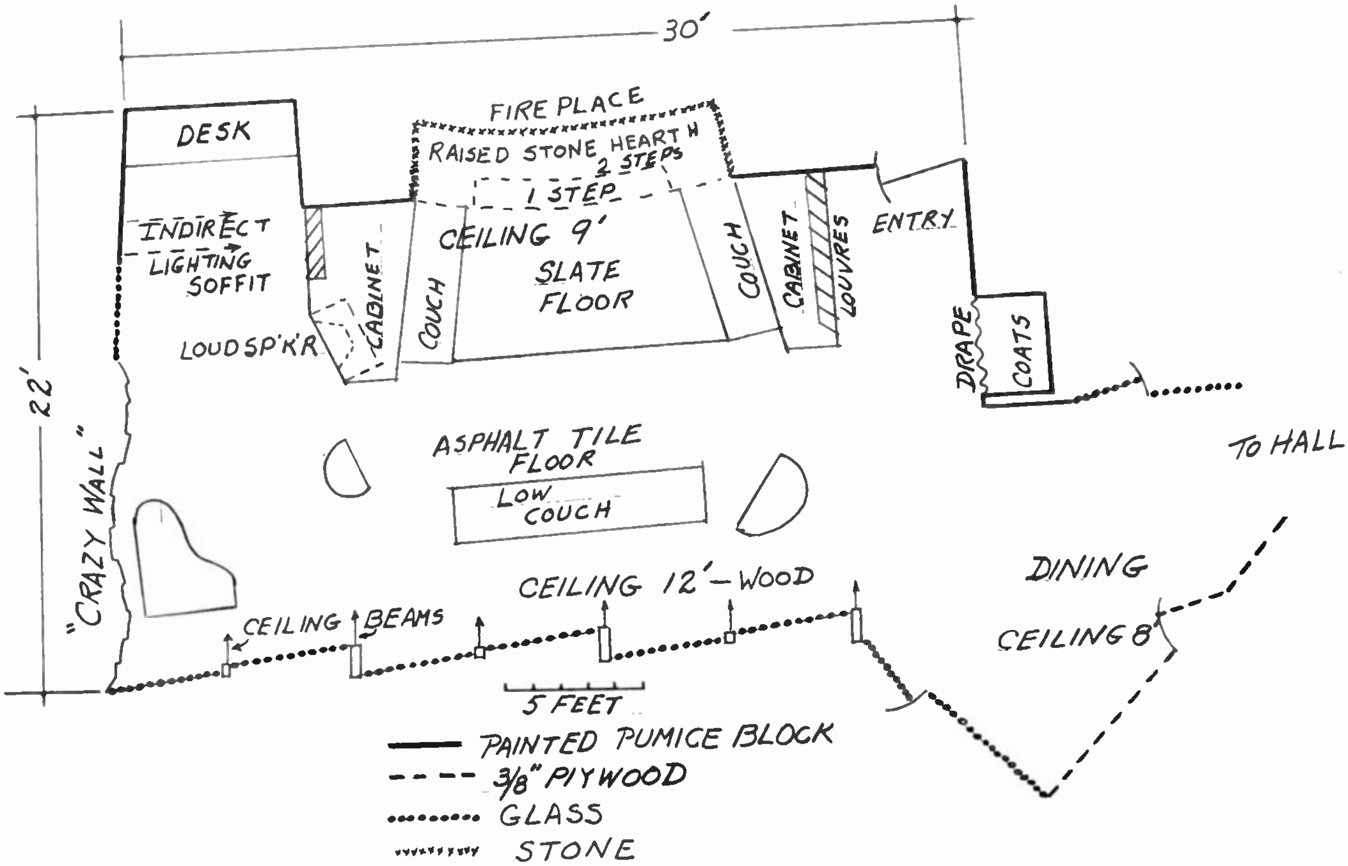

Fig. 5—Floor plan of room having excellent acoustics for music.

transmit the sound through. Therefore, *cement* or *seal* the opposite side.

