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of the

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1931

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GENERAL INFORMATION

Institute History

Prior to the formation of the Institute of Radio Engineers, two other organized groups of radio enthusiasts held meetings in New York and Boston. These were the Wireless Institute and the Society of Wireless Telegraph Engineers.

On May 13, 1912, these two organizations were merged, taking the new name of the Institute of Radio Engineers. Headquarters were established in New York.

The Society of Wireless Telegraph Engineers had a membership of eleven on January 1, 1907, and forty-three on January 1, 1912. The Wireless Institute had fourteen members on January 1, 1909, and twenty-seven members on January 1, 1912. The Institute of Radio Engineers, at the time of its foundation, had less than fifty paid-up members.

Prominent in the early work of the Society of Wireless Telegraph Engineers were John Stone Stone, Lee de Forest, and Fritz Lowenstein. Those identified with the initial work of the Wireless Institute included: John S. Murphy, R. A. Somerville, Joseph D. Fountain, R. B. Respress, R. A. Cleva, John Gregg, E. Barnwell, Philip Farnsworth, Sidney L. Williams, R. H. Marriott, G. W. Pickard, Harry Shoemaker, and Eugene Thurston. The consolidation of these two societies and the initial work of organizing the Institute of Radio Engineers were done by J. V. L. Hogan, A. N. Goldsmith, and R. H. Marriott.

Aims of the Institute

The Institute of Radio Engineers functions solely to advance the art and science of radio communication. It numbers among its members nearly all of the men who have been prominent in the development of radio in the United States, as well as many noted radio engineers and scientists in other countries.

The membership of the Institute consists of those persons who are qualified for any of its several grades of membership, either through their interest in radio communication, or by practice of some phase of radio engineering as a profession. The eligibility of an applicant to membership in any grade is finally determined by the Board of Direction of the Institute, in most cases on the recommendation of the Committee on Admissions.

Through the presentation and publication of original papers, by affording its members the opportunity of meeting to discuss radio prob-

lems, by awards of honors and prizes, and in other ways, the Institute fosters and encourages the development of this important means of communication, and particularly aids in the exchange of radio information of a technical and engineering nature.

Publications

The papers presented at the meetings of the Sections and of the Institute in New York, together with the discussions and other papers submitted by Institute members, are printed in the PROCEEDINGS of the Institute of Radio Engineers, published monthly. The PROCEEDINGS thus constitutes a continually growing store of information on all phases of radio engineering. Since the first issue in 1913, 777 papers have been printed. The PROCEEDINGS is sent free to all Institute members of all grades. The subscription price to nonmembers is $10.00 per year.

Standardization reports giving definitions of terms and standard graphical symbols used in radio communication were issued in 1913, 1915, 1922, and 1926. The standardization report for 1928 was published in the 1929 YEAR BOOK. These standardization reports have become an important reference authority on terminology and symbols in radio practice.

This YEAR BOOK is the eighth one the Institute has published; the first appearing in 1914, the second in 1916, the third in 1926, and subsequent issues each year.

Institute Awards for Meritorious Achievement in Radio

The Institute each year makes two awards to radio investigators in recognition of noteworthy inventions or other developments in radio technique.

One award, the Institute Medal of Honor, is a gold medal suitably engraved. The Medal of Honor is awarded to that person who has made public the greatest advance in the science or art of radio communication, regardless of the time of performance or publication of the work on which the award is based.

The advance may be an unpatented or patented invention which has been completely and adequately described in a scientific or engineering publication of recognized standing, and must be in actual operation. Preference will be given to widely used and widely useful inventions.

The advance may also be a scientific analysis or explanation of hitherto unexplained phenomena of distinct importance to the radio art, though the application thereof need not be immediate. Preference will

be given analyses directly applicable in the art. Publication, in this case also, must be in full and approved form.

The advance may further be a new system of traffic regulation or control; a new system of administration of radio companies or of service of steamship, railroad, or other companies; a legislative program beneficial to the radio art, or any portion of the operating or regulating features of the art. It must be described publicly in clear and approved form and must, in general, be actually adopted in practice.

This medal has been awarded to the following:

E. H. Armstrong	1918	M. I. Pupin	1924
E. F. W. Alexanderson	1919	G. W. Pickard	1926
G. Marconi	1920	L. W. Austin	1927
R. A. Fessenden	1921	Jonathan Zenneck	1928
Lee de Forest	1922	G. W. Pierce	1929
John Stone Stone	1923	P. O. Pedersen	1930

The other award is known as the Morris Liebmann Memorial Prize. This award was made possible through the generosity of Emil J. Simon, a Fellow of the Institute. It is given to perpetuate the memory of the late Colonel Morris N. Liebmann. The award consists of the sum of five hundred dollars which is the annual income derived from the principal of the gift of ten thousand dollars.

The award is made by a special committee, appointed annually by the Board of Direction, to that member of the Institute who, in the opinion of this committee, shall have made the most important contribution to the radio art during the preceding calendar year.

The Morris Liebman Memorial Prize has been awarded to the following:

L. F. Fuller	1919	Frank Conrad	1925
R. A. Weagant	1920	Ralph Bown	1926
R. A. Heising	1921	A. Hoyt Taylor	1927
C. S. Franklin	1922	Walter G. Cady	1928
H. H. Beverage	1923	E. V. Appleton	1929
J. R. Carson	1924	A. W. Hull	1930

All members of the Institute are eligible as candidates for these highly valued prizes. Each year's developments are carefully reviewed and examined by the Committees appointed, and by the Board of Direction, the awards being made by vote of the Board in the case of the Institute Medal of Honor, and by vote of the committee appointed by the Board in the case of the Liebmann Memorial Prize.

Grades of and Qualifications for Membership

The several grades of membership in the Institute of Radio Engineers as well as the qualifications required for each, dues, fees, etc., are tabulated on page 13. Full details will be found in the Constitution under Articles II and III. All the benefits of membership are available at once to all new members of any grade, except that Juniors are not eligible to vote. Membership means, also, that one is enrolled with others having a similar interest in radio, and that one is on record as being among those who are interested and active in the development of this new and useful branch of the electrical engineering industry.

The grades of Fellow and Member require a much higher degree of technical training and experience than the grade of Associate. In order to maintain a high standard of membership, the Board of Direction in each case very carefully scrutinizes the applications for Fellow and Member grades.

Before applying for membership in any grade the applicant should carefully read the Constitution of the Institute to ascertain for which of the several grades he is eligible. An extract from the Constitution dealing with admissions, eligibility, fees, etc., is printed on the back of the application form obtainable from Institute Headquarters.

When filling in the application form, the applicant should submit the names of those persons who have knowledge of his professional experience, rather than those who have a high professional standing, but cannot vouch for him. The personal signatures of references are not required.

Institute Badges

The authorized Institute badge is of 14-karat gold, finished in enamel and gold lettering. The Fellow's badge is of blue lettering on a gold background; Member's badge of gold lettering on a blue background; Associate's badge of gold lettering on a maroon background; and Junior's badge of gold lettering on a white background. The badge is made in three different forms: a screw-back lapel button, a lapel pin, and a watch charm. The lapel button is approximately one-half the size of the emblem shown here, and sells for $2.75 (any grade). The lapel pin and watch charm are approximately of the size of the illustration. The charm is finished on both sides and is provided with a ring for suspending the charm from a watch chain or fob. The lapel pin is priced at $3.00 (any grade) and the watch charm is supplied at $5.00 (any grade). Any of these may be ordered through the office of the Secretary.

MEMBERSHIP REQUIREMENTS, FEES, ETC.

Grade	Minimum Age	Years in Active Radio Engineering	References Required	Entrance Fee	Transfer Fee to Next Grade	Annual Dues
Fellow.....	30	7	Five Fellows	$10	—	$15
Member.....	25	4	Five Fellows or Members	$ 5	$5	$10
Associate.....	21	A Person Who is Interested in or Connected with the Radio Arts	‡Five Fellows, Members, or Associates	$ 3	$2	$6
Junior.....	16*	A Person Interested in the study of Radio.	‡Five Fellows, Members, or Associates	$ 1	$2	$4

* The maximum age of a Junior member is 20 years. Upon attaining the age of 21, the Junior member is transferred to the grade of Associate.

‡ In the case of the Junior or Associate applicant who is unable to supply the names of five members of the required grade, it is sufficient, usually, if the names of five business associates or friends are given. These should preferably be persons engaged in engineering or scientific work.

Members of the Institute of Radio Engineers are authorized to indicate their grade of membership in the Institute only in the following manner:

Fellow I. R. E.
Member I. R. E.
Associate I. R. E.

Certificates of Membership

Upon application to the Secretary's office membership cards are sent to all members each year, and diplomas are supplied to Members and Fellows. The membership cards are signed by the Secretary and the diplomas are signed by the President and the Secretary

Meetings

New York meetings of the Institute of Radio Engineers are held on the first Wednesday of each month (except during July and August) at the Engineering Societies Building, 33 West 39th Street, New York City. On these occasions engineering papers are presented. These papers describe recent developments in radio, and are the subject of general discussion on the part of those in attendance.

Sections

The following Sections of the Institute, which in most cases meet once a month, have been organized in localities where there is a sufficient number of Institute members:

ATLANTA—H. F. Dobbs, chairman; Philip C. Bangs, secretary, 23 Kensington Road, Avondale Estates, Georgia.

BOSTON—George W. Pierce, chairman; Melville Eastham, secretary, General Radio Co., 30 State Street, Cambridge, Mass.

BUFFALO-NIAGARA—Stanley W. Brown, chairman; E. C. Waud, secretary, 235 Huntington Ave., Buffalo, N. Y.

CHICAGO—Byron B. Minnium, chairman; J. Barton Hoag, secretary, Ryerson Laboratory, University of Chicago, Chicago, Ill.

CINCINNATI—D. D. Israel, chairman; Ralph P. Glover, secretary, Crosley Radio Corp., Cincinnati, Ohio.

CLEVELAND—G. B. Hammon, chairman; P. A. Marsal, secretary, National Carbon Co., Inc., P. O. Box No. 400, Cleveland, Ohio.

CONNECTICUT VALLEY—R. S. Kruse, chairman; George Grammer, secretary, 52 S. Beacon St., Hartford, Conn.

DETROIT—Lewis N. Holland, chairman; Samuel Firestone, secretary, Room 615, 200 Second Ave., Detroit, Mich.

LOS ANGELES—T. E. Nikirk, chairman; L. Elden Smith, secretary, 340 N. Painter Ave., Whittier, Calif.

NEW ORLEANS—Pendleton E. Lehde, chairman; Anton A. Schiele, secretary, 1812 Masonic Temple, New Orleans, La.

PHILADELPHIA—W. R. G. Baker, chairman; G. C. Blackwood, secretary, 243 E. Upsal St., Mt. Airy, Philadelphia, Pa.

PITTSBURGH—L. A. Terven, chairman; C. F. Donbar, secretary, 233 South Starr Ave., Bellevue, Pa.

ROCHESTER—Harry E. Gordon, chairman; Howard A. Brown, secretary, Rochester G. & E. Co., 89 East Ave., Rochester, N. Y.

SAN FRANCISCO—Walter D. Kellogg, chairman; Paul R. Fenner, secretary, Custom House, San Francisco, Calif.

SEATTLE—Abner R. Willson, chairman; L. C. Austin, secretary, Woolley and Co., Inc., 1113 Third Ave., Seattle, Wash.

TORONTO—J. M. Leslie, chairman; R. A. Hackbusch, secretary, Stromberg Carlson Tel. Mfg. Co., 211 Geary Ave., Toronto, Ont., Canada.

WASHINGTON—L. P. Wheeler, chairman; Herbert G. Dorsey, secretary, U. S. Coast and Geodetic Survey, Washington, D. C.

Procedure to be Followed in Forming a Section

In forming a Section of the Institute, the following is the approved procedure:

a. Carefully read the "By-Laws Governing Sections" found on page 38 of this book.

b. Make a tentative canvass of the members residing within the territorial limits of the proposed Section. If at least fifty (preferably seventy-five) members, of whom five or more are Members or Fellows, favor and will support a Section, if established, obtain from Institute Headquarters a petition form. In making this tentative canvass effort should be made to obtain applications from desirable and eligible nonmembers. Wherever there are less than twenty-five members of the Institute, but it is felt that applications can be obtained from the necessary number of eligible nonmembers, this tentative canvass may be made and the membership applications forwarded to the Institute office. In making this tentative canvass consideration should be given to the probable permanent chairman and other officers of the Section, if formed. Much of the success of a Section depends on the caliber of the chairman and the interest taken by him in the affairs of the Section. Institute Headquarters, therefore, would like information as to the probable candidates at the time the request is made for the petition forms.

c. On receipt of the petition forms and list of members residing within the territorial limits, an organization meeting should be called for the purpose of obtaining signatures to the petition, and to form a temporary organization.

d. The petition form, properly signed by the required number of members and accompanied by the minutes of the temporary organization meeting, should then be forwarded to the Institute Headquarters for presentation to the Board of Direction.

e. Upon receipt of the approval of the Board of Direction of the Institute, a meeting should be called for the purpose of forming the permanent organization. At this meeting the officers of the Section should be elected and the several standing committees organized.

f. Thereafter not less than five meetings shall be held annually.

g. A full report of each meeting must be made to the Headquarters of the Institute on the form supplied by the Institute.

American Standards Association

The American Standards Association serves as a national clearing house for engineering and industrial standardization and acts as the official channel of coöperation in international standardization. It conducts its work through the activity of Sectional Committees, the responsibility for each of the several hundred standardization projects being in the hands of one or more coöperating agencies known as "sponsors."

The Institute of Radio Engineers and the American Institute of Electrical Engineers are joint sponsors for the Sectional Committee on Radio. The Institute of Radio Engineers is also coöperating in the formulation of standards on five other subjects, its representatives on all of these Sectional Committees being given on page 8.

The Sectional Committee on Radio is composed of representatives from sixteen coöperating organizations. The Executive Committee of the Sectional Committee on Radio consists of the following officers and Chairmen of Technical Committees:

ALFRED N. GOLDSMITH, *Chairman*
C. H. SHARP, *Vice Chairman*
B. DUDLEY, *Secretary*

Chairmen of Technical Committees:

Radio Receivers and Parts.....VIRGIL M. GRAHAM
Radio Transmitters and Parts.....HARADEN PRATT
Vacuum Tubes.....J. C. WARNER
Electro-Acoustic Devices.....IRVING WOLFF

REPORT OF THE SECRETARY

INSTITUTE OF RADIO ENGINEERS

1930

IN ORDER to inform the membership of the Institute as to its operation, the following report of the Secretary has been prepared. It summarizes briefly the major activities of the Institute for the fiscal year of 1930 and is obviously a compilation of reports of various committee chairmen and others.

General

On December 31, 1930, the paid membership of the Institute totaled 6535 as compared with 5695 as of December 31, 1929. This is an increase of 840 members. In addition to the usual section meetings, a four-day convention was held in Toronto, Ontario, Canada, during August with excellent attendance. A highly successful general meeting, known as the Rochester Fall Meeting of the Institute, was held in Rochester during November. The number of pages in the PROCEEDINGS devoted to technical papers has shown a slight increase.

The Committee on Standardization has submitted its report which is the result of its activities during 1929 and 1930. This report, which is over 80 per cent larger than the previous one, is published elsewhere in this Year Book. The Committee on Broadcasting has continued its active examination of important problems which have been submitted to it by the Federal Radio Commission. Its reports have been approved by the Board of Direction and forwarded to the Commission.

The policy of expanding the Institute activities to include publication of papers on telephone, telegraph, and cable engineering has resulted in publication of several valuable papers in these fields. In addition the applications for transfer to higher grades of a number of associate members whose main activities are in these allied fields have been approved.

Board of Direction

The Board of Direction has complete control of the operation of the Institute; it establishes the policies under which the various committees and the secretarial force operate. Eleven meetings of the Board of Direction were held during 1930, one of these being a special meeting held on December 3, 1930, to consider a number of basic matters of importance to the Committee on Constitution and Laws which committee is

preparing a revision of the Constitution of the Institute. In addition to the thirteen standing committees such temporary committees as were required in considering specific problems which arose during the year were appointed by the Board.

The following were designated as representatives of the Institute on other bodies:

American Standards Association, Standards Council: Dr. Alfred N. Goldsmith, B. Dudley (alternate).

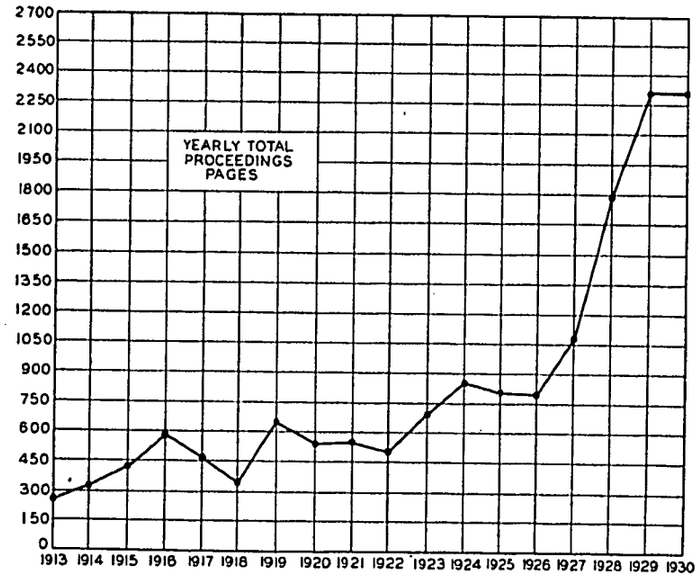

FIG. 1

A.I.E.E., Subcommittee on Radio of the Committee on Applications to Marine Work: T. E. Nivison, J. L. Preston.

Committee on Aeronautic Radio Research, Department of Commerce: F. M. Ryan.

Committee for Observance of Decennial of Commercial Broadcasting: C. W. Horn.

Council of the American Association for the Advancement of Science: Professor J. C. Jensen.

Engineering Index: Dr. J. H. Dellinger.

Radio Advisory Committee, Bureau of Standards, Department of Commerce: Dr. L. M. Hull.

Radio Broadcasting Committee, American Engineering Council: Melville Eastham.

U.R.S.I., (International Scientific Radio Union) Executive Committee, American Section: R. H. Marriott.

U.S. National Committee, Advisers on Electrical Measuring Instruments (I.E.C.): Melville Eastham, Harold Olesen.

Presidential Addresses

President de Forest presided at four of the New York meetings of the Institute in addition to a special meeting held at Atlantic City in conjunction with the Radio Manufacturers' Association trade show. Unfortunately, it was necessary that he leave for the Pacific Coast after presiding during the first day of the annual Convention held in Toronto. His location so removed from New York made it impossible for him to preside at New York meetings and meetings of the Board of Direction held thereafter. He has, however, been active in the affairs of the San Francisco and Los Angeles Sections since his location in California.

Annual Convention

Toronto, Ontario, Canada, was the location for the Fifth Annual Convention which was held August 18–21, 1930. The Convention was attended by 575 members and guests, a great majority of whom were from outside the Toronto Section territory. Vice-President Lee journeyed from England to be present and in addition to delivering a technical paper, presided over the technical sessions and banquet held after the departure of President de Forest. The technical program comprised twenty-three papers on many subjects of interest to radio engineers. Three technical inspection trips, three trips exclusively for the ladies, a general sight-seeing trip, and an all-day trip from Toronto to Niagara Falls and return were made. In addition to the banquet, a luncheon and a golf tournament were held. A. M. Patience, chairman of the Convention Committee, and all those who served under his direction are to be congratulated on their efforts in preparing for this convention.

Rochester Fall Meeting

A one-day technical meeting was held at the Hotel Sagamore in Rochester on November 21 and was attended by over two hundred members and guests. Three technical sessions at which six papers were delivered comprised the major portion of the program. A luncheon and dinner were also held. Arrangements were made by the Rochester section under the guidance of R. H. Manson.

Joint I.R.E. and R.M.A. Meeting

A technical program of five papers was prepared for presentation on June 3 at a joint meeting of the Institute of Radio Engineers and the

Radio Manufacturers' Association during the annual trade show of the Radio Manufacturers' Association at Atlantic City. Although it was not possible to present all five papers as originally planned, four were delivered together with two impromptu papers.

New York Meetings

Nine regular meetings were held in New York City in the Engineering Societies Building. No meeting was held in June as this was con-

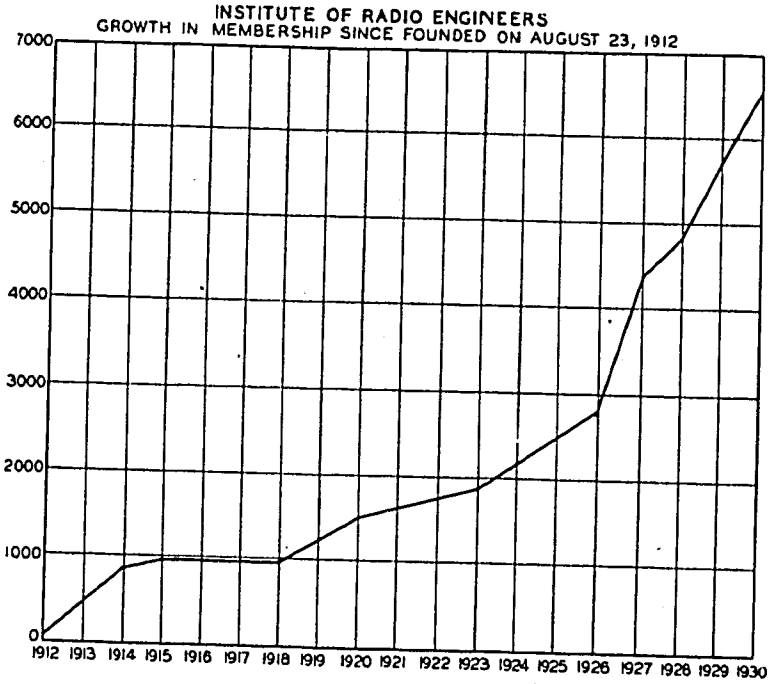

FIG. 2

sidered unnecessary in view of the program prepared for the joint I.R.E. and R.M.A. meeting held in Atlantic City during that month.

Headquarters

The headquarters office staff now comprises sixteen members, an increase of one during 1930. It is the object of the staff to carry on as large a proportion of the routine work of the Institute as possible, leaving to the Board of Direction and the various committees the determination of governing policies. The Secretary acknowledges herewith the loyal support and coöperation of all the members of the office staff, without which the operation of the Institute would have been considerably hampered.

Committees

While the Board of Direction determines the general policies under which the Institute operates, it relies heavily upon the coöperation of the various committees not only in carrying out its policies but in the accumulating and interpreting of the large quantities of data which bear directly upon the formation of these policies. Without the invaluable assistance of these committee workers the Institute would be

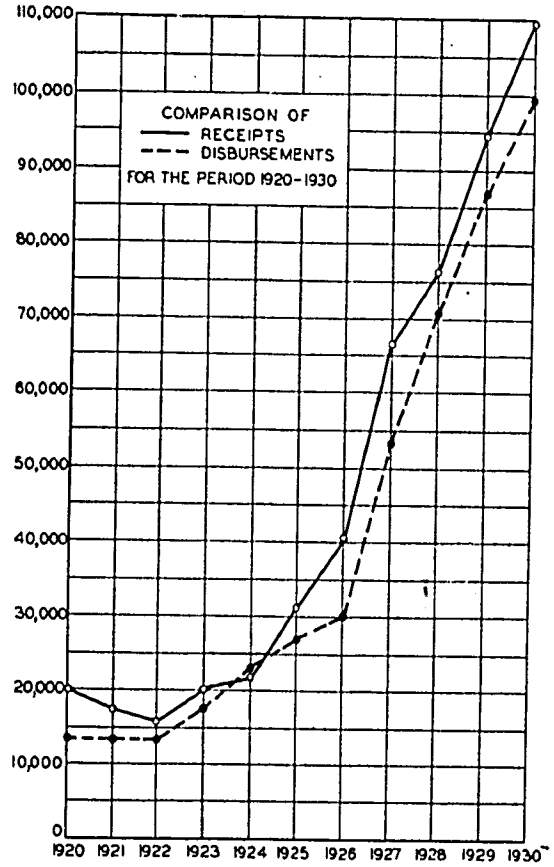

FIG. 3

sorely pressed to carry on, and while it is not possible for each individual member of the Institute to thank those who have contributed of their time and efforts in this way, the debt is nevertheless apparent. On behalf of the Institute, the Secretary tenders herewith deep appreciation and thanks for their efforts.

ADMISSIONS

The Committee on Admissions has probably one of the most difficult and responsible problems of all committees. It is its duty to inves-

tigate applications for transfer to the higher grades of membership and determine upon the fitness of the applicants therefor. Without the high ideals, thorough consideration, keen insight, and careful interpretation of the policies and Constitution of the Institute, manifest by this committee, under the direction of R. A. Heising, chairman, the higher grades of membership in the Institute would not have retained their high standing.

The committee held twelve regular meetings, the average attendance being five members. At these meetings, the following number of applications were considered and the decisions reached confirmed by the Board of Direction:

	Acted upon	*Approved*
Transfer to Fellow grade	10	5
Recommended by Membership Committee for transfer to Fellow grade	15	3
Elected to Fellow grade	2	2
Transfer to Member grade	80	43
Recommended by Membership Committee for transfer to Member grade	60	34
Election to Member grade	70	40
Election to Associate grade	1620	1620
Election to Junior grade	155	155

A memorandum prepared by the 1928 Committee on Admissions setting forth the general policies of the committee was reviewed and given minor amendment.

Awards

Only a single meeting of the Committee on Awards operating under the chairmanship of W. G. Cady was necessary. It was the committee's recommendation, approved by the Board of Direction, that the Institute Medal of Honor be presented to P. O. Pedersen and the Morris Liebmann Memorial Prize be awarded to A. W. Hull. The awards were presented at the banquet which was a part of the Fifth Annual Convention held in Toronto. Unfortunately, it was not possible for Professor Pedersen to be present at the convention and the medal was accepted for him by H. H. Friis who had studied under Professor Pedersen.

Broadcasting

The Committee on Broadcasting under the chairmanship of Dr. L. M. Hull held eight meetings to consider a number of problems which were presented to it by the Federal Radio Commission. A considerable portion of the work of this committee had to be accomplished by the members individually as it involved technical problems the answers to

which were not immediately available. In addition to its Report No. 10 on "Service Area of Broadcast Stations," the committee prepared replies to letters from the Federal Radio Commission regarding proposed general orders on power rating of broadcast transmitters and the limitation of harmonics emitted by radio stations.

Board of Editors

The Board of Editors is responsible for all papers published in the Proceedings and under the chairmanship of Dr. Alfred N. Goldsmith examined one hundred and thirty-six papers submitted for publication. Of these, one hundred and thirteen were accepted.

As practically all of the work of the Board of Editors is accomplished by correspondence, it was necessary to hold but one meeting to discuss matters of publication policy.

Sections

The Committee on Sections under the chairmanship of Dr. Austin Bailey, held four meetings during the year.

The committee reviewed six constitutions submitted by various sections of the Institute. These constitutions were based upon a model constitution prepared by the 1929 committee. The data incorporated in these several constitutions were examined carefully and discussed thoroughly at the annual meeting of the Committee on Sections held in Toronto during the Fifth Annual Convention and resulted in the drafting of a new constitution for sections which was approved by the Board of Direction for mandatory adoption by all sections of the Institute.

During the past, sections have obtained their income in the form of rebates received at the rate of $1.00 for each member residing in the territory of the section. This system took no cognizence of the expense entailed by the section in holding meetings and left the smaller sections in a poor financial condition. To correct this condition, the committee recommended to the Board of Direction that the rebate be on the basis of 50 cents for each member residing in the section territory plus $10.00 for each meeting held during the year. The Board of Direction approved this recommendation and the section rebates starting as of January 1, 1931, will be computed upon this basis.

The *Manual for Section Guidance and Operation* was revised and a policy requiring that there reside in a proposed section territory at least fifty members of the Institute of whom five or more shall be of the Member or Fellow grade before a petition for a new section of the

Institute shall be approved, was recommended to the Board of Direction and approved.

Some pertinent facts concerning section operation are listed below:

Section	*Membership Dec. 31, 1930*	*Meetings Held 1928*	*1929*	*1930*	*Average Attendance*	*Per cent of Average Attendance to Total Membership*
Atlanta	20	7	6	4	17	85
Boston	268	3	2	5	124	47
Buffalo-Niagara	55	10	9	7	27	49
Chicago	394	6	6	4	181	46
Cincinnati	106	—	4	8	57	54
Cleveland	128	10	10	8	48	38
Connecticut Valley	146	5	4	1	37	25
Detroit	140	10	9	7	82	59
Los Angeles	254	8	8	10	70	28
New Orleans	45	3	5	2	35	78
Philadelphia	429	8	7	9	125	29
Pittsburgh	112	6	8	9	54	48
Rochester	64	8	7	6	145	226
San Francisco	170	6	10	11	65	38
Seattle	62	8	8	7	98	63
Toronto	156	8	8	6	73	47
Washington	211	8	9	9	88	42
Totals	2760	114	120	113	1326	48

New York Program

The New York Program Committee under the chairmanship of R. H. Ranger held two meetings and arranged for speakers for the meetings of the Institute held in New York City.

Nominations

A single meeting of the Committee on Nominations was held under the chairmanship of Alfred N. Goldsmith to determine upon a list of candidates for the offices of President, Vice-President, and Manager. The recommendations of this committee were forwarded to the Board of Direction.

Membership

The gain of approximately 15 per cent in the membership of the Institute during the past year has been brought about to a large extent through the activity of the Committee on Membership under the guidance of I. S. Coggeshall as chairman.

In order to place in the hands of section officers a sufficient amount of data to permit them to solicit applications for membership conveniently and effectively, the committee has prepared a *Section Membership Manual*. In addition to outlining the general membership problems of the Institute and effective methods of carrying on the organized membership work, this manual contains over thirty sample letters which may be used as the basis of bringing to the attention of prospects the advantages the Institute holds for them. The letters are classified as to the type of work or position the prospect may hold and are written to appeal specifically to the major classes of workers who might be interested in the Institute.

Distribution of Institute Membership

Continental United States	5349
Africa	27
Alaska	3
Australia	47
Austria	1
Belgium	3
Bermuda	1
British North Borneo	1
British West Indies	2
Canada	263
Canal Zone	4
Central America	2
Channel Islands	3
China	38
Colombia	3
Costa Rica	1
Cuba	4
Czechoslovakia	4
Denmark	12
Dutch East Indies	2
Egypt	2
England	386
Federated Malay States	8
France	29
Friendly Islands	1
Germany	19
Great Britain	2
Greece	1
Holland	12
Hungary	2
India	19
Ireland	8
Italy	8
Japan	113
Mariannas Islands	1

Mexico	9
Morocco	1
New Zealand	25
Palestine	2
Philippine Islands	9
Poland	5
Porto Rico	5
Portugal	2
Republic of Panama	4
Samoa	1
Scotland	16
Siam	1
South America	30
Spain	8
Straits Settlements	1
Sweden	6
Switzerland	2
Tasmania	1
Territory Hawaii	19
U.S.S.R. (Russia)	5
Virgin Islands	1
Wales	1
Total	6535

Meetings and Papers

The duties of the Committee on Meetings and Papers operating under the chairmanship of J. W. Horton comprise essentially the solicitation and reviewing of papers for publication in the Proceedings.

The structure of the committee has been somewhat changed during 1930. The field covered by the Proceedings has been divided into a number of specialized divisions each in charge of one or two members of the committee. This permits manuscripts to be scrutinized by a specialist in the particular subject covered and also allows a better solicitation of manuscripts as each member of the committee is solely or jointly responsible for a particular field. One meeting of this committee was held to determine upon the course of procedure, the relative quantity of space to be devoted to each general subject, and the type of editing to be done to manuscripts. Some idea of the extent of the work accomplished by this committee can be had from the following compilations.

Papers secured for publication	136
Papers published during 1930	113
Papers rejected	12
Papers returned for revision	14
Book reviews prepared and published	16
Discussions published	3

Publicity

The general publicity for the Institute was in the hands of the Committee on Publicity under the chairmanship of W. G. H. Finch. Releases were prepared on New York meetings and forwarded to a large group of newspapers throughout the country. Publicity for the Fifth Annual Convention in United States' newspapers was arranged to a very large extent by the Committee on Publicity. General items of news including presidential addresses were also forwarded to the press.

Standardization

The Committee on Standardization appointed in 1929 carried over into 1930 to complete its report which is published in another section of this Year Book. The committee under the chairmanship of J. H. Dellinger held five meetings during 1930 with an average attendance of approximately eighteen.

The Technical Committee on Radio Receivers under the chairmanship of E. T. Dickey held seven meetings. Three subcommittees of this committee, on aircraft receivers, high-frequency receivers, and miscellaneous tests, held nine meetings in all.

The Technical Committee on Transmitters and Antennas under the chairmanship of Haraden Pratt held two meetings, and two meetings of the subcommittee on methods of tests and one meeting of the subcommittee on nomenclature took place.

The Technical Committee on Vacuum Tubes under the chairmanship of Stuart Ballantine held three meetings.

The Technical Committee on Electro-Acoustic Devices of which H. A. Frederick is chairman held one meeting.

The total number of meetings of technical committeees or subcommittees during 1930 was thirty-two with an average attendance of eight members at each.

The 1931 Report of the Committee on Standardization is 83 per cent larger than the preceding report published in the 1929 Year Book. It contains much new material including reports on methods of testing and rating transmitters, performance indexes of electro-acoustic devices, and safety provisions for transmitters.

Sectional Committee on Radio

The Sectional Committee on Radio which operates under the American Standards Association procedure is sponsored jointly by the American Institute of Electrical Engineers and the Institute of Radio Engineers.

The Technical Committee on Radio Receivers held three meetings, the Committee on Transmitters held four meetings, and the Committees on Vacuum Tubes and Electro-Acoustic Devices held two and three meetings, respectively. The average attendance at these meetings totaled nine.

The report of the Sectional Committee on Radio of the American Standards Association has been held up pending final approval of the report of the Committee on Standardization of the Institute which report will be used as a basis for some of the work of the Sectional Committee on Radio. The technical committees have been in active operation and it is anticipated that their reports will be available shortly.

American Standards Association

On October 1, 1930, the Institute accepted the invitation of the American Standards Association to become a member body of that organization. It is felt that the active coöperation of the Institute in the work of the American Standards Association will be of great importance to the radio industry.

Deaths

It is with regret that we list here the names of those members of the Institute who died during 1930:

James H. Carroll
E. B. Craft
Louis M. Evans
Arthur W. Ganz
Ralph W. Goidard
R. V. Hansford
Ernest R. Hentschel
F. W. Kless
Fred W. Kush
W. L. Morley
Oscar C. Roos
Carl E. Trube
John L. Wuertz

The Institute of Radio Engineers, Inc.

COMPARATIVE BALANCE SHEET

December 31, 1930 and 1929

ASSETS		Dec. 31, 1930	Dec. 31, 1929	INCREASE DECREASE
CASH				
General Fund—Corn Exchange Bank		$14,831.61	15,603.90	772.29
Special Fund—Corn Exchange Bank		348.41	222.75	125.66
Petty Cash Fund		175.00	175.00	
Funds—National State Bank, Newark			5,566.91	5,566.91
TOTAL CASH		15,355.02	21,568.56	6,213.54
ACCOUNTS RECEIVABLE				
Juniors		122.00	73.00	49.00
Associates		1,479.67	1,181.31	298.36
Members		20.00	25.00	5.00
Entrance Fees		978.00	803.00	175.00
Transfer Fees		10.00	52.20	42.20
Advertising		2,510.81	2,645.79	134.98
Reprints		301.87		301.87
TOTAL ACCOUNTS RECEIVABLE		5,422.35	4,780.30	642.05
INVENTORY				
Proceedings on Hand		4,444.92	3,688.88	756.04
Bound Volumes on Hand		111.55	194.36	82.81
Binders on Hand		157.08	181.70	24.62
Emblems on Hand		252.30		252.30
TOTAL INVENTORY		4,965.85	4,064.94	900.91
INVESTMENTS		47,493.00	37,238.00	10,255.00
FURNITURE AND FIXTURES	$8,117.86			
Less—Reserve for Depreciation	3,011.94	5,105.92	4,480.14	625.78
ACCRUED INTEREST ON INVESTMENTS		892.43	739.18	153.25
PREPAID EXPENSES				
Unexpired Insurance Premiums		74.32	43.68	30.64
Stationery Inventory		728.37	300.00	428.37
TOTAL ASSETS		$80,037.26	73,214.80	6,822.46

LIABILITIES AND SURPLUS	Dec. 31, 1930	Dec. 31, 1929	INCREASE DECREASE
ACCOUNTS PAYABLE	$ 491.04	3,912.29	3,420.65
SUSPENSE	115.70	120.32	4.62
DUES, ETC., PAID IN ADVANCE			
Juniors	40.00	9.70	30.30
Associates	902.68	732.73	169.95
Members	67.23	75.15	7.92
Fellows	58.71	2.00	56.71
Entrance Fees	142.50		142.50
Subscriptions to Proceedings	3,365.29	2,722.07	643.22
TOTAL LIABILITIES	5,183.75	7,574.26	2,390.51
MORRIS LIEBMANN MEMORIAL FUND			
Principal	10,000.00	10,000.00	
Unexpended Income	77.87	77.87	
TOTAL MORRIS LIEBMANN FUND	10,077.87	10,077.87	
SURPLUS			
Balance, January 1	55,562.67	47,823.23	7,739.44
Operating Profit for Year	9,212.97	7,739.44	1,473.53
SURPLUS, DECEMBER 31	64,775.64	55,562.67	9,212.97
TOTAL LIABILITIES AND SURPLUS	$80,037.26	73,214.80	6,822.46

Patterson and Ridgway. Certified Public Accountants,
74 Trinity Place, New York City

CONSTITUTION

ADOPTED AT THE FIRST MEETING OF THE INSTITUTE OF RADIO ENGINEERS, MAY 13, 1912; AMENDED NOVEMBER 2, 1914, AND DECEMBER 5, 1915

ARTICLE I

NAME AND OBJECT

SEC. 1—The name of this organization shall be the Institute of Radio Engineers.

SEC. 2—Its object shall be 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. Among the means to this end shall be the holding of meetings for the reading and discussion of professional papers and the publication of such papers, discussions and communications as may seem expedient.

ARTICLE II

MEMBERSHIP

SEC. 1—The membership of the Institute shall consist of:

a. Honorary Members, who shall be entitled to all rights and privileges of the Institute except the right to nominate, vote and hold office.

b. Fellows, who shall be entitled to all rights and privileges of the Institute.

c. Members, who shall be entitled to all rights and privileges of the Institute except the right to hold the office of President and Vice-President.

d. Associates, who shall be entitled to all rights and privileges of the Institute except the right to hold the office of President, Vice-President, and Editor.

e. Juniors, who shall be entitled to attend all meetings and to receive copies of all Institute publications.

SEC. 2—Honorary members may be chosen from among those who have rendered acknowledged eminent service to radio science, or the radio arts.

SEC. 3—Fellow shall be not less than thirty years of age and shall be either:

a. A radio engineer by profession. As such he shall be qualified to design and take responsible charge of important radio work; he shall have been in the active practice of his profession for at least seven years, and shall have had responsible charge of important radio work for at least three years.

When the applicant holds in a principal national society of an allied branch of engineering, membership in a grade for which the qualifications indicate a standing equal to that required for the grade of Fellow herein, such membership shall be considered equivalent to three of the required seven years of active practice of the radio profession.

b. A professor of physical science or of electrical engineering. As such he shall have attained special distinction as an expounder of the principles of radio

science and of radio engineering; he shall have had at least seven years experience as a teacher of physical or electrical subjects and shall have had responsible charge, for three years, in a radio course of a principal school of science and engineering. Any years of experience as defined in paragraph "*a*" that the applicant may have had as a radio engineer shall be considered the equivalent of the same number of years of experience as a "teacher of radio subjects."

c. A person who has done notable original work in radio science of a character to give him a recognized standing at least equivalent to that required for the Fellows under paragraphs "*a*" and "*b*."

d. A person regularly engaged in radio work for at least seven years, who, by inventions or special proficiency in contributions to the radio science or the radio arts or radio literature, has attained a standing at least equivalent to that required for Fellows under paragraphs "*a*" and "*b*."

SEC. 4—A Member shall be not less than twenty-five years of age and shall be either:

a. A radio engineer by profession. As such, under general direction he shall have designed and taken responsibility for important radio engineering work; he shall have been in the active practice of his profession for at least four years.

When the applicant holds in a principal national society of an allied branch of engineering, membership of a grade for which the qualifications indicate a standing equal to that required for the grade of Member herein, such membership shall be considered equivalent to two years of the requisite four years of active practice of the radio profession.

b. A teacher of physical science or of electrical engineering. He shall have had at least four years experience as a teacher of radio subjects in a school of recognized standing. Any years of experience the applicant may have had as a radio engineer shall be considered the equivalent of the same number of years of experience as a "teacher of radio science or of radio engineering."

c. A person regularly employed in radio or closely allied work for at least four years, who, by invention or by proficiency in radio science, the radio arts, or radio literature, or as an executive of any radio enterprise of large scope, has attained a standing equivalent to that required for Members under paragraphs "*a*" and "*b*." In the case of such an executive the applicant must be qualified to take responsible charge of the broader features of radio engineering involved in the work under his direction.

d. A commissioned officer of the Army or Navy of the United States Government or of any foreign government, who has been regularly engaged in radio work for a period of at least three years, who shall have had responsible charge of important government radio work for at least one year and who shall have attained the rank of Captain in the Army or Lieutenant in the Navy.

SEC. 5—An Associate shall be not less than twenty-one years of age and shall be:

a. A radio engineer by profession.

b. A teacher of radio subjects.

c. A person who is interested in and connected with the study or application of radio science or the radio arts.

SEC. 6—A Junior shall be not less than sixteen years of age nor over twenty-one years of age, and shall be a person who is interested in the study or application of radio science or the radio arts.

On attaining the age of twenty-one years, Juniors shall be transferred to the grade of Associate.

SEC. 7—In all cases, graduation from the radio course or electrical course of of a school of science or of engineering of recognized standing shall be considered the equivalent of one year's radio experience.

SEC. 8—Any person who is a Member at the time this group of amendments is adopted, shall not be barred from eligibility to the grade of Fellow because of the age limitation, provided he shall otherwise be eligible as herein defined.

Any person who is an Associate at the time this group of amendments is adopted, shall not be barred from eligibility to the grade of Member because of age limitations, provided he shall otherwise be eligible as herein defined

ARTICLE III

ADMISSIONS AND EXPULSIONS

SEC. 1—Honorary Members shall be recommended by at least ten members of the Board of Direction, and upon unanimous vote of the Board shall be proposed to the membership for election. A person elected an Honorary Member shall be promptly notified thereof by letter. The election shall be cancelled if an acceptance is not received within six months after the mailing of notice.

SEC. 2—Applications may be made for admission or transfer to any grade of membership. Applicants shall give references to members of the Institute as follows:

For the grade of Fellow, to five Fellows.
For the grade of Member, to five Fellows, or Members.
For the grade of Associate, to five Fellows, Members or Associates.
For the grade of Junior, to five Fellows, Members or Associates.

Each application for admission or for transfer from one grade to another shall embody a concise statement, with dates, of the candidate's training and experience, and shall be in such form and such details as may be prescribed by the Board of Direction. It shall be signed by the applicant and shall contain a promise to conform to the requirements of that grade of membership to which he may be elected.

Each of the members referred to by the applicant shall be requested by the Secretary to address a letter to the Board of Direction stating the extent of the writer's personal knowledge of the applicant and his training and experience. If at least a majority of the corporate members named as references do not furnish the requisite endorsement, the Secretary shall call upon the applicant for additional names, and not until written communications have been received from at least three members shall the application be considered by the Board of Direction.

The requirements of the foregoing paragraph may be waived in whole or in part where the applicant is well-known, either personally or by reputation, to the Board of Direction, or where the application is for Junior or Associate grade

An applicant who is so situated as not to be personally known to the required number of members of any grade may give the names, occupations and addresses of responsible non-members to complete the required number of references.

SEC. 3—A list comprising the names, ages, addresses and occupations of all new applicants for admission or transfer shall be sent by the Secretary to each member of the Board of Direction.

The Board of Direction may consider applications for admission or transfer to the grade of Member at any regular meeting held at least two weeks after the list containing the applicants' names has been sent to each member of the Board of Direction.

The Board of Direction may consider applications for admission or transfer to the grade of Fellow at any regular meeting held at least four weeks after the list containing the applicants' names has been sent to each member of the Board of Direction.

A record affirmative vote, oral or written, of at least two-thirds of the Board members voting at any regular meeting, shall elect or transfer an applicant for any grade. A vote on any application shall stand, unless withdrawn by the Board member voting, until the application is finally acted upon.

SEC. 4—A rejected applicant may renew his application for membership at any time after the expiration of one year from the date of the ballot rejecting his previous application.

SEC. 5—All elected candidates shall be duly notified and shall subscribe to the Constitution and Rules of the Institute. Forms for this purpose shall be prescribed by the Board of Direction. If these provisions are not complied with within six months from the notification of election, such election shall be considered void, unless for special reasons the time shall be extended by the Board of Direction. Membership of any person shall date from the date of his election.

SEC. 6—Fellows, Members, Associates or Juniors, if found delinquent in their duties may be tried by the Board of Direction, and upon decision of the Board their names shall be submitted to the Institute to determine their suspension or expulsion. A three-quarters vote of the Institute shall be necessary to ratify such action of the Board.

SEC. 7—A member may resign his membership by a written communication to the Secretary, who shall present the same to the Board of Direction; when, if all his dues have been paid, his resignation shall be accepted.

ARTICLE IV

DUES

SEC. 1—The entrance fee, payable on admission to the Institute, shall be as follows:

Admission to the grade of Fellow, ten ($10) dollars.
Admission to the grade of Member, five ($5) dollars.
Admission to the grade of Associate, three ($3) dollars.
Admission to the grade of Junior, one ($1) dollar.

The transfer fee from one grade of membership to another shall be the difference between the corresponding admission fees.

The entrance fees shall be waived until January 1, 1927.

SEC. 2—The annual dues payable by members, whether resident or non-resident, shall be as follows:

a. By Fellows, ten ($10) dollars.
By Members, seven dollars and fifty cents ($7.50).

By Associates, four ($4) dollars.

By Juniors, three dollars and fifty cents ($3.50).

b. Honorary Members shall be exempt from all payments.

SEC. 3—The annual dues shall be payable on the first day of January, in advance of the ensuing year. It shall be the duty of the Secretary to notify each member of the amount due at the time of giving notice of the annual meeting.

SEC. 4—Persons elected after July 1st of any year shall pay only one-half of the dues for that year.

SEC. 5—Any person whose dues are more than three months in arrears shall be notified by the Secretary. Should his dues not be paid when they become six months in arrears, he shall lose the right to vote or to receive the publications of the Institute. Should his dues become nine months in arrears, he shall be again notified in form prescribed by the Board of Direction, and if such dues become one year in arrears, he shall forfeit his connection with the Institute. The Board of Direction may, however, for cause deemed by it sufficient, extend the time for payment and for the application of these penalties.

SEC. 6—The Board of Direction may, for sufficient cause, temporarily excuse from payment of annual dues any member; and the Board may remit the whole or part of dues in arrears, or accept in lieu thereof desirable additions to the library or collections.

SEC. 7—Every person admitted to the Institute shall be considered as belonging thereto and liable for the payment of all dues until he shall have resigned, been expelled, or have been relieved therefrom by the Board of Direction.

ARTICLE V

OFFICERS

SEC. 1—The governing body of the Institute shall be a President, a Vice-President, a Secretary, a Treasurer, and an Editor of Publications, six elected Managers, and three appointed Managers who shall together constitute the Board of Direction.

SEC. 2—The terms of all officers, except the six elected Managers, shall be one year each, and shall begin at the close of the annual meeting at which election is made. The terms of all officers shall continue until successors are duly elected. The President and the Vice-President shall not be eligible for immediate renomination to the same office.

SEC. 3—Two Managers shall be elected each year and serve for three years.

For the year 1915 six elected Managers were voted upon as follows: The two candidates receiving the highest number of votes to serve three years; the two candidates receiving the next highest number of votes, two years; the two candidates receiving the next highest number of votes, one year.

SEC. 4—The three appointed Managers shall be chosen by the Board of Direction to serve for terms of one year. These appointed Managers shall have no vote in the election of their successors.

ARTICLE VI

MANAGEMENT

SEC. 1—The President shall have general supervision of the affairs of the Institute. He shall preside at meetings of the Institute and of the Board of Direction at which he may be present and shall be an ex-officio member of all committees. He shall deliver an address at the annual meeting.

SEC. 2—The Board of Direction shall manage the affairs of the Institute in conformity to the laws under which the Institute is organized and the provisions of the Constitution. It shall direct the investment and care of the funds of the Institute; make appropriations for specific purposes; act upon applications for membership as heretofore provided; take measures to advance the interests of the Institute; appoint all its employees, and generally direct its business. The Board of Direction shall make an annual report at the annual meeting, transmitting the report of the Treasurer and of the other officers and of committees. Five members of the Board of Direction shall constitute a quorum.

SEC. 3—The Treasurer shall receive all moneys and deposit same in the name of the Institute. He shall invest all funds not needed for current disbursements, as shall be ordered by the Board of Direction. He shall pay all bills, when certified and audited, as provided by this Constitution and by the rules to be prescribed by the Board of Direction. He shall make an annual report and such other reports as may be prescribed by the Board of Direction.

The Board of Direction shall secure a satisfactory surety for the faithful performance of his duties by the Treasurer, and shall renew the same during the month of January of each year.

SEC. 4—The Secretary will be expected to attend all meetings of the Institute and of the Board of Direction; prepare the business thereof, and duly record the proceedings thereof. He shall see that all moneys due the Institute are carefully collected, and without loss transferred to the custody of the Treasurer. He shall carefully scrutinize all expenditures and use his best endeavor to secure economy in the administration of the Institute. He shall personally certify the accuracy of all bills or vouchers on which money is paid, and shall countersign the checks drawn by the Treasurer against the funds of the Institute when such drafts are known to him to be proper, and duly authorized by the Finance Committee. He shall have charge of the books of account of the Institute, and shall furnish, when required by the Board of Direction, a statement of receipts and expenses under their several headings, and also a statement of monthly balances. He shall present annually, to the Board of Direction, a balance sheet of his books as of December 31st and shall furnish from time to time such other statements as may be required of him. He shall conduct the correspondence of the Institute and keep full records of the same. He shall perform all other duties which may from time to time be assigned to him by the Board of Direction.

SEC. 5—The Board of Direction may also, if they deem it necessary, appoint an Assistant Secretary, who shall aid the Secretary and be under his immediate direction in all matters.

SEC. 6—The President, as soon as expedient after the annual meeting, shall appoint from the membership, with the advice and consent of the Board of Direction, the following standing committees:

Committee on Papers.
Committee on Standardization.
Committee on Publicity.

Members appointed shall serve until their successors are appointed or the Committees dissolved.

ARTICLE VII

NOMINATION AND ELECTION OF OFFICERS

SEC. 1—Two months before the annual meeting, nominations for the offices of President, Vice-President, Secretary, Treasurer, and two Managers, shall be called for from the membership qualified by this Constitution. Before nominees' names are submitted to the membership for final vote, each nominee shall be consulted and if he so requests, his name shall be withdrawn and the next ranking name substituted.

For the year 1915, nominations for six Managers were called for.

One month before the annual meeting, the Board of Direction shall submit to the entire membership excepting Honorary Members and Juniors, a list of all nominees, which list shall consist of the pairs of names receiving the largest number of nominations for each office. In the event of ties in nominations the Board of Direction shall select the name of the man in its opinion best fitted for that office. The membership shall then submit written ballots in plain sealed envelopes enclosed within mailing envelopes marked "Ballot," and bearing the member's signature, voting for officers from the list of nominees. A majority vote received up to the time of the closing of the polls (twenty-four hours before the opening of the annual meeting) shall elect, and no votes by proxy shall be counted. The methods of balloting herein described shall be used for nominating as well as for voting, except the outer envelope shall be marked "Nomination" in the former case. In nominating, as in voting, no proxies or ballots within unsigned outer envelopes shall be opened for counting. Ballots, whether for nomination or voting, shall be checked, opened and counted by a quorum of the Board of Direction, at a regular meeting of the Board. At the time of call for nominations, the Board of Direction shall submit to qualified voters a list of suggested nominations containing at least two names for each office.

SEC. 2—The Editor of Publications shall be elected by vote of the Board of Direction as soon as possible after May 1st.

ARTICLE VIII

MEETINGS

SEC. 1—There shall be an Annual Meeting, at which the annual reports for the year ending December 31st previous shall be presented, and the Ballot for officers reported. At this meeting fifteen (15) members shall constitute a quorum.

SEC. 2—Business meetings shall be held as prescribed by the by-laws.

SEC. 3—In addition to the Annual Meeting, meetings for the reading and discussion of papers shall be held as ordered by the Board of Direction

SEC. 4—Special meetings may be called by the Board of Direction, and shall be so called upon request of ten members, which request shall state the purpose of such meeting. The call for such meeting shall be issued ten days in advance, and shall state the purpose thereof, and no other business shall be taken up at such meeting. At these meetings ten members shall constitute a quorum.

SEC. 5—The Institute may adopt, from time to time, rules for the order of business at its meetings.

SEC. 6—Meetings of the Board of Direction shall be held at the time of the annual meeting and at such other times as the Board may determine, but only on notice to all members of the Board by the Secretary. Notices of time and place of meeting are to be mailed in New York at least two days in advance.

ARTICLE IX

AMENDMENTS

SEC. 1—Proposed amendments to this Constitution must be reduced to writing and signed by not less than twenty Fellows, Members or Associates, and be submitted to the entire membership, except Honorary Members and Juniors, who shall vote by letter ballot. The amendment shall be adopted if seventy-five per cent of the votes received are in favor of such action, the polls having been open for at least one month after mailing to the qualified membership, notices of the proposed amendments. Votes upon the adoption of proposed amendments shall be checked, opened and counted by a quorum of the Board of Direction at a regular meeting of the Board.

AMENDMENTS

INCREASE OF MEMBERSHIP DUES

In October, 1919, in accordance with the provision of Section 1,above,the membership approved adoption of an amendment to the Constitution authorizing increasing the dues as follows:

	Per Year
Fellows	$15.00
Members	10.00
Associates	7.50
Juniors	5.00

At the Board meeting held in January, 1920, it was decided to defer advancing the dues to the full amount authorized until a later date. The dues adopted were:

	Per Year
Fellows	$12.00
Members	9.00
Associates	5.00
Juniors	4.00

On January 1, 1926, the dues were advanced as follows:

	Per Year
Fellows	$15.00
Members	10.00
Associates	6.00
Juniors	4.00

This leaves the annual dues for Associates and Juniors below the amount authorized by the membership in October, 1919.

On January 1, 1927, the entrance fees were reinstated. These are:

Fellow	$10.00
Member	5.00
Associate	3.00
Junior	1.00

NOMINATION AND ELECTION OF OFFICERS

In January, 1921, the membership by letter vote approved change in Article VII of the Constitution to read as follows:

Article VII, Section 1 of the Constitution to read:

"SEC. 1—Six weeks before the annual meeting, the Board of Direction shall submit to the entire membership, excepting Honorary Members and Juniors, a list of candidates (nominees) for the offices of President, Vice-President, (Secretary, Treasurer) and two Managers. This list shall comprise at least one name and not more than three names for each office, the names being proposed either by Petition as hereinafter provided, or by (a quorum of) the Board of Direction, at one of these stated meetings. The list shall contain no indication as to whether the candidate has been proposed by Petition or by Board of Direction.

"Nomination by Petition shall be made by letter, addressed to the Board of Direction, setting forth the name of the proposed candidate and the office for which it is desired he be nominated. For acceptance, a letter of Petition must reach the Board of Direction on or before October 15th of any year, and shall be signed by at least thirty-five Fellows, Members or Associates.

"The list of nominees shall contain the names of all candidates proposed by formal Petition or by the Board of Direction, but before this list is submitted to the membership for final vote, each candidate should be consulted and if he so requests, the fact that he has withdrawn from election shall be stated after his name.

"The entire membership, excepting Honorary Members and Juniors, shall vote by written ballots in plain sealed envelopes, enclosed within mailing envelopes marked "Ballot" and bearing the member's signature, for the officers whose names appear on the list of candidates. A majority vote received up to the time of the closing of the polls (twenty-four hours before the opening of the annual meeting, the date of which shall be stated in the election notice) shall elect, and no votes by proxy shall be counted. No proxies or ballots within unsigned outer envelopes shall be opened for counting. Ballots shall be checked, opened and counted by a quorum of the Board of Direction, at a regular meeting of the Board.

"Sec. 2—The Treasurer, Secretary, and Editor of Publications shall be appointed by majority vote of the Board of Direction as soon as practicable after January 15th of each year, for a term of one year or until their successors be appointed."

BY-LAWS GOVERNING SECTIONS

(The purpose of the Institute in furthering the establishment of Sections is to afford opportunity for members situated in various parts of the United States and other countries to meet in organized groups for the discussions of radio engineering topics.)

1—A petition for the formation of a Section shall be signed by not less than twenty-five members (any grade except Juniors) residing within the territorial limits hereinafter prescribed. The Board of Direction may decline to authorize the formation of a Section when, in its judgment, such an organization would not be compatible with the interests of the Institute.

2—A Section shall be known as: The (name of place or geographical district) Section of the Institute of Radio Engineers.

3—The principal activity of a Section shall be the holding of periodical meetings (monthly or bi-monthly, but not less than five regular meetings annually) for the presentation of original papers already presented at New York meetings of the Institute, or at other Sections.

4—The territory of a Section shall be the territory naturally tributary thereto, but shall not include territory so remote or inaccessible that members cannot readily attend meetings. For the purpose of determining the maximum amount of money to which a Section is entitled under these by-laws, points more than sixty miles from the regular meeting place of the Section shall not be considered a part of the Section except when special conditions warrant such action, territory within a reasonable distance may be authorized by the Board of Direction. If adjacent Sections should be so situated that the sixty-mile limit embraces common territory, the question as to which Section shall claim such members as reside within this common territory shall, if possible, be decided by agreement between the Sections concerned; otherwise by the Board of Direction. (Sections may carry on their mailing list for meeting announcements the names of members located outside of the prescribed Section territory.)

5—The Chairman, Vice-Chairman, Secretary, and any other officers of each Section must be Fellows, Members or Associates of the Institute, and shall be elected for the term of one year beginning January 1, or May 1, and until their successors are elected.

6—The Board of Direction may at any time terminate the existence of any Section when in its judgment the interests of the Institute make such action desirable.

7—Papers and discussions presented before a Section and published in the PROCEEDINGS shall not be republished except with due acknowledgment of the original source.

8—Original papers presented before a Section, suitable for publication in the PROCEEDINGS may be presented to the Meetings and Papers Committee for consideration, which, in judging suitability, will be governed by the same considerations applied to similar matter offered from other sources.

9—The Secretary of the Institute will forward to the Secretary of each Section copies of all printed announcements of the regular meetings in New York, and shall forward also to the Secretary of each Section, three complete sets of proofs, or three pamphlet form copies of each technical paper intended for presentation at New York or for publication in the PROCEEDINGS. This latter is for the purpose of supplying Sections with advance copies for Section discussion.

10—Each Section shall have a Meetings and Papers Committee and a Membership Committee, appointed by the Chairman.

11—Each Section shall conduct its affairs in such manner that no indebtedness shall accrue in excess of the amount due annually as per-member rebate, specified in paragraph 12.

12—The appropriation of Institute funds during any fiscal year for aid in Section maintenance shall be the sum determined as follows: one dollar for each Fellow, Member, and Associate residing within the territory of the Section at the

beginning of the administrative year, namely, January 1. Each year, beginning in 1926, the Treasurer will place to the credit of each Section the accrued rebate calculated from members' dues paid in the Section as of March 1 and September 1. Section Treasurers may draw upon this account quarterly; that is, January 1st, April 1st, July 1st and October 1st.

13—Section Secretaries shall forward to the Secretary of the Institute a report of each meeting held by the Section for the presentation or discussion of papers, and on January 1 of each year a statement of the past year's accounts.

The Institute of Radio Engineers

1931 REPORT OF THE COMMITTEE ON STANDARDIZATION

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INTRODUCTION

SINCE its organization in 1912, the Institute of Radio Engineers has had a Committee on Standardization whose duty it has been to study and define suitable terms used in radio communication, and to propose standard methods of testing and rating radio equipment.

The first Report of the Committee on Standardization was issued in 1913 as a part of Volume 1 of the Proceedings. This was succeeded by revised reports issued in 1915, 1922, 1926, and 1928.

The present Report is an outgrowth and expansion of the 1928 Report. All of the material in the 1928 Report has been carefully reviewed and retained or revised, as necessary, to keep pace with the progress of the science. The Standard Methods of Measuring Important Characteristics of Vacuum Tubes and Standard Tests of Broadcast Radio Receivers in the 1928 Report formed the basis of the corresponding material in this report although in both cases a considerable amount of new material has been added. Among the major new items which are included in this report are: Tentative Suggested Methods of Testing and Rating Radio Transmitters and Antennas, Performance Indexes and Tests of Electro-Acoustic Devices, and Provisions for Safety of Operating Personnel in Relation to Radio Transmitting Equipment.

The sections entitled Tentative and Suggested Methods of Testing and Rating Radio Transmitters and Antennas, and Tentative and Suggested System of Symbols for Electro-Acoustic Devices are in a different class from the other sections of the report. They are not adopted standards but are tentative material included for information and trial.

The Institute has been actively interested in related standards of other organizations as well as in its own standards, and has coöperated with the standardizing bodies of the Acoustical Society of America, the American Institute of Electrical Engineers, the American Society of Mechanical Engineers, the American Standards Association, the International Electrotechnical Commission, and the Radio Manufacturers' Association. For several years the Institute has been joint sponsor, with the American Institute of Electrical Engineers, of the Sectional Committee on Radio of the American Standards Association, and became a member body of the American Standards Association in October, 1930.

The scope of the Institute's standardization work includes standardization, with respect to radio communication and closely allied fields of science and engineering, of:

1. Nomenclature, symbols, and definitions.
2. Methods of testing apparatus, equipment, devices, and materials used in radio communication.
3. Acceptable limits for performance, ratings, capacities, operation, and other characteristics and standards for such apparatus, equipment, devices, and materials.
4. Standardization of sizes and dimensions, and electrical and mechanical characteristics of parts, apparatus, equipment, and devices to provide for interchangeability and interworking, or economy in manufacture and use.
5. Standardization of specifications governing quality of material and methods of test therefor.
6. Establishment of provisions for safety of operating and other personnel in relation to radio equipment.

The work of the Committee on Standardization has to date been limited to items Nos. 1, 2, and 6. The Institute's work on the other items is in general done through its sponsorship of the A. S. A. Sectional Committee on Radio.

The standards of other organizations, listed below, will be found of interest to radio engineers:

"R.M.A. Standards and Engineering Information." Issued by Radio Manufacturers' Association, Inc., 32 W. Randolph St., Chicago. Latest edition, 1930.

"Graphical Symbols for Telephone and Telegraph Use." A.S.A. Z10g6. 1929.

"Graphical Symbols Used for Electric Power and Wiring." A.I.E.E., No. 17g2. July, 1930.

"Symbols for Photometry and Illumination." A.S.A. Z10d. 1930.

"Mathematical Symbols." A.S.A. Z10f. 1928.

"Letter Symbols for Electrical Quantitites." A.S.A. Z10g1. 1929.

"Table of Preferred Numbers." A.S.A. Z17. 1927.

"Electrical Measuring Instruments." A.I.E.E., No. 33. January, 1927.

"Telephony and Telegraphy." A.I.E.E., No. 34. June, 1922.

"Storage Batteries." A.S.A. C40. 1928.

"National Electrical Code," Art. 37. A.S.A. Cl. 1930.

"National Electrical Safety Code," Part 5. A.S.A. C2. 1927.

The last eight of these were published in the 1930 YEAR BOOK of the Institute of Radio Engineers.

The Institute of Radio Engineers

MEMBERSHIP OF THE COMMITTEE ON STANDARDIZATION

J. H. DELLINGER, *Chairman*
B. DUDLEY, *Secretary*

Wilson Aull	S. W. Edwards	E. L. Nelson
Stuart Ballantine	P. H. Evans	L. G. Pacent
M. C. Batsel	General Ferrié	Haraden Pratt
W. R. Blair	H. A. Frederick	D. E. Replogle
E. L. Bowles	A. N. Goldsmith	J. L. Reynolds
C. E. Brigham	V. M. Graham	H. B. Richmond
C. M. Burrill	H. E. Hallborg	C. E. Rickard
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H. W. Dreyer	C. B. Mirick	William Wilson
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Committees Operating Under the Committee on Standardization

TECHNICAL COMMITTEE NO. 1, RADIO RECEIVERS

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C. E. Brigham	Malcolm Ferris	R. H. Langley
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SUBCOMMITTEE ON MARINE AND DIRECTION FINDING RECEIVERS

F. A. KOLSTER, *Chairman*

T. McL. Davis	J. L. Preston
W. H. Murphy	G. P. Shandy

SUBCOMMITTEE ON AIRCRAFT RECEIVERS

V. M. GRAHAM, *Chairman*

S. E. Anderson	T. McL. Davis	H. O. Peterson
J. F. Byrnes	Harry Diamond	R. M. Wilmotte
	W. H. Murphy	

SUBCOMMITTEE ON HIGH-FREQUENCY RECEIVERS

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T. McL. Davis	H. M. Lewis	Paul Watson

TECHNICAL COMMITTEE NO. 2, RADIO TRANSMITTERS AND ANTENNAS

HARADEN PRATT, *Chairman*

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T. A. M. Craven	H. E. Hallborg	A. D. Ring
B. R. Cummings	F. G. Kear	R. M. Wilmotte
W. F. Diehl	J. J. Lamb	William Wilson

SUBCOMMITTEE ON NOMENCLATURE, SYMBOLS, AND DEFINITIONS

T. A. M. CRAVEN, *Chairman*

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SUBCOMMITTEE ON ESTABLISHMENT OF PROVISIONS FOR SAFETY

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TECHNICAL COMMITTEE NO. 3, VACUUM TUBES

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TECHNICAL COMMITTEE NO. 4, ELECTRO-ACOUSTIC DEVICES

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Melville Eastham	R. H. Manson	H. A. Wheeler
C. R. Hanna	D. C. Miller	Irving Wolff
P. R. Heyl	S. V. Perry	

STANDARD DEFINITIONS OF TERMS USED IN RADIO

SECTION 1—GENERAL

1001. Cycle. A cycle is one complete set of the recurrent values of a periodic phenomenon.

1002. Frequency. Frequency is the number of cycles per second.

1003. Kilocycle. A kilocycle, when used as a unit of frequency, is a thousand cycles per second.

1004. Megacycle. A megacycle, when used as a unit of frequency, is a million cycles per second.

1005. Audio Frequency. An audio frequency is a frequency corresponding to a normally audible sound wave.

1006. Radio Frequency. A radio frequency is a frequency usually higher than those corresponding to normally audible sound waves.

Note—It is not implied that radiation cannot be secured at lower frequencies, nor that radio frequencies are necessarily above the limit of audibility.

1007. Fundamental Frequency. A fundamental frequency is the lowest component frequency of a periodic wave or quantity.

1008. Harmonic. A harmonic is a component of a periodic wave or quantity having a frequency which is an integral multiple of the fundamental frequency. For example, a component the frequency of which is twice the fundamental frequency is called the second harmonic.

1009. Subharmonic. A subharmonic is a component of a periodic wave or quantity having a frequency which is an integral submultiple of the fundamental frequency. For example, a component the frequency of which is half the fundamental frequency is called the second subharmonic.

1010. Oscillatory Circuit. An oscillatory circuit is a circuit containing inductance and capacitance, such that a voltage impulse will produce a current which periodically reverses.

1011. Signal. A signal is the intelligence, message, or effect, conveyed in communication.

1012. Signal Wave. A signal wave is a wave, the form of which conveys a signal.

1013. Band of Frequencies. A band of frequencies is a continuous range of frequencies between two specified frequency limits.

1014. Side Band. A side band is a band of frequencies on either side of the carrier frequency produced by the process of modulation.

1015. Side Frequency. A side frequency is a frequency on either side of the carrier frequency, produced by the process of modulation.

1016. Carrier Wave. A carrier wave is a wave which is modulated by a signal and which enables the signal to be transmitted through a specific physical system.

1017. Carrier Current. A carrier current is the current associated with a carrier wave.

1018. Carrier. Carrier is a term broadly used to designate carrier wave, carrier current, or carrier voltage.

1019. Carrier Frequency. A carrier frequency is the frequency of a carrier wave.

1020. Beating. Beating is a phenomenon in which two or more periodic quantities of different frequencies react to produce a resultant having pulsations of amplitude.

1021. Beat. A beat is a complete cycle of pulsations in the phenomenon of beating.

1022. Beat Frequency. Beat frequency is the number of beats per second.

1023. Series Phase Resonance. Series phase resonance is a condition which exists in a circuit comprising inductance and capacitance connected in series, when the current entering the circuit is in phase with the voltage across the circuit.

1024. Parallel Phase Resonance. Parallel phase resonance is a condition which exists in a circuit comprising inductance and capacitance connected in parallel, when the current entering the circuit is in phase with the voltage across the circuit.

1025. Tuning. Tuning is the adjustment of a circuit or system to secure optimum performance in relation to a frequency; commonly, the adjustment of a circuit or circuits to resonance.

1026. Coupling. Coupling is the association of two circuits in such a way that power may be transferred from one to the other.

1027. Coupling Coefficient. The coupling coefficient is the ratio of the mutual or common impedance component of two circuits to the square root of the product of the total impedance components of the same kind in the two circuits. (Impedance components may be inductance, capacitance, or resistance.)

1028. Direct Coupling. Direct coupling is the association of two circuits by having an inductor, a condenser, or a resistor common to both circuits.

1029. Inductive Coupling. Inductive coupling is the association of one circuit with another by means of inductance common or mutual to both. (This term, when used without modifying words, is commonly used for coupling by means of mutual inductance, whereas coupling by means of self-inductance common to both circuits is called direct inductive coupling.)

1030. Capacitive Coupling. Capacitive coupling is the association of one circuit with another by means of capacitance common or mutual to both.

1031. Resistance Coupling. Resistance coupling is the association of one circuit with another by means of resistance common to both.

1032. Logarithmic Decrement. The logarithmic decrement is the napierian logarithm of the ratio of the first to the second of two successive amplitudes of the same sign for an exponentially damped alternating current. The logarithmic decrement can also be considered as a constant of a simple radio circuit, being π times the product of the resistance and the square root of the ratio of the capacitance to the inductance of the circuit.

1033. Damping Constant. The damping constant is the napierian logarithm of the ratio of the first to the second of two values of an exponentially decreasing quantity separated by unit time. It is the coefficient α appearing in the exponent of the damping factor, $e^{-\alpha t}$, which occurs in expressions of the following forms for damped currents:

$$i = I_0 e^{-\alpha t}$$
$$i = I_0 e^{-\alpha t} \cos 2\pi f_n t.$$

In an oscillatory circuit containing resistance, inductance, and capacitance, in series, $\alpha = R/2L$.

1034. Voltage Amplification. Voltage amplification is the ratio of the alternating voltage produced at the output terminals of an amplifier to the alternating voltage impressed at the input terminals, for specific circuit conditions. (This term should not be used to describe a process.) (See 7039, Amplification Factor.)

1035. Current Amplification. Current amplification is the ratio of the alternating current produced in the output circuit of an amplifier to the alternating current supplied to the input circuit for specific circuit conditions.

1036. Power Amplification. Power amplification is the ratio of the alternating-current power produced in the output circuit to the alternating-current power supplied to the input circuit for specific circuit conditions.

1037. Regeneration. Regeneration is the process by which a part of the power in the output circuit of an amplifying device reacts upon the input circuit in such a manner as to reinforce the initial power, thereby increasing the amplification. (This is sometimes called feed-back or reaction.)

1038. Fidelity. Fidelity is the degree to which a system, or a portion of a system, accurately reproduces at its output the form of the signal which is impressed upon its input. (See page 122 for fidelity as applied to radio receivers.)

1039. Distortion. Distortion is a change in wave-form occurring in a transducer or transmission medium. The principal sources of distortion are:

(a) Nonlinear relation between input and output at a given frequency,

(b) Nonuniform transmission at different frequencies, and

(c) Phase shift not proportional to frequency.

1040. Modulation. Modulation is the process whereby the frequency or amplitude of a wave is varied in accordance with a signal wave.

1041. Double Modulation. Double modulation is the process of modulation in which a carrier wave of one frequency is first modulated by a signal wave and is then made to modulate a second carrier wave of another frequency.

1042. Intermodulation. Intermodulation is the production, in a nonlinear circuit element, of frequencies corresponding to the sums and differences of the fundamentals and harmonics of two or more frequencies which are transmitted to that element.

1043. Cross Modulation. Cross modulation is a type of intermodulation due to modulation of the carrier of the desired signal in a radio apparatus by an undesired signal.

1044. Percentage Modulation. Percentage modulation is the ratio of half the difference between the maximum and minimum amplitudes of a modulated wave to the average amplitude, expressed in per cent.

1045. Ripple Voltage. Ripple voltage is the alternating component of unidirectional voltage from a rectifier or generator. Per cent ripple is the ratio of the effective (root-mean-square) value of the ripple voltage to the algebraic average value of the total voltage, expressed in percentage.

1046. Direct Capacitance. Direct capacitance is the quotient of the charge, produced on one conductor by the voltage between it and another conductor, by this voltage, all other conductors in the neighborhood being at the potential of one of the conductors.

1047. Radio Channel. A radio channel is a band of frequencies of a width sufficient to permit of its use for radio communication. The width of a channel depends upon the type of transmission.

1048. Transducer. A transducer is a device actuated by power from one system and supplying power in the same or any other form to a second system. Either of these systems may, for example, be electrical, mechanical, or acoustical.

1049. Passive Transducer. A passive transducer is a transducer in which the power supplied to the second system is obtained exclusively from the power available from the first system.

1050. Active Transducer. An active transducer is a transducer in which the power supplied to the second system is obtained from a local source and is controlled by the power from the first system.

1051. Ideal Transducer. An ideal transducer for connecting two specific systems is a passive transducer which converts the maximum possible power from the first system to the second.

