March, 1926

Over 200,000 Copies

Fifty Cents

RADIO REVIEW

Reg. U.S. Pat. Off.

Combined With

Radio Listeners' Guide and Call Book

Edited by S. Gernsback

The Radio Set Owners' Book of Information and 16 Page Radio Encyclopedia

Published by the CONSRAD CO. Inc
NEW YORK

Just Seven Simple Tools

—and you can build the finest Radio Receivers

Quickly and Easily

It takes but one or two evenings, using only the simplest tools to construct, at home, any one of the big, popular receivers shown on this page.

All you need is the well known CONSRAD Pattern that covers this particular receiver. CONSRAD Patterns are marvelously simple. You don't have to measure the spacing on the panel board or the placing of the parts. It is all drawn for you on the Blueprints the same as indications are given on a lady's dress pattern.

And you don't have to use 100 different tools to complete the job—just six or seven ordinary tools found in every household. A screwdriver, a pen-knife, a pair of pliers, etc., and you are ready to go ahead.

Visit your nearest Radio Dealer, ask him to let you look at some CONSRAD Patterns, select the one you want. Pay the Dealer 50c and you have complete instructions and blueprints for the construction of the Receiver.

IF YOUR DEALER CANNOT SUPPLY YOU, WRITE DIRECT, MENTIONING THE RECEIVER YOU WISH TO BUILD AND ENCLOSING FULL PRICE.

REMEMBER: CONSRAD Patterns—only 50c—give complete full sized blueprints and instruction booklet. Everything ready to build.

The CONSRAD COMPANY, 233 Fulton St., New York

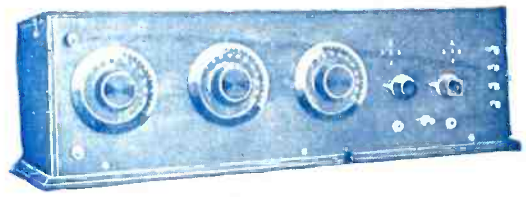
Consrad

EVERYTHING IN RADIO BOOKS, PATTERNS AND DIAGRAMS

SUPER-HETERODYNE

THE TROPADYNE

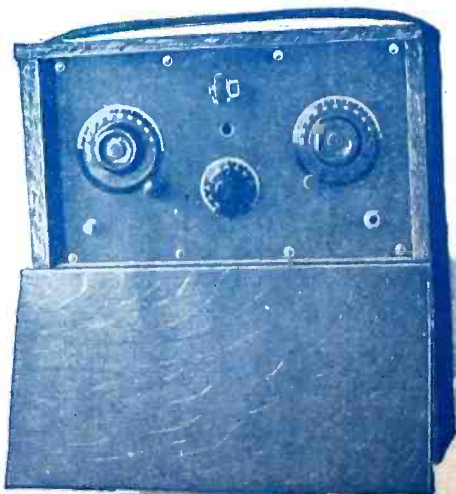
THE NEUTRODYNE



5-TUBE COCKADAY

THE REFLEX

THE PORTABLE

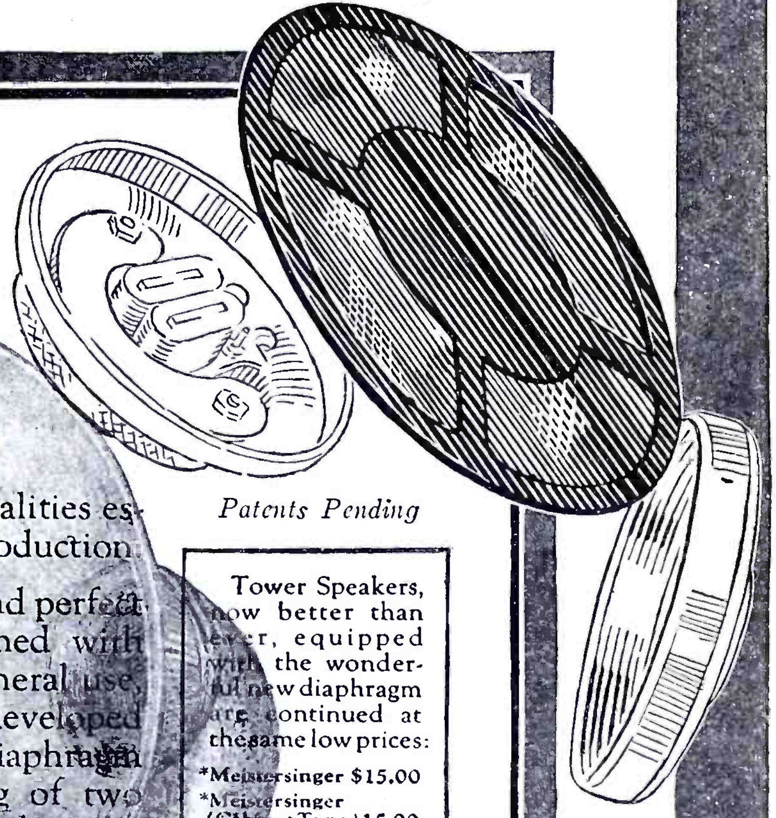


Tower Achieves another Sensation

Develops NEW Diaphragm

IT has long been recognized that the Tower Reproducing Unit gives the most perfect tone quality that science has developed. This already dependable unit is now endowed with new super-performing and super-efficiency qualities establishing a new peak in radio reproduction.

Realizing that true tone color and perfect resonance could never be obtained with the type of diaphragm now in general use, the Tower Mfg. Corporation developed this distinctively new type — a diaphragm of varying thicknesses, consisting of two different materials, so arranged that the deep bass notes of the organ or drum as well as the high notes of the clarinet or violin are reproduced with a clarity and roundness of tone that *is wholly new*. Thus, this new diaphragm covers the *entire* musical register as never before accomplished in the art of radio — an achievement long sought but not until now fully realized.



Patents Pending

Tower Speakers, now better than ever, equipped with the wonderful new diaphragm are continued at the same low prices:

*Meistersinger	$15.00
*Meistersinger (Cabinet Type)	15.00
*Scientific	8.50
*Little Spitfire	4.95
Midget Speaker	3.95
*Phonograph Attachment	3:95
*Scientific Headset	2.95

*REG U.S PAT. OFF

On sale by Reliable Dealers from Coast to Coast

DR. HERMAN FISHER

Designer of the new Tower Diaphragm, first won world fame by discovering the tone secrets of the master violin-makers. In tone tests in Paris, Fisher violins outscored genuine Stradivarius and Guadagnini instruments. Dr. Fisher, retained by the Tower Mfg. Co., now applies to radio his wonderful new discoveries, exclusively employed in the new Tower Speakers.

TOWER MFG. CORPORATION

BOSTON MASS.

RADIO REVIEW

Reg. U.S. Pat. Off.

Combined With

Radio Listeners' Guide and Call Book

WITH this number, we present the new combined RADIO REVIEW and RADIO LISTENERS' GUIDE and CALL BOOK to our readers.

We hope that our friends will be as pleased with this first issue as we ourselves are. We are proud of our new magazine. We have spared no cost or effort and we feel that we have achieved something, in both the appearance and contents of this initial issue, that surpasses in completeness, variety, and usefulness—and attractiveness—all that the two separate old publications had to offer.

A change in the publication plans, as announced in the last issue of RADIO REVIEW, makes this the March number instead of the February number which was originally planned. The next issue will be the June number.

Proud as we are of what we have accomplished in the new RADIO REVIEW we realize also that the new magazine is in its beginning. We look forward to possibilities of further expansion, and are eager to seize on all means to open up further avenues of enjoyment and information for our readers, in all directions that may present themselves.

To help us to do this, and because we desire above all things to keep up the close working relation with our readers which has been built up through our previous efforts—a relation which we value as one of the chief gratifications and sources of encouragement in our work—we should be very glad to hear from our readers at the outset as to how they like the new plan of the combined magazines, how well this number has met their expectations, and what other features they would like to see incorporated, or what present ones further developed, in our and their—new RADIO REVIEW.

RADIO REVIEW, Combined with RADIO LISTENERS' GUIDE AND CALL BOOK

VOLUME I, NUMBER 8 MARCH, 1926

Published quarterly by The Consrad Co., Inc., 64 Church Street, New York, N. Y., telephone number Barclay 7220; H. Gernsback, President; S. Gernsback, Vice President and Treasurer; R. W. De Mott, Secretary. Price 50c a copy; subscriptions $1.75 a year in the United States of America, Canada and all countries within the domestic postal zone; elsewhere $2.00 a year, payable in advance. Subscriptions only acceptable in U. S. currency or stamps. No foreign currency or stamps. Checks and money orders should be drawn to the order of THE CONSRAD CO., Inc.

When subscribing to RADIO REVIEW, combined with RADIO LISTENERS GUIDE AND CALL BOOK, send your name and remittance to The Consrad Company, Inc., 64 Church Street, New York, N. Y. Mention that you desire to subscribe to RADIO REVIEW. We also publish and distribute CONSRAD PATTERNS, E. I. COMPANY BOOKS, etc. Write clearly.

Entered as second class matter, March 10, 1925, at the Post Office at New York, N. Y., and Long Island City, N. Y., under the Act of March 3, 1879.

New England Advertising Representative
T. F. Magrane
Park Square Building, Boston, Mass.

Western Advertising Representatives
S. B. Darmstader
337 W. Madison St.,
Chicago, Ill.

Pacific Coast Advertising Representatives
A. J. Norris Hill Co.
Hearst Bldg., San Francisco, Calif.

General Advertising Department
53 Park Place
New York City

(*Index to this issue on page* 176)

Radio Review
Combined With
Radio Listeners' GUIDE and CALL BOOK

Sidney Gernsback, Editor W. G. Many, Associate Editor.

THE CONSRAD COMPANY, Inc., 64 Church Street, New York, N. Y.
PUBLISHERS

RADIO BROADCAST STATIONS OF THE UNITED STATES

Indexed Alphabetically by Call Letters

The following list of stations has been so arranged that it can be readily referred to in finding the location, name, power, wave length, frequency and time of a station, providing the call letters are known. The list also serves another purpose and that is for logging the stations received. On the blank side of the page, alongside of a station which has been received on your set, the date, time and dial settings can be written directly on the page.

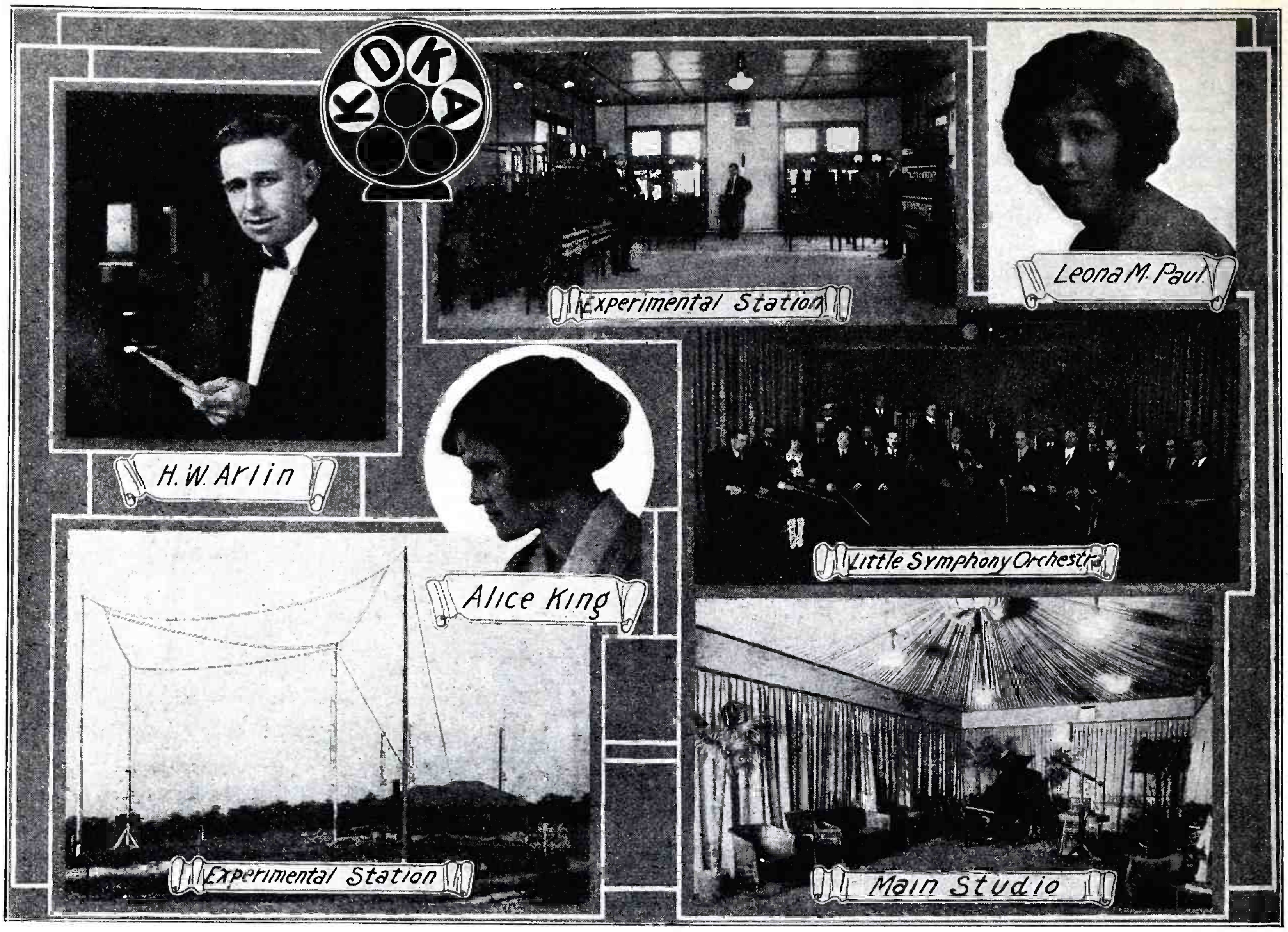
	Radio Call Letters	BROADCAST STATIONS Location and Name	Power Watts	Wave Length (Meters)	Frequency (Kilocycles)	Time at Station	Date	Time Received	Dial 1	Dial 2	Dial 3
KD	KDKA	Pittsburgh, Pa. (Transmitter is in East Pittsburgh)—Westinghouse Electric and Manufacturing Co.	Var.	309.1	970	Eastern					
	KDLR	Devils Lake, N. D.—Radio Elec. Co. & Wilson Ins. Agency	5	231	1300	Central					
	KDPM	Cleveland, Ohio.—Westinghouse Elec. & Mfg. Co.	500	250	1200	Eastern					
	KDYL	Salt Lake City, Utah.—Newhouse Hotel	50	246	1220	Pacific					
	KDZB	Bakersfield, Calif.—Frank E. Siefert	100	209.7	1430	Pacific					
KF	KFAB	Lincoln, Nebr.—Nebraska Buick Auto Co.	1000	340.7	880	Central					
	KFAD	Phoenix, Ariz.—Electrical Equipment Co. and McArthur Bros. Mercantile Co.	100	273	1100	Mountain					
	KFAF	San Jose, Calif.—Alfred E. Fowler, Montgomery Hotel	50	217.3	1380	Pacific					
	KFAJ	Boulder, Colo.—University of Colo.	100	261	1150	Mountain					
	KFAU	Boise, Idaho.—Boise High School	750	282.8	1060	Pacific					
	KFBB	Havre, Mont.—F. A. Buttrey Co.	50	275	1090	Mountain					
	KFBC	San Diego, Cal.—W. K. Azbill, 5038 Cliff Place.	10	224	1340	Pacific					
	KFBG	Tacoma, Wash.—First Presbyterian Church	50	250	1200	Pacific					
	KFBK	Sacramento, Calif.—Kimball-Upson Co., 607 K. St.	100	248	1210	Pacific					
	KFBL	Everett, Wash.—Leese Bros. 2814 Rucker Ave.	100	224	1340	Pacific					
	KFBS	Trinidad, Colo.—School Dist. No. 1	15	238	1220	Mountain					
	KFBU	Laramie, Wyo.—The Cathedral, Bishop N. S. Thomas.	500	270	1110	Mountain					
	KFCB	Phoenix, Ariz.—Nielsen Radio Supply Co., 311 N. Central Ave.	100	238	1260	Mountain					
	KFCF	Walla Walla, Wash.—Frank A. Moore, 707 Baker Bldg.	100	256	1170	Pacific					
	KFDD	Boise, Idaho.—St. Michaels Cathedral	50	278	1080	Pacific					

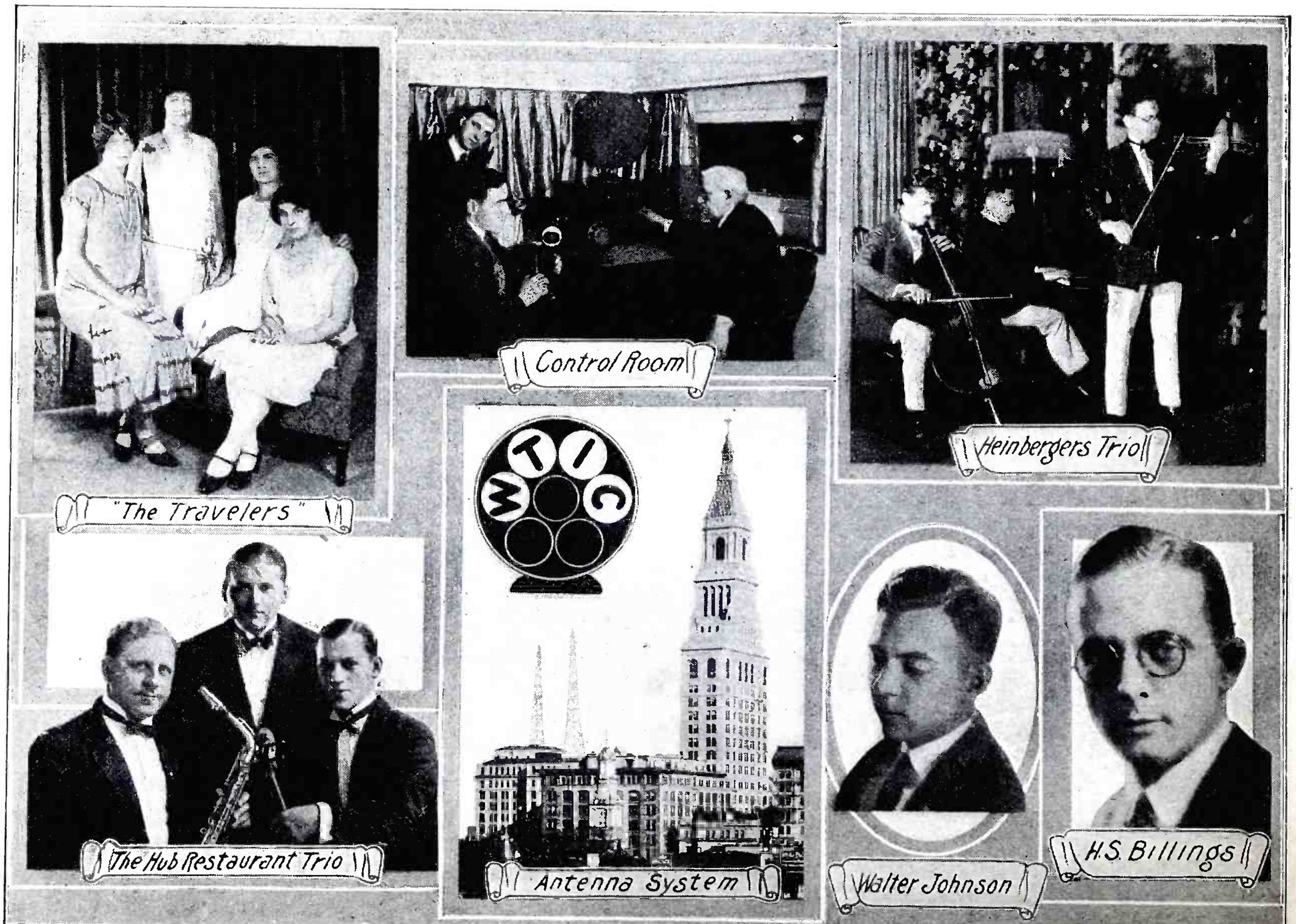
KF

Radio Call Letters	BROADCAST STATIONS Location and Name	Power Watts	Wave Length (Meters)	Frequency (Kilocycles)	Time at Station	Date	Time Received	Dial 1	Dial 2	Dial 3
KFDJ	Corvallis, Oregon.—Oregon Agricultural College	500	282.8	1060	Pacific					
KFDM	Beaumont, Tex.—Magnolia Petroleum Co.	500	315.6	950	Central					
KFDX	Shreveport, La.—1st Baptist Church	100	250	1200	Central					
KFDY	Brookings, S. Dakota.—South Dakota State College of Agricultural & Mechanic Arts.	100	273	1100	Central					
KFDZ	Minneapolis, Minn.—H. O. Iverson, 2510 Thomas Ave. South	10	231	1300	Central					
KFEC	Portland, Oregon.—Meier & Frank Co.	50	248	1210	Pacific					
KFEL	Denver, Colo.—W. L. Winner Radio Shop	50	254	1180	Mountain					
KFEQ	Oak, Nebr.—Scroggin & Co. Bank	500	268	1120	Central					
KFEY	Kellogg, Idaho.—Bunker Hill & Sullivan Mining and Concentrating Co.	10	233	1290	Pacific					
KFFP	Moberly, Mo.—First Baptist Church	50	242	1240	Central					
KFFY	Alexandria, La.—Louisiana College	50	275	1090	Central					
KFGC	Baton Rouge, La.—Louisiana State University	100	268	1120	Central					
KFGH	Stanford University, Calif.—Leland Stanford Junior University	500	270	1110	Pacific					
KFGQ	Boone, Iowa.—Crary Hardware Co.	10	226	1330	Central					
KFHA	Gunnison, Colo.—Western State College of Colo.	50	252	1190	Mountain					
KFHL	Oskaloosa, Iowa.—Penn. College	10	240	1250	Central					
KFI	Los Angeles, Calif.—Earle C. Anthony, Inc.	3000	468.5	640	Pacific					
KFIF	Portland, Oregon.—Benson Polytechnic Institute	100	248	1210	Pacific					
KFIQ	Yakima, Wash.—First Methodist Church.	100	256	1170	Pacific					
KFIZ	Fondulac, Wis.—Daily Commonwealth & Wis. Radio Sales, 22 Forest Ave.	100	273	1100	Central					
KFJB	Marshalltown, Iowa.—Marshall Electric Co.	10	248	1210	Central					
KFJC	Junction City, Kans.—Episcopal Church.	10	218.8	1370	Central					
KFJF	Oklahoma, Okla.—National Radio Mfg. Co.	500	261	1150	Central					
KFJI	Astoria, Oreg.—Liberty Theatre (E. E. Marsh).	10	246	1220	Pacific					
KFJM	Grand Forks, N. D.—University of N. D.	100	278	1080	Central					
KFJR	Portland, Oreg.—Ashley C. Dixon & Son.	50	263	1140	Pacific					
KFJX	Cedar Falls, Ia.—Iowa State Teachers' College	50	258	1160	Central					
KFJY	Fort Dodge, Iowa.—Tunwall Radio Co.	50	246	1220	Central					
KFJZ	Fort Worth, Tex.—Southwestern Baptist Theological Seminary.	50	254	1180	Central					
KFKA	Greeley, Colo.—Colorado State Teachers College	50	273	1100	Mountain					
KFKU	Lawrence, Kansas.—University of Kansas.	500	275	1090	Central					
KFKX	Hastings, Neb.—Westinghouse Elec. & Mfg. Co.	5000	288.3	1040	Central					
KFKZ	Kirksville, Mo.—F. M. Henry.	10	226	1330	Central					
KFLR	Albuquerque, N. Mex.—University of New Mexico.	100	254	1180	Mountain					
KFLU	San Benito, Tex.—San Benito Radio Club.	10	236	1270	Central					
KFLV	Rockford, Ill.—Swedish Evangelical Mission Church	100	229	1310	Central					
KFLX	Galveston, Tex.—Geo. R. Clough, 1214-40th St.	10	240	1250	Central					
KFLZ	Atlantic, Iowa.—Atlantic Automobile Co.	100	273	1100	Central					
KFMQ	Fayetteville, Ark.—University of Arkansas	750	299.8	1000	Central					
KFMR	Sioux City, Iowa.—Morningside College	100	261	1150	Central					
KFMW	Houghton, Mich.—M. G. Sateren, 127 Blanche St.	50	263	1140	Central					
KFMX	Northfield, Minn.—Carleton College	500	336.9	890	Central					
KFNF	Shenandoah, Iowa.—Henry Field Seed Co.	500	263	1140	Central					
KFOA	Seattle, Wash.—Rhodes Department Store.	1000	454.3	660	Pacific					
KFOB	Burlingame, Calif.—Burlingame Chamber of Commerce (Albert Sherman).	50	220	1360	Pacific					
KFOJ	Moberly, Mo.—Moberly High School.	10	242.0	1240	Central					
KFON	Long Beach, Calif.—Echophone Radio Shop. (Hal G. Nichols).	500	233	1290	Pacific					
KFOO	Salt Lake City, Utah.—Latter Day Saints University.	250	236	1270	Pacific					
KFOR	David City, Neb.—David City Tire & Elec. Co. (Howard A. Shuman).	100	226	1330	Central					