7) Furniture, bookcases, dividers set about in the room promote sound diffusion.
8) Unpainted wood absorbs 10 to 15 per cent at high frequencies, but about half that when painted.
9) Absorption of the air goes up rapidly with frequency, being maximum in dry air. However, this is negligible in home-sized rooms, although it is very important in large halls.

Fig. 5 illustrates a room following the principles outlined here. It is in the home of Mr. Paul S. Veneklasen, Director of Western Electro-Acoustic Laboratory, Los Angeles, Calif. The "crazy wall" was named by the mason who built it, and consists of pumice blocks in a random curved outline, set with various projections from a smooth surface. Its purpose is to promote diffusion. The reverberation time of this room is about 0.8 second, and it is an excellent room for both playing and listening.

Electronic Music

Most of the music listened to in contemporary home music rooms will be electronically reproduced. Electronic techniques not only bring to every home the standard musical performances, but also make possible entirely new types of music which were hitherto impossible to create. Since opinions differ radically in this field, those which follow can only be considered the author's.

An efficient wide-range loudspeaker is a large piece of furniture and not simple to place in a room. Low-frequency radiation is expensive, and is favored by a corner location, which also excites all modes in the room. However, there is not enough difference between a corner location and any other against a wall to dictate the corner when it does not fit in with other uses of the room.

All loudspeakers become more directional at high frequencies, some excessively so. Such units may maintain uniform response directly on the axis, but radiate much less sound to the sides. This has the effect of reducing the apparent reverberation in the room, as shown by the dotted curve on Fig. 2. In general, this is undesirable and a loudspeaker with wide directivity will give more pleasing reproduction.

Since stereophonic reproduction is rapidly gaining in popularity, it must be considered in the design of home music rooms. Its use restricts the listening geometry, since to get the full effect the auditors must be grouped between the loudspeakers and as nearly equidistant from them as possible. The listening angles should be maintained about as they are in a concert hall. This usually means placing the loudspeakers 10 to 12 feet apart in moderate sized rooms and 12 to 15 feet apart in large rooms. Having both units alike is the best condition. However, much benefit from stereophonic reproduction can be gained with a smaller unit for one channel—the "normally high frequency" one. The smaller unit should have high frequency response comparable to that of the main loudspeaker.

Good reproduction can be obtained from a loudspeaker installed in a wall, but it must be remembered that it radiates in both directions. The back radiation may cause annoyance, and the loudspeaker will transmit noise through the wall nearly as well as an open hole.

It is a great convenience to have the volume and tone controls for the reproducing system at the listening position. This is especially true of the balancing controls for a stereophonic setup. If his conscience will allow it, a listener can derive great satisfaction from adding his own interpretation in quality and dynamics to that of the music as originally recorded.

Conclusion

In conversations around the Hollywood studios, the author has been impressed by what he has frequently been told by members of the sound and other technical departments, who might well be expected to hold a different view. They say that "the story is the important thing—if it is poor, technique alone won't make a good picture." In the home the music is the important thing. This paper gives much advice on how to enhance its appeal—but music can be enjoyed under very primitive conditions. Therefore, no one should feel that all the conditions elaborated above are required for home music. Use them as a guide in making improvements, but in the meantime enjoy the music in whatever surroundings exist.

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[7] Snow, W. B. "Basic Principles of Stereophonic Sound," *Journal of the Society of Motion Picture and Television Engineers*, Vol. 61 (November, 1953), pp. 567–589. See also, IRE Transactions on Audio, Vol. AU-3 (March–April, 1955), pp. 42–53.

[8] For general ideas on design and decoration, magazines such as *Architectural Forum, Architectural Record, Art and Architecture, Interiors, Sunset, House Beautiful, House and Garden, Better Homes and Gardens*, and proprietary magazines of the acoustical materials and building materials manufacturers.