1052. Facsimile Transmission. Facsimile transmission is the electrical transmission of a graphic record having a limited number of shade values.

1053. Picture Transmission. Picture transmission is the electrical transmission of a picture having a gradation of shade values.

1054. Television. Television is the electrical transmission of a succession of images and their reception in such a way as to give a substantially continuous and simultaneous reproduction of the object or scene before the eye of a distant observer.

1055. Service Band. A service band is a band of frequencies allocated to a given class of radio communication service.

1056. Communication Band. The communication band is the band of frequencies due to modulation (including keying) actually occupied by the emission, for a given type of transmission.

1057. Power Level. The power level at any point in a system is an expression of the power being transmitted past that point.

1058. Overload Level of a Transducer. The overload level of a transducer is that power level at which the transducer ceases to operate satisfactorily as a result of distortion, heating, breakage, etc.

1059. Transmission Level. The transmission level is the radio field intensity of the signaling power amplitude at any point in a communication system expressed either in some absolute unit or with reference to an arbitrary base value.

1060. Transmission Unit. A transmission unit is a unit expressing the logarithmic ratios of powers, voltages, or currents, in a transmission system.

There are now in international use two transmission units, a napierian unit called the neper, and a decimal unit called the bel. Decimal multiples or submultiples of either of these units may be used, such as decineper and decibel.

The number of units of transmission in the case of a ratio of two powers, P_1 and P_2 is:

in the napierian system: $1/2 \log_e \frac{P_1}{P_2}$

in the decimal system: $\log_{10} \frac{P_1}{P_2}$

The number of units of transmission in the case of a ratio of two voltages E_1 and E_2, or of two currents I_1 and I_2, if the squares of these ratios are equal to the power ratio, is:

in the napierian system: $\log_e \frac{E_1}{E_2}$ or $\log_e \frac{I_1}{I_2}$

in the decimal system: $2 \log_{10} \frac{E_1}{E_2}$ or $2 \log_{10} \frac{I_1}{I_2}$

The unit based on the decimal system and having a size one-tenth of that here defined is widely used in the United States. This unit is therefore, the decibel, (abbreviated db) and was formerly referred to as the transmission unit or TU.

The following table gives the numerical values of power, voltage, and current ratios corresponding to particular numbers of decibels:

Power Ratio	Transmission Units in Decibels (db)
1 ($=10^0$)	0 ($=10 \log_{10} 1$)
1.259 ($=10^{0.1}$)	1 ($=10 \log_{10} 1.259$)
10 ($=10^1$)	10 ($=10 \log_{10} 10$)
100 ($=10^2$)	20 ($=10 \log_{10} 100$)
1000 ($=10^3$)	30 ($=10 \log^{10} 1000$)

Voltage or Current Ratio	Transmission Units in Decibels (db)
0.001	−60.00
0.005	−46.02
0.01	−40.00
0.05	−26.02
0.1	−20.00
0.2	−13.98
0.5	− 6.02
1.0	0.00
1.5	3.52
2	6.02
5	13.98
10	20.00
20	26.02
50	33.98
100	40.00
500	53.98
1000	60.00

1061. Radio Broadcasting. Radio broadcasting is radio transmission intended for general reception.

SECTION 2—WAVE PROPAGATION

2001. Wave. A wave is:

(a) A propagated disturbance, usually periodic, as an electric wave or sound wave,

(b) A single cycle of such a disturbance, or,

(c) A periodic variation as represented by a graph.

2002. Wavelength. A wavelength is the distance traveled in one period or cycle by a periodic disturbance. It is the distance between corresponding phases of two consecutive waves of a wave train. Wavelength is the quotient of velocity by frequency.

2003. Continuous Waves. Continuous waves are waves the successive oscillations of which are identical under permanent conditions.

2004. **Interrupted Continuous Waves.** Interrupted continuous waves are waves obtained by interruption at audio frequency in a substantially periodic manner of otherwise continuous waves.

2005. **Tone-Modulated Waves.** Tone-modulated waves are waves obtained by modulation at audio frequency in a substantially periodic manner of otherwise continuous waves.

2006. **Telegraph-Modulated Waves.** Telegraph-modulated waves are continuous waves the amplitude or frequency of which is varied by means of telegraphic keying.

2007. **Damped Waves.** Damped waves are waves of which the amplitude of successive cycles, at the source, progressively diminishes.

2008. **Radio Field Intensity.** Radio field intensity is the effective (root-mean-square) value of the electric or magnetic field intensity at a point due to the passage of radio waves of a specified frequency. It is usually expressed in terms of the electric field intensity in microvolts per meter or millivolts per meter. When the direction in which the field intensity is measured is not stated, it is to be taken that it is measured in the direction of maximum field intensity.

2009. **Radio Noise Field Intensity.** Radio noise field intensity is a measure of the field intensity, at a point (as a radio receiving station), of electromagnetic waves of an interfering character. In practice the quantity measured is not the field intensity of the interfering waves, but some quantity which is proportional to, or bears a known relation to, the field intensity.

2010. **Signal-Noise Ratio.** Signal-noise ratio is the ratio, at a point of the field intensity of the radio wave to the radio noise field intensity.

2011. **Strays.** Strays are electromagnetic disturbances in radio reception other than those produced by radio transmitting systems.

2012. **Atmospherics.** Atmospherics are strays produced by atmospheric conditions. (In the United States the term static has come to be used quite generally as a synonym for atmospherics.)

2013. **Absorption.** Absorption is the loss of power in transmission of radio waves due to dissipation.

2014. **Atmospheric Absorption.** Atmospheric absorption is the loss of power in transmission of radio waves due to dissipation in the atmosphere.

2015. **Ground Absorption.** Ground absorption is the loss of power in transmission of radio waves due to dissipation in the ground.

2016. **Fading.** Fading is the variation of the signal intensity received at a given location from a radio transmitting station as a result of changes in the transmission path.

2017. **Swinging.** Swinging is the momentary variation in frequency of a received wave.

2018. **Attenuation.** Attenuation is the reduction in magnitude of a wave with increasing distance from its source or from a specified point of reference.

2019. **Transmission Loss.** Transmission loss is the loss of power in a wave in passing along a transmission path or through a circuit device.

SECTION 3—TRANSMISSION

3001. **Radio Transmission.** Radio transmission is the transmission at radio frequencies of signals by means of radiated electromagnetic waves.

3002. **Radio Transmitter.** A radio transmitter is a device for producing radio-frequency power, with means for producing a signal.

3003. **Modulated Wave.** A modulated wave is a wave of which either the amplitude or frequency, or both, is varied in accordance with a signal wave.

3004. **Marking Wave.** The marking wave, in telegraphic communication, is the emission which takes place while the active portions of the code characters are being transmitted.

3005. **Spacing Wave.** The spacing wave, in telegraphic communication, is the emission which takes place between the active portions of the code characters or while no code characters are being transmitted.

3006. **Carrier Suppression.** Carrier suppression is that method of operation in which the carrier wave is not transmitted.

3007. **Single Side Band Transmission.** Single side band transmission is that method of operation in which one side band is transmitted and the other side band is suppressed. The carrier wave may be either transmitted or suppressed.

3008. Vacuum Tube Transmitter. A vacuum tube transmitter is a radio transmitter in which vacuum tubes are utilized to convert the applied electric power into radio-frequency power.

3009. Oscillator. An oscillator is a nonrotating device for producing alternating current, the output frequency of which is determined by the characteristics of the device.

3010. Master Oscillator. A master oscillator is an oscillator of comparatively low power so arranged as to establish the carrier frequency of the output of an amplifier.

3011. Radio-Frequency Alternator. A radio-frequency alternator is a rotating type of alternating-current generator which generates radio-frequency power.

3012. Alternator Transmitter. An alternator transmitter is a radio transmitter which utilizes radio-frequency power generated by a radio-frequency alternator.

3013. Arc Converter. An arc converter is a form of oscillator utilizing an electric arc for the generation of alternating or pulsating current.

3014. Spark Transmitter. A spark transmitter is a radio transmitter which utilizes the oscillatory discharge of a condenser through an inductor and a spark gap as the source of its radio-frequency power.

3015. Spark Gap. A spark gap is an arrangement of electrodes used for closing a circuit (usually oscillatory) at a predetermined voltage. Among the types of spark gaps are plain gap, rotary gap, synchronous gap, and quenched gap.

3016. Impulse Excitation. Impulse excitation is a method of producing damped oscillatory current in a circuit in which the duration of the impressed voltage is short compared with the duration of the current produced.

3017. Modulator. A modulator is a device to effect the process of modulation. It may be operated by virtue of some nonlinear characteristic or by a controlled variation of some circuit quantity.

3018. Magnetic Modulator. A magnetic modulator is a magnetic device employed as a modulator and functioning by virtue of its nonlinear magnetization characteristic.

3019. Vacuum Tube Modulator. A vacuum tube modulator is a modulator employing a vacuum tube as a modulating element.

3020. Duplex Operation. Duplex operation is the operation of associated transmitting and receiving apparatus in which the processes of transmission and reception are concurrent.

3021. Diplex Transmission. Diplex transmission is the simultaneous transmission of two signals using a specified common feature, such as a single antenna or a single carrier.

3022. Multiplex Transmission. Multiplex transmission is the simultaneous transmission of two or more signals using a specified common feature, such as a single antenna or a single carrier.

3023. Radio Circuit. A radio circuit is a radio system for carrying out one communication at a time in either direction between two points.

3024. Frequency Tolerance. The frequency tolerance is the extent to which the frequency of a station may be permitted to vary on either side of the frequency assignment.

3025. Interference Guard Bands. The interference guard bands are the two bands of frequencies additional to, and on either side of, the communication band and frequency tolerance, which may be provided in order that there shall be no interference between stations having adjacent frequency assignments.

3026. Spurious Radiation. Spurious radiation is any emission from a radio transmitter at frequencies outside of its communication band.

3027. Modulation Capability. Modulation capability is the maximum percentage modulation that is possible without objectionable distortion.

Note—A number of definitions specifically pertaining to transmitters are given in "Tentative Suggested Methods of Testing and Rating Radio Transmitters and Antennas," page 99.

SECTION 4—RECEPTION

4001. Radio Receiver. A radio receiver is a device for converting radio waves into perceptible signals.

4002. Monitoring Radio Receiver. A monitoring radio receiver is a radio receiver arranged to permit a check to be made on the operation of a transmitting station.

4003. Heterodyne Reception. Heterodyne reception is the process of receiving radio waves by combining in a detector a received voltage with a locally generated alternating voltage. The frequency of the locally generated voltage is commonly different from that of the received voltage. (Heterodyne reception is sometimes called beat reception.)

4004. Autodyne Reception. Autodyne reception is a system of heterodyne reception through the use of a device which is both an oscillator and a detector.

4005. Homodyne Reception. Homodyne reception is a system of reception by the aid of a locally generated voltage of carrier frequency. (Homodyne reception is sometimes called zero-beat reception.)

4006. Superheterodyne Reception. Superheterodyne reception is a method of reception in which the received voltage is combined with the voltage from a local oscillator and converted into voltage of an intermediate frequency which is usually amplified and then detected to reproduce the original signal wave. (This is sometimes called double detection or supersonic reception.)

4007. Intermediate Frequency, in Superheterodyne Reception. Intermediate frequency, in superheterodyne reception, is a frequency between that of the carrier and the signal, which results from the combination of the carrier frequency and the locally generated frequency.

4008. Reflex Circuit Arrangement. A reflex circuit arrangement is a circuit arrangement in which the signal is amplified, both before and after detection, in the same amplifier tube or tubes.

4009. Interference. Interference is disturbance of reception due to strays, undesired signals, or other causes; also, that which produces the disturbance.

4010. Demodulation. Demodulation is the detection of a modulated wave, current, or voltage, in order to obtain the signal imparted to it in the modulation process.

4011. Detection. Detection is the process of operation on a frequency or combination of frequencies by means of an asymmetrical conducting device to produce certain desired frequencies or changes in current.

4012. Linear Detection. Linear detection is that form of detection in which the output voltage under consideration is substantially proportional to the carrier voltage throughout the useful range of the detecting device.

4013. Power Detection. Power detection is that form of detection in which the power output of the detecting device is used to supply a substantial amount of power directly to a device such as a loud speaker or recorder.

4014. Detector. A detector is a device having an asymmetrical conduction characteristic which is used for operation on a frequency or combination of frequencies to produce certain desired frequencies or changes in current. (See 9023, Rectifier; 1040, Modulation; and 4010, Demodulation.)

Note—A number of definitions specifically pertaining to receiving sets are given in "Standard Tests of Broadcast Radio Receivers," p. 121.

SECTION 5—ANTENNAS

5001. Antenna. An antenna is a conductor or a system of conductors for radiating or receiving radio waves.

5002. Aerial. An aerial is the elevated conductor portion of a condenser antenna.

5003. Loop Antenna. A loop antenna is an antenna consisting essentially of one or more complete turns of wire. (This is also called a coil antenna.)

5004. Condenser Antenna. A condenser antenna is an antenna consisting of two conductors or systems of conductors, the essential characteristic of which is its capacitance.

5005. Directional Antenna. A directional antenna is an antenna having the property of radiating or receiving radio waves in larger proportion along some directions than others. (An antenna of this type used for transmitting is often called a directive antenna.)

5006. Multiple Tuned Antenna. A multiple tuned antenna is an antenna with connections to ground or counterpoise through tuning reactances at more than one point, these being so determined that their reactances in parallel present a total reactance equal to that necessary to give the antenna the desired frequency.

5007. Wave Antenna. A wave antenna is a horizontal antenna, the length of which is of the same or greater order of magnitude as

that of the signaling wave, and which is so used as to be strongly directional.

5008. Antenna Resistance. Antenna resistance is the quotient of the power supplied to the entire antenna circuit by the square of the antenna current measured at the point where the power is supplied to the antenna.

Note—Antenna resistance includes radiation resistance, ground resistance, radio-frequency resistance of conductors in antenna circuit, equivalent resistance due to corona, eddy currents, insulator leakage, dielectric power loss, etc.

5009. Effective Height of an Antenna. The effective height of an antenna is a term applicable only to simple non-directive antennas, and is the height h in the equation,

$$h = \frac{\mathcal{E}d}{1.25fI}$$

where,

h is the height in meters,

$\mathcal{E}$ is the measured radio field intensity in microvolts per meter,

d is the distance in kilometers at which $\mathcal{E}$ is measured,

f is the frequency in kilocycles, and

I is the antenna current in amperes measured at the point where the power is supplied to the antenna, this point being ordinarily that at which the antenna current has its maximum value.

The field intensity, $\mathcal{E}$, is measured at a distance small enough to avoid ground absorption, and d is usually greater than one wavelength, in all cases sufficiently great so that the induction field is negligible. (In some cases the effective height of an antenna is different for different frequencies or different distances.)

5010. Meter Amperes. Meter amperes is the product of the effective height h and the antenna current I in the formula given in the definition for effective height of an antenna. (See 5009.)

5011. Radiation Resistance. Radiation resistance is the quotient of the power radiated by an antenna by the square of the antenna current measured at the point where the power is supplied to the antenna.

5012. Radiation Efficiency. The radiation efficiency of an antenna at a given frequency is the ratio of the power radiated to the total power supplied to the antenna.

5013. Natural Frequency of an Antenna. The natural frequency of an antenna is the lowest resonant frequency of an antenna, without added inductance or capacitance.

5014. Lead-In. A lead-in is that portion of an antenna which completes the electrical connection between the instruments or disconnecting switches and the main portion of the antenna.

5015. Counterpoise. A counterpoise is a system of wires or other conductors, elevated above and insulated from the ground, forming the lower system of conductors of an antenna.

5016. Ground System of an Antenna. The ground system of an antenna is that portion of the antenna, below the antenna loading devices or generating apparatus, most closely associated with the ground, and including the ground itself.

5017. Ground Wire. A ground wire is a conductive connection to the ground.

5018. Ground Equalizer Inductors. Ground equalizer inductors are coils of relatively low inductance placed in the circuit connected to one or more of the grounding points of an antenna, to distribute the current to the various points in any desired manner.

5019. Antenna Array. An antenna array is a system of elemental antennas, usually similar, excited by the same source, for the purpose of obtaining directional effects.

5020. Broadside Directional Antenna. A broadside directional antenna is an antenna array directional substantially at right angles to the line along which its elements are arrayed.

5021. End-on Directional Antenna. An end-on directional antenna is an antenna array directional substantially along the line in which its elements are arrayed.

5022. Antenna Reflector. An antenna reflector is a portion of a directional antenna array which serves to reverse the direction of propagation of radio waves.

5023. Doublet Antenna. A doublet antenna is an antenna consisting of two elevated conductors substantially in the same straight line, of substantially equal length, with the power delivered at the center.

5024. Artificial Antenna. An artificial antenna is a device having all the necessary characteristics of an antenna with the exception that

it dissipates in the form of heat instead of in the form of radio waves substantially all the power fed to it.

Note—A number of definitions applying particularly to the measurement of antenna characteristics are given in "Tentative Suggested Methods of Testing and Rating Radio Transmitters and Antennas," page 99.

SECTION 6—DIRECTION FINDING

6001. Direction Finder. A direction finder is a radio receiving device which permits determination of the line of travel of radio waves as received.

6002. Radio Compass. A radio compass is a direction finder used for navigational purposes.

6003. Observed Radio Bearing. An observed radio bearing is the angle between the observed direction of the line of travel of the received radio wave and an arbitrarily fixed line (such as the center line of a ship).

6004. Corrected Radio Bearing. A corrected radio bearing is an observed radio bearing to which all known corrections have been added algebraically.

6005. Direction Finder Deviation. The direction finder deviation is the difference between the observed radio bearing and the corrected radio bearing. (It is the algebraic sum of all known corrections to the indication of the direction finder.)

6006. Direction Finder Calibration. A direction finder calibration is the determination of the direction finder deviation at a number of scale readings.

6007. Sense Finder. A sense finder is that portion of a direction finder which permits determination of direction without 180-degree ambiguity.

6008. Radio Beacon. A radio beacon is a radio transmitting station in a fixed geographic location which emits a distinctive or characteristic signal for enabling mobile stations to determine bearings or courses.

6009. Radio Range Beacon. A radio range beacon is a radio beacon which transmits directed waves by means of which departures from a given course may be observed.

6010. Equisignal Radio Range Beacon. An equisignal radio range beacon is a radio range beacon which transmits two distinctive signals which may be received with equal intensity only in certain directions.

6011. Equisignal Sector. An equisignal sector is a region in which two distinctive signals from an equisignal radio range beacon are received with equal intensity.

6012. Balancer. A balancer is that portion of a direction finder which is used for the purpose of improving the sharpness of the direction indication.

6013. Compensator. A compensator is that portion of a direction finder which automatically applies to the direction indication all or a part of the correction for the deviation.

SECTION 7—VACUUM TUBES

General

7001. Vacuum Tube. A vacuum tube is a device consisting of a number of electrodes contained within an evacuated enclosure.

7002. Electron Tube. An electron tube is a vacuum tube evacuated to such a degree that its electrical characteristics are due essentially to electron emission.

7003. Thermionic Tube. A thermionic tube is an electron tube in which the electron emission is produced by the heating of an electrode.

7004. Phototube. A phototube is a vacuum tube in which electron emission is produced by the illumination of an electrode. (This has also been called photo-electric tube.)

7005. Thermionic Emission. Thermionic emission is electron or ion emission under the influence of heat.

7006. Electron Emission. Electron emission is the liberation of electrons from an electrode into the surrounding space. In a vacuum tube it is the rate at which the electrons are emitted from a cathode. This is ordinarily measured as the current carried by the electrons under the influence of a voltage sufficient to draw away all the electrons.

7007. Secondary Emission. Secondary emission is electron emission under the influence of electron or ion bombardment.

7008. Emission Characteristic. An emission characteristic is a graph plotted between a factor controlling the emission (such as the temperature, voltage, or current of the cathode) as abscissas, and the emission from the cathode as ordinates.

7009. Diode. A diode is a type of thermionic tube containing two electrodes which passes current wholly or predominantly in one direction.

7010. Triode. A triode is a type of thermionic tube containing an anode, a cathode, and a third electrode, in which the current flowing between the anode and the cathode may be controlled by the voltage between the third electrode and the cathode.

7011. Tetrode. A tetrode is a type of thermionic tube containing a plate, a cathode, and two additional electrodes. (Ordinarily the two additional electrodes are of the nature of grids.)

7012. Pentode. A pentode is a type of thermionic tube containing a plate, a cathode, and three additional electrodes. (Ordinarily the three additional electrodes are of the nature of grids.)

7013. Screen-Grid Tube. A screen-grid tube is a type of thermionic tube in which the capacitance between certain electrodes (ordinarily the control electrode and the plate) is substantially eliminated by the interposition of an additional electrode and suitable screening.

7014. Cathode. A cathode is the electrode from which the electron stream flows.

7015. Indirectly Heated Cathode. An indirectly heated cathode is a cathode of a thermionic tube, in which heat is supplied from a source other than the cathode itself. (Compare 7020, Filament).

7016. Heater. A heater is an electrical heating element for supplying heat to an indirectly heated cathode.

7017. Heater Voltage. The heater voltage is the voltage between the terminals of a heater.

7018. Heater Current. The heater current is the current flowing through a heater.

7019. Cathode Heating Time. The cathode heating time is the time, in seconds, required after application of normal voltage to the heater of an indirectly heated cathode for the plate current to attain a value equal to ninety per cent of its final value.

7020. Filament. A filament is a cathode of a thermionic tube in which heat is supplied by current passing through it. (Compare 7015, Indirectly Heated Cathode.)

7021. Filament Voltage. Filament voltage is the voltage between the terminals of a filament.

7022. Filament Current. Filament current is the current supplied to a filament to heat it.

7023. Control Electrode. A control electrode is an electrode upon which a voltage is impressed to vary the current to one or more other electrodes.

7024. Grid. A grid is an electrode having openings through which electrons or ions may pass.

7025. Grid Voltage. Grid voltage is the voltage between a grid and a specified point of the cathode.

7026. Grid Bias. Grid bias is the direct component of grid voltage.

7027. Grid Current. Grid current is the current passing from or to a grid through the vacuous space.

7028. Grid Conductance.[1] Grid conductance is the ratio of the change in the grid current to the change in grid voltage producing it, other electrode potentials being maintained constant. As most precisely used, the term refers to infinitesimal changes, as indicated by the defining equation:

$$s_{gg} \equiv s_g = \frac{\partial i_g}{\partial e_g}.$$

7029. Grid Characteristic. A grid characteristic is the graph plotted between grid voltage as abscissas and grid current as ordinates, other electrode potentials being maintained constant.

7030. Grid Condenser. A grid condenser is a series condenser in a grid circuit of a vacuum tube.

7031. Grid Leak. A grid leak is a resistor in a grid circuit, through which the grid current flows, to affect or determine a grid bias.

[1] See symbols of this and related terms on pages 88–91.

7032. Screen Grid. A screen grid is an electrode, usually associated with suitable auxiliary screening, and interposed between certain of the other electrodes to substantially eliminate the capacitance between them. (See 7013, Screen-Grid Tube.)

7033. Anode. An anode is an electrode to which an electron stream flows.

7034. Plate. Plate is a common name for the principal anode in a vacuum tube.

7035. Plate Voltage. Plate voltage is the voltage between the plate and a specified point of the cathode.

7036. Plate Current. Plate current is the current passing to or from the plate through the vacuous space.

7037. Cathode Current. Cathode current is the total current passing to or from the cathode through the vacuous space. (This term should be carefully distinguished from 7018, Heater Current and 7022, Filament Current.)

7038. Mu-Factor. The mu-factor is a measure of the relative effect of the voltages on two electrodes upon the current in the circuit of any specified electrode. It is the ratio of the change in one electrode voltage to a change in the other electrode voltage, under the condition that a specified current remains unchanged. As most precisely used, the term refers to infinitesimal changes as indicated by the defining equation:

$$\mu_{xyz} = -\frac{\partial e_y}{\partial e_z}; \quad i_x = \text{constant}.$$

7039. Amplification Factor. The amplification factor is a measure of the effectiveness of the control electrode voltage relative to that of the plate voltage upon the plate current. It is the ratio of the change in plate voltage to a change in control electrode voltage in the opposite direction, under the condition that the plate current remains unchanged. As most precisely used, the term refers to infinitesimal changes as indicated by the defining equation:

$$\mu = -\frac{\partial e_p}{\partial e_g}; \quad i_p = \text{constant}.$$

Amplification factor is a special case of mu-factor, applying only to triodes.

7040. Transfer Characteristics. A transfer characteristic is a graph plotted between the voltage on an electrode as abscissas and the current in the circuit of another electrode as ordinates.

7041. Electrode Conductance. Electrode conductance is the quotient of the change in the current in the circuit of an electrode to a change in the voltage on the same electrode, all other electrode voltages being maintained constant. As most precisely used, the term refers to infinitesimal changes as indicated by the defining equation:

$$s_{xx} \equiv s_x = \frac{\partial i_x}{\partial e_x}.$$

7042. Transconductance. Transconductance is the ratio of the change in the current in the circuit of an electrode to the change in the voltage on another electrode, under the condition that all other voltages remain unchanged. As most precisely used, the term refers to infinitesimal changes as indicated by the defining equation:

$$s_{xy} = \frac{\partial i_x}{\partial e_y}.$$

7043. Grid-Plate Characteristic. A grid-plate characteristic is a transfer characteristic plotted between grid voltage as abscissas and plate current as ordinates. (See 7029, Grid Characteristic; 7042, Transconductance; 7047, Plate Characteristic; and 7008, Emission Characteristic.)

7044. Grid-Plate Transconductance. Grid-plate transconductance is the name for the plate current to grid voltage transconductance. Symbolically,

$$s_{pg} \equiv s_m = \frac{\partial i_p}{\partial e_g}.$$

(This has also been called mutual conductance.)

7045. Plate Conductance. Plate conductance is the ratio of the change in plate current to the change in plate voltage producing it, all other electrode voltages being maintained constant. As most precisely used, the term refers to infinitesimal changes as indicated by the defining equation:

$$s_{pp} \equiv s_p = \frac{\partial i_p}{\partial e_p}.$$

7046. Plate Resistance. Plate resistance is the reciprocal of the plate conductance. Symbolically,

$$r_p = \frac{1}{s_p} = \frac{\partial e_p}{\partial i_p}.$$

7047. Plate Characteristic. A plate characteristic is a graph plotted between plate voltages as abscissas and plate currents as ordinates. (See 7029, Grid Characteristic; 7042, Transconductance; and 7008, Emission Characteristic.)

7048. Interelectrode Capacitance. Interelectrode capacitance is the direct capacitance between two electrodes.

7049. Cathode Capacitance. Cathode capacitance is the sum of the direct capacitances between the cathode and all other electrodes of a vacuum tube.

7050. Grid Capacitance. Grid capacitance is the sum of the direct capacitances between a grid and all other electrodes of a vacuum tube.

7051. Plate Capacitance. Plate capacitance is the sum of the direct capacitances between the plate and all other electrodes of a vacuum tube.

7052. Grid-Plate Capacitance. Grid-plate capacitance is the direct capacitance between a grid and the plate.

7053. Grid-Cathode Capacitance. Grid-cathode capacitance is the direct capacitance between a grid and the cathode.

7054. Plate-Cathode Capacitance. Plate-cathode capacitance is the direct capacitance between the plate and the cathode.

Note—The following relations exist in a triode between the capacitances defined in 7049 to 7051:

$$C_f = C_{gf} + C_{pf}; \qquad C_p = C_{pf} + C_{gp}; \qquad C_g = C_{gf} + C_{gp}.$$

7055. Output Impedance of a Vacuum Tube. The output impedance of a vacuum tube is the quotient of an externally applied alternating voltage impressed on the output terminals of a vacuum tube by the alternating current thereby produced.

7056. Output Admittance of a Vacuum Tube. The output admittance of a vacuum tube is the reciprocal of the output impedance.

7057. Input Impedance of a Vacuum Tube. The input impedance of a vacuum tube is the quotient of the alternating voltage impressed on the input terminals of the tube by the alternating current thereby produced.

7058. Input Admittance of a Vacuum Tube. The input admittance of a vacuum tube is the reciprocal of the input impedance.

Rectification and Detection

7101. Ordinary Rectification. Ordinary rectification is the rectification taking place in an electrode circuit, as indicated by a change in the average direct current therein, when an alternating voltage is applied to the same electrode.

7102. Rectification Factor. The rectification factor is the quotient of the change in average current in an electrode circuit (as indicated by a direct-current instrument) by the change in alternating sinusoidal voltage applied to the same electrode, the direct voltages of this and other electrodes being held constant. As most precisely used, the term refers to infinitesimal changes.

7103. Rectification Characteristic. A rectification characteristic is a family of graphs plotted between the average current in an electrode circuit (as indicated by a direct-current instrument), the direct voltage on that or another electrode, and the sinusoidal alternating voltage applied to the same electrode. These graphs are ordinarily plotted in two ways: (a) average currents as ordinates, direct voltages as abscissas, alternating voltages as parameter; (b) average currents as ordinates, alternating voltages as abscissas, direct voltages as parameter.

7104. Transrectification. Transrectification is the rectification taking place in an electrode circuit, as indicated by a change in average current therein, when an alternating voltage is applied to another electrode.

7105. Transrectification Factor. The transrectification factor is the quotient of the change in average current in an electrode circuit (as indicated by a direct-current instrument) by the change in the alternating sinusoidal voltage applied to another electrode, the direct voltages of this and other electrodes being held constant. As most precisely used, the term refers to infinitesimal changes.

7106. Transrectification Characteristic. A transrectification characteristic is a family of graphs plotted between the average current

in an electrode circuit (as indicated by a direct-current instrument), the direct voltage on that or another electrode, and the sinusoidal alternating voltage applied to another electrode. These graphs are ordinarily plotted in two ways: (a) average currents as ordinates, direct voltages as abscissas, alternating voltages as parameter; (b) average currents as ordinates, alternating voltages as abscissas, direct voltages as parameter.

7107. Conductance for Rectification. Conductance for rectification is the quotient of the change in the average plate current (as indicated by a direct-current instrument) by the change in direct voltage applied to that electrode, a sinusoidal alternating voltage being applied to the same or another electrode and the direct voltage of the other electrodes being maintained at their specified values. As most precisely used, the term relates to infinitesimal changes as indicated by the defining equation:

$$s_x' = \frac{\partial \bar{i}_x}{\partial e_x}.$$

7108. Plate Conductance for Rectification. The plate conductance for rectification is the quotient of the change in average plate current by the change in direct plate voltage, a sinusoidal alternating voltage being applied to an electrode. As most precisely used, the term refers to infinitesimal changes as indicated by the defining equation:

$$s_p' = \frac{\partial \bar{i}_p}{\partial e_p}.$$

7109. Plate Resistance for Rectification. The plate resistance for rectification is the reciprocal of the plate conductance for rectification:

$$r_p' = \frac{1}{s_p'}.$$

7110. Grid Conductance for Rectification. The grid conductance for rectification is the quotient of the change in average grid current by the change in direct grid voltage, a sinusoidal alternating voltage being impressed on an electrode circuit. As most precisely used, the term refers to infinitesimal changes as indicated by the defining equation:

$$s_g' = \frac{\partial \bar{i}_g}{\partial e_g}.$$

7111. Grid Resistance for Rectification. The grid resistance for rectification is the reciprocal of the grid conductance for rectification:

$$r_g' = \frac{1}{s_g'}.$$

Amplifier Classification

7201. Class A Amplifier. A class A amplifier is an amplifier which operates in such a manner that the plate output wave form is essentially the same as that of the exciting grid voltage.

This is accomplished by operating with a negative grid bias such that some plate current flows at all times, and by applying such an alternating voltage to the grid that the dynamic operating characteristics are essentially linear. The grid must usually not go positive on excitation peaks and the plate current must not fall low enough at its minimum to cause distortion due to curvature of the characteristic. The amount of second harmonic present in the output wave which was not present in the input wave is generally taken as a measure of distortion, the usual limit being five per cent.

The characteristics of a class A amplifier are low efficiency and output with a large ratio of power amplification.

7202. Class B Amplifier. A class B amplifier is an amplifier which operates in such a manner that the power output is proportional to the square of the grid excitation voltage.

This is accomplished by operating with a negative grid bias such that the plate current is reduced to a relatively low value with no grid excitation voltage, and by applying excitation such that pulses of plate current are produced on the positive half cycle of the grid voltage variations. The grid may usually go positive on excitation peaks, the harmonics being removed from the output by suitable means.

The characteristics of a class B amplifier are medium efficiency and output with a relatively low ratio of power amplification.

7203. Class C Amplifier. A class C amplifier is an amplifier which operates in such a manner that the output varies as the square of the plate voltage within limits.

This is accomplished by operating with a negative grid bias more than sufficient to reduce the plate current to zero with no excitation. An alternating grid excitation voltage is applied such that large amplitudes of plate currents are passed during a fraction of the positive half cycle of the grid excitation voltage variation.

The grid voltage usually swings sufficiently positive to allow saturation plate current to flow through the tube. Thus the plate output waves are not free from harmonics, and suitable means are usually provided to remove harmonics from the output.

The characteristics of a class C amplifier are high plate circuit efficiency and output with a relatively low ratio of power amplification.

Phototubes

7301. Gas Phototube. A gas phototube is a type of phototube in which a quantity of gas has been introduced, usually for the purpose of increasing its sensitivity.

7302. Vacuum Phototube. A vacuum phototube is a type of phototube which is evacuated to such a degree that the residual gas plays a negligible part in its operation.

7303. Sensitivity of a Phototube. The sensitivity of a phototube is the electrical current response of a phototube, with no impedance in its external circuit, to a specified amount and kind of light. It is usually expressed in terms of the current for a given radiant flux, or for a given luminous flux. In general the sensitivity depends upon the tube voltage, flux intensity, and spectral distribution of the flux.

7304. Static Sensitivity. Static sensitivity is the direct-current response of a phototube to a light flux of specified value.

7305. Dynamic Sensitivity. Dynamic sensitivity is the alternating-current response of a phototube to a pulsating light flux at specified values of mean light flux, frequency of pulsation, degree of pulsation, and steady tube voltage.

7306. Monochromatic Sensitivity. Monochromatic sensitivity is the response of a phototube to light of a given color, or narrow frequency range. For a given frequency, ν, this is the limit of the quotient of the current which flows through the tube at a specified steady voltage by the radiant flux of power (in watts) between the frequencies ν and $\nu+\Delta\nu$, which is approached as $\Delta\nu$ diminishes without limit. Mathematically,

$$S_\nu \equiv S(\nu, \Phi) = \lim_{\Delta\nu \to 0} \frac{1}{\Phi_\nu} \frac{\Delta i}{\Delta \nu},$$

where Φ represents the mean value of radiant flux in the range $\Delta\nu$.

Note—In the special case of a simple vacuum phototube the relation between current and radiant flux is linear. Also in this case the specified voltage may be taken as any voltage sufficient for saturation current.

7307. Total Sensitivity. Total sensitivity is the quotient of the current which flows through a phototube at a specified steady voltage by the total radiant flux (in watts) of specified spectral energy distribution entering the tube. Mathematically,

$$S = \frac{i}{\Phi},$$

where Φ is the total radiant flux. The total sensitivity depends upon the spectral distribution of energy of the light and is related to the monochromatic sensitivity as follows,

$$i = \int_0^\infty S_\nu(\nu, \Phi)\Phi_\nu(\nu)d\nu$$

where,

ν denotes the light frequency, and

$\Phi_\nu(\nu)$ the specific light flux (light flux per frequency interval).

Note—In the special case of a simple vacuum phototube, S_ν is independent of the light flux and equals the variational sensitivity, 7311. Also in this case the specified voltage may be taken to be a voltage sufficient for saturation current.

7308. Total Luminous Sensitivity. Total luminous sensitivity is the response of a phototube to luminous flux, i.e., radiant flux weighted according to its visibility. This is the quotient of the current which flows through the tube at a specified steady voltage by the total luminous flux in lumens. Mathematically,

$$S_F = \frac{i}{F}$$

where F is the total luminous flux.

7309. Tungsten Sensitivity. Tungsten sensitivity is the quotient of the current which flows through the tube at a specified steady voltage by the total luminous flux in lumens entering the tube from a tungsten filament lamp at specified temperature.

7310. 2870 Tungsten Sensitivity. 2870 tungsten sensitivity is the quotient of the current which flows through the tube at a specified steady voltage by the total luminous flux in lumens entering the

the tube from a tungsten filament lamp at a color temperature of 2870 degrees Absolute.

7311. **Variational Sensitivity.** Variational sensitivity is the quotient of the change in current which flows through the tube at a specified voltage by the change in the total flux entering the tube. As most precisely used, the term refers to infinitesimal changes as indicated by the defining equation:

$$S = \frac{\partial i}{\partial \Phi}, \quad \text{or} \quad \frac{\partial i}{\partial F}.$$

Note: When the current changes linearly with illumination, the variational sensitivity is independent of illumination and is equal to the total sensitivity, defined in 7307.

7312. **Variational Sensitivity Amplitude Relation.** The variational sensitivity amplitude relation is the relation between variational sensitivity of a phototube and the amplitude of the total steady light flux entering the tube.

7313. **Response Color Relation.** Response color relation is the relative response of a phototube to light of various colors (frequencies). This is the relation between the monochromatic sensitivity and the light frequency of a steady light flux.

7314. **Response Pulsation Frequency Relation.** Response pulsation frequency relation is the relation between the generated alternating open circuit voltage or short circuit current of a phototube and the pulsation frequency of a pulsating light flux at specified values of mean light flux, degree of pulsation, and steady tube voltage.

7315. **Conductance of a Phototube.** The conductance of a phototube is the quotient of the change in the current through a phototube at a specified light flux by the change of voltage at its terminals. As most precisely used, the term refers to infinitesimal changes as indicated by the defining equation:

$$s = \frac{\partial i}{\partial e}.$$

Note: In a vacuum phototube this is a linear function of the illumination.

7316. **Resistance of a Phototube.** The resistance of a phototube is the reciprocal of the conductance. Mathematically,

$$r = \frac{1}{s}.$$

7317. **Conductance Per Lumen.** The conductance per lumen is the quotient of the change in current through a phototube at a specified luminous flux by the change of voltage at its terminals, divided by the luminous flux in lumens. Mathematically,

$$S_F = \frac{1}{F}\,\frac{i}{e},$$

where F is the luminous flux in lumens.

Note: This quantity is constant if the relation between current and luminous flux is linear.

7318. **Photo-Voltage Coefficient.** The photo-voltage coefficient is an expression of the open circuit voltage generated by a phototube in response to a unit variation in light flux when the tube is regarded as a constant voltage generator. It is the quotient of the variational sensitivity by the tube conductance at specified values of operating direct voltage at the terminals of the tube, and of light flux. Mathematically, it is defined as being equal to

$$\frac{\partial i}{\partial F} \Big/ \frac{\partial i}{\partial e}.$$

Note: For a simple vacuum phototube and with voltage sufficient to draw saturation current, this quantity becomes infinite. In this case the tube is more conveniently regarded as a constant-current generator. The tube is likewise more conveniently regarded as a constant-current generator when the impedance is very high. For this purpose definition 7319, Photo-Current Coefficient is useful.

7319. **Photo-Current Coefficient.** The photo-current coefficient is an expression of the short circuit current generated by a phototube in response to a unit variation in light flux when the tube is regarded as a constant-current generator. It is numerically equal to the variational sensitivity as defined in 7311.

Photometric Definitions

These definitions are abstracted from the list of photometric definitions standardized by the Illuminating Engineering Society and the American Standards Association. They are copied here for reference as being of interest in the phototube art.

7401. **Radiant Flux.** Radiant flux is the rate of flow of radiation evaluated with reference to energy, and is expressed in ergs per second or in watts.

7402. Luminous Flux. Luminous flux is the rate of flow of radiation evaluated with reference to visual sensation, and is expressed in lumens.

7403. Visibility. The visibility of radiation of a particular frequency, ν, is the ratio of the luminous flux at that frequency to the corresponding radiant flux. Defining equation:

$$K_\nu = \frac{F}{\Phi_\nu}.$$

7404. Luminous Intensity. The luminous intensity of a point source in any direction is the flux per unit solid angle (one steradian) emitted by the source in that direction. Unit: Candle. Defining equation:

$$I = \frac{\partial F}{\partial \omega}.$$

7405. Illumination. The illumination at any point of a surface is the luminous flux density at that point, or when the illumination is uniform, the flux per unit of intercepting area. Unit: Phot. Defining equation:

$$E = \frac{\partial F}{\partial S} = \frac{\cos \theta}{r^2}.$$

7406. Candle Power. Candle power is luminous intensity expressed in candles.

7407. Lumen. The lumen is the unit of luminous flux. It is equal to the flux emitted in a unit solid angle by a uniform point source of one international candle.

7408. Phot. The phot is a unit of illumination, and is equal to one lumen per square centimeter. Other units of illumination are the foot-candle and lux.

Note—A number of additional definitions pertaining to vacuum tubes, of use in tube measurements and performance studies are given in "Standard Methods of Testing Vacuum Tubes," page 144. Letter symbols for thermionic tube notation and phototube notation are given on pages 90 and 91, and 92, respectively.

SECTION 8—ELECTRO-ACOUSTIC DEVICES

General

8001. Electro-Acoustic Transducer. An electro-acoustic transducer is a transducer which is actuated by power from an electrical system and supplies power to an acoustic system or vice versa.

8002. Blocked Impedance. The blocked impedance of an electro-acoustic transducer is the impedance measured at the terminals of its electrical system when the impedance of the attached mechanical system is infinite, or vice versa.

8003. Normal Impedance. The normal impedance of an electro-acoustic transducer is the impedance measured at the terminals of its electrical system when the mechanical system is connected to its normal load, or vice versa.

8004. Motional Impedance. The motional impedance of an electro-acoustic transducer is the vector difference between the normal and the blocked impedance.

8005. Force Factor. The force factor of an electro-acoustic transducer is a measure of the coupling between its electrical and mechanical systems. It is the ratio of the open circuit force or voltage in the secondary system to the current or velocity in the primary system.

8006. Compliance of a Mechanical Element. The compliance of a mechanical element is its displacement per unit of force. This is the reciprocal of its stiffness. Compliance in a mechanical system is analogous to capacitance in an electrical system and is expressed in centimeters per dyne. Negative compliance (reciprocal of negative stiffness) occurs in a case of unstable equilibrium where a small displacement results in a force tending to give a further displacement in the same direction.

8007. Mechanical Impedance of a Mechanical System. The mechanical impedance of a mechanical system is the complex quotient of the alternating force applied to the system by the resulting alternating linear velocity in the direction of the force at its point of application.

8008. Mechanical Resistance of a Mechanical System*. The mechanical resistance of a mechanical system is the real component of

* A mechanical impedance, reactance, or resistance is said to have a magnitude of one unit when a force of one dyne produces a velocity of one centimeter per second.

the mechanical impedance. It may also be expressed as the quotient of the power absorbed by the system by the square of the alternating velocity at the point of application of the force.

8009. Mechanical Reactance of a Mechanical System*. The mechanical reactance of a mechanical system is the imaginary component of the mechanical impedance. It may also be expressed as the component of the mechanical impedance of the system resulting from its effective mass or compliance.

8010. Bar. A bar is a pressure of one dyne per square centimeter.

8011. Acoustic Impedance of a Sound Medium†. The acoustic impedance of a sound medium, on a given surface, is the complex quotient of the pressure (force per unit area) on the surface by the flux (volume velocity, or linear velocity multiplied by the area) through that surface. The acoustic impedance may be expressed in terms of mechanical impedance, acoustic impedance being equal to the mechanical impedance divided by the square of the area of the surface considered.

8012. Acoustic Resistance of a Sound Medium†. The acoustic resistance of a sound medium is the real component of the acoustic impedance. This is the component of the acoustic impedance associated with the dissipation of energy.

8013. Acoustic Reactance of a Sound Medium†. The acoustic reactance of a sound medium is the imaginary component of the acoustic impedance. It is the component of the acoustic impedance resulting from the effective mass or compliance of the medium.

Telephone Receivers and Loud Speakers

8101. Telephone Receiver. A telephone receiver is an electro-acoustic transducer actuated by power from an electrical system and supplying power to an acoustic system, the wave form in the acoustic system corresponding to the wave form in the electrical system.

8102. Loud Speaker. A loud speaker is a telephone receiver designed to radiate acoustic power into a room or open air. (The shorter term, speaker, is frequently used where no ambiguity will result, as in compound terms.)

* See footnote on page 77.

† An acoustic impedance, reactance, or resistance is said to have a magnitude of one unit when a pressure of one bar produces a volume velocity of one cubic centimeter per second.

8103. Motor Element. The motor element is that portion of a telephone receiver which receives power from the electrical system and converts it into mechanical power.

8104. Acoustic Radiator. An acoustic radiator is that portion of an electro-acoustic transducer which initiates the radiation of sound vibrations.

8105. Baffle. A baffle is a partition which may be used with an acoustic radiator to impede circulation between front and back.

8106. Horn. A horn is an acoustic transducer consisting of a tube of varying sectional area.

8107. Throat of a Horn. The throat of a horn is the end with the smaller cross sectional area.

8108. Mouth of a Horn. The mouth of a horn is the end with the larger cross sectional area.

8109. Exponential Horn. An exponential horn is a horn whose sectional area varies exponentially with its length. It is defined by the following relation:

$$\frac{S}{S_0} = e^{Tx},$$

where,

S is the area of plane section of the horn normal to the axis at a distance x from the throat of the horn,

S_0 is the area of plane section of the horn normal to the axis at the throat, and

T is a constant which determines the rate of taper of the horn.

8110. Conical Horn. A conical horn is a horn whose equivalent sectional radius ($\sqrt{S/\pi}$) has a constant rate of increase.

8111. Diaphragm. A diaphragm is a vibrating sheet, in a telephone receiver or loud speaker, which initates sound vibrations.

8112. Magnetic Speaker. A magnetic speaker is a loud speaker in which the mechanical forces result from magnetic reactions. (See 8114, Moving-Armature Speaker.)

8113. Moving-Coil Speaker. A moving-coil speaker is a magnetic speaker in which the mechanical forces are developed by the interaction of currents in a conductor and the polarizing field in which it is located. (This is sometimes called an electrodynamic or a dynamic speaker.)

8114. Moving-Armature Speaker. A moving-armature speaker is a magnetic speaker whose operation involves the vibration of a portion of the ferromagnetic circuit. (This is sometimes called an electromagnetic or a magnetic speaker.)

8115. Induction Speaker. An induction speaker is a moving conductor speaker in which the current which reacts with the polarizing field is induced in the moving member.

8116. Condenser Speaker. A condenser speaker is a loud speaker in which the mechanical forces result from electrostatic reactions.

8117. Thermal Telephone Receiver. A thermal telephone receiver is a telephone receiver in which the temperature of a conductor is caused to vary in response to the current input, thereby producing sound waves as a result of the expansion and contraction of the adjacent air.

Microphones

8201. Microphone. A microphone is an electro-acoustic transducer actuated by power in an acoustic system and delivering power to an electrical system, the wave form in the electrical system corresponding to the wave form in the acoustic system. (This is also called a telephone transmitter.)

8202. Carbon Microphone. A carbon microphone is a microphone which depends for its operation upon the variation in resistance of carbon contacts.

8203. Condenser Microphone. A condenser microphone is a microphone which depends for its operation upon variations in capacitance.

8204. Magnetic Microphone. A magnetic microphone is a microphone whose electrical output results from the motion of a coil or conductor in a magnetic field.

8205. Push-Pull Microphone. A push-pull microphone is a microphone which makes use of two elements functioning 180 degrees out of phase.

Electromechanical Devices

8301. Phonograph Pick-up. A phonograph pick-up is an electromechanical transducer actuated by a phonograph record and delivering power to an electrical system, the wave form in the electrical system corresponding to the wave form in the phonograph record.

8302. Magnetic Pick-up. A magnetic pick-up is a phonograph pick-up whose electrical output is generated in a coil or conductor in a magnetic circuit or field.

8303. Carbon Contact Pick-up. A carbon contact pick-up is a phonograph pick-up which depends for its operation upon the variation in resistance of carbon contacts.

8304. Condenser Pick-up. A condenser pick-up is a phonograph pick-up whose electrical output is generated by a mechanical variation of its capacitance.

8305. Electrical Phonograph Recorder. An electrical phonograph recorder is an electromechanical transducer actuated by power in an electrical system and supplying power to a recording mechanical system, the recorded wave form produced by the mechanical system corresponding to the wave form in the electrical system.

Note—A number of additional definitions pertaining to electro-acoustic devices, of use in measurements and performance considerations, are given in "Performance Indexes of Electro-Acoustic Devices," page 177.

SECTION 9—CIRCUIT ELEMENTS, DEVICES, AND INSTRUMENTS

9001. Frequency Meter. A frequency meter is an instrument for measuring frequency. (Frequency meters used in radio work are sometimes called wavemeters.)

9002. Decremeter. A decremeter is an instrument for measuring the logarithmic decrement of a train of waves.

9003. Hot-Wire Ammeter, Expansion Type. A hot-wire ammeter, expansion type, is an ammeter dependent for its indications on a change in dimensions of an element which is heated by the current to be measured.

9004. Thermocouple Ammeter. A thermocouple ammeter is an ammeter dependent for its indications on a change in thermoelectromotive force in a thermocouple which is heated by the current to be measured.

9005. Vacuum Tube Voltmeter. A vacuum tube voltmeter is a device utilizing the characteristics of a vacuum tube for measuring alternating voltages.

9006. Thermoelement. A thermoelement is a device consisting of a combination of a thermocouple and a heating element for measuring small currents.

9007. Amplifier. An amplifier is a device for increasing the amplitude of electric current, voltage, or power, through the control by the input power of a larger amount of power supplied by a local source to the output circuit.

9008. Relay. A relay is a device by means of which contacts in one circuit are operated by a change in conditions in the same circuit or in one or more associated circuits.

9009. Automatic Regulator. An automatic regulator is a device for regulating a system in such a manner that changes in its functioning are initiated by changed conditions and carried out without the intervention of an attendant.

9010. Automatic Starter. An automatic starter is a device for starting a system in such a manner that its functioning is initiated by changed conditions and carried out without the intervention of an attendant.

9011. Automatic Volume Control. An automatic volume control is a self-acting device which maintains the output constant within relatively narrow limits while the input voltage varies over a wide range.

9012. Attenuation Equalizer. An attenuation equalizer is a device for altering the total transmission loss of a circuit for various frequencies in order to make substantially equal the total transmission loss for all frequencies within a certain range.

9013. Loading Coil. A loading coil is an inductor inserted in a circuit to increase its inductance but not to provide coupling with any other circuit.

9014. Choke Coil. A choke coil is an inductor inserted in a circuit to offer relatively large impedance to alternating current.

9015. Banked Winding. A banked winding is a compact multilayer form of coil winding, for the purpose of reducing distributed capacitance, in which single turns are wound successively in each of two or more layers, the entire winding proceeding from one end of the coil to the other, without return.

9016. By-Pass Condenser. A by-pass condenser is a condenser used to provide an alternating-current path of comparatively low impedance around some circuit element.

9017. Stopping Condenser. A stopping condenser is a condenser used to introduce a comparatively high impedance in some branch of a circuit for the purpose of limiting the flow of low-frequency alternating current or direct current without materially affecting the flow of high-frequency alternating current.

9018. Filter. A filter is a selective circuit network designed to pass currents within a continuous band or bands of frequencies, or direct current, and substantially reduce the amplitude of currents of undesired frequencies.

9019. Low-Pass Filter. A low-pass filter is a filter designed to pass currents of all frequencies below a critical or cut-off frequency and substantially reduce the amplitude of currents of all frequencies above this critical frequency.

9020. High-Pass Filter. A high-pass filter is a filter designed to pass currents of all frequencies above a critical or cut-off frequency and substantially reduce the amplitude of currents of all frequencies below this critical frequency.

9021. Band-Pass Filter. A band-pass filter is a filter designed to pass currents of frequencies within a continuous band, limited by an upper and a lower critical or cut-off frequency, and substantially reduce the amplitude of currents of all frequencies outside of that band.

9022. Ripple Filter. A ripple filter is a low-pass filter designed to reduce the ripple current, while freely passing the direct current, from a rectifier or generator.

9023. Rectifier. A rectifier is a device having an asymmetrical conduction characteristic which is used for the conversion of an alternating current into a pulsating current. Such devices include vacuum tube rectifiers, gaseous rectifiers, oxide rectifiers, electrolytic rectifiers, etc.

Note—In dealing with rectification in the reception of radio signals the term detector is preferred to rectifier.

9024. Half-Wave Rectifier. A half-wave rectifier is a rectifier which changes alternating current into pulsating current, utilizing only one-half of each cycle.

9025. Full-Wave Rectifier. A full-wave rectifier is a double element rectifier arranged so that current is allowed to pass in the same direction to the load circuit during each half cycle of the alternating-current supply, one element functioning during one-half cycle and the other during the next half cycle, and so on.

9026. Trickle Charger. A trickle charger is a device designed to charge a storage battery at a low rate continuously or during a major portion of the 24-hour day.

9027. Tuned Transformer. A tuned transformer is a transformer whose associated circuit elements are adjusted as a whole to be resonant at the frequency of the alternating current supplied to the primary, thereby causing the secondary voltage to build up to higher values than would otherwise be obtained.

9028. Radio-Frequency Transformer. A radio-frequency transformer is a transformer for use with radio-frequency currents.

9029. Audio-Frequency Transformer. An audio-frequency transformer is a transformer for use with audio-frequency currents.

9030. Rheostat. A rheostat is a resistor which is provided with means for readily adjusting its resistance.

9031. Voltage Divider. A voltage divider is a resistor provided with fixed or movable contacts and with two fixed terminal contacts; current is passed between the terminal contacts, and a desired voltage is obtained across a portion of the resistor. (The term potentiometer is often erroneously used for this device.)

9032. A Power Supply. An A power supply is a power supply device which provides power for heating the cathode of a vacuum tube.

9033. B Power Supply. A B power supply is a power supply device connected in the plate circuit of a vacuum tube.

9034. C Power Supply. A C power supply is a power supply device connected in the circuit between the cathode and grid of a vacuum tube so as to apply a grid bias.

9035. Protective Device. A protective device is a device for keeping current, voltage, or power of undesirably large magnitude out of a given part of an electric circuit.

9036. Frequency Changer. A frequency changer is a device delivering alternating current at a frequency which differs from the frequency of the supply.

9037. Frequency Multiplier. A frequency multiplier is a frequency changer used to multiply by an integer the frequency of an alternating current.

ABBREVIATIONS AND LETTER SYMBOLS

GENERAL ABBREVIATIONS

Ordinarily, all words, both technical and otherwise, should be spelled out. Certain circumstances arise, however, such as the headings of columns, the tabulation of data, and a very limited number of other occasions when abbreviations are required. In such unusual circumstances, the following list of abbreviations may be used.

Many of the abbreviations are given in lower case letters. Obviously, however, there will be occasions, such as when the abbreviations are used in titles of columns, where the original word would have been capitalized. In these cases, the abbreviations should be similarly capitalized.

A two-word adjective expression should contain a hyphen.

Term	Abbreviation
Alternating-current (adjective)	a-c
Alternating current (noun)	a.c.
Ampere	a
Antenna	ant.
Audio-frequency (adjective)	a-f
Audio frequency (noun)	a.f.
Continuous waves	cw
Cycle per second	~
Decibel	db
Direct-current (adjective)	d-c
Direct current (noun)	d.c.
Electric field intensity	$\mathcal{E}$
Electromotive force	e.m.f.
Frequency	f
Henry	h
High-frequency (adjective)	h-f
Intermediate-frequency (adjective)	i-f
Intermediate frequency (noun)	i.f.
Interrupted continuous waves	icw
Kilocycle (per second)	kc
Kilowatt	kw
Low-frequency (adjective)	l-f
Magnetic field intensity	H
Megohm	MΩ
Microfarad	μf

Microhenry	μh
Micromicrofarad	μμf
Microvolt	μv
Microvolt per meter	μv/m
Millivolt per meter	mv/m
Milliwatt	mw
Ohm	Ω
Power Factor	p.f.
Radio-frequency (adjective)	r-f
Radio frequency (noun)	r.f.
Revolutions per minute	r.p.m.
Root-mean-square	r-m-s
Volt	v
Watt	w

Abbreviations for Metric Prefixes

Prefix	Abbreviation
centi	c
deci	d
deka	dk
hecto	h
kilo	k
mega	M
micro	μ
milli	m

LETTER SYMBOLS FOR THERMIONIC TUBE NOTATION

Note—It is recognized that these symbols are still in the process of evolution. Suggestions for future revision are welcomed by the Institute

The system of notation given here was chosen with regard both to current practice and to convenience in printing and in typing. All special characters or signs are avoided. The only character not ordinarily found on a typewriter is the Greek letter μ, and in typing it is fairly satisfactory to use the letters mu or the letter u as an alternative.

1. Currents and Voltages. When current, voltage, and power vary with time, lower-case italics should be used for instantaneous values and capital italics for constant or representative values. The capital letters may be used to designate either maximum or effective (root-mean-square) values and if it is necessary to distinguish between the two, the subscripts m for maximum values, and e for effective (root-mean-square) values may be used.

2. Vector Quantities. In alternating-current circuit equations boldface italics may be used for complex or vector quantities. In typing, where it is desired to distinguish italics from Roman letters, underscoring may be employed to indicate italicized letters and wavy underscoring to indicate bold-face letters.

3. Frequency Designation. Whenever it is necessary to restrict the use of a quantity to a particular frequency, the quantity may be enclosed in parentheses and the frequency distinguished by a subscript outside the parentheses; e.g., $(Z_b)_{2p+q}$ as indicating external plate impedance at the angular velocity $2p+q$.

4. Explanatory Note on the Generalized System of Nomenclature for a Thermionic Tube of n-electrodes. The increasing technical importance of tubes of more than three electrodes made necessary the formulation of a system of nomenclature of sufficient generality as to be applicable to a tube of any number of electrodes. The need of such a systematic scheme is particularly felt in mathematical analyses where the number of differential parameters required to describe fully the first order operation of the device increases rapidly with the number of electrodes. (For a triode, four parameters are required; for a tetrode, nine; and so forth.)

The μ concept can be carried over and generalized for a tube of n-electrodes as suggested in the definition of mu-factor. It is suggested, however, that a convenient formulation can be achieved by selecting conductance parameters of the type $\partial i_j/\partial e_k$ as fundamental quantities. Two types of parameters occur in the consideration of the ordinary first-order effects: (1) the type $\partial i_j/\partial e_j$ called conductances, relating to current and voltage in the circuit of the same electrode, and (2) the

type $\partial i_j/\partial e_k$ called transconductances, relating to the current in electrode j and the voltage on electrode k. The term transconductance is intended to replace the term mutual conductance which was used in the past in reference to the triode. Transconductance is a more rational and descriptive term and overcomes the objection which was generally entertained for the term mutual conductance as being an improper use of a term which has a definite, and quite distinct, technical meaning. The small letter s is used to designate the conductance parameters instead of g which is the usual symbol for conductance. Among the reasons for this are the following: (1) it is easily written, (2) the letter s is not at present used to denote any electrical quantity, (3) it has a certain mnemonic value as suggesting slope, a word extensively used in England, (4) it is the English equivalent of the German symbol S, designating Steilheit (slope), (5) it has no tail, as in the case of g, to interfere with the writing of subscripts and with division lines in in writing fractions, (6) these parameters are strictly not conductances, but variational conductances.

The system of designating by subscripts the circuit branches, or electrodes, in which the currents or voltages appear, is uniform with that of conventional electrical circuit theory.[1] The transconductance in the vacuum tube differs from the transfer conductance in a passive electrical network in that it is unilateral, and $\partial i_j/\partial e_k$ does not in general equal $\partial i_k/\partial e_j$. The transconductance symbol $s_{jk}=\partial i_j/\partial e_k$ refers to the effect of the voltage of electrode k upon the current in electrode j. In the case of simple conductances where the subscripts are identical, one may be dropped, for example $s_{jj}\equiv s_j=\partial i_j/\partial e_j$. In the triode, and certain uses of the shielded tetrode, s_m, is used to denote the quantity which had been conventionally designated as g_m and called the mutual conductance. In accordance with the generalized scheme the full expression of this is control-grid plate transconductance and it is designated by s_{pg} (see definition 7044.) Where no confusion is likely to occur, as in the case of the triode and the ordinary use of the shielded tetrode, it is sufficient to use the term transconductance.

The convenience and simplicity attending the use in circuit theory of conductance parameters designated by s_{jk} in the case of a tube of n electrodes is of the order of that enjoyed by the components of the strain tensor e_{jk} in the elasticity theory.

It is believed that this scheme of notation is sufficiently general and flexible to be applicable in most circumstances and will serve as a rational framework for any extensions that may be demanded by the future development of the art.

[1] J. R. Carson, Electric Circuit Theory and Operational Calculus, p. 14, 1926, and V. Bush, Operational Circuit Analysis, pp. 33, 43, 44, 1929.

THERMIONIC TUBE LETTER SYMBOLS

Quantity	Symbol
Current in electrode j	I_j, i_j
Plate current	I_p, i_p
Grid current	I_g, i_g
Voltage on electrode j	E_j, e_j
Plate voltage	E_p, e_p
Grid voltage	E_g, e_g
Grid bias voltage	E_c
Plate supply voltage	E_b
Screen-grid supply voltage	E_d
Filament, or heater, terminal voltage	E_f
Filament, or heater, supply voltage	E_a
Filament, or heater, current	I_f
Total emission current	I_s
Conductance of electrode j	$s_j = \frac{\partial i_j}{\partial e_j}$
Resistance of electrode j	$r_j = 1/s_j = \frac{\partial e_j}{\partial i_j}$
Plate conductance	$s_p = \frac{\partial i_p}{\partial e_p}$
Plate resistance	$r_p = 1/s_p = \frac{\partial e_p}{\partial i_p}$
Grid conductance	$s_g = \frac{\partial i_g}{\partial e_g}$
Grid resistance	$r_g = 1/s_g = \frac{\partial e_g}{\partial i_g}$
Transconductance, electrodes j and k	$s_{jk} = \frac{\partial i_j}{\partial e_k}$

Quantity	Symbol
Grid-plate transconductance (mutual conductance)	$s_m \equiv s_{gp} = \frac{\partial i_p}{\partial e_g}$
Plate-grid transconductance (inverse mutual conductance)	$s_n \equiv s_{pg} = \frac{\partial i_g}{\partial e_p}$
Mu-factor, electrodes k and l i_j = constant	$\mu_{jkl} = -\frac{\partial e_k}{\partial e_l}$,
Amplification factor (triode) i_p = constant	$\mu = -\frac{\partial e_p}{\partial e_g}$,
Grid-plate capacitance	C_{gp}
Grid-cathode capacitance	C_{gf}
Plate-cathode capacitance	C_{pf}
Grid capacitance	C_g
Plate capacitance	C_p
Cathode capacitance	C_f
Conductance for rectification, electrode j	$s_j' = \frac{\partial i_j}{\partial e_j}$
Resistance for rectification, electrode j	$r_j' = \frac{1}{s_j'} = \frac{\partial e_j}{\partial i_j}$

LETTER SYMBOLS FOR PHOTOTUBES

Quality	Symbol
Current	I, i
Voltage at terminals	E, e
Monochromatic sensitivity	$S = 1/\Phi_\nu \dfrac{\partial i}{\partial_\nu}$
Total sensitivity (radiant flux)	$S = i/\Phi$
Total luminous sensitivity	$S_F = i/F$
Tungsten sensitivity	$S_T = i/F$
2870 Tungsten sensitivity	$S_{2870} = i/F$
Conductance (variational)	$s = \dfrac{\partial i}{\partial e}$
Resistance (variational)	$r = \dfrac{\partial e}{\partial i}$
Conductance per lumen	$S_F = 1/F \dfrac{\partial i}{\partial e}$
Photo-voltage coefficient	$\dfrac{\partial i}{\partial F} \Big/ \dfrac{\partial i}{\partial e}$
Radiant flux	Φ, ϕ
Luminous flux	F, f
Average radiant flux between ν and $\nu+\Delta\nu$	Φ_ν
Average luminous flux between ν and $\nu+\Phi\nu$	F_ν
Visibility	$K_\nu = F_\nu/\Phi_\nu$

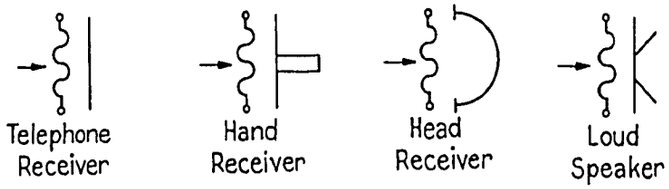
TENTATIVE SUGGESTED SYSTEM OF SYMBOLS FOR ELECTRO-ACOUSTIC DEVICES

The accompanying system of symbols for electro-acoustic devices is suggested for trial use in order to determine whether or not these symbols are suitable for adoption as standard.

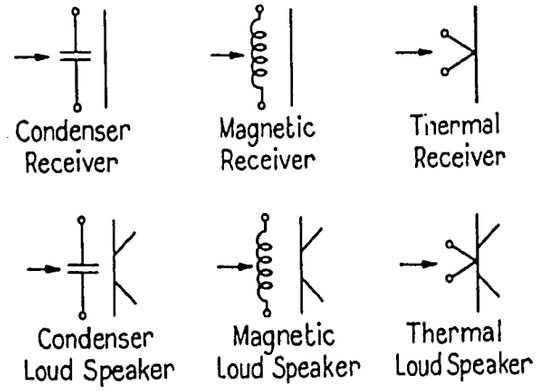
It should be observed that the complete symbol consists of a portion representing the electrical part of the system and another portion representing the acoustic or mechanical part of the system. An arrow associated with the electrical portion of the symbol is used to indicate whether the direction of energy flow is from the electrical to the acoustic portion of the system or the reverse. The ordinary symbol for resistance, inductance, or capacitance is used where appropriate, and a sine wave is used as a general symbol for impedance. The mechanical portion of the system is represented by a vertical line, modified in certain cases to indicate particular mechanical forms.

TELEPHONE RECEIVERS

General Symbols

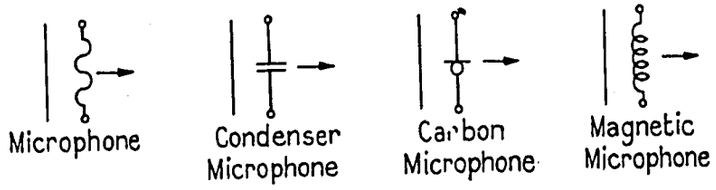


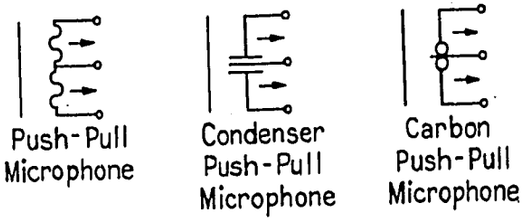
Specific Symbols



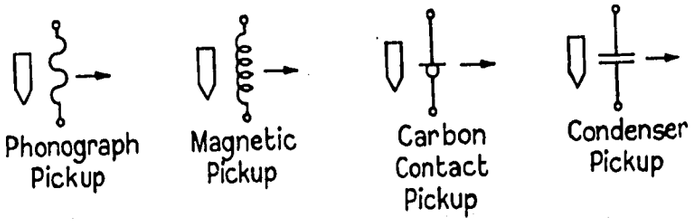
It is suggested that, when letter symbols are used to indicate electro-acoustic systems, the electrical terms be represented by capital letters Z, X, and R, and the mechanical terms be represented by small letters z, x, and r. It is suggested that blocked impedance, reactance, or resistance be represented by the appropriate letter with the subscript lower case d, that motional impedance, reactance, or resistance be indicated by the subscript lower case m, and that normal impedance, reactance, or resistance be represented by the appropriate letter with no subscript.

MICROPHONES





ELECTROMECHANICAL DEVICES



STANDARD GRAPHICAL SYMBOLS USED IN RADIO

Antenna

Ammeter

Arc

Battery
(positive electrode indicated by the long line)

Condenser, Fixed *

Condenser, Fixed, Shielded

Condenser, Variable

Condenser, Variable
(moving plate indicated)

Condenser, Variable, Shielded

Counterpoise

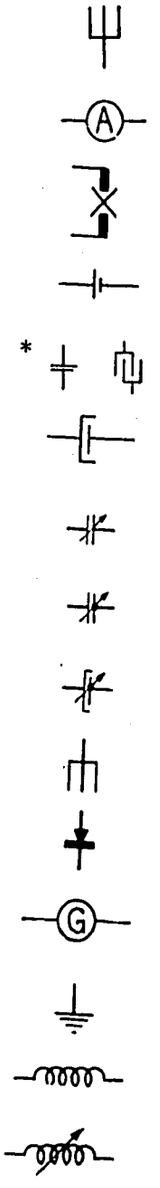
Crystal Detector

Galvanometer

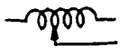
Ground

Inductor

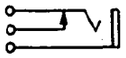
Inductor, Variable

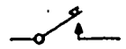


* Preferred symbol for radio purposes.

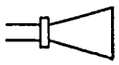
Inductor, Adjustable (by steps) 

Inductor, Iron Core 

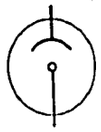
Jack 

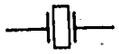
Key 

Loop Antenna 

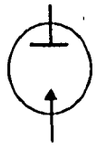
Loud Speaker 

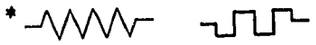
Microphone (Telephone Transmitter) 

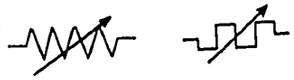
Phototube 

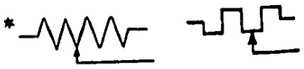
Piezo-Electric Plate 

Rectifier Tube, Full-Wave
(with cold cathode) 

Rectifier Tube, Half-Wave
(with cold cathode) 

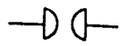
Resistor * 

Resistor, Variable * 

Resistor, Adjustable (by steps) * 

* Preferred symbol for radio purposes.

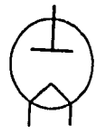
Spark Gap, Rotary 

Spark Gap, Plain 

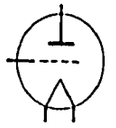
Spark Gap, Quenched 

Telephone Receiver 

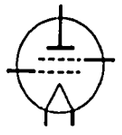
Thermionic Tubes

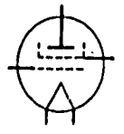
Diode (Half-Wave Rectifier)
(with directly heated cathode) 

Full-Wave Rectifier
(with directly heated cathode) 

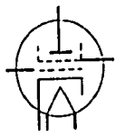
Triode
(with directly heated cathode) 

Triode
(with indirectly heated cathode) 

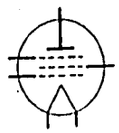
Tetrode
(with directly heated cathode) 

Screen-Grid Tube
(with directly heated cathode) 

Screen-Grid Tube
(with indirectly heated cathode)

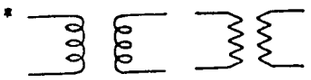


Pentode
(with directly heated cathode)

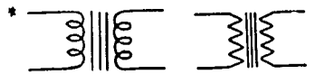


Thermoelement

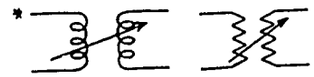
Transformer, Air Core *



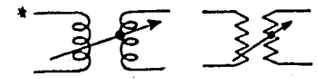
Transformer, Iron Core *



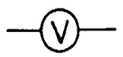
Transformer, Variable Coupling *



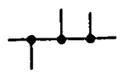
Transformer, Variable Coupling *
(moving coil indicated)



Voltmeter



Wires, Joined



Wires, Crossed, not Joined

* Preferred symbol for radio purposes.

METHODS OF MEASUREMENT AND TEST

TENTATIVE SUGGESTED METHODS OF TESTING AND RATING RADIO TRANSMITTERS AND ANTENNAS

Introduction

The purpose of this part of the report of the Committee on Standardization is to discuss, in a preliminary manner, the various factors which must be taken into consideration in specifying the performance of transmitters and antennas.

On account of its preliminary nature, the report has many obvious omissions and some of the subjects are treated inadequately. In view of the rapidly changing state of the art it does not seem desirable to suggest definite requirements at the present time. It is hoped, however, that this report will be useful in drawing attention to the major factors involved and that it may serve as a basis for the ultimate formulation of criteria of satisfactory transmitter and antenna performance.

I. Transmitters

A. Power Rating.

1. General Definition

The power rating of a radio transmitter is the power in watts available at the output terminals of the transmitter when the output terminals are connected to the normal load circuit or to a circuit equivalent thereto.

2. Rating of Continuous Wave Modulated Transmitters

The power rating of a modulated transmitter should apply to the unmodulated condition. An additional rating should be given specifying the maximum percentage modulation which may be obtained without exceeding the degree of distortion allowable for the type of service involved.

Note—The term percentage modulation is discussed in part E, section I, page 106.

3. Rating of Continuous Wave Telegraph Transmitters

A continuous wave telegraph transmitter should be rated by the power delivered with the key closed.

It does not follow that the transmitter need be able to withstand having the key closed for any great length of time. It is considered good engineering practice to design transmitters with a safety factor such that the transmitter will be capable of withstanding the key closed condition for a period long enough to permit tuning to be accomplished.

In telegraph service the key may be considered closed one-half of

the time, in so far as loading, from the standpoint of temperature rise of component parts, is concerned.

4. Methods of Power Measurement

There are several methods of measuring the radio-frequency power delivered by a transmitter. The following are typical methods of measurement:

a. Current-Resistance Method.

In this method the current through a known resistance is measured, a thermoammeter and noninductive resistor being the measuring instruments generally employed. This method lends itself well to the measurement of small amounts of power.

b. Photometric Method.

In this method a lamp filament heated to incandescence provides the resistive load. The direct-current or alternating-current power required to heat a similar lamp to the same brightness, is a measure of the radio-frequency power dissipated in the load. This method is useful for the measurement of power up to a few kilowatts.

c. Calorimeter Method.

In this method of measurement a noninductive resistor carrying the radio-frequency power is cooled by water or other liquid surrounding and passing over it. The power dissipated is then calculated from the temperature rise, rate of flow measured in mass per unit time, and specific heat of the cooling fluid. This method is most advantageous for powers above two kilowatts.

d. Anode Dissipation Method.