KF

Radio Call Letters	BROADCAST STATIONS Location and Name	Power Watts	Wave Length (Meters)	Frequency (Kilocycles)	Time at Station	Date	Time Received	Dial 1	Dial 2	Dial 3
KFOT	**Wichita, Kans.**—College Hill Radio Club (College Hill Methodist Church).	50	231	1300	Central					
KFOX	**Omaha, Neb.**—Technical High School (Board of Education).	100	248	1210	Central					
KFOY	**St. Paul, Minn.**—Beacon Radio Service (M. G. Goldberg) 711 Dayton Ave.	50	252	1190	Central					
KFPL	**Dublin, Tex.**—C. C. Baxter, 205 Crafton St..	15	252	1190	Central					
KFPM	**Greenville, Tex.**—New Furniture Co.	10	242	1240	Central					
KFPR	**Los Angeles, Calif.**—Los Angeles County Forestry Dept.	500	231	1300	Pacific					
KFPW	**Carterville, Mo.**—St. Johns M. E. Church, South.	20	258	1160	Central					
KFPY	**Spokane, Wash.**—Symons Investment Co.	100	266	1130	Pacific					
KFQA	**St. Louis, Mo.**—The Principia, 5539 Page Ave.	100	261	1150	Central					
KFQB	**Fort Worth, Texas.**—Searchlight Publishing Co., 408 Throckmorton St.	150	263	1140	Central					
KFQP	**Iowa City, Iowa.**—Geo. S. Carson, Jr. 906 E. College St.	10	224	1340	Central					
KFQU	**Alma (Holy City) Calif.**—W. E. Riker	100	217.3	1380	Pacific					
KFQW	**North Bend, Wash.**—Carl F. Knierim	50	215.7	1390	Pacific					
KFQZ	**Hollywood, Calif.**—Taft Products Co., 5653 De Longpre Ave.	50	226	1330	Pacific					
KFRB	**Beeville, Tex.**—Hall Bros.	250	248	1210	Central					
KFRC	**San Francisco, Calif.**—City of Paris Dry Goods Co.	50	268	1120	Pacific					
KFRM	**Fort Sill, Okla.**—Lieut Jas. P. Boland.	50	242	1240	Central					
KFRU	**Columbia, Mo.** —Stephens College.	500	499.7	600	Central					
KFRW	**Olympia, Wash.**—United Churches of Olympia.	50	218.8	1370	Pacific					
KFRY	**State College, N. Mex.**—New Mexico College of Agriculture and Mechanic Arts	50	266	1130	Mountain					
KFSG	**Los Angeles, Calif.**—Echo Park Evangelistic Ass'n, 1100 Glendale Blvd.	500	275	1090	Pacific					
KFUJ	**Breckenridge, Minn.**—Hoppert Plumbing & Heating Co. and F. H. Rettig, 120 North Fifth St.	50	242	1240	Central					
KFUL	**Galveston, Tex.**—Thos. Groggan & Bros. Music Co., 2126 Market St.	50	258	1160	Central					
KFUM	**Colorado Springs, Colo.**—W. D. Corley, Cascade Ave.	100	242	1240	Mountain					
KFUO	**St. Louis, Mo.**—Concordia Seminary	500	545.1	550	Central					
KFUP	**Denver Colo.**—Fitzsimons General Hospital.	50	234	1280	Mountain					
KFUR	**Ogden, Utah,**—Peery Building Co., 420-25th St.	50	224	1340	Pacific					
KFUS	**Oakland, Calif.**—Louis L. Sherman, 529-28th St.	50	256	1170	Pacific					
KFUT	**Salt Lake City, Utah.**—University of Utah.	100	261	1150	Pacific					
KFUU	**Oakland, Calif.**—Colburn Radio Laboratories, 3020 Broadway.	50	220	1360	Pacific					
KFUV	**Springfield, Mo.**—G. Pearson Ward, 236 W. State St.	10	252	1190	Central					
KFVD	**San Pedro, Calif.**—McWhinnie Elec. Co., 1825 So. Pacific Ave.	50	205.4	1460	Pacific					
KFVE	**St. Louis, Mo.**—Film Corp. of America, 6800 Delmar Blvd.	500	240	1250	Central					
KFVG	**Independence, Kans.**—First Meth. Episcopal Church.	10	236	1270	Central					
KFVH	**Manhattan, Kans.**—Whan Radio Shop, 221 Poyntz St.	15	218.8	1370	Central					
KFVI	**Houston, Tex.**—Fifty Sixth Cavalry Brigade, Headquarters Troop	10	240	1250	Central					
KFVN	**Welcome, Minn.**—Carl E. Bagley.	50	227	1320	Central					
KFVR	**Denver, Colo. (near)**—Eugene Rossi, Moonlight Ranch, Route 6.	50	244	1230	Mountain					
KFVS	**Cape Girardeau, Mo.**—Cape Girardeau Battery Station, (Oscar C. Hirsch).	50	224	1340	Central					
KFVU	**Eureka, Calif.**—Standard Publishing Co., 537 G. St.	5	209.7	1430	Pacific					
KFVW	**San Diego, Cal.**—Airfan Radio Corp., 402 B. St.	500	246	1220	Pacific					


KDKA
H. W. Arlin
Experimental Station
Leona M. Paul
Alice King
Little Symphony Orchestra
Experimental Station
Main Studio


"The Travelers"
Control Room
Heinbergers Trio
WTIC
The Hub Restaurant Trio
Antenna System
Walter Johnson
H. S. Billings

	Radio Call Letters	BROADCAST STATIONS Location and Name	Power Watts	Wave Length (Meters)	Frequency (Kilocycles)	Time at Station	Date	Time Received	Dial 1	Dial 2	Dial 3
KF	KFVY	**Albuquerque, N. Mex.**—Radio Supply Co., 413 West Central Ave.	10	250	1200	Mountain					
	KFWA	**Ogden, Utah.**—Browning Bros. Co., 2451 Kiesel Ave.	500	261	1150	Pacific					
	KFWB	**Hollywood, Calif.**—Warner Bros. Pictures (Inc.), 5842 Sunset Blvd.	500	252	1190	Pacific					
	KFWD	**Arkadelphia, Ark.**—Arkansas Light & Power Co.	500	266	1130	Central					
	KFWF	**St. Louis, Mo.**—St. Louis Truth Center, 4030 Lindell St.	250	214.2	1400	Central					
	KFWH	**Chico, Calif.**—F. Wellington Morse, Jr., 522 Grand Ave., Oakland, Calif.	100	254	1180	Pacific					
	KFWI	**So. San Francisco, Calif.**—Radio Entertainments Inc. 205 Wiley B. Allen Bldg., San Francisco, Calif.	500	226	1330	Pacific					
	KFWM	**Oakland, Calif.**—Oakland Education Society, 1136 Bella Vista Ave.	500	206.8	1430	Pacific					
	KFWO	**Avalon, Calif.**—Lawrence Mott.	250	211.1	1420	Pacific					
	KFWP	**Brownsville, Tex.**—Rio Grande Radio Supply House	10	214.2	1400	Central					
	KFWU	**Pineville, La.**—Louisiana College	100	238	1260	Central					
	KFWV	**Portland, Ore.**—Wilbur Jerman, 385 E. 58th St., So.	50	212.6	1410	Pacific					
	KFXB	**Big Bear Lake, Calif.**—Bertram O. Heller	500	202.6	1480	Pacific					
	KFXC	**Santa Maria, Calif.**—Santa Maria Valley R. R. Co.	100	209.7	1430	Pacific					
	KFXD	**Logan, Utah.**—L. H. Strong (Packard Motor Co.)	10	205.4	1460	Mountain					
	KFXE	**Waterloo, Iowa.**—Electrical Research & Mfg. Co.	10	236	1270	Central					
	KFXF	**Colorado Springs, Colo.**—Pikes Peak Broadcasting Co. 226 Hagerman Building.	500	250	1200	Mountain					
	KFXH	**El Paso, Tex.**—Bledsoe Radio Co., 2857 Montana St.	50	242	1240	Central					
	KFXJ	**Denver, Colo.**—Mountain States Radio Distributors, 917-14th St.	10	215.7	1390	Mountain					
	KFXM	**Beaumont, Tex.**—Neches Electric Co., 259 Crockett St.	10	227	1320	Central					
	KFXY	**Flagstaff, Ariz.**—Mary M. Costigan (Orpheum Theater)	50	205.4	1460	Mountain					
	KFYF	**Oxnard, Calif.**—Carl's Radio Den (Newcomb Radio Co.)	10	205.4	1460	Pacific					
	KFYJ	**Houston, Tex. (Portable)**—Houston Chronicle Pub. Co.	10	238.0	1260						
	KFYR	**Bismark, N. D.**—Hoskins-Meyer Inc., 200 Fourth St.	10	248	1210	Central					
KG	KGB	**Tacoma, Wash.**—Tacoma Daily Ledger.	100	250	1200	Pacific					
	KGO	**Oakland, Calif.**—General Electric Co.	3000	361.2	830	Pacific					
	KGTT	**San Francisco, Calif.**—Glad Tidings Tabernacle.	50	234	1280	Pacific					
	KGW	**Portland, Ore.**—Portland Morning Oregonian.	500	491.5	610	Pacific					
	KGY	**Lacey, Wash.**—St. Martins College.	50	246	1220	Pacific					
KH	KHJ	**Los Angeles, Calif.**—Times Mirror Co., 100 N. Broadway.	500	405.2	740	Pacific					
	KHQ	**Spokane, Wash.**—Louis Wasmer	500	273	1100	Pacific					
KJ	KJBS	**San Francisco, Calif.**—Julius Brunton & Sons Co., 1380 Bush St.	5	220	1360	Pacific					
	KJR	**Seattle Wash.**—Northwest Radio Service Co., 611 Terminal Sales Bldg.	1000	384.4	780	Pacific					
KL	KLDS	**Independence, Mo.**—Reorganized Church of Jesus Christ of Latter Day Saints.	1000	440.9	680	Central					
	KLS	**Oakland, Calif.**—Warner Bros. Radio Supplies Co., 2301 Telegraph Ave.	250	252	1200	Pacific					
	KLX	**Oakland, Calif.**—Oakland Tribune	500	508.2	590	Pacific					
	KLZ	**Denver, Colo.**—Reynolds Radio Co., 1534 Glenarm Place.	250	266	1130	Mountain					
KM	KMA	**Shenandoah, Iowa.**—May Seed & Nursery Co.	500	252	1190	Central					
	KMJ	**Fresno, Calif.**—Fresno Bee.	50	234	1280	Pacific					
	KMO	**Tacoma, Wash.**—Love Elec. Co., 818 North L St.	100	250	1200	Pacific					
	KMOX	**St. Louis, Mo.**—Mayfair Hotel	1000	261	1150	Central					
	KMTR	**Los Angeles, Calif.**—K. M. Turner Radio Corp. (Oliver S. Garretson), 1517 N. Wilton St.	500	238	1260	Pacific					
KN	KNRC	**Los Angeles, Calif.**—Clarence B. Juneau, 8083 Santa Monica Blvd.	250	208.2	1440	Pacific					

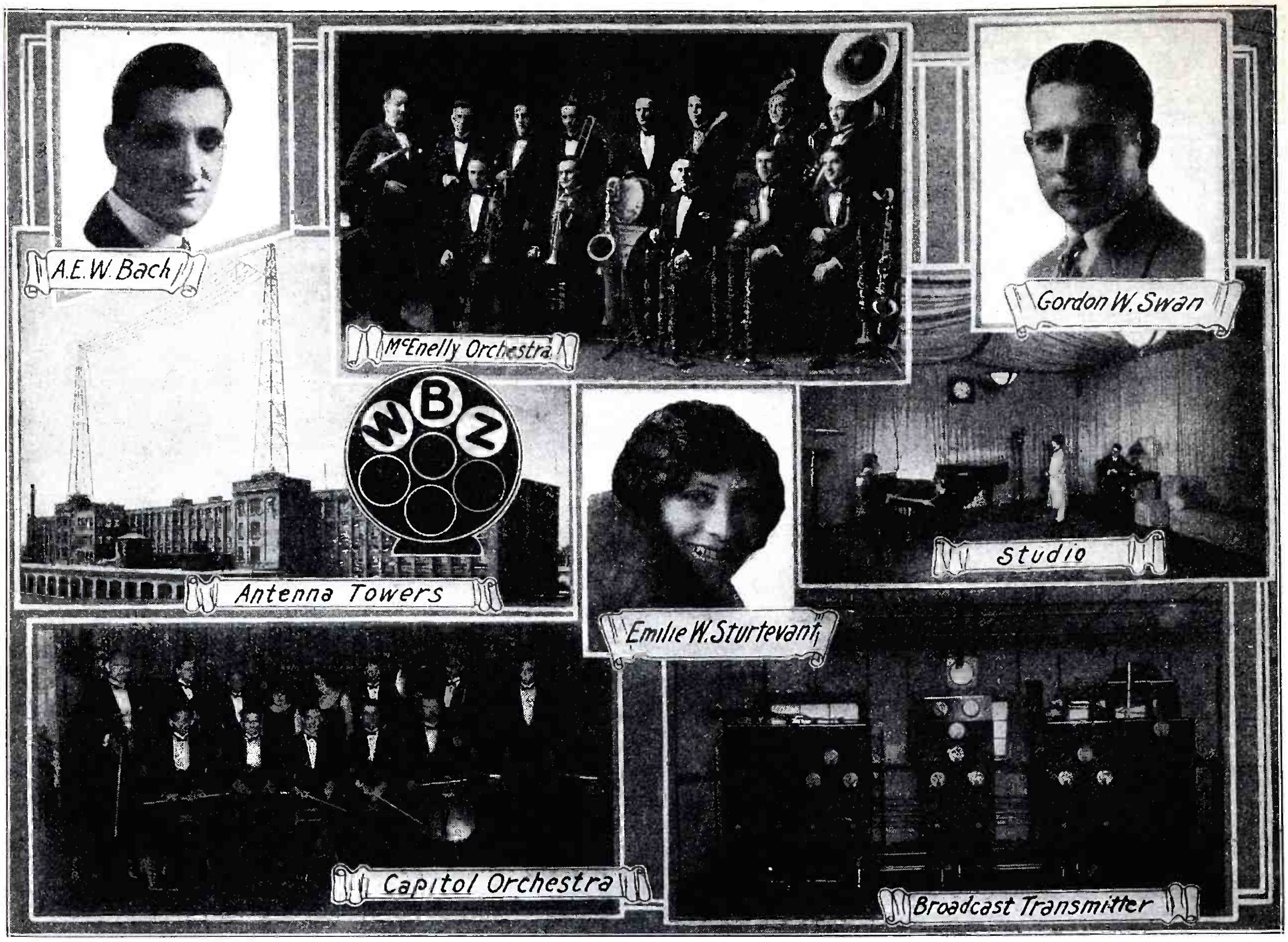
	Radio Call Letters — BROADCAST STATIONS Location and Name	Power Watts	Wave Length (Meters)	Frequency (Kilocycles)	Time at Station	Date	Time Received	Dial 1	Dial 2	Dial 3
KN	KNX—Los Angeles, Calif.—Los Angeles Evening Express, 6116 Hollywood Blvd.	500	336.9	890	Pacific					
KO	KOA—Denver, Colo.—General Electric Co., 1370 Krameria St.	5000	322.4	930	Mountain					
	KOB—State College, N. Mex.—New Mexico College of Agriculture and Mechanic Arts.	1000	348.6	860	Mountain					
	KOCH—Omaha, Neb.—Omaha Central High School.	250	258	1160	Central					
	KOCW—Chickasha, Okla.—Oklahoma College for Women.	200	252	1190	Central					
	KOIL—Council Bluffs, Iowa.—Monarch Mfg. Co.	500	278	1080	Central					
KP	KPO—San Francisco, Calif.—Hale Bros.	1000	428.3	700	Pacific					
	KPPC—Pasadena, Calif.—Pasadena Presbyterian Church	50	229	1310	Pacific					
	KPRC—Houston, Tex.—Post Dispatch.	500	296.9	1010	Central					
	KPSN—Pasadena, Calif.—Pasadena Star-News.	1000	315.6	950	Pacific					
KQ	KQP—Portland, Oregon.—H. B. Read, 441 Sixth St.	500	212.6	1410	Pacific					
	KQV—Pittsburgh, Pa.—Doubleday-Hill Electric Co., 719 Liberty Ave.	500	275	1090	Eastern					
	KQW—San Jose, Calif.—First Baptist Church, Montevina Ave.	500	231	1300	Pacific					
KR	KRE—Berkeley, Calif.—Berkeley Daily Gaazette.	100	256	1170	Pacific					
KS	KSAC—Manhattan, Kas.—Kansas State Agricultural College.	500	340.7	880	Central					
	KSD—St. Louis, Mo.—Post Dispatch.	500	545.1	550	Central					
	KSL—Salt Lake City, Utah.—Radio Service Corp. of Utah, 505 Templeton Building.	1000	299.8	1000	Pacific					
	KSO—Clarinda, Iowa.—A. A. Berry Seed Co.	500	242	1240	Central					
KT	KTAB—Oakland, Calif.—Tenth Ave. Baptist Church.	1000	240	1250	Pacific					
	KTBI—Los Angeles, Calif.—Bible Institute of Los Angeles.	750	293.9	1020	Pacific					
	KTBR—Portland, Oregon—Brown's Radio Shop, 172-10th St.	50	263	1140	Pacific					
	KTCL—Seattle, Wash.—American Radio Telephone Co.	1000	305.9	980	Pacific					
	KTHS—Hot Springs, Ark.—New Arlington Hotel Co.	500	374.8	800	Central					
	KTNT—Muscatine, Iowa.—Norman Baker.	500	256	1170	Central					
	KTW—Seattle, Wash.—First Presbyterian Church.	1000	454.3	660	Pacific					
KU	KUO—San Francisco, Cal.—Examiner Printing Co.	150	250	1200	Pacific					
	KUOM—Missoula, Mont.—University of Montana.	250	244	1230	Mountain					
	KUSD—Vermillion, S. D.—University of S. D.	100	278	1080	Central					
	KUT—Austin, Tex.—University of Texas.	500	231	1300	Central					
KV	KVOO—Bristow, Oklahoma—Voice of Oklahoma.	500	374.8	800	Central					
KW	KWCR—Cedar Rapids, Iowa.—H. F. Paar, 1444 Second Avenue, E.	500	278	1080	Central					
	KWG—Stockton, Calif.—Portable Wireless Telephone Co., 530 East Market St.	50	248	1210	Pacific					
	KWKC—Kansas City, Mo.—Wilson Duncan Studios, Werby Building.	100	236	1270	Central					
	KWKH—Kennonwood, La.—W. G. Patterson, 406 Market St.	500	261	1150	Central					
	KWSC—Pullman, Wash.—State College of Washington.	500	348.6	860	Pacific					
	KWUC—Le Mars, Iowa.—Western Union College.	50	252	1190	Central					
	KWWG—Brownsville, Tex.—City of Brownsville, Board of City Development.	500	278	1080	Central					
KY	KYW—Chicago, Illinois—Westinghouse Electric & Manufacturing Co.	2000	535.4	560	Central					
KZ	KZM—Oakland, Calif.—Preston D. Allen, 13th & Harrison Sts.	100	240	1250	Pacific					
NA	NAA—Arlington, Virginia—United States Navy.	1000	434.5	690	Eastern					
WA	WAAB—New Orleans, La.—Valdemar Jensen, 137 So. Saint Patrick St.	100	268	1120	Central					
	WAAD—Cincinnati, Ohio.—Ohio Mechanics Institute.	25	258	1160	Central					
	WAAF—Chicago, Ill.—Chicago Daily Drovers Journal.	200	278	1080	Central					

WA

Radio Call Letters	BROADCAST STATIONS Location and Name	Power Watts	Wave Length (Meters)	Frequency (Kilocycles)	Time at Station	Date	Time Received	Dial 1	Dial 2	Dial 3
WAAM	Newark, N. J.—I. R. Nelson Co., 1 Bond St. (This station is temporarily broadcasting from New York, N. Y. under call WBPI)	500	263	1140	Eastern					
WAAW	Omaha, Neb.—Omaha Grain Exchange.	500	278	1080	Central					
WABB	Harrisburg, Pa.—Harrisburg Sporting Goods Co.	10	266	1130	Eastern					
WABC	Asheville, N. C.—Asheville Battery Co., 19 Haywood St.	20	254	1180	Central					
WABI	Bangor, Me.—First Universalist Church.	100	240	1250	Eastern					
WABO	Rochester, N. Y.—Lake Ave. Baptist Church (Hickson Electric Co.)	100	278	1080	Eastern					
WABQ	Haverford, Pa.—Haverford College Radio Club.	100	261	1150	Eastern					
WABR	Toledo, Ohio.—Scott High School.	50	263	1140	Central					
WABW	Wooster, Ohio.—College of Wooster.	50	206.8	1450	Eastern					
WABX	Mount Clemens, Mich. (near)—Henry B. Joy, 1830 Penobscot Building, Detroit, Mich.	500	246	1220	Central					
WABY	Philadelphia, Pa.—John Magaldi, Jr., 815 Kimball St.	50	242	1240	Eastern					
WABZ	New Orleans, La.—Coliseum Place Baptist Church.	50	275	1090	Central					
WADC	Akron, Ohio.—Allen Theater (Allen T. Simmons).	500	258	1160	Eastern					
WAFD	Port Huron, Mich.—Albert B. Parfet Co., 1432 Military Road.	500	275	1090	Central					
WAGM	Royal Oak, Mich.—Robert L. Miller.	50	258.6	1160	Central					
WAHG	Richmond Hill, N. Y.—A. H. Grebe & Co.	500	315.6	950	Eastern					
WAIT	Taunton, Mass.—A. H. Waite & Co., 32 Weir St.	10	229	1310	Eastern					
WAIU	Columbus, Ohio.—American Insurance Union.	500	293.9	1020	Central					
WAMD	Minneapolis, Minn.—Hubbard & Co. (Twin City Barber College, Marigold Gardens).	500	244	1230	Central					
WAPI	Auburn, Ala.—Alabama Polytechnic Institute.	500	248	1210	Central					
WARC	Medford Hillside, Mass.—American Radio & Research Corp.	100	261	1150	Eastern					

WB

Radio Call Letters	BROADCAST STATIONS Location and Name	Power Watts	Wave Length (Meters)	Frequency (Kilocycles)	Time at Station	Date	Time Received	Dial 1	Dial 2	Dial 3
WBAA	West Lafayette, Ind.—Purdue University.	250	273	1100	Central					
WBAK	Harrisburg, Pa.—Pennsylvania State Police.	500	275	1090	Eastern					
WBAL	Baltimore, Md.—Consolidated Gas, Electric Light & Power Co.	1000	374.8	1800	Eastern					
WBAO	Decatur, Ill.—James Millikin University.	100	270	1110	Central					
WBAP	Fort Worth, Texas.—Star Telegram	1500	475.9	630	Central					
WBAX	Wilkes-Barre, Pa.—John H. Stenger, Jr. 66 Gildersleeve St.	100	256	1170	Eastern					
WBBL	Richmond, Va.—Grace Covenant Presbyterian Church.	100	229	1310	Eastern					
WBBM	Chicago, Ill.—Atlass Investment Co., 1554 Howard St.	1500	226	1330	Central					
WBBP	Petoskey, Mich.—Petoskey High School.	200	238	1260	Central					
WBBR	Rossville, N. Y.—Peoples Pulpit Ass'n., 124 Columbia Heights, Brooklyn.	500	273	1100	Eastern					
WBBS	New Orleans, La.—First Baptist Church.	50	252	1190	Central					
WBBW	Norfolk, Va.—Ruffner Junior High School.	50	222	1350	Eastern					
WBBY	Charleston, S. C.—Washington Light Infantry.	10	268	1120	Eastern					
WBCN	Chicago, Ill.—Foster & McDonnell, 728 W. 65th St.	500	266	1130	Central					
WBBZ	Chicago, Ill. (Portable)—C. L. Carrell, 1506 North American Building.	50	215.7	1390						
WBDC	Grand Rapids, Mich.—Baxter Laundry Co.	50	256	1170	Central					
WBES	Takoma Park, Md.—Bliss Electrical School.	100	222	1350	Eastern					
WBOQ	Richmond Hill, N. Y.—A. H. Grebe & Co., 70 Van Wyck Boulevard.	100	236	1270	Eastern					
WBPI	New York, N. Y.—Warner Bros. Theatre. (WAAM at Newark, N. J. is temporarily broadcasting from New York, N. Y. under call WBPI)	500	263	1140	Eastern					
WBRC	Birmingham, Ala.—Bell Radio Corporation, 1913 Fifth Ave. N.	10	248	1210	Central					
WBRE	Wilkes Barre, Pa.—Baltimore Radio Exchange, 17 W. Northampton St.	100	231	1300	Eastern					