[9] *Portions of the following books:*

Knudsen, V. O., and Harris, C. M. *Acoustical Designing in Architecture.* New York: John Wiley & Sons, Inc., 1950.

Rettinger, M. *Applied Architectural Acoustics.* Chemical Publishing Company, 1947.

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(Many other references will be found in those listed above.)

On Making Accurate Measurements with a Harmonic Distortion Meter*

J. ROSS MACDONALD†

Summary—It is pointed out that an avoidable error occurs in making total harmonic distortion measurements by the usually recommended method with an instrument incorporating an average-responding output meter. The error arises from the fact that the average value of a full-wave rectified distortion signal can be reduced by adding a small phase-shifted fundamental component to the distortion. The error is always in the direction to make equipment seem better than it actually is and can amount to ten per cent or more It can be readily avoided by changing the instrument operating procedure.

THE rms harmonic distortion of a complex periodic waveshape may be defined as[1]

$$D_h = \frac{\left[\sum_{i=2}^{\infty} e_i^2\right]^{1/2}}{\left[\sum_{i=1}^{\infty} e_i^2\right]^{1/2}},$$

where e_i is the effective value of the ith distortion component and e_1 is the effective value of the fundamental. Sometimes the denominator is given as e_1 only,[2] but the above form is that best adapted to measurements of total harmonic distortion.

The quantity D_h may be calculated directly from measurements of the individual harmonic components e_i using a heterodyne type of wave analyzer. Here, however, we are concerned with the direct measurement of D_h using a total harmonic distortion meter.[2] With such an instrument, the rms value of the complex waveform [the denominator of (1)] is first measured or its indicated level set to a fixed value, then the fundamental component is eliminated by means of a tuned bridge, bridged T, parallel T, or other method, and the rms value of the remaining distortion components measured. If the original level is set to a reading of 100, then the second reading yields D_h directly in per cent.

The errors which are discussed here arise from the usual failure to employ true rms reading meters in commercial total harmonic distortion instruments. Instead, the general practice is to use meter scales calibrated in rms values, but meters which themselves respond to the average value of the full-wave rectified waveshape. The first error arising from this practice is well known—true rms readings are not obtained for complex waveforms. The size of the error depends on the specific waveform measured; for example, for a signal containing 20 per cent third harmonic, the maximum error from this source is 6.7 per cent.

The second error is more insidious. The usual instructions for the use of a total harmonic distortion meter call for the fundamental-eliminating circuit to be adjusted or balanced by varying the controls to give a minimum reading on the output meter. Generally, this minimum reading is then taken to be the per cent total harmonic distortion. This procedure would be strictly correct if a true rms reading output level indicator, such as a thermocouple or square-law VTVM, were used. It is incorrect when an average-responding output meter is used.

The reason the above procedure is incorrect when an average-responding meter is employed is that it is possible for the average value of a complex waveshape containing no fundamental to be reduced by the subsequent addition of a small amount of fundamental component. On the other hand, such addition increases the rms value. The above procedure of tuning for a minimum using an average-responding meter therefore involves tuning not for complete elimination of the fundamental, but, instead, tuning for the amount of fundamental which makes the resulting average value a minimum and less than the value which would be obtained with no fundamental component. This conclusion can be readily verified by observing the output of such a distortion meter before rectification and noting the presence of a fundamental component when the meter reading has been minimized.

The actual amount of the error arising from the above cause depends on the form of the distortion and upon the specific method of fundamental component elimination. Measurements made by the author with a commercial instrument, which employed a Wien bridge with feedback for fundamental elimination and an average-responding output meter, showed that the difference in readings between the minimum obtainable reading and that found when the fundamental was completely eliminated often amounted to ten per cent or more in the total harmonic distortion range from 0.5 to 10 per cent.