In this method, which is applicable only in the case of transmitters using water-cooled tubes, the total power delivered to the filament and plate circuits is measured. The power dissipated by the cooling fluid is also observed and the difference between this and the total power delivered to the filament and plate circuits gives the sum of the radio-frequency power delivered by the transmitter into its load circuit, and the loss in the output or coupling circuits. The latter is usually relatively small and can be estimated by repeating the observations with the load disconnected. This method is particularly applicable to the measurement of higher powers at high frequencies where suitable resistance loads are not readily available. It has the advantage that measurements may be made while the transmitter is in service.

B. Spurious Radiations.

1. Classification

Any radiation, the frequency of which is outside the communication band of the transmitter, is considered spurious. The term will, therefore, include the following:

a. Any component whose frequency is an integral multiple or submultiple of the carrier frequency (harmonics and subharmonics).
b. Spurious modulation products.
c. Key clicks and other transient effects.
d. Parasitic oscillations which bear no definite relation to the operating frequency and which sometimes occur in poorly designed or improperly adjusted transmitters.

2. Conditions for Measurement

Since many radio transmitters are designed for operation with particular antenna arrays and frequently for particular locations, measurements of spurious radiation are preferably made with the transmitter installed in its permanent location and working under normal conditions of power, modulation, etc.

3. Harmonics and Subharmonics

Measurements of harmonics and subharmonics can best be made with a suitable field intensity measuring device which permits the desired frequency spectrum to be covered. The Committee on Broadcasting of the Institute of Radio Engineers has already recommended[1] that such measurements be made at a specified distance, say one mile from the transmitter, and that the harmonics be expressed in terms of harmonic field intensities and of percentages representing the ratio of the intensity of each harmonic to that of the fundamental at the same distance. This method is applicable down to the lowest radio frequencies but as discussed below its use at high frequencies may be misleading from the standpoint of interference.

In the case of high power transmitters the absolute values of the field intensities of the harmonics are more significant than the relative values. Owing to the irregularity of field intensity patterns such measurements should be made at several points about the station, all at the same distance and with approximately equal angular separation. The number of points taken should be large enough to make a suitable plot of any directional pattern which may exist in the harmonic radiation. The maximum value of the harmonic percentage and the maximum absolute value at a specified distance, as obtained by field intensity measurements, may be considered as indexes of the harmonic radiation. The relative value does not have significance in the case of transmitters with directional antennas.

Attention is called to the fact that when the harmonic frequency

[1] Reports of I. R. E. Committee on Broadcasting, Proc. I.R.E., 18, 15; January, 1930.

is sufficiently high (for example 10,000 kc) measurements made on harmonics at the surface of the earth a short distance from the transmitter are not necessarily significant from the standpoint of the interfering effect. These high frequencies are strongly absorbed in transmission along the surface but in directions elevated above the horizontal plane the field may be greater with resultant interference at greater distances. This effect may be accentuated by accidental directional effects which may become marked when the wavelength of the harmonic is small compared with the dimensions of the antenna. The whole question of the measurement of harmonics from systems employing directional antennas, especially at high frequencies, is very complicated. It would be exceedingly difficult to lay down any specific procedure for the determination of harmonics in such systems and at the present time any interference due to this cause can only be resolved by considering the special case involved.

In some special cases, such as that of airplane transmitters, it is not feasible to make tests under operating conditions. In such cases it may be helpful to make a frequency analysis of the harmonic output into an artificial antenna or to take observations of the harmonics around a model antenna, making such corrections as may seem desirable in view of the shortcomings of the model.

In the case of a transmitter designed to cover a range of frequencies, data should be taken for several points in the operating range.

4. Key Clicks

The term key clicks is understood to mean those components of telegraphic radiation which are set up as transients by the opening or closing of the signaling key and which are not essential for communication. They may be produced by an unnecessarily abrupt rise or fall of the current amplitude with keying, or by a transient shift of phase or frequency. Due to the transient nature of key clicks, their total power averaged over a long period may be small although their interfering effect may be considerable due to high instantaneous amplitudes. For the purpose of obtaining quantitative results in cases where work is being done to eliminate this source of interference, relative values of the interfering signal may be determined by making a comparison of the loudness of the key clicks with the intensity of a source of interference whose field intensity is adjustable and can be measured. This interference may be supplied by a local modulated oscillator.

Further work on standard methods of measuring interference due to key clicks is desirable. One of the main points to emphasize at this time is that the interfering effect of key clicks is much greater than would be expected from the total power in them.

5. Higher Order Modulation Products

Modulation in transmitter amplifiers produces not only harmonics of the frequencies being amplified but also other frequency components which may fall either within or outside of the communication band and thus may cause interfering effects. These products are due to the presence in the amplifier characteristic of terms of higher order than the second and are, therefore, called higher order modulation products. The higher order products falling within the communication band are discussed under Distortion, part **F**, section **I**, page 109.

The higher order modulation products of a telephone transmitter may be measured in the same manner as key clicks, particularly when speech is being transmitted. In this case the procedure may be similar to that described in the preceding section, except that steady speech modulation is substituted for keying. For more accurate determination two equal tones whose total amplitude is equivalent to that of the speech may be applied simultaneously to the transmitter. The higher order products which result in this case are steady oscillations whose intensities may be measured.

6. Parasitic Oscillations

Parasitic oscillations are due to faulty design or to improper operation. They should not be present in any commercial operating system. There appears to be no object in including a statement of their magnitude in a transmitter rating.

C. Frequency Tolerance.

1. Definition

As applied to a radio transmitter, the term frequency tolerance is defined as the extent to which the frequency of the station may be permitted to vary on either side of the frequency assignment.

2. General

It should be recognized that the frequency generating system of some radio transmitters is of such design as to permit frequency maintenance to within close limits over a long period of time without adjustment, while in other transmitters the frequency is compared at intervals against a standard frequency and adjustments made if necessary. In checking station frequencies care should be taken that the measurements cover a length of time sufficient to include a large number of cycles of any recurrent deviation in order that the over-all performance of the transmitter as regards frequency variation may be determined. In specifying the frequency deviation of any particular transmitter information should be given which leaves no ambiguity

as to its performance at any time during operation. It is also desirable to specify the means used for maintaining the frequency constant.

The measurement of frequency resolves itself into a procedure by which oscillations are counted for an accurately determined time interval. It should be borne in mind that present practice, except in special types of service, demands a high degree of precision in maintaining the transmitter frequency. In cases where the transmitter is maintained at constant frequency by reference to a frequency meter it is advisable, therefore, that the meter should be referred at intervals, either directly or indirectly, to the mean solar second.

3. Frequency Meters

There are two general classes of frequency meters, namely, the absorption type and the heterodyne type. There is still a further classification as to range, certain meters being designed to indicate only one frequency while others cover bands of varying width.

a. Absorption Frequency Meters.

The absorption type of frequency meter consists of a resonant system which picks up a small amount of power from the transmitter whose frequency it is desired to measure. Some form of voltage or current indicator is included to show when the emitted frequency coincides with the free period of the resonant system. In this class are the LC frequency meter and the crystal glow tube. LC frequency meters are of two classes, one of which has a wide frequency range and the other a narrow frequency range. The wide range instrument is only employed in general for rapid and approximate measurements of frequency. Its accuracy is limited to about one-half of one per cent.

Limited range absorption meters, carefully constructed and calibrated, with frequent checking of the calibration against a standard, and with means for correcting for temperature changes, may be relied upon to about one-tenth of one per cent if special means are taken to determine the resonance point. Special instruments for monitoring over a very narrow range (about three-tenths of one per cent of the frequency to be measured) may be relied upon to about three-hundredths of one per cent if they are carefully constructed, calibrated, and mounted, and are corrected for temperature changes.

In the crystal glow tube a small specially cut quartz plate is mounted between two electrodes in an atmosphere of rarified neon. The electrodes are connected to a coil which is used to pick up the power whose frequency is to be determined. When the frequency of mechanical vibration of the quartz is equal to that of the electrical system under test the gas is observed to glow. This type of apparatus is not used to any considerable extent in this country but it appears to

be reliable to a few parts in 100,000. A separate unit is required for each frequency to be measured.

b. Heterodyne Frequency Meters.

The recent rapid advances in the radio art have called for more precise knowledge of transmitter frequencies than had heretofore been considered necessary. Heterodyne frequency meters are generally used for the precise determination of these frequencies. These meters generally depend for their accuracy on a stable oscillation generator of accurately known frequency. Comparison between the frequency to be determined and an accurately known frequency is effected by the method of beats. Various methods are used for making this comparison.

In some portable meters a variable frequency oscillator, calibrated at frequent intervals over its range by beating it against the harmonics of a master oscillator, is adjusted to zero beat with the unknown. The unknown frequency is then determined from the calibration curve of the portable frequency meter. This method is not capable of great accuracy and can only be depended on to about one part in ten thousand.

In more precise instruments the frequency to be measured is made to beat with a frequency which is built up from the harmonics and subharmonics of the master frequency by successive stages of modulation. In another method the unknown frequency is stepped down by successive beating with the harmonics and subharmonics of the master frequency until an audible note is obtained whose frequency can be determined from a calibrated audio-frequency oscillator.

The accuracy of these methods is dependent on the accuracy of the master oscillator. With well designed and stable oscillators which have means incorporated for checking against time, accuracies of the order of a few parts in a million are readily obtainable. Many other variations of these methods may be employed of course. The exact arrangement to be used will depend on the desired accuracy and on the special nature of the problem.

D. Operational Stability.

1. Stability as Related to Abnormal Operation

Spurious oscillations may be set up in a transmitter by improper setting of neutralizing condensers, improper location of adjustable coils, improper coupling to load, etc. Maladjustments of a lesser degree may cause abnormal operation without necessarily affecting the frequency. For example, a change in antenna impedance, due to weather

conditions, may cause an unusually large or small amount of power to be delivered to the antenna. It may so change the impedance relations within the transmitter as to cause bad distortion. Similar results may come about from other causes, such as fluctuation of supply voltages, changes in resistance due to high temperature coefficients, carelessness in operation of the equipment, etc.

2. Determination of Degree of Operational Stability

The stability of a transmitter means, in a general way, its tolerance toward such maladjustments as are described above. In view of the present rate of development of the art, operational stability is incapable of definition or measurement in quantitative terms. A standard method of describing stability, however, would be of considerable use, both in comparing individual transmitters or types of transmitters, and in recording the progress of the art. Tentatively, the stability of a cw telegraph transmitter may be described in terms of the amount of maladjustment of particular elements required to produce certain changes in the power output. The stability of a telephone transmitter may be described in terms of the amount of maladjustment required to produce a certain amount of distortion in the side bands. In making tests for comparative purposes very simple criteria may be used, even though the maladjustments they entail would not actually be tolerated in commercial operation. For example, the variation in neutralizing capacity required to produce oscillations in an amplifier, the variation in a damping resistance required to produce spurious oscillations, or the variations in load impedance required to change the power output by a factor of two, may provide useful information to the engineering personnel in charge of a transmitter, although optimum adjustments would be maintained during the normal operation of the transmitter.

In cases where facilities are available for more detailed tests, more stringent criteria may be used, for example, the amount of maladjustment required to increase the ratio of higher order side frequency amplitude to fundamental side frequency amplitude by a given amount.

E. Modulation.

1. Percentage Modulation

Percentage modulation is defined as the ratio of half the difference between the maximum and minimum amplitudes of a modulated wave to the average amplitude, expressed in per cent.

Percentage modulation is generally determined by measuring the instantaneous value of peak voltages either of the radio-frequency oscillations or of the rectified signal wave. Measurements made in this way may be vitiated by the presence of harmonics, especially under

conditions of overloading. If the peak voltages are measured by means of oscillograph records these disturbing factors are of course apparent. The use of an oscillograph is difficult outside of a laboratory and it is therefore convenient to define a quantity which may be called the effective percentage modulation which, in the absence of distortion, is equivalent to percentage modulation but which is more convenient to measure.

2. Effective Percentage Modulation

Effective percentage modulation, as applied to the modulation of a single carrier by a single sinusoidal signal wave, is the ratio of the amplitude of the fundamental component of the envelope to the amplitude of the carrier expressed in per cent. For the case of modulation by a simple sinusoidal wave, in the absence of distortion, it is evident that percentage modulation and effective percentage modulation as defined above are identical. Effective percentage modulation, as applied to the modulation of a single carrier by two or more sinusoidal signal waves, is the sum of the effective percentages associated with the individual signal waves, each measured in the presence of the others.

3. Effective Percentage Modulation as Applied to Speech

The definition of effective percentage modulation as applied to speech necessarily involves some arbitrary qualifications. It is neither easy nor significant to apply the first stated definition to any particular syllable of extended speech. Speech intensity may be measured by means of volume indicators, a number of which are commercially available. These volume indicators give a measure of the average speech energy in arbitrary units and are capable of reproduction. Very good correlation with regard to distortion is obtained between the behavior of speech and of two tones of equal intensity which give the same reading on the volume indicator as the speech. Effective percentage modulation as applied to speech, therefore, may be taken as equivalent to that for two tones of equal intensity. The volume indicators measure the speech power, while percentage modulation is concerned with peak amplitudes. Two tones, the sum of whose amplitudes is double that of either, have together only twice the power of either. To obtain this double amplitude by a single tone involves multiplying the power by four. This gives a power ratio of two. Hence, the effective percentage modulation for speech may, without change of meaning, be defined as being the same as that for a single tone whose power reading on the volume indicator is double that of the speech.

4. Method of Measurement

Rectifiers suitable for making measurements of percentage modulation and effective percentage modulation are shown in Figs. 1 and 2. Both are essentially vacuum tube peak voltmeters which reproduce the carrier envelope.

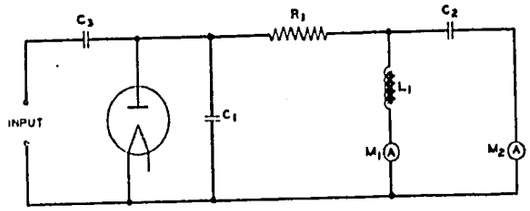


Fig. 1

The source of voltage to be measured is connected as in Fig. 1 if the rectifier presents high impedance at speech frequencies, or as in Fig. 2 if it presents low impedance at speech frequencies. The im-

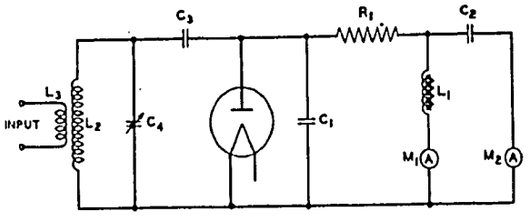


Fig. 2

pedance of R_1 is high compared to the internal impedance of the tube when it is conducting. Compared to that of C_1 the impedance of R_1 is also high at the carrier frequency and low at speech frequencies. The current through R_1 is, therefore, proportional to the amplitude of the radio-frequency voltage and follows variations in it at an audible rate. Since the instrument operates on peak voltages it reproduces the envelope of the radio-frequency wave and provides a detector of very satisfactory fidelity. Measurements of percentage modulation may be obtained by recording the instantaneous values of the current in R_1 by means of an oscillograph.

Effective percentage modulation may be measured with simpler instruments. By means of the arrangement shown in Figs. 1 and 2, the direct-current and alternating-current components may be separated and measured by means of the ammeters M_1 and M_2. M_2 may be any of the usual forms of alternating-current measuring instruments for high frequencies such as a thermocouple or a low impedance vacuum tube voltmeter. The net impedance of the circuit to the right of R

should be either independent of frequency or small compared to R_1.

For modulation by a single tone the effective percentage modulation is $100\sqrt{2}\, I_2/I_1$, where I_1 is the direct current and I_2 the r-m-s. value of the alternating current. For n equal tones the effective percentage modulation is $100\sqrt{2n}\, I_2/I_1$. The effective percentage modulation for speech is best determined by substituting a steady tone equivalent to the speech as discussed above and making measurements as outlined above on this tone.

5. Carrier Noise

Commutator ripple, alternating-current hum, and other carrier noise should be expressed in terms of percentage modulation.

F. Distortion.

1. Classification

Distortion as applied to modulation in a radio transmitter involves at least three important types:

a. Distortion due to frequency discrimination, or differences in the relative magnitudes of the components of a wave at different frequencies.

b. Distortion due to a nonlinear amplitude characteristic.

c. Distortion due to phase or frequency modulation, in which the carrier frequency, while maintaining a constant average value, varies within the speech frequency cycle.

2. Nonuniform Transmission at Various Audio Frequencies

This type of distortion is determined by comparing the percentage modulation at various audio frequencies for constant input. It is desirable that the input be about the same amplitude as in normal operation. The term fidelity is often used in this connection.

3. Distortion Due to Nonlinear Amplitude Characteristic

Nonlinear distortion may be studied through the analysis of an oscillographic record. Simpler and more rapid ways involve the use of audio-frequency filters. In this method the modulating tone is passed through a filter to suppress harmonics and is then applied to the transmitter. Some of the transmitted output power is picked up and passed through a detector, the output of which is effectively a measure of the fundamental except in cases of unreasonable distortion. The output of the detector is then passed through a high-pass filter which suppresses the fundamental, and the measurement of resultant output gives the root-sum-square of the various harmonic components.

For more detailed work several band pass filters may be used and the harmonics measured individually. In another method, two equal tones of frequencies p and q are impressed on the amplifier, and the distortion products $2p-q$ and $2q-p$, or their root-sum-square values, are measured in the output of a detector. The input filter for suppression of harmonics is not important here, but two filters or a bridge circuit must be used to prevent intermodulation within the input equipments.

4. Distortion Due to Phase or Frequency Modulation

Frequency or phase modulation may be a troublesome source of distortion in radio transmission when the signal simultaneously passes to the receiver over two paths of different lengths. It is well known that under such circumstances stability of the carrier frequency is very important. It is not necessary to discuss the distinction between phase modulation and frequency modulation. Obviously these terms refer respectively to variations during the audio cycle of phase and frequency, i.e., these quantities, as well as the amplitude, may be modulated. In this discussion these variations will be of concern only as a source of distortion. The simplest method of measuring phase modulation is by means of the oscillograph. The radio frequency is modulated by a low audio frequency (say one hundred cycles) and it is then heterodyned down to an audible frequency which is ten or more times the modulating frequency (say one thousand cycles). Precautions must be taken to have the frequency of the beating or heterodyne oscillator constant. This audible frequency is impressed on one element of an oscillograph, and a timing wave is applied to a second element. An oscillogram is taken and the distances along the time axis where the trace crosses the zero input line in the positive direction are measured with a microcomparator. For the frequencies assumed, a two-hundred cycle high-pass filter is needed to keep the rectified one hundred cycle current out of the oscillograph. The phase shift of the beat note during the audio cycle is the same in angular measure as that in the high-frequency wave. By comparing the actual intersections with those which would have occurred in the absence of phase modulation the maximum deviation, k, of the phase may be obtained in radians. If the deviation in phase is also simple harmonic the frequency modulation is then ka, where a is the audio modulating frequency, in this case one hundred. Various refinements of the method are of course possible.

II. Antennas

In dealing with methods of testing and rating antennas it is convenient to recognize two major classifications, viz., those antennas whose dimensions are less than a half wavelength and those whose dimensions are of the order of a half wavelength or more. It is recognized that this division is somewhat arbitrary, and that there is no obvious line of demarcation. The first class includes most antennas used at low and intermediate frequencies. In the second class fall most high-frequency antennas.

A. Antennas whose Dimensions are Small Compared to the Wavelength (Low-Frequency Antennas).

1. Classification

This class includes most of the conventional types of low-frequency antennas, such as the inverted L type, the T type, the umbrella type and the multiple tuned antenna. The aerial conductors may consist of one or several wires or wire cages.

2. Natural Frequency

The natural frequency is defined as the lowest resonant frequency of an antenna without added inductance or capacitance. It is usually measured by means of a loosely coupled oscillator and an absorption type frequency meter.

3. Static Capacity

The static capacity of the antenna is that which is measured with direct current or low frequencies. In making the measurement it is often important to eliminate or correct for the effect of leakage currents.

4. Effective Capacity and Inductance

The effective (or equivalent) capacity and inductance at a given frequency are the lumped values of capacity and inductance which, when connected in series, give the same series reactances for frequencies near the given frequency, as does the antenna itself. The effective capacity and inductance may be calculated from two readings of the observed resonant frequency with inductances L_1 and L_2 successively inserted in series with the antenna, by the use of the following formulas:

$$C_a = \frac{\frac{1}{\omega_1^2} - \frac{1}{\omega_2^2}}{L_1 - L_2}, \tag{1}$$

and,

$$L_a = \frac{L_1\omega_2^2 - L_2\omega_1^2}{\omega_2^2 - \omega_1^2}, \tag{2}$$

where,

ω_1 is $2\pi \times$ frequency (in cycles per second) at which the inductance in henries of L_1 is measured, and

ω_2 is $2\pi \times$ frequency (in cycles per second) at which the inductance in henries of L_2 is measured.

The values of C_a and L_a are in farads and henries, respectively.

5. Antenna Resistance

The resistance of an antenna may be determined in various well known ways, including the resistance and reactance variation methods, the substitution method, and the method using a radio-frequency bridge. The first is perhaps the simplest and most generally applicable method. Two readings of antenna current are taken, one with and the other without a known resistance, R_k, in series with the antenna. The antenna resistance in ohms is obtained from the formula,

$$R_a = \left(\frac{I_k}{I - I_k}\right) R_k, \tag{3}$$

where,

I is the antenna current with R_k short-circuited, and

I_k is the antenna current with R_k in the circuit.

In making this measurement it is necessary to couple the oscillator loosely to the antenna and to maintain the current in the oscillator circuit constant. The various other precautions customarily observed in the resistance variation method are also necessary in antenna measurements.

When the added resistance is inserted in the feed lead of a multiple tuned antenna the result gives the feed resistance. The multiple resistance is found as follows,

$$R_m = R_a \left(\frac{I}{I_m}\right)^2, \tag{4}$$

where,

R_a is the feed resistance,

I is the feed current, and

I_m is the sum of the currents in the radiating down leads.

(The expression I_m/I is called the feed ratio.)

6. Radiation Resistance

The radiation resistance of an antenna in which radiation from horizontal portions is negligible may be found from the formula,

$$R_r = 1579 \left(\frac{h}{\lambda}\right)^2, \tag{5}$$

where,

λ is the wavelength in meters, and

h is the effective height in meters.

7. Power Input

The power input is readily calculated as follows:

$$P_i = I^2 R_a, \tag{6}$$

where,

R_a is the antenna resistance as determined from (3), and

I is the current measured at the point where R_a was determined

In the case of the multiple tuned antenna,

$$P_i = I_m^2 R_m, \tag{7}$$

where,

I_m and R_m are as defined in (4).

8. Power Output

The power output or radiated power of the antenna system may be calculated from the radiation resistance and the antenna current by the usual formula,

$$P_r = I^2 R_r, \tag{8}$$

where,

R_r is the radiation resistance as found in (5).

In the case of the multiple tuned type,

$$P_r = I_m^2 R_r, \tag{9}$$

where,

I_m is as defined in (4).

9. Radiation Efficiency

The radiation efficiency of an antenna, η_r, is defined and calculated by the formula,

$$\eta_r = \frac{P_r}{P_i}, \tag{10}$$

where,

P_r is the power output, and

P_i is the power input to the antenna.

10. Effective Height of an Antenna

The effective height, h, is defined and experimentally determined by means of the formula indicating field intensity at a distance from a grounded antenna which is as follows:

$$\mathcal{E} = \frac{1.25Ifh}{d} \qquad (11)$$

from which,

$$h = \frac{\mathcal{E}d}{1.25If} \qquad (12)$$

where,

h is the effective height of the antenna in meters,
$\mathcal{E}$ is the field intensity in microvolts per meter,
f is the frequency in kilocycles,
d is the distance in kilometers from the antenna at which $\mathcal{E}$ is measured, and
I is the antenna current.

It is assumed here that d is sufficiently small for absorption attenuation to be negligible. If this condition is not satisfied it is necessary to introduce into the formula whatever absorption factor is most fitting for the particular frequency and terrain being considered. Often the most satisfactory procedure is to take field intensity readings at two or more distances and solve for the effective height, or the meter-amperes (hI), and the absorption coefficient simultaneously.

B. Antennas whose Dimensions are of the Order of a Half Wavelength (High-Frequency Antennas).

1. General

The present discussion is confined to tests such as may be useful in examining the performance of a high-frequency directional antenna. While this subject is hardly ready for standardization, agreement regarding tests which have thus far proved useful may be helpful in approaching a standard test procedure.

The transmission line (if any) connecting the transmitting set with the radiating structure is usually regarded as part of the antenna. The tests to be described may be made with or without the line.

2. Definitions

a. Standard Vertical Comparison Antenna.

In the high-frequency range, a standard vertical comparison antenna is a vertical conductor half a wavelength long, the lower end of which is substantially at the surface of the earth, the antenna being excited in such a manner as to have a standing wave with a current loop at the middle and nodes at the ends.

b. Antenna Array.

An antenna array is a system of elemental antennas usually similar, excited by the same source, for the purpose of obtaining directional effects.

c. Broadside Array.

A broadside array is an array whose elements are arranged along a horizontal line, the currents in all the elements being in the same phase. Such an array has its maximum radiation in a direction perpendicular to the line of the array.

d. Tier.

An array is said to be arranged in tiers if it is made up of rows of elements placed one above another.

e. Reflector or Pseudo-Reflector.

A reflector or pseudo-reflector is part of an antenna array not metallically connected to the source of power, deriving its current parasitically from the other parts of the array, and so designed as to increase the signal in one direction at the expense of that in the opposite direction.

f. Exciter.

In a directional system as defined in (e), an exciter is the section of the array connected directly to the source of power.

g. Gain of an Array.

The ratio of the power supplied to the standard antenna to the power supplied to the directional antenna array when the signals in a specified direction are equal is called the gain of the array in that direction.

h. Plane of Polarization of a Wave.

The plane perpendicular to the wave front and parallel to the electric vector of the wave is the plane of polarization of a wave.

Note—This is different from the convention used in optics, but for radio work it seems more logical and is already in general use among engineers.

4. Testing Facilities

Some of the more special facilities for testing are the following:

a. Source of High-Frequency Power.

The source of high-frequency power may be a simple electric oscillator provided with adjustments sufficiently flexible to permit efficient coupling to loads having a wide range of impedance.

b. Field Intensity Comparison Equipment.

For making comparisons of field intensity a receiver capable of making a quantitative comparison of two signals is needed. A superheterodyne (double detection) receiver having a calibrated attenuator in the intermediate-frequency circuit is satisfactory. It is sometimes desirable to provide a field intensity measuring set capable of making absolute measurements in microvolts per meter, although this is usually not essential.

c. Comparison Antenna.

Several agencies have tentatively adopted the standard vertical comparison antenna defined above. This is very convenient, especially when the structure being tested also radiates vertically polarized waves. The standard antenna, when compared at the remote point with the antenna under test, gives the gain of the latter. It is frequently advantageous to use a simple array as the comparison antenna. In this case its gain must be known in terms of the standard.

5. Impedance Test

Only the important special case of impedance measurement in which the antenna input has previously been tuned, making the input impedance resistive will be considered. This condition is obtained when the antenna input leads form a smooth line, the terminals being chosen at a current node or antinode. The input resistance, R_a, can then be obtained by the use of a second section of smooth line whose length is a quarter wavelength and whose characteristic impedance, Z_0, is any convenient value. The second section of smooth line is connected between the antenna input leads and the source of power. A device for measuring current or voltage is used at each end of the auxiliary line. If the currents or voltages so read are designated I or E, and subscripts s and r are used to denote, respectively, the ends of the line nearer to and more remote from the transmitter, the antenna impedance is given by the expressions,

$$Z_r = \frac{Z_0 I_s}{I_r} = \frac{Z_0 E_r}{E_s}. \tag{13}$$

6. Radiation Tests

a. General.

In measuring the effective radiation of an antenna array, the ideal method of test would involve an absolute determination of the radiation in any specified direction. Usually, however, the relative radiation in a specific direction is the important factor under consideration and

recourse is had to comparison of the radiated field in this direction with that from a standard antenna.

For remote point tests, not involving the ground wave, the comparison with a standard vertical antenna gives significant results even when the short-wave structure under test emits horizontally polarized radiation. Usually, if not always, the polarization of a wave as it arrives from the ionized upper atmosphere is no indication of its polarization at the beginning of its journey. Remote point transmission tests are generally of more significance than are tests made locally.

For local tests the half-wave antenna is also useful, in particular when the structure under observation is a broadside array of elements similar to the standard and having a similar directional pattern in the vertical plane through the direction of transmission. When the components of the array differ from the standard, caution is needed in interpreting results. It is obviously impossible to employ the vertical standard in local tests in connection with antennas which radiate waves of horizontal polarization.

b. Frequency Characteristics.

The purpose of the frequency characteristic test is to determine that the antenna is properly adjusted to the operating frequency. The test involves a variation of the frequency over a narrow band around the operating value. Proper adjustment is indicated by maximum front-to-rear ratio, defined below, and maximum gain over the comparison antenna.

As the operating frequency is varied it is desirable to keep the power input constant, for which purpose observations may be made of current or voltage associated with a section of the transmission line through which the power is supplied. These current (or voltage) measurements should be made at nodes and loops of a line with negligible loss in which case the power transmitted is given by,

$$P = Z_0 I_s I_r = \frac{E_s E_r}{Z_0} \tag{14}$$

where,

Z_0 is the characteristic impedance of the line,

I is the current in the line, and

E is the voltage across the line.

The subscripts s and r in this case refer to measurements made at nodes and loops, respectively.

For many purposes a sufficiently good indication of relative power is provided by the direct-current power supplied to the vacuum tubes in the last stage, assuming a careful tuning and efficiency adjustment

to have been made. If, for different frequencies, the plate and grid couplings in the tube circuit have been adjusted to values such that the direct grid and plate voltages and currents are independent of frequency it may be assumed that the output is also substantially constant over the same range.

It is desirable to make field intensity observations at equal distances in front of the antenna and at the rear. In the case of an antenna designed to be unidirectional the measurements made at the rear are particularly useful, since they provide a sensitive indication of the degree to which back radiation has been reduced. If the antenna is equipped with a reflector these measurements, together with relative current measurements in exciter and reflector, indicate whether or not the position and tuning of the reflector are correct.

This test can be improved by the use of a comparison antenna, which is furnished power equal to that supplied to the antenna under test. In this way the gain in front and at the rear may be measured as a function of frequency. If the attenuator in the field intensity measuring equipment is adjusted to give the same detector current for the antenna under test as for the comparison antenna, the antenna gain can be calculated from the difference in readings. The ratio of the gain in front to that in the rear is often referred to as the front-to-rear ratio.

c. Horizontal Plane Directional Pattern.

In the case of small antennas the surrounding land may permit of directional diagrams being measured nearby, in which case a comparison antenna is not needed. In the case of large installations the surface of the earth near the station may be irregular, not only because of the topography, but also because of artificial structures. Under such circumstances directional diagrams can best be obtained by two measurements in each direction, one of the field from the antenna under test and the other from the standard comparison antenna, which is nondirectional in the horizontal plane.

The angular location of the maxima and minima and the depth of the minima are usually good criteria of the correctness of the phase and amplitude relations of the currents in different sections of the antenna system.

d. Vertical Plane Directional Pattern.

This important test is difficult to make and for that reason it is often neglected. When made some form of aircraft is generally used to obtain requisite vertical angles of comparison.

e. Gain Measured at a Distance.

The gain measured at great distances is the most important to be made on an antenna because it enables information to be obtained concerning its performance under actual operating conditions. This test is more difficult to carry out than the local gain test since the presence of fading necessitates the averaging of a series of data over a considerable period of time. The gain at a remote point does not remain a constant quantity over a period of time, but varies irregularly depending upon the optimum inclination of the transmitted ray, which latter condition is dependent upon the transmitting medium. These variations, like fading, may be rapid or slow. In measuring field intensity it is customary to average a number of individual measurements over a period of several minutes. As usually carried out observations are made on the antenna under test and on the comparison antenna, this cycle being repeated several times. Significant results cannot usually be secured unless observations continue for at least half an hour. Since the gain is a variable, observations should continue over a prolonged period. The actual gain of an antenna at a distant point is also dependent on the transmission path and it is sometimes found that the gain of a directive antenna varies with transmission conditions.

7. Additional Tests

a. Load and Breakdown Tests.

It is usually impossible to test antennas under overload or breakdown conditions similar to those employed in connection with the testing and rating of many other types of apparatus. Tests of this character should be made on the component parts before assembly.

b. Antennas as Affected by Weather Conditions.

It is recommended that antennas be tested in different kinds of weather. Moisture or sleet on the wires and insulators can have a pronounced effect on the impedance characteristics of the antenna and transmission lines. The emphasis placed on this phase of testing will depend on the relative amount of rain or sleet encountered in the general region where the antenna is located. Usually, tests are made in dry weather.

c. Measurement of Current in Radiating Wires.

In many types of antennas the gain tests may be supplemented to advantage by measurements of the currents flowing in the several radiating wires. This can be accomplished by cutting the wires and inserting meters, the indications of which may be observed using a

telescope when necessary. The current distribution can also be secured by coupling a calibrated circuit of special design, which contains the indicating meter, to the radiating wires. This arrangement should be constructed so that it can always be located in the same position with respect to the wire near which it is placed. This method permits the examination of standing waves on the wire under observation, enabling the location of maximum and minimum current values to be readily determined. This device is particularly useful in securing information concerning transmission lines having an open wire termination.

STANDARD TESTS OF BROADCAST RADIO RECEIVERS

I. General

The purpose of the standard tests here proposed is to provide by general agreement a basis upon which the complete normal performance of any broadcast radio receiver may be reasonably predicted. It is believed that no simple "figure of merit" can properly be derived that will by itself give an index of complete performance. This follows from the varying weights that may be applied at different times and in different services, to the fundamental properties of sensitivity, selectivity, and fidelity. Consequently it is believed to be essential to define and to provide for the separate measurement of each of these fundamental properties. Such information is of somewhat too highly technical a nature to appeal directly to the average user of broadcast radio receivers, but is thought to be useful to radio distributors and dealers in guiding their selection of apparatus for specific service conditions, and to engineers and manufacturers in aiding the comparison and improvement of their products.

It is recognized that the tests do not comprehend the entire range of service conditions that may be met in practice, and that peculiarities of design not reflected in the test data may in special cases affect the deductions to be made properly from the test results. It is also recognized that the three basic properties of sensitivity, selectivity, and fidelity are in some radio receivers dependent upon adjustments that will change the relative prominence of each, and consequently the three factors should be invariably measured at the same settings of the radio receiver adjustments. Nevertheless, it is thought that acceptance of the procedure outlined, together with proper interpretation and correlation of the results obtained by the tests, will serve to permit a standard comparison of normal radio receiver performance.

II. Definition of Terms

A. Sensitivity. Sensitivity of a radio receiver is that characteristic of the radio receiver which determines to how weak a signal it is capable of responding. It is measured quantitatively in terms of the input voltage required to give a standard output.

B. Selectivity. The selectivity of a radio receiver is the degree to which the radio receiver is capable of differentiating between the desired signal and signals of other carrier frequencies. This characteristic is not ex-

pressible by a single numerical value, but requires one or more graphs for its expression.

C. Band Width. As applied to selectivity, the band width of a radio receiver is the total width of a selectivity curve at a specified point on the scale of ordinates. The specified points are usually two, ten, and successive powers of ten.

D. Fidelity. The fidelity of a radio receiver is the degree to which the radio receiver accurately reproduces at its output the form of the signal which is impressed upon it. The fidelity of a radio receiver is measured by the accuracy of reproduction, at the output terminals, of the modulation of the received wave.

E. Normal Test Output. As applied to the testing of a broadcast radio receiver, the term represents an audio-frequency power of 0.05 watt in a noninductive resistor arranged to carry alternating current only and connected across the output terminals of the radio receiver (usually the loud speaker terminals), the resistance of the resistor having been adjusted to that value recommended by the tube manufacturer to give maximum undistorted output power for the type of vacuum tube intended to be used in the output of the radio receiver, with normal adjustments of this vacuum tube. If the radio receiver is not arranged to filter out direct current from its output circuit, then an external filter system shall be employed, of such character as to introduce negligible resistance to direct current, to have negligible loss and to have negligible shunt admittance and negligible series impedance relative to the output resistor.

F. Normal Radio Input Voltage. As applied to the testing of a broadcast radio receiver, this term represents the root-mean-square voltage of a received signal, modulated 30 per cent at 400 cycles per second, which results in normal test output (definition **E**, section II) at resonance. If the radio receiver does not include a self-contained antenna, then the signal is to be impressed on a real or artificial standard antenna* (see definition **G**, section II).

For a method of measuring the percentage modulation, the reader is referred to "The use of the electron tube peak voltmeter for the measurement of modulation" by C. B. Jolliffe, Proc. I.R.E., **17**, 660-669; April, 1929. The method described in this article has much to recommend it from the point of view of simplicity, and with proper care the method is sufficiently accurate and reliable for general use. The method involves calculation of the percentage modulation from measured values of the peak voltage of the radio-frequency oscillator output under modulated and unmodulated conditions. The voltage measurements are made with a vacuum tube peak voltmeter. The paper indicates that this method is capable of giving results accurate to within about five per cent. For use in calibrating the percentage modulation of a radio-frequency oscillator for radio receiver measurement work, however, this accuracy is generally sufficient.

* Experience has indicated that with some radio receivers, an artificial antenna adversely affects the stability. In such cases it is necessary to employ a real antenna.

G. Standard Antenna (Real or Artificial). As applied to the testing of a broadcast radio receiver not having a self-contained antenna, this term represents an antenna having in series a capacity of 200 micromicrofarads, a self-inductance of 20 microhenries, and a resistance of 25 ohms.

H. Standard Test Frequencies. In the testing of a broadcast radio receiver, the five standard carrier frequencies are 600, 800, 1000, 1200, and 1400 kilocycles per second. When tests are required at only three carrier frequencies, the values 600, 1000, and 1400 kilocycles per second are recommended.

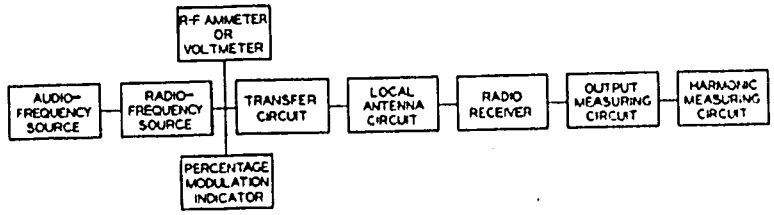


Fig. 1—Schematic arrangement of apparatus used in tests of radio receivers.

III. Requirements and Characteristics of Testing Apparatus

The apparatus employed in testing radio receivers should be as simple as is consistent with accurate performance of the necessary functions. As far as possible, the same apparatus should be used in the different tests. The values of the electrical quantities and the calibrations should not change with time, or if some change is unavoidable, means for checking should be provided.

The required apparatus for tests of sensitivity, selectivity, and fidelity, is indicated schematically in Fig. 1. Both frequency sources should be calibrated so that separate measurement of frequency is not needed. The requirements of the separate elements are stated in the following paragraphs.

A. Audio-Frequency Source. For sensitivity and selectivity tests this may be a mechanical oscillator of fixed frequency (400 cycles per second), but a vacuum tube oscillator having a frequency range at least from 40 to 10,000 cycles per second is preferred and for the fidelity test

is necessary. The total harmonic content in the output of this oscillator should not exceed five per cent. The audio-frequency oscillator is arranged to modulate the radio-frequency oscillator by a known amount and preferably should furnish the same degree of modulation without readjustment at all carrier frequencies and all modulation frequencies. Means should be provided for adjusting the degree of modulation for at least the normal value of 30 per cent.

B. Radio-Frequency Source. This consists of a vacuum tube oscillator supplied preferably from batteries, either fully shielded in itself or so shielded from the radio receiver under test that there is no direct radiation to the receiver. If the power supply is external to the shielding system which encloses the oscillator all ungrounded leads to the oscillator should pass through shielded low-pass filters. The frequency should be adjustable by an external control to any desired value between 500 and 1500 kilocycles per second, and the frequency should not be affected by changes in output power. Means should be provided for varying the frequency in small steps immediately on each side of any specified frequency. A second external control should be provided for varying the modulated radio-frequency output supplied to the transfer circuit, and an instrument should be provided which indicates the effective value of this output. The oscillator in conjunction with the transfer system used (see part C below) should be capable of supplying in series with the receiving antenna system at least 200,000 microvolts at all carrier frequencies.

C. Transfer Circuit. The radio receiver under test is provided with a local antenna circuit consisting of either a loop antenna (which may be self-contained) or an artificial antenna. In determining the significant characteristics, as outlined in the preceding sections, modulated radio-frequency voltages of known value are impressed in the local antenna circuit through the transfer circuit which should assume one of two forms as follows:

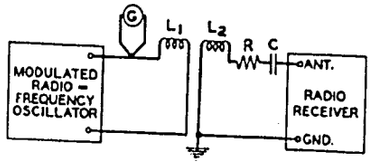
1. A coupling coil fed from the radio source and mounted in inductive relation with the loop antenna or with the 20-microhenry inductance coil of the artificial antenna. In the latter case the coupling coil is used as the primary of a calibrated mutual inductor, the secondary of which is the 20-microhenry coil.

2. A calibrated attenuator of the resistance type terminating in a low impedance of known value (usually a resistance of about one ohm) which may be inserted in series with the artificial or loop antenna. This attenuator should be so constructed that all attenuation ratios are substantially independent of frequency within the broadcast band. It is preferably made variable in steps with additional provision for

continuous variation between the steps. As an alternative to continuous variation within the attenuation network, provision may be made for continuously varying the measured current or voltage supplied from the source to the attenuator over a sufficient range to cover all values of receiver input voltage which lie between the steps of the attenuator. Design details of attenuators fulfilling these requirements are available in the literature. The combined range of ratios on the attenuator and variable currents from the source should be such as to allow a range of voltage across the terminal unit which feeds the receiving set of one microvolt to 200,000 microvolts.

D. Output Measuring Circuit. The components of the output measuring circuit should be as follows:

1. A noninductive load resistor adjustable to any desired value between one and 20,000 ohms and capable of dissipating 10 watts at any setting.



Artificial antenna
$L_2 = 20$ μh
$C = 200$ μμf
$R = 25$ ohms

Fig. 2—Standard input circuit arrangement—mutual inductive coupling.

2. An output filter to be used with radio receivers normally having direct current in their outputs. This filter should fulfill the requirements given under definition D, section II, and a recommended form consists of an inductance of not less than 100 henries (with 50 milliamperes direct current in the winding) and a capacitance of not less than eight microfarads arranged as shown in Fig. 5.

3. A vacuum tube voltmeter or an equivalent device which will accurately measure the root-mean-square values of output voltage. At normal test output the voltage is of the order from 10 to 20 volts for ordinary output vacuum tubes. For the sensitivity and selectivity tests the output meter need be calibrated only at these values. For the fidelity test continuous calibration is required, and for the overload level test calibration for much higher values is needed.

IV. Test Procedures

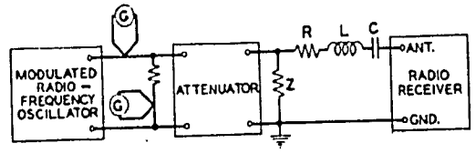
A. Preliminary. The present day radio receivers vary so greatly in their manner of operation that it is difficult to set down a single test procedure for each fundamental characteristic and have the procedure

include all the allowances that should be made for the peculiarities of different sets. It is simpler to describe in general the test set-ups and adjustments of input and output, the operating conditions, and the radio receiver adjustments as applied to any type of receiver. Then standard procedures for measuring sensitivity, selectivity, and fidelity, can be outlined.

B. Input Measurements.

1. Radio Receiver Without A Self-Contained Antenna

Standard input circuits are shown in Figs. 2 and 3. Either circuit may be used depending on whether an impedance device or a mutual inductance (see section III) is used to attenuate and introduce the radio-frequency voltage in the artificial antenna circuit.



Artificial antenna
$L = 20\ \mu h$
$C = 200\ \mu\mu f$
R + Resistance component of $L = 25$ ohms
Z = Coupling Impedance

Fig. 3—Standard input circuit arrangement—impedance coupling.

The mutual inductor is used as shown in Fig. 2. The input to the receiving set is controlled by adjustment of either the coupling between coils L_1 and L_2 or the current through L_1. The value of radio-frequency voltage impressed on the artificial antenna is determined from the formula,

$$E = 2\pi fMI, \qquad (1$$

where,

E is the radio-frequency input voltage in microvolts,
f is the carrier frequency in kilocycles per second,
M is the mutual inductance between L_1 and L_2 in millihenries, and
I is the current through L_1 in microamperes.

The circuit for use with an impedance coupling device is shown in Fig. 3. The voltage impressed in series with the artificial antenna is brought to the desired value by selecting the proper degree of attenuation and accurately adjusting either the current or the voltage input to the attenuator. The value of Z should be small compared with that of the circuit to be connected to it. If the attenuator is calibrated in terms of current, the radio-frequency voltage impressed on the artificial antenna may be expressed as,

$$E = KZI, \qquad (2)$$

where,

E is the radio-frequency input voltage in microvolts,
K is the attenuation factor,
Z is the impedance of the coupling device in ohms, and
I is the measured value of current fed to the attenuator in microamperes.

If the attenuator is calibrated in terms of voltage and includes the impedance Z, then,

$$E = Ke, \qquad (3)$$

where,

E is the radio-frequency input voltage in microvolts
K is the attenuation factor, and
e is the measured input voltage in microvolts.

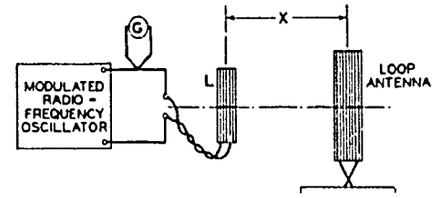


Fig. 4—Radio receiver with loop antenna.

2. Radio Receiver with a Loop Antenna

There are two methods by which such receivers may be measured. The first method consists of inducing a known voltage in the loop antenna, while the second method introduces the known voltage in series with loop antenna.

a. For the first of these methods an arrangement of apparatus as shown in Fig. 4 is suggested. The voltage induced in the loop antenna is,

$$E = \mathcal{E}Q, \qquad (4)$$

where,

E is the voltage induced in the loop antenna in microvolts,
$\mathcal{E}$ is the field intensity in microvolts per meter at the loop antenna, and
Q is the effective height of the loop antenna.

The values of $\mathcal{E}$ and Q may be calculated as follows:

$$\mathcal{E} = \frac{18850 N_1 A^2 I}{(A^2 + X^2)^{3/2}} \cos B, \tag{5}$$

where,

N_1 is the number of turns in the coupling coil L,
A is the radius of the coupling coil in centimeters,
I is the ammeter reading in microamperes,
X is the distance in centimeters between the center of the coupling coil and the center of the loop antenna, and
B is the angle, if any, between the axis of the loop antenna and the line between the coil centers,

and,

$$Q = 2N_2 h \sin \frac{\pi f s}{300{,}000}, \tag{6}$$

where,

N_2 is the number of turns in the loop antenna,
h is the height of the loop antenna in meters,
s is the length of the loop in meters, and
f is the frequency in kilocycles per second.

The induced voltage in the loop antenna may be adjusted by varying the distance X and the current through the coil L. The distance X should always be large as compared with the dimensions of the loop antenna. The axis of the coupling coil L should always pass through the center of the loop antenna. Equation (6) applies only to rectangular loops.

b. In the second method of test, the radio-frequency voltage may be introduced in the loop antenna by inserting the terminal impedance of a resistance type attenuator in series with the loop at a point of ground potential in a manner similar to that shown for an artificial antenna in Fig. 3. In this case the loop takes the place of the artificial antenna and the radio-frequency voltage is measured across the impedance which should be kept low in comparison with the impedance of the loop.

C. Output Measurements.

1. Radio Receiver with Direct Current in its Output

If the radio receiver is not equipped to filter direct current from its output, the circuit which should be used in making output measurements is shown in Fig. 5. The specifications for the components of the above circuit are given in section III.

The value for R is dependent on the operating conditions of the output tubes used in the radio receiver. Its value is arbitrarily taken (from the specifications of the tube manufacturer) as that resistance which gives the maximum undistorted power output under the given operating conditions.

In the case of a radio receiver having an output transformer, the load resistance, R_L, to be used across the output terminals is taken as the transferred value of the resistance R as specified above. That is,

$$R_L = \frac{R}{A^2}, \tag{7}$$

where,

R_L is the load resistance actually connected across the output terminals,
R is the load resistance recommended by the manufacturer for maximum undistorted output, (in the case of push-pull operation, this value is the sum of the resistances for the individual tubes), and
A is the transformer ratio of the total primary to total secondary turns.

The voltage across R for normal test output is,

$$E = \sqrt{0.05R}. \tag{8}$$

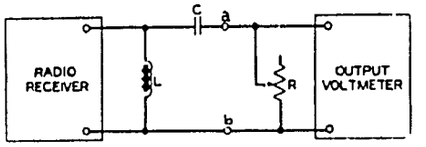


Fig. 5—Radio receiver with direct current in its output.

2. Radio Receiver with no Direct Current in Output

If the radio receiver has a device eliminating direct current from its output, (referring to the circuit of Fig. 5) L and C are removed and the points a and b connected directly to the output terminals of the receiver.

3. Radio Receiver with Extraneous Voltages in the Output

The voltages due to alternating-current hum, tube noises, etc., that may exist across the output of some radio receivers must be considered where the output voltage to be measured is small. For example, if these voltages are comparable with the normal test output voltage, let the voltage across the resistor R for normal test output be,

$$E_t = \sqrt{E_1^2 + E_2^2}, \tag{9}$$

where,

E_1 is the root-mean-square voltage due to extraneous effects, and

E_2 is the value for normal test output voltage which gives 0.05 watt power in R.

In any case, if the extraneous voltage is appreciable, the measured voltage across R should be considered as the vector sum of the extraneous voltage and that due to the desired signal.

D. Operating Conditions.

1. Battery Operated Radio Receivers

The A and B battery voltages supplied to the radio receiver should be held constant at the values specified for the receiver. If a battery cable is not furnished with the receiver, the leads to the batteries should be as short as possible. The batteries used should be in good condition.

2. Socket Powered and Electric Radio Receivers

The alternating- or direct-voltage input to the radio receiver should be held constant at the value specified for the set or at 115 volts. If the receiver is provided with adjustments for reducing hum or ripple in the output, such adjustments should be made.

3. Tubes

The tubes used should have characteristics which represent the arithmetical mean values as regards filament emission, plate current, plate resistance, mu-factor, and transconductance for that type of tube.

E. Radio Receiver Adjustment.

1. General

The test frequency adjustment is normally obtained by adjusting all the external tuning and volume controls, with which a radio receiver is equipped, until maximum response is had at its output for a given signal impressed on its input.

2. Regenerative Radio Receivers

All tests should be made for each of the following conditions:

a. With the radio receiver adjusted as in part 1 without causing oscillation at radio or audio frequencies to occur within the receiver.

b. With the receiver adjusted as in part 1 with the minimum of regeneration that can be obtained by adjustment of the external controls only.

3. Stabilized Radio Receivers

If a radio receiver is provided with external stabilization controls that are to be used in the normal operation of the receiver, it should be tested as a regenerative receiver. No other modifications of the general instructions of part 1 are necessary for the testing of stabilized radio receivers.

4. Superheterodyne Radio Receivers

If a superheterodyne radio receiver has a separate control of its oscillator frequency all tests should be made with the oscillator adjusted to the higher frequency above the signal, unless the instructions accompanying the receiver specify other conditions for operation. Selectivity tests should include the response at the lower frequency. In making selectivity tests the radio-frequency oscillator should be moved over twice the intermediate frequency. If this falls outside the broadcast band it should not be ignored. Otherwise, tests are to be in accordance with part 1.

F. Sensitivity and Tuning Range Tests.

1. Sensitivity Test

The sensitivity is determined by impressing a radio-frequency voltage, with 400 cycles, 30 per cent modulation, in series with a standard antenna (definition **G**, section **II**), or by inducing a known radio-frequency voltage in the self-contained antenna, if the radio receiver is so provided, and adjusting the intensity of the input voltage until normal test output is had under conditions stated in **E** and **F**, section **II**, for carrier frequencies between 550 and 1500 kilocycles per second.

A graph is plotted with normal radio input voltage as ordinates and carrier frequency as abscissas. A uniform scale should be used for the abscissas and either a uniform or logarithmic scale may be used for ordinates.

2. Tuning Range Test

In conjunction with the sensitivity test it is convenient to make a test of the tuning range of the radio receiver. Using the same test conditions as for the sensitivity test, the radio receiver tuning adjustment should be set for the lowest carrier frequency it is capable of receiving under normal operation. The radio-frequency oscillator is then adjusted in frequency until it is at that frequency which gives maximum output in the output meter. The output signal used should be approximately normal test output, to avoid inaccuracies due to overloading. The radio-frequency setting of the oscillator is then

recorded as the lower frequency limit of the tuning range. If the radio-frequency oscillator is incapable of reaching the low-frequency limit of the receiver, the oscillator should be set at its minimum frequency and the receiver tuned to it. The dial scale reading of the radio receiver is then recorded for that frequency. The process is then repeated at the high-frequency limit of the range. The maximum and minimum frequency settings of the tuning control will generally correspond to the maximum and minimum dial scale markings. If they do not, the dial settings corresponding to the limit frequency settings should be recorded.

If a calibration of dial setting versus carrier frequency is desired, it can be obtained by adding to the limit values, a set of readings of the dial settings for each of the standard test frequencies used in the sensitivity test. The dial calibration is plotted in the form of a graph with carrier frequency as abscissas and dial setting as ordinates, both to a linear scale.

G. Selectivity Test. The selectivity is determined by tuning the radio receiver to each standard test frequency (definition **H**, section II) in succession, with the receiver in the same condition as in the sensitivity test, and measuring the radio-frequency input voltage necessary to give normal test output at a series of carrier frequencies in steps not greater than 10 kilocycles per second at least up to 100 kilocycles per second on either side of resonance, or until the radio input voltage has increased to at least 1000 times its value at resonance (and preferably 10,000 times or more if the measuring equipment permits).

The conditions of modulation of the radio-frequency oscillator are to be the same as given under the definition for normal radio input voltage (definition **F**, section II). For each standard test frequency a graph is plotted with carrier frequency as abscissas and the ratio of input off resonance to the input at resonance, as ordinates. The scale of ordinates should be logarithmic and the most accurate representation is secured by plotting the graphs for selectivity with separate enlarged frequency scales, which should be uniform and alike.

On some receivers the volume control setting has an effect on the selectivity, and this fact should be considered when making this test. (See part **B**, section V, for outline of test for this performance characteristic.)

H. Fidelity Test. This is determined by tuning the radio receiver to each standard test frequency (definition **H**, section II) in succession, with the receiver in the same condition as in the sensititivy and selectivity tests, adjusting the impressed voltage to the normal radio input voltage, (definition **F**, section II) and then varying the modulation frequency from 40 to 10,000 cycles per second at 30 per cent modulation and constant radio-frequency input voltage throughout, taking readings of relative output voltage at convenient modulation frequencies. For each standard test frequency, a graph is plotted with modulation frequency as abscissa, and as ordinate, the ratio of the output voltage at the modulation frequency of measurement to the output voltage at the modulation frequency of 400 cycles per second. A logarithmic scale should be used for the abscissas and either a uniform or logarithmic scale for the ordinates.

It is often useful to make fidelity tests at output levels higher than normal test output. The output levels to be used are left to the discretion of the test engineer and should be stated in the results.

Certain types of volume controls have an effect upon the fidelity of the receiver and this fact should be considered when making this test. (See part **B**, section V, for outline of test for this characteristic.)

V. Additional Tests

The tests outlined in this section are to be regarded as tentative only. They are included for the purpose of bringing before the industry the need for tests of certain other factors of performance, in addition to major radio receiver tests which have been outlined in the preceding sections.

In some of the following tests, limits have been set in a somewhat arbitrary manner for the purpose of providing a basis for experimentation and further development. After some general experience has been had in making these additional tests, it is intended that definite standards for procedure in investigating these factors of radio receiver performance shall be drawn up. The Committee will be greatly assisted to this end if those laboratories finding a use for such tests will try out the methods outlined, and send in their comments and criticisms.

The tests which have appeared necessary thus far under this heading include:

A. Tests of radio receivers at high output levels.*
B. Tests for volume controls of radio receivers.
C. Tests for hum produced in radio receivers.

* In the opinion of the Committee, tests at high output levels are considered worthy of a place among the preceding standard tests, but it is felt that there has not been sufficient experience with this test by various laboratories to warrant the setting up of a definite standard test for this characteristic of radio receivers. The following paragraphs on "Tests of Radio Receivers at High Output Levels" are therefore placed in the section on "Additional Tests," pending the collection of further data. It is expected that the material will be revised in further editions of this report.

A. Tests of Radio Receivers at High Output Levels.

1. Determination of Overload Level

It is conceded that the effect of distortion on the human ear is highly variable, and dependent upon many conditions which cannot be specified in any manner which shall be standard practice for any length of time. There is a basis on which overloading can be defined from the technical viewpoint, however, that may be used for the purpose of comparing radio receivers with respect to this factor of performance. A radio receiver can be said to be overloaded when distortion is manifested in the output, i.e., when the electrical output differs in wave form from the electrical input by a specified amount. The output of the radio receiver should be tested for the introduction of spurious frequencies, that is, those not present in the input.

The test apparatus will be that used for the fidelity test, except that a harmonic measuring instrument is to be connected across the standard output load, and this instrument so chosen as to constants, that it exerts negligible effect on the load circuit. For this purpose the instrument described in "The alternating-current bridge as a harmonic analyzer"[1] is recommended.

The radio-frequency input (with modulation adjusted to 30 per cent at 400 cycles) is to be increased in steps until a value is reached which causes the output voltage to contain ten per cent of total harmonics.

When this input value has been reached, the output voltage is to be measured (as in fidelity test) and the power in the output circuit calculated. The overload level of the radio receiver shall then be considered to be that value of power output.

2. Overload Curves

Curves showing the radio-frequency input in microvolts as abscissas, and the corresponding audio-frequency output in watts, as ordinates, furnish valuable data on the overloading of a radio receiver, especially if taken at lower percentages of modulation, as well as at 30 per cent. The same arrangement of apparatus can be used as in measuring the overload level. Observations at 30 and 10 per cent modulation at 400 cycles are usually sufficient, although other values may be used at the discretion of the test engineer. It is suggested that the test be made at 1000 kilocycles per second although other test frequencies may be used if desired. The radio frequency and percentage modulation should be designated on each curve. Logarithmic scales should be used for both ordinates and abscissas.

[1] Irving Wolff, "Alternating current bridge as a harmonic analyzer" *Jour. Opt. Soc. Am. and Rev. Sci. Inst.*, 15, No. 3, 163–170; September 1927.

3. Sensitivity at Maximum Undistorted Power Output

In view of the output power capabilities of present day broadcast receivers, it is felt desirable to have a test for sensitivity at an output power greater than the normal test output. For this purpose it is suggested that the input radio-frequency voltage necessary to produce maximum undistorted output in the load resistor be determined. The value of output may be determined as described in the preceding section on Determination of Overload Level, or if it is not desired to make this test, that value may be used which is given by the tube manufacturer for the particular output tube and voltage conditions in the receiver. It is realized that this output may not be the maximum undistorted output as defined in part 1 above, but it is felt that some useful information will, nevertheless, be obtained by such a test.

The data obtainable from these measurements should be plotted in the same form as for sensitivity measurements except that the ordinate values should be the radio-frequency input voltages for maximum undistorted output instead of the normal radio-frequency input voltages, and the power output obtained should be noted on the graph sheet.

In cases where the power output varies for the different carrier frequencies, note of this should also be made.

B. Tests for Volume Controls of Radio Receivers. Briefly, the most important of these are:

1. Tests of the effect of the volume control on the sensitivity, selectivity, and fidelity of the radio receiver.

2. Tests of the effect of the radio-frequency field to which the radio receiver is exposed (input signal not subject to the volume control adjustment).

1. Tests of the Effect of the Volume Control on the Sensitivity, Selectivity, and Fidelity of the Radio Receiver

a. Effect of Volume Control on Sensitivity.

The radio input voltage required to produce normal test output should be measured at various volume control settings. These can be plotted in the form of a graph using percentage of maximum setting of volume control as abscissa, and normal radio input voltage in microvolts as ordinate. This graph can be plotted on the same type of paper used for selectivity graphs with the logarithmic axis as ordinate. The graph should be taken all the way to the minimum end of the volume control unless this is impossible with the equipment avail-

able. In the latter case the graph should be taken to a radio-frequency input of at least 200,000 microvolts. This graph can be taken at any one or more of the standard test frequency settings desired, and enough points should be taken to show the graph shape accurately.

b. Effect of Volume Control on Selectivity.

In addition to the usual inverse resonance graphs, a selectivity graph should be taken with a radio-frequency input at resonance of 5000 microvolts. This signal is to be reduced by means of the volume control until it gives normal test output at the receiver output. One or more such selectivity graphs should be taken at reduced volume control as required in the opinion of the test engineer, and in cases of apparent erratic behavior of the volume control, graphs may be taken at higher values of radio-frequency input voltage.

c. Effect of Volume Control on Fidelity.

In addition to the usual fidelity graphs, one should be taken with a radio-frequency input of 50,000 microvolts, with the radio receiver output reduced by means of the volume control to give normal test output at 400 cycles per second. Such curves should be taken at 600 and 1400 kilocycles, and at other standard test carrier frequencies if thought desirable.

d. Test of Automatic Volume Control Characteristics.

Curves of audio-frequency output against radio-frequency input voltages, modulated 30 per cent at 400 cycles per second are taken for several settings of the manual volume control. The radio-frequency input voltages should be varied over a range of at least one hundred to one. The audio-frequency output voltages or current are plotted as ordinates and the radio-frequency input voltages as abscissas. Logarithmic scales should be used for both ordinates and abscissas.

2. Tests of the Effect of the Radio-Frequency Field to Which the Radio Receiver is Exposed (Input Signal Not Subject to the Volume-Control Adjustment)

It is intended that this test evaluate the pickup by the radio receiver circuit, of radio-frequency fields through unshielded or poorly shielded coils or wires within the radio receiver, and through the power line in the case of radio receivers deriving part or all of their power supply from that source, under conditions where the volume control is set at minimum. Such a test appears desirable, but the Committee knows of no satisfactory way of making such a test quantitatively at the present time, and recommends that the various laboratories keep in mind the need for such a test. If a method is later developed which permits results of a useful quantitative nature to be obtained, it is requested that this be brought to the attention of the Institute.

C. Test for Hum Produced in Radio Receivers. Radio receivers of the type which derive their power from alternating-current supply generally produce in the output circuit a certain amount of audio-frequency voltage composed of a combination of various harmonics of the alternating-current supply frequency and occasionally containing the fundamental. This voltage is commonly called the alternating-current hum voltage, and this section is intended to outline certain tests for evaluating it.

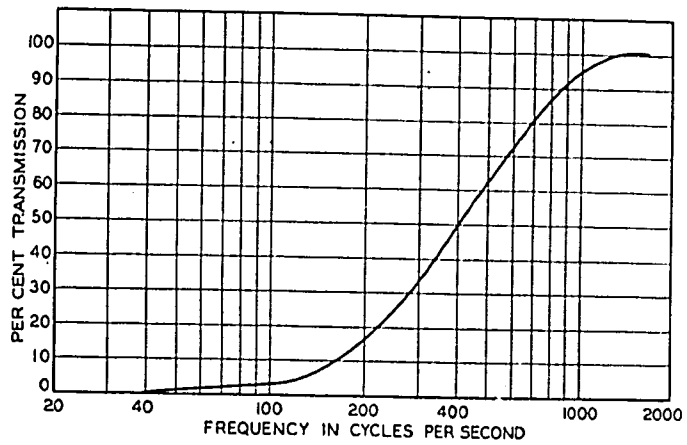
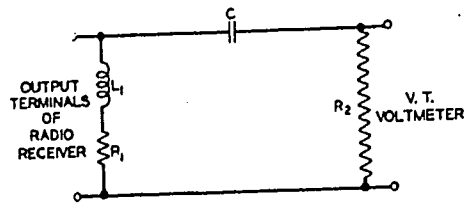


Fig. 6—Possible attenuation characteristic of arbitrary network for use in hum measurement.

A measure of the root-mean-square hum voltage across the output terminals of the radio receiver is not an indication of its quantitative effect on the ear, since the audio response characteristics of audio-frequency amplifiers and loud speakers, and of the human ear, cause the higher harmonics of the alternating-current power supply to result in more sound response from the loud speaker than do the lower harmonics or the fundamental. Therefore, it is desirable to evaluate the various harmonic components of the hum voltage in order to obtain a useful conception of the degree of unpleasantness which the hum from a particular radio receiver will create. A simple way of doing this would be to construct a filter network having an attenuation characteristic which would take account of the dropping off in loud speaker response and ear response below 1500 cycles per second. (It is felt that frequencies above 1500 cycles per second can be disregarded in the hum measurement.) This network should be connected between the radio

receiver output and the output voltmeter. If the voltmeter is calibrated in root-mean-square volts it will then measure the square root of the sum of the squares of the various hum harmonic voltages, each harmonic being attenuated to a percentage of its actual value corresponding to its importance from the point of view of the loud speaker and ear response characteristics. Thus, a single voltage measurement is made to give a measure of the degree of unpleasantness which the hum from a particular radio receiver would create with an average loud speaker. From this voltage measurement and the value of the radio receiver output resistance the hum power should be calculated.

While the ear characteristic is fairly well known, the preparation of a network which would include the response characteristic of an average loud speaker would, of course, necessitate the measurement of all the loud speakers upon the market at the present time and for some time past. It would also require the use of sound measuring equipment and measurement conditions whose absolute accuracy has been



L_1=0.9 henry
R_1=180 ohms (including R_{dc} of L_1)
R_2=r_p of output tube
C=0.045 μf for 5000 ohm R_2
C=0.065 μf for 2000 ohm R_2

Fig. 7—Network intended to approximate an average loud speaker characteristic.

proved. These requirements are impossible of complete realization at the present time, but it is felt that some valuable experience in the field of hum measurement can be obtained by the adoption of an arbitrary network, having characteristics which appear, in light of present knowledge, to be of the general order of magnitude of the frequency attenuation factors involved, and to approximate an average loud-speaker characteristic. A possible attenuation characteristic for such a network is shown in Fig. 6, and a network having approximately this characteristic is shown in Fig. 7.

It should be emphasized that the graph of Fig. 6 is not intended to include an accurate representation of an average loud speaker frequency response characteristic. The network characteristic is only tentative, and has been prepared as a guide for those desiring to make investigations in the field of hum measurement.

Other conditions which must be considered in connection with the measurement of hum from a radio receiver are:

1. Use of an alternating-current power supply having known and definitely limited harmonic characteristics.

2. Adjustment of any devices provided on the receiver for hum regulation, such as filament mid-tap potentiometers, for minimum hum.

In connection with condition 1 above, it is suggested that use be made of the differential distortion factor circuit, which has been used in the past in the electrical art in evaluating the harmonic content of alternating-current power supplies. The circuit is shown in Fig. 8. The

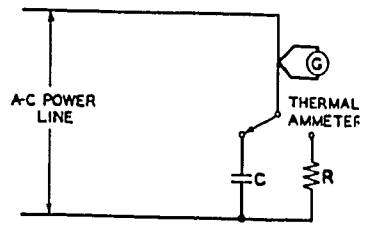


Fig. 8—Differential distortion factor circuit.

constants of the circuit are governed by the relation,

$$R = \frac{1}{2\pi f C}, \tag{10}$$

where f is the fundamental frequency of the alternating-current line. The value of R can be chosen to suit the particular thermocouple meter available. The resistance of the thermocouple should be, of course, small compared with R.

The differential distortion factor is then given by the following relation

$$d.d.f. = \frac{I_c}{I_r} \tag{11}$$

where,

I_c is current through the condenser, and
I_r is current through the resistor.

It is recommended tentatively, in making measurements of hum on alternating-current radio receivers, that the power supply have a differential distortion factor not greater than 1.05.

It should be noted that in some radio receivers, more hum will be produced when a carrier is tuned in. On this account it is necessary to measure the hum under two conditions of the radio receiver unless only

the value of the worst hum condition is desired, in which case that one of the following receiver adjustment conditions should be used which gives the greater hum:

a. No incoming carrier frequency and no other voltages such as static, induction, etc., in the output circuit. In radio receivers where the position of the volume control does not affect the hum (with no incoming carrier), the last condition may be most easily complied with by setting the volume control to zero.

b. With an incoming unmodulated carrier having a radio-frequency input of 50,000 microvolts impressed on the radio receiver input circuit, and with the volume control so set that, were the incoming carrier to be modulated 30 per cent at 400 cycles per second, it would give normal output power in the radio receiver output circuit. Here, static and induction voltages in the output voltage should be reduced to a negligible percentage, as in condition a.

VI. Receiver Performance Graph Sheets

In an engineering analysis of general trends in receiver design and performance, it is necessary to consider data on a large number of receiver designs, and on a large number of particular receivers of each design, for it is well known that the performance of a random sample of a type of receiver may be far from representative of the type as a whole. In order to facilitate such analyses, and to aid in the evaluation of a particular design relative to the field, the receiver performance graph sheets to be described below were developed. It is hoped that they will be found useful and freely used. The Institute will welcome any comments or suggestions of the members relative to their improvement.

Great accuracy is not usually justified in plotting typical or average characteristic curves, for large probable errors are inherent in a determination of what is typical or average from the relatively small quantity of data which are usually available. And furthermore, the usefulness of the sheet as a summary for frequent reference would be decreased by including too much detail. Therefore, in the form shown in Fig. 9, advantage has been taken of these facts by making the sheet small—standard Lefax size, 3¾ in.×6¾ in.—thus gaining the utmost in compactness without sacrifice of needed accuracy.

Curves plotted on this sheet may be easily read to an accuracy of five per cent, which should prove sufficient for the original record of many receiver tests which are made with test equipment not of the highest order of accuracy, or which are rapidly made when great accuracy is not required. However, this small sheet has been designed with the

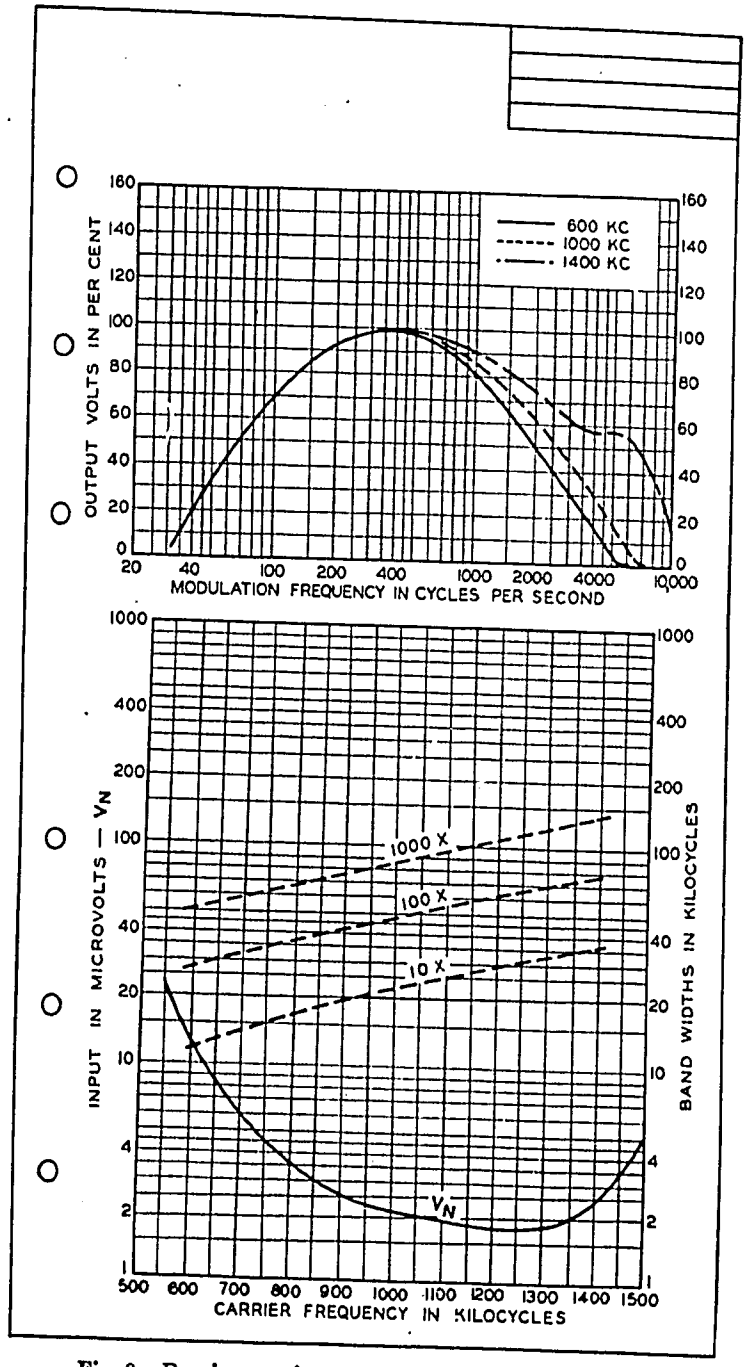


Fig. 9—Receiver performance graph sheet. (Full size.)

principal object in view of providing a means of recording average or typical data in summary form for ready reference. Tests made to dis-

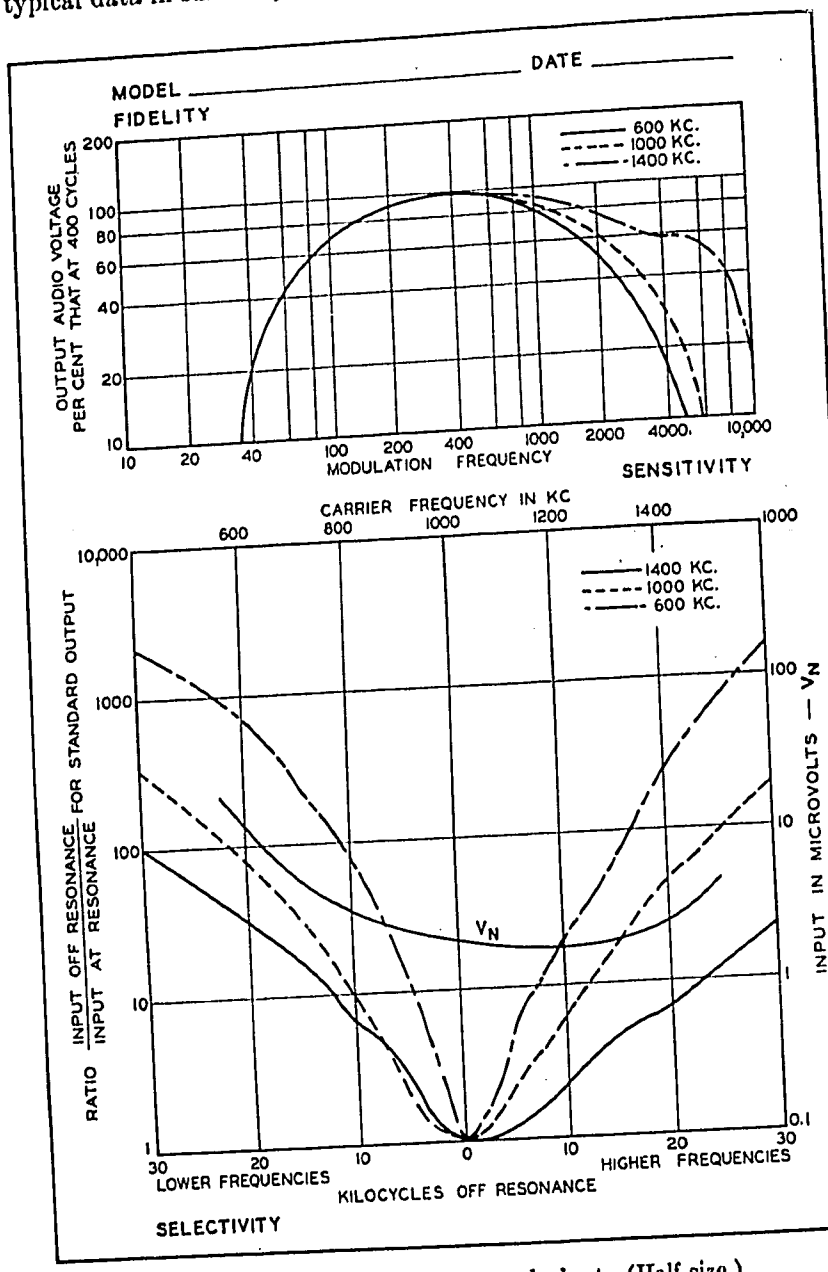


Fig. 10—Receiver performance graph sheet. (Half size.)

close small differences in individual receivers, or to discover errors or defects, should be recorded in other ways more suitable for such tests.