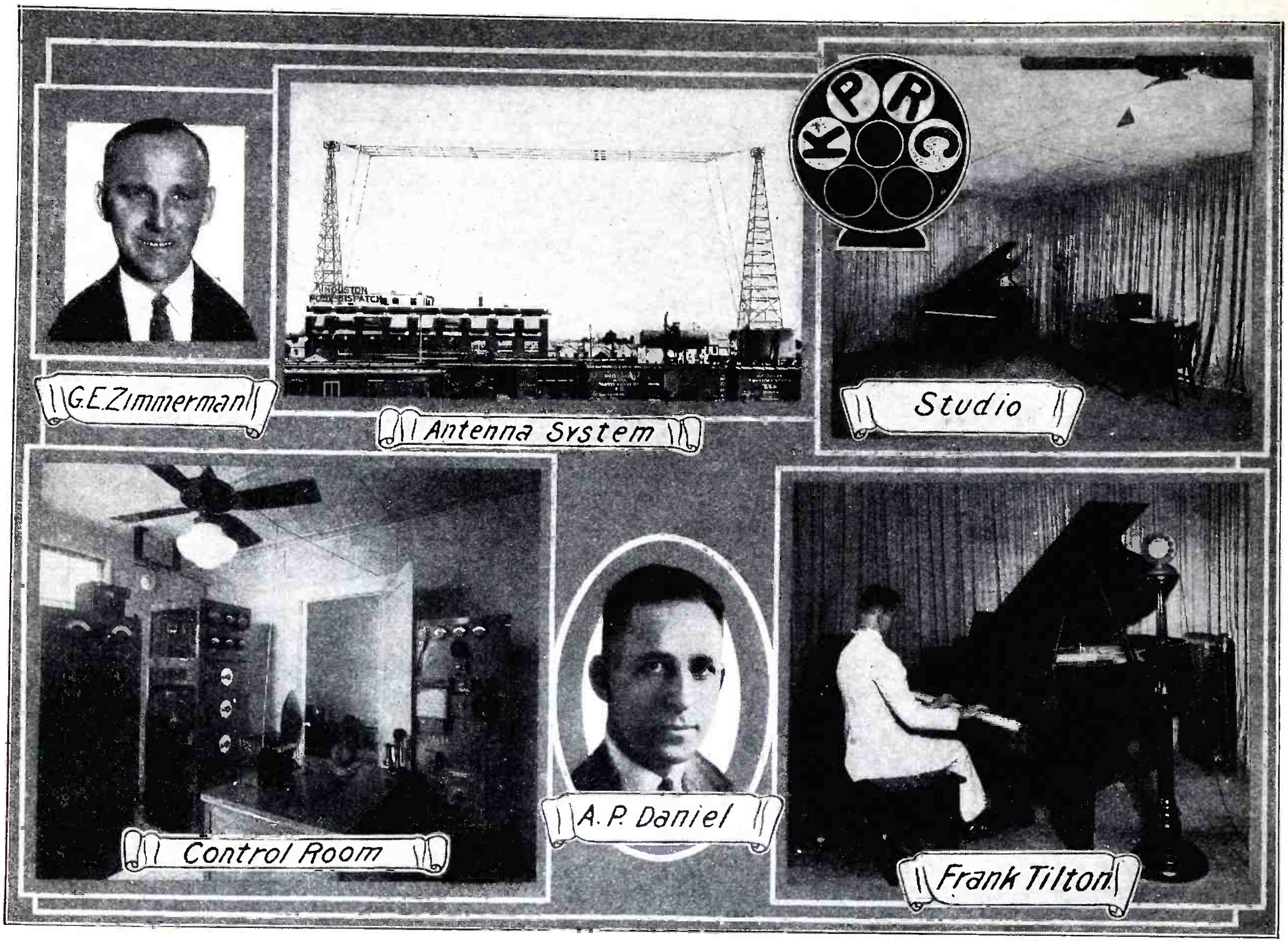

A.E.W. Bach
McEnelly Orchestra
Gordon W. Swan
WBZ
Antenna Towers
Emilie W. Sturtevant
Studio
Capitol Orchestra
Broadcast Transmitter

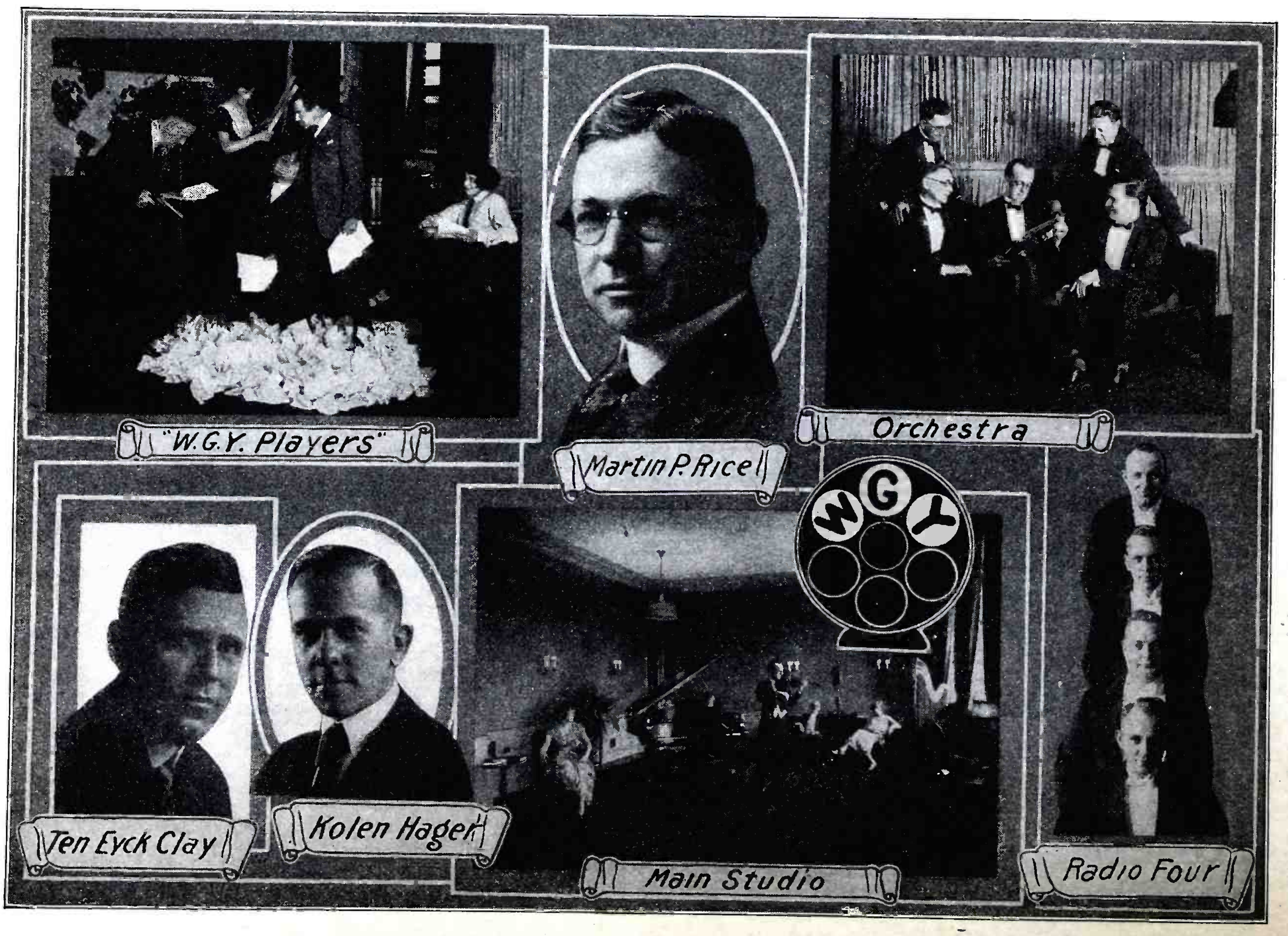

Patsy Ruth Miller
Charlie Wellman
Warner Bros Entertainers
KFWB
Irene Rich
Gordon-Blue-Moore
Louise Fazenda

	Radio Call Letters — BROADCAST STATIONS Location and Name	Power Watts	Wave Length (Meters)	Frequency (Kilocycles)	Time at Station	Date	Time Received	Dial 1	Dial 2	Dial 3
WB	WBT—Charlotte, N. C.—Charlotte Chamber of Commerce. (C. C. Coddington).	250	275	1090	Eastern					
	WBZ—Springfield, Mass.—Westinghouse Elec. & Mfg. Co.	2000	331.1	900	Eastern					
	WBZA—Boston, Mass.—Westinghouse Elec. & Mfg. Co.	250	242	1240	Eastern					
WC	WCAC—Mansfield, Conn.—Connecticut Agricultural College.	500	275	1090	Eastern					
	WCAD—Canton, N. Y.—St. Lawrence University.	250	263	1140	Eastern					
	WCAE—Pittsburgh, Pa.—Kaufmann & Baer Co., 6th and Smithfield Streets.	500	461.3	650	Eastern					
	WCAH—Columbus, Ohio.—Entrekin Elec. Co., 321 W. 10th Ave.	500	266	1130	Central					
	WCAJ—University Pl., Neb.—Nebraska Wesleyan University.	500	254	1180	Central					
	WCAL—Northfield, Minn.—St. Olaf College.	500	336.9	890	Central					
	WCAO—Baltimore, Md.—Albert A. and A. Stanley Brager.	100	275	1090	Eastern					
	WCAP—Washington, D. C.—Chesapeake & Potomac Telephone Co.	500	468.5	640	Eastern					
	WCAR—San Antonio, Tex.—Southern Radio Corp. of Texas, 324 North Navarro St.	500	263	1140	Central					
	WCAT—Rapid City, S. Dak.—South Dakota State School of Mines.	50	240	1250	Mountain					
	WCAU—Philadelphia, Pa.—Universal Broadcasting Co. (Durham & Co.)	500	278	1080	Eastern					
	WCAX—Burlington, Vt.—University of Vermont.	100	250	1200	Eastern					
	WCBA—Allentown, Pa.—Charles W. Heimbach, 1015 Allen St.	15	254	1180	Eastern					
	WCBC—Ann Arbor, Mich.—University of Michigan.	200	229	1310	Central					
	WCBD—Zion, Ill.—Wilbur G. Voliva.	5000	344.6	870	Central					
	WCBE—New Orleans, La.—Uhalt Bros. Radio Co., 200 Camp St.	5	263	1140	Central					
	WCBG—Pascagoula, Miss. (Portable)—Howard S. Williams.	10	268	1120						
	WCBH—Oxford, Miss. (near)—University of Mississippi.	50	242	1240	Central					
	WCBM—Baltimore, Md.—Hotel Chateau (Chas. Schwarz).	50	229	1310	Eastern					
	WCBQ—Nashville, Tenn.—First Baptist Church.	100	236	1270	Central					
	WCBR—Providence, R. I. (Portable)—Chas. H. Messter, 42 Doyle Ave.	30	205.4	1460						
	WCCO—St. Paul-Minneapolis, Minn.—Washburn-Crosby Co.	5000	416.4	720	Central					
	WCEE—Elgin, Ill. (near)—Liberty Weekly.	1000	275	1090	Central					
	WCLO—Camp Lake, Wis.—C. E. Whitmore.	50	231	1300	Central					
	WCLS—Joliet, Ill.—Harold M. Couch.	150	214.2	1400	Central					
	WCSH—Portland, Me.—Congress Square Hotel Co.	500	256	1170	Eastern					
	WCSO—Springfield, Ohio.—Wittenberg College.	100	248	1210	Central					
	WCUW—Worcester, Mass.—Clark University.	250	238	1260	Eastern					
	WCWS—Providence, R. I. (Portable)—Chas. W. Selen, 69 Exchange St.	100	209.7	1430						
	WCX—Pontiac, Mich.—Detroit Free Press.	2500	516.9	580	Central					
WD	WDAD—Nashville, Tenn.—Dad's Auto Accessories Inc., 160 Eighth Ave. North.	150	226	1330	Central					
	WDAE—Tampa, Fla.—Daily Times.	250	273	1100	Eastern					
	WDAF—Kansas City, Mo.—Kansas City Star.	500	365.6	820	Central					
	WDAG—Amarillo, Texas—J. Laurance Martin.	100	263	1140	Central					
	WDAY—Fargo, N. D.—Radio Equipment Corp.	50	261	1150	Central					
	WDBC—Lancaster, Pa.—Kirk, Johnson & Co., 16 W. King St.	50	258	1160	Eastern					
	WDBE—Atlanta, Ga.—Gilhan-Schoen Elec. Co., 35 Cone St.	100	270	1110	Central					
	WDBJ—Roanoke, Va.—Richardson-Wayland Electric Corp., 106 Church St. S. W.	50	229	1310	Eastern					
	WDBK—Cleveland, Ohio.—M. F. Broz Furniture, Hdwe. and Radio Store, 13918 Union Ave.	100	227	1320	Eastern					
	WDBO—Winter Park, Fla.—Rollins College.	500	240	1250	Eastern					
	WDBR—Boston, Mass.—Tremont Temple Baptist Church.	100	261	1150	Eastern					
	WDBZ—Kingston, N. Y.—Boy Scouts of America (Ulster County Council).	10	233	1290	Eastern					

Radio Call Letters	BROADCAST STATIONS Location and Name	Power Watts	Wave Length (Meters)	Frequency (Kilocycles)	Time at Station	Date	Time Received	Dial 1	Dial 2	Dial 3
WD										
WDCH	Hanover, N. H.—Dartmouth College	100	256	1170	Eastern					
WDOD	Chattanooga, Tenn.—Chattanooga Radio Co., 540 McCallie Ave.	500	256	1170	Central					
WDRC	New Haven, Conn.—Doolittle Radio Corporation, 115 Crown St.	100	268	1120	Eastern					
WDWF	Cranston, R. I.—Dutee W. Flint.	500	440.9	680	Eastern					
WDZ	Tuscola, Ill.—Jas. L. Bush.	10-100	278	1080	Central					
WE										
WEAF	New York, N. Y.—American Telephone & Telg. Co., 195 Broadway	5000	491.5	610	Eastern					
WEAH	Wichita, Kans.—Hotel Lassen (Rigby Gray Hotel Co.)	50	268	1120	Central					
WEAI	Ithaca, N. Y.—Cornell University.	500	254	1180	Eastern					
WEAM	North Plainfield, N. J.—Borough of North Plainfield (W. G. Buttfield)	250	261	1150	Eastern					
WEAN	Providence, R. I.—Shepard Co.	500	270	1110	Eastern					
WEAO	Columbus, Ohio.—Ohio State University.	500	293.9	1020	Central					
WEAR	Cleveland, Ohio.—Goodyear Tire & Rubber Co.	750	389.4	770	Eastern					
WEAU	Sioux City, Iowa—Davidson Bros. Co.	100	275	1090	Central					
WEAY	Houston, Texas—Iris Theatre (Will Horowitz, Jr.).	500	270	1110	Central					
WEBC	Superior, Wis.—Walter C. Bridges, 1225 Tower St.	100	242	1240	Central					
WEBD	Anderson, Ind.—Electrical Equipment & Service Co.	15	246	1220	Central					
WEBE	Cambridge, Ohio.—Roy W. Waller, 319 Wall Ave.	10	234	1280	Eastern					
WEBH	Chicago, Ill.—Edgewater Beach Hotel Co., 5349 Sheridan Road.	1500	370.2	810	Central					
WEBJ	New York, N. Y.—Third Ave. Railway Co., 2396 Third Ave.	500	273	1100	Eastern					
WEBK	Grand Rapids, Mich.—Grand Rapids Radio Co., 211 Diamond Ave. S. E.	100	242	1240	Central					
WEBL	United States (Portable)—Radio Corp. of America.	100	226	1330						
WEBM	United States (Portable)—Radio Corp. of America.	100	226	1330						
WEBQ	Harrisburg, Ill.—Jos. R. Tate, 700 W. Robinson St.	10	226	1330	Central					
WEBR	Buffalo, N. Y.—H. H. Howell, 54 Niagara St.	50	244	1230	Eastern					
WEBT	Dayton, Ohio.—Dayton Cooperative Industrial High School.	5	256	1170	Central					
WEBW	Beloit, Wis.—Beloit College.	500	268	1120	Central					
WEBZ	Savannah, Ga.—Savannah Radio Corp., 11 E. York St.	5	263	1140	Eastern					
WEEI	Boston, Mass.—Edison Electric Eluminating Co.	500	475.9	630	Eastern					
WEHS	Evanston, Ill.—Robert E. Hughes.	10	202.6	1480	Central					
WEMC	Berrien Springs, Mich.—Emmanuel Missionary College.	500	285.5	1050	Central					
WENR	Chicago, Ill.—All American Radio Corporation, 4201 Belmont Avenue.	1000	266	1130	Central					
WEW	St. Louis, Mo.—St. Louis University.	100	248	1210	Central					
WF										
WFAA	Dallas, Tex.—Dallas News and Dallas Journal	500	475.9	630	Central					
WFAM	St. Cloud, Minn.—Times Publishing Co.	10	273	1100	Central					
WFAV	Lincoln, Neb.—University of Nebraska, Dept. of Electrical Engineering.	500	275	1090	Central					
WFBC	Knoxville, Tenn.—First Baptist Church.	50	250	1200	Central					
WFBD	Philadelphia, Pa.—Gethsemane Baptist Church.	5	234	1280	Eastern					
WFBE	Seymour, Ind.—Van DeWalle Music & Radio Co., 208 West Second St.	10	226	1330	Central					
WFBG	Altoona, Pa.—William F. Gable Co.	100	278	1080	Eastern					
WFBH	New York, N. Y.—Concourse Radio Corporation, Hotel Majestic.	500	273	1100	Eastern					
WFBI	Camden, N. J.—Galvin Radio Supply Co., 521 Market St.	250	236	1270	Eastern					
WFBJ	Collegeville, Minn.—St. John's University.	100	236	1270	Central					
WFBL	Syracuse, N. Y.—Onondaga Hotel Co.	100	252	1190	Eastern					
WFBM	Indianapolis, Ind.—Merchants Heat & Light Co.	250	268	1120	Central					

Radio Call Letters	BROADCAST STATIONS Location and Name	Power Watts	Wave Length (Meters)	Frequency (Kilocycles)	Time at Station	Date	Time Received	Dial 1	Dial 2	Dial 3
WF										
WFBR	Baltimore, Md.—Fifth Infantry Maryland National Guard. Fifth Regt. Armory.	100	254	1180	Eastern					
WFBZ	Galesburg, Ill.—Knox College.	20	254	1180	Central					
WFDF	Flint, Mich.—Frank D. Fallain, Police Bldg.	100	234	1280	Central					
WFI	Philadelphia, Pa.—Strawbridge & Clothier.	500	394.5	760	Eastern					
WFKB	Chicago, Ill.—Francis K. Bridgman, 4536 Woodlawn Ave.	500	217.3	1380	Central					
WFRL	Brooklyn, N. Y.—Robt. M. Lacey and Jas. A. Bergner (Flatbush Radio Lab.). 1421 East 10th St.	100	205.4	1460	Eastern					
WG										
WGAL	Lancaster, Pa.—Lancaster Elec. Supply & Construction Co.	10	248.	1210	Eastern					
WGBB	Freeport, N. Y.—Harry H. Carman.	100	244	1230	Eastern					
WGBC	Memphis, Tenn.—First Baptist Church.	10	278	1080	Central					
WGBF	Evansville, Ind.—Finke Furniture Co., 307 South Seventh St.	100	236	1270	Central					
WGBI	Scranton, Pa.—Frank S. Megargee, 608 Linden St.	10	240	1250	Eastern					
WGBK	Johnstown, Pa.—Lawrence W. Campbell (Fountaine Chateau).	5	248	1210	Eastern					
WGBM	Providence, R. I.—Theo. N. Saaty, 92 Dover St.	30	234	1280	Eastern					
WGBQ	Menominee, Wis.—Stout Institute.	100	234	1280	Central					
WGBR	Marshfield, Wis.—Geo. S. Ives, 731 West Fifth St.	10	229	1310	Central					
WGBS	New York, N. Y.—Gimbel Bros.	500	315.6	950	Eastern					
WGBT	Greenville, S. C.—Furman University.	15	236	1270	Eastern					
WGBU	Fulford-by-the-Sea, Fla.—Florida Cities Finance Co.	500	278	1080	Eastern					
WGBX	Orono, Me.—University of Maine.	100	252	1190	Eastern					
WGCP	New York, N. Y.—Grand Central Palace. (Transmitter is in Newark, N. J. Owned by D. W. May (Inc.), 325 Central Avenue, Newark, N. J.)	500	252	1190	Eastern					
WGES	Oak Park, Ill.—Oakleaves Broadcasting Station (Coyne Electrical School).	500	250	1200	Central					
WGHB	Clearwater, Fla.—The Geo. H. Bowles Developments.	500	266	1130	Eastern					
WGHP	Detroit, Mich.—Geo. H. Phelps, 110 Rowena St.	1500	270	1110	Central					
WGMU	Richmond Hill, N. Y. (portable)—A. H. Grebe & Co.	100	236	1270	Eastern					
WGN	Chicago, Ill.—The Tribune (Drake Hotel).	1000	302.8	990	Central					
WGR	Buffalo, N. Y.—Federal Radio Corp. (Federal Telephone Mfg. Corp.)	750	319	940	Eastern					
WGST	Atlanta, Ga.—Georgia School of Technology	500	270	1110	Central					
WGY	Schenectady, N. Y.—General Electric Co.	5000	379.5	790	Eastern					
WH										
WHA	Madison, Wis.—University of Wisconsin	750	535.4	560	Central					
WHAD	Milwaukee, Wis.—Marquette University and Milwaukee Journal	500	275	1090	Central					
WHAG	Cincinnati, Ohio.—University of Cincinnati	100	233	1290	Central					
WHAM	Rochester, N. Y.—University of Rochester (Eastman School of Music)	100	278	1080	Eastern					
WHAP	New York, N. Y.—W. H. Taylor Finance Corp., 426 West 31st Street	500	240	1250	Eastern					
WHAR	Atlantic City, N. J.—Seaside Hotel	500	275	1090	Eastern					
WHAS	Louisville, Ky.—Courier-Journal and Louisville Times	500	399.8	750	Central					
WHAT	Minneapolis, Minn.—Geo. W. Young, 2219 North Bryant Ave.	500	263	1140	Central					
WHAV	Wilmington, Del.—Wilmington Elec. Specialty Co. 405 Delaware Ave.	100	266	1130	Eastern					
WHAZ	Troy, N. Y.—Rensselaer Polytechnic Institute	1000	379.5	790	Eastern					
WHB	Kansas City, Mo.—Sweeney School Co., Sweeney Bldg.	500	365.6	820	Central					
WHBA	Oil City, Pa.—Shaffer Music House	10	250	1200	Eastern					
WHBC	Canton, Ohio.—Rev. E. P. Graham, 627 McKinley Avenue, N. W.	10	254	1180	Eastern					
WHBD	Bellefontaine, Ohio.—Chas. W. Howard	20	222	1350	Central					


KPRC
G.E.Zimmerman
Antenna System
Studio
Control Room
A.P. Daniel
Frank Tilton


"W.G.Y. Players"
Martin P. Rice
Orchestra
WGY
Ten Eyck Clay
Kolen Hager
Main Studio
Radio Four

Radio Call Letters	BROADCAST STATIONS Location and Name	Power Watts	Wave Length (Meters)	Frequency (Kilocycles)	Time at Station	Date	Time Received	Dial 1	Dial 2	Dial 3
WH										
WHBF	**Rock Island, Ill.**—Beardsley Specialty Co., 217 Eighteenth Street	100	222	1350	Central					
WHBG	**Harrisburg, Pa.**—John S. Skane, 1810 North Fourth St.	20	231	1300	Eastern					
WHBH	**Culver, Ind.**—Culver Military Academy	100	222	1350	Central					
WHBJ	**Fort Wayne, Ind.**—Lauer Auto Co., 2315 South Calhoun Street.	50	234	1280	Central					
WHBK	**Ellsworth, Me.**—Franklin Street Garage	10	231	1300	Eastern					
WHBL	**Logansport, Ind.**—Jas. H. Slusser, 1214 A Avenue	50	215.7	1390	Central					
WHBM	**Chicago, Ill. (Portable)**—C. L. Carrell, 1536 S. State St.	20	233	1290	Central					
WHBN	**St. Petersburg, Fla.**—First Avenue Methodist Church	10	238	1260	Eastern					
WHBP	**Johnstown, Pa.**—Johnstown Automobile Co.	100	256	1170	Eastern					
WHBQ	**Memphis, Tenn.**—Men's Fellowship Class of St. Johns Methodist Episcopal Church South	50	233	1290	Central					
WHBR	**Cincinnati, Ohio.**—Scientific Electric & Mfg. Co., 1745 Reading Road	20	215.7	1390	Central					
WHBU	**Anderson, Ind.**—Rivera Theatre & Bing's Clothing, 1002 Meridian St.	10	218.8	1370	Central					
WHBW	**Philadelphia, Pa.**—D. R. Kienzie, 4916 Chestnut St.	100	215.7	1390	Eastern					
WHBY	**West De Pere, Wis.**—St. Norbert's College	50	250	1200	Central					
WHDI	**Minneapolis, Minn.**—Wm. Hood Dunwoody Industrial Institute	500	278	1080	Central					
WHEC	**Rochester, N. Y.**—Hickson Electric Co., 36 South Ave.	100	258	1160	Eastern					
WHK	**Cleveland, Ohio.**—Radio Air Service Corp., 1031 Winton Hotel	250	273	1100	Eastern					
WHN	**New York, N. Y.**—Geo. Schubel, 1540 Broadway	500	361.2	830	Eastern					
WHO	**Des Moines, Iowa.**—Bankers Life Co.	5000	526	570	Central					
WHT	**Chicago, Ill.**—(Transmitter is in Deerfield, Ill.)—Radiophone Broadcasting Corp., 410 N. Michigan Blvd., Chicago, Ill.	2500	238	1260	Central					
WI										
WIAD	**Philadelphia, Pa.**—Howard R. Miller, 6318 N. Park Ave.	100	250	1200	Eastern					
WIAS	**Burlington, Iowa.**—Home Electric Co.	100	254	1180	Central					
WIBA	**Madison, Wis.**—Capital Times Studio, 237 West Gilman Street	100	236	1270	Central					
WIBC	**St. Petersburg, Fla.**—L. M. Tate Post No. 39, Veterans of Foreign Wars	100	222	1350	Eastern					
WIBG	**Elkins Park, Pa.**—St. Paul's Protestant Epis. Church	50	222	1350	Eastern					
WIBH	**New Bedford, Mass.**—Elite Radio Stores, 55 Hillman St.	5	209.7	1430	Eastern					
WIBI	**Flushing, N. Y.**—Frederick B. Zittell, Jr. 49 Boerum Ave.	50	218.8	1370	Eastern					
WIBJ	**Chicago, Ill. (Portable)**—C. L. Carrell, 36 So. State St.	50	215.7	1390						
WIBK	**Toledo, Ohio.**—University of the City of Toledo	100	205.4	1460	Central					
WIBM	**Chicago, Ill. (Portable)**—Billy Maine, 36 West Randolph Street	10	215.7	1390						
WIBO	**Chicago, Ill.**—Nelson Bros. (Russo & Fiorito Orchestral Exchange), 6310 Broadway	1000	226	1330	Central					
WIBR	**Weirton, W. Va.**—Thurman A. Owings	50	246	1220	Eastern					
WIBS	**Elizabeth, N. J. (Portable)**—New Jersey National Guard, Fifty-seventh Infantry Brigade.	10	202.6	1480						
WIBU	**Poynette, Wis.**—The Electric Farm	20	222	1350	Central					
WIBV	**Henderson, N. C.**—Jewell Radio Co.	25	263	1140	Eastern					
WIBW	**Logansport, Ind.**—L. L. Dill, Barnes Building.	100	220	1360	Central					
WIBX	**Utica, N. Y.**—Grid-Leak (Inc.), 236 Genesse St.	150	205.4	1460	Eastern					
WIBZ	**Montgomery, Ala.**—Powell Electric Co., 811 Adams Ave.	10	231	1300	Central					
WIL	**St. Louis, Mo.**—St. Louis Star and Benson Radio Co.	250	273	1100	Central					
WIP	**Philadelphia, Pa.**—Gimbel Bros.	500	508.2	590	Eastern					
WJ										
WJAD	**Waco, Tex.**—Frank P. Jackson	500	352.7	850	Central					
WJAG	**Norfolk, Nebr.**—Daily News	200	270	1110	Central					
WJAK	**Greentown, Ind.**—Rev. C. L. White	50	254	1180	Central					
WJAM	**Cedar Rapids, Ia.**—D. M. Perham, 322 Third Ave. W.	100	268	1120	Central					