Because fundamental-elimination can be carried out in a number of ways for each of which the above type of error will vary, it is impractical to treat it mathematically even for the simple case of pure second harmonic distortion. We have, however, established the following results. When a small fraction of the fundamental, $\epsilon \sin \theta$, is added to a second harmonic term, sin

* Manuscript received by the PGA, January 9, 1957.
† Texas Instruments, Inc., Dallas 9, Texas.
[1] F. Langford-Smith, "Radiotron Designer's Handbook," Amalgamated Wireless Valve Co., Ltd., Sydney, Australia, 4th ed., p. 609; 1952.
[2] F. E. Terman, "Radio Engineers' Handbook," McGraw-Hill Book Co., Inc., New York, N. Y., p. 944; 1943.

2θ or $\cos 2\theta$, the average value of the full-wave rectified sum is a monotonically increasing function of ϵ as ϵ increases from zero. For this simplified case, the meter reading would, therefore, be that with zero fundamental component. Unfortunately, the experimental case is always more complex than this. Even with only pure second-harmonic distortion as the instrument is tuned away from the point of zero fundamental transmission, both ϵ and the phase of the injected fundamental component will vary. At the same time, the amplitude and phase of the second harmonic (and of any higher harmonics if they are present) will also vary, although such variation will be essentially negligible compared to that of the fundamental. Neglecting this latter variation, the calculation of the full-wave average value of $[\sin 2\theta+\epsilon \sin (\theta+\psi)]$ turns out to be exceedingly complex for even the Wien bridge case since both ϵ and ψ vary as the bridge is unbalanced.

What then can be done to use a total harmonic distortion meter with maximum accuracy? The best and obvious answer is to eliminate both of the kinds of errors we have discussed by using an rms-responding output indicator. When this is impractical, the second type of error can still virtually be eliminated in the following way. Instead of applying the distorted waveshape from the output of the device being measured to the distortion meter and tuning for a minimum, use a low-distortion, stable oscillator and first apply its output directly to the input of the distortion meter. Then tune the instrument to eliminate the fundamental. Here, it is allowable to tune for a minimum, since the distortion of the oscillator has been assumed very low; alternatively, the output of the distortion meter may be monitored with an oscilloscope and the tuning for fundamental elimination aided thereby. Next, the oscillator output is connected to the device to be tested and its output applied to the distortion meter input. First, the level of the complete waveform is adjusted to give a fixed reading on the (average-responding) output meter, say a reading of 100. Then, without readjusting the fundamental elimination circuit, the instrument is switched so that the fundamental is eliminated and the resulting percentage harmonic distortion is read on the output meter. If then the controls of the fundamental-eliminating circuit are readjusted for a minimum reading, it will be found that this reading is appreciably lower than the first more accurate reading, because a small amount of fundamental signal component has been added to the distortion components. This error is particularly insidious and is to be avoided in high-quality audio work because it always makes the device being measured seem better than it is in actuality.

Contributors

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Marvin Camras (S'41–A'42–SM'48–F'52) was born in Chicago, Ill. in 1916. He received the B.S. degree in electrical engineering from Armour Institute of Technology in 1940, and the M.S. degree from Illinois Institute of Technology in 1942. Since 1940, as a member of the staff at Armour Research Foundation, he has done research on projects in the electronics department, including remote control, high speed photography, magnetostriction oscillators, and static electricity.

Mr. Camras contributed developments which are used in modern magnetic tape and wire recorders, including high-frequency bias, improved recording heads, wire and tape materials, magnetic sound for motion pictures, multitrack tape machines, and binaural sound reproduction.

He is a Fellow of the Acoustical Society of America; and a member of AIEE, SMPTE, AAAS, Eta Kappa Nu, Tau Beta Pi, and Sigma Xi; and a former Chairman of the IRE Professional Group on Audio.