The sheet consists of two ruled sections, one with logarithmic abscissas and linear ordinates, for fidelity curves, and the other with linear abscissas and logarithmic ordinates, upon which may be recorded sensitivity and band-width (selectivity) curves. The scales are all properly marked and are so chosen as to be universal, that is, they will be suitable for practically any present or contemplated broadcast receiver, without change.

The use of universal scales is considered essential so that different receivers may be compared at a glance by noting the shape and location of their characteristic curves on the standard sheet, without the necessity of translating the curves back into figures. This requirement necessitates—if undue loss of accuracy is to be avoided—the plotting of the selectivity characteristic by means of the band width, derived from the inverse resonance curves (or measured directly) instead of the inverse resonance curves. It is obvious that to cover all types of receivers, a logarithmic scale for sensitivity and band width is required. Linear ordinates for the fidelity curves are chosen because, on a small sheet, they indicate with greater accuracy the essential fidelity characteristics.

Space has been left at the top of the sheet for a title and any general memoranda which may be desirable. The standard Lefax index ruling may be included in the upper right-hand corner of the sheet, if desired, subject to any legal restrictions there may be to the use of this ruling. The figure shows the proposed sheet, full size, upon which have been plotted, for the purpose of illustration, the basic characteristics of a receiver; sensitivity; band widths at 10, 100, and 1000 times normal radio input voltage at resonance; and fidelity, measured at the three standard test frequencies of 600, 1000 and 1400 kilocycles per second.

For those who prefer to plot complete selectivity curves, instead of band-width data, a different form has been prepared, and is shown in Fig. 10. This form is designed for standard letter size paper, 8½ in. ×11 in.

The lower part of the form provides for plotting complete selectivity curves, and also provides for a sensitivity curve. As in the smaller form, the upper section of the form is for fidelity curves. Logarithmic ordinates are provided for the fidelity curves, as many engineers consider these show the fidelity more nearly as it sounds.

The curves plotted on Fig. 10 are from the same data as those on Fig. 9.

STANDARD METHODS OF TESTING VACUUM TUBES

I. General

A. Scope. This section of the Report of the Committee on Standardization deals with the methods of measurement of the important characteristics of vacuum tubes, including phototubes.

B. General Precautions. Attention is called to the necessity, especially in tests of apparatus of low power, such as vacuum tubes intended for reception, of eliminating or correcting for errors due to the presence of the measuring instruments in the test circuit. This applies particularly to the currents taken by voltmeters and other shunt connected apparatus, and to the voltage drops in ammeters and other series connected apparatus.

Attention is also called to the desirability of keeping the test conditions such as filament heating, plate potential, and plate current within the safe limits specified by the manufacturers. If the specified safe limits are exceeded the characteristics of the vacuum tube may be permanently altered and subsequent tests vitiated. When particular tests are required to extend somewhat beyond a specified safe limit (see parts A and E, section II, pages 145 and 148) such portions of the test should be made as rapidly as possible and preferably after the conclusion of the tests within the specified safe limit.

C. General Test Conditions. Except when the nature of a test calls for varying or abnormal conditions, all tests should be made at the normal rated conditions specified by the manufacturers of the vacuum tubes. In case the manufacturer's rating is not specific, test conditions not specified should be selected in accordance with the best judgement of the tester, and should be clearly and fully stated as a part of the test data.

When a filament is rated in both voltage and current, the rated voltage should be employed in tests, except that in cases where filaments are to be used in series the rated current may be employed, this to be stated as a part of the test data. Direct current should be used for filament heating, except where the normal operating condition is with alternating-current heating, in which case the use of the latter should be stated. When direct-current heating is employed, the negative filament terminal should be taken as the datum of potential. If the proper filament terminal to be used as the negative is not indicated by the manufacturer or specified in any recognized standard manner for a given vacuum tube structure, the terminal used as the negative should be stated with the test data. When alternating-current heating is employed in the case of a filamentary cathode, the mid-point (i.e.,

the center tap on the filament transformer secondary, or the mid-point on a resistor shunting the filament) should be taken as the datum. It should be noted that these two potential datum conditions are not equivalent and should not be expected to give equivalent readings. If substantially equivalent readings are desired between the two cases (alternating- and direct-current heating), the datum of potential for alternating-current heating must be taken at a point whose direct potential is more negative than that of the filament mid-point by an amount numerically equal to one-half of the root-mean-square value of the filament voltage. In the case of indirectly heated equipotential cathodes, the cathode is taken as the datum of potential. The connection of cathode to any part of the heater circuit will usually be without effect upon the measured characteristics.

II. Characteristic Graphs

The term characteristic or characteristic graph is employed in this report to designate the graphical relation between two or more variables such as voltage and current. As applied to any electrode circuit in a vacuum tube it designates the relation between the voltage on an electrode and the current flowing in the circuit of that electrode. Another characteristic of fundamental importance is the transfer characteristic, which is the relation between the voltage on an electrode and the current in the circuit of another electrode.

A. Filament, or Heater, Characteristic. Readings of filament, or heater current and voltage are taken for the conditions of zero grid voltage and zero plate voltage. (Ordinarily the grid and plate electrodes simply may be left floating in potential.) Measurements should be made over a range of filament temperatures from values too low to give appreciable electron emission in service to at least the safe maximum temperature (see part B, section I, page 144). Curves should be plotted with filament voltage as abscissa and filament current and filament power as ordinate.

B. Emission Characteristic (7008). Readings of emission current and filament power are taken for this characteristic. The emission characteristic is to be plotted with filament power as abscissas and emission current as ordinates. Emission current is measured with the grid or grids and the plate connected together and a sufficiently positive voltage (with respect to the filament) applied to these electrodes to obtain the full electron emission. Since the emission current at normal filament power would ordinarily be so great as to damage the vacuum tube, readings are taken at lower filament powers only and normal emission current may be obtained by extrapolation. A suitable proce-

dure is as follows, the values applying to ordinary receiving vacuum tubes. Readings are taken with emission currents of 0.1, 0.2, 0.5, 1.0,

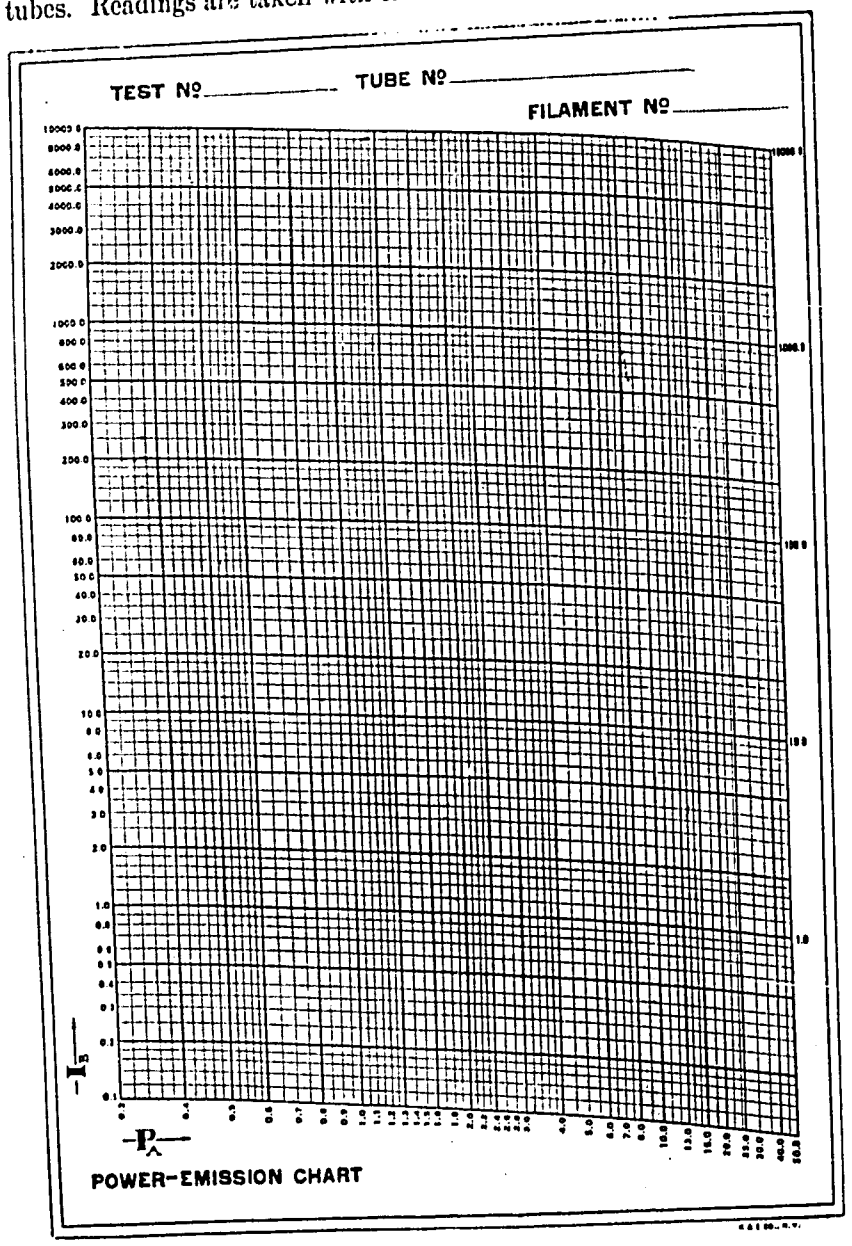


FIG. 1—Power emission chart.

2.0, and 5.0 milliamperes, with 45 volts positive voltage applied to the electrodes of the tube which are connected together to form a common anode. The results are plotted in Davisson coördinates (Fig. 1), which

is a special system of curvilinear coördinates. If the emission follows Richardson's temperature law and the cathode follows the Stefan-Boltzmann law of radiation, the characteristic will be a straight line when plotted in these coördinates. The observed points may be extended or extrapolated to obtain the emission at normal filament power.*

According to Richardson's temperature law, the electron emission from a hot body varies with the Absolute temperature, T, according to the law,

$$I_s = A\sqrt{T}e^{-b/T}. \tag{1}$$

Richardson has also derived the following law,

$$I_s = A'T^2e^{-b/T}. \tag{2}$$

The principal variation in emission is due to the variable exponential term, so that either of these equations may usually be employed.

According to the Stefan-Boltzman law of radiation, the total energy radiated from a black body at Absolute temperature, T, is,

$$W = AT^4. \tag{3}$$

Precautions: If the curve is not straight, but bends downward, this may be an indication of: (1) departure from Stefan-Boltzmann cooling, (2) anode voltage too low to draw off all the electrons, and/or (3) effect of cooling due to heat of evaporation of electrons. The cooling due to electron evaporation amounts to ϕI_s watts, where I_s represents the emisson current in amperes and ϕ represents the work function of the cathode expressed in volts. This is particularly important in transmitting tubes, where the currents are high, and with tungsten filaments where the work function is large. If the curve is bent upward, this may be an indication of: (1) poor vacuum (gas ionization effects), and/or (2) heating of the anodes by the electron current. In these cases reliable and analytical data cannot be obtained by this method.

C. Electron Emission (7006). Normal electron emission is determined with the filament power adjusted to the normal operating value. All electrodes in the tube, excepting the cathode, are connected together and a sufficiently positive voltage with respect to the cathode applied to them to obtain the full electron emission.

Precautions: In some cases, particularly with large tubes, it is not always advisable to make this test on account of possible damage to the tube. The emission currents in these cases are preferably deter-

* Suitable coördinate paper may be obtained from Institute Headquarters or from the publisher, Keuffel & Esser Co., 127 Fulton St., New York City.

mined by extrapolation (see part B, section II.) For ordinary receiving tubes the test can be made safely if the time of application of the voltage is not permitted to exceed that required for rapid reading of the emission current meter. For ordinary receiving tubes an anode voltage of about forty-five is suitable. Since this test usually results in the liberation of gas and abnormal heating of the electrodes, it usually should be postponed until after the completion of other tests, or a sufficient time should elapse between this and other tests for clean-up and return to normal temperature conditions. For other effects see precautions in part B, section II.

D. Grid Characteristics (7029). In a vacuum tube containing a number of grids, several grid characteristics may be obtained, but in most cases the control-grid characteristic will be principally required. Readings of the grid current and grid voltage are taken for the condition of constant plate voltage and constant voltage on other grids. These voltages should ordinarily be the normal rated values if only a single curve is to be obtained. In the case of the control grid the range in grid current ordinarily need not extend to reversed grid currents due to gas ionization and other causes, as such currents are relatively very small and are included in another test (part A, section IV, page 156). The grid characteristic is plotted with grid voltage as abscissas and grid currents as ordinates.

E. Plate Characteristics (7047). The plate characteristic represents the relation between plate current and plate voltage, the voltages of all other electrodes being maintained at specified values. A family of such graphs may be obtained by selecting different voltages on other electrodes for each graph.

Precautions: The tube may be overloaded and unduly heated by attempting to make observations at high values of current and voltage. The part of the graph corresponding to abnormally high values of current and voltage is seldom used, but if the characteristic in this region is desired, the voltage should be applied only long enough to obtain and note the meter deflection.

F. Grid-Plate Characteristic (7043). The control-grid voltage plate current transfer characteristic is generally all that is required, but the transfer characteristics for other grids may be of interest in special cases. Readings of plate current and grid voltage are taken for constant voltages on the plate and other grids, if present. These voltages ordinarily should be the normal rated values if a single curve is to be obtained. The graph is plotted with grid voltages as abscissas and plate currents as ordinates. A family of graphs may be obtained by selecting different values of voltage for the plate and other grids for each characteristic.

Precautions: See precautions in part E, section II, above.

III. Thermionic Tube Coefficients

The coefficients, or differential parameters, of thermionic tubes which occur in circuit calculations, such as resistances, conductances, transconductances, and mu-factors, may be evaluated graphically from the characteristic graphs, or by direct measurement. The use of characteristic graphs is often of some descriptive and instructive value, but usually is less precise and less suited to the rapid testing of a large number of tubes than direct measurement. Both methods should yield concordant results, and the graphical method is often useful in roughly checking direct measurements for errors in technique.

Direct measurements are commonly made by balance or bridge methods employing an audio-frequency generator as the source of power. The null indicator is usually a telephone receiver, which may

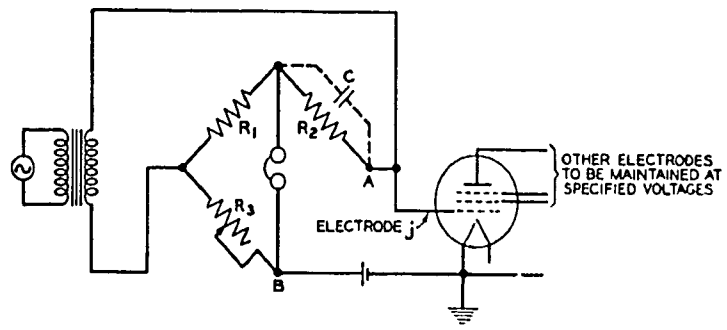


FIG. 2—Circuit arrangement for measuring conductance of an electrode circuit

be preceded by an audio amplifier where most precise null indications are desired, the sensitivity (and to a certain extent the accuracy) of the method depending upon the amount of amplification used. The magnitude of the impressed alternating voltage should always be small enough so that the results of the measurement are unaffected by a reduction of the impressed voltage. Balance methods with an alternating-current source require that consideration be given to the effects of stray capacitances and couplings, which may render balance difficult, or may even cause a false balance and vitiate the results. The grounding and shielding of the apparatus should be given special attention.

In general, allowance must be made in balance networks for the effect of the network in lowering the direct voltage of the electrode below the battery electromotive force. This may be done conveniently by measuring the voltage directly at the electrode by means of a voltmeter of sufficiently high resistance. The effect of the network upon the alter-

nating currents in the electrode circuits is also of occasional importance and proper values of circuit elements should be used or corrections made.

A. Conductance of an Electrode Circuit (7041). The electrode conductance may be obtained graphically from the graph of current in the electrode plotted against the voltage between that electrode and the cathode. The slope of this characteristic gives the conductance of the electrode circuit.

Electrode conductance may also be determined by a balance method, employing a Wheatstone bridge as shown in Fig. 2. When the bridge is balanced the electrode conductance is given by,

$$s_j = \frac{1}{r_j} = \frac{R_1}{R_2 R_3}. \tag{4}$$

The other electrodes of the tube are maintained at specified voltages.

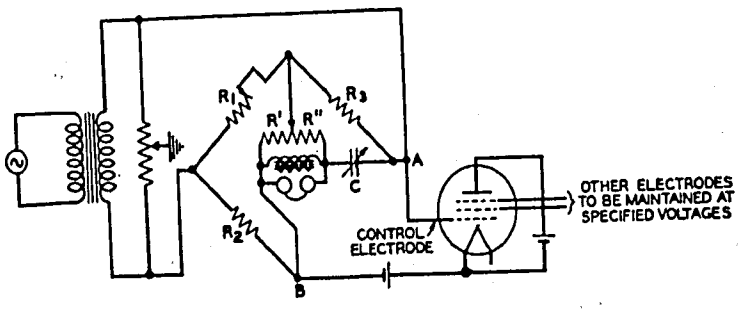


FIG. 3—Circuit arrangement for measuring control-grid conductance.

Precautions: A variable condenser across an adjacent arm may sometimes be necessary to secure a perfect balance in view of the capacity of the tube.

B. Grid Conductance (7028). Grid conductance may be determined graphically from the slope of the graph of grid voltages as abscissas plotted against grid currents as ordinates, other electrode voltages being maintained constant. The reciprocal of this slope is a measure of the grid resistance. Grid conductance and resistance may be measured directly by the general balance method shown in Fig. 2 the grid in this case being connected to point A and the cathode to point B.

A second balance method which is especially suitable for this measurement is shown in Fig. 3. R'' is adjusted to approximately $R'/10$. With the cathode cold, C is adjusted to $R'(C_{gf}+C_{gp})/R''$. Approximate values for the resistive arms of the bridge are: R_3 = 10,000 or 100,000 ohms, R_2 = 10 or 100 ohms, R_1, adjustable. Low

resistance chokes shunt the source and the telephones to avoid direct voltage drops due to grid current. When balance has been attained,

$$r_g = \frac{R_2 R_3}{R_1} \tag{5}$$

and,

$$s_g = \frac{1}{r_g} = \frac{R_1}{R_2 R_3}. \tag{6}$$

C. Plate Conductance (7045) and Resistance (7046). The plate conductance and resistance can be determined graphically from the slope of the plate characteristic, in the same manner as described in the preceding section. These values also may be directly measured by

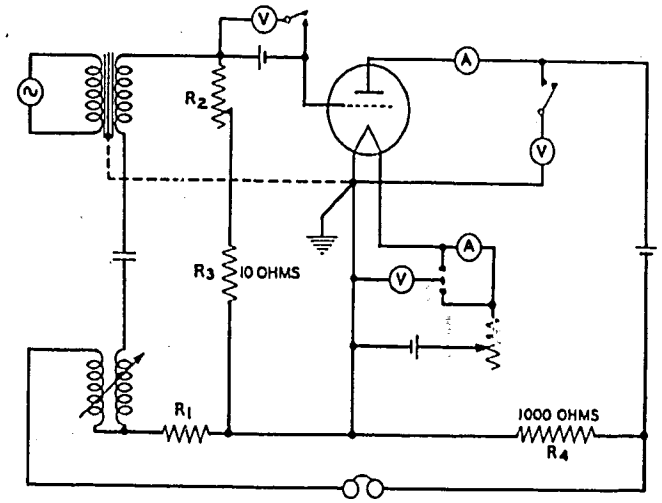


FIG. 4—Circuit arrangement for measuring plate resistance.

means of the balance method shown in Fig. 2, the plate being connected to point A and the cathode to point B. When balance has been attained,

$$s_p = \frac{R_1}{R_2 R_3}, \tag{7}$$

and,

$$r_p = \frac{1}{s_p} = \frac{R_2 R_3}{R_1}. \tag{8}$$

An alternative balance method is shown in Fig. 4. R_1 is adjusted to the value required in the measurement of the mu-factor (see part **G**, section **III**, page 154). When balance has been attained by proper adjustment of R_2 and M,

$$s_p = \frac{0.01}{R_2}, \tag{9}$$

and,

$$r_p = \frac{1}{s_p} = 100R_2. \tag{10}$$

When r_p is high, as in the usual operation of the shielded tetrode, extreme care must be exercised to obtain accurate results. It is somewhat preferable in these cases to determine r_p graphically from the slope of the plate characteristic.

D. Conductance for Rectification (7107). Conductance for rectification is most simply determined from the slope of the graph showing the relation between the direct voltage on an electrode as abscissas and the average direct current in the circuit of the same electrode as ordinates.

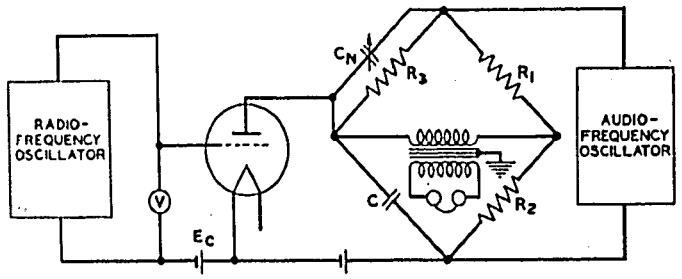


FIG. 5—Circuit arrangement for measuring (plate) conductance for rectification.

A balance method for measuring conductance for rectification is also available. An application to the case of the plate conductance for transrectification in a triode is shown in Fig. 5. In this case the alternating voltage is applied to the grid and is of radio frequency. When balance is obtained,

$$s_p' = \frac{R_1}{R_2R_3}. \tag{11}$$

The plate resistance for rectification, r_p', is the reciprocal of the plate conductance for rectification, i.e.,

$$r_p' = \frac{1}{s_p'} = \frac{R_2R_3}{R_1}. \tag{12}$$

Although Fig. 5 shows only the application of measurement of plate conductance for transrectification of a triode, the method is applicable, of course, to the measurement of conductance of any electrode for ordinary rectification or transrectification. For multielectrode tubes, all electrodes not directly involved in the measurements should be maintained at constant and specified voltages.

REFERENCE

Stuart Ballantine, PROC. I.R.E., 17, 1164; July, 1929.

E. Transconductance in a Tube of *n*-Electrodes (7042). Transconductance may be determined graphically from the slope of the graph of voltage on a specified electrode as abscissas plotted against current in another electrode circuit as ordinates.

Transconductance may also be measured directly by the balance method using the circuit of Fig. 6. When balance is attained,

$$s_{jk} = \frac{R_1}{R_2R_3}. \tag{13}$$

The electrodes, other than j and k, not directly involved in the measurement, are to be maintained at their specified voltages.

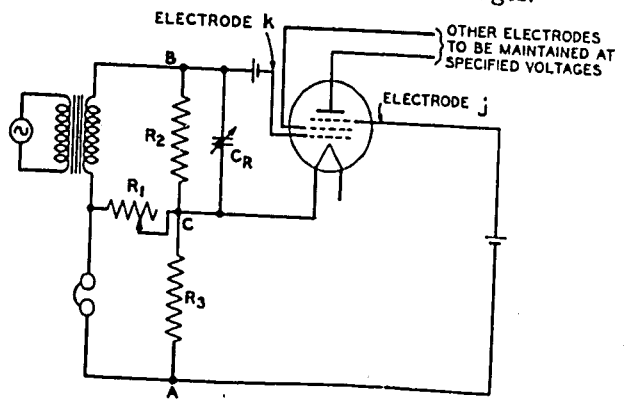


FIG. 6—Circuit arrangement for measuring transconductance.

Precautions: R_2 and R_3 should be small so that their effects on the alternating currents in their respective electrode circuits may be within reasonable bounds. The effect of R_2 and R_3 upon the electrode direct voltage should be allowed for. A small capacity across R_2, or equivalently connected, may be necessary to balance the capacities in the tube and associated apparatus.

F. Grid-Plate Transconductance (7044). The grid-plate transconductance, or mutual conductance, may be determined graphically from the slope of the grid-plate transfer characteristic (see part F, section II, page 148). It may also be calculated from measurements of the mu-factor and the plate conductance, since,

$$s_{gp} \equiv s_m = \frac{\mu}{r_p}. \tag{14}$$

A direct measurement may be obtained by the method shown in Fig. 6, the control-grid being connected to point B, the cathode to C, and the plate to A. When balance has been attained,

$$s_{gp} = \frac{R_1}{R_2R_3}. \tag{15}$$

It should be observed that the resistance R_3 in series with the plate circuit, and a grid conductance r_g across R_2 may cause errors. The true value of s_{gp} is given by,

$$s_{gp} = \frac{R_1}{R_2 R_3}\left(\frac{r_p + R_3}{r_p}\right)\left(\frac{r_g + R_2}{r_g}\right). \tag{16}$$

If the grid resistance is very large in comparison with R_2,

$$s_{gp} = \frac{R_1}{R_2 R_3}\left(1 + \frac{R_3}{r_p}\right). \tag{17}$$

The error due to R_3 depends upon the magnitude of the plate resistance. It will usually be negligible in the case of a shielded tetrode where r_p is

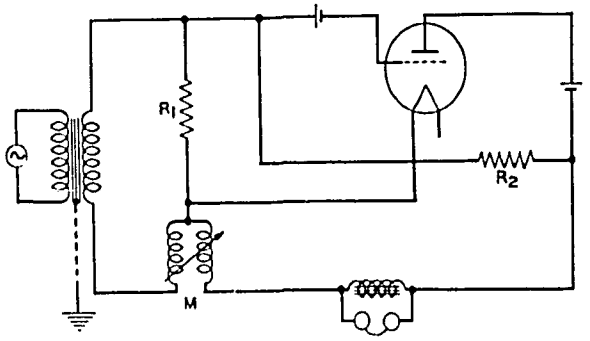


Fig. 7—Simplified circuit arrangement for measuring transconductance.

of the order of 500,000 ohms, but may be important in a power tube of low plate resistance. In the case of power tubes, and in general when r_p is small, the method shown in Fig. 7 is convenient since it requires no corrections. When balance has been attained by variation of R_1, R_2, and M,

$$s_{gp} = \frac{1}{R_2}. \tag{18}$$

Precautions: The telephones are shunted by a low resistance choke and the resistance of the secondary of the supply transformer should be low to provide low resistance paths for direct current.

G. Mu-Factor in a Tube of *n*-Electrodes (7038). The mu-factor may be conveniently measured by a balance method such as that shown in Fig. 8. The electrode in which the current is to be held constant is connected to point A; the other two electrodes entering directly in the measurement are connected to points B and C. R_1, R_2, and M are adjusted for silence in the telephones and when balance is attained,

$$\mu_{jkl} = \frac{R_2}{R_1}. \tag{19}$$

The small variable mutual inductor, M, compensates for any slight difference in phase of the currents caused by vacuum tube capacitances or slight residual reactances in the plate and grid circuits.

Precautions: The remaining electrodes should be maintained at their specified potentials. The effect of the telephones in electrode

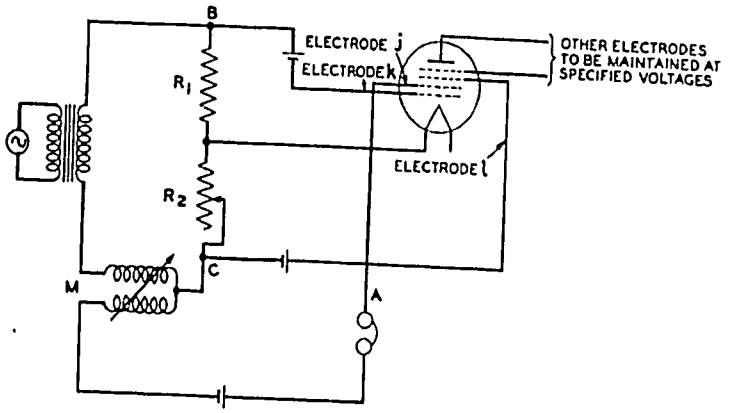


Fig. 8—Circuit arrangement for measuring mu-factor.

circuit j, and of R_1 and R_2 in the other circuits, on the electrode direct voltages should be allowed for when estimating these voltages from the battery electromotive forces. The effect of the conductances of electrode circuits k and l in shunting R_1 and R_2 should also be corrected for when necessary.

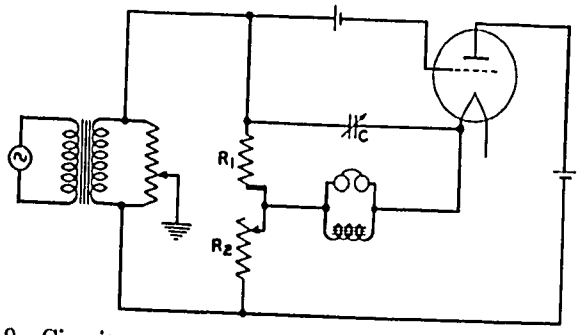


Fig. 9—Circuit arrangement for measuring amplification factor.

H. Amplification Factor (7039). Amplification factor, a special case of the mu-factor applying only to triodes, may be measured with the circuit of Fig. 8 as described in the preceding section. In this case the plate is connected to point A, and the control grid to B. When balance is attained,

$$\mu = \frac{R_2}{R_1}. \tag{20}$$

A modification of this method, shown in Fig. 9, is useful when the control-grid current is zero. The capacity C balances the tube capacities, and its value must be changed each time R_2 is changed since the condition of balance is,

$$\frac{R_2}{R_1} = \frac{C + C_{gf}}{C_{pf}}. \tag{21}$$

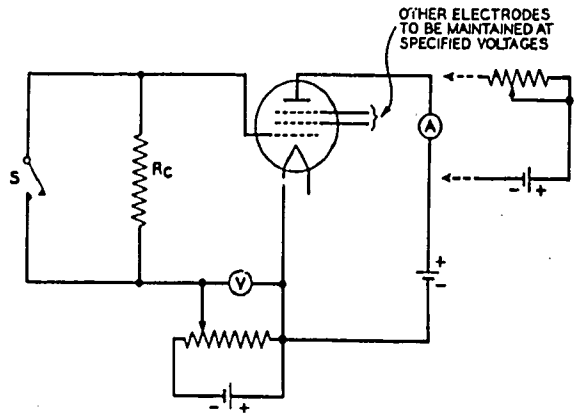


Fig. 10—Circuit arrangement for measuring small control-grid currents.

When balance is attained,

$$\mu = \frac{R_2}{R_1}. \tag{20}$$

Precautions: The direct voltage drop in R_2 should be allowed for.

References

Figs. 4, 9. J. M. Miller, Proc. I.R.E., 6, 141, 1918.
Figs. 2, 6. Stuart Ballantine, Proc. I.R.E., 7, 134, 1919.
Figs. 3, 7, 9. E. L. Chaffee, Electron Tubes, (to be published by McGraw-Hill, New York City, in 1931).

IV. Ionization and Leakage Currents

A. Control-Grid Current. A sensitive method of measuring total control-grid current, which is especially useful when the current is too small for convenient direct measurement by ordinary deflection instrument is illustrated in Fig. 10. With the switch, S, closed and the grid and plate voltages adjusted to the desired values, the reading of plate current is noted. The switch is then opened, placing R_c in the grid circuit, and the grid bias, E_c, is readjusted so that the plate current returns to its former value. The desired grid current can be computed

from the change in grid voltage, ΔE_c, necessary to maintain constant plate current, since,

$$i_g = \Delta E_c / R_c. \tag{22}$$

The necessary value of R_c will depend upon the current to be measured. A value of one hundred megohms will be found convenient. When a number of tubes of the same type are to be compared for grid current it is often sufficient to estimate the relative grid current by noting the change in plate current when S is opened and closed.

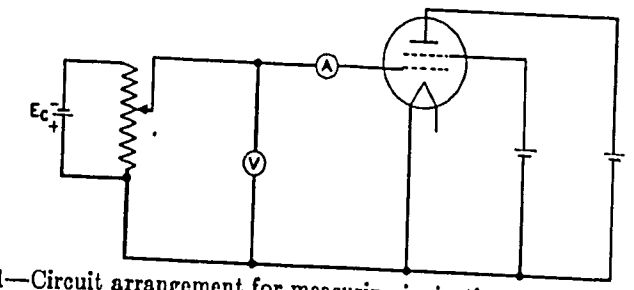


Fig. 11—Circuit arrangement for measuring ionization current—Method A.

The sensitivity of the method can be greatly improved by balancing out the normal plate current, by the connections shown in the dotted lines in Fig. 10, which will permit the employment of a more sensitive plate-current meter.

Precaution: The customary precautions regarding leakage across the switch, S, should be observed when R_c is large.

References

M. von Ardenne, *Zeit. für Hoch.*, 29, 88; March, 1927.
Editorial, *Experimental Wireless*, 4, 457; August, 1927.

B. Ionization, or Gas, Current. Two methods of measuring ionization or gas current are given. Method A may usually be advantageously employed, but where the anode dissipation is high, method B is preferable.

1. Method A

The ionization in a tube containing gas at low pressure may be estimated by the current which flows in a negatively biased control-grid circuit. The direction of the current due to this cause is opposite to the electron current from the cathode. The connections for measurement are shown in Fig. 11. The total current flowing to the negatively biased control grid is chiefly composed of:

(1) Electrons from the cathode which reach the grid by virtue of contact potentials and initial velocities,

(2) Electrons from other electrodes to the control grid,
(3) Ionization current,
(4) Leakage current, and
(5) Electron emission from the control grid.

These may be separated as follows: Fig. 12 shows the contributions of the various sources enumerated with the exception of (2), which is generally negligible. The leakage current (4) may often be measured separately (see next section). The grid emission current can be esti-

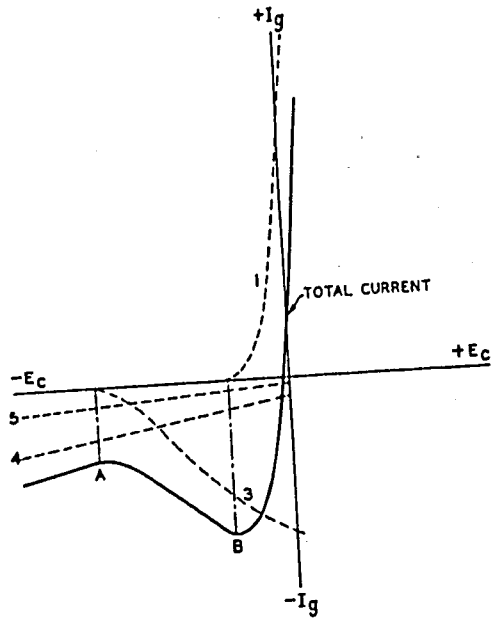


Fig. 12—Composition of total grid current.

mated by noting the current at a bias sufficiently negative (point *A*) to stop the plate current, since at this point (*A*) the ionization current (3), being proportional to the plate current, is negligible. The true ionization current (3) is the difference between the total grid current and the sum of (4) and (5) in the range of grid bias over which this difference is proportional to the plate current. The presence of current (1) is indicated by a failure of this proportionality.

Precautions: Since the emission current (5) is momentarily increased and the ionization current (3) may be affected by the heating and release of gas following a test for normal emission (see part B, section II) it is advisable to make the test for emission from the grid prior to the test for ionization current, or to leave a sufficient time for cooling and clean-up between these tests. This applies to the applica-

tion of a spark coil to reduce leakage with the same force as it does to the test for emission.

In the case of large (e.g., transmitting) tubes the anode dissipation during this test may be high enough to produce abnormal temperature conditions which may result in abnormal gas, emission, and leakage currents. In such cases the following method has the advantage of permitting the measurements to be made at lower anode dissipations.

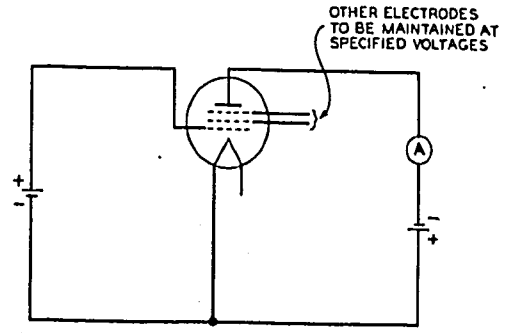


Fig. 13—Circuit arrangement for measuring ionization current—Method B.

2. Method B

An alternative method of measuring the ionization current in a tube consists in measuring the current flowing in the plate circuit which is produced by ionization due to electrons flowing in the grid circuit. The grid is maintained at a positive voltage and the plate at a negative voltage with respect to the cathode (Fig. 13). The cathode temperature is then adjusted to give a suitably small electron current in the grid circuit. The resulting ion current in the plate circuit gives an indication of the gas pressure in the tube.

This measurement may be made with only a small current flowing in the grid circuit so there is but a slight chance of the evolution of gas from the electrodes.

References

O. E. Buckley, *Proc. Nat. Acad. Sciences*, 2, 683, 1916.
C. G. Found and S. Dushman, *Phys. Rev.*, 17, 7, 1921.
S. Dushman, High Vacua, p. 118, (Schenectady, 1922).

C. Leakage Currents. Leakage currents should be measured with a voltage impressed between each two electrodes of the vacuum tube in turn, with the other electrodes floating. Measurements should be made immediately after the filament has been turned off so that all parts (excepting the filament itself) will be as near their operating temperatures as possible. The vacuum tube should be in its complete form with its base, but without socket or holder. A voltage high enough to give convenient readings is suitable. From these readings,

the insulation resistance between the various electrodes may be computed.

Precautions: The results of this test may be obscured by thermionic emission from any electrode which is hot enough to omit electrons.

D. Grid Emission Current. Two methods are available for measuring grid emission current.

1. Method A

If the leakage current can be measured separately, the grid emission current can be estimated by subtracting the leakage current from the

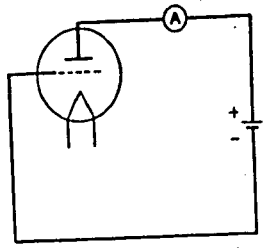


Fig. 14—Circuit arrangement for measuring grid-emission current—Method B.

reversed grid current at a grid bias sufficiently negative to reduce the plate current substantially to zero. (*A* in Fig. 12.) If the leakage current is negligible or can be made so by the application of a spark coil, the test gives the grid emission current directly.

2. Method B

The connections for direct measurement of grid emission are shown in Fig. 14. During this test the electrodes should be at their normal operating temperatures. To this end it is recommended that the tube be operated in the usual way at its normal voltages for a time sufficient to attain normal temperature conditions. By means of switches the connections shown in Fig. 14 are then quickly made and the grid emission noted while the electrodes are still approximately at their normal temperatures. The cathode should be at its normal operating temperature throughout.

Precautions: The above test gives the grid emission directly if the leakage between the grid and plate electrodes is neglibible. If this is not negligible but is known, the leakage current can be subtracted from the observed current to obtain the true grid emission current. The results of this test may be affected by leakage between cathode and grid.

Reference

A. F. Van Dyke and F. H. Engel, Proc. I.R.E., 16, 1532; November, 1928.

V. Interelectrode Capacitance

Interelectrode capacitance should be measured with the cathode cold and with no direct voltages present. The vacuum tube should be in its complete form with its base, but without socket or holder. For most precise results, it is necessary to mount the vacuum tube in a specified way, as with a form of shielding plate. A plate for this purpose has been standardized by the Radio Division of NEMA, Standard No. 340–511.

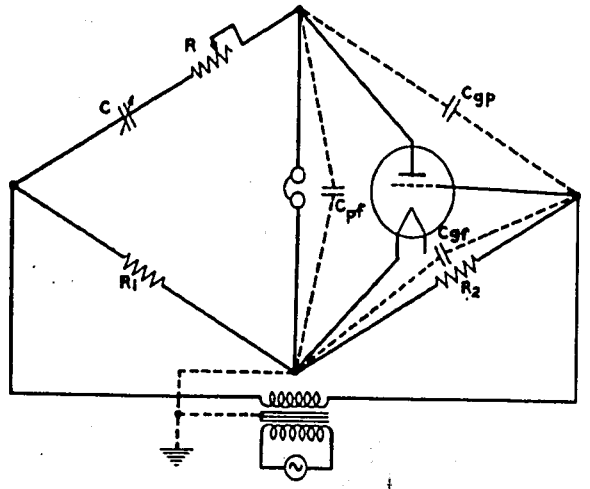


Fig. 15—Bridge method for measuring direct interelectrode capacity.

It is recommended that direct capacitances be measured, rather than total capacitances, which are each the sum of two direct capacitances (see definitions). It is particularly recommended that capacitances be not measured with one electrode floating in potential, as such capacitances are likely to be misleading of themselves and the calculation of the direct capacitances from them is indirect and laborious. The three direct capacitances of a triode are grid-plate capacitance (C_{gp}), grid-cathode capacitance (C_{gf}), and plate-cathode capacitance (C_{pf}). The first of these is the most important on account of its relation to the stability of an amplifier.

When the tube is active the direct interelectrode capacitances differ in general from the values obtained with a cold tube due to the effect of the space charge limited electron current. This difference may be of importance in certain one-way radio-amplifier stages relying upon a balancing network for elimination of feed-back.

A. Direct Interelectrode Capacitances. A bridge method for the measurement of direct interelectrode capacitance in a triode is shown in Fig. 15. In this figure the capacity C_{gp} is shown under measurement

and is connected across an arm of the bridge, the other capacitances being in shunt across R_2 and the telephones. The method is based on the plausible assumption that the shunting effect of a capacity of the order of a few micromicrofarads across R_2 is negligible. The other capacitances may be measured in turn by suitable interchanges of connections, the one under measurement being placed in the upper right arm of the bridge between points A and B.

The resistance R_1 balances the capacitance C_{af} which is in parallel with R_2 and also corrects any accidental phase shifts present elsewhere in the bridge. It is small and does not enter into the calculation so it

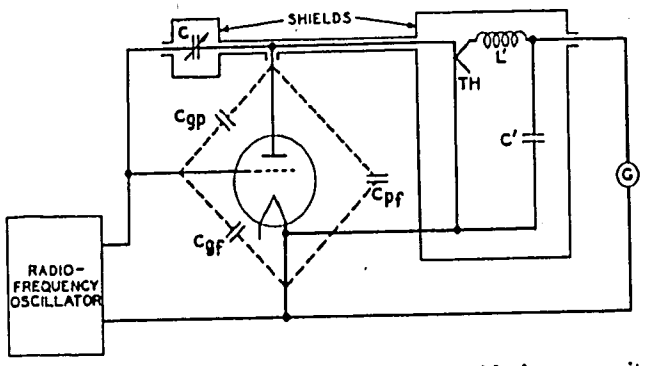


FIG. 16—Substitution method for measuring grid-plate capacity.

may be replaced by other phase correcting means, such as a capacitance in parallel with R. When the bridge is balanced the capacity is

$$C_x \equiv C_{gp} = R_1 C / R_2. \tag{23}$$

Precautions: Leakage, g, across C_x will cause an error amounting to $(g/\omega C)^2$. With $C_x = 5\mu\mu f$ and with an impressed voltage having a frequency of 1000 cycles per second, a leakage of 100 megohms will cause an error of approximately 10 per cent. When accurate results are required, the leakage should be taken into account.

REFERENCES

Lincoln Walsh, PROC. I.R.E., 16, 482; April, 1928.
E. T. Hoch, PROC. I.R.E., 16, 487; April, 1928.

B. Grid-Plate Direct Capacitance. Fig. 16 illustrates a substitution method for measuring grid-plate capacitance, C_{gp}, using a radio-frequency oscillator as a source and a thermoelement, TH, and a galvanometer, G, as an indicator. The shielded condenser, C, is calibrated to read capacitance above an arbitrary reference point and should have a range as great as the largest capacitance to be measured. With C set at this reference point and the vacuum tube in the circuit, the galvanometer reading is taken. The vacuum tube is then removed and

C is adjusted until the galvanometer reading is the same as before. The added capacitance of C is then equal to the grid-plate capacitance C_{gp}. The radio-frequency oscillator should maintain constant voltage and frequency (or at least a constant product of these quantities). The connection from the plate of the vacuum tube through the thermocouple TH to the filament should be short, if it is not shielded. The condenser C' and coil L' constitute a filter system to keep radio-frequency current from flowing through the lead to the galvanometer G.

The arrangement of Fig. 16 may be modified to give a direct deflection method by omitting the condenser C. The galvanometer, G, is read before and after inserting the vacuum tube, the first reading (which may be negligibly small, with proper shielding of the plate lead) being a measure of the direct capacitance present between the wiring to the grid and plate terminals and the second reading being a measure of this capacitance plus the desired grid-plate capacitance C_{gp}. To verify that the oscillator is maintaining a constant product of voltage times frequency, a thermocouple with galvanometer and filter may be connected in series with a small capacitance across the oscillator terminals.

C. Grid-Plate Direct Capacitance of Screen-Grid Tubes. The small grid-plate capacity of screen-grid tubes presents some difficulty when measurements of this capacity are made on tetrodes with the usual capacity bridges. Substitution methods for this purpose are described below.

1. METHOD A

For screen-grid tubes, in which the grid-plate capacitance is small, the substitution method of Fig. 16 can be employed with a calibrated condenser, C, of suitable range, a radio-frequency source of suitable voltage and a detector of somewhat greater sensitivity than the thermocouple shown. Suitable apparatus is shown in Fig. 17.

Due to the great sensitivity required to measure the very small values of capacity, it is desirable that all disturbing influences be minimized. This is accomplished by keeping the capacities across the oscillator and across the detector constant, by means of a balancing tube.

The low capacity switch, S, is first thrown to the tube under test, T_1, and the reading of the microammeter noted. The switch is then thrown to T_2, the balance tube, which should be of the same type as T_1, and the condenser, C, adjusted to give the same reading of the microammeter as before. The feed-back capacity, C_{gp}, is then equal to the added capacity of C.

To obtain the required sensitivity, it is desirable to use a vacuum tube rectifier, D.

Precautions: Outside of the customary precautions of constant voltage supply and thorough shielding, no special precautions are necessary to obtain useful results. However, it is desirable that the ocillator be adjusted so that a small change in the capacity across it does not change the current through the substitution condenser, as indicated on the microammeter.

REFERENCE

A. V. Loughren and H. W. Parker, PROC. I.R.E., 17, 957, 1929.

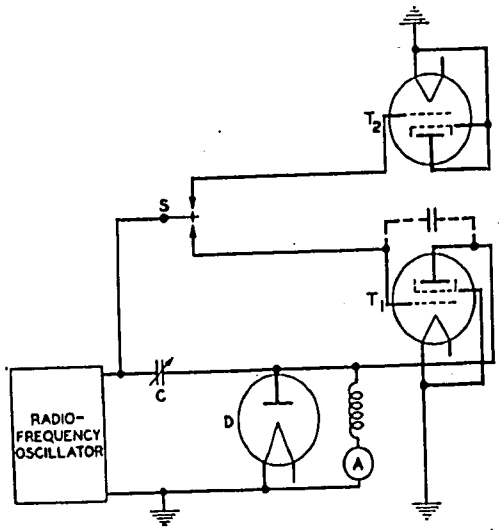


FIG. 17—Circuit arrangement for measuring grid-plate capacity of screen grid tubes—Method A.

2. METHOD B

An alternative substitution method for screen-grid tubes is shown in Fig. 18. This employs a calibrated variable voltage source and a fixed standard capacitor instead of the fixed voltage source and calibrated variable capacitor of Method A.

The output of a radio-frequency generator is led to an attenuator which may terminate in a slide-wire as shown. A standard signal generator, such as employed for receiver measurements, is convenient for this purpose. The current through the grid-plate capacitance of the tube produces a voltage across the antiresonant LC circuit. This voltage is amplified and measured in some convenient way, e.g., by a radio-frequency amplifier terminating in a vacuum tube voltmeter. In the arrangement shown in Fig. 18 a radio receiver is used for this purpose, the radio-frequency oscillator being modulated and an alternating-

current voltmeter connected across the terminals of the loud speaker being used as an indicator.

A standard fixed condenser, C_s, of the order of one-half micromicrofarad, suitably shielded, is substituted for the tube shown in Fig. 18 and the attenuator set so that the impressed radio-frequency voltage is E_s with a standard audio output. The tube to be measured is next substituted for the standard condenser and the attenuator readjusted until an impressed radio frequency voltage, E_x, produces the same deflection at V. Then the unknown grid-plate capacity is,

$$C_{gp} = C_s E_s / E_x. \tag{24}$$

The standard condenser can be enclosed within a vacuum tube blank of standard dimensions. Two circular disks two centimeters in

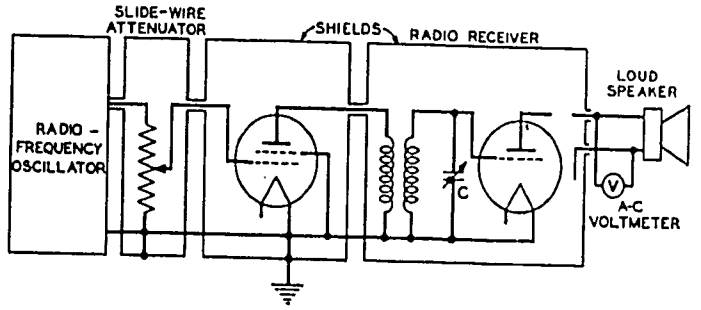


FIG. 18—Substitution method of measuring grid-plate capacity of screen-grid tubes—Method B.

diameter and separated by eight-tenths of a centimeter will provide a standard capacitor of the proper order. This may be calibrated by measurement on a differential capacity bridge.

Precautions: The variable condenser, C, should be readjusted for resonance for each tube being measured. The leads from the attenuator to the tube shield and from the latter to the voltage measuring unit should be completely shielded and the tube itself should be enclosed in a rather closely fitting cylindrical shield. This is provided with a small contactor to the control grid, and the lead to this contactor entering at the top. The lead from the plate leaves at a point near the bottom of the shield.

The input impedance of the detector (a radio receiver in this case) should be small compared with the reactance of the one-half micromicrofarad standard condenser. Generally, this will be assured by connecting to the antenna-ground terminals of the receiver.

VI. Undistorted Power Output

The measurements in this section relate to the power output characteristics of vacuum tubes operating as class A amplifiers. The out-

put capabilities of such devices are conveniently rated as the power output into a resistance load under the conditions that there shall be no grid current during the positive part of the grid voltage excitation cycle and that the total generated harmonics with a sinusoidal excitation voltage shall not exceed five per cent. The power obtained under these conditions is conventionally called the undistorted power output.

The output power will depend upon the magnitude of the external output resistance as well as upon the electrode voltages other than the control grid bias. The maximum undistorted power output which may be obtained is limited by the safe total anode dissipation. These conditions should be specified in determining the undistorted power output of a given tube or amplifier.

If the load resistance is taken as the value for maximum power output regardless of distortion the undistorted power may be called the normal undistorted output. In other cases the load resistance is allowed to vary and that value selected which results in the greatest undistorted output; the output in this case may be termed the maximum undistorted output.

A. Measurement of Harmonics. The harmonic distortion is defined as,

$$D = \frac{(I_2^2 + I_3^2 + \cdots I_n^2)^{1/2}}{I_1} \qquad (25)$$

where,

I_1 is the amplitude of the fundamental, and

$I_2, I_3, \ldots . I_n$ are the amplitudes of the 2nd, 3rd, ... nth harmonics.

The distortion may be measured by a harmonic analyzer, of which several types have been described in the literature. When merely the value of D is desired, as in determining the undistorted output, those analyzers which measure the root-mean-square value of all harmonics present are preferable to those which measure the separate harmonics.

The method of C. C. Suits,[1] is a particularly good example of the type of analyzer which measures the harmonics separately. The Suits method requires only the simplest apparatus and where laboratory facilities are limited this advantage may outweigh the disadvantages involved in the computation of D.

The Belfils analyzer[2] utilizes an alternating-current Wheatstone bridge balance for the suppression of the fundamentals, and is particularly useful for direct measurement of D. For maximum convenience

[1] Proc. I.R.E., 18, 178; January, 1930.
[2] G. Belfils, *Rev. Gen. d'Elec.*, 19, 523, 1926; Irving Wolff, *Jour. Opt. Soc. Amer.*, 15, 163; September, 1927.

the frequency of the audio source should be very stable. This instrument can be operated so that it is direct reading by maintaining a constant input voltage.

In the McCurdy-Blye analyzer[3] low- and high-pass filters are used to separate the harmonics from the fundamental. This instrument is superior to the Belfils type in that the frequency of the source may vary somewhat without necessitating readjustment.

A differential analyzer especially designed for power output work has been described by Ballantine and Cobb[4].

Precautions: The sinusoidal electromotive force applied to the control grid should be free from harmonics. This can normally be assured by the use of a low-pass filter (see Fig. 19).

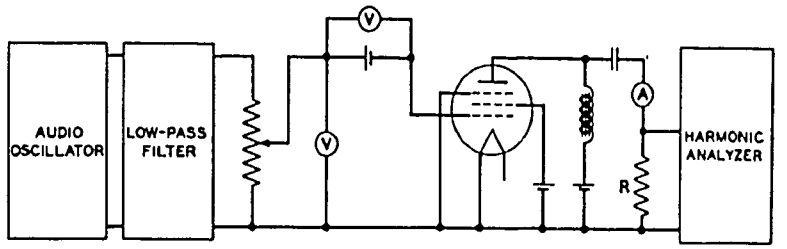


Fig. 19—Circuit arrangement for measuring undistorted power output of a pentode.

If an iron-cored choke is employed for shunt feed in the plate circuit (Fig. 19) care should be exercised in its selection or design to avoid the generation of harmonics in it due to the nonlinear and hysteretic behavior of the iron.

B. Maximum Undistorted Power Output of a Triode. Assuming constant plate voltage, the maximum undistorted power output of a triode is experimentally determined as follows: A value of load resistance equal to twice the estimated plate resistance is chosen, this being approximately the optimum value when the allowed percentage of harmonics is five per cent. A sinusoidal alternating voltage of peak value E, and a steady grid bias E_c, are applied to the grid of the tube and increased together ($E = E_c$) until the percentage of harmonics in the output reaches five per cent. If the plate resistance at this value of bias differs from the estimated plate resistance the value of load resistance is readjusted to approximate more closely twice the actual plate resistance and a second variation of E and E_c made. The final values of r_p and E_c are reached by successive approximations of this sort, the process being continued to obtain the accuracy desired.

If the grid bias is specified, the maximum output is found by re-

[3] *Jour. A.I.E.E.*, p. 461; June, 1929.
[4] Proc. I.R.E., 18, 450; March, 1930.

peating measurements with different load resistances. An alternating voltage having a maximum value equal to the grid bias is impressed on the grid circuit and successive measurements of output are made with increasing values of load resistance until the percentage of harmonics is reduced to five per cent. The output at this point is then the maximum for the given conditions. The load resistance for the maximum output will never be less than the plate resistance and will be greater or less than twice the plate resistance depending on whether the specified grid biases are greater or less, respectively, than the bias found for maximum output when there are no restrictions except plate voltage.

Limitation on plate power dissipation or on direct plate current may be expressed in terms of a specified grid bias and the measurements made as just described.

C. Normal Undistorted Power Output of a Triode. The normal undistorted power output is the maximum undistorted output when the load resistance is specified. The measurement is made in the same way as described in the preceding paragraphs, by applying the highest alternating voltage and bias which will not cause the harmonics to exceed five per cent.

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E. W. Kellog, *Jour. A.I.E.E.*, May, 1925.
J. C. Warner and A. V. Loughren, PROC. I.R.E., 14, 735; 1928.
C. R. Hanna, L. Sutherlin, and C. B. Upp, PROC. I.R.E., 16, 462, 1928.

D. Maximum Undistorted Power Output of a Pentode. This test relates particularly to the type of pentode containing a retarding grid next to the plate which is maintained at a potential near that of the cathode; it also applies to other tubes, such as the screen-grid tetrode, having a plate characteristic which is concave downwards.

Assuming the plate and screen voltages to be specified, two procedures may be followed:

(1) With the load resistance adjusted to some value, the sinusoidal grid voltage E, whose peak value is equal to the grid bias and the grid-bias voltage E_c, are increased together until the harmonics total five per cent. The value of load resistance is changed and this process repeated; this is continued until the maximum power output is obtained.

(2) A sinusoidal alternating voltage is applied to the control grid, the load resistance is set at some large value and the grid bias is adjusted until the harmonic output is a minimum. This is judged by ear, listening to the harmonic output of the analyzer with the fundamental suppressed. Using this value of grid bias and load resistance, the grid voltage is increased until the root-mean-square value of all the harmonics (or as an approximation, the fundamental plus harmonics)

equals five per cent of the fundamental. The load resistance is then decreased and this process is repeated until the peak value of the alternating grid voltage required for five per cent harmonic production attains the value of the direct-current grid bias. The alternating-current power in the external plate resistance is then taken as the maximum undistorted power output at the plate and screen-grid voltage used.

E. Normal Undistorted Power Output of a Pentode. When the load resistance is specified the procedure is the same as in (1) above,

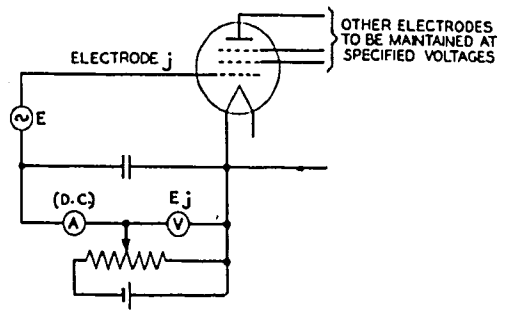

FIG. 20 —Circuit arrangement for measuring rectification characteristic.

E and E_c being increased together until the harmonics total five per cent. The power output at this voltage is the normal power output.

In the case of the pentode the effective plate resistance depends greatly upon the alternating voltage amplitude and the value of load resistance for maximum power output must be selected by successive approximations.

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Stuart Ballantine and H. L. Cobb, PROC. I.R.E., 18, 450, 1930.

VII. Detection Characteristics

The following tube characteristics are of interest in connection with detection, particularly at high signal voltages.

A. Rectification Characteristic (7103). The rectification characteristic is the relation between the average direct current in the electrode circuit in which rectification takes place, the amplitude (or root-mean-square value) of an alternating voltage impressed on the same electrode, and the value of the direct voltage on the electrodes. In the general case of a tube of n-electrodes, the connections are shown in Fig. 20. E is an alternating-current generator considered as having zero direct- and alternating-current impedance. All electrodes not entering directly in the measurements are maintained at steady and specified voltages.

The direct voltage, E_j, on the electrode is usually plotted as abscissa against the average current in this electrode circuit as read

by a direct-current instrument as ordinate, for various values of E as a parameter, (i.e., E is held constant for each graph).

B. Transrectification Characteristic (7106). The transrectification characteristic is the graph between the average current in the circuit of an electrode, the direct voltage on that electrode and the amplitude (or root-mean-square value) of an alternating voltage impressed on another electrode. The connections for this test for a tube of n-electrodes

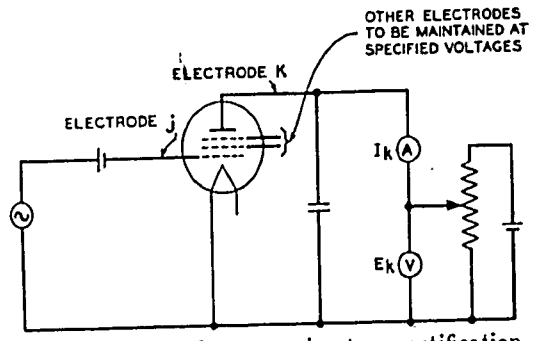

FIG. 21—Circuit arrangement for measuring transrectification characteristic.

are shown in Fig. 21. The electrode j and other electrodes are to be maintained at their specified values of direct voltage.

The direct voltage, E_k, in the electrode circuit, k, is plotted as abscissas against the average current, I_k, in that circuit as ordinates for various values of alternating voltage, E, applied to the other electrode as a parameter (i.e., E is held constant for each graph).

VIII. Phototubes

The rapidly increasing technical importance of photo-electric devices makes it desirable to include in this report a description of the methods of measuring their more important characteristics. This art is young and while the following material is based upon the actual experience of several laboratories and workers, it will be understood that complete standardization is undesirable and impossible at the present time. The methods are therefore set forth tentatively.

A. Technique and Apparatus. For measurements of the photo-electric response the following apparatus is necessary: a light source, a photometer box, and the electrical circuit.

1. Light Source

Considerable discretion is necessary in the selection of the light source. The proper light source to employ will be governed by the use to which the phototube is to be put. For example, in the case of a lithium tube used to measure ultra-violet radiation, a mercury arc in quartz would be indicated as a suitable light source. If the phototube is to be used for sound on film reproduction a desirable source would be a tungsten lamp at the same temperature as the lamp used in the reproducing machine. In practice this temperature is not far from 2870 degrees Absolute and for that reason this value is customarily employed in testing. For tests of this character a standard tungsten lamp should be obtained, preferably one with a concentrated filament (to approximate a point source), sufficiently heavy to insure a reasonable calibrated life. The calibration of this lamp should be checked at the end of every one hundred hours. The bulb should be large enough to allow the tungsten vapor from the filament to rise and deposit thinly over the unused area of the glass. The standardization laboratory should specify the filament current (or voltage) corresponding to a color temperature of 2870 degrees Absolute as well as the candle power at this temperature. The lamp should be operated at this specified value of filament current. The filament current should be accurately measured since a variation of one per cent in current will produce a variation in light intensity of about six per cent. The standard lamp should have its power supplied from a storage battery source and should be fitted with a prefocused base.

2. Photometer Box

The phototube and lamp must be placed in an enclosure from which every trace of extraneous light is excluded. To insure precision in determining the luminous flux incident upon the phototube cathode, a mask should be provided directly in front of the phototube with an aperture exposing either the entire cathode or some definitely described portion of it. The minimum distance from aperture to filament must be great enough to permit the use of the inverse square law in computing the illumination. The value of the light flux in lumens may be calculated from the formula,

$$F = AC/d^2 \tag{26}$$

where,

A is the area of the aperture,
C is the candle power of the lamp, and
d is the distance from the aperture to the filament.

A and d must be measured in the same units. A scale should be provided by means of which d is accurately measured. The lamp socket may be conveniently mounted on a carriage which can be moved toward or away from the lamp just as in the usual photometer practice. It is essential that baffles with central apertures be placed between the lamp and the phototube to exclude extraneous light.

3. Electrical Circuit

The connections usually employed are those shown in Fig. 22. R is conventionally a one-meghom resistor whose function is to limit the current through the tube in the case of a glow discharge in gas phototubes. It is also useful in simulating the actual circuit conditions of the tube in use. The direct-voltage drop in R is ordinarily negligible, but may be corrected for where accurate results are desired. The ammeter A is a multiscale microammeter.

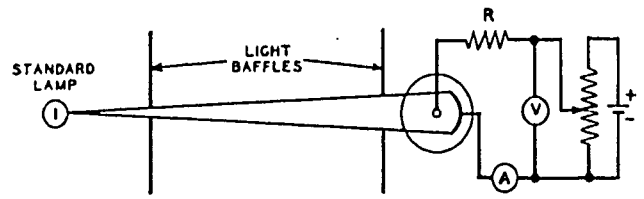

Fig. 22—Electrical circuit arrangement for phototube tests.

B. 2870 Tungsten Sensitivity. When the relation between light flux and current is known to be linear a test of sensitivity at one value of light flux and at the normal tube voltage is usually sufficient for a practical rating of the tube. For a vacuum phototube a light flux of one-half lumen is suitable, and for a gas phototube one-tenth lumen may be used. The standard tungsten lamp is adjusted to a color temperature of 2870 degrees Absolute.

The sensitivity is calculated from,

$$S = I/F, \tag{27}$$

where,

F is the light flux in lumens, and
I is the current in amperes.

C. Current-Voltage Characteristic. With the light source adjusted for a given light flux into the phototube, the voltage across the tube is varied and the current noted. The voltage-current characteristic is usually plotted with voltage as abscissas and current as ordinates. A family of graphs may be obtained by repeating measurements with various values of light flux for each curve.

Precautions: If the tube has appreciable electrical leakage, the leakage must be read with zero light flux for each voltage. The leakage may be subtracted from the observed photo-currents to determine the true current-voltage characteristic.

When the observations are made on gas phototubes at the higher voltages, it is well to proceed cautiously in order to prevent the occurrence of a glow discharge, since even an instantaneous discharge will alter the cathode surface.

D. Current-Illumination Characteristic. At a given voltage, the light flux is varied and the corresponding tube currents are noted. A family of such graphs, each for a different tube voltage, is useful. The light flux is plotted as abscissa and the current as ordinate.

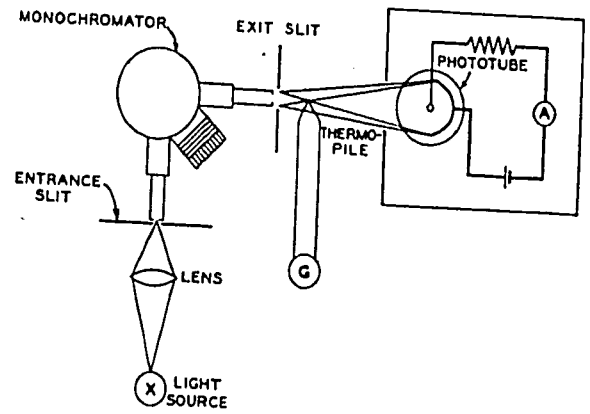

Fig. 23—Optical system for determining monochromatic sensitivity or response-color relation of a phototube.

Precautions: A gas phototube may glow when the illumination exceeds a critical value, even through the rated maximum voltage is not exceeded. This should be guarded against.

E. Response-Color Characteristic (7313). For determining the response-color characteristic some optical means of obtaining light flux having a known uniform energy distribution over a narrow range of frequencies is necessary. A convenient instrument for this purpose is the quartz monochromatic illuminator with a constant deviation optical system. The arrangement is shown in Fig. 23. The slits should both be adjusted to about one hundred Angstroms effective width at 8000 Angstroms. A sensitive linear thermopile is mounted immediately in front of the exit slit and is connected to a sensitive, critically damped galvanometer of approximately equal resistance. The usual precautions must be observed to avoid vibration of the galvanometer and to prevent contact and spurious thermal electromotive forces. The energy which falls between the silver squares of the thermopile is proportional to that which falls on the squares and is transmitted to the phototube. The phototube is mounted in a light-tight box directly behind the thermopile and is connected to a sensitive, direct-current single stage or bridge amplifier. The current output of the amplifier must be propor-

tional to the photo-current in the tube. The maximum phototube current will probably never exceed one-tenth microampere.

The data for the curve are obtained by dividing the output current reading of the amplifier by the thermopile galvanometer current reading for different wavelength settings throughout the spectrum, and the resulting ratios plotted against wavelength.

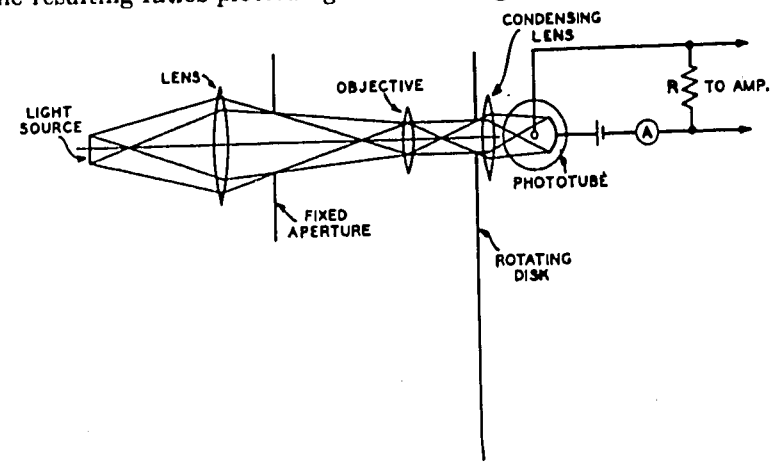

Fig. 24—Pulsating light source for determining pulsation frequency response characteristic.

For the infra-red and visible ranges up to about 5000 Angstroms, an ordinary tungsten lamp with condensing lens serves as a source of energy. For the violet and ultra-violet, a mercury arc in quartz without a condensing lens is very satisfactory.

F. Pulsation Frequency Response Characteristic (7314). Curves of the dynamic response, or of the alternating-current output of the tube for various modulation frequencies of a modulated light flux, are of interest in the case of tubes, such as the gas types, which show inertia in response. The important requirement for this test is a light source whose modulation can be varied over the required frequency range. Variation of the degree of modulation is seldom essential, and one hundred per cent modulation will generally suffice. The variation of the modulated light flux is of the type,

$$\phi = \Phi(1 + \sin \omega t). \qquad (28)$$

Various methods of modulation may be employed, such as: (1) the Kerr cell, (2) properly excited neon, or other glow discharge lamps, or (3) a rotating disk system. Considerable care must be employed with the first two methods to obtain accurate results. The sectored disk is accurate and convenient. A suitable disk arrangement is shown in Fig. 24.

The optical system of Fig. 24 avoids wandering of the light upon the light-sensitive surface of the tube. The shapes of the fixed and rotating apertures are shown in Fig. 25. That of the fixed aperture is sinusoidal; that of the rotating apertures is rectangular. The dimensions of the apertures should be chosen so that the dimensions of the image of the stationary aperture at the plane of the rotating disk are accurately equal to those of the apertures of the rotating disk. The image a' should equal a and the image of b' should not be larger than b. The

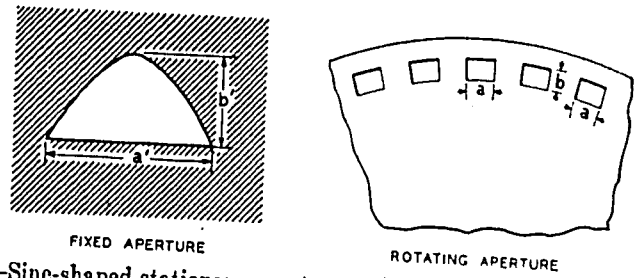

Fig. 25—Sine-shaped stationary aperture and rectangular rotating aperture for producing completely pulsating light flux.

modulation frequency may be varied by varying the speed of rotation. For a given speed range the frequency range can be extended by employing several sets of apertures in the rotating disk, proper fixed apertures being used with each set.

The alternating-current output of the tube is measured by a calibrated amplifier-voltmeter connected across the one-megohm resistor.

To obtain a frequency-response characteristic, first adjust the rotating disk so that the deflection of the direct-current microammeter is a maximum. Then by consulting the static current-illumination characteristic of the tube adjust the light so that a deflection corresponding to twice the mean flux desired is obtained at this aperture setting. The rotating disk is then rotated to give the modulation frequencies desired.

Reference

R. Moeller, *Farnsehen*, 1, 127; March, 1930.

G. Gas Tests. In a gas phototube the residual gas pressure may be estimated by measuring the ratio of currents at two different anode voltages. For example with a tube intended to operate at ninety volts the currents are noted at ninety and twenty-five volts. The ratio of the currents at these two voltages gives an indication of the gas pressure and should not exceed a specified maximum. No minimum limit is necessary since the sensitivity test eliminates danger of the gas pressure being too low.

H. Leakage. The leakage should be measured with the tube in absolute darkness and with normal applied voltage.

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PERFORMANCE INDEXES AND TESTS OF ELECTRO-ACOUSTIC DEVICES

Introduction

The purpose of the performance indexes and tests in this section is to define indexes by which the more important performance characteristics of electro-acoustic devices associated with radio can be specified and evaluated, to indicate the general method of procedure in determining these indexes, to point out the precautions which it is necessary to observe in order that the results obtained be not greatly influenced by extraneous factors, and to recommend a preferred form for presenting the data and necessary associated information. In general the performance indexes given specify the over-all performance of the devices in a form most readily associated with their ordinary usage. The determination of many of these performance indexes involves acoustic measurements which are complicated and on which the technique is in a state of development. As a result rigid standardization of testing technique does not appear advisable at this time since a complete specification of a suitable measuring method that would permit a close duplication of results by different individuals would be so involved and so arbitrary as to make adhering to such a specification quite impracticable. Furthermore such standardization would tend to discourage progress in developing better testing methods and be altogether adverse to the intended purpose of this work. On the other hand it is possible to indicate here a suitable method of procedure for determining these performance indexes so that by observing certain precautions and stating roughly the measuring conditions, the data obtained can be interpreted. It is, therefore, to encourage reliable and interpretable methods of measuring and expressing the performance characteristics of electro-acoustic devices that the following section has been prepared.