Radio Call Letters	Broadcast Stations Location and Name	Power Watts	Wave Length (Meters)	Frequency (Kilocycles)	Time at Station	Date	Time Received	Dial 1	Dial 2	Dial 3
WJ										
WJAR	Providence, R. I.—The Outlet Co.	500	305.9	980	Eastern					
WJAS	Pittsburgh, Pa.—Pittsburgh Radio Supply House	500	275	1090	Eastern					
WJAX	Jacksonville, Fla.—City of Jacksonville	1000	336.9	890	Eastern					
WJAZ	Chicago, Ill.—(Transmitter is in Mount Prospect, Ill.) Zenith Radio Corporation, 312 South Michigan Ave.	1500	322.4	930	Central					
WJBA	Joliet, Ill.—D. H. Lentz, Jr., 301 Whitley Ave.	50	206.8	1450	Central					
WJBB	St. Petersburg, Fla.—L. W. McClung, 1922 Central Ave.	10	254	1180	Eastern					
WJBC	LaSalle, Ill.—Hummer Furniture Co., 2nd and Joliet Sts	100	234	1280	Central					
WJBG	Charlotte, N. C.—Interstate Radio (Inc.), 7 West Fourth Street	10	224	1340	Eastern					
WJBI	Red Bank, N. J.—Robt. S. Johnson, 63 Broad St.	250	218.8	1370	Eastern					
WJBK	Ypsilanti, Mich.—Ernest F. Goodwin, 803 Congress St.	10	233	1290	Central					
WJBL	Decatur, Ill.—Wm. Gushard Dry Goods Co., 301 N. Water Street	500	270	1110	Central					
WJBN	Sycamore, Ill.—St. Johns Evengelical Lutheran Church	10	256	1170	Central					
WJBP	Buffalo, N. Y.—Seneca Vocational School	50	218.8	1370	Eastern					
WJBQ	Lewisburg, Pa.—Bucknell University	100	211.1	1420	Eastern					
WJD	Granville, Ohio.—Denison University	10	217.3	1380	Central					
WJJD	Mooseheart, Ill.—Supreme Lodge, Loyal Order of Moose	500	370.2	810	Central					
WJR	Detroit, Mich. (Transmitter is in Pontiac, Mich.)—Jewett Radio & Phonograph Co.	2500	516.9	580	Central					
WJY	New York, N. Y.—Radio Corp. of America	1000	405.2	740	Eastern					
WJZ	New York, N. Y.—Radio Corp. of America	1000	454.3	660	Eastern					
WK										
WKAD	East Providence, R. I.—Chas. Looff (Crescent Park)	20	240	1250	Eastern					
WKAF	Milwaukee, Wis.—WKAF Broadcasting Co., 130 2nd St.	500	261	1150	Central					
WKAR	East Lansing, Mich.—Michigan State College	1000	285.5	1050	Central					
WKAV	Laconia, N. H. (Portable)—Laconia Radio Club.	50	224	1340						
WKBB	Joliet, Ill.—Sanders Bros., 607 Jefferson St.	100	214.2	1400	Central					
WKBE	Webster, Mass.—K. & B. Electric Co.	100	231	1300	Eastern					
WKBG	Chicago, Ill.—(Portable) C. L. Carrell, 36 So. State St.	100	215.7	1390						
WKRC	Cincinnati, Ohio.—Kodel Radio Corp., 507 E. Pearl St.	1000	325.9 422.3	920 710	Central Central					
WKY	Oklahoma, Okla.—E. C. Hull and H. S. Richards	100	275	1090	Central					
WL										
WLAL	Tulsa, Okla.—First Christian Church	100	250	1200	Central					
WLAP	Louisville, Ky.—W. V. Jordon, 306 W. Breckenridge St.	20	275	1090	Central					
WLAX	Greencastle, Ind.—Greencastle Community Broadcasting Station	10	231	1300	Central					
WLB	Minneapolis, Minn.—University of Minnesota	500	278	1080	Central					
WLBL	Stevens Point, Wis.—Wisconsin Department of Markets	500	278	1080	Central					
WLIB	Elgin, Ill.—Liberty Weekly	2500	302.8	990	Central					
WLIT	Philadelphia, Pa.—Lit Bros.	500	394.5	760	Eastern					
WLS	Chicago, Ill.—(Transmitter is in Crete, Ill) Sears Roebuck & Co.	1500	344.6	870	Central					
WLTS	Chicago, Ill.—Lane Technical High School	100	258	1160	Central					
WLW	Cincinnati, Ohio—(Transmitter is in Harrison, Ohio) Crosley Radio Corp. Alfred & Cook Sts., Cincinnati, O.	5000	422.3	710	Central					
WLWL	New York, N. Y.—Missionary Society of St. Paul the Apostlé	1500	288.3	1040	Eastern					
WM										
WMAC	Cazenovia, N. Y.—Clive B. Meredith	100	275	1090	Eastern					
WMAF	Dartmouth, Mass.—Round Hills Radio Corporation.	1000	440.9	680	Eastern					
WMAK	Lockport, N. Y.—Norton Laboratories	500	266	1130	Eastern					
WMAL	Washington, D. C.—M. A. Leese Optical Co., 712 Eleventh Street	15	212.6	1410	Eastern					
WMAN	Columbus, Ohio.—W. E. Heskett (1st Baptist Church)	50	278	1080	Central					
WMAQ	Chicago, Ill.—Daily News	500	447.5	670	Central					
WMAY	St. Louis, Mo.—Kingshighway Presbyterian Church	100	248	1210	Central					
WMAZ	Macon, Ga.—Mercer University	500	261	1150	Central					

Radio Call Letters	BROADCAST STATIONS Location and Name	Power Watts	Wave Length (Meters)	Frequency (Kilocycles)	Time at Station	Date	Time Received	Dial 1	Dial 2	Dial 3
WM										
WMBB	**Chicago, Ill.**—American Bond & Mortgage Co., 6201 Cottage Grove Ave.	500	250	1200	Central					
WMBC	**Detroit, Mich.**—Hotel Addison, Mich. Broadcasting Co. (F G. Siegel)	100	256.4	1170	Central					
WMBF	**Miami Beach, Fla.**—Fleetwood Hotel Corporation	500	384.4	780	Eastern					
WMC	**Memphis, Tenn.**—Commercial Appeal	500	499.7	600	Central					
WMCA	**New York, N. Y.**—(Transmitter is in Hoboken, N. J.) Greely Square Hotel Company	500	340.7	880	Eastern					
WN										
WNAB	**Boston, Mass.**—Shepard Stores	100	250	1200	Eastern					
WNAC	**Boston, Mass.**—Shepard Stores	500	280.2	1070	Eastern					
WNAD	**Norman, Okla.**—University of Oklahoma	250	254	1180	Central					
WNAL	**Omaha, Neb.**—Omaha Central High School	50	258	1160	Central					
WNAT	**Philadelphia, Pa.**—Lenning Bros. Co.	100	250	1200	Eastern					
WNAX	**Yankton, S. Dak.**—Dakota Radio Apparatus Co.	100	244	1230	Central					
WNBH	**New Bedford, Mass.**—New Bedford Hotel, (Irving J. Vermilya and A. J. Lopez)	250	248	1210	Eastern					
WNJ	**Newark, N. J.**—Radio Shop of Newark (Herman Lubinsky) 89 Lehigh Ave.	150	252	1190	Eastern					
WNOX	**Knoxville, Tenn.**—Peoples Telephone & Telegraph Co.	500	268	1120	Central					
WNYC	**New York, N. Y.**—City of New York, Dept. of Plants and Structures	1000	526	570	Eastern					
WO										
WOAC	**Lima, Ohio.**—Page Organ Co.	50	261	1150	Central					
WOAI	**San Antonio, Tex.**—Southern Equipment Co.	2000	394.5	760	Central					
WOAN	**Lawrenceburg, Tenn.**—Jas. D. Vaughn	500	282.8	1060	Central					
WOAW	**Omaha, Nebr.**—Woodmen of the World	1000	526	570	Central					
WOAX	**Trenton, N. J.**—Franklyn J. Wolff	500	240	1250	Eastern					
WOC	**Davenport, Iowa.**—Palmer School of Chiropractic	5000	483.6	620	Central					
WOCG	**Sycamore, Ill.**—Triple Alliance Radio Station, 108 West State St.	10	205.4	1460	Central					
WOCL	**Jamestown, N. Y.**—Hotel Jamestown	15	275	1090	Eastern					
WODA	**Paterson, N. J.**—O'Dea Temple of Music	250	224	1340	Eastern					
WOI	**Ames, Iowa.**—Iowa State College	750	270	1110	Central					
WOK	**Chicago, Ill**—(Transmitter is in Homewood, Ill.) Neutrowound Radio Mfg. Co., 1721 Prairie Ave.	5000	217.3	1380	Central					
WOKO	**New York, N. Y.**—Otto Baur, 138 Dyckman St.	50	233	1290	Eastern					
WOO	**Philadelphia, Pa.**—John Wanamaker	500	508.2	590	Eastern					
WOQ	**Kansas City, Mo.**—Unity School of Christianity	1000	278	1080	Central					
WOR	**Newark, N. J.**—L. Bamberger & Co.	500	405.2	740	Eastern					
WORD	**Batavia, Ill.**—Peoples Pulpit Assn.	5000	275	1090	Central					
WOS	**Jefferson City, Mo.**—Missouri State Marketing Bureau	500	440.9	680	Central					
WOWL	**New Orleans, La.**—Owl Battery Co., 901 Carondelet Street.	10	270	1110	Central					
WOWO	**Fort Wayne, Ind.**—Main Auto Supply Co., 213 West Main St.	500	227	1320	Central					
WP										
WPAK	**Agricultural College, N. D.**—North Dakota Agricultural College	50	275	1090	Central					
WPCC	**Chicago, Ill.**—North Shore Congregational Church	500	258	1160	Central					
WPDQ	**Buffalo, N. Y.**—Hiram L. Turner, 121 Norwood Ave.	50	205.4	1460	Eastern					
WPG	**Atlantic City, N. J.**—Municipality of Atlantic City	500	299.8	1000	Eastern					
WPRC	**Harrisburg, Pa.**—Wilson Printing & Radio Co., Fifth and Keller Streets	100	215.7	1390	Eastern					
WPSC	**State College, Pa.**—Pennsylvania State College	500	261	1150	Eastern					
WQ										
WQAA	**Parkersburg, Pa.**—Horace A. Beale, Jr.	500	220	1360	Eastern					
WQAE	**Springfield, Vt.**—Moore Radio News Station	50	246	1220	Eastern					
WQAM	**Miami, Fla.**—Electrical Equipment Co., 42 Northwest Fourth St.	100	263	1140	Eastern					
WQAN	**Scranton, Pa.**—Scranton Times.	100	250	1200	Eastern					
WQAO	**New York, N. Y.**—Calvary Baptist Church	100	360	833	Eastern					

Rev. R. R. Brown — Mrs. Carl R. Grey — E. Konecky — Lou. Chansky — Lester Palmer — Gene Rouse — Goldie Funk — Val McLoughlin — Station WOAW — W. A. Fraser & Staff.

Arrowhead Inn Orchestra — Belle Bart — Dailey Paskman — WGBS. Towers — Donald Clark — Studio Corner

Radio Call Letters	BROADCAST STATIONS Location and Name	Power Watts	Wave Length (Meters)	Frequency (Kilocycles)	Time at Station	Date	Time Received	Dial 1	Dial 2	Dial 3
WQ										
WQJ	**Chicago, Ill.**—Calumet Rainbo Broadcasting Co., Rainbo Gardens	500	447.5	670	Central					
WR										
WRAF	**Laport, Ind.**—The Radio Club Inc.	100	224	1340	Central					
WRAK	**Escanaba, Mich.**—Economy Light Co., 1105 Ludington Street	100	256	1170	Central					
WRAM	**Galesburg, Ill.**—Lombard College	100	244	1230	Central					
WRAV	**Yellow Springs, Ohio.**—Antioch College	100	263	1140	Central					
WRAW	**Reading, Pa.**—Avenue Radio & Electric Shop (Horace D. Good), 460 Schuylkill.	10	238	1260	Eastern					
WRAX	**Gloucester City, N. J.**—Flexon's Garage	500	268	1120	Eastern					
WRBC	**Valparaiso, Ind.**—Immanuel Lutheran Church	500	278	1080	Central					
WRC	**Washington, D. C.**—Radio Corporation of America	1000	468.5	640	Eastern					
WRCO	**Raleigh, N. C.**—Wynne Radio Co., 226 1-2 Fayetteville Street.	100	252	1190	Eastern					
WREC	**Coldwater, Miss.**—Wooten's Radio & Electric Co.	10	254	1180	Central					
WREO	**Lansing, Mich.**—Reo Motor Car Co.	500	285.5	1050	Central					
WRHM	**Minneapolis, Minn.**—Rosedale Hospital	50	252	1190	Central					
WRK	**Hamilton, Ohio**—Doron Bros. Electrical Co.	100	270	1110	Central					
WRM	**Urbana, Ill.**—University of Illinois	500	273	1100	Central					
WRMU	**Richmond Hill, N. Y.** MU-1 (Yacht) A. H. Grebe & Co.	100	236	1270	Eastern					
WRNY	**New York, N. Y.**—Experimenter Publishing Co., 53 Park Place	500	258	1160	Eastern					
WRR	**Dallas, Tex.**—City of Dallas, Police and Fire Signal Dpt.	500	246	1220	Central					
WRST	**Bay Shore, N. Y.**—Radiotel Mfg. Co., 5 First Ave.	250	215.7	1390	Eastern					
WRVA	**Richmond, Va.**—Larus & Brother Co.	1000	256	1170	Eastern					
WRW	**Tarrytown, N. Y.**—Tarrytown Radio Research Laboratories, (Koenig Bros.)	500	273	1100	Eastern					
WS										
WSAI	**Cincinnati, Ohio.**—(Transmitter is in Mason, Ohio)—United States Playing Card Co., Cinicinnati, Ohio	5000	325.9	920	Central					
WSAJ	**Grove City, Pa.**—Grove City College	250	229	1310	Eastern					
WSAN	**Allentown, Pa.**—Allentown Call Publishing Co.	100	229	1310	Eastern					
WSAR	**Fall River, Mass.**—Doughty & Welch Electrical Co.	100	254	1180	Eastern					
WSAU	**Chesham, N. H.**—Camp Marienfeld	10	229	1310	Eastern					
WSAX	**Chicago, Ill.**—(Portable) Zenith Radio Corp., 332 South Michigan Avenue	100	268	1120						
WSAZ	**Pomeroy, Ohio.**—Chase Electric Shop	50	244	1230	Eastern					
WSB	**Atlanta, Ga.**—Atlanta Journal	1000	428.3	700	Central					
WSBC	**Chicago, Ill.**—World Battery Co., 1219 So. Wabash Ave.	500	209.7	1430	Central					
WSBF	**St. Louis, Mo.**—Stix, Baer & Fuller	250	273	1100	Central					
WSBT	**South Bend, Ind.**—South Bend Tribune	250	275	1090	Central					
WSDA	**New York, N. Y.**—The City Temple (Seventh Day Adventist Church), 130th St. Lenox Ave.	250	263	1140	Eastern					
WSKC	**Bay City, Mich.**—World's Star Knitting Co.	100	261	1150	Central					
WSM	**Nashville, Tenn.**—National Life & Accident Ins. Co.	1000	282.8	1060	Central					
WSMB	**New Orleans, La.**—Saenger Amusement Co. and Maison Blanche Co.	500	319	940	Central					
WSMH	**Owosso, Mich.**—Shattuck Music House, 207 Washington Street	20	240	1250	Central					
WSMK	**Dayton, Ohio.**—S. M. K. Radio Corporation, 39 East Third Street	500	275	1090	Central					
WSOE	**Milwaukee, Wis.**—School of Engineering of Milwaukee, 415 Marshall Street	500	246	1220	Central					
WSRO	**Hamilton, Ohio**—The Radio Co. (Harry W. Fahrlander)	100	252	1190	Central					
WSUI	**Iowa City, Iowa.**—State University of Iowa	500	483.6	620	Central					
WT										
WTAB	**Fall River, Mass.**—Fall River Daily Herald	100	266	1130	Eastern					
WTAC	**Johnstown, Pa.**—Penn Traffic Co.	100	268	1120	Eastern					
WTAD	**Carthage, Ill.**—Robt. E. Compton	50	236	1270	Central					

Radio Call Letters	BROADCAST STATIONS Location and Name	Power Watts	Wave Length (Meters)	Frequency (Kilocycles)	Time at Station	Date	Time Received	Dial 1	Dial 2	Dial 3
WT	**WTAG—Worcester, Mass.**—Worcester Telegram Pub. Co.	500	268	1120	Eastern					
	WTAL—Toledo, Ohio.—Toledo Radio & Electric Co., 316 Jackson St.	10	252	1190	Central					
	WTAM—Cleveland, Ohio.—Willard Storage Battery Co.	3500	389.4	770	Eastern					
	WTAP—Cambridge, Ill.—Cambridge Radio & Electric Co.	50	242	1240	Central					
	WTAQ—Osseo, Wis.—S. H. Van Gorden & Son	100	254	1180	Central					
	WTAR—Norfolk, Va.—Reliance Electric Co., 519 W. 21st St. ..	100	261	1150	Eastern					
	WTAT—Boston, Mass.—(Portable) Edison Electric Illuminating Co., 39 Boylston St.	100	244	1230	Eastern					
	WTAW—College Station, Tex.—Agricultural and Mechanical College of Texas	500	270	1110	Central					
	WTAX—Streator, Ill.—Williams Hardware Co., 115 So. Vermillion Street	50	231	1300	Central					
	WTAZ—Lambertville, N. J.—Thos. J. McGuire	15	261	1150	Eastern					
	WTG—Manhattan, Kans.—Kansas State Agricultural College	50	273	1100	Central					
	WTIC—Hartford, Conn.—Travelers Insurance Co.	500	348.6	860	Eastern					
WW	**WWAD—Philadelphia, Pa.**—Wright & Wright Inc., 2215 N. Broad street	250	250	1200	Eastern					
	WWAE—Plainfield, Ill.—Electric Park (Lawrence J. Crowley)	500	242	1240	Central					
	WWAO—Houghton, Mich.—Michigan College of Mines	250	263	1140	Central					
	WWGL—Richmond Hill, N. Y.—Radio Engineering Corp., 8501 One Hundred and Twenty Fourth Street	500	212.6	1410	Eastern					
	WWI—Dearborn, Mich.—Ford Motor Co.	500	266	1130	Central					
	WWJ—Detroit, Mich,—Detroit News	1000	352.7	850	Central					
	WWL—New Orleans, La.—Loyola University	100	275	1090	Central					

Additions, changes and eliminations of the foregoing list of Radio Broadcast Stations up to and including January 1st, 1926 given on page 176.

RADIO DISTRICTS OF U. S. AND CANADA

The supervision of radio in the United States is under the Department of Commerce. The country is divided into 9 Districts and all Broadcast Stations and Amateur sending stations are under the supervision of the Radio Inspectors, now called Supervisors of Radio. All complaints about interference; applications for licenses for transmitting stations (receiving stations are not subject to Government control) etc., should be addressed to the Supervisor of Radio of the District in which the writer is located.

The radio inspection districts are as follows:

1. Headquarters, Boston, Mass. (supervisor of radio, custom house): Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut.

2. Headquarters, New York, N. Y. (supervisor of radio, U. S. Sub-Treasury): New York (county of New York), Staten Island, Long Island, and counties on the Hudson River to and including Schenectady, Albany, and Rensselaer) and New Jersey (counties of Bergen, Passaic, Essex, Union, Middlesex, Monmouth, Hudson, and Ocean).

3. Headquarters, Baltimore, Md. (supervisor of radio, custom house): New Jersey (all counties not included in second district), Pennsylvania (counties of Philadelphia, Delaware, all counties south of the Blue Mountains, and Franklin County), Delaware, Maryland, Virginia, District of Columbia.

4. Headquarters, Atlanta, Ga. (supervisor of radio, Federal Building): North Carolina, South Carolina, Georgia, Florida, Tennessee, Porto Rico.

5. Headquarters, New Orleans, La. (supervisor of radio, custom house): Alabama, Mississippi, Louisiana, Texas, Arkansas, Oklahoma, New Mexico.

6. Headquarters, San Francisco, Calif. (supervisor of radio, custom house): California, Hawaii, Nevada, Utah, Arizona.

7. Headquarters, Seattle, Wash. (supervisor of radio, 2301 L. C. Smith Building): Oregon, Washington, Alaska, Idaho, Montana, Wyoming.

8. Headquarters, Detroit, Mich. (supervisor of radio, Federal Building): New York (all counties not included in second district), Pennsylvania (all counties not included in third district), West Virginia, Ohio, Michigan (lower peninsula).

9. Headquarters, Chicago, Ill. (supervisor of radio, Federal Building): Indiana, Illinois, Wisconsin, Michigan (upper peninsula), Minnesota, Kentucky, Missouri, Kansas, Colorado, Iowa, Nebraska, South Dakota, North Dakota.

CANADA

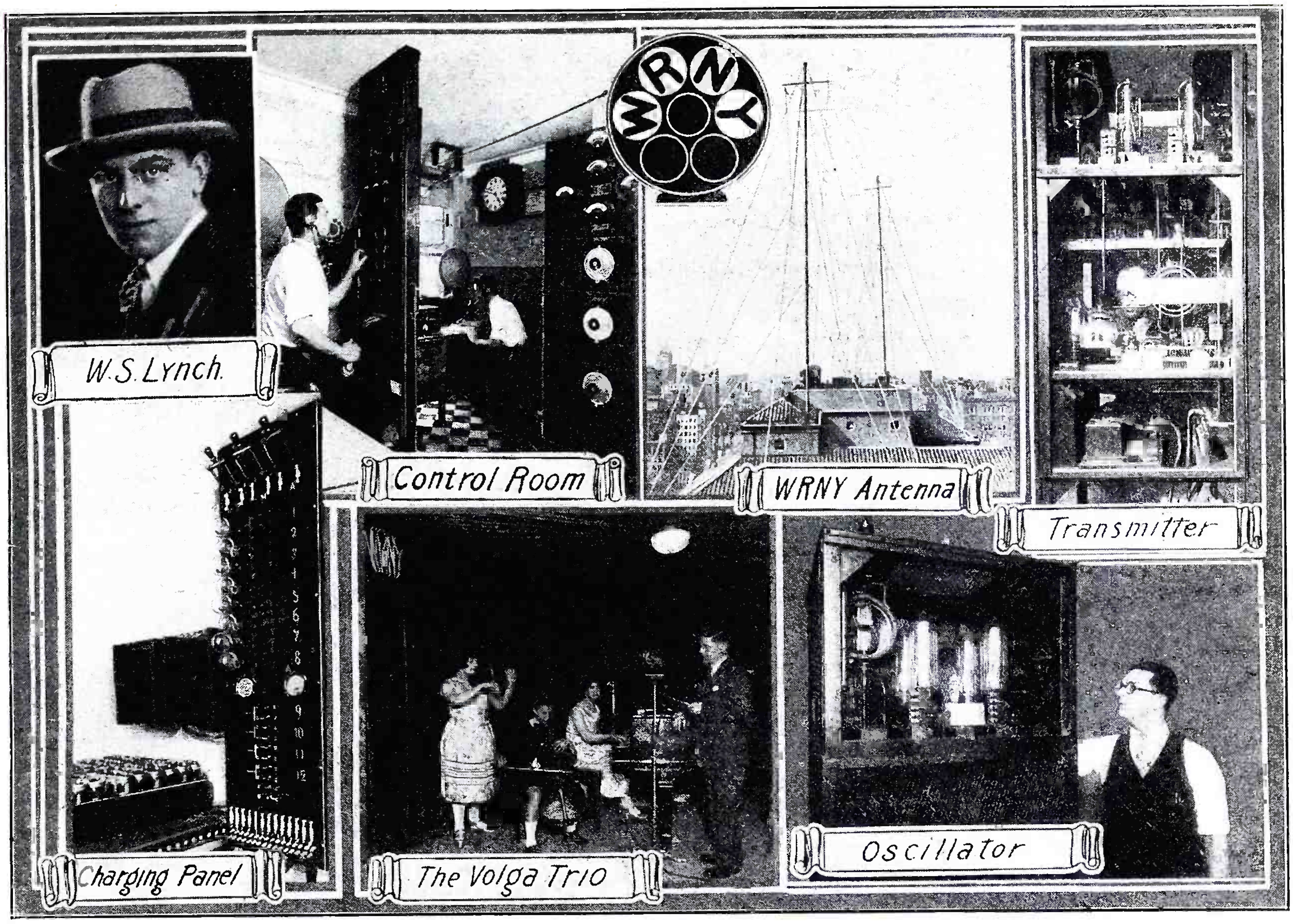
District No. 1—Nova Scotia, New Brunswick and Prince Edward Island.