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J. Ross Macdonald

J. Ross Macdonald (S'44–A'48–SM'54) was born in Savannah, Ga., on February 27, 1923. He received the B.A. degree in physics from Williams College and the S.B. degree in electrical engineering from M.I.T. in 1944. After a semester of teaching at the M.I.T. Army-Navy Technical Radar School, he was commissioned an ensign in the U. S. Naval Reserve in 1944. Upon completing radar courses at the Harvard and M.I.T. radar schools, he served as a technical radar officer. Upon release to inactive duty in 1946, he returned to M.I.T. and received the S.M. degree in electrical engineering, in 1947. During this period, he carried out research on storage tubes for the M.I.T. digital computer project. After a year's further graduate study in the M.I.T. Physics Department, he was awarded a Rhodes Scholarship from Massachusetts for study at Oxford University. Dr. Macdonald received a D.Phil. degree in physics from Oxford, in 1950, for theoretical and experimental work on ferromagnetic phenomena.

In 1950, Mr. Macdonald joined the physics department of the Armour Research Foundation and there carried out and directed work in theoretical and experimental physics until 1952. He then spent a year's leave of absence at the Argonne National Laboratory of the A.E.C. working on solid-state problems. He is presently director of solid-state physics at Texas Instrument, Inc., Dallas, Texas. In addition, he is serving as clinical associate professor of medical electronics at Southwestern Medical School of the University of Texas in Dallas.

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W. B. Snow

William B. Snow (A'26–VA'39–SM'50) was born on May 16, 1903 in San Francisco, Calif. He received the B.S. and E.E. degrees from Stanford University. From 1925 to 1941, he was at Bell Telephone Laboratories in the Acoustical Research Department, working on numerous phases of acoustics and electronics. During these years, he was intimately connected with Bell Telephone Laboratories' studies of very high-fidelity reproduction and recording of speech and music. This work resulted in papers on audible frequency ranges of musical instruments and the basic principles of stereophonic sound.

During the war years, Mr. Snow continued his work in acoustics at the U. S. Navy Underwater Sound Laboratory in New London, Conn. From 1946 to 1952, he was employed by Vitro Corporation of America working on classified research and development projects for the U. S. Armed Services.

Since 1953, he has been engaged in consulting engineering in acoustics.

IRE Professional Group on Audio Combined Index for 1957

Use of the Index

The combined indexes which follow are of three types. The first type is simply a compilation of Tables of Contents of the IRE TRANSACTIONS ON AUDIO and the Audio portion of the NATIONAL CONVENTION RECORD and IRE WESCON CONVENTION RECORD. Next is an Author Index. The third type is an Analytic Subject Index.

The volume system of indexing began with the first issue of 1953. Volume AU-5, issues 1, 2 . . . 6, contain all IRE-PGA publications for the year 1957 and the Audio parts of Section 7 of the 1957 NATIONAL CONVENTION RECORD and the IRE WESCON CONVENTION RECORD. In the Tables of Contents, these sections are numbered CR-5-7 and CR-1-7, and inserted following the AU-5-6 issue, IRE TRANSACTIONS ON AUDIO.

In both the Author Index and the Analytic Subject Index references are made to publications by the issue and page number in the volume (*e.g.*, AU-5-2, 32).

The Analytic Subject Index lists titles under the appropriate classifications in the series shown below. In many cases valuable material is published under titles which cannot be fully descriptive of all the material which the paper covers. It is for this reason that some titles are listed under various classifications, some of which may seem inappropriate to the title itself. It is hoped that this will increase the probability of finding quickly most of the information available under a particular classification.

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   - 1.3 National and Regional Meetings
   - 1.4 Chapters
   - 1.5 Membership
   - 1.6 Transactions
   - 1.7 People
2. Bibliographies, Reviews, Standards, Tapescripts
   - 2.1 Bibliographies
   - 2.2 Reviews
   - 2.3 Standards
   - 2.4 Tapescripts
3. Sound Systems
   - 3.1 General
   - 3.2 Stereophonic, Binaural, and Spatial Effects
   - 3.3 Military
4. Microphones
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   - 5.4 Frequency-Range Dividing Networks
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   - 5.9 Special Amplifiers
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