Many of the performance indexes defined may be expressed in terms of the transmission unit, decibel (db). This unit is logarithmic in nature. For comparison of tones of similar composition one decibel corresponds closely to the minimum perceptible change in loudness. The use of a logarithmic unit facilitates comparisons of curves since the shape of the curve is not altered by a change in the general level.

While the indexes defined indicate, in the majority of cases, the degree of perfection of an electro-acoustic device, it should be understood that a satisfactory rating according to these indexes does not necessarily assure a completely satisfactory device. For example, a

loud speaker may possibly appear attractive from the response frequency curve and from loudness efficiency data and at the same time have a strident rattle or excessive harmonics that completely disqualify it. If this rattle were due to excessive power levels and disappeared at low levels this difficulty would be signified by a low overload power rating. But if the rattle were present at all levels it could not be attributed to overloading and none of the quantities defined below would show the loud speaker to be unsatisfactory. It is very difficult to define and evaluate indexes relating specifically to such characteristics and until the more tangible indexes have been given more adequate consideration it is proposed not to attempt any such evaluation.

I. General

A. Absolute Efficiency. The absolute efficiency of an electro-acoustic transducer for a given circuit condition is the ratio of the output of the transducer to the output of the ideal electro-acoustic transducer. This may be expressed as a ratio, a percentage, or in decibels relative to unity or one hundred per cent, for example:

Power Ratio	Percentage	Decibels
1.0	100	0.0
0.5	50	− 3.0
0.1	10	−10.0

II. Loud Speakers

A. Relative Loudness Efficiency. The relative loudness efficiency is a comparative measure of the acoustic outputs of two loud speakers as observed aurally in the sound medium at a specified point relative to the location of the two loud speakers. It is expressible as a percentage or in decibels by the following ratio,

$$\frac{E_1^2 R_2}{E_2^2 R_1} \qquad (1)$$

where,

E_1 is a voltage in series with the first loud speaker taken as a standard and a resistance R_1 equal to the impedance to which this loud speaker is designed to be connected,

E_2 is the voltage in series with the other loud speaker and a resistance R_2 equal to the impedance to which the second loud speaker is designed to be connected.

The values of E_1 and E_2 are such that the two loud speakers give the same loudness of sound at the observer's position as judged by the ear.

The purpose of this index is to give a suitable means for rating loud speakers on a basis of loudness for a specified type of input program, i.e., speech, orchestral music, single frequencies, etc. Although a curve showing the absolute efficiency as a function of frequency gives an indication of the loudness to be expected from a loud speaker, the comparative results to be expected from two or more loud speakers are sometimes difficult to determine since the frequency ranges that are covered and the shape of the curves may be different. While it would be desirable to compare the loudness of two loud speakers directly from objective measurements this is not possible at the present time.

Comparison of the relative loudness of several sounds directly by listening is also impossible. In a listening test we have no basis for stating that one sound is twice as loud as another and tests have shown that different observers would disagree on what twice as loud means. However, two sounds may be adjusted to have practically the same loudness, and different observers will agree closely as to their equality. For this reason the indirect method of adjusting the electrical supply to the loud speakers until the same loudness has been obtained is used rather than the more direct one of obtaining a comparison of the loudness with equal electrical inputs.

In this and some of the following performance indexes the electrical input to the loud speaker is expressed in terms of the open circuit voltage and impedance of the supply source rather than in terms of the current through the loud speaker, the voltage across it, or the actual power absorbed from the source, because in this way an important characteristic of the loud speaker, its ability to absorb power from the source, is given proper consideration. For example, a loud speaker having a normal impedance with a large reactive component can absorb relatively little power from an amplifier and the acoustic effect must be small although the ratio of the acoustic effect to the power actually absorbed may be large. Such a loud speaker, however, would not be considered as desirable as one that could produce a greater acoustic effect by absorbing more power; by expressing the electrical input by the voltage and impedance of the source the relative desirability is properly indicated.

In specifying the conditions for these and other tests a resistance equal to the impedance to which the loud speaker is designed to be connected is mentioned as being placed in series with the loud speaker. This is a convenient way of specifying or expressing the equivalent

circuit condition that exists when the loud speaker is properly connected to a vacuum tube either directly or through an impedance matching transformer. The specification of the source for purposes of testing loud speakers in terms of a voltage and a resistance is justified by the fact that the source of power for practically all loud speakers in present day use is one or more thermionic tubes whose internal impedance is a pure resistance and whose characteristics within sensible error may be duplicated by supplying a voltage of $E=\mu E_g$ in series with a resistance, r_p, where E_g is a voltage supplied to the grid, μ is the mu-factor for the tube in question, and r_p is the internal plate resistance.

B. Response. The response of a loud speaker is a measure of the sound produced at a designated position in the medium with the electrical input, frequency, and acoustic conditions specified. It is expressible by the ratio,

$$\frac{p}{\frac{E}{\sqrt{R}}}, \qquad (2)$$

where,

R is a resistance equal to that of the source to which the loud speaker is designed to be connected,

E is the voltage (at the specified frequency) supplied to the loud speaker in series with the resistance R, and

p is the resultant sound pressure in the medium (at the specified frequency) at a specified point, or the average of the resultant pressures at specified points relative to the loud speaker.

The response may be expressed by a value equal to the above ratio or may be expressed in decibels relative to an arbitrary value of response corresponding to one volt, one ohm, and one bar. Thus the response of a loud speaker in decibels equals

$$20 \log_{10} \frac{\frac{p}{E/\sqrt{R}}}{\frac{1}{1/\sqrt{1}}} = 20 \log_{10} \frac{p}{E/\sqrt{R}}. \qquad (3)$$

Frequency discrimination is probably the most frequent and dominant cause of distortion in present commercial loud speakers. While other factors are important the first consideration in loud speaker design is an attempt to reduce to a minimum variations in performance with frequency. Measured data showing quantitatively the performance at each frequency are probably the most important information upon which to judge the merits of a loud speaker. A suitable and convenient manner of expressing this performance of a loud speaker at each frequency is provided by the above definition of response.

Measured response values on a loud speaker at a particular frequency may be widely different depending upon the acoustic measuring conditions. For this reason the phrase "under specified acoustic conditions" in the above definition is very important. A measured response value without a specification of the measuring conditions is not significant. Furthermore, it is possible to measure the response of a loud speaker under such acoustic conditions that the measured data

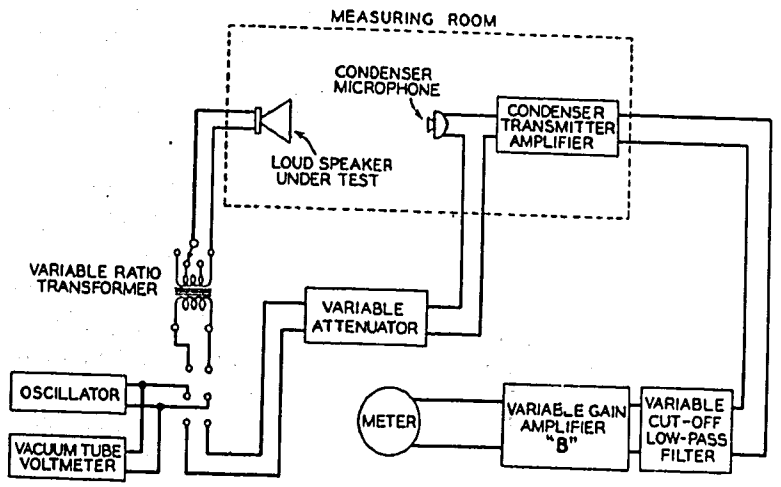

FIG. 1—Loud speaker response measuring system.

will give little or misleading information regarding the performance of the loud speaker as it would be observed aurally. If, however, suitable precautions are taken and certain of the more important measuring conditions are specified the response data plotted as a graph provide the most useful index of the frequency discrimination in a loud speaker. The general procedure for obtaining a response-frequency graph of a loud speaker, important measuring precautions and expedients that must be observed, and a proposed form for a response frequency curve with its associated information are discussed below.

C. Measuring Apparatus and General Procedure. Fig. 1 shows a circuit in schematic form for measuring the response of a loud speaker. With the possible exception of the condenser microphone the apparatus shown is in such general use that it requires little further comment. The condenser microphone is proposed for this purpose because of its ruggedness and the straightforward manner in which it can be used.

A thermophone or other suitable calibration, corrected if necessary to show the relation between the undisturbed root-mean-square pressure in a plane progressive sound wave in which the microphone is located and the root-mean-square open circuit voltage, should be obtained from the manufacturer of the microphone. This calibration graph is used as discussed later. A variable cut-off low-pass filter is shown in the amplifier circuit to insure that the performance at only one frequency is being measured. The variable ratio transformer between the oscillator and the loud speaker makes it possible to connect the loud speaker to an impedance equal to that for which it is designed. Care should be taken in the selection of this transformer to be certain than the impedance (looking back from the loud speaker) is practically a pure resistance for the frequency range over which measurements are made.

Although similar apparatus may be used for either step-by-step change of frequency or continuous variation of frequency with a recording meter the procedure of adjustment is somewhat different so that the complete procedure in each case will be described. The step by step method has the advantage that no output calibration of the amplifier B or of the oscillator is necessary and offers the possibility of readjusting the low-pass filter for all frequencies so that even though harmonics are present in the oscillator and loud speaker output the readings give a true indication of the output of fundamental frequencies. The continuous frequency variation method offers the advantage of speed in making measurements but requires an oscillator, microphone, and amplifier, which have been equalized over the frequency range to be covered and makes it difficult to use the harmonic reduction filter. If the harmonic reduction filter is not used a check of the output wave form of amplifier B by means of a cathode ray or other oscillograph is advisable.

The adjustment procedure for step by step measurement will first be described. The loud speaker under test and the microphone are suitably placed in a relatively large room or outdoors. The output or terminal voltage of the oscillator when open-circuited or connected to the attenuator is then adjusted to a suitable value by means of the vacuum tube voltmeter. The oscillator is then switched to the loud speaker and the sensitivity of the amplifier B adjusted until a satisfactory deflection of the indicating meter is obtained as a result of the sound pressure on the microphone. The oscillator is then switched from the loud speaker to the input terminals of the attenuator and the attenuator adjusted to give the same meter deflection. The attenuator is calibrated either in decibels or the corresponding voltage ratios and the response value is read directly from the attenuator. An adjustment

of the attenuator such that there is no attenuation, however, does not correspond to a response of zero decibels or unity power ratio, depending on the method of expression. This latter response is indicated by the attenuator setting when, with a unity value for the ratio of the oscillator open-circuit voltage to the square root of its impedance, the voltage at the attenuator output terminals is equal to that generated by the microphone with one bar pressure on the diaphragm. The generated volts per bar* can be obtained from the microphone calibration and the total attenuation corresponding to zero decibels or unity response can thereby be readily calculated. If the attenuator input impedance is equal to the oscillator impedance the total attenuation in decibels corresponding to zero response is,

$$db = 20 \log_{10} \frac{\sqrt{R_s}}{2m}, \tag{4}$$

where,

R_s is the oscillator impedance, and
m is the microphone sensitivity in volts per bar.

The response measurements are then expressed as a number of units above or below this reference setting, i.e., +17 db or −6 db, or as the corresponding current or voltage ratios, 7.1 or 0.5.

The procedure of adjustment, if continuous recording is used, can be as follows: In order to determine the proper equalization of the system the oscillator is connected to the attenuator and either the attenuator or the variable gain amplifier is adjusted until a convenient reading of the output meter is obtained. By varying the frequency of the oscillator the over-all frequency characteristic of the system can be recorded. The amplifier should be equalized until the output frequency curve with this connection has the same shape as the inverse of the condenser transmitter calibration curve It is a good plan to check this equalization in a similar manner from time to time when taking a loud speaker graph.

Before taking a loud speaker graph the oscillator should be set at some convenient frequency and connected to the attenuator. Adjustment is then made, either by means of a variation in the gain of amplifier B or the oscillator output, until the recording meter reads

$$\frac{S\sqrt{R_s}}{n\,m} \text{ divisions}, \tag{5}$$

* A value should be chosen that obtains over the greatest portion of the frequency range. Variations from this value should be corrected for in the measured response data.

where,

S is the ratio of the attenuated output to the open-circuit voltage of the oscillator as determined by the attenuator setting,

R_s is the output impedance of the oscillator,

n is the numerical value of the response per division it is desired to record, and

m is the microphone sensitivity in volts per bar at the frequency at which the adjustment is made.

After the adjustment has been made as described above the oscillator output is connected to the loud speaker and the frequency response of the loud speaker can be recorded.

While there are other circuit arrangements by which it is possible to obtain satisfactory results the above systems have the advantage of requiring the precise calibration only of the condenser microphone and the associated attenuator or resistances. The amplifiers and the meter serve only to compare the magnitude of the microphone voltage with the attenuator voltage and any variation in their sensitivity over a period of time can in no way affect the accuracy of the results. In the first method described it is also unnecessary to maintain a definite frequency characteristic in the amplifier. In the second method the frequency characteristic must be checked from time to time as has been indicated. Furthermore if the loud speaker under test is not overloaded the results obtained will not be influenced even by large variations in the oscillator output with frequency. The change in the oscillator output changes both the sound intensity and the attenuator output in the same proportion so that the measured response value does not change. The loud speaker sound intensity may be of any magnitude below the overload power and well above any extraneous noise level. It should be remembered, however, that the microphone sensitivity depends upon the polarizing voltage and that the methods outlined do not compensate for changes in microphone sensitivity. Precautions therefore must be taken to make sure that the voltage at the microphone is maintained constant at the value used in the microphone calibration.

D. Acoustic Difficulties, Precautions, and Expedients. In making loud speaker measurements it is desirable to eliminate, in so far as possible, any effect of the measuring room enclosure on the results. While the room may influence the aurally observed performance to a considerable extent, loud speakers are used under such widely varying conditions that measurements incorporating the peculiarities of any one room would not be of general interest. On the other hand, if the measurements show the performance of the loud speaker only,

allowance can be made at least qualitatively for the probable influence of the enclosure where it is to be used and a more accurate prediction of the suitability of the loud speaker for the purpose can be obtained.

The most useful response measurements for many purposes are those in which the sound pressures are measured at some point (usually one directly in front of the loud speaker) and the radiation of the loud speaker in other directions is ignored. If, however, the loud speaker is to be used where a large part of the sound reaching the listener will have been reflected, the prediction of the result necessitates ascertaining not only the radiation directly toward the listener, but also that in other directions, in order that the reflected sound which will reach him may be estimated. For such purposes the forward response data may be supplemented by response measurements obtained at various positions around the loud speaker or by measurements of total sound power output as a function of frequency.

Sound reflections from the walls, ceiling, and floor of the measuring room may produce a large amount of sound energy at the microphone which it is not desired to include in the measurements and under steady state conditions may cause complicated standing wave patterns. These patterns change greatly as the sound source changes from one frequency to another. The result is that the pressure at the microphone goes through a series of maxima and minima which may differ widely from the actual response of the loud speaker. Reduction of the standing wave effect may be secured either by reducing the magnitude of the reflected sound as compared with the direct sound or by some method of averaging the sound pressures.

For a constant sound output from the loud speaker the intensity of the reflected sound in a measuring room is dependent upon the sound absorbing ability of the enclosing surfaces. As an approximation this intensity decreases as the sum of the products of the areas of the enclosing surfaces and their respective absorption coefficients increases. Thus, by increasing the size of the measuring room and by increasing the absorption at the walls with sound absorbing materials, the energy density of the reflected sound can be diminished until it is small compared to the outwardly radiated sound close to the loud speaker. The microphone can then be placed near the loud speaker and if the distance from the loud speaker and microphone to the walls, ceiling, and floor is considerably greater than their distance from each other, the resultant measurements will be essentially that of the direct radiation.

There is, however, a minimum satisfactory measuring distance that is dependent upon the size of the loud speaker radiating surface; the larger the surface the larger must be the measuring distance. If the

microphone is placed closer than this minimum satisfactory measuring distance, the measured response data will be influenced by peculiarities in the sound field near the radiating surface and will not give a true representation of the performance as it would be observed normally at a more remote point. It is recommended that the microphone be placed not less than $d^2f/4500$ feet nor less than $2d$ feet from the loud speaker, d being the maximum dimension of the radiating surface in feet, and f being the highest measured frequency. The first of these quantities is derived from an analysis[1] of diffraction effects and while based on the case of a circular piston in an infinite baffle, has been found a satisfactory guide for other radiating surfaces. The second expression is chosen so that radiation from some points on the radiating surface will not be too much attenuated in comparison with that from other points as would be the case if the microphone were placed too close. On the other hand, a distance greater than the normal listening distance should not be used because irregularities existing at the normal listening distance are indicative of the normally observed performance of the loud speaker. In making measurements at short distances care should be taken to prevent standing waves between the microphone and loud speaker by maintaining sufficient separation or by a suitable angular displacement of the plane of the microphone.

In practice, measuring rooms sufficiently free from reflections are usually difficult and expensive to obtain. Sound absorbing materials at present available vary in their absorption at different frequencies to such an extent that a very large measuring room (50,000 cubic feet or larger) with much absorbing material is generally necessary for a loud speaker with a broad frequency range if no other means of obviating the effect of reflections is to be employed. In many cases this is not attainable and it is, therefore, usual to use a moderate sized room (i.e., 5,000 cubic feet with a high ceiling), to cover the walls, ceiling and also the floor with the best obtainable absorbing material, to place the loud speaker and microphone well above the floor, and to use an averaging means. One such means[2] consists in swinging or rotating the microphone in order to obtain an average reading throughout a region having at least one dimension larger than one-half a wavelength at the measuring frequency. The indicating system for this purpose should preferably have a long period so that a fairly steady average reading is obtained as the microphone is rotated. The thermocouple meter is well suited in this respect. Another method[3] of averaging consists in varying the frequency of the oscillator re-

[1] I. B. Crandall, Theory of Vibrating Systems and Sound, p. 137.
[2] L. G. Bostwick, *Bell Syst. Tech. Jour.*, 8, 135, 1929.
[3] E. Meyer and Paul Just, *Zeit. f. Tech. Phys.*, 10, 309, 1929.

peatedly over a frequency band sufficient to change materially the standing wave pattern. These two expedients, however, become rather inadequate at low frequencies, due, in one case, to the mechanical difficulty of moving the microphone more than one-half a wave length and, in the other case, to the necessity of using a frequency band in which the frequency variation is so large that little information regarding the single frequency performance results. At very low frequencies measurements in a very large room or outdoors are most reliable and least influenced by standing wave difficulties.

A third method[4] of averaging consists in swinging through the frequency band in the continuous frequency measuring method described above, at such a rapid rate that the output indicating meter cannot follow the interference maxima and minima but indicates an average of these. This method assumes that the peaks and depressions in the loud speaker response are broad compared to those due to interference and does not give a true indication of a loud speaker's performance if the acoustic output varies sharply with frequency.

The above averaging methods measure the total average energy density due to both the reflected sound and that radiated directly from the loud speaker and therefore give measured response values that are larger than would be the case if the reflected sound were not present. While in general the error due to the inclusion of the reflected sound energy is much smaller than that due to standing wave interference patterns, it is still by no means negligible. For example, if a room 20′x20′x15′ were lined with absorbing material having an absorption coefficient of 0.25 at 100 cycles (a typical value for available materials at this frequency), the average reflected energy density would be approximately 120 per cent of that outwardly radiated from a nondirectional source at a distance of four feet. This would cause the response to be about 3.4 decibels higher than if the reflected sound were not present. This error obviously varies with variations in the coefficient of the absorbing material with frequency and can only be reduced by diminishing the relative magnitude of the reflected sound as discussed above. The illustrative figures were calculated from the following formulas:

$$\text{Average reflected sound energy density} = \frac{4P}{CAS}(1 - A), \quad (6)$$

$$\text{Sound energy density directly from source at distance } R = \frac{P}{4\pi R^2 C}, \quad (7)$$

[4] I. Wolff and A. Ringel, Proc I. R. E., 15, 363, 1927; E. W. Kellogg, *Jour. Acous. Soc. Am.*, 1930.

where,

P is the power radiated by the sound source,

C is the velocity of sound,

A is the absorption coefficient of sound absorbing material, and

S is the combined area of walls, ceiling, and floor of measuring room.

How far it will be necessary to go in reducing reflections depends upon the measurements to be made and the characteristics of the

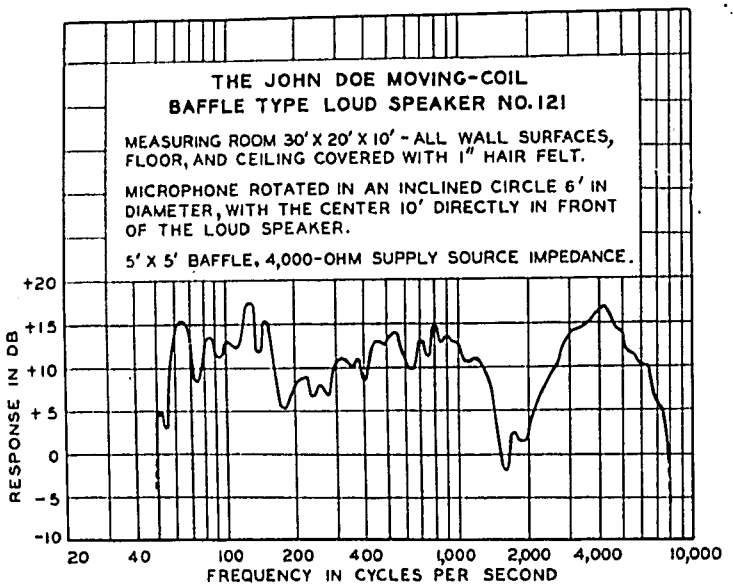

FIG. 2—Response frequency graph of loud speaker.

loud speakers to be tested. If the loud speakers are very directional and only the response within the concentrated sound field is to be measured, the difference between the direct and reflected sound would normally be greater than in the case of nondirective loud speakers in the same room and consequently the room might be suitable for the former but not suitable for the latter. On the other hand, if measurements outside the concentrated sound field are to be made, such as for determining directional characteristics, it is necessary that the reflected sound be of a very small magnitude, the exact magnitude, of course, depending upon how far from the concentrated field it is desired to measure. In general, measurements intended to show the sound field distribution should be made outdoors.

E. Response Frequency Graph. The response measurements at each frequency are most satisfactorily presented as a curve on rectangular coördinate graph paper with frequency values as abscissas

and response values as ordinates. A logarithmic frequency scale is preferable. To obtain a satisfactory graph it is recommended that about ten measurements per octave be made except when the response curve is very irregular, in which case the measurements should be made sufficiently close together to define the graph clearly.

As previously mentioned the response graph has little significance unless accompanied by information regarding the measuring conditions. This information should preferably be lettered on the graph paper as a caption. It should state briefly, or indicate by a sketch, the approximate dimensions of the measuring room and the extent and nature of the sound absorbing material in the room, the location of the microphone relative to the loud speaker when the measurements were made, and the method of minimizing standing wave effects. While it is not possible to give very explicit information in the caption, brief statements regarding these three conditions will enable a comparison of the response frequency curves measured under different conditions and permit one familiar with such curves to interpret the significance of any differences which may exist. Fig. 2 shows a response frequency graph in its preferred form and illustrates the manner of expressing measuring conditions.

The input overload power of a loud speaker at a specified frequency is

$$E^2/4R \text{ watts} \qquad (8)$$

where,

E is the maximum value to which the open circuit root-mean-square voltage of the electrical supply source can be increased without any aurally perceptible change other than intensity occurring in the sound output, and

R is the output resistance of the supply source to which the loud speaker is designed to be connected.

F. Summary. A complete specification of the performance of a loud speaker should include in general the following information:

(1) A response frequency graph for a given microphone position, usually directly in front of the loud speaker.

(2) A series of graphs showing the directional distribution of the sound field in free space. These graphs may be either polar coördinate graphs showing the variation in response at each frequency in a series of microphone positions in both the horizontal and vertical planes, or they may be the complete response frequency graphs on rectangular coördinate paper taken for each of several microphone positions. In the

first case the frequency interval should be so small and in the second case the microphone positions should be so close together as to show in both cases, a gradual progression of one curve toward another. The curves should be taken throughout a sufficiently large angle in both the horizontal and vertical planes to subtend substantially the total radiation.

(3) An absolute efficiency frequency curve, or in case of the comparison of two loud speakers, relative loudness efficiency data. A definite relation holds between the response and the absolute efficiency of a loud speaker. The absolute efficiency is equal to the surface integral, over a sphere with the loud speaker at the center, of the square of the response ratio, i.e., $p/(E/\sqrt{R})$ multiplied by 10^{-8}. This integral can be approximately obtained by computation from the response frequency curve and from the directional characteristics taken over a sphere sufficiently distant from the loud speaker so that its ultimate directional characteristics have been obtained.

(4) A curve showing the input overload power at different frequencies. When the loud speaker is limited in its power capacity by rattling, buzzing, overheating, or mechanical breakage due to vibration this information should also be given.

III. Microphones

A. Relative Loudness Efficiency. The relative loudness efficiency of two microphones (with their associated connecting circuits), when these are alternately connected to the grid-filament circuit of a vacuum tube, is a comparative measure of their useful outputs for these conditions when placed successively at the same position in the sound field. It is expressible as the necessary percentage or decibel change in the power output of the vacuum tube using one microphone as a standard in order that the output shall be of the same magnitude as when using the other microphone, equality of the output being judged by listening to a connected telephone receiver or loud speaker.

B. Response. The response of a microphone (with its associated connecting circuit) when used in conjunction with a vacuum tube having a designated input capacitance is a measure of its electrical output for a specified frequency and pressure on the diaphragm. It is expressible by the ratio.

$$\frac{E_g}{p}, \tag{9}$$

where,

E_g is the voltage produced by the microphone between the grid and filament of the associated vacuum tube when the microphone is connected thereto and operated in the manner for which it was designed, and

p is the sound pressure in bars at the specified frequency on the microphone diaphragm.

The response may be expressed by a value equal to the above ratio or may be expressed in decibels relative to an arbitrary reference condition of one volt per bar. Thus the response in decibels equals

$$20 \log_{10} \frac{\frac{E_g}{p}}{\frac{1}{1}} = 20 \log_{10} \frac{E_g}{p}. \tag{10}$$

C. Burning. Burning is a rapid, transitory, and for the most part, nonperiodic resistance fluctuation in a carbon microphone. It is evidenced by a frying or sputtering noise sometimes heard from a connected receiver.

D. Breathing. Breathing is a slow and, for the most part, periodic variation in the resistance of a carbon microphone. It may be of relatively large magnitude and is not in general audible.

E. Packing. Packing in a carbon microphone is a condition caused by excess mechanical pressure between points of contact or by coherence between points of contact resulting from excessive voltages. It is evidenced by decreased resistance and sensitivity of the microphone.

SAFETY STANDARDS

PROVISIONS FOR SAFETY OF OPERATING PERSONNEL IN RELATION TO RADIO TRANSMITTING EQUIPMENT

Introduction

THE following Provisions for Safety of Operating Personnel in Relation to Radio Transmitting Equipment are recommended as a safety code for use in all cases where radio transmitting equipment is installed or used, either permanently or experimentally. The recommendations are to be construed as offering supplementary material not ordinarily covered in the existing electrical codes. In all cases, it is recommended that radio equipment shall have safety provisions in accordance with the standard practices prevailing for electrical machinery in addition to the provisions contained herein.

I. Antenna Protection

A. Outdoor Insulation. Insulators will operate with a minimum electrical safety factor of three (3) at normal rated transmitter output. The mechanical safety factor will be not less than four (4).

B. Interior Antenna Leads. Leads are to be of the self-supporting type, preferably of copper tubing, so mounted as to be out of reach, or protected against direct contact. It is desirable that the leads be conspicuously marked or colored. Conductors mounted on insulators and covered with inadequate insulation will be avoided.

C. Exterior Antenna Leads. All leads subject to direct contact will be protected by a grille or lattice. If the grille or lattice is of metal, it will be grounded.

D. Blocking Condensers. The antenna system should have protection from direct application of high voltages from the power supply, by the insertion of blocking condensers or other means, between the high voltage power source and the antenna.

E. Static Charges. Means should be provided at the antenna entrance or in proximity thereto, for protecting the antenna against lightning, or energy pick-up from near-by antennas during periods of shutdown.

F. Antenna Entrance. Means should be provided to prevent conduction of rain water directly to the point of entrance.

G. Safety Strain Insulator. A safety strain type of insulator should be used in locations where mechanical hazard exists.

H. Protective Ground Connections. Ground surface networks should be supplemented with a system of ground rods designed to contact with the permanent moisture level when practicable. Building grounds will firmly contact with the cold water supply and all other grounded piping systems, and with structural steel when available. Ship grounds will contact directly with the hull.

II. Transmitter Protection

A. Frame. The transmitter will be enclosed in a metal frame, or grille or other equivalent means, all parts of which are solidly connected to ground.

B. Operating Controls. All external metal handles and controls accessible to the operating personnel are to be solidly grounded.

C. Switchboard Voltages. No circuit in excess of 150 volts should have any metal parts exposed to direct contact. A complete dead-front type of switchboard is preferred.

D. Interlocks. All access doors should be provided with interlocks which will remove all voltages when any door is opened.

III. Power Supply Protection

A. General. All power equipment and switchboards, except rectifiers and special power equipment, shall have provisions for safety in accordance with the standard practices prevailing for electrical machinery.

B. Special Equipment. Special equipment, such as rectifiers, should have provisions for safety the same as specified for transmitters.

C. Filter and Other Condensers. Means should be provided for quickly discharging filter and other condensers upon the removal of power.

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INDEX TO PROCEEDINGS

These titles are listed in the order in which they were published The letters and numbers at the left of the titles are keys for use in referring from the Authors Index and the Cross Index. The letters are opposite the titles of papers published in the PROCEEDINGS of The Wireless Institute. The numbers are opposite those published in the PROCEEDINGS of The Institute of Radio Engineers.

STANDARDS REPORTS

The first report of the Committee on Standardization (1913) will be found in the back of Volume 1. Subsequent revised reports of the 1915, 1922, 1926, and 1928 Committees were published as separate pamphlets. The 1928 report was also included in the 1929 Year Book, Pages 43–153.

INDEX TO AUTHORS

Numbers refer to the chronological list. Boid-face type indicates papers, light-face type indicates discussions, and italics refer to book reviews.

INDEX TO SUBJECTS

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CURRENT PUBLICATIONS OF INTEREST TO RADIO ENGINEERS

Acoustical Society of America, Journal of
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450 Ahnaip St.,
Menasha, Wisconsin.

American Institute of Electrical Engineers, Journal of
American Institute of Electrical Engineers,
29 West 39th Street,
New York, N. Y.

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American Institute of Electrical Engineers,
29 West 39th Street,
New York, N. Y.

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J. A. Booth,
Solomon-strasse 18 B,
Leipzig, Germany.

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Germany.

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American Telephone and Telegraph Company,
195 Broadway,
New York, N. Y.

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International Standard Electric Corp.,
67 Broad Street,
New York, N. Y.

Electrician
Electrician,
Bouverie House,
154 Fleet Street,
London, E. C. 4, England.

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McGraw-Hill Publishing Company, Inc.,
10th Avenue at 36th Street,
New York, N. Y.

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Berlin, W. 9,
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33 West 39th Street,
New York, N. Y.

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E. and F. N. Spon, Ltd.,
57 Haymarket,
London, S. W. 1, England.

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71, Kingsway,
London, W. C. 2, England.

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Berne,
Switzerland.

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Taylor and Francis,
Red Lion Court,
Fleet St.,
London, E. C. 4.

Modern Wireless
Amalgamated Press, Ltd.,
Fleetway House,
Farringdon Street,
London, E. C. 4, England.

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E. Chiron, editor,
40 Rue de Seine,
Paris, (4e), France.

Optical Society of America, Journal of
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450 Ahnaip St.,
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450 Ahnaip Street,
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1 Lowther Gardens,
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London, S. W. 7, England.

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Leipzig C 1,
Germany.

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4, Ludgate Hill,
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QST
American Radio Relay League, Inc.,
38 La Salle Road,
West Hartford, Connecticut.

Radio
Pacific Radio Publishing Company,
428–430 Pacific Building,
San Francisco, California.

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53, rue Réaumur,
Paris (2e), France.

Radio Engineering
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52 Vanderbilt Avenue,
New York, N. Y.

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381 Fourth Ave.,
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450–454 Ahnaip Street,
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44–47, St. Martin's Lane,
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24 West 40th Street,
New York, N. Y.

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T. S. F. Moderne,
9, Rue Castex,
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Wireless World and Radio Review
Wireless World and Radio Review,
Dorset House,
Tudor Street,
London, E. C. 4, England.

CATALOG *of* MEMBERSHIP

ARRANGED ALPHABETICALLY

and

GEOGRAPHICALLY

NOTE

The following list of membership is divided into two sections; the first contains an alphabetical list of members of the Institute of all grades and the second comprises a geographical list of members. In the alphabetical portion, the letter and date immediately following the member's name indicate the grade of membership and date of election. Where more than one letter and date group follow the member's name, the subsequent notations refer to the grade and date of transfer to a higher grade. (F) denotes the grade of Fellow; (M) Member; (A) Associate; (J) Junior.

Where only one address is shown in the alphabetical list it is the mailing address.

The geographical list contains the state and town in which the member is located and his present grade of membership in the Institute.

CATALOG OF MEMBERSHIP

(This list is corrected only to December 15, 1930)

LIST OF MEMBERS OF ALL GRADES

Arranged Alphabetically

(See note on page 260)

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ZUEV, VITALY V. (A'28), Chief of Technical Commercial Department, Philips South American Export Company, 1451, Rivadavia, Buenos Aires, Argentina. For mail: Rivadavia 1447, Buenos Aires, Argentina.

ZURIAN, P. D. (J'27–A'29), 3001 Addison St., Chicago, Ill.

ZWEIGER, OWEN (J'27), 1259 S. Harcourt Ave., Los Angeles, Calif.

ZWORYKIN, VLADIMIR K. (M'30), Research Engineer, RCA-Victor Company, Inc., Camden, N.J. For mail: 416 Warwick Rd., Haddonfield, N.J.

ZYLSTRA, WILLIAM G. (A'30), Service Division, E. A. Nichols, Inc., 111 N. Canal St., Chicago, Ill. For mail: 718 W. 73rd St., Chicago, Ill.

CATALOG OF MEMBERSHIP

January 1, 1931

Arranged Geographically

UNITED STATES

ALABAMA

Auburn
Waldo, George V. (A)

Birmingham
Bell, John C. (A)
Duran, Albert E. (A)
Giglio, James A. (A)
Hassler, W. Dan (A)

Mobile
Helt, Scott (A)

Montgomery
Hallman, L. B., Jr. (A)
Trum, Alexander D. (A)

ARIZONA

Kingman
Wallace, P. H. (A)

Phoenix
Harold, George (A)

Prescott
De Witt, Harold (A)

Tucson
Bannister, M. W. (A)
Percy, F. W. (A)

ARKANSAS

Blytheville
Lintzenich, C. L. (A)

Conway
Cordrey, E. E. (M)

Fort Smith
Barry, James A. (A)
Miller, Jesse Lee (A)

Hot Springs
Peel, Delacy J. (A)
Tuggle, Granville D. (A)

Little Rock
Beem, Arthur W. (A)
Beem, Raymond M. (A)
Bilheimer, Joe A. (A)
Boone, Virgil (A)
Bracken, Ben (A)
Gunn, L. C. (A)
Hofstatter, F. H. (A)
Logan, E. Warren, Jr. (A)
Simmons, Guy A., Jr. (A)
Stover, Arthur R., Jr. (J)
Tracy, Kermit F. (A)
Waller, Paul (A)
Winn, Dan L. (J)

McGehee
Wallace, L. E. (A)

Siloam Springs
Chandler, C. G. (A)

CALIFORNIA

Alameda
Ramsay, Alan N. (A)
Schlueter, Edward A. (A)
Singleton, Harold C. (A)
White, Ray H. (A)

Alhambra
Breeding, Charles S. (A)
Chini, Carl J. (A)
Grimes, William F. (A)
Lee, George Richard (A)
Nolan, Arthur B. (A)

Altadena
Johnson, Paul F. (M)

Arcadia
Willson, Clarence L. (A)

Artesia
Corcoran, Edward M. (A)
Corcoran, George L. (A)

Azusa
Holcomb, Clyde A. (A)

Bakersfield
Schoonmaker, C. Granville (J)

Bell
Anderson, Edward R. (A)

Berkeley
Armer, Austin A. (A)
Davis, Daryl D. (A)
Dempster, Everett R. (A)
Greves, George L. (A)
Heinrich, Mortimer (J)
Jones, Frank C. (A)
McKay, William K. (A)
Meissner, Earl R. (A)
Reukema, Lester Edwin (A)

Beverly Hills
Balsley, James R. (A)
Larsen, C. W. (A)
MacKenzie, Frank B. (A)
Waite, Samuel A. (A)
Whitaker, John C. (A)

Bishop
Wheeler, Walter R. (A)

Bolinas
Fickas, Merwin J. (A)
Park, Charles W. (A)
Tanck, Henry (A)

Burbank
Clement, Jack D. (A)
Shaw, Theodore S. (A)
Wainwright, Stuart F. (A)

Burlingame
Michalic, C. T. (A)

Claremont
Packard, Alden C. (A)

Compton
Smith, F. E. (A)

Corning
Russell, Charles (A)

Coronado
Pierce, Francis E. (M)

Covina
Ross, M. F. (A)

Culver City
Wersen, David T. (A)

Daly City
Hart, Arthur H. (A)

CALIFORNIA (Continued)

Eagle Rock
Ford, Walter B. (A)
Sprague, G. M. (A)
Tatreault, Leon E. (A)

El Centro
Cook, John W. (A)
Irey, Earl R. (A)
Lewis, Vergil E. (A)

El Segundo
Hart, William J. (A)

Fresno
Foin, Owen F., Jr. (J)
Gifford, Delbert K. (A)

Fullerton
Atherton, Malcolm J. V. (A)
Lewis, Evan J. (J)

Glendale
Bockhoven, Louis Murray (A)
Bowles, Theodore C. (A)
Eilers, John (J)
Engen, Ralph E. (A)
Farnsworth, Earl S. (M)
Kepler, O. L. (A)
Klingsmith, W. B. (A)
Murray, Robert W. (A)
Shomler, H. B. (A)

Hemet
Sorkness, Hardus (A)

Hermosa Beach
Carter, Everett D. (A)
Cooper, Harold G. (A)

Hollywood
Aves, Fred J. (J)
Blackburn, John F. (A)
Brockway, Don C. (A)
Campbell, Carleton W. (J)
Coe, Ernest W. (A)
Cunningham, Lodge (A)
Davey, Cedric V. (A)
Dering, Fred J. (A)
Ellis, George D. (A)
Fox, Bert M. (J)
Goldsmith, Lloyd T. (A)
Hansen, Edmund H. (M)
Hanson, Harry (A)
Hart, Roy H. (M)
Heineman, John T. (A)
Hill, Arthur P. (M)
Hilliard, John K. (M)
Levinson, Nathan (M)
Lubcke, Harry R. (A)
Manderfeld, Emanuel C. (A)
Masley, Paul (A)
Newman, David H. (M)
Phillips, Joseph H., Jr. (A)
Pierce, Franklin W. (A)
Ringold, H. Russell (A)
Sawyer, Gordon E. (A)
Sheldon, Clinton C. (A)
Stewart, Ronald B. (A)
Taylor, Jay L. (A)
Threlkeld, Howard M. (A)
Van Why, Forbes W. (M)
Wood, Stanford J. (A)

Hollywoodland
Mott, Lawrence (A)

Huntington Park
Dalton, Stuart P. (A)
Keyes, Edwin F. (A)

Inglewood
Brittain, Louis B. (A)
Underwood, Ernest G. (A)

Inverness
Case, Myron D. (A)
Culley, Lester D. (A)

Jackson
Snyder, W. Gilman, Jr. (A)
Van Thiel, Jan (A)

La Canada
Benioff, Hugo (A)

La Crescenta
Robinson, Frederick (A)

La Habra
Inns, Stephen H. (A)

Long Beach
Brown, Hillis M. (A)
Cooke, Willard H. (A)
Gray, William (A)
Howell, Roger A. (A)
Moore, Raymond C. (A)
Wallace, Donald C. (A)

Los Angeles
Albin, Frederick O. (A)
Alford, Andrew (A)
Alverson, James G. (A)
Anderson, H. W. (A)
Anderson, Henry A. (A)
Appleton, Harry (A)
Barlow, Roy G. (A)
Berkoll, Gustave F. (A)
Best, Gerald M. (M)
Bilkie, W. (A)
Bradley, John C. (A)
Brown, Cutler (A)
Bryan, William J. (A)
Buffinger, W. G. (A)
Bumbaugh, Harold L. (A)
Campbell, William N. (A)
Chapple, James M. (A)
Coblentz, Orhan R. (A)
Collins, Edward M. (A)
Cook, Frank W. (A)
Cook, Robert O. (A)
Curran, George W. (A)
de Forest, Lee (F)
Dewey, Fred L. (M)
Dickson, H. L. (A)
Dixon, A. L. (A)
Dreher, Carl (F)
Edgecomb, A. J. (A)
Eldridge, Robert H. (A)
Farran, Dean (A)
Felstead, Charles F. (A)
Fenton, A. Norwood (A)
Flickinger, J. H. (A)
Gill, William (A)
Gioga, Peter C. (A)
Greger, J. G. (A)
Gronoff, Harry (A)
Grove, Howard G. (A)
Haas, Clarence H. (A)
Hagen, B. W. R. (A)
Hankins, Marvin J. (A)
Hardison, Arthur A. (A)
Hassel, Gunnar B. (A)
Hauser, Carroll R. (A)
Heather, Harold (A)
Hecht, Royal H. (A)
Herrnfeld, Frank P. (A)
Hill, Alfred L. (A)
Homsy, John H. (A)
Hopkins, Stephen (A)
Houdyshell, Lowell B. (A)
Howard, L. W. (A)
Howe, Franklin Joachim (A)
Keith, Harold M. (A)
Kennedy, Douglas (A)
Kennedy, John C. (A)
Kent, Oliver C. (A)
Ketchum, Robert W. (A)
Korntved, George W. (A)
Kruger, Bernard (A)
Langrick, Paul D. (A)
Lee, Gilbert C. (A)
Leighton, Harold W. (A)

CALIFORNIA (Continued)

Los Angeles (Continued)
Lindsay, W. W., Jr. (M)
Ludlum, W. F. (A)
Marshall, Cloyd, Jr. (A)
Mason, Curtis W. (A)
McCabe, William E. (A)
McCarroll, Marshall G. (A)
McCash, Perry V. (A)
McCreery, M. E. (A)
McDonough, Thomas F. (A)
McGonagil, H. A. (A)
Metcalf, David E. (A)
Meyer, R. H. (A)
Miller, Burton F. (A)
Miller, Charles E. (A)
Miller, Gerald B. (A)
Moore, Raymond M. (A)
Newcomb, Robert (A)
Newman, William H. (A)
Olmstead, Charles B. (A)
Oodrys, Arthur (A)
Ormiston, Kenneth G. (A)
Ourieff, Paul (J)
Partch, Paul C. (A)
Perkins, Lucius J. (M)
Pfleger, Robert A. (A)
Power, Ralph L. (A)
Randle, Herrin E. (A)
Reed, Jess M. (A)
Reiter, Frank P. (A)
Rhodes, L. G. E. (A)
Richards, W. S. (A)
Riggs, Clare A. (A)
Sarver, Frank M. (A)
Schreiber, Ernest H. (A)
Schwartz, Nathan (A)
Silent, Harold C. (A)
Sleeper, J. Lloyd (A)
Smith, C. Bernard (A)
Sorge, Barthold W. (A)
Stolle, R. A. (A)
Stratton, Ross A. (A)
Tami, Joseph, Jr. (A)
Taufenbach, L. E. (M)
Thistlewhite, Robert (A)
Turner, J. Glenn (J)
Whiston, R. William (A)
Wisegarver, Orton H. (A)
Witt, Harold A. (A)
Yurgionas, John A. (A)
Zweiger, O. (A)

Manhattan Beach
Tischer, Frank A. (A)

Mare Island
Weigand, Jos. S. (A)

Marshall
Marsh, Hallock Snyder (A)

Merced
Shaffer, Frank (J)

Monrovia
Barnard, T. A. (J)

Monterey
Brokaw, Hal R. (A)

Monterey Park
Alker, Charles (A)
Nikirk, Thomas E. (A)
Sanmann, Edgar J. (A)

Napa
Streich, Robert J. (A)

Oakland
Allen, Preston D. (A)
Branson, Albert K. (A)
Brearty, Lawrence S. (A)
Brown, James F. (A)
Freeman, Robert H. (A)
Gilbertson, Bernard (A)
Hazeltine, Louis A. (F)
Mangelsdorf, F. (A)
Penther, Carl J. (A)
Slavin, Samuel B. (A)
Summers, James W. (A)
Weaver, Chester E. (A)
Wild, Sydney J. (A)
Wilson, Charles McC., Jr. (A)

Ocean Beach
Quist, Jesper S. M. (A)

Ocean Park
Poorman, Edwin H. (J)

Olympia
Kaufman, Arthur W. (A)

Orange
Charbonneau, L. H. (A)
Waters, John E. (A)

Oxnard
Newcomb, Carleton A. (A)

Pacific Palisades
Mann, Theodore H. (A)

Palo Alto
Beal, Ralph R. (A)
Boyson, Carl V. (A)
Brolly, A. H. (A)
Brower, William M. (M)
Brown, Archibald S. (A)
Byrne, Paul F. (A)
Cattell, Gilbert W. (A)
Clayton, John M. (M)
Fuller, Leonard F. (F)
Green, Irving L. (A)
Jensen, Sven (A)
Julien, Ira F. (M)
Kolster, Frederick A. (F)
Miller, Holmes C. (A)
Morgan, Nathaniel R. (A)
Morrison, G. K. (A)
Odell, Carl H. (A)
Overacker, Horace E. (A)
Redeker, Harry E. (A)
Redeker, Ivan M. (A)
Romander, Hugo (A)
Saunders, William W. (A)
Scofield, Philip F. (M)
Shermund, Ralph C. (A)
Storm, Hans Otto (A)
Suydam, C. H. (M)
Thomas, Charles C. (A)
Tinney, Francis B. (A)
Veirup-Jensen, J. G. (A)
Wagener, Winfield G. (A)
Walton, Robert C. (A)
Whitwan, Lloyd F. (A)
Whittern, Ray (A)
Woodbury, E. (A)

Pasadena
Bradshaw, Robert C. (A)
Brown, Howell C. (A)
Cook, Ronald P. (A)
Felch, H. F. (A)
Hopper, Francis L. (A)
Howes, Edgar T. (A)
Kinney, E. S., Jr. (A)
Kraft, Walter C. (A)
Lathrop, Kenneth A. (A)
MacKeown, Samuel S. (M)
MacMurphy, F. (A)
Taylor, E. Kenneth (A)
Warner, Earle H. (A)
White, Harold (A)

Piedmont
Myers, Walter M. (A)
Scott, Leo L. (A)

Pine Knot
Betterley, Jack A. (A)

Placentia
Gaines, Benjamin R. (A)

CALIFORNIA (Continued)

Point Reyes Station
Canfield, N. A. (A)
Reid, Irl H. (A)

Pomona
Parker, Evert L. (A)

Redwood City
Litton, Charles V. (A)

Richmond
Trolese, Louis (A)

Riverside
Norwood, Donald W. (A)
West, L. E. (A)

Sacramento
Hayden, J. W. (A)
Melnicoe, Samuel (A)
Messner, Roy L. (A)
Semoni, Anthony J. (A)

St. Helena
Lewelling, Raymond (A)

San Bernardino
Kiernan, Earl F. (A)

San Bruno
Bradley, John T. (A)
McAulay, William H. (A)
McCullough, F. S. (A)

San Diego
Burnett, William L. (A)
Christides, Stratis C. (A)
Crosby, Gordon J. (A)
Doig, John H. (A)
Gruenewald, Harold C. (A)
Hamlin, Frank E. (A)
Mihalko, Alex M. (A)
Neimo, Peter J. (A)
Peterson, Arthur W. (M)
Riddle, George E. (J)
Scott, Carl A. (A)
Stone, John Stone (F)
Wisner, Fred L. (A)

San Francisco
Arrigoni, Arthur (A)
Baker, Lewis C. (A)
Bear, William P. (A)
Benson, Francis S. (A)
Bouson, Herbert H. (M)
Bradshaw, Lynwood (A)
Clark, Kenneth G. (A)
Clark, Robert W. (A)
Coombs, Clyde F. (A)
Danforth, Richard S. (A)
Danielson, Ernest G. (A)
Derry, F. R. (A)
Farnsworth, Philo T. (A)
Fass, Sydney J. (A)
Fenner, Paul R. (A)
Fletcher, Earle S. (M)
Franklin, Lyman T. (A)
Freiermuth, Vincent J. (A)
Gary, L. A. (A)
Gould, George B. (A)
Graham, Lloyd E. (A)
Greene, Harry A. (A)
Halloran, A. H. (M)
Hanscom, W. W. (M)
Heeder, M. E. (A)
Heintz, Ralph M. (F)
Held, Herman E. (A)
Henry, Franklin M. (A)
Highleyman, Richard (M)
Hoffman, Samuel O. (A)
Kaufman, Jack (A)
Kellogg, Richard B. (A)
Kellogg, Walter D. (A)
Kennedy, David Wayne (A)
King, Howard D. (A)
Lacabanne, Washington D. (A)
Lane, Howard D. (A)
Langevin, Carl C. (M)
Lebedeff, George M. (A)
Linden, Bernard H. (A)
Lippincott, Donald K. (M)
MacDonald, H. J. (A)
MacMahon, Alvin E. (A)
Martin, Ronald G. (A)
Maynard, Raymond K. (A)
McDowell, C. S. (M)
Moore, Paul (A)
Mowry, Charles E. (A)
Nikonenko, Paul (A)
O'Brien, Daniel L., Jr. (A)
Parker, Ray H. (A)
Parkhurst, Edgar L. (A)
Patron, Alfonso E. (A)
Pearce, Harry G. (A)
Pinkney, J. L. (A)
Powell, Louis H. (A)
Rosa, Walter P. (J)
Rowe, Victor G. (A)
Royden, George T. (M)
Ryan, R. (A)
Saxton, Alfred H. (A)
Schofield, William D. (A)
Smith, Charles S., Jr. (A)
Smith, Herbert H. (A)
Smith, Mortimer O. (A)
Soderquist, Clement J. (A)
Sphar, Clark H. (A)
Stagnaro, John A. (A)
Taylor, G. W. (A)
Ternow, Helmut G. (A)
Thiel, Harold A. (A)
Todd, Stedman F. (A)
Tustin, John L. (A)
Weir, F. Torres (A)
Wells, W. Bruce (A)
Wetzel, Joseph A. (A)
Winnegar, W. A. (A)
Winner, William Lane, Jr. (M)
Woolverton, R. B. (F)

San Gabriel
Ashbrook, Roy B. (A)

San Jose
Anderson, Jack L. (A)
Cozzens, Bradley (A)
Engwicht, Harry (A)
Kelliher, John E. (A)
Quement, Frank J. (A)
Reynolds, F. T. (A)
Saine, Harry (A)

San Marino
Pohlman, G. Anton (A)

San Mateo
Mason, Howard F. (A)

San Pedro
Ammon, William B. (A)
Carlson, Carl F. (A)
Cooper, Lowell (M)
DeBaun, George H. (A)
Honeycutt, Vaughan C. (A)
Johnson, V. (A)
McCandlish, B. V. (A)
Patten, Stanley F. (A)
Skov, Jens Ingvard (A)

San Rafael
Lyman, Harry J. (A)
Parkin, John, Jr. (A)

Santa Barbara
Kempton, Walter D. (A)
Means, Paul S. (A)

Santa Cruz
Fisher, E. H. (A)

CALIFORNIA (Continued)

Santa Maria
Seal, H. Robert (A)

Santa Monica
Willis, Edward N. (A)

Sawtelle
Spiller, Cecil Charles (J)

Sherman
Smith, Wade H. (A)

Southgate
Magnuson, Herman A. C. (A)

Stanford University
Rathbun, Harry (A)
Ryan, Harris J. (M)
Skinner, Clinton Ross (A)
Terman, Frederick E. (A)

Stockton
Clarkson, Charles N. (A)
Green, Alfred H. (A)
Holt, Pliny E. (A)
Schulz, Paul C. (A)

Sunnyvale
Paul, Ernest E. (A)

Tuolumne
Elliott, William H. (A)

Vallejo
Robinson, R. J. (A)

Van Nuys
Black, Robert (A)
Marsden, George K. (A)

Venice
Du Vall, Charles (A)
Gleason, Sterling (A)

Ventura
Snow, Louis A. (A)

Wasco
Morrison, L. H. (A)

West Hollywood
Cooper, George R. (A)

Whittier
Eagle, Roy D. (J)
Smith, L. E. (A)

COLORADO

Arvada
Kelso, Rupert E. (A)

Colorado Springs
Blair, Wiley, Jr. (A)

Delta
Fulghum, Charles K. (A)

Denver
Earnhart, Glen W. (M)
Foraker, William Nelson (J)
Giese, Raymond C. (A)
Grove, William C. (A)
McClimans, Abner E. (A)
Owen, Robert H. (A)
Painter, Charles E. (A)
Pyle, William D. (A)
Reynolds, William D. (A)
Sterling, M. F. (A)
Westphal, Richard D. (A)
Williams, Howard M. (A)

Durango
Dieckman, William (J)

Eaton
Nichols, Frederick A. (A)

Fort Collins
Sammons, Floyd (A)

Golden
Pawley, Myron G. (A)

Holyoke
Scheneman, Ernest (A)
Scheneman, Henry Wesley (A)

Pictou
Anderson, William A. (A)

Pueblo
Finch, Joseph E. (A)
Nelson, A. Leroy (A)
Penrose, L. A. (A)

Seibert
Fingado, Francis H. (A)

CONNECTICUT

Bridgeport
Bishop, Nathaniel (A)
Campbell, Charles H. (A)
Chopsky, Peter A. (A)
Gravlin, Lee F. (A)
Ham, Frank M. (A)
Harrington, Carlton E. (J)
Ivanko, John G. (A)
Norton, Leland D. (A)
Nothnagle, George E. (A)
Tomlinson, Harry E. (A)

Bristol
Dreyer, Harry W. (M)

Danielson
La Bossiere, Louis E. (A)

East Hartford
Randall, J. Clayton (M)

Greenwich
Nally, Edward J. (A)
Thomas, William A. (M)

Hartford
Beckwith-Ewell, Starr L. (A)
Bourne, Roland B. (M)
Coe, Robert S. (A)
Cowles, Walter G. (A)
Grammer, George (A)
Handy, Francis E. (A)
Hebert, Arthur A. (M)
Hull, Ross A. (M)
Lamb, James J. (A)
Le Conche, Carl C. (A)
Maxim, Hiram Percy (A)
Page, Atwood C. (A)
Pember, Harold H. (A)
Rodiman, Clark C. (A)
Rushing, Wallace E. (A)
Sceli, Russell G. (A)
Tasker, Joseph M. (A)
Weston, Francis B. (J)

Hazardville
Thompson, Stanley W. (A)

Kensington
Edgerly, Albert Henry (A)

Litchfield
Vanderpoel, Floyd L. (A)

Meriden
Wilcox, Ernest C. (A)
Young, Frank A. (A)

Middletown
Cady, Walter G. (F)
Van Dyke, Karl S. (M)

Milford
Hadden, Harold L. (A)

Mount Carmel
Croteau, Carlton W. (A)

Naugatuck
Wood, William Forrest (A)

New Britain
Johnston, Douglas A. (A)

CONNECTICUT (Continued)

New Haven
Behner, Herbert C. (M)
Doolittle, Franklin M. (M)
Gubin, Samuel (A)
Layne, Frank C. (A)
Smith, Franklin S. (A)
Sumner, Raymond Stokes (A)
Turner, H. M. (M)
Weed, C. Bronson (A)
Wenstrom, William H. (A)
Wood, Herbert H. (A)

Noroton Heights
Beisel, Keith (A)
Meserve, G. Donald (A)

Norwich
Hubbard, James L. (A)

Plainville
Jones, H. Garfield (A)
Stephenson, Martin A. (A)

Seymour
Dana, Alan S. (A)

Southington
Lewis, Earl B. (A)

Stamford
Carlson, Einar C. (A)

Storrs
Noble, Daniel E. (A)

Stratford
Austin, Kirby B. (A)

Torrington
Foth, Erich A. W. (J)

Waterbury
Bennett, Morris H. (A)
Buckley, Francis P. (A)
Greenblatt, Louis (A)
Winchell, Alfred M. (A)

Westbrook
Kelsey, Philip C. (A)

West Hartford
De Soto, Clinton B. (A)
Houldson, Clyde J. (A)
Kruse, Robert S. (M)
Kutscher, Louis F. (A)
Montgomery, Philip (A)
Warner, Kenneth B. (M)

West Haven
Phillips, Edward I. (A)

Westport
Perry, William A. (A)

West Suffield
Colson, James L. (J)

West Suffield
Carini, Louis (J)
Mitchell, James A. (A)

Wilton
Van Heiningen, Willard A. (A)

Windsor
Keily, Delbar P. (A)

DELAWARE

Claymont
Tatnall, Joseph S. (A)

Wilmington
Boylan, E. Brandt (A)
Casey, K. K. V. (A)
Henning, Clarence I. B. (A)
Wilcox, Robert L. (A)

DISTRICT OF COLUMBIA

Anacostia
Cooper, Orville T. (A)
Griffith, M. H. (A)
Harvey, Lester M. (M)
Hyland, Lawrence A. (A)
Meyer, R. B. (A)
Moore, Adam H. (A)
Overton, George P. (A)
Owens, Raymond B. (M)
Struthers, Francis W. (A)
Taylor, A. Hoyt (F)
Walker, Guy P. (A)
Wallace, James D. (A)
Wheeler, Lynde P. (F)
Wilkie, Harry (A)
Williams, Charles Haddon (A)

Takoma Park
Aurynger, John J. (A)

Washington
Appich, William H. (A)
Arps, Mervin W. (M)
Austin, Louis W. (F)
Backus, Cyrus D. (M)
Bailey, Stuart L. (A)
Barron, J. H., Jr. (M)
Berkner, Lloyd V. (A)
Black, Joel Cantrell (J)
Bower, Ward E. (A)
Boyer, William P. (A)
Bradford, Henry K. (A)
Burger, Clarence Walter (A)
Burgess, Warren B. (A)
Burke, David J., Jr. (A)
Burke, James William (A)
Butman, Carl H. (M)
Caldwell, Louis G. (M)
Chamberlin, Robert R. (A)
Chromy, B. J. (A)
Chubb, William M. (A)
Codel, Martin (A)
Cohen, Louis (F)
Cole, G. C. (A)
Colvin, Ruel (A)
Cooper, Donald H. (A)
Corderman, William P. (A)
Corrigan, James T. (A)
Craven, T. A. M. (F)
Crawford, David M. (A)
Culver, Clarence C. (M)
Curtis, Westley F. (A)
Davis, R. K. (A)
Davis, Thomas M. (M)
Day, John F. (A)
Diamond, Harry (M)
Doremus, Cornelius W. (A)
Dorsey, Herbert G. (M)
Dow, J. B. (M)
Downey, W. E. (M)
Drury, Paul O. (A)
Elliott, Clifford E. (A)
Ferguson, Theodore P. (A)
Fugazzi, Frank J. (A)
Gebhard, Louis A. (A)
Graf, Alois W. (A)
Greaves, Ford V. (F)
Greeley, Philip H. (A)
Guthrie, Frederick P. (M)
Hafstad, L. R. (A)
Hall, Albert Casper (J)
Hall, E. L. (A)
Hanson, Malcolm P. (M)
Hardesty, George K. C. (J)
Harris, Richard P. (A)
Hastings, Harris F. (A)
Hatter, Angerean A. (A)
Heaton, Vincent E. (A)
Heron, Louis M. (M)
Hooper, S. C. (F)

DISTRICT OF COLUMBIA (Continued)

Washington (Continued)
Hromada, Joseph C. (A)
Jackson, William E. (A)
Jansky, C. M., Jr. (F)
Jardine, W. N. (A)
Jenkins, C. Francis (A)
Jett, Ewell K. (A)
Johnson, Albert E. (A)
Jolliffe, Charles B. (F)
Judson, Elbert B. (A)
Kalbfleisch, Albert C., Jr. (A)
Kallio, Wilho (A)
Kaplan, Jacob (A)
Kaufman, Joseph (M)
Kear, Frank G. (A)
Kinley, Clifford B. (A)
Kirby, Samuel S. (A)
Kriz, Joseph (A)
Leahy, John E. (A)
Lee, Wm. Justice (M)
Link, John C. (A)
Loomis, Mary Texanna (M)
Loucks, Philip G. (A)
Luckel, Frank (A)
Mac Gregor, John J. (A)
Maddox, Charles H. (M)
Martin, George L. (A)
Mates, T. Joaquin (A)
May, Albert (A)
McClelland, Harold M. (M)
McIlwraith, Charles G. (A)
McKinley, Howard W. (A)
McNallan, Wilbur T. (A)
Mirick, C. B. (M)
Mitchell, Hugh (M)
Moulton, Theodore S. (A)
Nair, W. Earl (A)
Page, Robert M. (A)
Pierce, James F. (A)
Powell, Edwin L. (M)
Reynolds, W. W. (A)
Rhoades, A. L. (A)
Rietzke, Eugene H. (A)
Ring, Andrew D. (A)
Rittenhouse, Joseph P. (A)
Roberts, Matthew H. (A)
Rohrich, George J. (A)
Seaton, Stuart L. (A)
Segal, Paul M. (M)
Shepherd, Henry Clayton, (A)
Smith, David H. (A)
Smith, James E. (M)
Sprayberry, Frank L. (A)
Squier, George O. (F)
Stahl, Barton E. (A)
Starbuck, W. D. L. (M)
Stevens, Waldo W. (A)
Stewart, Jessica Dee (M)
Stewart, Ralph B. (M)
Terrell, Robert L. (A)
Terrell, W. D. (F)
Weber, Carl F. (A)
Webster, E. M. (A)
Willoughby, John A. (M)
Wiseman, William W. (A)
Worrall, Robert H. (A)
Wright, J. Warren (A)
Young, Leo C. (M)
Zandonini, Elizabeth M. (A)

FLORIDA

Clearwater
Mitchell, Joseph H. (A)

Gainesville
Loucks, Ivan H. (A)

Hialeah
Angle, G. B. (A)
Corrigan, C. J. (A)
Davis, Maynard F. (A)
Meggers, A. L. (A)
Rowan, F. C. (A)

Jacksonville
Cooper, John C., Jr. (A)
Weiss, Glover (A)

Key West
Fernandez, Manuel (A)

Largo
Wittstruck, Harold H. (A)

Miami
Adams, George G. (A)
Bliss, Alonzo O., Jr. (A)
Borton, F. W. (A)
Erickson, Carl E. (A)
Fisher, Carroll S. (A)
Hoselton, Frank B. (A)
Monteith, J. W. (A)
Sherwood, Leslie F. (A)
Sullinger, Ferris W. (A)

Orlando
Green, Charles M., Jr. (A)
Skelton, Kenneth W. (A)

Pensacola
Taylor, Francis William (A)

Sarasota
Service, Charles A., Jr. (A)

South Jacksonville
Grange, Gifford (A)

St. Petersburg
Fill, John V. (J)
Johnson, Carl C. (A)
Link, Louis J. (A)
Napper, Charles J. (A)
Preece, Richard, Jr. (A)

Tampa
Moore, William P. (A)
Reynolds, Frank J. (A)
Weaver, Henry Ray (A)

GEORGIA

Albany
Garant, Edward C. (A)

Atlanta
Barker, Howard J. (J)
Brewin, Robert R. (A)
Clemans, Hershel L. (A)
Cook, J. M. (A)
Dobbs, Harry F. (A)
Gardberg, Joseph (A)
Gray, Floyd E. (A)
Herndon, Paul H., Jr. (A)
Holliday, F. S. (A)
MacNaughton, A. K. (A)
Reed, Pinckney B. (A)
Reid, Henry L. (A)
Rothenberger, William L. (A)
Russell, B. A. (A)
Sartain, L. B. (A)
Thornton, Henry P. (A)
Wills, Harry L. (M)
Yancey, E. F. (A)

Avondale Estates
Bangs, Philip C. (A)

Columbus
Kirkland, A. H. (A)

Commerce
Hood, Sam (J)

Decatur
McCorvey, Avis (A)

Macon
Breedlove, Bernard H. (J)

GEORGIA (Continued)

Royston
Berryman, Forrest G. (A)

Savannah
Carlson, C. O. (J)
Donovan, James R. (A)
Lord, Wilfred F. (J)
Szabo, Paul (A)

Statesboro
Blitch, James D. (A)

IDAHO

American Falls
Brose, Fred O. (A)

Grangeville
Greene, Warren L. (A)

Pocatello
Davis, Glenwood (A)
Ritland, Hubert O. (A)

Twin Falls
Belleville, Logan (A)

ILLINOIS

Alton
Duval, D'Adrian A. L. (M)

Aurora
Bliss, Floyd D. (A)
Hendren, Kenneth E. (A)

Beardston
Barregarye, Laurence H. (J)

Berwyn
Burns, Elmer E. (A)
Komm, Paul M. (A)
Million, John W., Jr. (M)
Schnell, William J. (A)
Wilkinson, L. G. (A)

Bloomington
Stillhamer, Arthur G. (A)

Blue Island
Damm, George J., Jr. (A)

Brookfield
Courter, H. L. (A)

Canton
Ingersoll, William P. (A)

Chicago
Adair, Samuel E. (M)
Alexander, Donald W. H. (A)
Allain, Joseph A. (J)
Andrew, Victor J. (M)
Andrews, Edward F. (A)
Ankersen, G. W. (A)
Armstrong, Harold W. (A)
Bank, Maurice (A)
Barlow, William H. (A)
Beane, E. A. (M)
Beindorf, Lucien J. (A)
Benjamin, Abraham S. (A)
Bergman, G. Wiley (A)
Beusman, Robert M. (A)
Blom, Roy (A)
Braun, W. C. (A)
Bridgman, Francis K. (A)
Brittin, Frank L. (M)
Bronson, G. E. (A)
Burchard, John C. (M)
Burdett, Sam (A)
Burger, Emil S. (A)
Burkhart, Virgil S. (A)
Burkwest, Leonard G. (A)
Burns, Robert P. (A)
Campbell, Robert H. (A)
Canon, Hartman B. (A)
Carlson, Norlin G. (A)
Carney, Louis Paul (A)
Carter, A. J. (M)
Casciato, Dominick (A)
Cassens, Fred Benjamin (A)
Chadwick, Ray E. (J)
Cherne, Leo J. (A)
Chien, F. C. (A)
Chun, Herbert H. (A)
Church, John Franklin (M)
Clark, Paul H. (A)
Clausing, Leroy M. E. (A)
Clough, Kendall (A)
Cohen, Theodore (A)
Crossett, Edward C. (A)
Cubert, Joseph R. (A)
Cumming, George (A)
Curll, Van C. (A)
Dady, Arthur O. (A)
Dalton, Robert E. (A)
Dauber, Albert E. (A)
Davis, Joseph A. (A)
Deeley, Paul M. (M)
Demikis, Anton, Jr. (A)
Devine, William F. (A)
Dillow, Arthur P. (A)
Dodge, Richard M. (A)
Douglas, James M. (A)
Drobish, William M. (A)
Dubuclet, Sidonio L. (A)
Dudley, Beverly (A)
Duncan, Don C. (A)
Dymond, Clifton (A)
Edelman, Phillip E. (A)
Edwards, Charles (A)
Eells, M. Merwin (A)
Elam, David L. (A)
Elliot, Philip T. (A)
Ellis, Robert Marcus (A)
Eppstein, Ralph M. (A)
Erwood, John (A)
Esmaker, John B. (A)
Fast, John E. (A)
Fernandez, Dan T. (A)
Ferris, Frank (A)
Fetterman, D. M. (A)
Filmer, Walter L., Jr. (A)
Fischer, Andrew, Jr. (A)
Fitzgerald, John J. (A)
Flick, A. A., Jr. (A)
Forbes, Allan C. (M)
Forsberg, Otto J. (A)
Fortington, William H. (M)
Frankel, Mortimer (M)
Freeman, Ernest H. (M)
Freimann, Frank (A)
Friday, Wilbur L. (A)
Friedman, Joseph (A)
Fritzel, Joseph (A)
Gay, Paul F. (A)
Glassman, George (A)
Golding, Robert M. (A)
Goldman, Stanley (A)
Golten, J. N. (A)
Gray, Kline (A)
Gruiskin, George (A)
Hall, Edward G. (A)
Halligan, William J. (A)
Hansen, Harvey Bennett (A)
Hansen, William H. (J)
Hanson, Earl C. (A)
Harrell, Fred E. (A)
Harrower, J. C. (A)
Hassel, Karl E. (M)
Hauschild, John P. (A)
Hauser, Albert (A)
Hayes, H. D. (M)
Helman, Rolf A. (A)
Henninger, Andrew F., Jr. (A)
Henry, Charles C. (A)
Hines, Albert D. (A)
Hitzenhammer, Anthony De V. (A)
Hix, Clarence M. (A)
Hoag, J. Barton (M)

ILLINOIS (Continued)

Chicago (Continued)
Holmquist, Carl T. (A)
Holst, Wendell L. (M)
Hoover, Richard T. (A)
Howard, Austin A. (M)
Howard, C. M. (M)
Huffman, Kenneth C. (A)
Hungerford, N. C. (A)
Izenstark, Maurice J. (A)
Jelen, Matt J. (A)
Jenkins, J. Elliott (M)
Johnson, Edward T. (A)
Johnson, E. O. (A)
Johnston, Ivan F. (A)
Kahn, Lamos (A)
Kara, Alexander R. (A)
Kaynor, Harry J. (A)
Kehm, Clarence H. (A)
Kelsey, Elizabeth L. (A)
Kempf, Frank J. (A)
Keogh, Raymond J. (A)
Kephart, William M. (A)
Knowles, Hugh S. (A)
Koch, Earl L. (A)
Korbel, George W. (A)
Koutnik, J. A. (A)
Kramer, Andrew W. (A)
Kranz, Herman E. (M)
Krueger, Alfred (A)
Lagasse, Albert (A)
Lamb, Harold A. (A)
Lanterman, Walter F. (A)
Larson, John M. (A)
Lawton, Harvey B. (A)
Lazar, Jos. H. (A)
Lehnert, Frank H. (A)
Leidy, W. J. (A)
Levin, Sam (A)
Limberg, Raymond A. (A)
Littlepage, Orvole H. (A)
Lorch, George H. (A)
Lotter, John G. (A)
Lowitz, W. V. (A)
Lundeen, Adolph (A)
Magos, John P. (A)
Mao, C. S. (A)
Marco, Frederick J. (M)
Marshall, Charles E. (A)
Martens, Ray L. (A)
Martin, E. F. (A)
Martin, Neill H. (A)
McCarthy, F. M. (A)
McClintock, W. S., Jr. (A)
McCullah, Arthur B. (A)
McGregor, Arthur M. (A)
McJilton, De Witt (A)
McMaster, A. J. (A)
McNeill, Allison (A)
Mead, Leo R. (A)
Meinhard, Herman (A)
Melchiors, Frants Ansgar (A)
Michael, Charles (A)
Michalowicz, Leon (A)
Miles, William E. (A)
Miller, Donald H. (A)
Mills, Elmer E. (A)
Mills, Vern D. (A)
Minnium, Byron B. (A)
Mooney, Raymond (A)
Moore, James S. (A)
Morey, W. J. (A)
Morris, Carleton D. (M)
Morris, John F. (A)
Mraz, Edwin (A)
Mueller, Eugene L. (A)
Muirhead, John E. (A)
Nardin, George F., Jr. (J)
Nelson, R. G. (A)
Nichols, Dwight O. (A)
Nieman, Thomas A. (A)
Nordhaus, Charles H. (A)
Nourse, Philip R. (A)
Novak, Joe J. (A)
O'Brien, William J. (A)
O'Byrne, Leo C. (A)
O'Callaghan, Jerome J. (A)
Oxner, Edwin K. (A)
Paelig, Theodore H. (A)
Parisek, Edward E. (A)
Patterson, Joseph A. (A)
Paul, George Stewart (A)
Pestlin, LeRoy J. (A)
Petersen, Howard E. (A)
Petzing, Erwin W. (A)
Pew, Richard K. (A)
Pfaff, Ernest R. (M)
Pickett, C. E. (A)
Pletka, James (A)
Polydoroff, W. J. (M)
Prentiss, John G. (A)
Procunier, W. R. (A)
Rafferty, Frank A. (M)
Ramm, Carl H. (A)
Randall, Harris K. (A)
Reed, Clifford J. (A)
Remde, Jack (A)
Reynolds, George E. (A)
Riddel, O. A. (A)
Ross, Kenneth B. (A)
Rossiter, Donald R. (J)
Roth, Jesse E. (A)
Rowe, Thomas L. (A)
Royal, Roscoe (A)
Rulison, Earl W. (A)
Ruskin, Henry (A)
Ruszkiewicz, Leo (A)
Schaefer, Harold W. (J)
Schaper, William A. (A)
Scharf, Joachim Barschach (A)
Schnell, F. H. (M)
Schoenwolf, Fred L. (M)
Schor, F. W. (A)
Schulz, Emil H. (A)
Sear, Arthur W. (A)
Shaffer, Paul E. (A)
Shanafelt, Lysle O. (A)
Shaw, Robert E. (A)
Sieben, Clarence M. (A)
Silver, McMurdo (A)
Siovic, John E. (A)
Slechta, George W. (A)
Sloan, Francis V. (M)
Smith, Ernest F. (M)
Smith, Paul S. (A)
Smith, Wesley L. (A)
Smythe, Edwin H. (M)
Somersalo, G. A. (M)
Sorensen, Carl P. (A)
Stewart, Arthur C. (A)
St. James, Robert T. (M)
Stone, Carrington H. (M)
Stukey, L. I. (A)
Swisher, O. V. (A)
Symes, Wilfrid E. (A)
Tamburino, Anthony C. (A)
Ten Cate, Arthur C. (A)
Thineman, Edward H. (A)
Thomas, Charles F., Jr. (A)
Thompson, Sidney J. (A)
Thorsen, Orville T. (A)
Tittle, Hulburt C. (A)
Trimble, Loren (A)
Turner, C. G. (A)
Turner, George S. (M)
Turner, Harry E. (A)
Vanacore, Thomas (A)
Van Antwerp, Max C. (A)
Van Bockern, John H. (A)
Van Sickel, R. E. (A)
Vitellaro, Frank L. (A)
Walgren, C. A. (A)
Wallin, Harry E. (A)