District No. 2—Province of Quebec.

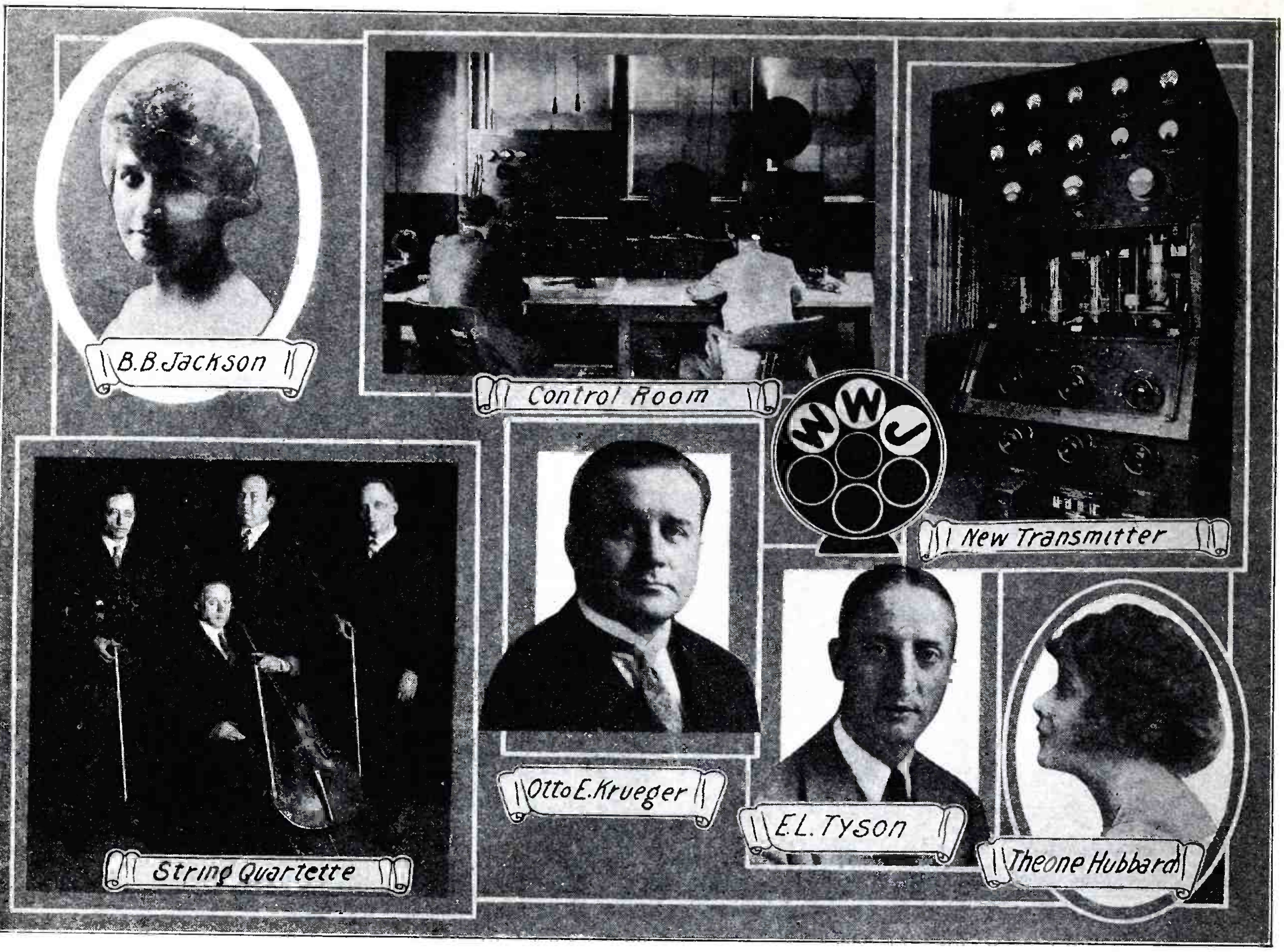
District No. 3—Province of Ontario.

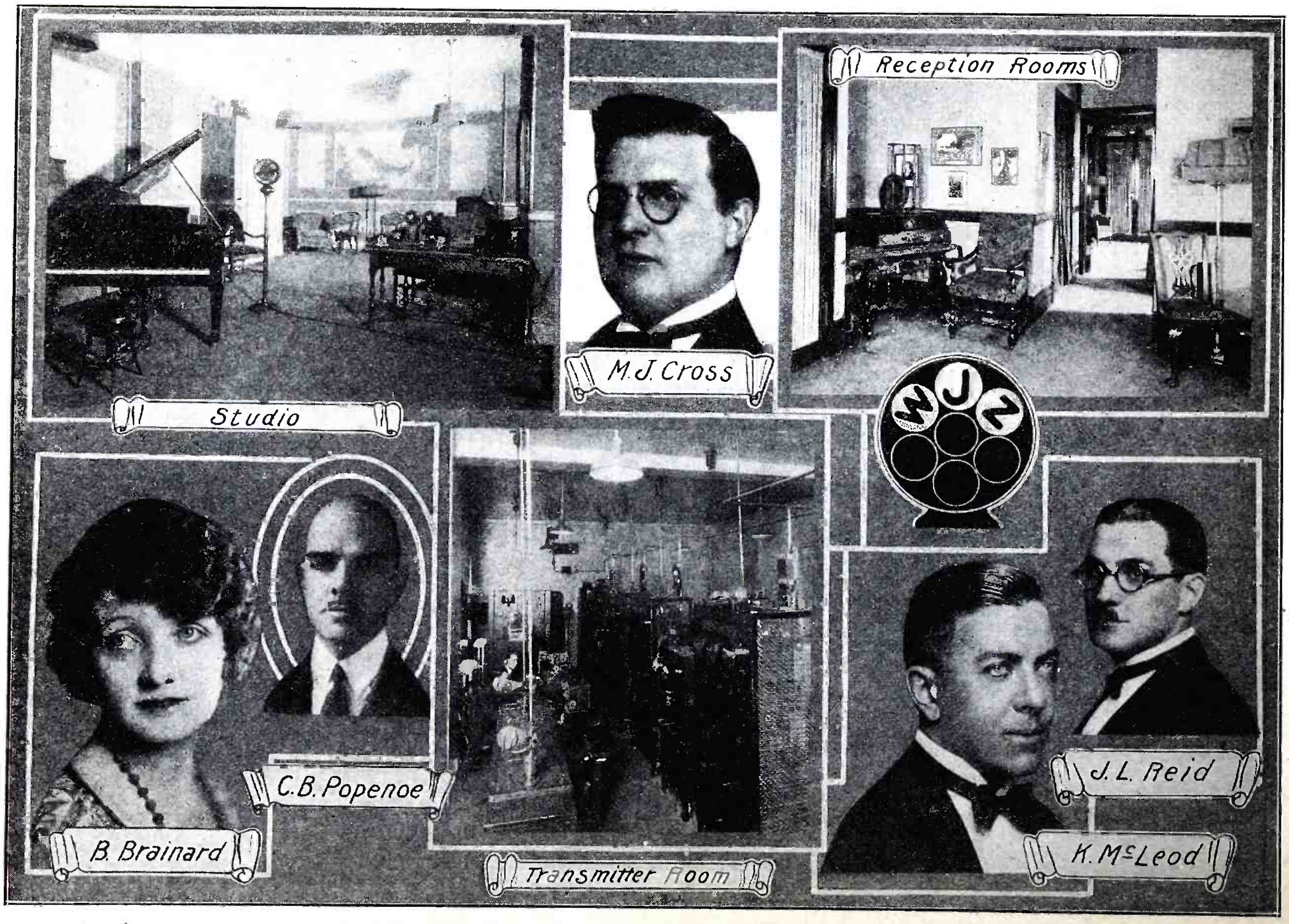
District No. 4—Manitoba, Saskatchewan and Alberta.

District No. 5—British Columbia, Yukon and Northwest Territories.


WRNY
W. S. Lynch.
Control Room
WRNY Antenna
Transmitter
Charging Panel
The Volga Trio
Oscillator


WRNY
Chas. D. Isaacson
Pierre Remington
Anna Russo
Harvey W. Corbett
Lorna Lea
Llonka & Children Dancers
B. Bernie Orchestra

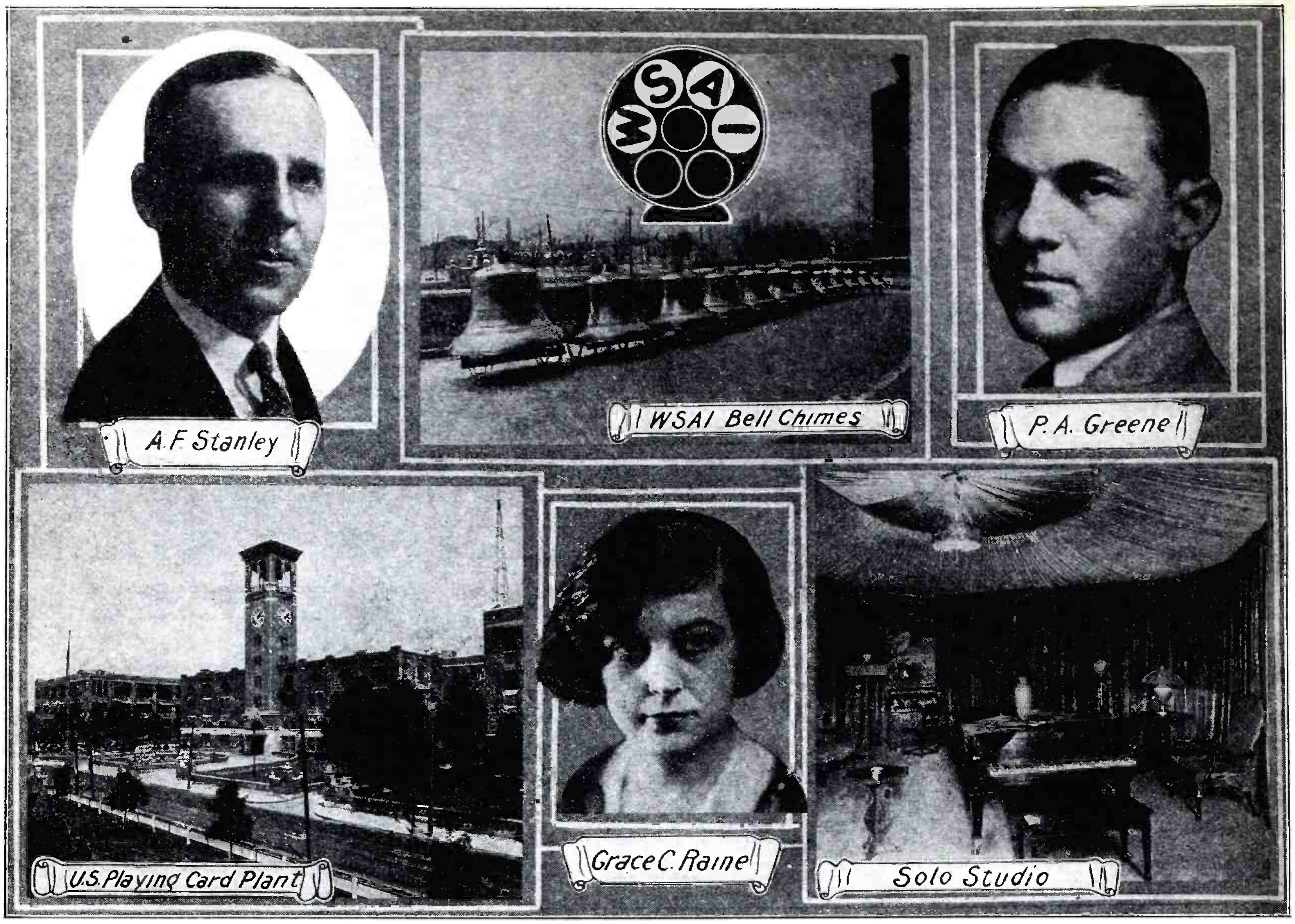

B.B.Jackson
Control Room
WWJ
New Transmitter
String Quartette
Otto E.Krueger
E.L.Tyson
Theone Hubbard


Reception Rooms
M.J.Cross
Studio
WJZ
C.B.Popenoe
B.Brainard
Transmitter Room
J.L.Reid
K.McLeod

RADIO BROADCAST STATIONS OF THE UNITED STATES

By Wavelengths and Frequencies

Wave Length (Meters)	Frequency (Kilocycles)	Call Letters	Location	Date	Time Received	Dial 1	Dial 2	Dial 3
202.6	1480	KFXB	Big Bear Lake, Cal.					
202.6	1480	WEHS	Evanston, Ill.					
202.6	1480	WIBS	Elizabeth, N. J.					
205.4	1460	KFVD	San Pedro, Cal.					
205.4	1460	KFXD	Logan, Utah					
205.4	1460	KFXY	Flagstaff, Ariz.					
205.4	1460	KFYF	Oxnard, Cal.					
205.4	1460	WCBR	Providence, R. I.					
205.4	1460	WFRL	Brooklyn, N. Y.					
205.4	1460	WIBK	Toledo, Ohio					
205.4	1460	WIBX	Utica, New York					
205.4	1460	WOCG	Sycamore, Ill.					
205.4	1460	WPDQ	Buffalo, N. Y.					
206.8	1450	KFWM	Oakland, Cal.					
206.8	1450	WABW	Wooster, Ohio					
206.8	1450	WJBA	Joliet, Ill.					
208.2	1440	KNRC	Los Angeles, Cal.					
209.7	1430	KDZB	Bakersfield, Cal.					
209.7	1430	KFVU	Eureka, Cal.					
209.7	1430	KFXC	Santa Maria, Cal.					
209.7	1430	WCWS	Providence, R. I.					
209.7	1430	WIBH	New Bedford, Mass.					
209.7	1430	WSBC	Chicago, Ill.					
211.1	1420	KFWO	Avalon, Cal.					
211.1	1420	WJBQ	Lewisburg, Pa.					
212.6	1410	KFWV	Portland, Oregon					
212.6	1410	KQP	Portland, Oregon					
212.6	1410	WMAL	Washington, D. C.					
212.6	1410	WWGL	Richmond Hill, N. Y.					
214.2	1400	KFWF	St. Louis, Mo.					
214.2	1400	KFWP	Brownsville, Tex.					
214.2	1400	WCLS	Joliet, Ill.					
214.2	1400	WKBB	Joliet, Ill.					
215.7	1390	KFQW	North Bend, Washington.					
215.7	1390	KFXJ	Denver, Colo.					
215.7	1390	WBBZ	Chicago, Ill.					
215.7	1390	WHBL	Logansport, Ind.					
215.7	1390	WHBR	Cincinnati, Ohio					
215.7	1390	WHBW	Philadelphia, Pa.					
215.7	1390	WIBJ	Chicago, Ill. (Portable)					
215.7	1390	WIBM	Chicago, Ill. (Portable)					
215.7	1390	WKBG	Chicago, Ill. (Portable)					
215.7	1390	WPRC	Harrisburg, Pa.					
215.7	1390	WRST	Bay Shore, N. Y.					
217.3	1380	KFAF	San Jose, Cal.					
217.3	1380	WFKB	Chicago, Ill.					
217.3	1380	KFQU	Alma, Cal. (Holy City)					
217.3	1380	WJD	Granville, Ohio.					


WSAI
A.F. Stanley
WSAI Bell Chimes
P.A. Greene
U.S. Playing Card Plant
Grace C. Raine
Solo Studio


KYW
Harold A. Fall
Lee Sims
Carpenter & Ingram
Wilson Wetherbee
A.W. Kaney
Loos Brothers
Coon & Sanders' Nighthawks
Harold H. Isbell

Wave Length (Meters)	Frequency (Kilocycles)	Call Letters	Location	Date	Time Received	Dial 1	Dial 2	Dial 3
217.3	1380	WOK	Chicago, Ill. (Transmitter in Homewood, Ill.).					
218.8	1370	KFJC	Junction City, Kans.					
218.8	1370	KFRW	Olympia, Wash.					
218.8	1370	KFVH	Manhattan, Kans.					
218.8	1370	WHBU	Anderson, Ind.					
218.8	1370	WIBI	Flushing, N. Y.					
218.8	1370	WJBI	Red Bank, N. J.					
218.8	1370	WJBP	Buffalo, N. Y.					
220	1360	KFOB	Burlingame, Cal.					
220	1360	KFUU	Oakland, Cal.					
220	1360	KJBS	San Francisco, Cal.					
220	1360	WIBW	Logansport, Ind.					
220	1360	WQAA	Parkersburg, Pa.					
222	1350	WBBW	Norfolk, Va.					
222	1350	WBES	Takoma Park, Md.					
222	1350	WHBD	Bellefontaine, Ohio					
222	1350	WHBF	Rock Island, Ill.					
222	1350	WHBH	Culver, Ind.					
222	1350	WIBC	St. Petersburg, Fla.					
222	1350	WIBG	Elkins Park, Pa.					
222	1350	WIBU	Poynette, Wis.					
224	1340	KFBC	San Diego, Cal.					
224	1340	KFBL	Everette, Wash.					
224	1340	KFQP	Iowa City, Ia.					
224	1340	KFUR	Ogden, Utah					
224	1340	KFVS	Cape Girardeau, Mo.					
224	1340	WJBG	Charlotte, N. C.					
224	1340	WKAV	Laconia, N. H. (Portable).					
224	1340	WODA	Paterson, N. J.					
224	1340	WRAF	Laport, Ind.					
226	1330	KFGQ	Boone, Iowa					
226	1330	KFKZ	Kirksville, Mo.					
226	1330	KFOR	David City, Neb.					
226	1330	KFQZ	Hollywood, Cal.					
226	1330	KFWI	So. San Francisco, Cal.					
226	1330	WBBM	Chicago, Ill.					
226	1330	WDAD	Nashville, Tenn.					
226	1330	WEBL	United States (Portable)					
226	1330	WEBM	United States (Portable)					
226	1330	WEBQ	Harrisburg, Ill.					
226	1330	WFBE	Seymour, Ind.					
226	1330	WIBO	Chicago, Ill.					
227	1320	KFVN	Welcome, Minn.					
227	1320	KFXM	Beaumont, Tex.					
227	1320	WDBK	Cleveland, Ohio.					
227	1320	WOWO	Ft. Wayne, Ind.					
229	1310	KFLV	Rockford, Ill.					
229	1310	KPPC	Pasadena, Cal.					
229	1310	WAIT	Taunton, Mass.					
229	1310	WBBL	Richmond, Va.					
229	1310	WCBC	Ann Arbor, Mich.					
229	1310	WCBM	Baltimore, Md.					
229	1310	WDBJ	Roanoke, Va.					
229	1310	WGBR	Marshfield, Wis.					

Wave Length (Meters)	Frequency (Kilocycles)	Call Letters	Location	Date	Time Received	Dial 1	Dial 2	Dial 3
229	1310	WSAJ	Grove City, Pa.					
229	1310	WSAN	Allentown, Pa.					
229	1310	WSAU	Chesham, N. H.					
231	1300	KDLR	Devils Lake, N. Dak.					
231	1300	KFDZ	Minneapolis, Minn.					
231	1300	KFOT	Wichita, Kans.					
231	1300	KFPR	Los Angeles, Cal.					
231	1300	KQW	San Jose, Cal.					
231	1300	KUT	Austin, Texas.					
231	1300	WBRE	Wilkes-Barre, Pa.					
231	1300	WCLO	Camp Lake, Wis.					
231	1300	WHBG	Harrisburg, Pa.					
231	1300	WHBK	Ellsworth, Me.					
231	1300	WIBZ	Montgomery, Ala.					
231	1300	WKBE	Webster, Mass.					
231	1300	WLAX	Greencastle, Ind.					
231	1300	WTAX	Streator, Ill.					
233	1290	KFEY	Kellogg, Idaho.					
233	1290	KFON	Long Beach, Cal.					
233	1290	WDBZ	Kingston, N. Y.					
233	1290	WHAG	Cincinnati, Ohio.					
233	1290	WHBM	Chicago, Ill. (Portable)					
233	1290	WHBQ	Memphis, Tenn.					
233	1290	WJBK	Ypsilanti, Mich.					
233	1290	WOKO	New York, N. Y.					
234	1280	KFUP	Denver, Colo.					
234	1280	KGTT	San Francisco, Cal.					
234	1280	KMJ	Fresno, Calif.					
234	1280	WEBE	Cambridge, Ohio.					
234	1280	WFBD	Philadelphia, Pa.					
234	1280	WFDF	Flint, Mich.					
234	1280	WGBM	Providence, R. I.					
234	1280	WGBQ	Menominee, Wis.					
234	1280	WHBJ	Fort Wayne, Ind.					
234	1280	WJBC	LaSalle, Ill.					
236	1270	KFLU	San Benito, Tex.					
236	1270	KFOO	Salt Lake City, Utah.					
236	1270	KFVG	Independence, Kans.					
236	1270	KFXE	Waterloo, Ia.					
236	1270	KWKC	Kansas City, Mo.					
236	1270	WBOQ	Richmond Hill, N. Y.					
236	1270	WCBQ	Nashville, Tenn.					
236	1270	WFBI	Camden, N. J.					
236	1270	WFBJ	Collegeville, Minn.					
236	1270	WGBF	Evansville, Ind.					
236	1270	WGBT	Greenville, S. C.					
236	1270	WGMU	Richmond Hill, N. Y. (Portable)					
236	1270	WIBA	Madison, Wis.					
236	1270	WRMU	Richmond Hill, N. Y. (Yacht)					
236	1270	WTAD	Carthage, Ill.					
238	1260	KFBS	Trinidad, Colo.					
238	1260	KFCB	Phoenix, Ariz.					
238	1260	KFWU	Pineville, La.					
238	1260	KFYJ	Houston, Texas					
238	1260	KMTR	Los Angeles, Cal.					

Wave Length (Meters)	Frequency (Kilocycles)	Call Letters	Location	Date	Time Received	Dial 1	Dial 2	Dial 3
238	1260	WBBP	Petoskey, Mich.					
238	1260	WCUW	Worcester, Mass.					
238	1260	WHBN	St. Petersburg, Fla.					
238	1260	WHT	Chicago, Ill. (Transmitter in Deerfield, Ill.).					
238	1260	WRAW	Reading, Pa.					
240	1250	KFHL	Oskaloosa, Iowa					
240	1250	KFLX	Galveston, Texas					
240	1250	KFVE	St. Louis, Mo.					
240	1250	KFVI	Houston, Texas					
240	1250	KTAB	Oakland, Cal.					
240	1250	KZM	Oakland, Cal.					
240	1250	WABI	Bangor, Me.					
240	1250	WCAT	Rapid City, S. D.					
240	1250	WDBO	Winter Park, Fla.					
240	1250	WGBI	Scranton, Pa.					
240	1250	WHAP	New York, N. Y.					
240	1250	WKAD	E. Providence, R. I.					
240	1250	WOAX	Trenton, N. J.					
240	1250	WSMH	Owosso, Mich.					
242	1240	KFFP	Moberly, Mo.					
242	1240	KFOJ	Moberly, Mo.					
242	1240	KFPM	Greenville, Texas					
242	1240	KFRM	Fort Sill, Okla.					
242	1240	KFUJ	Breckenridge, Minn.					
242	1240	KFUM	Colorado Springs, Colo.					
242	1240	KFXH	El Paso, Texas					
242	1240	KSO	Clarinda, Iowa					
242	1240	WABY	Philadelphia, Pa.					
242	1240	WBZA	Boston, Mass.					
242	1240	WCBH	Oxford, Miss.					
242	1240	WEBC	Superior, Wis.					
242	1240	WEBK	Grand Rapids, Mich.					
242	1240	WTAP	Cambridge, Ill.					
242	1240	WWAE	Plainfield, Ill.					
244	1230	KFVR	Denver, Colo.					
244	1230	KUOM	Missoula, Mont.					
244	1230	WAMD	Minneapolis, Minn.					
244	1230	WEBR	Buffalo, N. Y.					
244	1230	WGBB	Freeport, N. Y.					
244	1230	WNAX	Yankton, S. D.					
244	1230	WRAM	Galesburg, Ill.					
244	1230	WSAZ	Pomeroy, Ohio					
244	1230	WTAT	Boston, Mass. (Portable)					
246	1220	KDYL	Salt Lake City, Utah					
246	1220	KFJI	Astoria, Oregon					
246	1220	KFJY	Fort Dodge, Iowa					
246	1220	KFVW	San Diego, Cal.					
246	1220	KGY	Lacey, Wash.					
246	1220	WABX	Mount Clemens, Mich.					
246	1220	WEBD	Anderson, Ind.					
246	1220	WIBR	Weirton, W. Va.					
246	1220	WQAE	Springfield, Vt.					
246	1220	WRR	Dallas, Texas					
246	1220	WSOE	Milwaukee, Wis.					
248	1210	KFBK	Sacremento, Cal.					