ILLINOIS (Continued)

Chicago (Continued)
Wann, Richard H. (A)
Wegner, Charles W. (A)
Weibler, Carleton T. (A)
Weissmantel, C. H. (A)
Wiegrefe, Elmer J. (A)
Wilcox, G. M. (M)
Williamson, Frederick E. (A)
Wilm, Carl F. (A)
Woods, A. A. (A)
Woodward, Clarence H. (A)
Zurian, P. D. (A)
Zylstra, William G. (A)

Cicero
Durham, J. B. (A)
Engst, Norbert K. (A)
O'Brien, Elwin J. (A)
Taylor, H. S. (J)

Clinton
Arnold, Elmer J. (A)

Crete
Courchene, Homer B. (A)

Danville
Parsons, Charles (A)

Decatur
Maxwell, M. L. (A)
Spies, Mark C. (A)

Deerfield
Carment, James M. (A)

De Kalb
Clark, Bayard H. (A)

Des Plaines
Miller, Paul E. (A)

Dixon
Hall, Howard J. (A)

Downers Grove
Allen, Justus (A)
Hough, William E. (A)
Johnson, Arthur R. (A)
Vance, H. C. (M)

East Peoria
Hoffman, John L. (J)

Effingham
Osgood, Albert S. (A)

Elgin
Kadow, A. C. (A)

Elmhurst
Hercher, Frederick J. (A)
Inglis, Alexander W. (A)
Kenney, M. W. (M)
McIlvaine, Oran T. (M)
Walter, L. B. (A)

Evanston
Burt, Andrew G. (A)
Christopherson, Frederick (A)
Clarke, R. E. (A)
Fisk, Lawrence S. (A)
Hill, James H. (A)
Kurlbaum, Georg (A)
Lund, Russell O. (A)
Marty, Joe, Jr. (A)
Pennington, Paul (A)
Read, Oliver H. (A)
Stein, Harold A. (A)

Forest Park
Shabino, Clarke L. (A)

Freeport
Meyer, Winston F. (A)
Nestlerode, Boyd W. (A)
O'Connell, Gerald (A)

Geneva
Kranz, Frederick W. (A)

Glencoe
Marsh, Carlton H. (A)

Glen Ellyn
Pieri, Donald (M)

Great Lakes
Clark, Thomas F. (A)

Harrisburg
Tate, Joseph R. (A)

Highland Park
Berg, Berthil V. (J)
Rollefson, Karl E. (M)
Tucker, G. Lloyd (A)

Hinsdale
Armstrong, H. M. (A)
Doyle, E. J. (A)
Hill, Frederick A. (A)

Kankakee
Wilhelmi, Julian A. (A)

Kenilworth
Lahman, Wilford C. (A)

Kewanee
Larson, Clifford L. (A)

La Grange
Beckley, John G. (A)
Hofert, Fred A. (A)

Lake Bluff
Olesen, Harold L. (M)

Lake Forest
Baker, James M. (A)

Litchfield
Weller, Earl Selwyn (J)

Lockport
Carter, O. M. (A)

Lombard
Hollenbeck, A. T. (A)
Puhalski, Donald (A)

Macomb
Eller, Walter H. (M)
Snowden, P. T. (A)

Marion
Alley, Kenneth G. (A)

Maywood
Kamin, Vernon A. (A)
Teunisson, John F. (A)

Mt. Prospect
Gustafson, Gilbert E. (A)

Naperville
Stoos, Joseph A. (A)

Oak Park
Albee, Norman E. (A)
Augustine, Roy W. (M)
Bluzat, Claude R. (A)
Chase, Leslie H. (A)
Ewald, Fred J., Jr. (A)
Miller, John H. (M)
Nangle, W. O. (A)
Pearson, Oscar A. (M)
Philips, James H. (A)
Pye, Harold C. (A)
Roe, Douglas J. (A)
Sveen, Erwing A. (A)
Westcott, Philip S. (A)
Willing, William P. (A)
Woodruff, Albert E. (A)

Olney
Owens, Robert F. (A)
Schonert, K. E. (A)

Park Ridge
Butterfield, Roy O., Jr. (A)
Carr, J. O. (A)
Potter, M. L. (A)

Paw Paw
Braffet, Donald H. (A)

ILLINOIS (Continued)

Pekin
McGarvey, Harold R. (A)

Peoria
Kelly, Earl L. (A)
Shalkhauser, Eric George (M)
Snyder, Roy A. (A)
Williams, N. B. (A)

Quincy
Wilson, A. J. (A)

Rankin
Denton, Frank O. (A)

Rantoul
Arnold, Thos. E. (A)
Marriner, Alfred W. (A)
Richard, Charles W. (M)

River Forest
Edwards, George W. (A)
Heald, Merwyn (A)
McIlvaine, H. A. (M)

Riverside
Greaves, Walter M. (A)
Wills, David C. (A)

Rockford
Ferdinand, Harry P. (A)
Ward, Lloyd S. (A)
Westlund, J. V. (A)

Rock Island
Foley, Jack (J)
Stanley, Otis J. (A)

Savanna
Graham, George W. (A)

Springfield
Holtz, Frederick C. (A)
Kunz, H. L. (A)
Numrick, Fred (J)
Whannel, Raymond L. (A)

St. Charles
Shotwell, Harold H. (A)
Voorhaar, Frederick R. (A)

Stockton
Hanson, Ralph L. (A)

Streator
Licht, Henry M. (A)

Sycamore
Boynton, Frederick L. (A)

Tuscola
Fortner, Obed D. (A)
Moulden, Roy B. (A)

Urbana
Brown, Hugh A. (M)
Chapman, David E. (J)
Knipp, Charles T. (M)
Morris, Lloyd P. (A)
Reich, Herbert J. (A)
Tykociner, J. T. (M)

Villa Park
Jacker, Edward W. (A)

Waukegan
Cameron, Henry L., Jr. (A)
Glassford, J. O. (A)
Herrmann, Albert, Jr. (J)
Weeks, Robert H. (A)

West Liberty
Waddell, George G. (A)

Western Springs
Pomy, Herman J. (A)
Scott, Kenneth L. (A)

Westmont
Keim, Jacob A. (A)

Wheaton
MacCornack, Edwin A. (A)
Roman, Frank E. (J)
Taylor, Hawley O. (M)

Wilmette
Burrows, Fred A. (A)
Wolcott, C. Frederick (A)

Windsor Park
Falknor, Frank B. (M)

Winnetka
Gregory, Charlotte C. (A)
Hinson, Marcus W. (A)
Johnstone, George A. (A)
Manly, Harold P. (A)

INDIANA

Albion
Evans, Harry R. (A)
Ravenscroft, Carl Ernest (A)

Anderson
Miller, Louis (A)

Angola
Biar, L. E. (A)
Eiler, E. E. (M)
Johnson, H. Frank (A)

Aurora
Achatz, Raymond V. (A)

Bloomington
Ramsey, R. R. (M)

Connersville
Hamilton, Charles E. (J)
Hanes, Fred B. (A)

Crown Point
Hall, Fred F. (A)

Elkhart
Haselwood, W. E. (A)
May, Frank Darrell (A)
Schellenger, N. C. (A)

Evansville
Bender, Jack C. (A)
Norwood, Vandle Clarence (A)

Fort Wayne
Baker, Dean R. (A)
Bohling, C. F. (A)
Cook, Edward H. (A)
Hoffman, Walter H. (A)
Knouf, Ralph J. (A)
Ramm, Harold W. (A)
Ratts, Bruce H. (A)
Rekart, Arthur F. (A)
Schryver, Henry A. (A)

Gary
Gunther, W. J. (A)
Molony, John D. (A)

Indianapolis
Albershardt, Milton (A)
Barnett, Louis W. (A)
Byers, Russell R. (A)
Chapel, I. C. (A)
Dutton, Charles E. (A)
Lar Rieu, E. A. (A)
Reager, A. M. (A)

Kendallville
Jones, Richard Burton (A)

Lafayette
West, Glenn Edwin (M)

Linnsburg
Doyel, Lee Conan (A)

Marion
Boji, Louis D. (A)
Emerson, Kenneth H. (A)
Foster, Dudley E. (A)
Herrold, George V. (A)
Jarvis, Kenneth W. (M)
Pressley, Jackson H. (A)
Rose, Joseph K. (A)

INDIANA (Continued)

Princeton
Clark, Robert K. (A)
Karras, George S. (A)
McConnell, Roy E. (A)

Rushville
Russell, Merwyn A. (A)

South Bend
Bouchard, I. H. (A)
Crockett, David R. (A)
Kahn, Albert R. (A)
Kennedy, James P. (A)
Gebhardt, Paul B. (A)
Heimberger, Albert E. (A)
McNamee, B. F. (A)
Timmings, George H. (A)

Sweetser
Myers, Delbert (A)

Terre Haute
Hershman, J. B. (A)

Tipton
Gaiser, Martin (J)

Valparaiso
Cummings, Wilbur H. (A)
Fleming, Carl (J)
Leigh, Charles W. (A)
McConnell, Harley H. (A)
Noller, Roy E. (A)
Packman, M. E. (A)
Rosenberg, Bernard L. (J)
Terrill, Jeannette (A)

Wabash
Freeman, Stephen, Jr. (A)

Waterloo
Hamman, Howard L. (A)

Westfield
Brown, Wilfred E. (A)

West Lafayette
Poteet, Daniel P. (A)
Tanke, Harold F. (A)
Yoder, Leo E. (A)

IOWA

Ames
Huntsinger, Paul R. (J)
Lewis, John R. (J)

Britt
Mickelson, Silas (A)

Cedar Rapids
Collins, Arthur A. (J)
Fink, Jack (A)
Hajny, George F. (A)
Martz, Forrest W. (J)

Clarinda
Whitnah, R. B. (J)

Clinton
Labatt, Manor D. (A)

Council Bluffs
Anderson, Gordon A. (A)
Fisher, H. R. (A)
Mollring, Howard S. (A)

Davenport
Ehlers, Paul (A)
Elliott, Frank W. (A)
Klindt, H. M. (A)
Snyder, Reed E. (A)
Speers, John C. (A)
Wildman, Thomas S. (A)

Des Moines
Haigh, M. C. (A)
Hutchison, Sam T. (A)
Peavey, Everett A. (J)
Willits, Robert L. (A)

Douds
Greenfield, Daniel C. (J)

Estherville
Center, Edgar R. (A)

Fort Dodge
Willits, Andrew A. (A)

Iowa City
Griffith, Paul E. (A)
Stauffer, Ray Everett (A)

Keokuk
Davis, Chester L. (M)

McGregor
Woods, T. De Witt (A)

Monticello
Burrichter, Donald E. (J)

Mt. Vernon
Beranek, Leo L. (A)
Kafer, Merle D. (A)

North Liberty
Crozier, William D. (A)

Onslow
Koon, Cecil L. (A)

Red Oak
Coonley, F. A. W. (A)

Shenandoah
Rapp, John Cyril (A)

Sioux City
Coates, Frank M. (A)
Kerby, Edward J. (A)
Morris, Thomas J. (A)

Wapello
Fry, Lloyd L. (A)

Waterloo
Palmer, Paul M. (A)
Wilcox, Nathan (A)

KANSAS

Abilene
Brewer, Noble E. (A)

Atchison
Moore, Eugene A. (A)
Robb, Joseph S. (A)
Stein, Frederick W. (A)

Bendena
Johnson, Milton L. (A)

Ellis
Harrison, Louis A. (A)

Emporia
Miller, R. F. (A)

Independence
Elliott, Ralph W. (A)

Kansas City
Williams, Palmer H. (A)

Lawrence
Anderson, Harold W. (A)
Jones, George I. (A)
Omer, Guy C., Jr. (J)
Wheeler, Frederick (J)

Leavenworth
Hageman, Oliver C. (A)

Manhattan
Bueche, Harry S. (A)
Compton, Robin D. (A)
Whan, Loren H., Jr. (A)

Milford
Weldon, James O. (A)

Moran
Rand, George L. (A)

Neodesha
Crimmel, Henry W. (A)

Salina
Knittle, Theodore M. (A)

KANSAS (Continued)

Topeka
Cook, John W. (A)
Troeglen, Karl (A)

Wichita
Byers, Harrison O. (A)
Demuth, G. W. (J)
Marshall, George E. (A)
Mitchell, G. A. (A)
Mitchell, Theodore R. (A)

Winfield
Baden, Martin W. (A)

KENTUCKY

Ashland
Carr, Edward Mayes (A)

Covington
Bryant, William (A)
Davis, Irving C. (A)
Frassa, Charles F. (A)
Heffernan, S. K. (A)
Reid, Ralph J. (A)

Hopkinsville
Grimwood, Fred O. (A)

Jeffersontown
Strassman, Irving (A)

Lexington
McCammon, Donald (A)

Louisville
French, Richard D. (A)
Graft, J. Emmet (A)
Tillett, Jesse (A)

Newport
Kolo, R. E. (A)
Pepper, Robert K. (A)
Preuss, Arthur C. (A)
Richards, Amyle P. (A)

Owensboro
Biver, Carl J. (A)
Kirk, Walter C. (A)
Koechel, W. P. (A)

Paducah
Shelton, Raymond W. (A)

LOUISIANA

Alexandria
Keating, William J. (A)

Bastrop
Moeller, Jerome H. (A)

Baton Rouge
Lurry, Thomas M. (A)
Webre, Andrew S. (A)

Lake Charles
Lake, Thornton G. (J)

New Orleans
Adler, Leonard E. (A)
Alcus, Isaac (A)
Ammen, Charles E. (A)
Andres, Charles, Jr. (A)
Chateau, Arthur (A)
Clemmons, Wallace A. (A)
Collins, Jesse C. (A)
Collins, John Francis (A)
Dahlstrom, Hugo Wolf (J)
Deiler, Theodore G. (M)
Dover, M. H. (J)
Du Treil, L. J. N. (M)
Elliott, Harry M. (A)
Gallo, Louis J. (M)
Goldstein, Henry R. (A)
Hanna, G. E. (A)
Hart, M. E. (A)
Hibbett, James Orlin (A)
Hilgedick, W. C. (A)
Jensen, Valdemar (A)
Jones, Edward T. (M)
Labe, Henry, Jr. (A)
Lehde, Pendleton E. (F)
Long, Edwin G. (A)
Macke, William (A)
Maier, Otto T. (A)
McCabe, Louis L. (A)
Moore, Frank C. (A)
O'Neil, Maurice B. (A)
Pasquet, Jean E. (A)
Peirce, George H. (A)
Peters, C. W. (A)
Salzer, H. S. (A)
Scheffer, Roy J. (A)
Schiele, Anton A. (A)
Stevens, William J. (A)
Voegtlin, Elmo (A)

Shreveport
Claycomb, Hugh (A)
Temple, John M. (A)

Slagle
Hayes, Fred D. (A)

MAINE

Bangor
Baldwin, Richard B. (A)
Heartz, Leslie C. (A)
Kellom, Bernard (A)
Mullaney, John R. (A)

Brunswick
Little, Noel C. (A)

Houlton
Thrush, Paul W. (A)
Willes, Emerson T. (A)
Willis, F. H. (A)

Orono
Creamer, W. J., Jr. (A)

Portland
Collins, Lewis R. (A)
Rice, Harold E. (A)
Ryall, Henry (J)

Thomaston
Lee, Walter O. (A)

MARYLAND

Annapolis
Dowd, Alfred (A)
Giet, G. Robert (M)
Howard, David G. (A)
Kitchin, Howard Williams (M)
North, J. Harold (A)
Partello, Melville C. (A)
Robinson, Gordon D. (A)
Robison, Samuel S. (F)

Baltimore
Allen, John E. (A)
Allner, Frederick A. (A)
Berman, Henry O. (A)
Clark, Lloyd W. (A)
Cohen, Hyman A. (A)
Collins, Laurence H. (A)
Cooke, Gerald W. (A)
Baldwin, Preston De Grauw (A)
Dudley, Charles B., Jr. (A)
Ellert, Charles A. (A)
Emmerich, Henry J. S. (A)
Fetsch, Joseph T., Jr. (A)
Garvey, Joseph M. (A)
Goldstein, Maxwell K. (A)
Graf, Herman, Jr. (A)
Hannah, George M. (A)
Harris, Clifford C. (A)
Herndon, Landon C. (M)
Houston, George P. (A)
Krebs, William N. (A)

MARYLAND (Continued)

Baltimore (Continued)
Laker, Edwin F. (A)
Lange, Edward H. (A)
Mahone, George A. (A)
Mathers, Earl S. (A)
Miller, J. Purnell (A)
Nopper, Carlton G. (A)
Ranft, William Q. (A)
Ridenour, William S. (A)
Rodgers, John W. (A)
Rosso, Thomas (A)
Schultz, James (A)
Seitz, J. Fred (A)
Sterling, George E. (M)
Vacek, George J. (A)

Bethesda
Bush, George P. (M)

Boyds
Hargett, Wesley D. (A)

Chevy Chase
Bender, Louis B. (M)
Brady, John B. (M)
Dellinger, J. H. (F)
Gross, Gerald C. (M)
Kelley, George W., Jr. (A)
Walls, Hoy J. (M)
Wells, Harry W. (A)
White, Edwin L. (A)

Hyattsville
Lyon, Harry H. (A)

Laurel
Harrison, Lee (A)
Poist, Hohman J. (A)

Mt. Rainier
Eisenhauer, Harry D. (A)

Silver Spring
Mertie, J. B., Jr. (A)
Quaintance, Leland C. (A)
Thomsen, Paul H. (A)

MASSACHUSETTS

Adams
Barschdorf, Harry Oliver (J)

Allston
Becker, Carl William (A)

Andover
Stark, Eldon E. (A)

Arlington
Morrison, E. J. W. (A)
Trefry, Laurence D. (A)
Whittier, Ellerton W. (A)

Arlington Heights
Dallin, Edwin B. (M)
Lamson, Horatio W. (M)

Ashmont
Mullen, Joseph A. (A)

Atlantic
Brown, George W. (A)
Heap, Sheldon S. (A)
Moses, John P. (A)
O'Donnell, Edward T. (A)

Auburndale
Clapp, James K. (M)

Belmont
Anthony, A. W., Jr. (A)
Dolbear, Benjamin L. (M)
Gager, F. Malcolm (A)
Gleason, Harold H. (A)
Grant, Lawrence E. (A)
Lane, Henry M. (M)

Beverly
Appleton, Samuel (A)
Colby, Edward B. (A)
O'Neill, George D. (A)
Porter, Roland G. (A)
Woodbury, Stephen E. (A)

Boston
Allston, William F. (A)
Baird, Hollis S. (A)
Beakes, William E. (M)
Boyden, Davis S. (A)
Cabot, George E. (M)
Campbell, Donald W. (A)
Chetham, Harry R. (M)
Crawford, John D. (A)
Cumming, L. Gordon (A)
Emery, Ralph C. (A)
Fowler, Elisha (A)
Giro, Daniel J. (A)
Greene, Lloyd C. (A)
Harris, C. C. (M)
Haskins, Rupert L. (A)
Hayes, Hammond V. (A)
Hurd, Volney D. (A)
Jappe, Holger (M)
Mann, Hayward K. (A)
Nunez, F. J. (A)
O'Donnell, Edward F. (A)
Parnagian, Aram (A)
Pitts, Francis D. (A)
Putnam, John P. (A)
Rines, David (A)
Rosenwald, Edwin D. (A)
Stone, C. W. (A)
Weston, Irving L. (A)

Bradford
Knowlton, Robert G. (A)

Braintree
Robinson, Philip F. (A)

Brighton
Sylvester, John C. (A)
Wallace, Gordon S. (A)
Yurt, F. X. (A)

Brockton
Sampson, Edward J. F. (J)
Wright, William L. (A)

Brookline
Bowker, Winthrop H. (A)
Burdick, Adelbert B. (A)
Cabot, Sewell (M)
Campbell, Harold G. (A)
Fitts, Lincoln W. (A)
Peckham, J. H. (A)
Ready, William A. (A)
Weeks, Miles W. (A)

Cambridge
Batchelder, Laurence (A)
Bauer, Paul S. (A)
Bird, J. Raymond (A)
Blodgett, Edward D. (A)
Bousquet, Arthur G. (A)
Bowles, Edward L. (M)
Browne, Theodore C. (M)
Burke, Charles T. (M)
Chaffee, E. Leon (F)
Cullum, A. Earl (J)
Eastham, Melville (F)
Elser, F. Johnson (A)
Fahnstock, Harris, Jr. (A)
Ford, John R. (A)
Gilliland, Theodore R. (A)
Hickman, Roger W. (A)
Hisamoto, Masyauki (A)
Hollywood, John M. (J)
Horton, J. Warren (F)
Hunt, Frederick V. (A)

MASSACHUSETTS (Continued)

Cambridge (Continued)
Ide, John M. (A)
Jen, C. K. (A)
Johnson, Montgomery H., Jr. (A)
Kennelly, Arthur E. (F)
Le Van, James D. (A)
Liu, Sui-Fan (A)
McElroy, Paul K. (M)
Phillips, Henry B. (M)
Pierce, George W. (F)
Pilkington, E. J. (A)
Richmond, Harold B. (F)
Spike, J. Edward, Jr. (A)
Thiessen, Arthur E. (M)
Tuttle, William N. (A)
Weare, John (A)
Weeks, Paul T. (M)
Wilder, Marshall P. (A)
Wildes, Karl L. (A)
Woodrow, James A. S. (A)
Worthen, Charles E. (A)

Chatham
Kelly, Michael P. (A)
Robinson, Forrest D. (A)

Chelsea
Fox, Robert (A)
Murdock, D. R. W. (A)

Chestnut Hill
Dellenbaugh, F. S., Jr. (M)

Chicopee Falls
Davis, R. L. (A)
Ellsworth, William C. (A)
Gough, John H. (A)
Harlow, Fred G. (A)
Kinsman, Warren D. (A)
Laport, Edmund A. (M)
Lee, Donald C. (A)
Little, Donald G. (F)
Madsen, Carl J. (A)
Moatz, Daniel R. (A)
Taggart, Samuel E. (A)
Wolf, Lester J. (A)

Cliftondale
Tripp, Augustus B. (A)

Concord
Hall, Henry D. (A)

Danvers
Turenne, Wilford J. (A)

Dedham
Cowan, Edward J. (A)

Dennis Port
Skinner, Oscar E. (A)

Dorchester
Barry, Francis J. (A)
Berest, Anton (A)
Berkowitz, Louis (J)
Chessler, Maxwell A. (A)
Clarke, Ralph S. (A)
Feldman, Sarley M. (A)
Hardy, Carroll N. (A)
Meredith, William B. (A)
Purssell, Clarence V. (A)

East Pepperell
Frost, Edgar W. (A)
Hills, Eugene K. (J)

East Springfield
Henderson, Roy A. (A)
Hurff, Joseph L. (A)
Kowalczik, William J. (A)
Miller, Harold R. (A)
Smith, Edgar H. (A)
Trigger, Vernon A. (A)

Everett
Pratt, P. W. (A)

Fall River
Bowen, Harold C. (A)
Walsh, Philip S. (A)

Fitchburg
Wiinikka, Arthur O. (J)

Framingham
Forbes, E. D. (F)
MacAdam, Mark L. (A)

Gloucester
Adams, John C. (A)
Hammond, John Hays, Jr. (M)
Hoyt, Edward C. (J)

Great Barrington
Barkley, Howard F. (A)
Parrish, Robert R. (A)

Greenwood
Clement, Ivan C. (A)

Hamilton
Dane, Francis W. (M)

Haverhill
Dyer, John Newton (J)

Hingham
Phelps, Roger E. (A)
Pratt, Fearing (A)

Hingham Center
Imlach, George (A)

Holyoke
Klemm, Robert Carl, Jr. (A)

Hyannis
Stanko, Edward (A)

Hyde Park
Gould, William B., III (A)

Jamaica Plain
Bailey, William M. (M)
Canner, William (A)
Hazard, Willis Gilpin (A)
Mayer, Arthur W. (A)

Lawrence
Geloso, John (A)
Theberge, Albert R. (A)

Lexington
Chute, Dudley H. (A)

Longmeadow
Booth, James D. (A)
Brackett, Quincy A. (M)
Forbes, Henry C. (M)
Greis, W. Karl (A)

Lowell
Martel, Charles W. (J)
Morton, Clarence F. (A)

Lynn
Abrahams, Samuel L. (A)
Le Bel, C. J. (A)
Mayo, Royal E. (A)

Malden
Millen, James (A)

Marion
Brunette, Deo Z. (A)
Rau, David S. (A)

Mattapan
Hosford, Harold B. (A)
Rothberg, Joseph (A)
Weber, Harold C. (A)

Medford
Cook, Bernard L. (A)
Cook, Wilbert H. (A)
Greene, C. Francis (A)
Wyman, Raymond C. (A)

Melrose
Flanders, W. Hubert, Jr. (J)
Hubbard, Beverly R. (A)
Jepson, Warren F. (A)
Philbrick, Lawrence S. (A)
Tyzzer, Howard J. (A)

MASSACHUSETTS (Continued)

Melrose Highlands
Jewett, Raymond B. (A)

Milton
Arnold, Prescott N. (A)
Hoard, Norman F. (A)

Natick
Webster, R. G. (A)

Needham
Keim, J. D. (A)

New Bedford
Blanchet, Ovila J. (A)
Catterall, John (A)
Hodgson, Herbert J. (A)
Vermilya, Irving (M)
Wilson, Walter B. (A)

Newburyport
Scott, Gilbert H. (A)

Newton
Briggs, Thomas H., IV (A)
Colby, Charles C., Jr. (A)
Nelson, James R. (M)

Newton Center
Miller, William T. (A)
Pickard, Greenleaf W. (F)

North Adams
Clark, R. U. (A)
Dunleavey, Frank S. (A)
Leoser, Thomas S. (M)
Rickey, Lawrence (A)
Steen, J. Ralph (A)

North Attelboro
Barrett, Herman R. (A)
Hale, Willis L. (A)

North Quincy
Surette, Dennis C. (A)

North Weymouth
Hollis, Hammond H. (A)

Oak Bluffs
Horne, William P. (A)

Orleans
Snow, Albert E. (A)

Osterville
Sprague, Barbara Russell (J)

Oxford
Browning, Elliot Andrew (J)

Quincy
Girard, Leon F. (A)
Nolan, James J. (M)
Renton, Ralph James (A)

Revere
Burns, Laurence (A)
Gelardi, Matthew (A)

Roslindale
Mills, William P. (A)
Sykes, Roger Allen (A)
Van Brocklin, William S. (A)

Rowley
Hoopes, Thomas T. (A)

Roxbury
Ashenden, G. K. (A)
Gerber, Nathan (A)
Katz, Louis S. (A)
Stone, Elmer F. (A)

Salem
Bolan, Robert S. (A)
Cooke, Walter D. (A)
Hamilton, Hugh, Jr. (A)
Poor, Walter E. (A)
Porter, Ralph H. (A)
Rockwood, Alan C. (M)

Seekonk
Stackpole, Nelson B. (A)

Siasconset
Holden, Harry H. (A)

Silver Lake
Stein, Adam, Jr. (F)

South Braintree
Serreze, Victor C. (A)

Somerville
Balderson, James R. (A)
Dillaby, Edwin F. (A)
MacInnis, James A. (J)
Parker, William H., Jr. (A)
Root, Leland B. (M)

Southbridge
Wells, John M. (A)
Yates, Wilfred (A)

South Dartmouth
Chinn, Howard A. (A)
Hendricks, Paul S. (A)
Houghton, Henry G., Jr. (A)

South Medford
Hilles, Lewis M. (A)

Springfield
Applegate, Homer E. (A)
Beard, J. Gregson (M)
Benner, Howard J. (A)
Bock, Ashley P. (M)
Bond, M. E. (A)
Boyd, Bruce (A)
Bruce, Birger (A)
Bruce, Ragnar (A)
Burnside, Carrol J. (A)
Cameron, J. A. (A)
Cole, Neil D. (A)
Cotter, William F. (A)
Creaser, Isaiah (A)
Curtis, Leslie F. (M)
Davis, William G. (A)
Der Bedrossyan, Mark (A)
Dyson, H. R. (A)
Ferguson, George W. (A)
Fortier, Ralph L. (M)
French, Benedict V. K. (M)
Garvey, Edmond (A)
Gilliatt, Leland W. (A)
Holt, Hillis W. (A)
Hutcheson, John A. (M)
Lavallee, J. A. (M)
Moauro, Joseph S. (A)
Nystrom, Raymond A. (A)
Raskhodoff, Nicholas (A)
Russ, George H. (A)
Stuckert, E. M. (A)
Thomas, Harry E. (A)
Valentine, Francis B. (A)
Walker, C. L. (A)
Weber, C. A. M. (A)

Stow
Kaulback, Harold D. (A)

Swampscott
Humphrey, Stanley M. (A)

Tufts College
Campbell, Winferd H. (A)
de Mars, Paul A. (M)
Kenrick, Gleason W. (M)

Waban
Church, Vallette S. (A)

Waltham
Grenier, Henry M. (A)
Hatton, Arthur Thomas (A)

Watertown
Anderson, Homer G. (A)
Field, Robert F. (M)
Salvini, David K. (A)

Wellesley
McDowell, L. S. (M)
Russell, Robert D. (A)

MASSACHUSETTS (Continued)

Wellesley Farms
Hills, Charles E., Jr. (A)

West Milbury
Day, Ralph P. (A)

West Roxbury
Rochford, John (A)
Wolf, Edwin A. (A)

West Somerville
Ekstrand, Edward B. (A)
Kolster, Charles C. (M)

Winchester
Allen, Albert (A)
Browning, Glenn H. (M)
Burgoyne, Roger M. (A)
Page, Newell C. (A)

Winthrop
Colton, Howard C. (J)

Wollaston
Compton, G. Edwin (A)
Gray, Alfred R. (A)
Hoffman, E. F. (A)
Kennard, Kenneth F. (A)
McGrath, Joseph L. (A)
Sigmon, L. C. (A)
Waite, Amory H., Jr. (A)

Woods Hole
Speirs, George E. (A)

Worcester
Anderson, Paul E. (J)
Bates, Lee A. (A)
Cohen, Monte (A)
Gleason, Albert E. (A)
Godfrey, James S. (A)
Gruzin, Herman A. (J)
Joseph, J. Bernard (A)
Newell, Hobart H. (M)

MICHIGAN

Ann Arbor
Campbell, George R. (A)
Case, Nelson P. (A)
Fuller, Lyman D. (A)
Holland, Lewis N. (A)
Martin, Paul E. (A)
Parkinson, Taintor (A)
Uehling, Edwin A. (A)
Wilbur, Donald A. (A)
Williams, N. H. (A)

Battle Creek
Doty, W. E. (A)
Fay, Lewis C. (A)
Kinch, Oscar A. (A)
Roof, Raymond B. (A)

Bay City
Carpenter, Ralph H. (A)
Wesser, Carl H. (A)

Bellevue
Olinger, Robert (A)

Berrien Springs
Fetzer, John E. (M)

Blanchard
Kersey, Russell (A)

Dearborn
Knight, Donald M. (A)

Detroit
Almas, Stan L. (A)
Alston, Vernon C. (A)
Annett, Earl (A)
Blumenthal, Raymond W. (A)
Bond, Orville J. (A)
Brown, Jesse E. (M)
Buchanan, Arthur B. (A)
Byerlay, H. Le Roy (A)
Byram, F. Cameron (A)
Carson, Walter E. (A)
Carter, George W. (M)
Clark, Ralph L. (A)
Clark, Thomas E. (M)
Courtis, Reginald P. (A)
Crary, Frederick W. (A)
Davis, Chester (A)
De Hart, Delmar W. (J)
Denstaedt, Edwin C. (A)
Dow, Larry W. (A)
Du Bois, Edward P. (A)
Faulkner, Douglas (A)
Firestone, Samuel (A)
Friedenthal, Andrew (A)
Gasparovitch, Stephen (A)
Geiger, Arthur H. (A)
Goldman, Sherman (A)
Green, Walter M. (A)
Griva, John (A)
Grote, Ernest A. (A)
Grove, George A. (A)
Haire, A. F. (A)
Hand, Carl A. (A)
Harding, Lawrence M. (A)
Hemberger, E. F., Jr. (A)
Hibbs, Archie M. (A)
Hoffman, Walter R. (A)
Howey, William J. (A)
Jackson, C. H. (A)
Joy, Henry B. (A)
Kirby, Corley W. (A)
Kirby, Otto I. (A)
Kratokvil, Frank M. (A)
Kunins, Morris K. (A)
Lapham, Olin J. (A)
Lathrop, F. A. (A)
Ludvigsen, Leonard E. (J)
Malo, Charles D. (A)
Manning, Stanley R. (A)
McCaffry, James A. (A)
Miller, Gerald E. (A)
Moore, J. Burton (A)
Outzen, Andrew N. (A)
Pepin, Ronald H. (A)
Porter, Samuel (A)
Putnam, Erle T. (A)
Scanlan, Richard J. (A)
Schmalzriedt, T. (A)
Seilstad, Harold (A)
Seymour, Fred M. (A)
Sheridan, Russel J. (A)
Soeters, Raymond A. (A)
Stansfield, Selwyn (A)
Steinhauser, Clarence J. (A)
Sturman, George G. (A)
Tomchuck, John (J)
Trittenbach, John M. P. (A)
Trowbridge, O. H. (A)
Waynick, Arthur H. (A)
Wilber, Delbert J. (A)
Worel, Frank (A)

East Lansing
Fridgen, Edward N. (A)
Graham, Herbert T. (A)
Murray, William A. (A)
Osborn, Burr K. (A)
Richards, A. R. (A)

Farmington
Kreuzer, A. R. (A)

Fenton
Dobbs, F. W. (A)

Ferndale
Elliott, John E. (A)

Flint
Blanford, Edwin C. (A)
Blanford, Estill Kenneth (J)
Fallain, Frank D. (A)
Forbey, William D. (A)
Lutes, Clifford (A)
Raab, Edwin (A)

MASSACHUSETTS (Continued)

Frankfort
Hopper, C. L. (A)

Gladstone
Peterson, W. Earl (A)

Grand Haven
Detrick, Harold M. (A)

Grand Rapids
Andres, Lloyd J. (A)
Blett, E. Barton (A)
Goebel, Eugene S. (A)
Manchester, Raymond M. (A)
Sullivan, Robert J. (A)

Grosse Pointe Park
Smith, Walter C. (A)

Harbor Springs
Wright, Wilford C. (J)

Highland Park
Collins, Frederick V. (A)
Glatzel, Earle D. (A)
Gould, Howard S. (A)
Owen, Charles W. (J)

Holland
Hawkins, John B. (A)
Tysse, Henry L. (A)

Jackson
Adams, Eugene C. (A)
Atkins, Carl Edward (J)
Bailey, Neil (A)
Bowmaster, J. M. (A)
Mountjoy, Garrard (A)
Pacholke, Fred (A)
Pampel, Frank Linden (J)
Pickles, Arthur W. (A)
Planck, R. M. (A)
Rich, C. E. (A)
Riethmiller, Earl R. (A)
Strait, Clarence L. (A)
Volkenant, Gordon W. (A)
Ward, Donald H. (A)
Whitlock, Fred (A)

Kalamazoo
Evans, Nicholas O. (A)

Lakeside
Meier, H. G. (A)

Lansing
Aman, Bernard H. (A)
Barnwell, Walter J. (A)
Wells, Lawrence V. (A)
Willis, Ellsworth D. (A)

Lennon
Reed, Stanley C. (A)

Ludington
Fenton, Kenneth G. (J)

Menominee
Westervelt, H. P. (A)

Midland
Mathison, Gerald (A)

Mt. Clemens
Wendler, Erwin, Jr. (A)

Muskegon
Fonger, C. Irwin (A)
Hewitt, C. Tefft (A)
Lowe, Carr E. (A)
Retzlaff, K. C. (A)
Schwarz, Harvey F. (A)
Yoder, Raymond S. (A)

Oxford
Capron, E. S. (A)

Port Huron
Brown, Kenneth L. (A)
Fountain, J. Clarence (A)
Newland, Charles W. (A)

Republic
Ahlgren, William E. (A)

Saginaw
Trumble, L. A. (A)

St. Clair Shores
Osborne, Robert L. (A)

St. Joseph
Palmer, Edward D. (A)

Trenton
Williamson, Charles G. (A)

Sault Sainte Marie
Smith, Rex B. (A)

South Haven
Arthur, Ralph L. (A)
Bennett, Maurice C. (A)
Crossley, Alfred (M)
Hansen, Leland S. (A)
Hollands, Louis C. (A)
Jorgenson, Harold (A)

Spring Arbor
Stahl, Theodore H. (A)

Wyandotte
Steffin, V. J. (A)

Ypsilanti
Augustus, Lee M. (A)

MINNESOTA

Baudette
Gjelhaug, John A. (A)

Carver
Olson, Marvin S. (A)

Chisholm
Ambrozich, John L. (A)

Detroit Lakes
Hetland, L. C. (A)

Duluth
Cosandey, Charles J. (A)
Ross, Russell H. (A)

Edgerton
Rust, Leslie W. (A)

Hopkins
Fuxa, Albert E. (A)

Lakefield
Tkach, George (A)

Minneapolis
Almberg, Clarence H. (J)
Braum, C. M. (A)
Brooke, Robert O. (J)
Carney, Philip G. (A)
Cooke, Lawrence S. (A)
Edwards, Henry W. (A)
Fleming, Myron Neil (A)
Gibbs, Earl (A)
Gould, Payson R. (J)
Hawley, Douglass (A)
James, V. Norval (J)
Nergaard, Leon S. (A)
Roth, Harold B. (A)
Schnell, Louis J. (A)
Smeby, Lynne C. (A)
Stevens, Carl T. (A)
Sweeney, Claude D. (A)
Tynan, Thomas E. (A)
Webb, J. S. (A)
Young, Sumner B. (A)

Northfield
Culver, Charles A. (M)

Ponsford
Cox, Hector S. (J)

MINNESOTA (Continued)

St. Paul
Coil, Neil B. (A)
Hance, Kenneth M. (A)
Heiser, Edwin S. (A)
Janes, Clinton W. (A)
Parsons, J. B. (A)
Rankine, James C. (A)
Strout, Everett M. (A)

Virginia
Hauta, Theodore (A)

Waseca
Johnson, Edgar F. (A)

MISSISSIPPI

Corinth
Essary, William M. (A)

Greenwood
Fausett, Floyd (A)
Johnson, Vivion A. (A)

Hattiesburg
Crews, J. H. (A)

Jackson
George, Edward M. (A)
Myers, James A. (A)

Kosciusko
Sowell, George O. (A)

Meridian
Woodruff, B. H. (A)

Mississippi City
Pecoul, F. A. (A)

MISSOURI

Bucklin
Holmlund, A. Earle (A)

Cape Girardeau
Hirsch, Oscar C. (A)

Columbia
Lewis, Earl W. (A)

Gallatin
Payne, Kenneth (A)

Hughesville
Rissler, Harold D. (A)

Independence
Church, Arthur B. (A)
Moler, A. R. (A)

Jefferson City
Corwin, Willis P. (A)
Lance, Hubert H. (A)
Sloan, Fergus M. (A)
Webster, Glenn E. (A)

Kansas City
Boat, John (A)
Bradbury, G. V. (A)
Campbell, Donald O. (A)
Cook, Ellis C. (A)
Davis, Dudley J. (A)
Fouts, Avery L. (A)
Goldenberg, Henry E. (A)
Groendycke, Richard W. (A)
Hodge, Albert William (A)
Joyce, Gilbert B. (J)
Kent, James M. (A)
Kent, Paul N. (A)
MacDowell, Earl B. (A)
MacDowell, Karl P. (A)
McDonell, William J. (A)
Miller, Wayne (A)
Obright, Alvin C. (A)
Pitt, William (A)
Schilling, John T. (A)
Screechfield, R. M. (A)
Upham, Stuart W. (A)
Van Gundy, Clarence (A)
Vasen, Gustave (A)
Willing, James P., Jr. (A)
Yates, Clarence C. (A)
Young, William M. K. (A)

Kearney
Thomason, Marvin (A)

Kirksville
Davis, Robert J. (A)

Mendota
Davis, Glen A. (A)

Nevada
Kluth, William J., Jr. (A)

Robertson
Gray, Harold E. (M)

Rockport
Wolf, Ray O. (A)

Rolla
Frame, Floyd H. (A)
Martin, J. Douglas, Jr. (J)

Springfield
Larsen, John (A)
Moss, Terry L. (A)
Ward, G. Pearson (A)

St. Joseph
Abercrombie, Julius B. (A)
Bauer, Fritz (A)
Watts, Harold F. (A)

St. Louis
Althoff, Frederick E. (A)
Bergtold, A. L. (A)
Browning, Roy H. (A)
Bush, Walter S. (A)
Duffy, Charles A. (A)
Ferris, Harry J. (A)
Fillmore, Francis A. (A)
Fowler, D. W. (A)
Fritz, Harry R. (A)
Garvey, Arthur (A)
Humphreys, Irl W. (A)
Koehler, Elmer F. (A)
McDaniel, Otto S. (A)
Parish, Eugene V. (A)
Pennington, D. J. (A)
Pingree, Samuel J. (A)
Proehl, Robert O. (A)
Quinby, Porter H. (A)
Reiss, Paul E. (A)
Riddle, Ruston L. (A)
Sampson, John C. (A)
Schechter, Leo (A)
Tevis, Graham L. (A)
Van Sickle, George W. (A)
Welhoelter, Milton (A)
West, William H. (A)
Wirts, Charles C. (A)
Wooley, W. C. (A)
Zehr, Nicholas J. (A)

University City
Glasgow, Roy S. (M)

Waldron
Barker, L. T. (A)

MONTANA

Butte
Crouter, Leslie E. (A)
Doody, William R. (A)
Woodhouse, Geoffrey Arthur (A)

Forsyth
Pritchard, Charles A. (A)
Roberson, Carl (A)

MONTANA (Continued)

Great Falls
Haag, Merwin W. (A)
Van Blaricom, S. (A)

Havre
Peters, Vern (A)

NEBRASKA

Aurora
Spencer, Albert H. (A)

Carleton
Damm, Fred (J)

Clay Center
Hertel, Roger H. (J)
Swanson, Carl R. (A)

Falls City
Chesley, Arthur D. (A)
Quigley, James H. (A)

Grand Island
Ball, I. Dale (A)
Edwards, Samuel W. (M)
Jensen, George L. (A)
Martin, Robert D. (A)
Rollins, George K. (A)
Russ, John A. (A)
Wolf, Benjamin (M)

Howells
Prucha, Ernest F. (A)

Lincoln
Anderson, J. Sumner (A)
Brackett, Richard T. (A)
Harvey, H. C. (A)
Jensen, John C. (M)
Kimberly, Harbert D. (A)
Koch, J. Wesley (J)
Leeman, Wilson (A)
Norris, Ferris W. (A)
Norris, William C. (J)
Rohwer, Paul C. (A)
Schultz, Harvey R. (A)

North Platte
Spencer, Herbert L. (A)

Omaha
Badgerow, Bert E. (J)
Crawford, J. B. (A)
Diehl, Charles B. (A)
Glanton, D. R. (A)
Henry, Gordon I. (J)
Herold, Jos. L. (A)
Kotera, William J. (A)
Shirk, Kenneth C. (A)
Stratman, Fred W. (J)
Stultz, Erle D. (J)
Veverka, R. E. (A)

York
Meyer, Albert (A)

NEVADA

Reno
Peters, Jay (A)
Sandorf, Irving J. (A)

NEW HAMPSHIRE

Claremont
Hodge, V. W. (A)

Durham
Evans, Carl B. (J)

Exeter
Shaw, Henry S. (M)

Gorham
Dodge, Joseph B. (A)

Manchester
Ryan, M. John (A)

Newport
Walker, Charles M. (A)

Portsmouth
Martin, Julius (M)

Sunapee
Graves, William S. (A)

Tilton
Booth, Howard M. (M)

NEW JERSEY

Allenhurst
Hickley, Thomas J. (A)

Ampere
Adams, Harry (A)
Cassell, Joseph L. (A)
Goshaw, Irl R. (A)
Harrison, Jamison R. (A)
Hund, August (F)
Keary, Hugh F. (A)
Paynter, E. J. (A)
Powers, Walter P. (M)
Solomon, S. (A)
Walter, John C. (A)
Weston, John L. (A)

Asbury Park
Honnell, Pierre M. (A)

Atlantic City
Flett, William J. (A)
Riser, Morris (A)

Atlantic Highlands
Odenbach, Joseph F. (A)

Audubon
Batchelor, Harold (A)
Carlisle, Richard W. (M)
De Haven, Thomas V. (A)
Fisher, Norman (A)
Harris, William A. (A)
Knowles, Jerome H., Jr. (A)
Lynn, Roland A. (A)
Risinger, Paul (A)
Somers, Brock A. (A)
Stanton, Clair F. (A)
Stocker, Arthur C. (A)

Blackwood
Schneider, Edward (A)

Bloomfield
Beidleman, Howard B. (A)
Born, W. Theodore (A)
Bryan, Oscar F. (A)
Cunliffe, Paul R. (A)
Dingley, Edward N., Jr. (A)
Haines, Donald G. (A)
Hall, Norman C. (A)
Hanson, Ernest R. (A)
Henry, T. J. (A)
Kannenstine, F. M. (A)
McClary, James P. (A)
Mitchell, Clair D. (M)
Peck, Gordon V. (A)
Perkins, William M. (M)
Rouse, Guy F. (A)
Schoene, Russell L. (M)
Slattery, John J. (A)
Taber, Wm. T. (A)
Vermillion, Charles O. (A)
Weaver, Karl S. (A)
Widell, E. Gideon (M)
Winans, Roswell R. (A)
Zimber, Raymond M. (A)

Bogota
Bisbee, Robert H. (A)
Gilcher, V. J. (A)

NEW JERSEY (Continued)

Boonton
Albert, William H. (A)
Ballantine, Stuart (F)
Cobb, Howard L. (A)
Cordell, Peter C. (A)
Drake, Frederick H. (M)
Ferris, Malcolm (M)
Haas, John G. (A)
Hughes, Everett J. (A)
Hull, L. M. (F)
Landon, Vernon D. (M)
Loughlin, William D. (M)
Morrison, John F. (A)
Noyes, Atherton, Jr. (A)
Parkes, A. W., Jr. (A)
Pittenger, Arthur W. (A)
Seabury, Richard W. (M)
Snow, Harold A. (A)
Stone, G. Edgar (A)
Wilmotte, R. M. (M)

Bound Brook
Gullans, John H. (A)
Hagmann, Nicklaus (A)
Lindstrom, Arthur J. (A)
Stair, Daniel N. (A)

Bridgeton
Nichols, H. L. (A)

Caldwell
Cole, Arthur B. (M)
Eberhard, Lawrence E. (A)
Hotopp, Alfred H., Jr. (M)

Camden
Ackerman, Milton J. (A)
Adams, Quinton (M)
Anderson, Pierson A. (M)
Baker, W. R. G. (F)
Barbee, Virgil A. (A)
Bloomenthal, Sidney (A)
Bogardus, Henry L. (M)
Bohman, Victor A. (A)
Boswell, James R. (A)
Boucheron, Pierre H. (M)
Brail, Stephen L. (A)
Brown, Elmer L. (A)
Carlson, Wendell L. (A)
Castor, Amasea H. (A)
Cioffari, Bernard (A)
Cordova, F. B. (A)
Craig, P. M. (A)
Crite, Mitchel (A)
Cummings, John J. (A)
Darlington, Edgar T. (A)
Demmer, A. H. (A)
De Nardo, Federigo (J)
Dickey, Edward T. (M)
Douthit, M. L. (A)
Engstrom, Elmer W. (A)
Farrow, Frederick R., Jr. (A)
Frank, Charles W. (A)
Freudenthal, Jack (A)
Garrett, Charles R. (A)
Geoghegan, Eamonn D. A. (A)
Gillette, K. G. (A)
Goodrich, Robert R. (A)
Gunther, Clarence A. (A)
Haigis, C. D. (A)
Hansen, John C. (A)
Hardin, L. L., Jr. (A)
Hargrave, W. A. (A)
Hilton, Waldo R. (A)
Hutchko, Francis J. (A)
Johnson, Esmond (A)
Koch, Winfield R. (A)
Lehr, Rudolph (A)
Loughren, Arthur V. (M)
Lyndon, William L. (A)
Massa, Frank (A)
McCullough, Maurice B. (A)
McLennan, Miles Aryault (A)
Michelman, Edward A. (A)
Mkitarian, Luther M. (A)
Morse, Louis R. (A)
Ogloblinsky, Gregory (M)
Potts, John H. (A)
Reeber, Herman E. (A)
Reesor, Delbert A. (A)
Regottaz, Joseph M. (A)
Ringel, Abraham (M)
Roberts, Richard P. (A)
Selby, Eugene O. (A)
Smith, Carl E. (A)
Stayer, David (A)
Tolson, W. A. (M)
Troxell, George W. (A)
Ward, Donald G. (A)
Whelan, Dow O. (A)
Williams, Gurdon H. (A)
Wolff, Irving (A)
Zinnecker, Herman K. (A)

Carlstadt
Fuelling, Paul W. (A)

Cartaret
Cox, George C. (A)

Cedar Grove
Holborn, Frederick A. (M)
Wheeler, C. M. (A)

Clayton
Purvis, Charles G. (A)

Clementon
Attmore, William B. (A)

Cliffside
Dana, David W. (A)

Cliffside Park
Hudson, Julius (A)

Clifton
McConnel, W. G. (A)
Watts, Ivor B. (A)

Clinton
Wagner, Harry S. (A)

Collingswood
Allen, Hugh E. (A)
Barton, Loy E. (M)
Beers, G. Lisle (M)
Bell, Richard (A)
Charrier, George M. (A)
Closson, Luke E. (A)
Cunningham, Thomas D. (A)
Curtiss, Arthur N. (A)
Gihring, Herman E. (A)
Grundmann, Gustave L. (A)
Gunby, O. B. (A)
Hamilton, Sam (A)
Hudtwalker, William Theodore (A)
James, Wallace McMeal (A)
McCloskey, James Walter (A)
Orr, Robert W. (A)
Sherman, Kenneth S. (A)
Strasser, Edward J. (A)
Swanson, Milton A. (A)
Terrell, John A. (A)
Tiedje, John Q. (A)
Turner, Alfred H. (A)
Vose, Charles H. (A)
Walker, M. C. (A)
Weible, Norman R. (A)

Coytesville
McLaughlin, James L. (A)

Cranford
Briggs, Loyd A. (M)
Pulley, Lester A. (A)
Richards, Horace Jerome (A)
Wallgren, Alric E. (A)

NEW JERSEY (Continued)

Deal
Babcock, Stuart M. (A)
Eberhardt, George M. (A)
Ferrell, Enoch B. (M)
Goodall, William M. (A)
Kerwien, Arthur E., Jr. (A)
Schlaack, Norman F. (A)
Shaw, Robert C. (A)
Skellett, A. Melvin (M)
Smith, Phillip H. (A)
Sowers, Nelson E. (A)
Sterba, E. J. (A)

Denville
Harlan, Edwin W. (A)

East Orange
Ackerman, Rudolph W. (M)
Akers, Dallas C. (A)
Bagnall, Vernon B. (A)
Berry, James L. (A)
Billups, Robert W. (A)
Bohner, Chance E. (A)
Borgeson, Carl A. (A)
Brach, Leon S. (M)
Brigham, Cyril A. (A)
Butler, H. R. (A)
Clarry, Harold E. (A)
Curtis, Austen M. (M)
Curtis, R. C. (A)
Dannals, Earl W. (M)
Duncan, R. D., Jr. (M)
Edison, Theodore M. (A)
Fajen, Alfred H. (A)
Gawler, Henry C. (M)
Gerns, William H. (M)
Green, Ralph W. (A)
Harris, Sylvan (M)
Hiller, Harry E. (A)
Hoffman, Henry J. (A)
Isler, Samuel (M)
Kleinkauf, James D. (J)
Lederer, Ernest A. (M)
Mabey, Charles A. (A)
Miller, George A. (A)
Monfort, Ray A. (A)
Morrison, Howard (A)
Newell, Guy (A)
O'Donohue, James P. (A)
Oman, Nils Johann (A)
Perry, Irving D. (A)
Pickard, Richard W. (A)
Price, Harry J. (A)
Richards, Philip A. (A)
Roetken, A. A. (A)
Rudebock, Everett L. (A)
Salmons, George C. (A)
Shackelford, B. Estill (M)
Shultz, E. Patterson (A)
Somers, Richard M. (A)
Spencer, Millard C. (A)
Stanwick, Charles A. (A)
Taylor, Theodore (A)
Tucker, George B. (A)
Wallace, Milton W. (A)
Woods, William A. (A)
Woodworth, Fred B. (A)

Elizabeth
Bernhard, Frederick S. (A)
Brick, Frank R., Jr. (M)
Crowley, David A. (A)
Engel, Albert L. (J)
Jatlow, J. L. (A)
Mazik, John, Jr. (A)
Sery, Lester (A)
Tucker, John, Jr. (A)
Walsh, Lincoln (A)
White, Charles P. (A)

Englewood
Ashton, John E. (J)
Emanuel, John H. (A)
Gillett, Glenn D. (M)

Erlton
Briggs, Joseph A. (A)

Fanwood
Hall, Clifford A. (A)
Todd, Harold C. (A)

Fort Monmouth
Cohn, Ralph I. (A)
Hayden, Gilbert (A)
King, Cary J., Jr. (A)
Lenzner, Emil (A)
Lyman, Reginald P. (M)
Moriarty, James F. (M)
Murphy, William H. (M)
O'Connell, James D. (A)
Slonaker, Louis V. (A)
Spittle, Samuel E. (A)
Wilson, Russell A. (A)

Freehold
Englund, Carl R. (F)

Glen Ridge
Dart, Harry F. (M)
Umbach, Walter R. (A)

Glen Rock
Bailey, Ralph G. (A)
Clark, Louis E. (A)

Gloucester
Hayes, Earl David (J)
Stein, Victor (A)

Grantwood
Herbst, John A. (A)
Nickless, William H. (A)
Wichern, Leonard (A)

Guttenberg
Pramshefer, Thomas W. (A)

Hackensack
Kersta, Laurence G. (A)
Slocum, K. W. (A)

Haddonfield
Artzt, Maurice (A)
Barnes, John L. (A)
Bradbury, Burke (M)
Brokaw, Charles A. (A)
Carpenter, Glenn W. (A)
Diehl, William F. (M)
Elliott, H. F. (M)
Fithian, William S. (A)
Jones, Newell R. (A)
Junken, L. H. (A)
Murray, Albert F. (M)
Sadenwater, Harry (M)
Sateren, M. G. (A)
Scheldorf, Marvel W. (A)
Thomas, George G. (A)
Wadsworth, C. A. (A)
Zworykin, Vladimir K. (M)

Haddon Heights
Burrill, Charles M. (M)
Caller, James M. (A)
Chittick, K. A. (A)
Coleman, John B. (M)
Gottier, Thomas L. (A)
Holmes, Ralph S. (A)
More, Clifton C. (A)
Morgan, Howard K. (A)
Pettengill, George W., Jr. (A)
Roys, H. E. (A)
Serrell, Robert (A)
Stone, F. Byron (A)

NEW JERSEY (Continued)

Harrison
Baukat, Henry W. (M)
Brunet, Meade (M)
Burnap, Robert S. (A)
Ferris, Warren Robert (A)
Hansen, Rolf K. (A)
Hirlinger, John F. (A)
Miller, Leonard H. (A)
Ritter, E. W. (M)

Hasbrouck Heights
Beach, Chester L. (A)

Hawthorne
Hogencamp, Harold C. (A)

Hillside
McCauley, John H. (A)
Short, William P. (A)
Warren, Chester L. (A)

Hoboken
Chambers, James (A)
Izzo, Anthony (A)
Roters, Herbert C. (A)
Stempel, Waldemar M. (A)

Irvington
Bazley, Paul B. (A)
Corbett, Walter E. (A)
Coman, George E. (A)
Fread, Harold (A)
Hart, James J. (A)
Mommo, Ernest J. (A)

Jersey City
Bremer, Harry A. (A)
Coleman, C. C. (A)
Costello, John J. (A)
De Amicis, D. Sicari (A)
Drews, Ernest (A)
Gross, Ralph (A)
Hanks, Alfred J. (A)
Holmes, George R. (A)
Maylott, Carleton F. (A)
Oliver, George E. (M)
Palmer, C. Walter (A)
Perkins, George C. (A)
Scarr, Henry F. (A)
Scheuerer, John Lehman (A)
Walker, C. Robert (A)
Wallace, H. Edward (A)
Weber, Walter (A)

Kearny
Yarmack, John E. (A)

Lakehurst
Coulter, Howard N. (M)
Johnson, C. M. (M)

Lawrenceville
Ernst, Murray C. (A)
Gilman, George W. (A)
Wright, Oliver (A)

Leonia
Mustermann, H. G. A. (A)
Replogle, Delbert E. (M)

Linden
Hauck, Vernon D. (A)
Houston, Philip M. (A)

Little Falls
Farnsworth, Daniel W. (A)

Little Silver
Ohl, Russell S. (M)

Livingston
Arnold, Lowell George (A)

Long Branch
Goodwin, Edwin A. (A)
Herson, Jacob S. (A)
Marks, William S., Jr. (A)
McCollum, Harry J. (A)
Reinhart, Sidney M. (A)
Watson, Paul E. (A)

Lyndhurst
Kannenberg, Walter F. (A)

Madison
De Coutouly, Gustave C. (A)
Kellogg, William M. (A)
Manning, Charles T. (M)
Phelps, Walter A. (A)

Magnolia
Lathrope, Kenneth W. (J)

Maplewood
Barkley, William J. (M)
Bohn, William C. (A)
Brown, Bayne (A)
Cunningham, Frederick W. (M)
Darrow, Leo H. (A)
Pidgeon, Howard A. (M)
Poppele, Jacob R. (A)
Rowe, Charles R. (M)
Stinchfield, J. M. (A)
Strassner, Frank J. (A)
Trogner, Arthur M. (M)

Maywood
Stantley, J. J. (M)

McKee City
Read, George T. (A)

Merchantville
Ballard, Randall C. (A)
Bokovoy, Sam A. (A)
Braden, Rene A. (A)
Cone, F. E. (A)
Hopkins, A. R. (A)
Knapp, Harold D. (A)
Orner, Ralph J. (A)
Paschon, Hans E. (A)
Patterson, Edward B. (M)
Priebe, Frank (A)
Prinsky, Harold B. (A)
Roddy, Vincent S. (A)
Smith, J. P. (A)
Whitehead, Jesse C. (A)

Metuchen
Bohlke, W. Hollander (A)

Millburn
Cassedy, William F. (A)
Morris, Robert M. (A)
Schauler, Vincent A. (A)

Montclair
Caughey, William K. (A)
Charton, Paul W. (A)
De Long, Oscar A., Jr. (A)
Hattrup, Hubert E. (A)
Hervey, John P. (A)
Huffman, Charles E. (A)
Krahl, Walter L. (M)
Sandford, Richard Y. (A)

Moorestown
Ballentine, Edwin C. (M)
Shumard, Charles C. (M)

Morristown
Poole, Robert J. (A)

Mountain Lakes
Asserson, Raymond (M)
Currie, Alexander (A)
Flannagan, Coke (M)
Osterland, Edmund H. (J)

Mt. Ephraim
Williams, Ernest R. (A)

Neptune
Schafer, J. Peter (M)

NEW JERSEY (Continued)

Newark
- Amick, William M. (A)
- Barnes, T. Dana (A)
- Barone, Salvatore A. (A)
- Black, Oliver M. (A)
- Brigham, Cecil E. (M)
- Canfield, Wilson R. (A)
- Cavanaugh, John D. (A)
- Cerstvik, Stephen (A)
- Dauber, Arthur O. F. (A)
- Dolesh, Frank J. (A)
- Donovan, Daniel R. (A)
- Erstad, Johannes (A)
- Feindel, Abbott (A)
- Geiges, Karl S. (A)
- Glauber, John J. (A)
- Golden, Frank (A)
- Goodwin, W. Nelson, Jr., (M)
- Gordon, Malcolm K., Jr. (A)
- Hardwick, Ambrose H. (A)
- Herold, Edward W. (A)
- Heselton, Charles C. (M)
- Holmes, Arnold (A)
- Hooven, Morris D. (A)
- Horle, Lawrence C. F. (F)
- Kahn, Frederick J. (M)
- Levine, I. B. (M)
- Lewis, George H. (M)
- Marzulli, Angelo N. (A)
- McCrea, M. Walter (A)
- Meyer, Henry E. (A)
- Penk, Charles, Jr. (A)
- Ranger, Richard H. (F)
- Reiner, Leonard (A)
- Rodriguez, Alexander E. (A)
- Schermerhorn, J. L. (A)
- Scott, Walter F. (A)
- Sels, Hollis K. (A)
- Simpson, Frederick H., Jr. (A)
- Sternberg, F. B. (A)
- Weinfeldt, Sidney (A)
- Winstead, Theodore B. (A)

New Brunswick
- Bradford, C. Irving (J)
- Hull, Charles E. (A)
- Leeds, Lawrence M. (A)
- Lucas, Earle F. (A)
- Ruckle, Ernest G. (A)

Newton
- Landone, Brown (A)

North Arlington
- Collins, John (A)
- Jones, Dramin D. (A)

North Bergen
- Girard, Edward J. (A)
- Perryman, G. H. (A)

North Caldwell
- Tillson, Benjamin F. (M)

North Merchantville
- Frenz, Harry J. (A)

North Plainfield
- Sommer, Emitt H. (A)

Nutley
- Albright, Arthur W. (A)
- Humphrey, Hartley C. (A)
- Saunders, Alfred W. (A)

Oaklyn
- Alexander, J. Ebert (A)
- Bunday, Dale L. (A)
- Fowler, Lester T. (A)
- Sutherland, Edgar F. (A)
- Wells, Daniel W. (A)
- Welsh, Robert R. (A)

Oradell
- Brackett, Harold H. (A)

Orange
- Corbin, Francis L. (A)
- Harris, Gwin C. (A)
- Kynor, Merrill W. (A)
- Maul, Gilbert E. (A)
- Powell, Ralph C., Jr. (A)
- Reifel, Harry (A)
- Rypinski, Maurice C. (M)
- Schlenker, Vesper A. (A)

Palisades Park
- Miller, Horace G. (A)
- Short, Donald William (A)

Passaic
- Ayer, Oliver G. (A)
- Himoe, Clifford E. (A)
- Kent, Roscoe (A)
- Knight, J. B., Jr. (A)
- Link, Fred M. (A)
- Mercer, Ira G., Jr. (J)
- Rodgers, George H. (A)

Paterson
- Barry, Bert (A)
- Franck, Ernest W. (A)
- Gold, Herman (A)
- Kearns, Henry E. (A)
- Sonberg, Kenneth T. (A)
- Trifari, Edmund (A)

Penns Grove
- Douglass, William A. (A)

Pensauken
- Pulley, Albert A. (A)

Pitman
- Cooley, Elihu H. (A)

Plainfield
- Allcutt, E. Burton (A)
- Boise, Everett B. (A)
- Cumming, Kenneth N. (M)
- Lester, Paul Sabine (A)
- Nielsen, H. V. (A)
- Oscanyan, Paul C., Jr. (A)

Princeton
- Coker, Ralph T. (A)
- Roberts, Walter Van B. (F)
- Ware, Paul (A)

Rahway
- Gibson, Robert D. (A)
- Secor, Harry W. (A)

Red Bank
- Beck, Alfred C. (A)
- Bruce, Edmond (M)
- Crawford, Arthur B. (A)
- Feldman, Carl B. (A)
- Hinemon, John H., Jr. (A)
- Jansky, Karl G. (A)
- King, Archie P. (A)
- Lowry, Lewis R. (A)
- Mumford, William W. (A)
- Mutch, W. W. (A)
- Sharpless, William M. (A)

Ridgefield Park
- Smith, Arthur E. (A)

Ridgewood
- Affel, Herman A. (A)
- Bondy, Hugo A., Jr. (A)
- Felix, Edgar (M)
- Smith, Theodore A. (A)

Riverton
- Ehle, Francis R. (M)
- Harding, Henry B. (A)
- Holst, Poul F. G. (A)
- Jones, H. Rossiter (A)
- Poch, Waldemar J. (A)

Roselle
- Bosler, Gustave A. (A)
- Guber, Fred H. (A)

Roselle Park
- McNicol, Donald (F)

NEW JERSEY (Continued)

Rumson
- Friis, H. T. (F)

Rutherford
- Gage, David H. (M)
- Hild, George E. (A)
- Jackson, Benjamin B. (A)
- Wattson, Harry B. (A)

South Orange
- Field, W. Thayer (A)
- Hartley, Ralph V. L. (F)
- Leeb, Henry L. (M)
- Rodman, I. P. (M)
- Walsh, Arthur L. (A)

Springfield
- Hantzsch, Ralph E. (M)

Stanhope
- Moorhead, George H. (A)
- Peterson, Arthur C., Jr. (A)

Summit
- Biele, Charles E. (A)
- Fairchild, F. Earle (A)
- Snook, H. Clyde (M)

Toms River
- Nordstrom, B. H. (A)

Trenton
- Burroughs, Irving D. (A)
- Donohue, Edward F. (A)
- Kale, Samuel S. (A)
- Knowles, Edward P., Jr. (A)
- Raser, Edward G. (A)
- Wentzel, Amandus, Jr. (A)

Union
- Edwards, Joseph B. (A)

Union City
- Erhard, John A. (A)

Upper Montclair
- Du Mont, Allen B. (M)
- Glenn, Earl R. (A)
- Godley, Paul F. (A)
- Hallborg, H. E. (F)
- Versfelt, Emery L. (A)

Verona
- Heyman, Nicholas (A)
- Paret, F. Murray (A)

Weehawken
- Friedman, Louis (A)
- Masalkovics, J. A. (A)
- Pollack, Dale (J)

Weehawken Heights
- Spinner, Robert F. (A)

West Caldwell
- Willis, Frederick C. (A)

West Collingswood
- Konkle, Phil (A)
- Manke, Arthur G. (A)
- Pettit, Albert R. (A)
- Rohner, Arnold J. (A)

Westfield
- Kinsley, Carl (M)
- Swanson, John W. (M)

West Long Beach
- Burrows, Charles R. (A)

Westmont
- Crisante, Aldo (A)
- Cunningham, David H. (A)
- Zimmerman, Arthur G. (A)

West New York
- Busch, Gus A. (A)
- Machiorleti, Louis (A)
- Schoenfeld, K. (A)

West Orange
- Dunning, Orville M. (A)
- Kober, Paul A. (A)
- Lorch, Albert (A)
- Osgood, Victor L. (A)
- Schmidt, Joseph H. (A)
- Tucker, Murray E. (A)
- Vose, George E. (A)

Whippany
- Doherty, William H. (A)
- Hensel, W. G. (A)
- Mellor, William N. (A)
- Smith, John Wesley (A)
- Stansel, Frank R. (A)

Woodcliff
- Seid, Fred C. (A)

Wyckoff
- Frey, Robert H. (A)

NEW MEXICO

Raton
- Schulze, Heri T. (A)
- Schulze, Rehge L. (A)

NEW YORK

Albany
- Corey, James H. (A)
- Kaiser, Fred J. (A)
- Littlefield, R. W. (A)
- Mezger, George (A)
- Pozefsky, Leonard (A)
- Schultz, Arthur F. (A)
- Skinkle, Myron H., Jr. (A)
- Thomas, Joseph D. (A)

Amityville, L.I.
- Browne, Walram S. (A)
- Gabrielson, Henry M. (A)

Andes
- Gray, DeWayne R. (J)

Astoria, L.I.
- Berkley, Fred (A)
- Greene, George J. (A)
- Kunicky, Barney F. (A)
- Leslie, Frank (A)
- Molzen, Charles F. (A)
- Nagy, A. Wheeler (A)
- Schramm, William C. (A)
- Whittaker, Edmund (A)
- Zatorsky, E. F. (A)

Auburn
- Lumb, Frank J. (A)

Babylon, L.I.
- Thompson, Edward Philip (A)

Baldwin, L.I.
- Stewart, G. Edwin (A)

Bath
- Loveless, Lawrence M. (A)

Bayside, L.I.
- Babcock, Wallace C. (A)
- Dean, C. E. (A)
- Smith, Percy DeWillard (A)
- Trautwein, Paul K. (M)
- Wheeler, Harold A. (M)

Bellaire, L.I.
- Brennan, John B., Jr. (A)

Bellerose, L.I.
- Speicher, John D. (A)

Binghamton
- Adams, William E. (A)
- Hall, Victor E. (A)
- Cushman, Henry S. (A)
- Williams, Warren R. (A)

Brighton
- Long, John J., Jr. (A)

Brightwaters, L.I.
- Camp, V. F. (A)

NEW YORK (Continued)

Bronxville
Weeden, William N. (A)

Brooklyn
Abbott, Donald (A)
Abraham, Irving (A)
Adachi, William Y. (A)
Alexander, Louis (A)
Asch, Moe (A)
Bartal, Otto (A)
Bartnofsky, Harry (A)
Baum, Sydney H. (A)
Baunach, Edward L. (A)
Berner, Aaron (A)
Bernstein, Julius (A)
Berry, Robert C. (A)
Bower, James (A)
Brandt, Kristian (A)
Brimberg, Isaac (A)
Bristow, Frederick R. (A)
Bullock, Walter H. (A)
Burns, George D. (A)
Callahan, John L. (A)
Calligheris, John S. (A)
Castle, Donald Hewitt (A)
Charlat, Arnold (J)
Chinitz, Edward (A)
Coe, Alfred (A)
Cohen, Samuel (M)
Coke, Charles B. (A)
Cole, Fred S. (A)
Cook, Arthur L. (A)
Dean, Leon W. (A)
De Mann, William (J)
De Myer, Harold (A)
Dummett, H. W. (A)
Dunn, Lawrence J. (M)
Edgar, J. Clifton (A)
Ellingham, Irving (A)
Evans, Porter H. (M)
Ferrotta, Joseph L. (A)
Fishberg, Sidney (A)
Flomenbaum, Hyman (J)
Fogel, Mortimer H. (A)
Francione, Dominick A., Jr. (A)
Fultz, Miles E. (A)
Gabel, Morris (A)
Gerel, Alexander (A)
Gillule, William J. (A)
Glaser, Edward M. (A)
Goddard, Frederick M. (A)
Goldberg, Emanuel (A)
Gruetzke, Charles P. E., Jr. (A)
Haas, Milton J. (J)
Hadden, Weston (A)
Hajim, Jack (A)
Hakam, Samuel (A)
Halligan, Clair W. (A)
Hammer, Robert H. (A)
Hausmann, Erich (M)
Herdman, Raymond C. (A)
Herman, Joseph M. (A)
Hewlett, Oscar H., Jr. (A)
Heymann, Joseph (A)
Hines, Joseph (A)
Hintz, Robert T. (A)
Holland, Jesse W. (A)
Hughes, William P., Jr. (A)
Inskip, Leonard S. (A)
Isaacson, Herbert M. (A)
Jipp, John (A)
Johnson, R. Stanley (A)
Katzin, Martin (A)
Kayser, Herbert (A)
Kennedy, Harold E. (A)
Kirdahy, Emil (A)
Kissel, Alfred L. (A)
Layng, Grant (A)
Lequesne, Charles A. (A)
Levine, Harry (A)
LeViness, John E. (A)
Liberman, Henry C. (A)
Lucey, Kenneth (A)
Lussier, Elphege Achille (A)
Mahoney, Joseph N. (M)
Marra, Anthony (A)
Marriott, Robert H. (F)
Marsten, Jesse (M)
Martin, Louis (A)
Mauran, John (A)
Mazzola, Joseph R. (A)
McGonigle, William J. (A)
McLaughlin, Thomas J. (A)
Milanio, Clarence (A)
Miller, LeRoy J. (A)
Miller, Marvin L. (A)
Misterly, Frank S. (A)
Mittwol, David (J)
Moore, Henry H. (A)
Morro, Jack J. (A)
Newcombe, Jack (A)
Olmstead, Noel C. (A)
Ostrove, William (A)
Painting, John A. (A)
Palmer, Eric H. (A)
Parker, Oliver B. (M)
Patasnik, D. (A)
Pearson, Herbert B. (A)
Peck, William (A)
Perry, Harold D. (A)
Phelan, Thomas H. (A)
Porter, J. G. (A)
Potter, Max (A)
Redfern, Forest F. (A)
Rehbein, Arthur Frederick (A)
Renke, Adolph (A)
Riccobono, Sebastian (A)
Rice, Anthony J. (A)
Rippere, R. Oliver (A)
Romeo, Anthony (A)
Rosenbaum, Jacob (J)
Sachs, Bernhard A. (A)
Salzman, David (A)
Sass, Isidore (A)
Schenke, Kurtiss P. (A)
Scozzari, Peter (A)
Scruggs, Clarence H. (A)
Secan, Harry (A)
Seekamp, Walter J. (A)
Seidman, Charles (A)
Seligsohn, Max (A)
Shaffer, Irving R. (A)
Shestacovsky, John (A)
Shortland, James W. (A)
Siegal, Jack (A)
Siegel, Samuel (M)
Silver, Benjamin L. (A)
Sinsheimer, Arthur (A)
Skinker, Murray F. (A)
Slater, Saul I. (A)
Smalts, Franklin W. (A)
Starr, Alfred R. (A)
Starrett, John S. (A)
Steinberger, Louis (M)
Stobbe, John A. (A)
Stromeyer, Charles F. (A)
Talley, David (A)
Tallman, Clare LeRoy (A)
Thomas, Edward H. (A)
Torrell, Roy Verner (A)
Traeger, Sam H. (A)
Trott, Barnet (A)
Tucker, Morris H. (A)
Tuckerman, Lucian P. (A)
Uzmann, George J. (M)
Vogel, Erwin William (A)
Wardwell, Arthur S. (A)
Warren, William (A)
Weber, Paul (A)
Weinberg, Sidney (J)
White, Milton (A)

NEW YORK (Continued)

Brooklyn (Continued)
Winchell, Walter H. (A)
Wing, Arthur K., Jr. (A)
Wood, Wilbert C. (A)
Zeiger, Louis B. (A)

Buffalo
Andriatch, Nicholas D. (A)
Banditson, Harry (A)
Benin, Zolmon (A)
Bergmann, Howard J. (J)
Beyer, Glen R. (A)
Bickelman, John E. (A)
Brown, Stanley W. (M)
Burbank, Jerome (A)
Burns, Homer M. (A)
Chamberlain, Adolph B. (M)
Eichman, John, Jr. (A)
Fox, John (A)
Freedman, Sam (A)
Hayes, Wilber A. (A)
Hector, L. Grant (A)
Hemedinger, Willard (A)
Huntsinger, F. J. (A)
Jennings, Russell G. (A)
Johnson, James A. (A)
Karslake, James S. (A)
Knowlton, Eugene W. (A)
Landis, Oren J. (A)
Lewis, John C. P. (A)
Lounsberry, Isaac R., Jr. (M)
Miller, Edwin C. (A)
Miller, George H. (A)
Miller, John G. C. (A)
Moore, Chas. G. (A)
Mullett, Charles B. (A)
Mundie, Evan M. (J)
Nauth, Edgar K. (A)
Noel, Lionel S. (A)
Nowak, Victor V. (A)
Patey, Harold W. (A)
Peck, Emerson P. (A)
Pfleegor, Carroll M. (A)
Root, Harry (A)
Showalter, John L. E. (A)
Simpson, Burton T. (A)
Telaak, Theodore J. (A)
Wagener, W. Hall (A)
Waud, Eugene C. (A)
Weiss, Earl (J)
Yates, Raymond Francis (M)
Youngs, Howard E. (A)

Canandaigua
Goering, Raymond A. (A)

Canton
Priest, Ward C. (A)

Carmel
Light, Frank B. (A)

Cassville
McDermott, John J. (A)

Castleton-on-Hudson
Ennis, Joel B., Jr. (A)

Central Valley
Raynolds, Edward F. (A)

Clinton
Ellinwood, Carl W. (A)

College Point, L.I.
Hoehlein, Fred W. (A)

Coney Island
Singer, Louis (A)

Corning
Gage, Henry Phelps (A)

Corona, L.I.
Schubert, Fred (A)

Cortland
Greenman, Roger B. (A)

Croton-on-Hudson
Lescarboura, A. C. (M)
Osborn, William R. (A)

Dongan Hills, S.I.
Grimes, David (M)

Douglas Manor, L.I.
Weagant, Roy A. (F)

Douglaston, L.I.
Lewis, Harold M. (M)

Dover Plains
Pleasanton, Archie W. (A)

East Rockaway, L.I.
Carter, Frank L. (A)
Van Duyne, Eugene D. (A)

East Rochester
Lucia, Raymond H. (A)

Edgemere, L.I.
Carduner, William (A)

Elmira
Taylor, Dale L. (A)

Elmhurst, L.I.
Content, Edward J. (A)
Hotchkiss, Earle (A)
Lundie, Ernest S. (A)
McConnell, Alexander F. (A)

Far Rockaway, L.I.
Sharp, W. W. (A)

Fire Island, L.I.
Zamba, John (A)

Floral Park, L.I.
Densham, Robert S. (A)

Flushing, L.I.
Bouck, Zeh (M)
Carter, E. Finley (A)
Cook, Ellsworth D. (A)
Dreisbach, Robert H. (A)
Kuntze, Emmet L. (A)
Maccoun, Townsend D. (A)
Matthews, A. C., Jr. (A)
Scofield, Robert W. (A)
Troxler, Lucien J., Jr. (A)

Forest Hills, L.I.
Bonanno, Joseph L. (A)
Canavaciol, Frank E. (M)
Leonard, A. A. (A)
Leutz, Charles R. (M)
Waring, Alfred (A)

Garden City, L.I.
Henney, Julian K. (M)
Howe, Willard C. (A)
Wing, Willis K. (M)

Geneva
Biles, Frank V. (A)
Thompson, John M. (A)

Gerry
Starr, Troy S. (A)

Great Neck, L.I.
Rigney, Douglas (M)

Greece
Cote, Omer E. (A)

Greenport, L.I.
Boerum, Henry S. (A)
Larsen, Carl L. (A)

Hall
Phillips, Lloyd B. (A)

Hamburg
Hartloff, Gordon S. (A)

Hamilton
Goode, Kenneth H. (A)
Janes, Robert B. (A)

Hartsdale
Johnson, John K. (A)

NEW YORK (Continued)

Hastings-on-Hudson
Baker, Judd O. (A)

Hempstead, L.I.
Crane, Edwin S. (A)
Pfautz, Christian E. (A)

Hicksville, L.I.
Baker, Thomas S. (A)
Phelps, Boyd (A)

Hollis, L.I.
Batcher, Ralph R. (M)
Caputo, Nichols J. (A)
Ehlert, Fred C. (A)
Madan, Edwin M. (M)
Srebroff, Charles M. (M)

Huntington, L.I.
Flessel, Frank B., Jr. (J)

Hurley
Warren, William A. (A)

Ithaca
Ballard, William C. (M)
Bostwick, William E. (A)
Malter, Louis (A)
Merritt, Ernest (M)
Meserve, Wilbur E. (A)
Mingins, Charles R. (A)
Moeder, William D. (A)
Sohon, Harry (A)
Verman, Lal C. (A)
Wang, Yeoh-Min (A)

Jackson Heights, L.I.
Alverson, George S. (A)
Hasting, Gerald M. (A)
Hickman, C. Nichols (A)
Schuetz, Robert F. (A)
Stotler, Albert (A)
Wies, Jens A. (A)

Jamaica, L.I.
Bernhardt, Edward E. (A)
Bevitt, William D. (A)
Glasscock, Glen R. (A)
Roth, Louis H. (A)
Steinberger, Arthur W. (A)
Sterns, Morton W. (M)
Styles, Thomas J. (A)
Voight, George (A)
Yenoli, Dominick J. (A)

Jamesport, L.I.
Colvin, R. S. (A)
Seaman, Gerald C. (A)

Jamestown
Beaumont, William Frederick (A)

Kenmore
Patterson, Curtis B. (A)
Sheets, Harold M. (A)
Welsher, Carl E. (A)
Wullenweber, Milton O. (A)

Kew Gardens, L.I.
Montgomery, A. Peers (A)
Paulding, Herbert L. (A)

Larchmont
Nilson, Arthur R. (M)

Liberty
Mauer, William V. (A)

Little Neck, L.I.
Schultes, Martin F. (A)

Lockport
Connette, T. W. (A)
Fiedler, Leroy (A)

Long Island City, L.I.
Asch, Marcus (A)
Dinga, Emil (A)
Farrand, C. L. (M)
Greene, Harry A. (A)
Hanson, Oscar B. (M)
Holzinger, Theodore E. (A)
Morrison, Montford (M)
Ractliffe, Charles Lionel (A)
Schmidt, Erwin (A)
Sigety, Louis (A)
Underhill, Charles R. (A)

Lynbrook, L.I.
Fedotoff, Nicholas V. (A)
Shaw, James (A)

Malverne, L.I.
Seidler, Abraham (A)

Mamaroneck
Herdman, William P. (A)
Smith, J. O. (M)

Manhasset, L.I.
Young, Harold H. (A)

Maspeth, L.I.
Purzner, William H. (J)

Middletown
Callender, Edwin R. (A)
Dempsey, William E. (A)
Fish, Edward H. (A)

Mineola, L.I.
McCauley, George W. (A)

Mitchell Field, L.I.
Allen, Forrest G. (A)

Monticello
Fleischer, A. P. (A)

Mt. Vernon
Allen, John P. (A)
Anderson, J. E. (A)
Bernard, Herman (A)
Fletcher, Louis D., Jr. (A)
Houck, Harry W. (M)
Ka Dell, Harold W. (A)
Macalpine, William W. (A)
Muhleman, Maurice L. (A)
Podell, Samuel (A)
Stone, Clarence G., Jr. (A)

New Brighton, S.I.
Macken, H. I. (A)

Newburgh
Haines, Howard J. (A)

New City
Doellner, LeRoy J. (A)

New Rochelle
Annucci, Louis M. (A)
Cantor, Arthur B. (A)
Matthews, Basil W. (A)

New Springville, S.I.
Wissmann, Joseph T. (A)

New York
Adams, Ira J. (M)
Aiken, Charles B. P. (A)
Aikens, Andrew J. (A)
Allyn, R. S. (A)
Almquist, Milton L. (A)
Alpern, Dwight K. (A)
Amy, Ernest V. (M)
Anderson, Clifford N. (A)
Anderson, Edwin C. (A)
Anderson, Sidney E. (A)
Andrews, Joseph F. (M)
Ansley, Arthur C. (A)
Appel, Henry W. (A)
Armstrong, Edwin H. (F)
Arnold, John W. (A)
Atkin, Robert (A)
Aull, Wilson, Jr. (M)
Bailey, Arnold B. (A)
Bailey, Austin (M)
Bain, J. C. (A)
Bair, Ralph S. (A)
Barnes, James C. (A)
Barnueba, Richard (A)
Batcheller, Arthur (M)

NEW YORK (Continued)

New York (Continued)
Batsel, Max C. (F)
Bauer, Brunton (A)
Baxter, Charles E. (A)
Beatty, W. E. (A)
Beizer, Harold (A)
Beltz, Willis H. (A)
Bemis, Edwin W. (A)
Bender, Martin, Jr. (A)
Bennett, Donald P. (A)
Betts, Philander H. (A)
Beverage, Harold H. (F)
Beyer, Haim (A)
Beyer, Raymond G. (A)
Binns, John R. (A)
Black, Donald M. (A)
Black, K. Charlton (M)
Blackmar, Abel E., Jr. (A)
Blackwell, Otto B. (F)
Blan, Michael (A)
Blaufox, Joseph D. (A)
Blenheim, William J. (M)
Boehme, H. O. (M)
Boesche, F. W. (A)
Bohmann, Louis (A)
Boltson, Jacob A. (A)
Bonell, Ralph K. (A)
Bonett, David J. (A)
Booth, Howard A. (A)
Borislavsky, Michael A. (A)
Bostad, John (A)
Bostwick, L. G. (A)
Bown, Ralph (F)
Brady, Leslie R. (A)
Brainson, William (A)
Brake, Paul (J)
Brennecke, Cornelius (A)
Brown, Charles J. (A)
Brown, D. S. (A)
Brown, Orlan R. (A)
Brown, William A. R. (A)
Bruggeman, John T. (A)
Bucher, E. E. (F)
Buckler, John J. (A)
Buckley, B. E. (A)
Budenbom, Horace T. (A)
Bullard, William R. (A)
Burghard, G. E. (M)
Burns, G. Austin (A)
Burton, Everett T. (A)
Butler, E. W. (M)
Butterfield, Charles E. (M)
Buttner, Harold H. (M)
Bylander, J. Clifford (A)
Byrnes, Irving F. (A)
Cahill, William J. (A)
Cain, Robert E. (A)
Caldwell, O. H. (M)
Campbell, John A. (A)
Carleton, Thomas F. (J)
Carlton, Roger C. (A)
Carroll, Michael J. (A)
Carson, John R. (M)
Cass, Lewis S. (A)
Chaffee, Joseph G. (A)
Challenner, Ansel (A)
Challenor, George A. (A)
Chernow, Morris (A)
Chu, Quong Y. (J)
Clark, C. R. (M)
Clausen, H. P. (A)
Clement, Lewis M. (F)
Cochran, Eugene C. (A)
Cockaday, Laurence M. (A)
Coggeshall, Ivan S. (M)
Cohn, Hugo (M)
Cole, Burton R. (A)
Coles, Francis A. (A)
Colpitts, Edwin H. (F)
Conley, S. D. (A)
Cooper, C. B. (A)
Corbett, Edward L. (A)
Cornwell, Lionel B. (A)
Corwin, Charles I. (A)
Cousins, Van Meter (A)
Cowan, Frank A. (M)
Coxhead, Harry B. (M)
Credner, Louis L. (A)
Crosby, George L. (M)
Cunningham, H. C. (A)
Curry, Walter A. (A)
Custer, Charles J. (A)
Cutting, Fulton (F)
Dale, George V. (A)
Danz, Herman (A)
Danziger, Harold I. (M)
Daspit, Randall (A)
Davis, Clinton S. (A)
Davis, Nathan A. (A)
Deakin, Gerald (A)
Dean, Samuel W. (M)
Decino, Alfred (A)
De Forest, M. J. (A)
Della Corte, J. P. (A)
Demarest, Charles S. (M)
Desnoes, Arnold B. (A)
De Sousa, George S. (M)
Diaz, Ernesto (A)
Dietrich, Frederick (A)
Dietze, Eginhard (A)
Dodge, Frank R. (A)
Dolid, Abraham (A)
Dow, M. Thornton (A)
Downing, Richard E. (A)
Drew, Charles E. (M)
Drisko, Benjamin B. (A)
Dubilier, William (F)
Duncan, Rudolph L. (M)
Dunham, John S. (A)
Dunlap, Orrin E., Jr. (M)
Dunn, Gano (F)
Dunning, John R. (A)
Dunphy, Thomas O. (A)
Easton, J. H. (A)
Egert, Samuel S. (A)
Eldredge, Frank E. (M)
Eller, Keith B. (A)
Emerson, Charles W., Jr. (A)
Engel, Francis H. (M)
Espenschied, Lloyd (F)
Everett, Lynn C. (M)
Facey, John W. (A)
Fairburn, A. J. B. (A)
Farnsworth, Philip (F)
Farrington, John F. (M)
Fay, Clifford E. (A)
Feldstein, M. A. (A)
Felthousen, A. (A)
Fielding, Charles F. (M)
Finch, William G. H. (M)
Finlay, Robert C. (A)
Fischer, Fred F. (A)
Fischer, Herbert B. (A)
Fischer, Leonard O. (A)
Fish, Arthur S. (M)
Fisher, Theodore (A)
Flaum, Joe (J)
Florez, Hermann A. (A)
Flythe, Thomas Y. (J)
Frank, James, Jr. (A)
Frank, K. G. (M)
Franklin, L. W. (A)
Fredendall, Beverly (A)
Frederick, Halsey A. (M)
Freed, Joseph D. R. (F)
Friend, Holton H. (A)
Frimerman, Frank (A)
Furia, John J. (A)
Gati, Bela (A)
Gelardin, Benjamin (A)
Gerstein, M. George (J)

NEW YORK (Continued)
New York (Continued)
Giannini, Gabriel M. (A)
Gibson, Nesbit (A)
Gilbert, John J. (A)
Giovanini, Frank (A)
Glaser, Marcus (A)
Goldsmith, Alfred N. (F)
Gordon, George (A)
Graham, Frank H. (A)
Graham, William A. (M)
Graveson, George L. (A)
Green, Ashbel (A)
Green, Estill I. (A)
Greene, Paul A. (M)
Greenstein, Philip (A)
Greiff, Victor (M)
Greig, John W. (A)
Griffiths, Clarence M. (A)
Grinan, John F. (M)
Gritzner, Fred A. (A)
Grover, Harry G. (M)
Guild, Baldwin (M)
Gutoff, Boris (A)
Guy, Raymond F. (A)
Haldane-Duncan, B. (A)
Hanley, John F. (A)
Harley, John B. (A)
Harness, Sam A. (A)
Harnett, Daniel E. (A)
Harper, A. E. (M)
Harrison, Charles I. (A)
Harrison, Harry (A)
Harrison, Perry (A)
Hartman, Charles D. (A)
Hartmann, Albert (A)
Hauffe, Otto (A)
Heberlein, Arthur (A)
Hedges, Ellsworth J. (A)
Heindel, Harold J. (A)
Heising, Raymond A. (F)
Henderson, Ken L. (A)
Henline, Henry H. (M)
Herber, John C. (A)
Herbert, Harold R. (M)
Hershey, Arthur W. (A)
Hertzberg, Robert (A)
Heuschkel, Paul J. (A)
Hiller, Nicolai H., Jr. (A)
Hineline, Harris D. (M)
Hirsch, Harry (A)
Hogan, John V. L. (F)
Hogg, William S., Jr. (M)
Hohenstein, Jac (A)
Holcombe, Henry W. (M)
Holden, C. F. (M)
Holetz, Alexander C. (A)
Holloway, Jack (A)
Holm, Henry R. (A)
Honaman, R. Karl (A)
Hopfenberg, Joseph A. (A)
Horman, Frederick L. (A)
Horn, Charles W. (F)
Hornung, Julius L. (A)
Hough, Clinton Wallace (A)
Hovgaard, Ole M. (M)
Howard, Edward J. (A)
Howell, Clifford Alexander (A)
Howell, Walter J. (M)
Hubbard, Frank A. (A)
Hudack, John Martin (A)
Hulan, A. G. (A)
Hunkins, Harold R. (A)
Huntley, Kenneth L. (A)
Hurwitz, S. B. (A)
Hutchison, Miller (M)
Infeld, I. Arthur (A)
Isele, Harold Adolph (A)
Israel, John O. (A)
Jacobs, Louis (A)
Jamross, Rudolph (A)
Janke, Alfred H. (M)
Jarabin, Frank G. (A)
Jean, Robert P. (A)
Jensen, A. G. (M)
Jewett, F. B. (F)
Johnson, Kenneth S. (M)
Johnson, Reverdy (A)
Johnston, John P. (M)
Jones, Lester L. (F)
Jordan, Chester H. (A)
Kahant, Charles G. (A)
Kahn, Morton B. (A)
Kalb, Robert M. (A)
Keefe, Oscar A. (A)
Keene, K. W. (A)
Keim, Llewellyn B. (A)
Kelley, Leo A. (A)
Kelly, Mervin J. (M)
Kendall, John A. (A)
Kennedy, T. R., Jr. (A)
Kennedy, William A. (A)
Kenny, Matthew (A)
Kilbourne, Covington G. (A)
Kilmer, T. W., Jr. (A)
King, Frank (M)
Kircher, Reymond (A)
Kishpaugh, Arthur W. (M)
Kleist, Alfred H. (A)
Klesse, William (A)
Klosner, Morris (A)
Knaack, Frank E. (A)
Knapp, Joseph F. (A)
Knight, Octavius (A)
Knights, Alexander H. (A)
Knopp, Ernest (A)
Knott, William M. (A)
Koerner, Allan M. (A)
Koerner, Lawrence F. (A)
Kott, Herman (A)
Kouchnerkavich, Thomas A. (A)
Kovacs, Stephen (A)
Kreuzer, Barton (A)
Kroger, F. H. (F)
Kroger, H. B. (A)
Kuhn, Alfred S. (A)
Kunc, Frank (A)
Lack, Frederick R. (A)
Lakatos, Emory (A)
Lane, Frederic A. (A)
Langdon, G. G. (A)
Lawrence, Walter L. (A)
Lazarus, Benjamin N. (A)
Leach, Harvey B. (A)
Leamer, Frank D. (A)
Lebow, Samuel (A)
Lee, Emery H. I. (M)
Lee, Fat Chang (A)
Lefferts, B. (A)
Lemmon, Walter S. (A)
Lenz, Charles S. (A)
Levy, A. Kingdon (A)
Levy, Lester (A)
Levy, Mortimer N. (A)
Lewis, Elmer H. (A)
Lindmark, Elmer S. (A)
Lindsay, Maxwell H. A. (A)
Lindsay, Stewart (A)
Littman, Leon L. (A)
Llewellyn, Frederick B. (A)
Loftin, Edward H. (M)
Logan, Mason A. (A)
Long, Maurice B. (A)
Loynes, Owen H. (A)
Luisi, John (J)
Lundahl, Tore (A)
Lyford, Elmore B. (A)
Lynch, Arthur H. (M)
Macdonald, W. A. (M)
Mac Dougall, Arthur (A)
Mackay, William Andrew (A)
Maddocks, James H. (A)

NEW YORK (Continued)
New York (Continued)
Maloff, Ioury G. (M)
Manley, Edward (A)
Marrison, W. A. (M)
Marshall, Albert E. (A)
Marshall, Cesar B. (A)
Marshall, F. W. (A)
Martin, De Loss K. (M)
Martin, William G., Jr. (A)
Martin, W. H. (A)
Mathes, R. E. (A)
McCann, Thomas A. (A)
McCarroll, George M. (A)
McCutchen, Brunson S. (M)
McElrath, George (M)
McFarlane, M. L. D. (A)
McGarry, John (A)
McIntosh, Frank H. (A)
McLagan, Donald R. (A)
McLean, Philip S. (A)
McNally, James O. (A)
McNary, James C. (M)
McSweeny, Roger (A)
Meacham, J. F. B. (A)
Meyer, Henry W. (A)
Miles, Paul D. (A)
Miller, H. P., Jr. (M)
Miller, Samuel C. (M)
Mills, John (F)
Milnor, Joseph W. (M)
Misenheimer, Harvey N. (M)
Mix, Charles L. (A)
Mizell, M. H. (A)
Montcalm, S. R. (M)
Moran, H. G. (A)
Morecroft, J. H. (F)
Morehouse, Terry B. (A)
Morehouse, W. B. (M)
Morozoff, Harry (A)
Morse, Arthur H. (M)
Muller, Fred (M)
Myers, Gilbert B. (A)
Myers, Theobald (A)
Naimark, Boris S. (A)
Nakamura, T. (M)
Neely, Guy Morton (A)
Nein, Harry R. (A)
Nelson, Edward L. (M)
Neville, T. P. (A)
Newhouse, Russell C. (A)
Nicely, Ralph N. (A)
Nicholides, E. (A)
Nichols, Eldon (A)
Nichols, Leroy C. (A)
Nickerson, Fred W. (A)
Nielsen, John E. (A)
Nimmcke, Frederick E. (A)
Nisley, Paul H. (A)
Nivison, Theodore E. (A)
Nordahl, John G. (A)
Norton, Kenneth A. (A)
Nugent, Thomas (A)
Nyman, Alexander (M)
Oikle, O. A. (A)
Olander, L. W. (A)
Ornstein, Eugene (A)
Osborne, Harold S. (M)
Osheroff, Nathan H. (J)
Oswald, Arthur A. (F)
Pacent, Louis G. (F)
Palmer, Robert T. (A)
Pamphilon, Leon E. (A)
Pannill, Charles Jackson (F)
Parker, R. D. (A)
Pate, Carlton O. (A)
Pattee, John R. (A)
Pavlow, Nicholas (A)
Payne, Charles C. (A)
Pease, Reginald M. (M)
Pegram, George B. (A)
Penick, D. B. (A)
Peterson, Cornelius (A)
Peterson, Eugene (M)
Petry, C. A. (A)
Pfeiff, Frederick J. (A)
Pickett, Glenn H. (A)
Pierce, E. H. (A)
Pierce, Norman J. (A)
Pierrepont, John Jay (A)
Piety, Raymond G. (A)
Pilling, Thomas A. (A)
Pineau, Norman T. (A)
Plummer, William E. (A)
Polkinghorn, Frank A. (A)
Ports, Earl G. (A)
Potter, Ralph K. (M)
Pratt, Haraden (F)
Price, H. Stewart (M)
Prilik, Max R. (A)
Proskauer, Julien J. (A)
Pumphrey, Walter H. (M)
Pupin, Michael I. (F)
Putnam, Ralph E. A. (A)
Randolph, L. F. (A)
Ranson, G. B. (A)
Rathner, Jack (A)
Reb, Frank F. (A)
Reber, Samuel (F)
Reeves, J. Russell (A)
Reeves, Thomas J. (A)
Reinken, Louis W. (A)
Reoch, Alexander E. (F)
Reynolds, John L. (A)
Riddle, Robert H. (A)
Rider, John F. (A)
Ridgway, James L. (A)
Rifkin, J. L. (A)
Roberts, Horace, Jr. (A)
Roosevelt, H. L. (M)
Rose, Arthur F. (M)
Rose, Charles F. P. (A)
Rose, John A. (A)
Rosenberg, Irving (A)
Rossi, Ralph J. T. (A)
Roth, William (A)
Ryan, Francis M. (M)
Sacia, C. Fred (A)
Samoiloff, Leon (A)
Samuel, Arthur L. (A)
Samuels, George J. (A)
Sanborn, John W. (A)
Sandretto, Peter C. (A)
Sargeant, Charles E. (A)
Sarnoff, David (F)
Schanz, John A. (A)
Schechter, Jack (A)
Schelleng, John C. (F)
Schlesinger, Benjamin (A)
Schmied, James W. (A)
Schmit, Dominic F. (A)
Schneider, W. A. (M)
Schnoll, Nathan (A)
Scholle, Frederick (A)
Schramm, Fred W. (A)
Schwartz, Lyle H. (A)
Scott, Herbert J. (A)
Searing, Hudson R. (A)
Senauke, Alexander (M)
Shandy, George P. (A)
Shangraw, Clayton S. (M)
Shannon, Joseph H. (M)
Sheffield, Berthold (J)
Shelby, R. E. (A)
Sherman, Jesse B. (J)
Sherman, Warren K. (A)
Shore, Henry (M)
Shute, Emmet R. (M)
Siemens, R. H. (A)
Silberstein, Richard (A)
Singer, Emanuel (A)
Sivian, Leon J. (A)

NEW YORK (Continued)

New York (Continued)

Skirrow, John F. (M)
Smack, John C. (A)
Small, Percy L. (A)
Smith, Delmar E. (A)
Smith, H. E. J. (A)
Smith, Jesse H. (A)
Smith, John S. (M)
Smith, K. R. (M)
Smith, Samuel B. (A)
Snow, William B. (A)
Sohor, P. H. (M)
Sonkin, David (M)
Soule, Harold (A)
Southworth, G. C. (M)
Speed, Russell B. (A)
Spence, P. W. (A)
Sperry, Alexander T. (A)
Sprague, Clarence A. (M)
Stone, Ellery W. (F)
Swain, Robert R. (A)
Sweeny, Carey P. (A)
Taber, Ira De Witt (A)
Taussig, Charles W. (A)
Taussig, William S. (A)
Taylor, Alfred R. (A)
Taylor, Charles H. (F)
Taylor, Edmund R. (A)
Taylor, E. Gordon (M)
Taylor, S. Gordon (A)
Taylor, W. H., Jr. (M)
Teeter, Albert (A)
Theremin, Leon (A)
Thielen, E. J. (A)
Thompson, Albert C. (A)
Thompson, Gordon (A)
Thompson, Roy E. (M)
Thropp, Charles H. (A)
Thurston, George (A)
Tierney, Walter L. (M)
Toth, Albert F. (A)
Towner, Orrin W. (M)
Trapkin, Jack H. (A)
Truax, John (A)
Tuel, A. Y. (A)
Tumleson, James F. (A)
Turner, Alva (A)
Tuttle, Clarence W. (A)
Vaill, Edward W. (A)
Valesio, Mario J. (A)
Van Niman, Roy T. (A)
Vansant, F. T. (A)
Van Wyck, William Peterson (A)
Vaughan, Carroll B. (A)
Velasco, Jose M. (A)
Venable, Richard Neel (A)
Victoria, Joseph Lawrence (A)
Volkmann, John E. (A)
Volney, S. C. (A)
Vreeland, Frederick K. (F)
Wald, David (A)
Wallach, Moses U. (A)
Walworth, Fred (A)
Wang, Sherman R. (A)
Waterman, Frank N. (M)
Webster, Bethuel M., Jr. (A)
Weiland, Christian F. (A)
Weiler, Harold (A)
Weinberger, Julius (F)
Weintraub, Daniel H. (A)
Weisbroth, Sam (A)
Weitzman, Irwin (J)
Wettermann, John A. (A)
Wheeler, George D. (A)
Whitmer, Robert M. (A)
Whittemore, Laurens E. (F)
Wickersheim, L. W. (A)
Wilbur, Edwin C. (A)
Willhofft, Frederick O. (A)
Williams, Howard F. (A)
Wilson, H. Warden (A)
Wilson, Leon T. (M)
Wilson, William (F)
Winner, Lewis (A)
Winterbottom, William A. (M)
Wintringham, William T. (A)
Woodcock, N. A. (A)
Woodrow, William (A)
Wunderlich, H. A. F., Jr. (A)
Wurmser, Alphons V. (A)
Yolles, Jacob (A)
Young, Owen D. (F)
Youngstrom, Nels C. (A)
Zeamans, Harold R. (A)

Niagara Falls
Guinther, George (A)
Jenkins, Myron Z. (A)
La Mantia, Philip Vincent (J)
Lidbury, F. A. (A)

North Pelham
Siebert, George W., Jr. (A)

North Tarrytown
Crom, George C., Jr. (M)

North Tonowanda
Hesse, Henry R. (A)
Wesselman, Eugene (A)
Widmann, Erwin (A)

Orient
Vail, Leslie G. (A)

Ossining
Akin, Robert M., Jr. (A)
Gowen, Robert F. (M)

Ozone Park, L.I.
Eklund, Gus (A)
Hingle, Allen W. (A)
Misenheimer, Robert G. (A)
Newby, R. W. (A)
Weilminster, Charles (A)

Patchogue,
Wooldridge, Allen C. (A)

Pelham
Kelly, Charles M., Jr. (A)
Kolb, Walter R. (A)

Pelham Manor
Kelly, Dale (A)
Lewis, Frederick W., Jr. (A)

Poland
Prentiss, Howard H. (A)

Port Jefferson, L.I.
Carter, Philip S. (A)
Hansell, Clarence W. (M)

Port Jervis
Gibbons, Joseph W. (A)
Rutan, Paul D. (A)

Port Washington, L.I.
Hafner, Gilbert (A)
Whiting, Donald F. (M)

Poughkeepsie
Boyle, Frank A. (A)
Smith, Harold E. (A)
Wood, Raymond A. (A)

Queens Village, L.I.
Lowander, Reginald W. (A)

Rego Park, L.I.
Gunther, Frank A. (M)

Rhinebeck
Lang, Walter T. (A)

Richmond Hill, L.I.
Beach, Ernest W. (A)
Brothers, James T. (A)
Grebe, Alfred H. (F)
Heins, Henry F. (A)
Leyh, William D. (A)
Oram, Donald K. (A)
Saphir, Frank (A)
Weinwurm, Robert (A)

NEW YORK (Continued)

Riverdale-on-Hudson
High, John M., Jr. (A)

Riverhead, L.I.
Ashmore, J. W. (A)
Bond, Elmer Frederick (A)
Braaten, Arthur M. (A)
Crosby, Murray G. (A)
Matthews, Walter I. (A)
Morris, Hedley B. (A)
Moore, John B. (A)
Morris, Leon A. (A)
Peterson, Harold O. (A)
Rundquist, Elliot C. (A)
Schock, Robert E. (A)
Schoenborn, Ferdinand (A)
Simpson, Stephen H., Jr. (A)
Smith, Arthur Z. (A)
Stagg, Carl (A)
Trevor, Bertram (A)
White, Nathaniel (A)
Wickizer, Gilbert S. (A)

Rochester
Albright, Gordon E. (A)
Bachofer, C. Leonard (A)
Balling, Alfred W. (A)
Brown, Gordon P. (A)
Brown, Howard A. (A)
Clarke, Maurice H. (A)
Dwyer, Vincent J. (A)
Eoyang, Thomas T. (A)
Esten, Perry W. (A)
Foster, Charles W. (A)
Friedler, Dewey P. (A)
Gordon, Harry E. (A)
Graham, Virgil M. (M)
Haas, Paul (A)
Hanover, Edward A. (A)
Harvey, Clyde C. (A)
Haugh, Arthur T. (M)
Hitchcock, Joseph F. (A)
Huntington, Maurice E. (A)
Karker, Earl C. (A)
Klumb, Harvey J. (A)
Levy, Maurice L. (A)
Malone, Walter J. (A)
Manson, Ray H. (F)
Martin, V. G. (A)
McCanne, Lee (A)
McCanne, W. Roy (M)
Michael, David F. (A)
Moore, Eric J. T. (M)
Norris, Edward J. (J)
Sage, Frederick H. (A)
Schneider, Mendell (A)
Schoen, Arthur L. (A)
Scoville, George A. (A)
Serge, Igor Bobrovsky (M)
Sheve, Henry C. (A)
Soderholm, Arthur E. (A)
Sylvester, Arthur (A)
Welsh, Fred E. (A)
White, J. W. (A)
Wiebach, William T. (A)
Wishart, William R. (A)
Wood, Merrill A. (A)
Worrell, Richard A. (A)

Rockville Center, L.I.
Cardwell, Allen D. (A)
Fluharty, William G. (A)
Hinners, F. A. (F)
Schabbehar, Edwin A. (A)
Weeks, Norman E. (A)

Rocky Point, L.I.
Abbott, Walter (A)
Boerner, Thomas J. (A)
Clifton, B. S. Y. (M)
Finch, James L. (M)
Goldstine, Hallan E. (A)
Henery, R. S. (A)
Maclean, Kenneth G. (A)
Peterson, Lloyd E. (A)
Salzberg, Bernard (A)
Usselman, George L. (A)
White, W. L. (A)

Rome
Mueller, Paul M. (A)

Saranac Lake
Riddle, William E. (A)
Watts, E. G. (A)

Savannah
Redington, Edmund B. (A)

Sayville, L.I.
Hart, Frank A. (A)
O'Connor, John G. (A)

Scarsdale
Appel, Joseph H., Jr. (A)
Fearing, Justin L. (A)
Weis, Edward M. (A)

Schenectady
Acheson, Marcus A. (A)
Alexanderson, E. F. W. (F)
Andrews, Paul D. (M)
Anson, C. T. (A)
Ayer, Raymond B. (A)
Berejkoff, Anatol Petrovich (A)
Berg, Ernest J. (A)
Billings, James H. (A)
Brockman, Francis C. (A)
Broughton, W. G. (A)
Brown, William W. (M)
Cottrell, McKenzie (A)
Craig, Robert B. (A)
Crippen, Eugene G. (A)
Darlington, Eugene S. (A)
David, William R. (A)
Dewalt, K. C. (A)
Dickinson, Theodore M. (A)
Dodge, Albert O. (A)
Dome, Robert B. (A)
Durkee, K. M. (A)
Duttera, W. S. (A)
Eveleth, Laurence Nelson (A)
Farrell, John J. (A)
Fitch, William A. (A)
Ford, Warren A. (A)
French, Henry G. (A)
Frink, Frederick William (A)
Fritschel, Eugene H. (A)
Fulton, R. (A)
Fyler, George W. (A)
Gimmy, Norman H. (A)
Grover, Frederick W. (M)
Hall, Whitman N. (A)
Henyan, George W. (A)
Hitt, A. B. (A)
Hopkins, John S. (A)
Hoxie, Charles A. (A)
Jacklin, Norman L. (A)
Jackson, Henry W. (M)
Johnson T., Jr. (M)
Jones, L. F., 3rd (A)
Kaar, Ira J. (M)
Kinney, Ely M. (A)
Lamb, G. F. (A)
Larson, Robert W. (A)
Lee, Samuel T., Jr. (J)
Leibing, Joseph K. (A)
Lynn, L. H. (A)
Maser, Harold T. (A)
Maynard, J. E. (A)
Mead, Milton S. (A)
Meahl, Harry R. (A)
Metcalf, George F. (A)
Moles, Frank J. (A)
Morrison, R. J. (A)
Mullaney, Dudley A. (A)
Newton, Raymond A. (A)

NEW YORK (Continued)

Schenectady (Continued)
Nickle, Emil G. (A)
Nixdorff, Samuel P. (M)
Nolte, Henry J. (A)
Palermo, A. J. (A)
Patterson, Franklin G. (A)
Peck, Caid H. (J)
Pike, Otis W. (M)
Powles, Frederick T. (A)
Priest, Conan A. (A)
Rice, Chester W. (F)
Rossman, Donald V. O. (A)
Rowe, Hobart E. (A)
Ryder, Jack D. (A)
Simpson, Leroy C. (A)
Smith, Richard L. (A)
Snyder, Norman (M)
Spitzer, Edwin E. (A)
Taylor, Laurence A. (A)
Thompson, B. J. (A)
Tucker, William E. (A)
Van Alstyne, A. J. (A)
Wallace, Martin J. (A)
Warner, John C. (M)
Watts, D. E. (A)
Weir, Irwin R. (A)
Westendorp, W. F. (A)
White, William C. (M)
Woodworth, John L. (A)
Young, Charles J. (A)

Scotia
Clarke, Varro J. (A)
Cummings, Alan P. (A)
Eldridge, Frederick B. (A)
Fick, Clifford G. (A)
Gardiner, Paul C. (A)
Maxwell, John F. (A)
Richardson, L. W. (A)
Roder, Hans (M)
Schwarzhaupt, Paul J. (M)
Smith, Millard H. (A)
Steiner, Harry C. (A)
Towne, Alfred E. (A)
Yerian, Carlos S. (A)

Sea Cliff, L.I.
Mickelson, C. D. (A)

Skaneateles
Roberts, Edward (A)

Southampton, L.I.
Buckingham, William D. (A)
Hayward, Walter (A)
Homer, Edward C. (A)
Millar, J. Z. (A)
Pollard, Leon G. (A)
Weik, Adolph L. (A)

Springfield, L.I.
Benjamin, Wesley E. (A)

Stafford
Sheffer, Olan N. (A)

St. Albans, L.I.
Baldwin, Chester Paul (A)
Butt, Harvey R. (A)

Stapleton, S.I.
Mc Ardell, Wesley E. (A)
West, Clarence H. (A)

Staten Island
De Rosa, Louis A. (J)

Stewart Manor, L.I.
Dewhirst, Thornton P. (A)

St. George, S.I.
Rodwin, George (A)

St. James, L.I.
Flathman, Edward (J)

Suffern
Ennis, Fred E. (A)

Syracuse
Blaich, J. Ray (A)
Christy, Donald P. T. (A)
Nicholson, E. J. (A)
Porter, R. A. (A)
Potter, Melville R. (A)
Randall, Dormus P. (A)
Turner, Walter V. (A)
Wolverton, Byron C. (A)

Tonawanda
Maxwell, George G. (A)

Troy
Hadley, Raymond F. (A)
Harris, Hiram D. (A)
Herman, Philip S. (A)
Rives, Frank M. (A)
Sanders, Edwin R. (A)
Warner, Sydney E. (A)

Tuxedo Park
Loomis, Alfred L. (M)

Ulster Park
Wickery, John B. (A)

Utica
Gray, John E. (A)
Hart, M. J. Herbert (J)
Hatton, Richard R. (A)
Howlett, Charles A., Jr. (J)
King, Francis N. (A)
Lott, Harry H. (A)
Steates, E. Francis (A)
Terrill, W. Nessler (A)

Water Mill, L.I.
Corwith, Howard P. (M)

Watkins Glen
Pomeroy, Rupert C. (A)

West Hempstead, L.I.
Magness, Scott A. (A)
Westman, Harold P. (M)

West New Brighton, S.I.
Bedford, George W. (A)
Dinsdale, Alfred (A)

West Point
Serig, Howard W. (A)
Willis, James S. (A)

White Plains
Arcand, Wilfred E. (J)
Griggs, Elmer V. (A)
Halstead, William S. (A)
Lamarque, James W. (A)
Minton, John P. (F)

Whitestone, L.I.
Lederhaus, Herman William (A)
Summers, Llewelyn L. B. (A)

Williamsville
Hopkins, Nelson S. (A)
Trago, Robert A. (A)

Winfield, L.I.
Haug, Joseph (A)

Woodhaven, L.I.
Cooper, Gustavus A. (A)
Leuteritz, Hugo C. (A)
Stellwagen, Frank W. (A)

Woodmere, L.I.
Birkhahn, Robert C. (A)
Warren, Charles E., Jr. (A)
Ziegler, Frederick J. (A)

Woodside, L.I.
Carreau, E. L. (A)
Rettenmeyer, Francis X. (M)
Reuman, William H. (A)
Valentine, Russell D. (A)

NEW YORK (Continued)

Yonkers
Craig, Albert C. (A)
Enders, Charles F. (A)
Rollo, W. Smith (A)
Runyon, Carmen R., Jr. (A)
Seitz, Frank A., Jr. (J)
Van Dyck, Arthur F. (F)
Whitaker, James N. (A)

NORTH CAROLINA

Asheville
Hoover, Herbert, Jr. (A)
So Relle, J. L. (A)

Charlotte
Callahan, Thomas G. (A)
Gluck, E. J. (A)

Durham
Seeley, Walter J. (A)

Fort Bragg
Allen, Otis T. (A)

Gastonia
Morris, Robert S. (A)

Henderson
Woolard, E. W. (A)

High Point
Derond, Bernard (A)

Marion
Martin, Hubert C. (A)

Pittsboro
Roberson, Robert E. (J)

Raleigh
Massey, Andrew (A)

Saluda
Johnson, Roy L. (A)

Tarboro
Shaw, H. B., Jr. (A)

Washington
Jowdy, Mitchell (A)

Winston-Salem
Hedrick, Phil F., Jr. (J)
Lee, Douglas J. (A)

NORTH DAKOTA

Bismarck
Lucas, Stanley M. (A)

Fargo
Cook, Tedd W. (A)
Olson, Martin N. (A)

Grand Forks
Garard, Earl A. (A)
Jenkins, David R. (A)

OHIO

Akron
Aitkenhead, John, Jr. (A)
Branch, Gerald E. (J)
Campbell, O. V. (A)
Curtis, James O. (A)
Dinger, Harold E. (A)
Ehrisman, Henry O. (A)
Hood, Norman R. (A)
Nerhood, H. Elmer (A)
Palmer, Roland F. (A)
Smith, Paul Clarence (A)
Townsend, Samuel W. (A)
Weaver, Rayman E. (A)

Ashtabula
Andrus, Roy E. (A)
Cornell, James F. (A)

Athens
Green, Darrell B. (A)

Barberton
Austin, A. O. (F)
Hillebrand, W. A. (M)
Snyder, E. B. (M)

Bellefontaine
Wells, Martin M. (A)

Berea
Anderson, Raymond T. (A)

Bluffton
Steiner, Harold R. (A)

Brecksville
Leffler, Ralph H. (A)

Canton
Ackerman, F. R. (A)
Herbruck, William M. (A)
Pennock, P. L., Jr. (A)

Cincinnati
Aughenbaugh, William K. (A)
Austin, Edward (M)
Best, Paul J. (A)
Boblett, Arthur J. (A)
Boyle, H. G. (A)
Bussard, E. J. H. (M)
Chambers, Joseph A. (M)
Craig, Palmer H. (A)
Crosley, Powell, Jr. (M)
Dixon, C. C. (A)
Felix, Clarence G. (A)
Glessner, Jack M. (A)
Glover, Ralph P. (A)
Goheen, Richard C. (A)
Heina, William M. (A)
Hentz, Elmer G. (A)
Hoffman, Ralph (A)
Hunter, Theodore A. (A)
Israel, Dorman D. (M)
Kellogg, Leonard A. (A)
Kesheimer, Eugene V. (A)
Kidd, Andrew (A)
Kierulff, William E. (M)
Kilgour, Charles E. (M)
Klein, Helen (A)
Kolks, Richard H. (A)
Lampkin, Guy F. (A)
Langley, Ralph H. (F)
Lehnhoff, Raymond G. (A)
Leibrook, Brice (A)
Lockwood, Edward C. (A)
Meyrose, Hubert S. (A)
Myers, William H. (A)
Osterbrook, W. C. (A)
Peterson, Charles W. (M)
Platts, George F. (A)
Rockwell, Ronald J. (A)
Squires, C. E. (A)
Valentine, F. C. (A)
Vanek, Lawrence J. (A)
Verkley, B. M. (A)
Vickers, C. A. (A)
Walker, Frank (A)

Clayton
Jones, Carl C. (A)

Cleveland
Ackerman, E. K. (A)
Akers, William F. (A)
Beasley, Ira E. (A)
Benkelman, Glen F. (A)
Bowditch, Fred T. (A)
Butler, Roy (A)
Calkins, William G. (A)
Canady, Donald Ray (A)
Carlton, Raymond A. (A)
Covey, Gerald G. (A)
David, Bruce W. (M)
Daymude, John F. (A)
De Cola, Rinaldo (A)
Disbrow, John D. (A)
Domizi, Dante (A)

OHIO (Continued)

Cleveland (Continued)
Donaldson, Robert O. (A)
Dorazil, A. F. (A)
Dorn, Harry P. (A)
Drysdale, N. M. (A)
Eames, Albert M., Jr. (A)
Durcanshy, Michael (A)
Eberle, Wilbert H. (A)
Engholm, Bernard A. (M)
Evans, Lee C. (A)
Glatz, Henry (A)
Gove, Edward L. (A)
Hannum, J. C. (A)
Hunt, Louis W. (A)
Hybarger, H. K. (J)
Irvine, Robert P. (A)
Kaehni, Frank J. (A)
Kintner, Deane S. (A)
Klein, Israel (A)
Kope, Carl A. (A)
Leonard, S. Edwin, Jr. (A)
Lesinsky, Frank (A)
Little, D. S. (A)
Lyle, Charles F. (J)
McCall, Keith E. (A)
McCollister, Donald (A)
McGeorge, Donald H. (A)
McMahon, Alvin (A)
Neuert, H. L. (A)
Newman, Joseph S. (A)
O'Connor, Albert J. (A)
Okeson, Hugh Bingham (A)
Ostrander, Russell S. (J)
Owens, Richard M. (A)
Pruitt, Wilbur C. (A)
Robertson, Frank E. (A)
Roebuck, Neel (A)
Schneeberger, G. B. (A)
Schregardus, Dirk (A)
Scott, Hoyt S. (M)
Seitz, Valentine (A)
Shankland, Robert S. (A)
Simon, E. J. (F)
Smith, F. J. (A)
Snyder, Robert E. (A)
Sponagle, Charles E. (A)
Sturtevant, Mark (A)
Sypher, Edgar L., Jr. (A)
Tummonds, Harry A. (A)
Turner, Russel S. (A)
Victoreen, John A. (M)
Ward, Donald O. (A)
Waite, Howard G. (A)
Walsh, S. Charles (A)
Welman, Victor A. (A)
Wells, Leland E. (M)
Willard, Walter C. (A)
Woodward, V. M. (A)
Worst, J. S. (A)
Zinser, Henry (A)

Cleveland Heights
Baier, Arthur H. (A)
Farnham, Ralph E. (A)
Fowler, J. Randall (A)
Williams, Hollie (A)

Clyde
Last, George O. (A)

Columbus
Bidlack, Cecil S. (A)
Everitt, William L. (M)
Graham, J. P. (A)
Higgy, Robert C. (A)
Johnston, George David (A)
Krumm, Louis R. (M)
Leeka, Warren C. (A)
Mercer, Alva (A)
Smith, Sereno E. (A)
Storck, Howard C. (A)
Young, D. A. (A)

Custar
Talmage, Wilbur L. (A)

Dayton
Anderson, J. E. (A)
Baird, Robert E. (A)
Barbulesco, Constantin D. (M)
Bell, Floyd W. (A)
Bickels, Howard I. (A)
Boes, W. W. (A)
Bossard, Gisbert L. (M)
Braden, Paul F. (J)
Brump, H. L. (A)
Cooper, William H. (A)
Copp, R. S. (A)
Cotter, Edwin Meredith (A)
Desch, Joseph R. (A)
De Weese, Herbert William (A)
Eaton, W. G. (M)
Eckert, Clarence C. (A)
Filgate, John T. (A)
Finter, Clyde V. (A)
Flewelling, Edmund T. (A)
Franzwa, Frederick J. (A)
Friedman, Harry (A)
Gerstle, John (A)
Glendenning, D. B. (A)
Harmon, W. S. (A)
Hayslett, L. E. (A)
Hendricks, Lester A. (A)
Hieber, Raymond C. (A)
Jackson, Paul F. (A)
Loftis, Homer J. (A)
Lohmann, Robert S. (A)
Messer, Herbert G. (A)
Mohn, Olof (A)
Newill, Edward B. (A)
Nichols, Harry J. (A)
Noyes, Robert H. (A)
Perkins, Laurence M. (A)
Retter, Cleo Tressler (A)
Reynolds, Clay Elmer (A)
Richmond, L. P. (A)
Sawtell, Raymond I. (A)
Snyder, Ellsworth W. (A)
Stanley, Marion W. (A)
Sweighert, D. V. (A)
Tholstrup, Henry (A)
Zimmerman, Robert F. (A)

Dover
Weber, H. S. (A)

East Cleveland
Shipman, Charles H. (A)
Siddall, Richard (A)

East Sparta
Walker, Nolan S. (A)

Fostoria
Elsea, Farrel F. (A)

Gambier
Cottrell, Casper L. (A)

Garfield Heights
Melrose, James W. (A)

Granville
Clark, James V. (A)

Green Camp
Barber, D. G. (A)

Greentown
Myers, Willard D. (A)

Greenville
Taylor, Otho E. (A)

Hamilton
Norton, Thurman S. (A)
Probst, John E. (A)

Hiram
Stauffer, Robert W. (J)

Holland
Line, F. M. (A)

OHIO (Continued)

Indian Lake
Thomas, W. Raymond (A)

Kent
Kline, Robert L. (A)

Killbuck
Hammontree, Alvin W. (A)

Lakewood
Byrd, Harold F. (A)
Hamman, G. B. (A)
Hoff, Henry B. (J)
Marsal, Paul A. (A)
Sturtevant, James W. (A)
Thompson, J. Kent (A)
Worden, Ralph P. (A)

Lexington
Shuler, John H. (A)

Lorain
Fox, Robert A. (A)

Louisville
Noreen, Carl O. (A)

Marietta
Muscari, Pietro J. C. (A)
Withington, George M. (A)

Mason
Underwood, Norman B. (J)
Whitehouse, Joseph E. (A)

Massillon
Ax, Leland S. (A)
Schwab, Charles B. (A)
Trubey, Lester E. (A)

Medina
Kohli, Homer J. (A)

Milford
Hicks, Kenneth F. (A)

Mt. Gilead
Ashbaugh, Edwin C. (A)

Mt. Liberty
Bishop, Chester K. (A)

Mt. Washington
Vogelsang, George E. (A)

New Philadelphia
Murray, Charles J. (A)

Niles
Coleman, Robert M. (A)

North Canton
Boger, Clair E. (A)

Norwalk
Leonhardt, Charles C. (A)

Norwood
Blair, Russell M. (M)
Boerstler, Loren L. (A)
Dwyer, Robert J. (A)
Willging, Louis F. (A)

Parma
Burkhardt, Karl R. (A)

Port Clinton
Anderson, Gilbert J. C. (A)

Portsmouth
Brake, Basil H. (A)
Byers, James Clifton (A)
Feyler, H. C. (A)
Jackson, Sylvan E. (A)

Sandusky
Voight, Richard J. (A)

Shiloh
White, Kenneth E. (A)

Springfield
Bushong, Victor L. (A)
Fiedler, Oscar W. (A)
Morrow, Lorentz A. (A)
Reid, Thomas A. (A)
Schaefer, Carl A., Jr. (A)
Stolzenbach, R. W. (A)

Toledo
Bitter, A. Romeyn (A)
Browne, Merton S. (A)
Dietsch, Carl G. (A)
Dupuis, Ernest F. (J)
Foley, J. W. B. (A)
Krivitsky, George (A)
Pilzecker, Arthur (A)
Skeels, Dudley K. (A)
Stringfellow, William (A)

Wapakoneta
Copeland, Herman A. (A)

Westerville
Nafzgar, Lester H. (J)

Wright Field
Rives, Tom C. (M)

Youngstown
Kincaid, Owen D. (A)
Kratz, Luther M. (A)
Pennock, P. L., Sr. (A)
Phillips, R. G. (A)
Wilkens, Bernard T. (A)

OKLAHOMA

Bartlesville
Fisher, Frank E. (A)
Miller, Erdene K. (A)
Shultise, Q. M. (A)

Blackwell
Coston, Early G. (A)

Chelsea
Jones, Varnakale L. (A)

Clinton
Stuedle, Emory C. (A)

Enid
Edwards, Lyman M. (A)
Spear, Wade Hampton (A)

Felt
Abshere, Lilburn O. (A)

Fort Sill
Beckley, S. A. (A)

Hugo
Wright, A. J., Jr. (A)

Muskogee
Sams, E. E. (A)

Norman
Steele, Kenneth K. (A)

Oklahoma City
Allen, Roy (A)
Bathe, Charles E. (A)
Chapman, Alan B. (A)
Coates, B. Franklin (A)
Downey, C. E. (A)
Ehret, Kenneth M. (A)
Farris, Glen (A)
Gordon, Earl P. (A)
Herrmann, Frank (A)
Hirdler, F. C. (A)
Kramer, V. J. (A)
Lovell, Herman J. (A)
Marrinan, Horace J. (J)
Mier, C. W. (A)
Mooney, Julius B. (A)
Nott, Arthur C. (A)
Pata, Yaromir J. (A)
Prell, George R. (A)
Roberts, C. E. (A)
Stokes, Ray (A)
Wallace, David R. (A)

OKLAHOMA (Continued)

Ponca City
Murphy, Paul L. (A)

Shawnee
Barron, Arthur J. (A)

Stillwater
Oboukhoff, Nicholai M. (M)

Stillwell
Neeley, Carl E. (J)

Tulsa
Banks, J. Vernon (A)
Bowen, Leonard R. (A)
Carpenter, Hugh (A)
Hess, Harold R. (A)
Jones, Burle R. (A)
McNally, Eugene C. (J)
Miller, Claude E. (A)
Probert, Edward (A)
Sampson, Walter A. (A)
Stinson, Lawrence W. (A)
Van Doeren, C. A. (A)
White, Karl K. (J)
Willson, P. L. (A)
Wise, James O. (A)

Waynoka
Sears, Garold D. (J)

Woodward
Shircliff, Emmett (A)

OREGON

Boardman
Howell, James P. (A)

Corvallis
Feikert, Grant S. (A)
Jordan, Jacob (A)
Morris, James M. (A)

Eugene
Du Sair, Paul E. (A)

Falls City
Paul, Byron R. (A)

North Bend
Pickett, Earl L. (A)

Portland
Cotton, Richard J. (A)
Deardorff, Ralph W. (A)
Dixon, Ashley C. (A)
Harden, Edgar (J)
Holcomb, E. Russell (A)
Kleist, Walter A. (A)
Neubauer, Edwin William (A)
O'Day, Marcus (A)
Olin, R. C. (A)
Sachs, Harold S. (A)
Trumbull, A. F. (A)
Wimmer, Joseph (A)

Salem
Poujade, D. G. (A)

PENNSYLVANIA

Adelia
Woodward, Bruce J. (A)

Aldan
Earle, Ralph P. (A)

Allentown
Bowman, Charles W. (A)
Clauss, Fred W. (A)
Dreisbach, Blair (A)
Eckert, Byron H. (A)
Grammes, Clarence W. (A)
Hardner, Francis J. (A)
Heimbach, Charles W. (A)
Hilliard, Winfield E. (J)
Keck, Kenneth K. (A)
Kurtz, Clyde R. (A)
Pond, Edward W., Jr. (A)
Sauerwine, Charles Augustus (A)
Taylor, Russell R. (A)
Thomas, Charles V. (A)
Weckel, Wilson E. (A)
Williams, Thomas R. (A)
Wissler, Benjamin F. (A)
Young, Charles S. (A)

Allenwood
Schooley, Harold (A)

Altoona
Douglas, Earl C. (A)
Feld, John (A)
Gable, Robert B. (A)
Underhill, Charles R., Jr. (A)
Youngkin, Ernest E. (A)

Ambridge
Svegel, Peter J., Jr. (J)

Ardmore
Wilkinson, Gordon O. (A)
Worrell, Howard S. (A)

Avalon
Allen, James G. (A)

Bala-Cynwood
March, Hallman W. (J)

Bangor
Bruschi, Lewis John (A)

Bath
Graver, Frank S. (A)

Bellevue
Armor, James C. (A)
Bucher, John P. (A)
Donbar, C. Floyd (A)

Bethlehem
Bertolet, Benneville S. (A)
Hottel, C. W. (A)
Knutson, Henry C. I. (A)
Seyfert, Stanley S. (M)

Bradford
Francis, Thomas C. (A)
Gimera, George (A)

Bridesburg
Kearney, William A. (A)

Brownstown
Harnish, Ray M. (A)

Bywood
Brown, Henry J. (A)

Cambridge Springs
Lord, Harry R. (A)

Carlton
Maurer, Elvin E. (A)

Carrolltown
Brophy, Francis Joseph, Jr. (A)

Chambersburg
Ramsey, R. W. (A)

Chester
Baylor, Merle H. (A)
Mitchell, John Charles (A)
Nadig, Stanton E. (A)
Rapagnani, Peter A. (A)

Chestnut Hill
O'Neill, John P. (A)

Childs
Faling, Cecil (A)

Clarks Green
Mack, Dahl W. (A)

Connellsville
Armstrong, Reece M. (A)
Silcox, Albert S., Jr. (A)

Crafton
Hamilton, George H. (A)

Cresson
Vaughan, Kenneth A. (A)

PENNSYLVANIA (Continued)

Cynwyd
Chubb, Lewis W. (M)

Danville
Deaner, Haydn M. (A)

Darby
Knight, Winfield W. (A)

Darlington
Rohrmann, Edward R. (A)

Drexel Hill
Brandt, William A. (A)
Shafer, Albert G. (A)
Sharpless, A. Roberts (A)
Simons, Russell (A)
Willard, Joseph M. (A)

Easton
Beans, Floyd L. (A)
Deutschman, Borah (A)
Hatch, Ray D. (A)
Weller, Everett C. (A)

East Pittsburgh
Conrad, Frank (F)
Evans, Walter C. (M)
Hanna, Clinton R. (M)
Hitchcock, R. C. (M)
Kilgore, G. Ross (A)
Kintner, Samuel M. (F)
McKeel, P. DeForrest (A)
Osbon, William O. (A)
Upp, Charles B. (A)
Whitelock, Leland D. (A)

Edgewood
Lewis, L. V. (A)
McCullough, F. S. (M)

Elkins Park
Ellis, Nelson B. (A)

Emporium
Jones, Walter R. (A)
Kronenwetter, Harold G. (A)
Miller, Carl (A)
Rishell, George L. (A)
Wise, Roger M. (M)

Erie
Jordan, Ralph E. (A)
Metzner, Maxwell W. (A)
Persio, Louis N. (A)

Etna
Johnstone, R. S. (A)

Exeter Boro
Ferroni, Joseph A. (A)

Flemington
Kunkle, Charles F. (A)

Forest Hills
Wensley, Roy J. (A)

Fox Chase
MacFadden, Wilford C. (A)
Merman, John C. (A)

Fullerton
Bachman, Edwin J. (A)

Germantown
Burnside, Don G. (A)
Hettrich, John H. (A)
Weyl, Charles N. (M)
Wunderlich, N. E. (M)

Glenside
Griffith, Charles H. (A)

Greenside
Hawk, William K. (A)

Harrisburg
Detweiler, Jay E. (J)
Gardner, William L., Jr. (A)
Grim, Clair R. (A)
Hall, Thomas, Jr. (A)
Hardy, George E. (A)
Heckman, J. W. (A)
Kilheffer, Harold E. (A)
Knerr, G. Russell (A)
McCachren, W. S. (A)
Mummert, Russell E. (A)
Peffer, Ralph M. (A)
Sours, M. D. (A)
Steiger, Charles H. (A)
Stormfeltz, S. H. (A)
Walanka, M. R. (A)

Hummelstown
Cassady, P. H. (A)

Highland Park
Greenwald, Arthur A. (A)

Honesdale
Burlein, Lester F. (A)

Indiana
Beck, Howard J. (A)

Irwin
Brook, Alf (A)
Marstellar, Lester O. (M)

Jenkintown
Greenway, William L. (A)

Johnsonburg
Baldwin, Arthur V. (A)
Carson, William G. (A)

Johnstown
Hanson, Herbert (A)
Lohr, Lewis H. (J)
Reid, A. J. (A)

Kane
Beatty, Rue Thompson (A)

Kingston
Brown, Ralph M. (A)
Haines, Joseph, Jr. (A)

Kutztown
Sharadin, Francis A. (A)

Lancaster
Gaintner, Joseph R. (A)
Geise, Julius C., Jr. (A)
Snavely, B. L. (A)
Stauffer, J. Luke (A)

Langhorne
Newbold, W. H. (A)

Lansdale
Schieber, Leonard B. (A)

Lansdowne
Kimball, Gardner W. (A)
Thompson, Roland F. (A)
Wilson, A. T. (A)

Lehighton
Butler, Harry F. (A)

Lemoyne
Miles, Lester F. (A)
Rogers, Clifford H. (A)

Matamoras
Willers, Theodore H., Sr. (A)

Media
Delbert, Simon, Jr. (A)

Merion
Dolan, William R. (A)

Milton
Butler, Wilson M. (A)

Monongahela
McCallister, James D. (A)

Morton
Greathead, Arthur W. (A)

Mt. Airy
Blackwood, George C. (A)
Brown, Reynolds D., Jr. (A)
Ehret, Cornelius D. (F)
Ellinwood, Kenneth M. (A)
Keast, Philip M. (A)
McDowell, Albert P., Jr. (A)
Raycroft, Louis B. F. (A)

PENNSYLVANIA (Continued)

Mt. Carmel
Gross, Benjamin F. (A)

Mt. Lebanon
Shafer, William L. (A)

Narberth
Bates, Clifford W. (A)
Lafore, John A., Jr. (A)

New Castle
Martin, Norman A. (A)

New Cumberland
Reinbold, Joseph W. (A)

Norristown
Davis, George C. (A)
Hausmann, Ernest O. (A)
Place, Samuel W. (A)
Rue, William F. (A)
Sands, William F. (A)
Warren, George R. (A)

North Braddock
Berhalter, Joseph J. (A)

Oak Lane
Drueding, Albert J. (A)

Oakmont
Best, Victor C. (A)

Oil City
Baughman, Raymond C. (A)
Imler, Glenn M. (A)
Paca, William S. (A)
Rasmussen, Robert (A)

Overbrook
Closson, H. B., Jr. (A)

Palmyra
Balsbaugh, Clair L. (A)

Penn Wynne
Saunders, William P. (A)

Philadelphia
Apker, Charles L. (A)
Barish, William (A)
Bartlett, Millard C. (A)
Bechler, W. C., Jr. (A)
Benge, J. R. (A)
Berrien, Paul H. (A)
Bloom, Walter (A)
Bonn, Norman E. (A)
Borland, Albert S. (A)
Bosco, Joseph F. (J)
Bromley, John E., Jr. (A)
Brown, Herman C. (A)
Brown, H. Wilbur (A)
Burgess, Edward R. (A)
Caporale, Peter (A)
Chambers, Carl C. (A)
Chedaker, Joseph (A)
Chesney, John J. (A)
Clark, Charles F. (A)
Cummings, B. Ray (M)
Deal, Harmon B. (M)
Derr, C. R. (A)
Doyle, E. D. (A)
Dunn, James C. (A)
Earnshaw, David P. (A)
Ebert, Burton E. (A)
Eby, Hugh H. (A)
Eby, John B. (A)
Eckert, Edward J. (A)
Ellis, William G. (M)
Eskuchen, Frank G. (A)
Etkin, Harry (A)
Fisher, Roy S. (A)
Fossett, Fred E. (A)
Frederick, Calvin M. (A)
Freedman, H. J. (A)
Frigar, John, III (A)
Gengenback, Albert W. (A)
Gilbert, Walter E. (A)
Godsho, Albert P. (A)
Goulden, Stanley W. (M)
Guzik, Nicholas J. (A)
Hagan, Edward J. (A)
Helfenstein, Edwin (A)
Hofberg, Alf H. (A)
Holden, Ellis Gray (A)
Holland, Walter E. (M)
Holtsizer, Ralph (A)
Huttenloch, Robert M. (J)
Illingworth, F. H. (A)
Karcher, Donald (A)
Kearney, L. E. (A)
Keller, Paul A. (A)
Kienzle, D. R. (A)
Kinnier, Donald (A)
Klenk, Julius G. (A)
Korson, Sol (A)
Leshner, Edward (A)
Long, Marvin (A)
MacHugh, William L. (A)
MacNabb, Vernon C. (A)
Malcolm, John (A)
Martino, Alphonse E. (A)
Mattia, Ralph F. (A)
Mayea, Lawrence E. (A)
Mayers, Harvey F. (A)
McClosky, George W. (A)
Merkel, Henry F. (A)
Mevius, John C. (A)
Meyers, Ray E. (A)
Mickey, Leroy (A)
Miller, Charles C. (A)
Miller, John M. (F)
Morris, George W. (A)
Moss, Stanley A. (A)
Mouradian, H. (A)
Murri, Joseph (A)
Nagle, John F. (A)
Ness, Delmer N. (A)
Overmiller, Clair M. (A)
Podolsky, Leon (A)
Ponsford, Walter W. (A)
Prow, Albert H. (A)
Rabinowitz, Meyer (A)
Reeves, E. H. (A)
Reid, Floyd F. (A)
Riley, Albert S. (J)
Robinson, Aloysius V. (A)
Ross, Stewart C. (A)
Rucker, Frederick (A)
Schulmerich, G. J. (A)
Senior, David B. (A)
Shea, Richard F. (A)
Sirms, Wiswald J. (A)
Smuraglia, F. (A)
Snyder, Christopher L. (A)
Snyder, Richard L. (A)
Stroud, Ralph J. (A)
Sullivan, Edward S. (A)
Tarpley, Raymond E. (A)
Tarzian, Sarkes (A)
Taylor, John Pratt (A)
Tindel, Charles G. (A)
Trainer, George T. (A)
Traugott, Paul (A)
Travis, Charles (A)
Trinkle, W. S. (A)
Trumpy, Jay W. (J)
Tyler, Kenneth G. (A)
Tucci, Thomas J. (A)
Tuska, Clarence D. (A)
Van Horn, J. C. (M)
Van Housen, C. H. (A)
Walker, Harold (A)
Warren, S. Reid, Jr. (A)
Williams, Albert J., Jr. (A)
Wockey, Peter F. (A)
Wolf, Clarence, Jr. (A)
Wynne, Walter M. (A)

PENNSYLVANIA (Continued)

Phoenixville
Leibe, Frank A. (A)
Shuhart, John H. (A)

Pittsburgh
Baumgarten, Frank A. (A)
Buerger, Charles B. (A)
Buzzard, A. J. (A)
Clark, Clarence M. (A)
Clary, Howard L. (A)
Cruikshank, Omar T. (A)
Davis, Sheldon Irwin (A)
Diamond, Hyman (A)
Dill, George C. (A)
Douglass, Robert H. (A)
Estey, F. Clifford (A)
Faulstich, C. J. (A)
Gorham, Robert C. (A)
Green, Milton L. (A)
Griffith, Roy T. (A)
Haller, George L. (A)
Harness, Leroy R. (A)
Harrington, Reginald A. (A)
Herlihy, William J. (A)
Krause, C. K. (A)
McKinley, J. G. (A)
Molk, F. T. (A)
Murray, Alexander H. (A)
Osborn, Perry H. (A)
Ostermeir, C. H. (A)
Overholt, Ralph, Jr. (A)
Peters, Leo J. (A)
Reynolds, C. C. (A)
Richards, Folke (A)
Roth, Albert (M)
Schlessinger, L. B. (A)
Shreve, A. French (A)
Staege, Stephen A. (A)
Sunnergren, Arvid P. (A)
Terven, Lewis A. (M)
Thomas, William K. (A)
Thompson, Reginald G. (A)
Wiesmann, Edward T. (A)
Wittgartner, John S. (A)
Wyckoff, Ralph D. (M)

Pottstown
Fisher, Charles H. (A)
Mellon, Ralph E. P. (A)
Roeller, Henry S. (A)

Pottsville
McAllister, Ralph H. (A)

Quakertown
Bartholomew, Robert G. (A)

Reading
Albert, William V. (A)
Good, Horace D. (A)
Liesman, Francis J. (A)
Kissinger, J. Herbert (A)

Ridgway
Anderson, Thure C. (A)

Rosemont
Forstall, Edward L. (A)

Saxonburg
Irving, Herbert W. (A)
Stanier, Donald M. (A)

Schwenkville
Benner, Harold S. (A)

Scranton
Dolph, Stanley E. (A)
Irving, Ira M. (A)
Ornstine, Glenn C. (A)
Oschmann, Adolph W. (A)
Richards, Jack E. (J)
Stevens, Wilbur C. (A)
Witkowski, Joseph F. (A)
Sharon
Rankin, Samuel A. (A)

Sharon Hill
Travis, Irven A. (A)

Slatington
Newhard, Stanley C. (A)

Smethport
Biever, Fred H. (A)
Pierotti, William L. (A)

Souderton
Frederick, Albert P. (A)

South Tamaqua
Delp, Paul L. (A)

State College
Woodruff, Eugene C. (M)

St. Davids
Stewart, Charles H. (M)

St. Marys
Abbott, Harald W. (A)

Stroudsburg
Engel, G. C. (A)

Swarthmore
Fussell, Lewis (A)
Hayes, Ralph S. (A)

Swissvale
Bossart, Paul N. (A)
Lazich, Branko (A)
Shuey, Paul F. (A)

Tarentum
Porter, Harry F. (A)

Trafford
Kimmell, William J. (M)
Woodcock, Clay D. (A)

Troopet
Zern, Reber T. (A)

Uniontown
Crow, John B. (J)
Vincent, Charles W. (A)

Upper Darby
Cahill, James A. (A)
Chamberlain, Newton M. (A)
Dudley, D. Clinton (A)
Frazier, Howard S. (A)
Jenkins, George L. (A)
Lenhert, George R., Jr. (A)
Lewis, Oliver I. (A)
Shannon, Frank J. (A)

Warren
Gruninger, John E. (J)
Pratt, Donald R. (A)

Wayne
Adelberger, Paul J. (A)

Wesleyville
Dutton, George L. (A)

West Manayunk
Sweeney, Harold V. (A)

West Philadelphia
Caulton, Cyrus O. (A)
Eaton, George W., Jr. (A)
Jennings, Earle C. (A)
Knoll, Lloyd M. (M)
Muncey, Allan R. (A)

Wilkes-Barre
Dziadosz, Frank (A)
Paessler, Robert T. (A)
Shuster, Edmund F. (A)
Speicher, Ellsworth J. (A)
Stenger, J. H., Jr. (A)
Warner, Barney H. (A)

PENNSYLVANIA (Continued)

Wilkinsburg
Armstrong, Ralph W. (A)
Baudino, Joseph (A)
Bobertz, W. E. (A)
Brindley, William E. (M)
Carothers, W. D. McL. (A)
Dieffenbacher, C. C. (A)
Ellis, Grenville Brigham (A)
Furth, Ernest L. (A)
Gregory, S. D. (A)
Harmon, R. N. (A)
Johns, Francis J. (A)
Kotsch, Elmer G. (A)
Lehman, James N. (A)
Mag, Anthony (A)
Rosenfeld, Millard (A)
Schwartzenbach, Earl E. (A)
Seaverson, Oswald I. (A)
Sutherlin, Lee (M)
Trouant, Virgil E. (A)
Ulrey, Dayton (A)

Williamsport
Petts, Ronald G. (A)
Swanson, Merrill J. (A)

Willow Grove
Robinson, Harris A. (A)

Wilmerding
Irlam, William (A)
Simpson, Edmund H. (A)

Wynnewood
Seeley, Samuel W. (A)

York
Lever, Philip R. E. (A)
Weigel, Richard C. (A)

RHODE ISLAND

Cranston
Bargamian, John (A)

Edgewood
Brewster, O. H. (A)
Cumerford, Arthur S. (A)

North Providence
Thomas, Harold (A)

Pawtucket
Appleby, Bertie (A)

Providence
Andrews, Howard L. (A)
Aymar, Erwin (A)
Bellem, Lewis S., Jr. (A)
Gerry, Frank L. (A)
Huddy, Franklin S. (A)
Leibow, Saul A. (A)
Passarelli, Harold C. (A)
Peters, John L. (A)
Smith, Malcolm H. (A)
Wright, Marshall C. (A)

Woonsocket
Marier, Edward P. (A)
Massart, Raymond E. (A)
Teachman, Alfred E. (A)

SOUTH CAROLINA

Aiken
Terry, Laurence M. (A)

Anderson
Mitchell, John A. (A)

Charleston
Zeigler, T. W. (A)

Clemson College
Garrison, Paul J. (A)
Tingley, Freeman T. (A)

Spartanburg
Etheredge, George W., Jr. (A)

SOUTH DAKOTA

Brookings
Crothers, H. M. (A)

Emery
Janssen, Richard J. (A)

Lennox
Osterloo, John D. (A)

Rapid City
Halley, Samuel R. (A)
Kammerman, John O. (A)

Sanator
Tilgner, Shelton R. (J)

Vermillion
Vert, Henry F. (A)

Watertown
Sigelman, S. S. (A)

Yanktown
Bowyer, Robert A., Jr. (A)
Nelson, Ivar (A)
Seils, Harry A. (A)

TENNESSEE

Athens
Knight, Gaylord A. (A)

Chattanooga
Eiselein, J. E. (A)
George, Everett E. (A)

Cookeville
Stone, C. D. (A)

Greenville
Brown, J. Kenneth (A)

Knoxville
Adcock, S. E. (A)

La Grange
Sims, James W. (A)

Memphis
Blakeney, George H., Jr. (A)
Cowles, John W., Jr. (A)
Mason, Alfred E. (A)
Moss, W. Hall (A)
Pearce, Arthur (A)
Shafer, Arthur B. (A)
Slavick, Henry William (A)

Nashville
Leftwich, E. H. (A)
Montgomery, L. H., Jr. (A)
Montgomery, William C., Jr. (A)
Randolph, George T. (A)

Saltillo
Berry, James S. (A)

TEXAS

Abilene
Mancill, Maurice C. (A)

Albany
Codington, Jerome H. (A)

Amarillo
Berg, Arthur A. E. (A)
Martin, J. Laurance (A)
Reville, T. A., Jr. (J)
Todd, William F. (A)

Bastrop
Barrow, Lemuel T. (A)

Beaumont
Bryan, William J. (A)
Bush, Charles R. (A)
Gower, S. Gifford (A)
Greene, H. Bettis (A)
Knight, Charles (A)
Trevey, C. B. (A)
Wengel, Raymond W. (A)

TEXAS (Continued)

Brownsville
Daniels, Paul H. (A)
Minor, Robert Lee (A)
Mulhollan, Roye (A)
Ogg, Glen R. (A)

College Station
Dillingham, H. C. (A)

Corpus Christi
Dunn, Earl C. (A)
Lockhart, Hildred B. (A)
Nelson, C. L. (A)