Control Room
Edward A. Davies
Uncle WIP
GIMBELS RADIO WIP
Antenna Tower
WIP
Battery Installation
Main Studio
Chas E. Weir

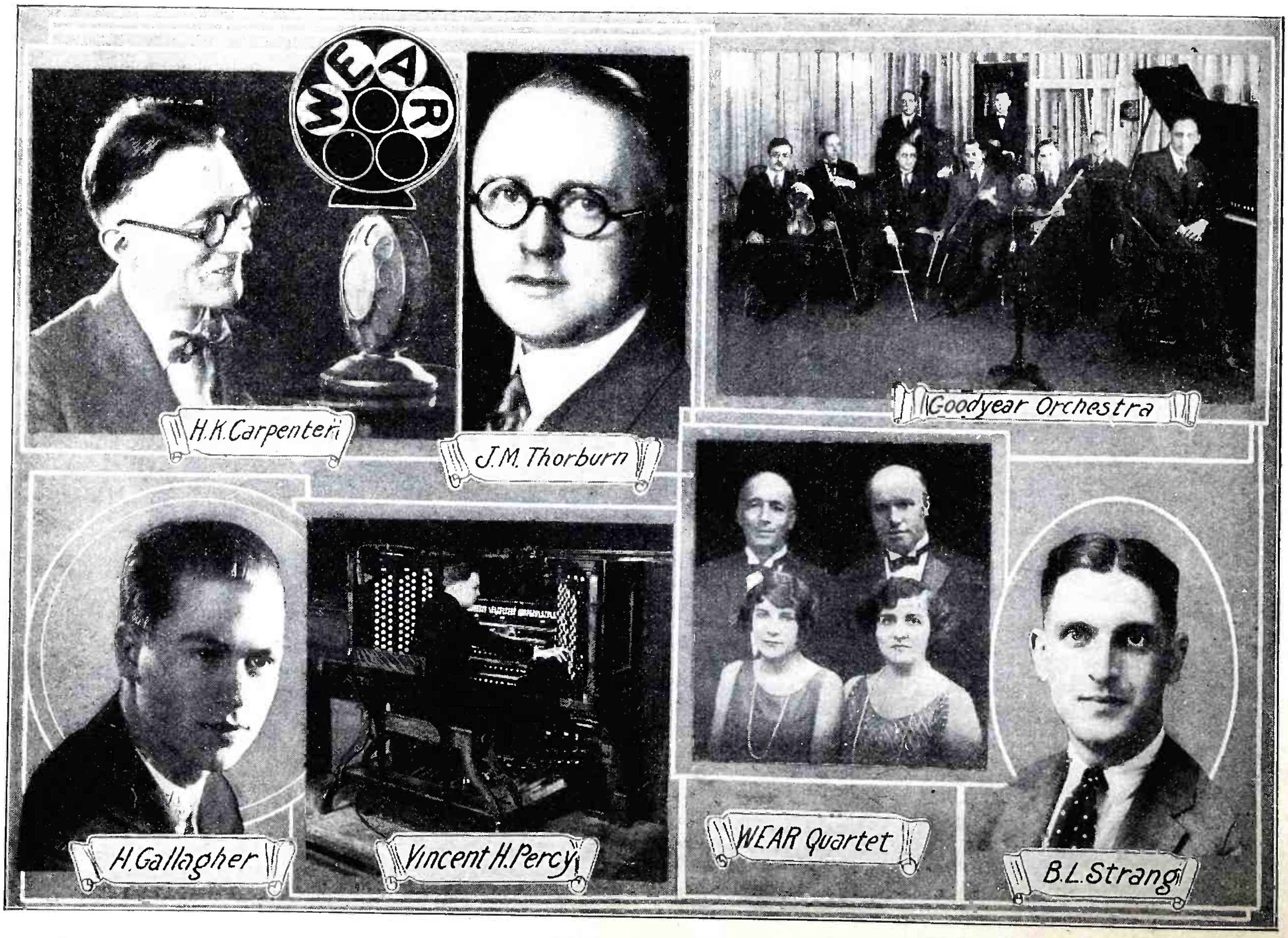

Studio
Johanna Grosse
John Johnan
WLW
"The Pups"
William Stoess
Powel Crosley Jr.
"Hello Boys"

Wave Length (Meters)	Frequency (Kilocycles)	Call Letters	Location	Date	Time Received	Dial 1	Dial 2	Dial 3
248	1210	KFEC	Portland, Oregon					
248	1210	KFIF	Portland, Oregon					
248	1210	KFJB	Marshalltown, Iowa					
248	1210	KFOX	Omaha, Neb.					
248	1210	KFRB	Beeville, Texas					
248	1210	KFYR	Bismarck, N. D.					
248	1210	KWG	Stockton, Cal.					
248	1210	WAPI	Auburn, Ala.					
248	1210	WBRC	Birmingham, Ala.					
248	1210	WCSO	Springfield, Ohio					
248	1210	WEW	St. Louis, Mo.					
248	1210	WGAL	Lancaster, Pa.					
248	1210	WGBK	Johnstown, Pa.					
248	1210	WMAY	St. Louis, Mo.					
248	1210	WNBH	New Bedford, Mass.					
250	1200	KDPM	Cleveland, Ohio					
250	1200	KFBG	Tacoma, Wash.					
250	1200	KFDX	Shreveport, La.					
250	1200	KFVY	Albuquerque, N. Mex.					
250	1200	KFXF	Colorado Springs, Colo.					
250	1200	KGB	Tacoma, Wash.					
250	1200	KMO	Tacoma, Wash.					
250	1200	KUO	San Francisco, Cal.					
250	1200	WCAX	Burlington, Vt.					
250	1200	WFBC	Knoxville, Tenn.					
250	1200	WGES	Oak Park, Ill.					
250	1200	WHBA	Oil City, Pa.					
250	1200	WHBY	West De Pere, Wis.					
250	1200	WIAD	Philadelphia, Pa.					
250	1200	WLAL	Tulsa, Okla.					
250	1200	WMBB	Chicago, Ill.					
250	1200	WNAB	Boston, Mass.					
250	1200	WNAT	Philadelphia, Pa.					
250	1200	WQAN	Scranton, Pa.					
250	1200	WWAD	Philadelphia, Pa.					
252	1190	KFHA	Gunnison, Colo.					
252	1190	KFOY	St. Paul, Minn.					
252	1190	KFPL	Dublin, Texas					
252	1190	KFUV	Springfield, Mo.					
252	1190	KFWB	Hollywood, Cal.					
252	1190	KLS	Oakland, Cal.					
252	1190	KMA	Shenandoah, Iowa					
252	1190	KOCW	Chickasha, Okla.					
252	1190	KWUC	Le Mars, Iowa					
252	1190	WBBS	New Orleans, La.					
252	1190	WFBL	Syracuse, N. Y.					
252	1190	WGBX	Orono, Me.					
252	1190	WGCP	New York, N. Y. (Transmitter in Newark, N. J.).					
252	1190	WNJ	Newark, N. J.					
252	1190	WRCO	Raleigh, N. C.					
252	1190	WRHM	Minneapolis, Minn.					
252	1190	WSRO	Hamilton, Ohio					
252	1190	WTAL	Toledo, Ohio					
254	1180	KFEL	Denver, Colo.					
254	1180	KFJZ	Fort Worth, Texas					

Wave Length (Meters)	Frequency (Kilocycles)	Call Letters	Location	Date	Time Received	Dial 1	Dial 2	Dial 3
254	1180	KFLR	Albuquerque, N. Mex.					
254	1180	KFWH	Chico, Cal.					
254	1180	WABC	Asheville, N. C.					
254	1180	WCAJ	University Place, Neb.					
254	1180	WCBA	Allentown, Pa.					
254	1180	WEAI	Ithaca, N. Y.					
254	1180	WFBR	Baltimore, Md.					
254	1180	WFBZ	Galesburg, Ill.					
254	1180	WHBC	Canton, Ohio					
254	1180	WIAS	Burlington, Iowa					
254	1180	WJAK	Greentown, Ind.					
254	1180	WJBB	St. Petersburg, Fla.					
254	1180	WNAD	Norman, Okla.					
254	1180	WREC	Coldwater, Miss.					
254	1180	WSAR	Fall River, Mass.					
254	1180	WTAQ	Osseo, Wis.					
256	1170	KFCF	Walla Walla, Wash.					
256	1170	KFIQ	Yakima, Wash.					
256	1170	KFUS	Oakland, Cal.					
256	1170	KRE	Berkeley, Cal.					
256	1170	KTNT	Muscatine, Iowa					
256	1170	WBAX	Wilkes-Barre, Pa.					
256	1170	WBDC	Grand Rapids, Mich.					
256	1170	WCSH	Portland, Me.					
256	1170	WDCH	Hanover, N. H.					
256	1170	WDOD	Chattanooga, Tenn.					
256	1170	WEBT	Dayton, Ohio					
256	1170	WHBP	Johnstown, Pa.					
256	1170	WJBN	Sycamore, Ill.					
256	1170	WRAK	Escanaba, Mich.					
256	1170	WRVA	Richmond, Va.					
256.4	1170	WMBC	Detroit, Mich.					
258	1160	KFJX	Cedar Falls, Ia.					
258	1160	KFPW	Carterville, Mo.					
258	1160	KFUL	Galveston, Texas					
258	1160	KOCH	Omaha, Neb.					
258	1160	WAAD	Cincinnati, Ohio					
258	1160	WADC	Akron, Ohio					
258	1160	WDBC	Lancaster, Pa.					
253	1160	WHEC	Rochester, N. Y.					
258	1160	WLTS	Chicago, Ill.					
258	1160	WNAL	Omaha, Neb.					
258	1160	WPCC	Chicago, Ill.					
258	1160	WRNY	New York, N. Y.					
258.6	1160	WAGM	Royal Oak, Mich.					
261	1150	KFAJ	Boulder, Colo.					
261	1150	KFJF	Oklahoma, Okla.					
261	1150	KFMR	Sioux City, Iowa					
261	1150	KFQA	St. Louis, Mo.					
261	1150	KFUT	Salt Lake City, Utah					
261	1150	KFWA	Ogden, Utah					
261	1150	KMOX	St. Louis, Mo.					
261	1150	KWKH	Kennonwood, La.					
261	1150	WABQ	Haverford, Pa.					
261	1150	WARC	Medford Hillside, Mass.					
261	1150	WDAY	Fargo, N. D.					

Wave Length (Meters)	Frequency (Kilocycles)	Call Letters	Location	Date	Time Received	Dial 1	Dial 2	Dial 3
261	1150	WDBR	Boston, Mass.					
261	1150	WEAM	No. Plainfield, N. J.					
261	1150	WKAF	Milwaukee, Wis.					
261	1150	WMAZ	Macon, Ga.					
261	1150	WOAC	Lima, Ohio					
261	1150	WPSC	State College, Pa.					
261	1150	WSKC	Bay City, Mich.					
261	1150	WTAR	Norfolk, Va.					
261	1150	WTAZ	Lambertville, N. J.					
263	1140	KFJR	Portland, Oregon					
263	1140	KFMW	Houghton, Mich.					
263	1140	KFNF	Shenandoah, Iowa					
263	1140	KFQB	Fort Worth, Texas					
263	1140	KTBR	Portland, Oregon					
263	1140	WABR	Toledo, Ohio					
263	1140	WBPI	New York, N. Y. (Transmitter is in Newark, N. J.)					
263	1140	WCAD	Canton, N. Y.					
263	1140	WCAR	San Antonio, Texas					
263	1140	WCBE	New Orleans, La.					
263	1140	WDAG	Amarillo, Texas					
263	1140	WEBZ	Savannah, Ga.					
263	1140	WHAT	Minneapolis, Minn.					
263	1140	WIBV	Henderson, N. C.					
263	1140	WQAM	Miami, Fla.					
263	1140	WRAV	Yellow Springs, Ohio					
263	1140	WSDA	New York, N. Y.					
263	1140	WWAO	Houghton, Mich.					
266	1130	KFPY	Spokane, Wash.					
266	1130	KFRY	State College, N. Mex.					
266	1130	KFWD	Arkadelphia, Ark.					
266	1130	KLZ	Denver, Colo.					
266	1130	WABB	Harrisburg, Pa.					
266	1130	WBCN	Chicago, Ill.					
266	1130	WCAH	Columbus, Ohio					
266	1130	WENR	Chicago, Ill.					
266	1130	WGHB	Clearwater, Fla.					
266	1130	WHAV	Wilmington, Del.					
266	1130	WMAK	Lockport, N. Y.					
266	1130	WTAB	Fall River, Mass.					
266	1130	WWI	Dearborn, Mich.					
268	1120	KFEQ	Oak, Nebr.					
268	1120	KFGC	Baton Rouge, La.					
268	1120	KFRC	San Francisco, Cal.					
268	1120	WAAB	New Orleans, La.					
268	1120	WBBY	Charleston, S. C.					
268	1120	WCBG	Pascagoula, Miss.					
268	1120	WDRC	New Haven, Conn.					
268	1120	WEAH	Wichita, Kans.					
268	1120	WEBW	Beloit, Wis.					
268	1120	WFBM	Indianapolis, Ind.					
268	1120	WJAM	Cedar Rapids, Iowa					
268	1120	WNOX	Knoxville, Tenn.					
268	1120	WRAX	Gloucester City, N. J.					
268	1120	WSAX	Chicago, Ill. (Portable)					
268	1120	WTAC	Johnstown, Pa.					


WTAM
John T. Voepe
Birds Eye View of WTAM
L.W. Zimmerman
A.R. Herske
Guy Lombardo's Royal Canadians
Blue Room Studio
Ralph Humphrey


WEAR
H.K. Carpenter
J.M. Thorburn
Goodyear Orchestra
H. Gallagher
Vincent H. Percy
WEAR Quartet
B.L. Strang

Wave Length (Meters)	Frequency (Kilocycles)	Call Letters	Location	Date	Time Received	Dial 1	Dial 2	Dial 3
268	1120	WTAG	Worcester, Mass.					
270	1110	KFBU	Laramie, Wyoming					
270	1110	KFGH	Stanford University, Cal.					
270	1110	WBAO	Decatur, Ill.					
270	1110	WDBE	Atlanta, Ga.					
270	1110	WEAN	Providence, R. I.					
270	1110	WEAY	Houston, Texas					
270	1110	WGHP	Detroit, Mich.					
270	1110	WGST	Atlanta, Ga.					
270	1110	WJAG	Norfolk, Nebr.					
270	1110	WJBL	Decatur, Ill.					
270	1110	WOI	Ames, Iowa					
270	1110	WOWD	New Orleans, La.					
270	1110	WRK	Hamilton, Ohio					
270	1110	WTAW	College Station, Texas					
273	1100	KFAD	Phoenix, Ariz.					
273	1100	KFDY	Brookings, S. Dak.					
273	1100	KFIZ	Fondulac, Wis.					
273	1100	KFKA	Greeley, Colo.					
273	1100	KFLZ	Atlantic, Iowa					
273	1100	KHQ	Spokane, Wash.					
273	1100	WBAA	West Lafayette, Ind.					
273	1100	WBBR	Rossville, N. Y.					
273	1100	WDAE	Tampa, Fla.					
273	1100	WEBJ	New York, N. Y.					
273	1100	WFAM	St. Cloud, Minn.					
273	1100	WFBH	New York, N. Y.					
273	1100	WHK	Cleveland, Ohio					
273	1100	WIL	St. Louis, Mo.					
273	1100	WRM	Urbana, Ill.					
273	1100	WRW	Tarrytown, N. Y.					
273	1100	WSBF	St. Louis, Mo.					
273	1100	WTG	Manhattan, Kans.					
275	1090	KFBB	Harve, Mont.					
275	1090	KFFY	Alexandria, La.					
275	1090	KFKU	Lawrence, Kans.					
275	1090	KFSG	Los Angeles, Cal.					
275	1090	KQV	Pittsburgh, Pa.					
275	1090	WABZ	New Orleans, La.					
275	1090	WAFD	Port Huron, Mich.					
275	1090	WBAK	Harrisburg, Pa.					
275	1090	WBT	Charlotte, N. C.					
275	1090	WCAC	Mansfield, Conn.					
275	1090	WCAO	Baltimore, Md.					
275	1090	WCEE	Elgin, Ill.					
275	1090	WEAU	Sioux City, Iowa					
275	1090	WFAV	Lincoln, Neb.					
275	1090	WHAD	Milwaukee, Wis.					
275	1090	WHAR	Atlantic City, N. J.					
275	1090	WJAS	Pittsburgh, Pa.					
275	1090	WKY	Oklahoma, Okla.					
275	1090	WLAP	Louisville, Ky.					
275	1090	WMAC	Cazenovia, N. Y.					
275	1090	WOCL	Jamestown, N. Y.					
275	1090	WORD	Batavia, Ill.					
275	1090	WPAK	Agricultural College, N. D.					

Wave Length (Meters)	Frequency (Kilocycles)	Call Letters	Location	Date	Time Received	Dial 1	Dial 2	Dial 3
275	1090	WSBT	South Bend, Ind.					
275	1090	WSMK	Dayton, Ohio					
275	1090	WWL	New Orleans, La.					
278	1080	KFDD	Boise, Idaho					
278	1080	KFJM	Grand Forks, N. D.					
278	1080	KOIL	Council Bluffs, Iowa					
278	1080	KUSD	Vermillon, S. D.					
278	1080	KWCR	Cedar Rapids, Iowa					
278	1080	KWWG	Brownsville, Texas					
278	1080	WAAF	Chicago, Ill.					
278	1080	WAAW	Omaha, Nebr.					
278	1080	WABO	Rochester, N. Y.					
278	1080	WCAU	Philadelphia, Pa.					
278	1080	WDZ	Tuscola, Ill.					
278	1080	WFBG	Altoona, Pa.					
278	1080	WGBC	Memphis, Tenn.					
278	1080	WGBU	Fulford-by-the-Sea, Fla.					
278	1080	WHAM	Rochester, N. Y.					
278	1080	WHDI	Minneapolis, Minn.					
278	1080	WLB	Minneapolis, Minn.					
278	1080	WLBL	Stevens Point, Wis.					
278	1080	WMAN	Columbus, Ohio					
278	1080	WOQ	Kansas City, Mo.					
278	1080	WRBC	Valparaiso, Ind.					
280.2	1070	WNAC	Boston, Mass.					
282.8	1060	KFAU	Boise, Idaho					
282.8	1060	KFDJ	Corvallis, Oregon					
282.8	1060	WOAN	Lawrenceburg, Tenn.					
282.8	1060	WSM	Nashville, Tenn.					
285.5	1050	WEMC	Berrien Springs, Mich.					
285.5	1050	WKAR	East Lansing, Mich.					
285.5	1050	WREO	Lansing, Mich.					
288.3	1040	KFKX	Hastings, Neb.					
288.3	1040	WLWL	New York, N. Y.					
293.9	1020	KTBI	Los Angeles, Cal.					
293.9	1020	WAIU	Columbus, Ohio					
293.9	1020	WEAO	Columbus, Ohio					
296.9	1010	KPRC	Houston, Texas					
299.8	1000	KFMQ	Fayetteville, Ark.					
299.8	1000	KSL	Salt Lake City, Utah					
299.8	1000	WPG	Atlantic City, N. J.					
302.8	990	WGN	Chicago, Ill.					
302.8	990	WLIB	Elgin, Ill.					
305.9	980	KTCL	Seattle, Wash.					
305.9	980	WJAR	Providence, R. I.					
309.1	970	KDKA	Pittsburgh, Pa.. (Transmitter is in East Pittsburgh, Pa.)					
315.6	950	KFDM	Beaumont, Texas					
315.6	950	KPSN	Pasadena, Cal.					
315.6	950	WAHG	Richmond Hill, N. Y.					
315.6	950	WGBS	New York, N. Y.					
319	940	WGR	Buffalo, N. Y.					
319	940	WSMB	New Orleans, La.					
322.4	930	KOA	Denver, Colo.					
322.4	930	WJAZ	Chicago, Ill. (Transmitter in Mount Prospect, Ill.).					
325.9	920	WKRC	Cincinnati, Ohio					

Wave Length (Meters)	Frequency (Kilocycles)	Call Letters	Location	Date	Time Received	Dial 1	Dial 2	Dial 3
325.9	920	WSAI	Cincinnati, Ohio (Transmitter is in Mason, Ohio).					
331.1	900	WBZ	Springfield, Mass.					
336.9	890	KFMX	Northfield, Minn.					
336.9	890	KNX	Los Angeles, Cal.					
336.9	890	WCAL	Northfield, Minn.					
336.9	890	WJAX	Jacksonville, Fla.					
340.7	880	KFAB	Lincoln, Nebr.					
340.7	880	KSAC	Manhattan, Kans.					
340.7	880	WMCA	New York, N. Y. (Transmitter is in Hoboken, N. J.).					
344.6	870	WCBD	Zion, Ill.					
344.6	870	WLS	Chicago, Ill. (Transmitter is in Crete, Ill.).					
348.6	860	KOB	State College, N. Mex.					
348.6	860	KWSC	Pullman, Wash.					
348.6	860	WTIC	Hartford, Conn.					
352.7	850	WJAD	Waco, Tex.					
352.7	850	WWJ	Detroit, Mich.					
360	833	WQAO	New York, N. Y.					
361.2	830	KGO	Oakland, Cal.					
361.2	830	WHN	New York, N. Y.					
365.6	820	WDAF	Kansas City, Mo.					
365.6	820	WHB	Kansas City, Mo.					
370.2	810	WJJD	Mooseheart, Ill.					
370.2	810	WEBH	Chicago, Ill.					
374.8	800	KTHS	Hot Springs, Ark.					
374.8	800	KVOO	Bristow, Okla.					
374.8	800	WBAL	Baltimore, Md.					
379.5	790	WGY	Schenectady, N. Y.					
379.5	790	WHAZ	Troy, N. Y.					
384.4	780	KJR	Seattle, Wash.					
384.4	780	WMBF	Miami Beach, Fla.					
389.4	770	WEAR	Cleveland, Ohio					
389.4	770	WTAM	Cleveland, Ohio					
394.5	760	WOAI	San Antonio, Texas					
394.5	760	WFI	Philadelphia, Pa.					
394.5	760	WLIT	Philadelphia, Pa.					
399.8	750	WHAS	Louisville, Ky.					
405.2	740	KHJ	Los Angeles, Cal.					
405.2	740	WJY	New York, N. Y.					
405.2	740	WOR	Newark, N. J.					
416.4	720	WCCO	St. Paul,—Minneapolis, Minn.					
422.3	710	WKRC	Cincinnati, Ohio					
422.3	710	WLW	Cincinnati, Ohio (Transmitter is in Harrison, Ohio.).					
428.3	700	KPO	San Francisco, Cal.					
428.3	700	WSB	Atlanta, Ga.					
434.5	690	NAA	Arlington, Va.					
440.9	680	KLDS	Independence, Mo.					
440.9	680	WDWF	Cranston, R. I.					
440.9	680	WMAF	Dartmouth, Mass.					
440.9	680	WOS	Jefferson City, Mo.					
447.5	670	WMAQ	Chicago, Ill.					
447.5	670	WQJ	Chicago, Ill.					
454.3	660	KFOA	Seattle, Wash.					