Dallas
Adler, Benjamin (A)
Bennett, Porter T. (A)
Crabtree, Alfred E. (A)
Crossland, Henry A. (A)
Eilert, Edward F. (A)
Ellis, W. C. (A)
Evans, W. J. (A)
Feickert, Carl A. (A)
Glass, Robert Z. (A)
Green, William G. (A)
Harington, Conrad F. (A)
Harrison, L. E. (A)
Hayes, Thomas P. (A)
Howard, G. M. (A)
Hull, Blake D. (A)
Lawther, Harry P., Jr. (A)
Lewis, William S. (A)
McDermott, Eugene (A)
McKinney, Joe H. (A)
Melroy, Harry C. (A)
Parkinson, Lee D. (A)
Rich, F. L. (A)
Ritzau, K. (A)
Scanlon, Dale L. (A)
Sheffield, H. M. (A)
Tucker, Durward J. (A)
White, R. Jordan (A)
Wilber, H. E. (A)
Wilkinson, Lee A. (A)
Wilks, Ernest L. (A)
Witty, W. M. (A)
Zeidlik, William J. (A)

Denton
Fain, Edgar A. (A)

Dublin
Stark, L. P. (A)

El Paso
Talbott, Edward P. (A)

Fort Worth
Abey, Robert E. (A)
Branch, William E. (M)
Golder, Frank E. (A)
Jackson, N. H. (A)
Palmer, James (J)
Sullivan, J. R. (A)

Galveston
Dickey, J. W. (A)
Unruh, Franklin T. (A)

Harlingen
Eggers, Earl L. (A)

Houston
Austin, Francis M. (A)
Carter, William H. (A)
Chinski, Gerald R. (A)
Coe, James C. (A)
De Bardeleben, John F. (A)
Dupree, Edmund M. (M)
Franklin, Robert E. (A)
Harvey, Francis M. (A)
Hoskins, Laban A. (A)
Hunt, J. W. (A)
Imle, John F. (A)
Kelly, Claude H. (A)
Machotka, Slavomir (A)
McFarland, M. Ralph (A)
Meyer, J. M. (A)
Perlitz, W. H. (A)
Ricker, Norman H. (A)
Robinson, King H. (J)
Rodgers, H. C. (A)
Van Orsdale, Allen A. (A)
Waters, James S. (A)
Wheeler, Harvey T. (A)
Wilson, W. W. (A)
Zimmerman, George E. (A)

Jacksboro
Isbell, G. Terrill (A)

Lubbock
Abbitt, William H. (A)

Plano
Hays, Howard D. (A)

Rockland
Wilson, S. Earle (A)

San Angelo
Jones, Frank M. (A)

San Antonio
Hallam, John T. (A)
Hyman, Kenneth R. (J)
Kidd, Thornton L. (A)
McShane, Joe Bailey (A)
Muller, Carl W. (A)
Rayburn, Geoffrey D. (A)
Wall, Leavell D. (A)

Tyler
Daniel, Charles L. (A)

Waco
Cole, Roy H. (A)
Jackson, Frank P. (A)

Wichita Falls
Drollinger, Kyle M. (A)
Ridling, Carroll W. (A)

UTAH

Murray
Smith, Edwin W. (A)

Ogden
Stanton, James M. (A)

Salt Lake City
Baldwin, John M. (A)
Baldwin, Nathaniel (M)
Benzon, C. G. (A)
De Remer, C. W. (M)
Farnum, Willis H. (A)
Lasky, Philip G. (A)
Salzer, Herman M. (A)
Whidden, Ira P. (A)
Yeates, Ephraim Leroy (A)

Spanish Forks
Fullmer, Don A. (A)

VERMONT

Northfield
Howes, Douglas E. (A)

Poultney
Western, Sidney E. (A)

Proctor
Barch, Henry S. (A)

St. Johnsbury
Enderle, Jackson J. (A)

VIRGINIA

Alexandria
Dowie, James A. (M)
Harrison, Edgar (A)
Roesch, Robert E. (A)

Arlington
Dresser, O. C. (A)
Fredericks, John E. (A)

VIRGINIA (Continued)

Bristol
Jellicorse, Harold L. (A)

Cherrydale
Stokes, Howard S. (A)

Clarendon
Looney, Don B. (A)

Culpeper
Jones, H. R. (A)

Danville
Clarke, Allen S. (A)

Dumbarton
Zaun, William J. (A)

Farmville
Harrison, Charles W., Jr. (J)

Fort Meyer
Mason, Dale P. (A)

Hampton
Craig, Jack (J)

Louisa
Bullock, John W. (J)

Lynchburg
Heiser, Albert E. (A)

Norfolk
Foley, W. R. (A)
Hodges, Arthur T. (A)
Kortes, George T. (A)
Payette, Walter S. (A)
Tellman, Herbert A. (A)

Portsmouth
Baart, John C. (A)
Regan, Smiley I. (A)

Quantico
Hawthorne, W. G. (A)

Richmond
Auckerman, U. H. (A)
Eubank, Robert N. (A)
Steere, James A. (A)
Woods, David C. (A)

Roanoke
Avery, Robert D. (J)
Maddox, Francis E. (A)

WASHINGTON

Auburn
Nagata, Charles N. (A)

Bremerton
Jorgenson, A. A. (A)
Novotney, Harry J. (A)
Riley, Conrad D. (A)
Wilson, George F. (A)

College Place
Kretchmar, G. G. (A)

Edmonds
Hammond, W. Murray (A)
Hoke, Vergne L. (A)

Everett
Malmstrom, Helmer W. (A)
Sands, Leo G. (J)

Gig Harbor
Berkheimer, R. H. (A)

Port Townsend
Mullaney, Harold F. (A)

Pullman
Hatfield, Lester N. (A)

Seattle
Austin, Leslie C. (A)
Bach, Roy O. (A)
Baker, Earl W. (A)
Begg, W. E. (A)
Brewington, Carl W. (A)
Burleigh, John A. (A)
Dailey, Arthur C. (A)
Douglas, William A. (A)
Du Marce, Herman (A)
Eastman, Austin V. (A)
Fitzpatrick, George William (A)
Foster, Clark H. (A)
Foster, Nick H. (A)
Gable, M. (A)
Hackett, Paul J. (A)
Haig, James H. (A)
Hamilton, Edward A. (A)
Hemrich, Walter A. (A)
Huber, Louis R. (A)
Hurlbut, Harold Charles (A)
Iversen, I. Vee (A)
Johnson, I. W. (A)
Kalin, Albert (A)
Klein, William S. (A)
Kraft, Vincent I. (A)
Kratz, C. F. (A)
Lovejoy, Edwin W. (M)
Melang, Bjorn L. (A)
Merritt, Ronald A. (A)
Morris, James E. (A)
Ramsey, Clarence B. (A)
Renfro, Harold E. (A)
Rieger, William (A)
Robinson, A. K. (M)
Ross, J. D. (A)
Smith, Oliver C. (A)
Thomas, William M. (A)
Thomson, Howard M. (J)
Tobey, E. S. (A)
Tolmie, J. R. (A)
Urey, George M. (A)
Voris, Don Lea (A)
Walker, Robert M. (A)
Williams, Charles E. (M)
Willson, Abner R. (A)
Winningham, Harold W. (A)
Zaluskey, Eugene R. (A)

Spokane
Drobig, Leo (A)
Dunnigan, Frank A. (A)
Eberly, Austin D. (A)
Johnson, Carl A. (A)
MacLean, T. Wendell (A)
Prince, Frank W. (A)
Rankin, Robert C. (A)
Reid, L. M. (A)
Schanks, Maurice J. (A)
Storms, Henry J. (A)
Sutton, Robert B. (J)

Tacoma
Beatty, Dwight L. (A)
Evans, Leon R. (A)
Miller, George C. (A)

Vancouver
Ryan, Lloyd F. (J)

Walla Walla
Elam, Daniel W. (A)

Wenatchee
Lanphere, Merle (A)

WEST VIRGINIA

Cameron
Chambers, Albert V. (A)

Charleston
Berry, Henry P. (A)
Moore, Thomas H. (A)
Morgan, J. T. (A)
Stalnaker, Burr (A)

Clarksburg
Chorpening, George B. (A)

WEST VIRGINIA (Continued)

Fayetteville
Goddard, John B. (J)

Huntington
Bieber, Clarence G. (A)

Institute
Evans, James C. (A)

Kingwood
Michelson, Peter (A)

Morgantown
Colwell, Robert C. (M)

Wheeling
Boundy, Glen G. (A)
Pierce, R. Morris (A)
Risley, F. S. (A)
Stroebel, John C., Jr. (M)
Weimer, Earl W. (A)

Williamson
Pirotte, Pete (A)

WISCONSIN

Antigo
Matthias, Lynn H. (A)

Eau Claire
Kovell, George (A)
Langdell, Henry R. (A)
Nelson, Orrin B. (A)

Fond du Lac
Hillegas-Baird, L. S. (A)

Janesville
Pyle, Kempster W. (A)

La Crosse
Jenks, Leslie E. (A)
Leeman, Alvin (A)
Van Loan, Cullen G. (A)

Lodi
Evert, W. E. (A)

Madison
Austin, Otto C. (A)
Bennett, Edward (F)
Hoffman, W. Hollis (A)
King, Ronald (A)
Koehler, Glenn (A)
Lighty, Russell D. (A)

Manitowoc
Scholten, Charles H. (A)

Marinette
Somerville, Harry V. (A)

Menasha
Peerenboom, Cyril A. (A)

Menomonie
Nathness, Semore T. (A)

Milwaukee
Almes, William E. (A)
Bogenberger, John W., Jr. (A)
Borek, John J. (A)
Brafford, Charles P. (A)
Charbonneau, Allan P. (A)
Cordes, Edwin L. (A)
De Land, Robert E. (A)
Frish, Ben F. (J)
Gainer, William P. (A)
Gebhart, Bernard R. (A)
Giard, E. A. (A)
Heim, Carl (A)
Hjermstad, Hans U. (A)
Holman, Henry (A)
Hostetler, Amos C. (A)
Irving, Emmanuel (J)
Kaetel, Herbert C. (A)
Kaul, William (A)
Kelly, Daniel S. W. (A)
Kruse, Charles C. (A)
Luecker, Fred W., Jr. (A)
Moorbeck, Clinton (A)
Nunn, E. D. (A)
Oetting, O. W. A. (M)
Pfeifer, Joseph W. (A)
Richardson, A. G. (M)
Richardson, Marston S. (A)
Roser, Clarence O. (A)
Simon, Arthur (A)
Snead, Sam (A)
Stoekle, Erwin R. (M)
Thomas, Morris W. (A)
Topolinski, Leo J. (A)
Vaughn, F. A. (A)
Wareing, Herbert F. (A)
Weiss, Tobias (A)

Neenah
Ponto, Aaron E. (A)

New Glarus
Becker, Sylvan J. (A)

Platteville
Bentz, Carl F. (A)

Portage
Brown, George H. (A)

Racine
Dally, Roy (A)
Host, Raymond H. (A)

Rewey
Carpenter, Archie V. (A)

Sheboygan
Pfeiler, Lawrence F. (A)

Shorewood
Gellerup, D. W. (A)

Stevens Point
Brickson, Herbert O. (A)
Spindler, Robert E. (A)

Superior
Bridges, W. C. (A)

Washington Island
Gunnlaugson, Jacob (J)

Wausau
Krueger, Otto J. (A)

Waukesha
Hebal, William H. (A)

Wauwatosa
Devendorf, H. H. (A)
Mattern, Ray P. (A)
Tagart, Sam W. (A)

WYOMING

Cheyenne
Fisher, Joseph J. (A)
Lawrenz, William (A)
Leland, Wallace H. (A)
McQueen, Harry D. (A)
Strelesky, Herbert J. (A)

Lander
Steinbrech, Joseph M. (A)

Torrington
O'Reilly, Gordon A. (A)

ALASKA

Hannon, John P. (A)
Maki, George J. (A)
Teague, Theodore T. (M)

CANAL ZONE

Bullock, Gilbert D. (A)
Grumman, F. W. (J)
Kosar, William S. (A)
Young, John W. (A)

HAWAII

Armagost, Harold C. (A)
Balch, J. A. (M)
Borthwick, James H. (A)
Branch, L. W. (M)
Clark, George W. (A)
Day, Laurence E. (A)
Eller, Willard H. (A)
Fiechtner, Theodore G. (A)
Greiner, H. J. (A)
Hill, Otis (A)
Janitschke, E. O. (A)
Macartney, A. Roy (A)
Muller, John H. (A)
Muller, P. H. (A)
Murai, Fred H. (J)
Schaefer, Carl T. (A)
Schick, John R. (A)
Shaw, Robert M. (A)
Simpson, Robert L. (A)

PHILIPPINE ISLANDS

Galvez, Manuel E. (A)
Grupe, Emilio (A)
Hill, Guy (F)
McKesson, Lewis J. (A)
Nance, Curtis H. (M)
Riddle, Elmer R. (A)
Rivera, T. L. (A)
Slater, F. Robert (A)
Soriano, Alfonso (A)

PORTO RICO

Agusty, Joaquin (A)
Behr, F. J. (F)
Delworth, Lee J. (A)
Draigh, Canton V. (A)
Schell, Richard, Jr. (A)

CANADA

ALBERTA

Duncan, James E. (A)
Field, Percy A. (A)
James, Cliff C. (A)
Ryley, Raymond (A)

BRITISH COLUMBIA

Barclay, Hugh N. (A)
Bartholomew, Francis J. (A)
Benson, John P. (A)
Filtness, Arthur W. (A)
Gilbert, George (A)
Hawkins, Leslie S. (M)
Insulander, Clarence H. M. (A)
Irvine, Basil (A)
Kitchin, J. E. (A)
Lapham, James B. (A)
Mawson, John T., Jr. (A)
Murdoch, G. (A)
Rose, F. W. (A)
Sealey, F. W. (A)
Sturrock, S. B. (A)
Thomas, Clarence W. (A)

MANITOBA

Bennett, Gordon S. (A)
Bishop, Ernest F. (A)
Ellinthorpe, J. W. (A)
Gillingham, A. (A)
Lee, Stanley A. (A)
Leitch, Donald J. H. (A)
McLaughlin, Harry R. (A)
Mills, Gilbert H. (A)
Pound, Harris D. (A)
Salton, Lynn V. (M)
Sinclair, D. B. (J)
Varcoe, H. R. (A)
Young, M. D. (A)

NEW BRUNSWICK

Shelfoon, A. J. (A)
Stevens, Ronald C. (A)
Thorne, Frank D. (A)
Vaughan, Frank P. (A)

NORTHWEST TERRITORY

Hastings, R. Stuart (A)

NOVA SCOTIA

Howard, William B. (A)
Nelma, Arsene (A)
Sutherland, Alexander (A)

ONTARIO

Andres, Paul G. (A)
Ainsworth, A. L. (A)
Anderson, John F. (A)
Bailey, Ambrose L. (A)
Bain, J. R. (A)
Baldwin, George (A)
Barber, Walter G. (A)
Bayly, B. de F. (A)
Bayne, R. R. (A)
Blackburn, Wesley (J)
Blakely, Robert John (A)
Bowers, E. J. (A)
Brown, Alvin H. (A)
Brown, Harry S. (A)
Butler, Ron (J)
Campbell, Henry Lawson (A)
Caton, William A. (A)
Choat, William F. (A)
Cline, Russell A. (A)
Clipsham, K. M. (A)
Cluff, Harold D. (A)
Cooper, Ashton B. (A)
Cooper, J. R. (A)
Crofts, Cecil T. (A)
Cronk, Harold W. (A)
Cusack, Sidney C. (A)
Dalton, F. K. (M)
Daly, Edmund (A)
De Grave, Claude (A)
Dibblee, John (A)
Dick, N. J. (A)
Diwell, Harry (A)
Dix, George (A)
Doan, George F. (A)
Dresser, Carl C. (A)
Edwards, Charles P. (F)
Emes, Karl C. (A)
Erwin, Raymond W. (A)
Evans, George L. (A)
Fiegehen, Maurice G. (A)
Field, George S. (A)
Fisher, Albert E. (A)
Ford, J. S. (A)
Foster, Leonard (A)
Fowler, Walter D. (A)
Fox, Florian J. (A)
Fox, Charles H. (A)
Fraser, D. M. (A)
Gaby, Frederick A. (A)
Geldert, George M. (A)
Goodspeed, Lynmore S. (A)
Gowan, Frank S. (A)
Gowan, Hubert S. (A)
Graham, Burwell (A)
Grant, Eric A. (A)
Gurd, Ronald H. (A)
Hackbusch, Ralph A. (M)
Hancox, Harold (J)

ONTARIO (Continued)

Hepburn, Dugald (M)
Henderson, J. P. (M)
Hewson, J. H. (A)
Hill, Orville (A)
Hodsoll, Martin (A)
Hollinsworth, V. E. (A)
Hughes, Peter (A)
Irwin, L. D. (A)
Jackson, Leslie (A)
Jessop, F. R. (A)
Kelterborn, W. H. (A)
Killem, Morris (A)
Kinnear, Donald R. (A)
Knapman, Jack (A)
Kniffen, Leslie D. (A)
Knight, Frank (A)
Kynnersley, Charles (A)
Langford, C. H. (A)
Laurie, William L. (A)
Leonard, Sydney L. (A)
Leslie, John M. (A)
Little, W. C. (A)
Lowry, Charles A. (A)
Lundy, Stanley R. (A)
Mann, George F. (A)
Maundrell, Douglas A. (A)
Maurer, G. P. (A)
McCardle, Henry (A)
McClain, Gordon W. (A)
McFarquhar, Charles Clifton (A)
McKichan, Donald B. (A)
McLean, Lloyd V. (A)
McMillan, Donald B. (J)
McMurtry, Cyril A. W. (A)
Meredith, C. C. (M)
Mitchell, Leonard W. (A)
Mogridge, J. Nairn (A)
Montagnes, Henry (A)
Morton, Howard J. (J)
Mott, Harold E. (A)
Moultrie, Frank C. (A)
Mullen, Joseph G. (M)
Nauth, Raymond (A)
Newman, John R. (A)
Nichols, W. A. (A)
Northover, Harold W. (A)
O'Byrne, Bernard (A)
Olson, E. (A)
Oxley, Allan B. (A)
Paisley, S. Roy (A)
Patience, A. Melbourne (M)
Penny, H. G. Y. (A)
Pipe, Gordon E. (A)
Pollock, Alexander (A)
Pollock, C. A. (A)
Potter, N. M. (A)
Potter, Robert C. (J)
Poulter, Robert C. (A)
Pounsett, Frank H. R. (A)
Price, Harold W. (A)
Price, Roland J. C. (A)
Purser, D. E. (A)
Richardson, Charles L. (M)
Roedell, Leroy W. F. (A)
Rogers, Edward S. (M)
Rose, Sidney (A)
Rosebrugh, Thomas R. (A)
Rothera, W. F. (A)
Ruedy, Richard (A)
Rush, Walter A. (F)
Russell, Arthur H. K. (A)
Russell, W. G. (A)
Schwarz, Bertram A. (M)
Sherratt, Joseph B. (A)
Smith, Arthur (A)
Smith, B. J. (A)
Smith, C. C. (A)
Smith, Victor G. (A)
Snell, Henry C. (A)
Stauffer, William J. (A)
Steel, W. Arthur (M)
Swabey, Henry C. (A)
Taber, Harold E. (A)
Thompson, Milton L. (A)
Tran, T. A. (A)
Underwood, Clifford C. (A)
Van Sickle, Melvin (A)
Waite, Griffin G. (A)
Wallace, J. M. (A)
Walsh, Harold E. (A)
Ward, Charles (A)
Warwood, W. E. (A)
Watson, J. E. (A)
Weaver, William E. (A)
Weber, Rennie I. (A)
Weir, Harold G. (A)
Whitmore, Walter R. (A)
Wilkinson, Allan E. (A)
Williams, James (A)
Wilson, James C. (A)

QUEBEC

Acton, Edward H. (A)
Andrae, Robert T. (A)
Andresen, Sigurd (A)
Baily, F. A. A. (A)
Barbour, John Henry (A)
Barrow, Frederick A. (A)
Bergeron, Rosario (A)
Bird, C. H. R. (A)
Blais, Alphy L. (A)
Cann, John O. G. (F)
Carr, John (A)
Carrick, William E. (A)
Cash, J. Allan (A)
Chagnon, Adolphe (A)
Chauvin, Stanley (A)
Clarke, J. L. (A)
Comach, Stanley I. (A)
Conroy, Joseph M. (A)
Cooper, Samuel J. (A)
East, Lawrence A. W. (A)
Eve, Harry (A)
Farmer, Eric W. (A)
Goldin, Hyman C. (A)
Higgins, H. H. (A)
Hodgson, Edward (A)
Howe, A. E. (A)
Hudon, Gerald F. (A)
Jackson, Arthur (A)
Leonard, Percy A. (A)
Lord, William (A)
Lyons, Walter (A)
Marceau, Jules P. (J)
McKay, William (A)
McWilliam, Eric A. (A)
Menard, J. L. (A)
Moore, William H. (A)
Mullin, James W. (M)
Olive, Gordon W. (A)
Patterson, C. F. (A)
Payne, L. Stanley (M)
Peachey, C. Arthur (A)
Platt, J. E. (A)
Ratchford, William J. (A)
Richardson, J. Stuart (A)
Robb, Robert J. (A)
Rogers, Harold A. (A)
Runciman, Arthur S. (A)
Russell, Herbert J. (A)
Short, Herbert M. (M)
Smith, Frederick A. (A)
Soucy, Chester I. (A)
Spencer, Leonard (M)
Starr, C. Harry (A)
Tanner, Charles J. (A)
Thompson, John H. (A)
Tremblay, Joseph (A)
Turnbull, Allison D. (A)
Vennes, H. J. (M)

QUEBEC (Continued)

Wade, David (A)
Wallace, G. A. (A)
Wallace, O. C. S., Jr. (A)
Weese, R. (A)
Wilcox, B. B. (A)
Wilson, Clifford A. (A)
Wilson, C. T. R. (A)

BRITISH ISLES

CHANNEL ISLANDS

Adams, A. M. (A)
Manning, William Montagu (A)
Poppleton, John (A)

ENGLAND

Abraham, F. X. J. (A)
Adams, Frank S. (A)
Agate, Carlton S. (M)
Albiston, William A. (A)
Allan, J. T. (A)
Allen, Charles G. (A)
Allinson, C. P. (A)
Amey, S. H. (A)
Amis, Frederick H. (M)
Andrewartha, H. C. (A)
Andrews, W. A. (M)
Angell, Douglas H. (A)
Appleton, Edward V. (A)
Appleton, William A. (M)
Armstrong, L. J. Heaton (A)
Ashwin, Cecil W. H. (A)
Atkinson, Cyril T. (A)
Axten, Bernard J. (A)
Bagshaw, George W. (A)
Bailey, Walter H. (M)
Bainbridge-Bell, L. H. (A)
Baird, Frederick (A)
Baker, Thomas T. (M)
Barber, J. H. (A)
Barker, Percy L. (A)
Bartlett, A. C. (A)
Bartlett, Wallace A. (A)
Baskett, Frederick J. (A)
Bates, Cyril R. (A)
Bennett, F. T. (A)
Bever, Anthony J. M. (A)
Binyon, Basil (M)
Bird, R. J. (M)
Bird, Sydney S. (A)
Bonong, Edward (A)
Booler, Ernest (A)
Booth, Charles F. (A)
Bowen, Harry L. (A)
Boyd, W. Forbes (A)
Boyle, Charles W. (M)
Brenchley, C. C. (A)
Brown, Walter J. (M)
Brown, William G. (A)
Bulgin, Arthur F. (M)
Burgess, A. G. (A)
Burnham, Walter W. (F)
Burrowes, Francis E. (A)
Calver, Frank N. (M)
Carpenter, Rupert E. H. (M)
Carter, F. C. (A)
Casperd, Christopher C. (A)
Caswall, Herbert (M)
Catt, James E. (M)
Chandler, Charles K. (A)
Chapman, Edward T. (A)
Chapman, J. P. J. (A)
Chesterton, Arthur J. (M)
Clarke, Douglas F. (A)
Clarke, George E. (A)
Clatworthy, Thomas (A)
Clear, K. Y. (A)
Cobb, F. Arthur (M)
Cohen, Isaac J. (A)
Cohen, Samuel H. (A)
Connell, W. H. (A)
Cooper, G. R. (A)
Cooper, J. A. (A)
Cooper, W. H. B. (J)
Coursey, Philip R. (A)
Courtenay-Price, George (A)
Cox, C. F. (A)
Crabtree, Herbert (A)
Crampton, William J. (M)
Crawford, Cecil G. (A)
Critchley, Walter H. (A)
Cross, A. (J)
Curd, David A. (A)
Curtis, Francis C. (A)
Cushion, L. (A)
Dack, Allan J. S. (A)
Dack, John H. A. (A)
Davy, Francis G. (A)
Dawes, Richard M. (A)
De Burgh, Desmond H. (M)
Dennis, Frank L. (A)
De Wardt, Robert G. (M)
Diggle, A. J. (A)
Ditcham, William T. (M)
Diver, Frederick G. (A)
Dixon, Ronald (A)
Dolovitz, Ronald (A)
Dorte, Philip N. (A)
Downing, George E. C. (A)
Dowsett, Harry M. (M)
Drake, George P. (A)
Dryland, Alan G. (M)
Dunstan, A. S. (A)
Durrant, Reginald F. (M)
Dyer, H. A. J. Shearman (A)
Eckersley, P. P. (F)
Eckersley, T. L. (F)
Edes, Noel H. (A)
Elliott, Isaac (A)
Elwell, Cyril F. (F)
Emerson, R. Waldo (A)
Emery, E. J. (M)
Erdman, H. (A)
Evans, Alfred (A)
Evans, Edward H. (A)
Evans, Young W. P. (M)
Everest, Augustine R. (A)
Everett, Lionel E. B. (M)
Faulkner, Harry (M)
Featherstone, William A. E. (A)
Fennessy, John R. (A)
Field, Harry T. F. (A)
Flagg, Leonard B. (A)
Flintham, Herbert (A)
Floyd, William F. (J)
Foord, Henry D. G. (M)
Franklin, T. Bedford (A)
Fuller, J. Conrad (M)
Galbraith, R. A. H. (A)
Galloway, C. Hadfield (A)
Gambrell, Horace W. (M)
Gardiner, William J. (A)
Gee, Harry T. P. (A)
George, Philip H. F. (A)
Gill, Archibald J. (M)
Glossop, Arthur A. (A)
Glover, Philip F. (M)
Godfrey, F. E. (A)
Goord, H. V. (A)
Gorman, Robert (A)
Gracie, John A. (A)
Graham, C. (A)
Green, Ernest (A)
Greig, James (A)
Griffiths, Herbert V. (A)
Griffiths, W. H. F. (M)
Haigh, Norman E. (A)
Hall, Albert (M)
Hall, Basil (J)

ENGLAND (Continued)

Hall, Norman (A)
Hall, Roland C. (A)
Hambling, Arthur W. (A)
Hamilton, D. (A)
Hannah, W. J. (A)
Harries, John H. O. (A)
Harris, Percy W. (M)
Harris, Raymond (A)
Hartshorne, W. L. (A)
Harvey, Herbert J. (A)
Harvey, Lionel (M)
Hawkeswood, A. E. (A)
Hawkins, John H. (A)
Healey, Oliver (A)
Heightman, D. W. (J)
Henderson, Francis A. (A)
Henderson, John T. (A)
Henderson, Walter B. (A)
Herbert, P. (A)
Herd, James F. (M)
Hermes, Lawrence W. (A)
Hewetson, Geoffrey B. (J)
Hill, Ernest N. (A)
Hinderlich, Albert (A)
Hinks, Goeffrey D. (A)
Hinks, Henry J. (A)
Hirshman, Cyril L. (A)
Holkinson, Henry (A)
Holbeach, William M. (A)
Holmes, Cyril T. (A)
Holmes, Robert (A)
Holzman, Louis (A)
Horn, C. O. (A)
Hotine, Leslie (M)
Howard, C. Alexander (A)
Howard, C. G. (A)
Hows, Leonard J. (A)
Howse, H. A. G. (M)
Hughes, D. W. (A)
Hughes, Lionel J. (A)
Hughes, Robert Penry (A)
Hughes, William Morris (A)
Inchley F. I. (A)
Irving, Donald H. (A)
Jackson, Willie (A)
James, William P. (A)
Jarratt, G. H. (A)
Jeffery, Jack H. (A)
Johnson, Arthur G. (A)
Jones, Arthur B. (A)
Jones, Frank E. B. (A)
Jones, H. Richardson (A)
Joice, W. S. (A)
Joseph, J. (M)
Keegan, William (A)
Kinman, Thomas H. (M)
Kirke, Harold L. (M)
Klein, Rene H. (M)
Kynaston, B. H. J. (A)
Ladner, Alan W. (A)
Lamb, William H. (A)
Lance, Thomas M. C. (A)
Landale, S. E. A. (A)
Lane, C. F. (M)
Lane, C. V. (A)
Langstaff, Horace (A)
Lassman, Henry H. (A)
Lawler, L. A. C. (A)
Lawson, C. J. F. (A)
Leathes, W. H. B. DeM. (A)
Lee, Albert G. (F)
Lemon, Cecil G. (A)
Lipowsky, J. (A)
Litchfield, Gordon A. (A)
Littledale, H. A. P. (A)
Lyle, Herbert B. (A)
Lyons, C. L. (M)
Mackenzie, D. G. (A)
Maitland, James L. (A)
Male, Samuel C. (A)
Mallinson, William (A)
Mansell, Lionel H. (M)
Marconi, Guglielmo (F)
Marshall, J. A. (A)
May, John (A)
McCullum, C. C. (A)
McDonald, George F. H. (A)
McIntosh, Ronald A. (A)
McLeod, John S. (A)
McMichael, Leslie (F)
Megaw, E. C. S. (A)
Mercer, Charles J. (M)
Millard, Alfred W. (A)
Mills, William F. (A)
Minter, Robert W. (A)
Mockford, Frederick S. (A)
Moore, John T. (A)
Morris, Robert (A)
Moullin, E. B. (M)
Murad, W. H. (A)
Murphy, Frank (A)
Murray, John W. (A)
Mustchin, Norman (A)
Myers, George T. (A)
Mulholland, William (A)
Mumford, Albert H. (A)
Nagase, Harutoshi (A)
Nancarrow, F. E. (M)
Newnham, Leonard E. (A)
Nicholson, James K. A. (M)
Noden, Joseph (A)
Nottage, William H. (A)
Odell, Leslie F. (A)
Ogden, S. (A)
Ogg, John George (A)
O'Neill, R. F. (A)
O'Shaughnessy, J. J. F. (M)
Owner, John S. (A)
Palmer, R. J. (A)
Panagakis, Harry (A)
Parker, A. Raymond (A)
Parkin, Thomas D. (A)
Payne, Eric A. (A)
Pearson, Laurence H. (A)
Pearce, R. A. (A)
Pecorini, Robert R. (M)
Pereira, Francis E. D. (A)
Petersen, Thomas G. (A)
Phillips, Charles F. (M)
Picken, William J. (A)
Pinnock, L. W. J. (A)
Pipe, Robert E. (A)
Pocock, Hugh S. (M)
Potts, Edward (A)
Pound, Ernest J. (A)
Rae, William T. (A)
Ramirez, Eduardo Garcia (M)
Ratcliffe, J. A. (M)
Rayment, K. I. (A)
Rayner, Harry (A)
Rees, H. G. P. (A)
Reyner, John H. (M)
Rhys-Jones, John E. (A)
Richardson, F. C. (A)
Rickard, Charles E. (M)
Riddiough, John W. (A)
Ridgeway, John W. (A)
Ripley, Henry P. (A)
Robb, Frederick G. (A)
Robb, William I. (A)
Roberts, R. (A)
Robertson, N. C. (A)
Robinson, Frederick H. (A)
Rogers, Arthur H. E. (M)
Rowland, Edgar S. (A)
Russell, M. W. G. (M)
Salt, William (A)
Saltmarsh, Beatrice (A)
Scott-Taggart, John (A)
Searle, Reginald F. T. (A)
Shaughnessy, E. H. (M)

ENGLAND (Continued)

Shaw, A. C. (M)
Shore, Anak (A)
Sieger, J. (A)
Simmonds, E. J. (M)
Simpson, Alexander V. (M)
Slater, Wilfred (A)
Slee, John A. (F)
Smith, Harold I. (A)
Smith, Sidney B. (M)
Smith, Thomas F. (A)
Smurtwaite, F. W. (A)
Somerset, E. T. (A)
Sparrow, A. W. (A)
Stamford, Norman C. (A)
Stanesby, Harold (A)
Storry, Thomas G. (A)
Strong, Charles E. (M)
Struthers, G. A. (M)
Summers, R. H. J. (A)
Sutton, William F. P. (A)
Sykes, William E. (A)
Tanton, John H. (A)
Taylor, Alfred O. (A)
Thacker, M. S. (A)
Thomas, Einion (A)
Thomas, L. H. (A)
Thompson, Alfred E. (M)
Thomsett, H. S. (A)
Thomson, John Morton (A)
Thorpe, Stewart Melville (A)
Tiltman, Ronald F. (A)
Tingey, Robert (M)
Tomlinson, Frank (A)
Tompsett, F. J. (A)
Towers, Robert (A)
Townsend, Frank T. G. (M)
Tozer, William C. (A)
Trippier, Francis J. (A)
Troutbeck, Wilfrid H. (A)
Turle, Edgar H. (M)
Turner, Laurence B. (A)
Turvey, Henry C. (A)
Vedy, L. G. (A)
Vernon, Basil H. (A)
Verralls, J. Maynard (A)
Wadsworth, Herbert A. (A)
Wainwright, Albert (A)
Walker, Harold S. (A)
Wallace, Alex T. (A)
Walmsley, Thomas (M)
Ware, William (A)
Warner, Frederick F. (A)
Warner, H. J. (M)
Warren, A. C. (A)
Watson, Cecil (A)
Watson, George H. (A)
Webb, James H. (A)
Weight, Aubrey H. (A)
Wetherill, J. E. (A)
Wheeler, Charles H. J. (A)
Wheeler, Edmund F. (A)
White, F. W. G. (A)
White, Herbert G. (A)
Wicks, Frank W. (A)
Wicks, Reginald P. (A)
Wilcox, Alfred E. (A)
Wilkins, A. F. (A)
Wilkinson, Henry E. (M)
Williams, Cecil G. (A)
Williams, Eric (A)
Wilson, Percy (A)
Wilson, William P. (A)
Wood, Charles E. (A)
Woodhead, H. C. (A)
Wood, Robert H. (M)
Woodward, Percy J. (M)
Wright, Sidney R. (M)
Wroughton, Thomas H. (A)
Wyborn, R. B. (A)
Young, Alfred W. (A)

IRELAND

Crook, W. M. (A)
Ferguson, John D. (M)
Jamison, Alexander (A)
Kennedy, M. F. (A)
Kitchen, James P. (A)
McVeigh, James P. (A)
Neill, Frank R. (A)
Waite, D. (A)

SCOTLAND

Allan, Ernest J. (A)
Beveridge, John A. (M)
Carnie, Ben (A)
Chadder, E. G. (A)
Dunbar, James (A)
Edwards, R. M. (A)
Fleming, Samuel (A)
Fox, John D. (A)
Gee, Harry L. (A)
Kerr, John (A)
Knowles, J. G. (A)
McConnell, W. J. (A)
Murchie, John (M)
Neil, William Russell, Jr. (A)
Ramsay, John F. (A)
Wilkie, J. McKenzie (A)

WALES

Carson, John M. (A)
Jinman, Arthur M. (A)
Rees, David (A)
Whale, Gordon S. (A)

AFRICA

EAST AFRICA

Ball, George F. (A)

EGYPT

Baroudi, Kamel S. (A)
Watterson, H. E. (F)

SOUTH AFRICA

Adendorff, Gerald V. (M)
Allaway, G. N. P. (M)
Archer, C. (A)
Barnett, Eric E. (A)
Brickhill, G. A. (A)
Chenik, Aaron (A)
Cumming, Noel D. (A)
Gilmour, Peter (A)
Goodman, Joseph M. (M)
Hendry, J. S. (A)
Howard, W. B. (A)
Jacobs, Alwyn J. (A)
Jephcott, Ernest L. (A)
Knight, Arthur W. (A)
Kos, Simon F. (M)
Lukat, John Frederick (A)
Morison, Bruce (A)
Morris, R. P. (A)
Nutt, A. (A)
Osborn, Eugene W. (A)
Perrow, F. A. P. (M)
Thompson, H. J. (A)
Van Der Bijl, Hendrik J. (F)
Yapp, William G. (A)
Yule, T. M. (A)

SPANISH MOROCCO

Simon, M. Lopez (A)

SUDAN

Edgeworth, Kenneth E. (M)

ASIA

CEYLON

Abeydeera, Alfred (A)
Harper, Edgar (M)
Wijeyeratne, P. De S. (A)

CHINA

Chang, Ting Chin (M)
Chen, C. C. (A)
Chen, C. Mayo (A)
Chen, Shujen (A)
Chen, Ying-Chien (A)
Chiu, Tsunyi (J)
Chu, Chih Teih (A)
Chu, K. T. (A)
Chu, Yun (J)
Chung, Chi Fah (A)
Dow, Clifford J. (A)
Ede, Frank C. (A)
Fedoroff, L. N. (A)
Francis, Oliver T. (A)
Fung, Huo-Siu (J)
Harmer, Leslie B. (A)
Harris, Arthur L. (M)
Hsu, Philip H. (A)
Hwang, Ju-Tsu (J)
Knipp, A. R. (M)
Lee, Shee Mou (A)
Lo, Tsu Zui (A)
Miao, T. V. (J)
Nee, Sangta (A)
Shen, Pinlu (A)
Seto, Joe N. (A)
Shen, Pao-Guay (A)
Shen, P. L. (A)
Shen, S. Z. (A)
Smith, R. G. (A)
St. Louis, A. R. (A)
Tsao, T. C. (A)
Tsao, Zeuson C. (A)
Tsia, Hock L. (A)
Tsiang, C. Y. (A)
Ward, Zangwill (A)
Wu, Frank Tin Sik (A)
Zee, Liang (A)

FEDERATED MALAY STATES

Cadman, Claude G. (M)
Carson, Andrew H. (A)
Gee, Walter C. (A)
MacIntosh, James (A)
Peck, George T. (A)
Singh, Harbaksh (J)
Suares, Jose B. (A)
Wilkinson, Bernard (A)

INDIA

Ashthana, Rajendra Prasada (A)
Bull, W. J. H. (A)
Chapman, Thomas J. (A)
Cornfield, M. (A)
Dighe, K. S. (A)
Doraswamy, M. N. (A)
Enon, Ernest R. (A)
Ghosh, B. N. (J)
Harrison, Walter L. (A)
Hawes, Nesbitt R. (M)
Kantebet, S. R. (A)
Lea, George (A)
O'Rourke, Sydney P. (A)
Pichumani, K. K. (A)
Rangachari, T. S. (A)
Sellick, A. M. (A)
Vasudeva, D. N. (A)

JAPAN

Akamatsu, Kaworu (A)
Akasaka, Toshi (A)
Akutsu, Shiuji (A)
Amari, S. (A)
Anazawa, Chuhei (A)
Arakawa, Daitaro (A)
Endo, K. (A)
Fujikura, Keijiro (A)
Jujimoto, Tadashi (M)
Fukushima, T. (A)
Hamada, Shigenori (A)
Hashimoto, Chuji (A)
Hashimoto, S. (A)
Hijikata, S. (A)
Hirose, M. (A)
Horiguchi, Jiro (A)
Imaoka, Yoshio (A)
Inada, Sannosuke (M)
Inanami, Sueo (A)
Iinuma, H. (A)
Inada, Shigeru (A)
Ishikawa, Shoichi (A)
Iso, E. (A)
Itow, Yutaka (A)
Iyoki, O. (A)
Jimbo, S. (A)
Kanayama, T. (A)
Kankiti, Kusama (A)
Kanko, Go (A)
Kanno, Gengo (A)
Kato, Y. (A)
Kawahara, Takewo (A)
Kimpara, Atsuski (A)
Kimura, Rokuro (A)
Kinase, Matsunago (M)
Kiyota, Y. (A)
Kobayashi, Kichijiro (A)
Kobayashi, M. (A)
Kobayashi, S. (A)
Kono, T. (M)
Koshikawa, A. (A)
Koshikawa, Y. (A)
Koyama, Kumenosuke (A)
Kuno, T. (A)
Kuramochi, Shaju (A)
Kusakari, T. (A)
Kusunose, Yuziro (A)
Kuwajima, T. (A)
Maeda, M. (A)
Marumo, Noboru (A)
Matsui, K. (A)
Matsumura, Sadao (A)
Mita, S. (A)
Mitsusishi, Hyde Kadzu (A)
Mitsutake, Katsumi (A)
Miyauchi, T. (A)
Mizuhashi, Tosaku (A)
Mori, Nobumitsu (A)
Morita, K. (A)
Morita, M. (A)
Moriwaki, Katsumi (A)
Nagai, Kenzo (A)
Nagao, R. (A)
Nagoshi, M. (A)
Nakagami, Minoru (A)
Nakagimi, T. (M)
Nakai, Tomozo (A)
Nakajima, S. (A)
Namba, Yasukazu (A)
Namba, Shogo (A)
Niiya, Takuji (A)
Niwa, Yasujiro (A)
Ono, Shoji (A)
Ono, Takashi (A)
Otani, S. (A)
Otsuka, Y. (A)
Owada, Mankitsu (A)
Saito, Masao (A)
Saitow, Kenjii (A)
Sakai, Sadao (A)
Sasaki, Tei (A)
Sasaki, Toshiro (A)
Sayeki, Mitsuru (F)
Shima, Shigeo (A)

JAPAN (Continued)

Shimayama, Tsuruo (A)
Shuzui, Saburo (A)
Simbori, Masayosi (A)
So, Manabu (A)
So, M. (M)
Suga, Y. (A)
Sugiyama, E. (A)
Suzuki, Hisao (A)
Taguchi, Minoru (A)
Takaya, Michihiro (A)
Takebayashi, K. (A)
Takeuchi, H. (A)
Tamai, I. (A)
Tanimura, Isao (A)
Terahata, Matsutaro (A)
Tesch, Walter L. (M)
Tsuji, Uichoro (A)
Tsumura, Kazuo (A)
Tsushima, Yonekichi (A)
Uchida, Satoshi (A)
Ueno, Shuzo (A)
Watanabe, Yasusi (M)
Wataru, Sugiyama (A)
Yagi. Hidetsugu (F)
Yamaguchi, T. (A)
Yamaguchi, Usaburo (A)
Yokoyama, Eitaro (M)
Yokoyama, Tetsumi (A)
Yoshiro, Kuroda (A)

PALESTINE

Instrall, Reginald C. (A)
Thompson, F. S. (A)

SIAM

Prakit, Phya (M)

STRAITS SETTLEMENTS

Sutherland, J. G. A. (M)

CENTRAL AMERICA

COSTA RICA

Carazo, Louis A. (A)
Carranza, Jose J. (M)

NICARAGUA

King, W. Milton (A)

REPUBLIC OF PANAMA

White, Robert F. (A)
Parkin, Louis S. (A)
Moxon, Alfred W. (A)
Jones, Roys C. (A)

EAST INDIES

BRITISH NORTH BORNEO

Wade, C. F. Newton (M)

JAVA

Groves, Wayland M. (A)
Verdam, Nicholas H. (M)

EUROPE

AUSTRIA

Ehrlich, Karl (A)

BELGIUM

Delvigne, Andre (A)
Philippson, Maurice (M)
Wise, S. J. (A)

CZECHOSLOVAKIA

Kafka, H. T. (A)
Strnad, Joseph (A)
Svoboda, Jaromir (M)
Zacek, August (M)

DENMARK

Bertzow, Johannes A. (A)
Christensen, Jens P. (A)
Heegaard, Frederick D. (A)
Hellstrom, G. (A)
Jorgensen, Laurits (A)
Nyholm, Christian (A)
Pedersen, Martin P. (A)
Pedersen, Peder Oluf (F)
Poulsen, Valdemar (F)
Rybner, Joergen C. F. (A)
Schou, Carl (A)
Steffensen, James (A)
Svenningsen, Karl (A)

FRANCE

Behm, Ludwig F. (A)
Berche, P. (A)
Bethenod, J. F. J. (A)
Braggio, J. C. (A)
Campbell, Howard E. (M)
Cheftel, Alexis M. (M)
Clavier, A. G. (M)
De Bellescize, Henri J. J. M. (M)
De Bozas, Guy Du Bourg (A)
Deloraine, Edmund M. (M)
Embechts, A. C. (A)
Ferrie, General (F)
Goyder, C. W. (A)
Gray, Richard E. (A)
Kahn, P. O. (A)
Knight, Sidney G. (A)
Kraemer, G. I. (M)
Leslie, Fred D. (A)
Levy, Lucien (M)
Lush, William G. (M)
McLean, Francis C. (A)
Mirk, D. Blair (A)
Morton, Alfred H. (M)
Paddon, Cecil John (A)
Pedersen, Gunner V. C. (A)
Riu, Augustin (A)
Ullrich, Edward H. (M)
Wallace, Marcel (A)
Westerveld, F. (A)

GERMANY

Barkhausen, H. (F)
Barrow, W. L. (A)
Fassbender, Heinrich (F)
Gothe, Albrecht (A)
Hamm, Arthur (A)
Hertweck, C. (A)
Kofes, Albert (M)
Lock, M. J. (A)
Lubcke, Ernst (M)
McClatchie, Stanley (A)
Meissner, A. (F)
Rothe, Horst (M)
Runge, Wilhelm T. (M)
Seibt, George (M)
Suadicani, Guenther (M)
von Ardenne, Manfred (A)
Wagner, Karl Willy (F)
Wasservogel, Gunther (A)
Zenneck, Jonathan (F)

HOLLAND

Bartelink, E. H. B. (A)
Bouman, H. J. J. (A)
Breimer, S. H. (A)
De Graaff, Antonius (A)
De Miranda, J. Rodrigues (A)

HOLLAND (Continued)

Langendam, S. G. C. (A)
Liebert, W. (M)
Moree, W. (A)
Roorda, J., Jr. (A)
Schotel, G. (M)
Van Der Bilt, Cornelius (A)
Van Der Pol, Balth, Jr. (F)

GREECE

Gounarides, A. (A)

HUNGARY

Alker, T. F. (M)
Detshy, Charles F. (A)

ITALY

Bacchini, Cesare (A)
Banfi, Alessandro (A)
Ducati, Adriano C. (A)
Marino, Algeri (A)
Osiatinsky, L. (M)
Pession, Giuseppe (F)
Ramsay, Frank R. F. (A)
Sella, Giuseppe (A)

POLAND

Lewinski, Casimir (J)
Modrak, Peter (A)
Plebanski, Josef (M)
Rzymowski, E. (A)
Sokolcow, Dmitri M. (M)

PORTUGAL

Lopes, John (A)
Tisshaw, Henry S. (M)

SPAIN

Alonso, Julio (A)
Crespo, Jose (M)
Cuervo, Luis S. (A)
Escolano, Manuel (M)
Matres, Trinidad (M)
Moya, Miguel (A)
Urgoiti, Ricardo M. de (A)
Wendell, E. N. (A)

SWEDEN

Elmquist, Torsten (A)
Fransson, F. (A)
Kruse, Sigurd (A)
Lemoine, A. S. (A)
Rolf, Bruno (A)
Sterky, Hakon K. A. (A)

SWITZERLAND

Anselmi, S. C. (A)
Guggenheim, S. (A)

U.S.S.R. (RUSSIA)

Bashenoff, Valerian (M)
Chernyshoff, Alexander (A)
Gladkov, Cyril A. (A)
Kacourine, Serge N. (A)
Thomas, Walter J. (A)

MEXICO

Bourgeois, Allen B. (A)
Cota, Pedro N. (A)
De Mello, William (A)
De Perez, Jose (A)
De Tarnava, C. (A)
Escrich, James P. (A)
Fernandez, Manuel A. (A)
Reuthe, Gustav (M)
Sardaneta, Raymundo (A)

OCEANIA

AUSTRALIA

Adams, Charles H. (A)
Bain, John L. (M)
Bardin, William F. (M)
Barthold, Godfrey L. (A)
Bearup, T. W. (M)
Brooker, Vivian M. (A)
Cherry, Richard O. (A)
Cook, William C. (A)
Coxon, Walter E. (A)
Craggs, Herbert Harold (A)
Elliott, Frank E. (A)
Fisk, Ernest T. (F)
Fitts, Rupert A. (A)
Goldfinch, H. R. (A)
Grace, A. (A)
Green, Alfred L. (A)
Hayman, William G. (A)
Hesson, W. Gordon (A)
Hooper, Edgar M. (A)
Horton, George Harry (A)
Israel, Bertram Francis (A)
Jackson, Alfred C. (A)
Jellett, B. C. (J)
Linnett, Douglas N. (A)
MacLurcan, Charles D. (A)
Malone, James J. (M)
Martin, A. F. (A)
Martyn, David F. (A)
McCulloch, George Robert (A)
McDonald, Arthur S. (M)
McIntyre, Daniel G. (A)
Menon, Geoffrey J. (A)
Miller, Francis G. (A)
Munro, George H. (A)
Neve, Gordon H. (A)
Phillips, Frank A. (A)
Sawford, L. F. (A)
Shaw, Raymond H. (A)
Shephard, Maxwell (A)
Skelton, Thomas H. (A)
Steane, G. W. (A)
Sutherland, George B. (A)
Sweeney, Walter M. (M)
Thompson, Cecil (A)
Tours, F. B. (A)
Wright, Eric P. (A)
Wyles, David G. (M)

FRIENDLY ISLANDS

Land, John R. (M)

GUAM

Terhune, J. A. (A)

NEW ZEALAND

Baggs, A. D. (A)
Barnett, M. A. F. (A)
Bauer, A. T. (A)
Bingham, John M. (A)
Bradley, Ernest A. (A)
Brent, Herbert C. (M)
Claridge, A. (A)
Clarkson, T. R. (A)
Collett, William George (J)
Cunningham, John (A)
Dawson, Wilfred M. (A)
Gerity, L. P. (A)
Gibbs, R. J. (A)
Grant, R. L. C. (A)
Johnson, Edward C. (A)
Macedo, Francis J. (J)
Matthews, P. H. (A)
McKewen, J. D. (A)
McLennan, Roderick Arthur (M)
Rubenstein, S. J. (A)
Ruscoe, Charles R. (A)
Russell, Cecil R. (M)

NEW ZEALAND (Continued)

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Svendsen, A. V. (A)
Thow, Keith H. (M)
Webster, Allan (A)

SAMOA

Taylor, Samuel (A)

TASMANIA

Tuck, H. P. (A)

SOUTH AMERICA

ARGENTINA

Acuna, Segundo P. (A)
Hayes, George W. (A)
Malamphy, Mark C. (A)
Noizeux, Pierre J. (A)
O'Reilly, C. (A)
Stevens, Archie M. (M)
Zuev, Vitaly V. (A)

BRAZIL

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Lacombe, Carlos G. (A)
Da Silva Lima, Antonio C. (A)
De Oliveira, A. Menezes (M)
Santos, Anthony S. (A)
Scholz, Carl E. (M)
Weeden, Edward H. (A)

BRITISH GUIANA

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Jarman, Alick D. (A)

CHILE

Basaure, Aliro (A)
Brito, Alberto R. (M)
Diamond, Harvey (A)
Hansen, Elmer (A)
Sazie, Enrique (A)
Vierling, Gustav (A)

COLOMBIA

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Hill, H. F. (A)
Shire, Leo E. (A)

PERU

Anderson, L. N. (A)
Delbord, Y. L. (A)
Madgwick, G. (M)
Maldonado, Arthur (A)
Robertson, Joseph J. C. (A)
Ross, Uda B. (M)
Shaw, Sydney Coates (J)

WEST INDIES

BAHAMAS

Salter, David (A)

BERMUDA

Cookson, Walter (M)

CUBA

Gonzales, Jorge L. (A)
Jones, Frank H. (A)
Lara, Jose (A)
Sebasco, Jorgeh G. (A)

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VIRGIN ISLANDS

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Formica concentrates the finest resources that exist in its industry on the problem of supplying you with better insulation, more promptly.

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FORMICA
Made from Anhydrous Bakelite Resins
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OVER 50% of the

BROADCASTING STATIONS IN THE U. S. A.

ARE USING **FLECHTHEIM** IN THEIR EQUIPMENT
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The KEYNOTE of SUCCESS, in Condensers, is DEPENDABILITY. FACTORS which make up this most necessary adjunct, are CONSERVATIVE RATING, HIGHEST QUALITY MATERIALS and WORKMANSHIP, and the employment of the VERY LATEST SPECIAL-PROCESS MANUFACTURING METHODS.

WHEN YOU BUY FLECHTHEIM CONDENSERS, YOU GET DEPENDABILITY AND HONEST VALUE.

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C ondensers
H aving
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H ighest
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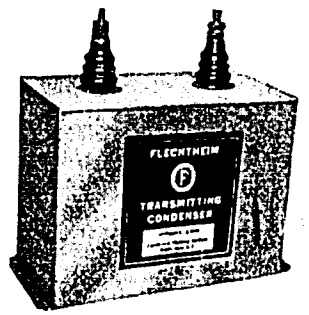

Announcing: a new transmitting condenser type ZX—rated at 7000 volts D.C., 5000 rms, RAC.

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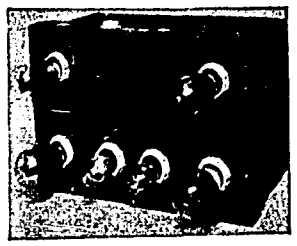
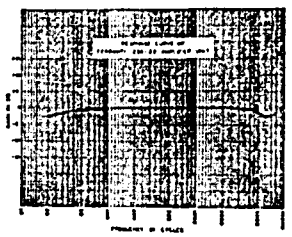


250 D-3
Amplifier Unit

FERRANTI
AMPLIFYING EQUIPMENT

•



Curve of 250 D-3
Amplifier

Ferranti amplifying equipment and special precision impedance matching transformers can be supplied for a wide variety of uses in laboratories, and in the educational and commercial distribution of voice and music.

New designs with especially flat characteristics giving faithful reproduction of both speech and music are available. Unit assembly makes the equipment exceedingly flexible, the various units being interchangeable without any change whatever in wiring.

The installation is extremely simple and all combinations are designed for utmost convenience in operation.

Type RPM universal panels meet various requirements of universities and other educational institutions for the distribution of radio, speech, and music in classrooms and auditoriums.

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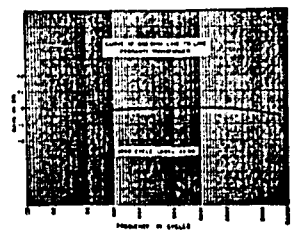
Amplifying units can be supplied with numerous transformer combinations especially suited for laboratory and experimental use. Any input and output requirements can be met.

Ferranti equipment is of the highest quality and is fully guaranteed. The 40 years successful experience of the parent Ferranti Company is a further guarantee of these products.



Curve of 600 ohm
line to line transformer

Send for special price list of power transformers, chokes, and 2000 volt condensers.

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FERRANTI Inc.
130 W. 42nd St., New York

1906-1931

BACK in 1906, when wireless communication was little more than a glorified experiment, Lee DeForest invented the Audion or three-element vacuum tube. Ever since, the DeForest organization has pioneered in the development and application of this outstanding invention, while unselfishly licensing and sub-licensing others under its basic patents.

The intervening quarter century has seen the transition from wireless to radio. The glorified experiment has become a practical communication means. The uncertain radio telephone has become the radio broadcasting art. From the realm of science, radio has come into the everyday life of the average man. Always has the DeForest organization taken an active, pioneering role. And that is why there is no greater name today in radio than

de Forest

We invite you to join us in celebrating our twenty-fifth birthday. As the original manufacturer of three-element tubes, maintaining our leadership through basic research coupled with controlled production that gears supply to demand and insures fresh, up-to-the-minute tubes for every application; as designers and builders of transmitting tubes and special tubes of all kinds; as purveyors of complete transmitters from smallest to largest, we are ready to share the fruits of our labor with you.

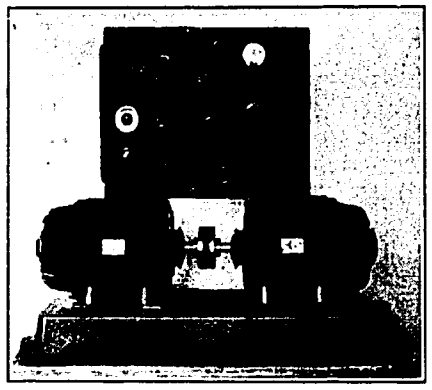
After All, There's No Substitute for 25 Years' Experience!

Write us for literature on receiving and transmitting Audions. Also, do not hesitate to place your radio problems before our engineering department. Our experience is yours for the asking, just as it has always been since the earliest radio days.

DE FOREST RADIO COMPANY

PASSAIC :: :: NEW JERSEY

ESCO *Motor-Generators*



"Fit" the application "Fit" the power supply

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Motors—Generators—Dynamotors—Rotary Converters

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Designed · Developed · Manufactured

Quick Delivery · Low Priced

"ESCO" is a company where "Special" does not mean "soak 'em" or "Let 'em wait." Because for twenty years "ESCO" has specialized in the "Special." "Special" voltages, frequency, speed, and mechanical design is the objective of our equipment and organization.

OUR EXPERIENCE IS BROAD. Below is a list of some of the special applications of our motors and generators, manufactured during this last December.

Telegraph	Speed reducers	Arc lamps	Knitting mills
Airplane dynamotors	Ventilators	Anti-corrosion	Printing press
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Radio beacons	Recording instruments	Ore-vibrators	Movie cameras
Radio transmitters	Elevator door control	Organ generators	Aerial cameras
Television	Elevators	Hoists	Cloth cutting
Talkies	Flexible shafts	Freight trucks	Coin counters
Radio receivers	Riveters	Temperature control	Pneumatic Valves
Automobile radio	Gasoline pumps	Polishers	Valve grinders
Valve control	Bottle washers	Stock quotations	Theater dimmers
Water tight doors	Phase shifters	Sun lamps	Cup vending
Pianos	Frequency changers	Bookkeeping unit	Refrigerator
Electric indicators	Hair dryers	Forced draft	Automatic stoker
			Weaving

Why not profit by our long experience? Up to date equipment and practical engineering talent. They are all at your disposal. Write us for bulletins or information.

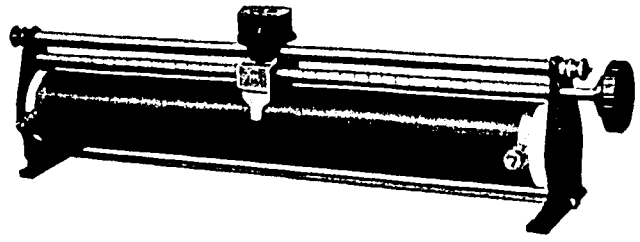
ELECTRIC ESCO SPECIALTY COMPANY

300 South St. Stamford, Conn.

Manufacturers of motors, generators, dynamotors and rotary converters.

Rheostats *slept for 20 years, too..*

But here at last is a radically improved instrument...



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For twenty years the slide-wire rheostat slept soundly as Rip Van Winkle: Electrical progress failed to awaken it. Obviously, then, the time is ripe for the modern rheostat we have produced. HH Tubular Rheostats are engineered apparatus. Every part and surface is precision machined. Porcelain tube construction assures ample insulation at highest voltages. A radically new contact system separates the functions of contact and pressure in the shoe: As no current is carried by the pressure springs, they cannot lose resiliency through overheating. The heavy phosphor bronze shoe contacts the wire firmly, but cannot tear it. Grasping the slider knob automatically disengages the screw selector mechanism. Releasing the knob engages the screw for finer selection. Let us send you Catalog No. 730 for complete information.

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For years we have specialized in Resistors. Today we are in quantity production for such firms as Western Union, Sundh, Signal, AmerTran and National Carbon. HH Resistors are better resistors: Just to consider the contacts, for example—even they are far finer than the average. Their resistance is low, they run no danger of hidden damage in manufacture, they are positively permanent under all conditions, they are protected both from relative movement and corrosion—they will soon be patented. We can furnish sample resistors to your specifications in 72 hours. Our Catalogue No. 429 contains unique Resistance Tables and full information—send for it Today.

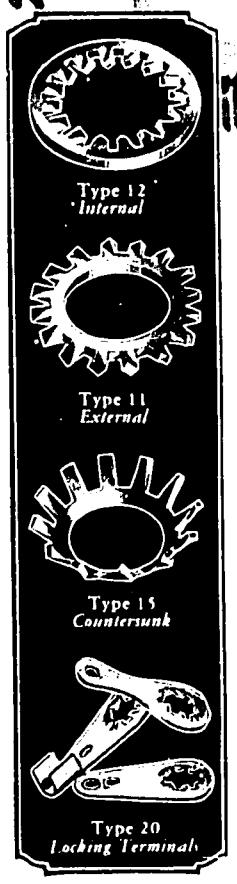
TUBULAR HH RHEOSTATS

HARDWICK, HINDLE, Inc.

226 Emmet Street, Newark, New Jersey

Turn Your Locking Problems Over to

SHAKEPROOF



U. S. Patents: 1,419,564
1,604,122—1,697,954
Other patents pending.
Foreign patents.

LEADING manufacturers in hundreds of industries have solved their locking problems by using Shakeproof on their products. Better performance, fewer customer complaints and reduced service costs have proved that Shakeproof Lock Washers are a real contribution to industrial progress.

The fact that the Shakeproof multiple-locking principle can also be incorporated in other parts means that a substantial saving is made possible by eliminating the purchase of separate lock washers and also in reducing the number of assembly operations. Our Shakeproof engineers are at your service and will gladly consult with you regarding your locking problems without cost or obligation.

Decide now to test Shakeproof on your product. Free samples of any type or size will be sent on request and, if you desire, a Shakeproof engineer will call and personally study your problems.

Write for your free samples today!

SHAKEPROOF
Lock Washer Company
(Division of Illinois Tool Works)
2543 North Keeler Ave., Chicago, Ill.

What's the BIG Idea *for 1931?*

THE BIG idea for radio manufacturers in 1931 is to provide additional useful sales features, so that sales will be easier.

Competition is keener than ever. Therefore the more talking points your receiver has, the easier it will sell.

AMPERITE Line Voltage Control solves one of radio's biggest problems. It makes a set operate in every locality as you intend it to operate. It makes your precise laboratory specifications *mean something* to the user in improved performance. *That's the BIG idea.*

AMPERITE reduces free service and lowers set upkeep costs. It smoothes out volume and insures uniform quality. It saves tubes and protects power equipment.

AMPERITE *automatically* regulates line voltage variations *up or down,* between 100 and 140 volts, to exact requirements.

It is easily included in chassis design without increasing chassis costs. Or it can be installed in five minutes in any electric radio not originally equipped for it.

Mail COUPON for full information and AMPERITE Set Chart

AMPERITE
Self-Adjusting
LINE VOLTAGE CONTROL

AMPERITE Corporation
Dept. YB-31, 561 BROADWAY, NEW YORK

Please send Amperite Set Chart, installation instructions and technical data to

Name .....

Address .....

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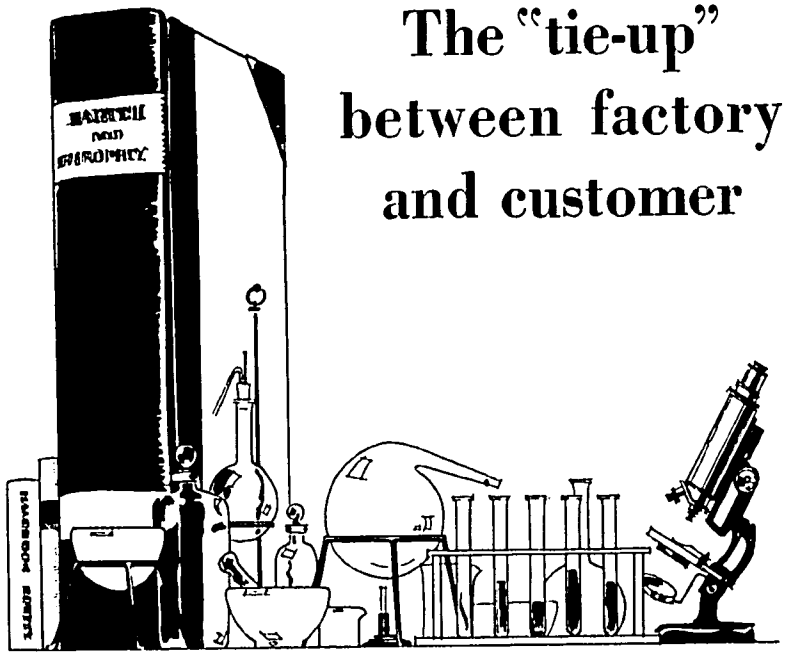

The "tie-up" between factory and customer

If our standard stocks do not include a grade of laminated bakelite or vulcanized fibre which meets your requirements *exactly*, we turn the responsibility over to our Service Engineering Department. It is their duty to devise a formula whose qualities are *right* for the job in question. And they have been highly successful in developing materials of unusual characteristics for difficult jobs of insulating or fabricating.

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Wilmington, Delaware, U. S. A.

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"—the material with a million uses"
SHEETS : RODS : TUBES : SPECIAL SHAPES
For every electrical and industrial use. Graded to your requirements. Adequate stock insures prompt delivery at all times.

PHENOLITE
Laminated BAKELITE
SHEETS : RODS : TUBES : SPECIAL SHAPES
There is a grade of Phenolite of correct mechanical, dielectric and physical properties to meet every electrical or industrial use.

TO ALL RADIO ENGINEERS

★

Should you make careful tests on a quantity of Eveready Raytheon 4-Pillar Radio Tubes, your measurements of Mutual Conductance, Plate Current, Heater or Filament Current, Input, Control Grid-Plate and Output Capacities would show exceptional uniformity and they would check closely with the standard published values around which your sets are designed.

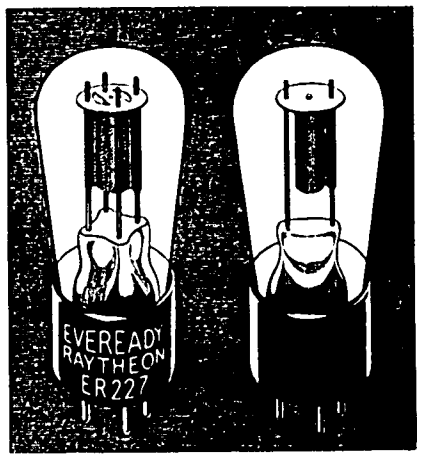
Should you go into the subject further and investigate Eveready Raytheon 224's and 227's for detector action, you would find surprising uniformity in both tubes when used either as a biased or gridleak-condenser detector.

Further work with automatic volume control systems would also show the greater uniformity of Eveready Raytheons.

Careful measurements would show the extremely low Gas, Grid Emission and Leakage Currents of Eveready Raytheon Tubes.

A thorough investigation of A.C. hum in radio tubes would prove to you that ER 224's and ER 227's have the lowest hum level of any tubes now on the market. Furthermore, this low hum level is independent of the Cathode-Heater Bias.

The greater ruggedness of Eveready Raytheon 4-Pillar Tubes makes them especially desirable for use in Air Craft and Automobile radio receivers.



LEFT—Notice the four strong pillars. With this solid foundation, the many fragile parts in the tube can be assembled with watch-making accuracy, and cannot move a hair's breadth from their fixed position!

RIGHT—In ordinary tubes, the many delicate parts have only a two-legged foundation. Two supports instead of four! Jolts, bumps, vibration from dynamic speakers—all can impair their vital accuracy.

Eveready Raytheon Radio Tubes are the result of several years of very thorough and painstaking research and development work which has been carried forward in our research laboratories backed with ample capital and resources and a firm resolve to make a radio tube second to none.

EVEREADY RAYTHEON
TRADE-MARKS
4-PILLAR TUBES

NATIONAL CARBON COMPANY, Inc.
General Offices: New York, N. Y.

Branches: Chicago Kansas City New York San Francisco
Unit of Union Carbide UCC *and Carbon Corporation*

The Institute of Radio Engineers
Incorporated

33 West 39th Street, New York, N. Y.

APPLICATION FOR ASSOCIATE MEMBERSHIP

(Application forms for other grades of membership are obtainable from the Institute)

To the Board of Direction
Gentlemen:

I hereby make application for Associate membership in the Institute.

I certify that the statements made in the record of my training and professional experience are correct, and agree if elected, that I will be governed by the constitution of the Institute as long as I continue a member. I furthermore agree to promote the objects of the Institute so far as shall be in my power, and if my membership shall be discontinued will return my membership badge.

Yours respectfully,

.....
(Sign with pen)

.....
(Address for mail)

.....
(Date) (City and State)

References:
(Signature of references not required here)

Mr. .....Mr. .....

Address .....Address .....

Mr. .....Mr. .....

Address .....Address .....

Mr. .....

Address .....

The following extracts from the Constitution govern applications for admission to the Institute in the Associate grade:

ARTICLE II—MEMBERSHIP

Sec. 1: The membership of the Institute shall consist of: * * * (d) Associates, who shall be entitled to all the rights and privileges of the Institute except the right to hold the office of President, Vice-president and Editor. * * *

Sec. 5: An Associate shall be not less than twenty-one years of age and shall be: (a) A radio engineer by profession; (b) A teacher of radio subjects; (c) A person who is interested in and connected with the study or application of radio science or the radio arts.

ARTICLE III—ADMISSION

Sec. 2: * * * Applicants shall give references to members of the Institute as follows: * * * for the grade of Associate, to five Fellows, Members, or Associates; * * * Each application for admission * * * shall embody a concise statement, with dates, of the candidate's training and experience.

The requirements of the foregoing paragraph may be waived in whole or in part where the application is for Associate grade. An applicant who is so situated as not to be personally known to the required number of members may supply the names of non-members who are personally familiar with his radio interest.

(Typewriting preferred in filling in this form) No.....

RECORD OF TRAINING AND PROFESSIONAL EXPERIENCE

1 Name .....
(Give full name, last name first)

2 Present Occupation .....
(Title and name of concern)

3 Permanent Home Address .....

4 Business Address .....

5 Place of Birth..... Date of Birth.....Age.....

6 Education .....

7 Degree .....
(college) (date received)

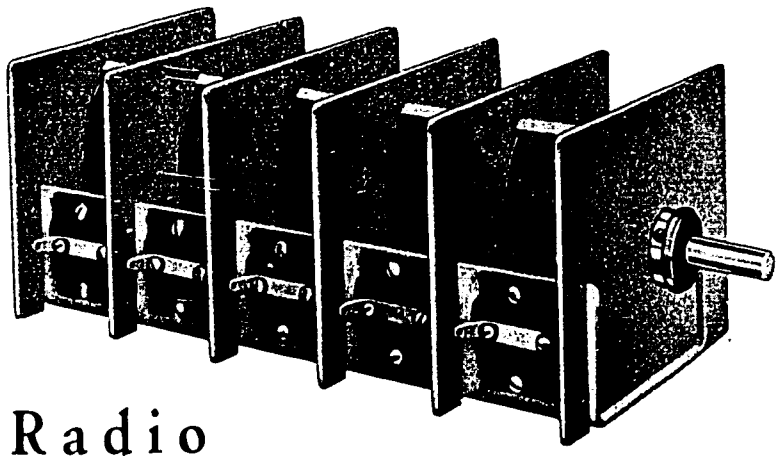
8 Training and Professional experience to date.....

NOTE: 1. Give location and dates. 2. In applying for admission to the grade of Associate, give briefly record of radio experience and present employment.

DATES HERE	

9 Specialty, if any.....

Receipt Acknowledged..... Elected..... Deferred.....
Grade ..... Advised of Election..... This Record Filed.....



Radio Specifications

Translated into Production Language

THE SCOVILL MANUFACTURING COMPANY makes a business of translating the designs and specifications of radio manufacturers into the practical language of production—producing in *quantity* the metal parts whose *quality* determines the success of the set.

Scovill is singularly well equipped for this type of work. From the standpoint of experience, Scovill has worked closely with many leading manufacturers since the founding of the industry, both on design and production. In physical equipment—laboratories, facilities for large-scale, high-quality production—Scovill is unmatched in its field. The speed and efficiency with which Scovill can supply metal parts has enabled many radio manufacturers to simplify their plants, reduce costs, and at the same time improve the standards of their sets.

Whether your needs are simple as machine screws, or complex as condensers, Scovill will be glad of an opportunity to study your problems.

SCOVILL

Established 1802

MANUFACTURING COMPANY

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ATLANTA
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CINCINNATI

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WESTON ELECTRICAL INSTRUMENT CORPORATION

589 Frelinghuysen Avenue **Newark, N. J.**

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When in the market for Accurately Ground Piezo Electric Crystals suitable for POWER USE, write us stating your requirements and our *seven years* of experience in this specialized field will be at your disposal.

Our prices for grinding these crystals are not the cheapest, but we believe our product to be *second to none* considering output and accuracy of frequency.

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A phrase synonymous with dependability—a phrase that has come to be applied to all Amertran equipment.

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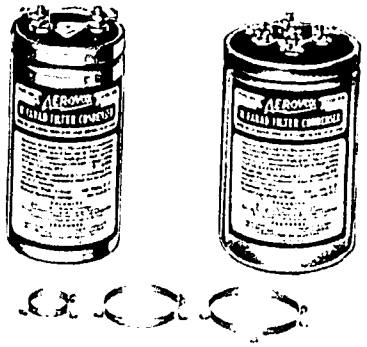
The Aerovox Hi-Farad Dry Electrolytic Condenser

Low Cost
Self-Healing
High Capacity
500 Volts Peak

DRY!



Universal mounting ring permits mounting of condensers in any position, upright or inverted.

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This Book Giving the Latest and Most Complete Information on All Electrolytic Condensers Sent Free on Request.

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Please send me, without charge or obligation, a copy of your book, "The Hi-Farad DRY Electrolytic Condenser."

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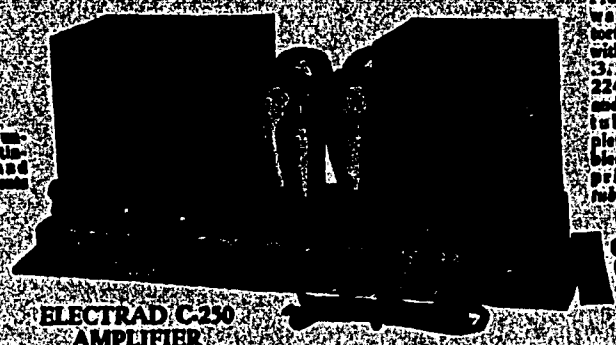

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