WCCO
Meta A. Birnbach
L. Emmel.
The Sumpmann Trio
H. A. Bellows
Paul Johnson
L. D. Lindstrom
Helen Smith


Studio
M. A. Rigg Jr.
O. E. Becker
WGR
Helen M. White
Control Room
K. M. Fickett

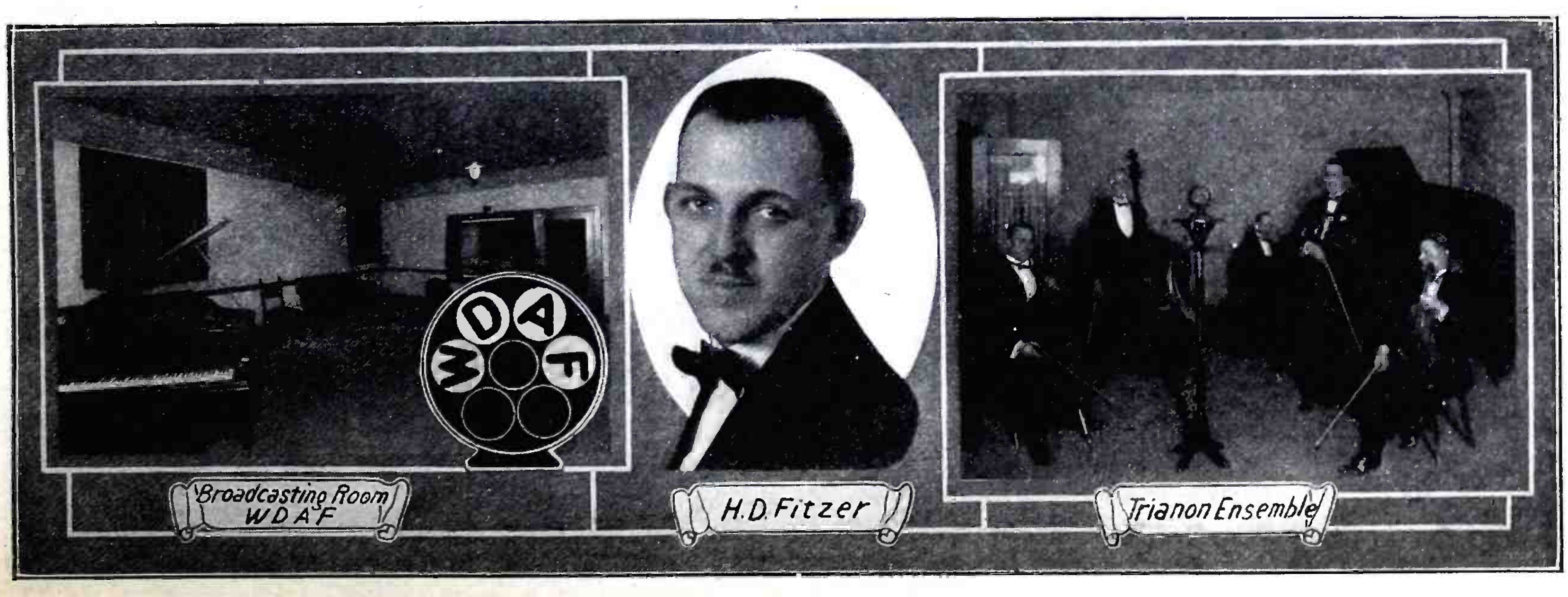
Wave Length (Meters)	Frequency (Kilocycles)	Call Letters	Location	Date	Time Received	Dial 1	Dial 2	Dial 3
454.3	660	KTW	Seattle, Wash.					
454.3	660	WJZ	New York, N. Y.					
461.3	650	WCAE	Pittsburgh, Pa.					
468.5	640	KFI	Los Angeles, Cal.					
468.5	640	WCAP	Washington, D. C.					
468.5	640	WRC	Washington, D. C.					
475.9	630	WBAP	Fort Worth, Tex.					
475.9	630	WEEI	Boston, Mass.					
475.9	630	WFAA	Dallas, Texas					
483.6	620	WOC	Davenport, Ia.					
483.6	620	WSUI	Iowa City, Iowa					
491.5	610	KGW	Portland, Oregon					
491.5	610	WEAF	New York, N. Y.					
499.7	600	KFRU	Columbia, Mo.					
499.7	600	WMC	Memphis, Tenn.					
508.2	590	KLX	Oakland, Cal.					
508.2	590	WIP	Philadelphia, Pa.					
508.2	590	WOO	Philadelphia, Pa.					
516.9	580	WCX	Pontiac, Mich.					
516.9	580	WJR	Detroit, Mich. (Transmitter is in Pontiac, Mich.)					
526	570	WHO	Des Moines, Iowa					
526	570	WNYC	New York, N. Y.					
526	570	WOAW	Omaha, Nebr.					
535.4	560	KYW	Chicago, Ill.					
535.4	560	WHA	Madison, Wis.					
545.1	550	KFUO	St. Louis, Mo.					
545.1	550	KSD	St. Louis, Mo.					

All About Standard Time

The United States adopted standard time in 1883, on the initiative of the American Railway Association, and at noon of November 18th, 1883, the telegraphic time signals sent out daily from the Naval Observatory at Washington were changed to the new system, according to which the meridians of 75°, 90°, 105°, and 120° west from Greenwich became the time meridians of Eastern, Central, Mountain, and Pacific standard time respectively.

United States standard Eastern time is used from the Atlantic Ocean to a line through Toledo, Monroeville, Mansfield and Newark, O.; thence through Huntington, W. Va; Norton, Va.; Johnson City, Tenn.; Asheville, N. C. Atlanta and Macon, Ga.; and Apalachicola, Fla. U. S. standard Central time is used from this first line to a line through Mandan, N. D.; Pierre, S. D.; McCook, Neb.; Dodge City, Kans., and along west line of Okla., and Tex.; standard Mountain time is used from the second line to a line that forms the western boundary of Mont., thence follows the Salmon River westward, the western boundary of Idaho southward, the southern boundary of Idaho eastward, and thence passes southward through Ogden and Salt Lake City, Utah; Parker and Yuma, Ariz. U. S. standard Pacific time is used from the third line to the Pacific Ocean.

Almost all countries throughout the world use standard time that differs from Greenwich time by a whole number of hours or half-hours; a few countries, however, use standard time based on the longitude of their national observatories.



Broadcasting Room WDAF — H. D. Fitzer — Trianon Ensemble

C. R. Randall

L. J. Gallo Quartette

Station WSMB

Dixola Novelty Orchestra

Mildred Butz

Studio

Marie Morgott

Eddie Loftus

Ziegler Sisters

Corinne Jordan

Chalie Garland

STX Orchestra

Fred Teske

RADIO BROADCAST STATIONS OF THE UNITED STATES

By States and Cities

STATES	CITIES	Call Letters	Wave Length (Meters)	Date	Time Received	Dial 1	Dial 2	Dial 3
ALABAMA	Auburn	WAPI	248					
"	Birmingham	WBRC	248					
"	Montgomery	WIBZ	231					
ARIZONA	Flagstaff	KFXY	205.4					
"	Phoenix	KFAD	273					
"	Phoenix	KFCB	238					
ARKANSAS	Arkadelphia	KFWD	266					
"	Fayetteville	KFMQ	299.8					
"	Hot Springs	KTHS	374.8					
CALIFORNIA	Alma (Holy City)	KFQU	217.3					
"	Avalon	KFWO	211.1					
"	Bakersfield	KDZB	209.7					
"	Berkeley	KRE	256					
"	Big Bear Lake	KFXB	202.6					
"	Burlingame	KFOB	220					
"	Chico	KFWH	254					
"	Eureka	KFVU	209.7					
"	Fresno	KMJ	234					
"	Hollywood	KFQZ	226					
"	Hollywood	KFWB	252					
"	Long Beach	KFON	233					
"	Los Angeles	KFI	468.5					
"	Los Angeles	KFPR	231					
"	Los Angeles	KFSG	275					
"	Los Angeles	KHJ	405.2					
"	Los Angeles	KMTR	238					
"	Los Angeles	KNRC	208.2					
"	Los Angeles	KNX	336.9					
"	Los Angeles	KTBI	293.9					
"	Oakland	KFUS	256					
"	Oakland	KFUU	220					
"	Oakland	KFWM	206.8					
"	Oakland	KGO	361.2					
"	Oakland	KLS	252					
"	Oakland	KLX	508.2					
"	Oakland	KTAB	240					
"	Oakland	KZM	240					
"	Oxnard	KFYF	205.4					
"	Pasadena	KPPC	229					
"	Pasadena	KPSN	315.6					
"	Sacramento	KFBK	248					
"	San Diego	KFBC	224					
"	San Diego	KFVW	246					
"	San Francisco	KFRC	268					
"	San Francisco	KGTT	234					
"	San Francisco	KJBS	220					
"	San Francisco	KPO	428.3					
"	San Francisco	KUO	250					
"	San Jose	KFAF	217.3					

STATES	CITIES	Call Letters	Wave Length (Meters)	Date	Time Received	Dial 1	Dial 2	Dial 3
CALIFORNIA	San Jose	KQW	231					
"	San Pedro	KFVD	205.4					
"	Santa Maria	KFXC	209.7					
"	So. San Francisco	KFWI	226					
"	Stanford University	KFGH	270					
"	Stockton	KWG	248					
COLORADO	Boulder	KFAJ	261					
"	Colorado Springs	KFUM	242					
"	Colorado Springs	KFXF	250					
"	Denver	KFEL	254					
"	Denver	KFUP	234					
"	Denver	KFVR	244					
"	Denver	KFXJ	215.7					
"	Denver	KLZ	266					
"	Denver	KOA	322.4					
"	Greeley	KFKA	273					
"	Gunnison	KFHA	252					
"	Trinidad	KFBS	238					
CONNECTICUT	Hartford	WTIC	348.6					
"	Mansfield	WCAC	275					
"	New Haven	WDRC	268					
DELAWARE	Wilmington	WHAV	266					
DIST. OF COLUMBIA	Washington	WCAP	468.5					
"	Washington	WMAL	212.6					
"	Washington	WRC	468.5					
FLORIDA	Clearwater	WGHB	266					
"	Fulford-by-the-Sea	WGBU	278					
"	Jacksonville	WJAX	336.9					
"	Miami	WQAM	263					
"	Miami Beach	WMBF	384.4					
"	St. Petersburg	WHBN	238					
"	St. Petersburg	WIBC	222					
"	St. Petersburg	WJBB	254					
"	Tampa	WDAE	273					
"	Winter Park	WDBO	240					
GEORGIA	Atlanta	WDBE	270					
"	Atlanta	WGST	270					
"	Atlanta	WSB	428.3					
"	Macon	WMAZ	261					
"	Savannah	WEBZ	263					
IDAHO	Boise	KFAU	282.8					
"	Boise	KFDD	278					
"	Kellogg	KFEY	233					
ILLINOIS	Batavia	WORD	275					
"	Cambridge	WTAP	242					
"	Carthage	WTAD	236					
"	Chicago	KYW	535.4					
"	Chicago	WAAF	278					
"	Chicago	WBBM	226					
"	Chicago	WBBZ	215.7					
"	Chicago	WBCN	266					
"	Chicago	WEBH	370.2					
"	Chicago	WENR	266					
"	Chicago	WFKB	217.3					
"	Chicago	WGN	302.8					
"	Chicago	WHBM	233					

STATES	CITIES	Call Letters	Wave Length (Meters)	Date	Time Received	Dial 1	Dial 2	Dial 3
ILLINOIS	Chicago	WHT	238					
"	Chicago	WIBJ	215.7					
"	Chicago	WIBM	215.7					
"	Chicago	WIBO	226					
"	Chicago	WJAZ	322.4					
"	Chicago	WKBG	215.7					
"	Chicago	WLS	344.6					
"	Chicago	WLTS	258					
"	Chicago	WMAQ	447.5					
"	Chicago	WMBB	250					
"	Chicago	WOK	217.3					
"	Chicago	WPCC	258					
"	Chicago	WQJ	447.5					
"	Chicago	WSAX	268					
"	Chicago	WSBC	209.7					
"	Decatur	WBAO	270					
"	Decatur	WJBL	270					
"	Elgin	WCEE	275					
"	Elgin	WLIB	302.8					
"	Evanston	WEHS	202.6					
"	Galesburg	WFBZ	254					
"	Galesburg	WRAM	244					
"	Harrisburg	WEBQ	226					
"	Joliet	WCLS	214.2					
"	Joliet	WJBA	206.8					
"	Joliet	WKBB	214.2					
"	LaSalle	WJBC	234					
"	Mooseheart	WJJD	370.2					
"	Oak Park	WGES	250					
"	Plainfield	WWAE	242					
"	Rockford	KFLV	229					
"	Rock Island	WHBF	222					
"	Streator	WTAX	231					
"	Sycamore	WJBN	256					
"	Sycamore	WOCG	205.4					
"	Tuscola	WDZ	278					
"	Urbana	WRM	273					
"	Zion	WCBD	344.6					
INDIANA	Anderson	WEBD	246					
"	Anderson	WHBU	218.8					
"	Culver	WHBH	222					
"	Evansville	WGBF	236					
"	Fort Wayne	WHBJ	234					
"	Fort Wayne	WOWO	227					
"	Greencastle	WLAX	231					
"	Greentown	WJAK	254					
"	Indianapolis	WFBM	268					
"	Laport	WRAF	224					
"	Logansport	WHBL	215.7					
"	Logansport	WIBW	220					
"	Seymour	WFBE	226					
"	South Bend	WSBT	275					
"	Valparaiso	WRBC	278					
"	West Lafayette	WBAA	273					
IOWA	Ames	WOI	270					
"	Atlantic	KFLZ	273					

Control Room

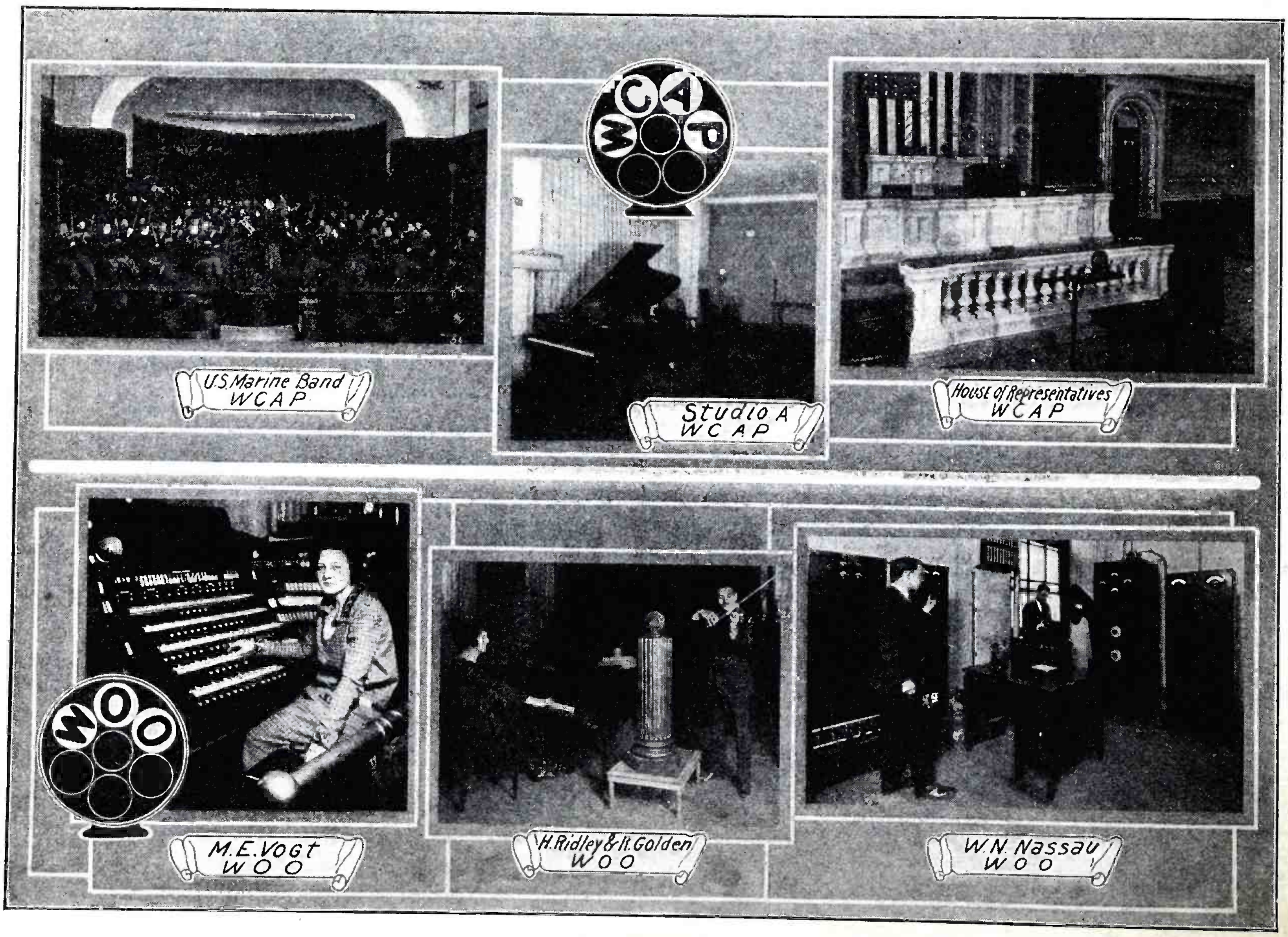
Antenna System

Studio at Night

Staff and Studio

Concert Studio

H. I. Milholland



U.S. Marine Band WCAP

Studio A WCAP

House of Representatives WCAP

M. E. Vogt WOO

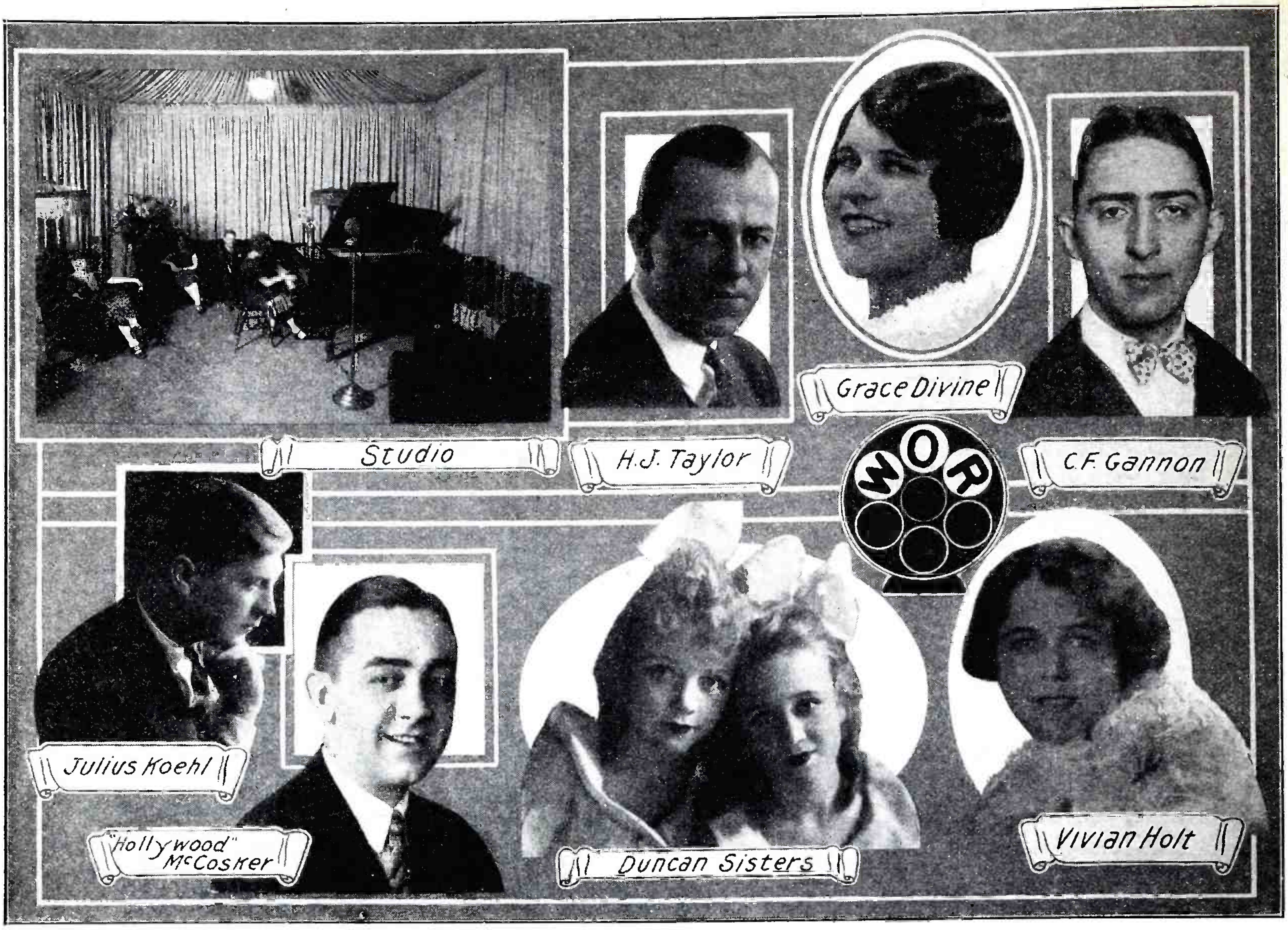
H. Ridley & H. Golden WOO

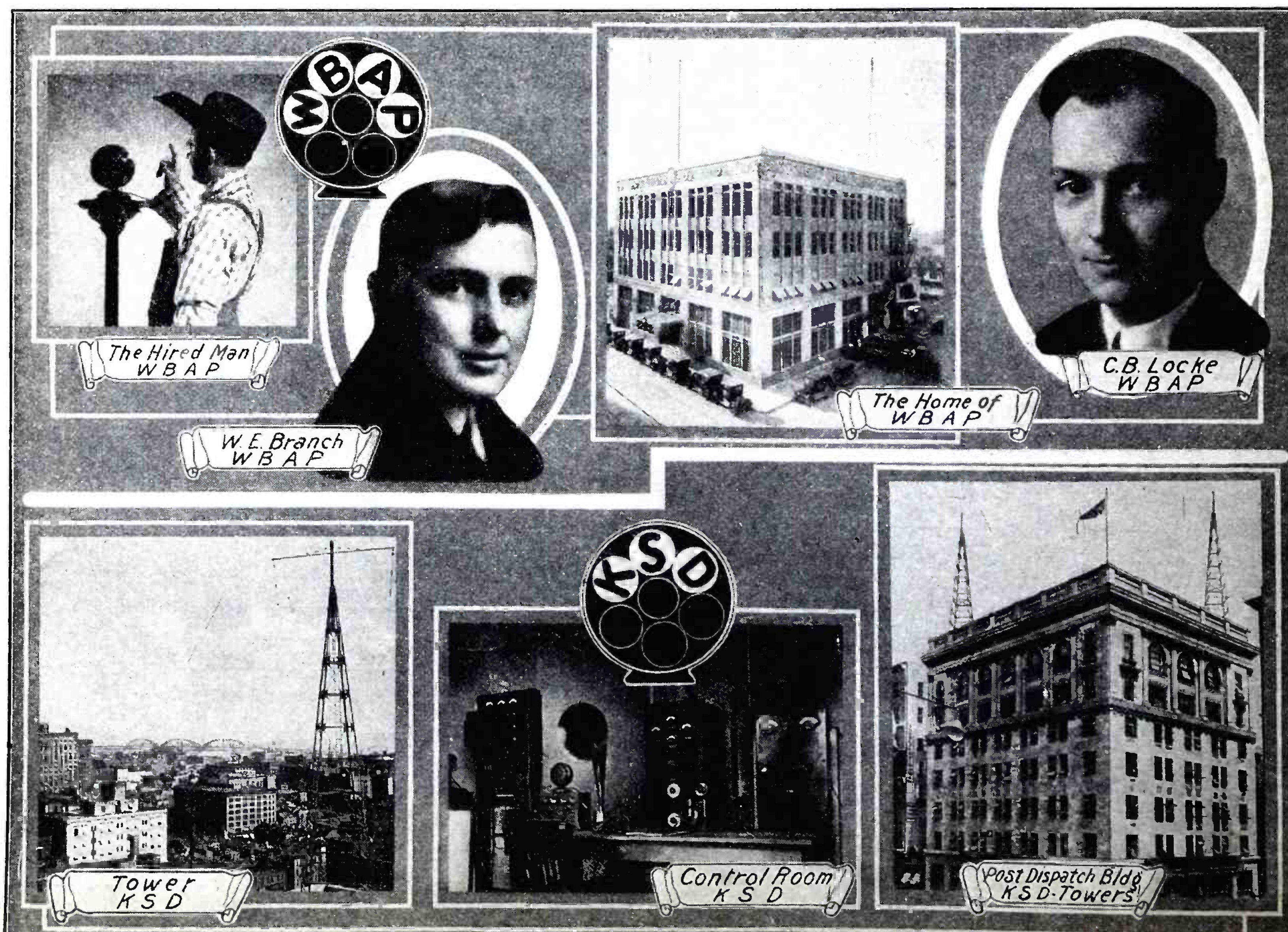
W. N. Nassau WOO

STATES	CITIES	Call Letters	Wave Length (Meters)	Date	Time Received	Dial 1	Dial 2	Dial 3
IOWA	Boone	KFGQ	226					
"	Burlington	WIAS	254					
"	Cedar Falls	KFJX	258					
"	Cedar Rapids	KWCR	278					
"	Cedar Rapids	WJAM	268					
"	Clarinda	KSO	242					
"	Council Bluffs	KOIL	278					
"	Davenport	WOC	483.6					
"	Des Moines	WHO	526					
"	Fort Dodge	KFJY	246					
"	Iowa City	KFQP	224					
"	Iowa City	WSUI	483.6					
"	Le Mars	KWUC	252					
"	Marshalltown	KFJB	248					
"	Muscatine	KTNT	256					
"	Oskaloosa	KFHL	240					
"	Shenandoah	KFNF	263					
"	Shenandoah	KMA	252					
"	Sioux City	KFMR	261					
"	Sioux City	WEAU	275					
"	Waterloo	KFXE	236					
KANSAS	Independence	KFVG	236					
"	Junction City	KFJC	218.8					
"	Lawrence	KFKU	275					
"	Manhattan	KFVH	218.8					
"	Manhattan	KSAC	340.7					
"	Manhattan	WTG	273					
"	Wichita	KFOT	231					
"	Wichita	WEAH	268					
KENTUCKY	Louisville	WHAS	399.8					
"	Louisville	WLAP	275					
LOUISIANA	Alexandria	KFFY	275					
"	Baton Rouge	KFGC	268					
"	Kennonwood	KWKH	261					
"	New Orleans	WAAB	268					
"	New Orleans	WABZ	275					
"	New Orleans	WBBS	252					
"	New Orleans	WCBE	263					
"	New Orleans	WOWL	270					
"	New Orleans	WSMB	319					
"	New Orleans	WWL	275					
"	Pineville	KFWU	238					
"	Shreveport	KFDX	250					
MAINE	Bangor	WABI	240					
"	Ellsworth	WHBK	231					
"	Orono	WGBX	252					
"	Portland	WCSH	256					
MARYLAND	Baltimore	WBAL	374.8					
"	Baltimore	WCAO	275					
"	Baltimore	WCBM	229					
"	Baltimore	WFBR	254					
"	Tokoma Park	WBES	222					
MASSACHUSETTS	Boston	WBZA	242					
"	Boston	WDBR	261					
"	Boston	WEEI	475.9					

STATES	CITIES	Call Letters	Wave Length (Meters)	Date	Time Received	Dial 1	Dial 2	Dial 3
MASSACHUSETTS	Boston	WNAB	250					
"	Boston	WNAC	280.2					
"	Boston	WTAT	244					
"	Dartmouth	WMAF	440.9					
"	Fall River	WSAR	254					
"	Fall River	WTAB	266					
"	Medford Hillside	WARC	261					
"	New Bedford	WIBH	209.7					
"	New Bedford	WNBH	248					
"	Springfield	WBZ	331.1					
"	Taunton	WAIT	229					
"	Webster	WKBE	231					
"	Worcester	WCUW	238					
"	Worcester	WTAG	268					
MICHIGAN	Ann Arbor	WCBC	229					
"	Bay City	WSKC	261					
"	Berrien Springs	WEMC	285.5					
"	Dearborn	WWI	266					
"	Detroit	WGHP	270					
"	Detroit	WJR	516.9					
"	Detroit	WMBC	256.4					
"	Detroit	WWJ	352.7					
"	East Lansing	WKAR	285.5					
"	Escanaba	WRAK	256					
"	Flint	WFDF	234					
"	Grand Rapids	WBDC	256					
"	Grand Rapids	WEBK	242					
"	Houghton	KFMW	263					
"	Hougnton	WWAO	263					
"	Lansing	WREO	285.5					
"	Mount Clemens	WABX	246					
"	Owosso	WSMH	240					
"	Petosky	WBBP	238					
"	Pontiac	WCX	516.9					
"	Port Huron	WAFD	275					
"	Royal Oak	WAGM	258.6					
"	Ypsilanti	WJBK	233					
MINNESOTA	Breckenridge	KFUJ	242					
"	Collegeville	WFBJ	236					
"	Minneapolis	KFDZ	231					
"	Minneapolis	WAMD	244					
"	Minneapolis	WHAT	263					
"	Minneapolis	WHDI	278					
"	Minneapolis	WLB	278					
"	Minneapolis	WRHM	252					
"	Northfield	KFM[illegible]	336.9					
"	Northfield	WCAL	336.9					
"	St. Cloud	WFAM	273					
"	St. Paul	KFOY	252					
"	St. Paul-Minneapolis	WCCO	416.4					
"	Welcome	KFVN	227					
MISSISSIPPI	Coldwater	WREC	254					
"	Oxford (near)	WCBH	242					
"	Pascagoula	WCBG	268					
MISSOURI	Cape Girardeau	KFVS	224					
"	Carterville	KFPW	258					

STATES	CITIES	Call Letters	Wave Length (Meters)	Date	Time Received	Dial 1	Dial 2	Dial 3
MISSOURI	Columbia	KFRU	499.7					
"	Independence	KLDS	440.9					
"	Jefferson City	WOS	440.9					
"	Kansas City	KWKC	236					
"	Kansas City	WDAF	365.6					
"	Kansas City	WHB	365.6					
"	Kansas City	WOQ	278					
"	Kirksville	KFKZ	226					
"	Moberly	KFFP	242					
"	Moberly	KFOJ	242					
"	St. Louis	KFQA	261					
"	St. Louis	KFUO	545.1					
"	St. Louis	KFVE	240					
"	St. Louis	KFWF	214.2					
"	St. Louis	KMOX	261					
"	St. Louis	KSD	545.1					
"	St. Louis	WEW	248					
"	St. Louis	WIL	273					
"	St. Louis	WMAY	248					
"	St. Louis	WSBF	273					
"	Springfield	KFUV	252					
MONTANA	Harve	KFBB	275					
"	Missoula	KUOM	244					
NEBRASKA	David City	KFOR	226					
"	Hastings	KFKX	288.3					
"	Lincoln	KFAB	340.7					
"	Lincoln	WFAV	275					
"	Norfolk	WJAG	270					
"	Oak	KFEQ	268					
"	Omaha	KFOX	248					
"	Omaha	KOCH	258					
"	Omaha	WAAW	278					
"	Omaha	WNAL	258					
"	Omaha	WOAW	526					
"	University City	WCAJ	254					
NEW HAMPSHIRE	Chesham	WSAU	229					
"	Hanover	WDCH	256					
"	Laconia	WKAV	224					
NEW JERSEY	Atlantic City	WHAR	275					
"	Atlantic City	WPG	299.8					
"	Camden	WFBI	236					
"	Elizabeth	WIBS	202.6					
"	Gloucester City	WRAX	268					
"	Lambertville	WTAZ	261					
"	Newark	WNJ	252					
"	Newark	WOR	405.2					
"	North Plainfield	WEAM	261					
"	Paterson	WODA	224					
"	Red Bank	WJBI	218.8					
"	Trenton	WOAX	240					
NEW MEXICO	Albuquerque	KFLR	254					
"	Albuquerque	KFVY	250					
"	State College	KFRY	266					
"	State College	KOB	348.6					
NEW YORK	Bay Shore	WRST	215.7					
"	Brooklyn	WFRL	205.4					

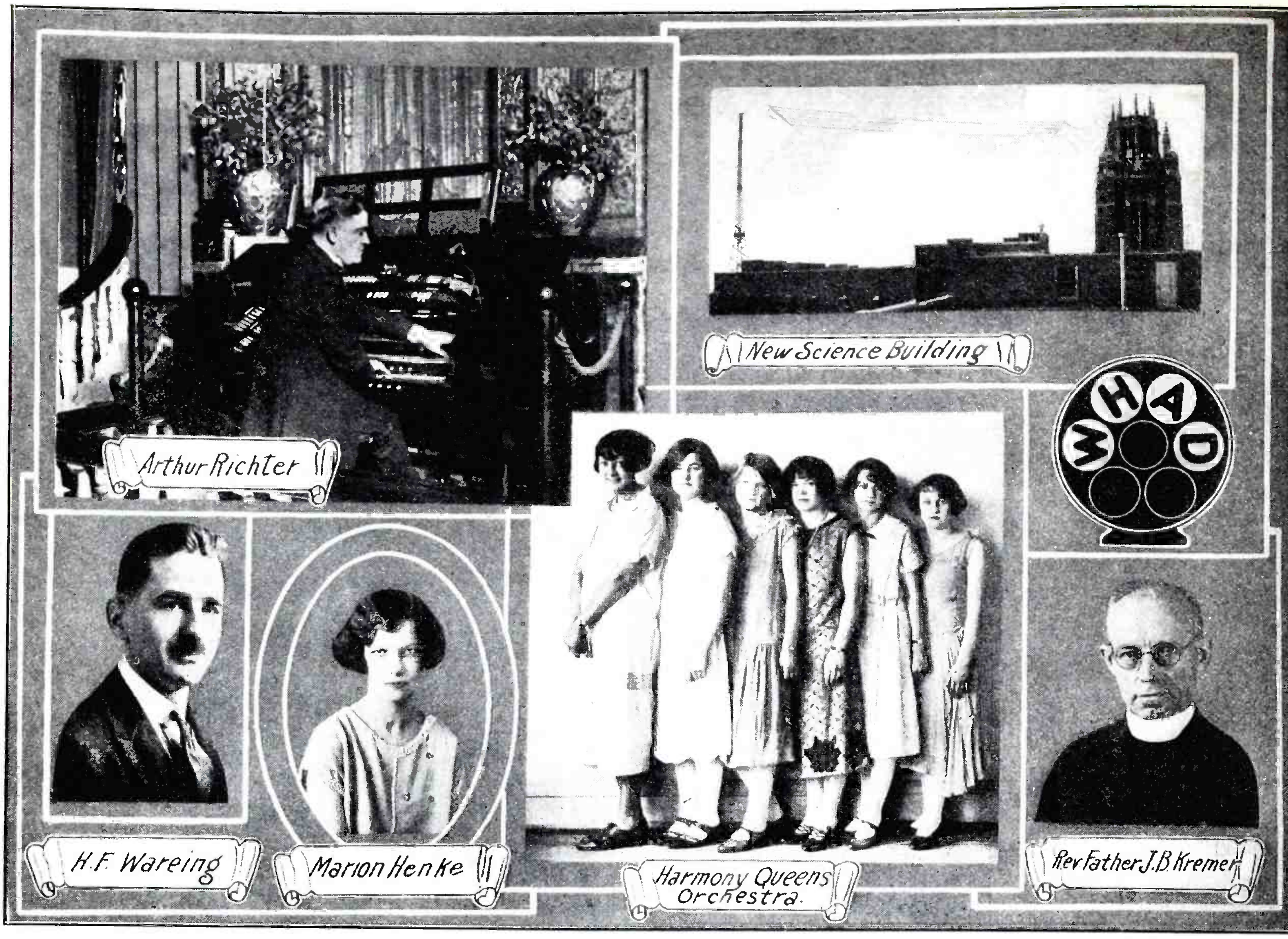

Studio
H.J. Taylor
Grace Divine
C.F. Gannon
WOR
Julius Koehl
"Hollywood" McCosker
Duncan Sisters
Vivian Holt


WBAP
The Hired Man WBAP
W.E. Branch WBAP
The Home of WBAP
C.B. Locke WBAP
KSD
Tower KSD
Control Room KSD
Post Dispatch Bldg KSD-Towers

STATES	CITIES	Call Letters	Wave Length (Meters)	Date	Time Received	Dial 1	Dial 2	Dial 3
NEW YORK	Buffalo	WEBR	244					
"	Buffalo	WGR	319					
"	Buffalo	WJBP	218.8					
"	Buffalo	WPDQ	205.4					
"	Canton	WCAD	263					
"	Cazenovia	WMAC	275					
"	Flushing	WIBI	218.8					
"	Freeport	WGBB	244					
"	Ithaca	WEAI	254					
"	Jamestown	WOCL	275					
"	Kingston	WDBZ	233					
"	Lockport	WMAK	266					
"	New York	WBPI	263					
"	New York	WEAF	491.5					
"	New York	WEBJ	273					
"	New York	WFBH	273					
"	New York	WGBS	315.6					
"	New York	WGCP	252					
"	New York	WHAP	240					
"	New York	WHN	361.2					
"	New York	WJY	405.2					
"	New York	WJZ	454.3					
"	New York	WLWL	288.3					
"	New York	WMCA	340.7					
"	New York	WNYC	526					
"	New York	WOKO	233					
"	New York	WQAO	360					
"	New York	WRNY	258					
"	New York	WSDA	263					
"	Richmond Hill	WAHG	315.6					
"	Richmond Hill	WBOQ	236					
"	Richmond Hill	WGMU	236					
"	Richmond Hill	WRMU	236					
"	Richmond Hill	WWGL	212.6					
"	Rochester	WABO	278					
"	Rochester	WHAM	278					
"	Rochester	WHEC	258					
"	Rossville	WBBR	273					
"	Schenectady	WGY	379.5					
"	Syracuse	WFBL	252					
"	Tarrytown	WRW	273					
"	Troy	WHAZ	379.5					
"	Utica	WIBX	205.4					
NORTH CAROLINA	Asheville	WABC	254					
"	Charlotte	WBT	275					
"	Charlotte	WJBG	224					
"	Henderson	WIBV	263					
"	Raleigh	WRCO	252					
NORTH DAKOTA	Agricultural College	WPAK	275					
"	Bismark	KFYR	248					
"	Devils Lake	KDLR	231					
"	Fargo	WDAY	261					
"	Grand Forks	KFJM	278					
OHIO	Akron	WADC	258					
"	Bellefontaine	WHBD	222					
"	Cambridge	WEBE	234					
"	Canton	WHBC	254					

STATES	CITIES	Call Letters	Wave Length (Meters)	Date	Time Received	Dial 1	Dial 2	Dial 3
OHIO	Cincinnati	WAAD	258					
“	Cincinnati	WHAG	233					
“	Cincinnati	WHBR	215.7					
“	Cincinnati	WKRC	325.9 422.3					
“	Cincinnati	WLW	422.3					
“	Cincinnati	WSAI	325.9					
“	Cleveland	KDPM	250					
“	Cleveland	WDBK	227					
“	Cleveland	WEAR	389.4					
“	Cleveland	WHK	273					
“	Cleveland	WTAM	389.4					
“	Columbus	WAIU	293.9					
“	Columbus	WCAH	266					
“	Columbus	WEAO	293.9					
“	Columbus	WMAN	278					
“	Dayton	WEBI	256					
“	Dayton	WSMK	275					
“	Granville	WJD	217.3					
“	Hamilton	WRK	270					
“	Hamilton	WSRO	252					
“	Lima	WOAC	261					
“	Pomeroy	WSAZ	244					
“	Springfield	WCSO	248					
“	Toledo	WABR	263					
“	Toledo	WIBK	205.4					
“	Toledo	WTAL	252					
“	Wooster	WABW	206.8					
“	Yellow Springs	WRAV	263					
OKLAHOMA	Bristow	KVOO	374.8					
“	Chickasha	KOCW	252					
“	Fort Sill	KFRM	242					
“	Norman	WNAD	254					
“	Oklahoma	KFJF	261					
“	Oklahoma	WKY	275					
“	Tulsa	WLAL	250					
OREGON	Astoria	KFJI	246					
“	Corvallis	KFDJ	282.8					
“	Portland	KFEC	248					
“	Portland	KFIF	248					
“	Portland	KFJR	263					
“	Portland	KFWV	212.6					
“	Portland	KGW	491.5					
“	Portland	KQP	212.6					
“	Portland	KTBR	263					
PENNSYLVANIA	Allentown	WCBA	254					
“	Allentown	WSAN	229					
“	Altoona	WFBG	278					
“	Elkins Park	WIBG	222					
“	Grove City	WSAJ	229					
“	Harrisburg	WABB	266					
“	Harrisburg	WBAK	275					
“	Harrisburg	WHBG	231					
“	Harrisburg	WPRC	215.7					
“	Haverford	WABQ	261					
“	Johnstown	WGBK	248					
“	Johnstown	WHBP	256					

STATES	CITIES	Call Letters	Wave Length (Meters)	Date	Time Received	Dial 1	Dial 2	Dial 3
PENNSYLVANIA	Johnstown	WTAC	268					
"	Lancaster	WDBC	258					
"	Lancaster	WGAL	248					
"	Lewisburg	WJBQ	211.1					
"	Oil City	WHBA	250					
"	Parkersburg	WQAA	220					
"	Philadelphia	WABY	242					
"	Philadelphia	WCAU	278					
"	Philadelphia	WFBD	234					
"	Philadelphia	WFI	394.5					
"	Philadelphia	WHBW	215.7					
"	Philadelphia	WIAD	250					
"	Philadelphia	WIP	508.2					
"	Philadelphia	WLIT	394.5					
"	Philadelphia	WNAT	250					
"	Philadelphia	WOO	508.2					
"	Philadelphia	WWAD	250					
"	Pittsburgh	KDKA	309.1					
"	Pittsburgh	KQV	275					
"	Pittsburgh	WCAE	461.3					
"	Pittsburgh	WJAS	275					
"	Reading	WRAW	238					
"	Scranton	WGBI	240					
"	Scranton	WQAN	250					
"	State College	WPSC	261					
"	Wilkes-Barre	WBAX	256					
"	Wilkes-Barre	WBRE	231					
RHODE ISLAND	Cranston	WDWF	440.9					
"	E. Providence	WKAD	240					
"	Providence	WCBR	205.4					
"	Providence	WCWS	209.7					
"	Providence	WEAN	270					
"	Providence	WGBM	234					
"	Providence	WJAR	305.9					
SOUTH CAROLINA	Charleston	WBBY	268					
"	Greenville	WGBT	236					
SOUTH DAKOTA	Brookings	KFDY	273					
"	Rapid City	WCAT	240					
"	Vermillion	KUSD	278					
"	Yankton	WNAX	244					
TENNESSEE	Chattanooga	WDOD	256					
"	Knoxville	WFBC	250					
"	Knoxville	WNOX	268					
"	Lawrenceburg	WOAN	282.8					
"	Memphis	WGBC	278					
"	Memphis	WHBQ	233					
"	Memphis	WMC	499.7					
"	Nashville	WCBQ	236					
"	Nashville	WDAD	226					
"	Nashville	WSM	282.8					
TEXAS	Amarillo	WDAG	263					
"	Austin	KUT	231					
"	Beaumont	KFDM	315.6					
"	Beaumont	KFXM	227					
"	Beeville	KFRB	248					
"	Brownsville	KFWP	214.2					



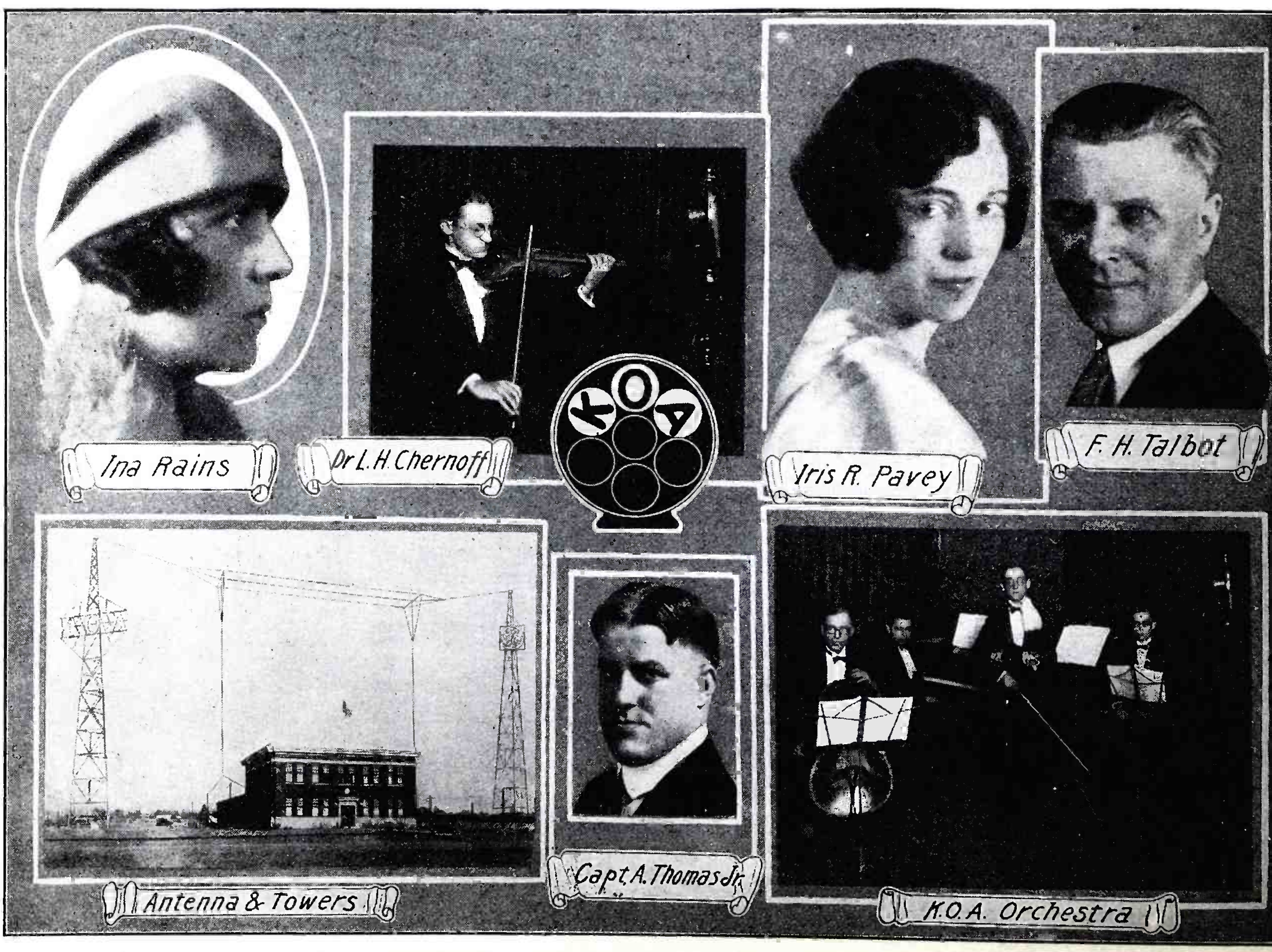
Arthur Richter — New Science Building — H. F. Wareing — Marion Henke — Harmony Queens Orchestra — Rev Father J. B. Kremer

Leo Fitzpatrick — Edith G. Bailey — Transmitter — Deora L. Wolfe — C. Gaylord Hall — Speech Input Equipment — H. C. Campbell — Transmitting Building.

STATES	CITIES	Call Letters	Wave Length (Meters)	Date	Time Received	Dial 1	Dial 2	Dial 3
TEXAS	Brownsville	KWWG	278					
"	College Station	WTAW	270					
"	Dallas	WFAA	475.9					
"	Dallas	WRR	246					
"	Dublin	KFPL	252					
"	El Paso	KFXH	242					
"	Fort Worth	KFJZ	254					
"	Fort Worth	KFQB	263					
"	Fort Worth	WBAP	475.9					
"	Galveston	KFLX	240					
"	Galveston	KFUL	258					
"	Greenville	KFPM	242					
"	Houston	KFVI	240					
"	Houston	KFYJ	238					
"	Houston	KPRC	296.9					
"	Houston	WEAY	270					
"	San Antonio	WCAR	263					
"	San Antonio	WOAI	394.5					
"	San Benito	KFLU	236					
"	Waco	WJAD	352.7					
UTAH	Logan	KFXD	205.4					
"	Ogden	KFUR	224					
"	Ogden	KFWA	261					
"	Salt Lake City	KDYL	246					
"	Salt Lake City	KFOO	236					
"	Salt Lake City	KFUT	261					
"	Salt Lake City	KSL	299.8					
U. S.	Portable	WEBL	226					
"	Portable	WEBM	226					
VERMONT	Burlington	WCAX	250					
"	Springfield	WQAE	246					
VIRGINIA	Arlington	NAA	434.5					
"	Norfolk	WBBW	222					
"	Norfolk	WTAR	261					
"	Richmond	WBBL	229					
"	Richmond	WRVA	256					
"	Roanoke	WDBJ	229					
WASHINGTON	Everett	KFBL	224					
"	Lacey	KGY	246					
"	North Bend	KFQW	215.7					
"	Olympia	KFRW	218.8					
"	Pullman	KWSC	348.6					
"	Seattle	KFOA	454.3					
"	Seattle	KJR	384.4					
"	Seattle	KTCL	305.9					
"	Seattle	KTW	454.3					
"	Spokane	KFPY	266					
"	Spokane	KHQ	273					
"	Tacoma	KFBG	250					
"	Tacoma	KGB	250					
"	Tacoma	KMO	250					
"	Walla Walla	KFCF	256					
"	Yakima	KFIQ	256					
WEST VIRGINIA	Weirton	WIBR	246					
WISCONSIN	Beloit	WEBW	268					
"	Camp Lake	WCLO	231					

STATES	CITIES	Call Letters	Wave Length (Meters)	Date	Time Received	Dial 1	Dial 2	Dial 3
WISCONSIN	Fondulac	KFIZ	273					
"	Madison	WHA	535.4					
"	Madison	WIBA	236					
"	Marshfield	WGBR	229					
"	Menomonie	WGBQ	234					
"	Milwaukee	WHAD	275					
"	Milwaukee	WKAF	261					
"	Milwaukee	WSOE	246					
"	Osseo	WTAQ	254					
"	Poynette	WIBU	222					
"	Stevens Point	WLBL	278					
"	Superior	WEBC	242					
"	West De Pere	WHBY	250					
WYOMING	Laramie	KFBU	270					

Additions, changes and eliminations in foregoing list of United States Broadcast Stations given on page 176.



Slogans of Broadcast Stations in U. S. and Canada

KDKA—PITTSBURGH, PA.
The Pioneer Broadcasting Station of the World.

KDYL—SALT LAKE CITY, UTAH.
Out on the Great Divide.

KFAB—LINCOLN, NEBRASKA.
The Home Sweet Home Station.

KFAU—BOISE, IDAHO.
Intermountain Station.

KFCB—PHOENIX, ARIZ.
When It's Wintertime in Michigan, It's Summer Time Down Here.

KFCF—WALLA WALLA, WASH.
The Valley They Liked so well They Named It Twice.

KFDM—BEAUMONT, TEXAS.
Kall for Dependable Magnolene.

KFEY—KELLOG, IDAHO.
Voice of the Coeur D'Alene.

KFFP—MOBERLY, MO.
The Gospel Messenger of the Air.

KFGQ—BOONE, IOWA.
Daniel Boone Station.

KFHA—GUNNISON, COLO.
Where the Sun Shines Every Day.

KFI—LOS ANGELES, CALIF.
The Radio Central Super-Station. (A National Institution.)

KFJB—MARSHALLTOWN, IOWA.
Marshalltown The Heart of Iowa.

KFJF—OKLAHOMA CITY, OKLA.
Radio Headquarters.

KFJM—GRAND FORKS, N. D.
Grand Forks, the Educational Center of the State.

KFKU—LAWRENCE, KANS.
Up at Lawrence on the Kaw.

KFKX—HASTINGS, NEBR.
The Empress of the Air The Pioneer Re-Broadcasting Station of the World.

KFLU—SAN BENITO, TEXAS.
Heart of the Magic Valley.

KFNF—SHENANDOAH, IOWA.
Friendly Station in a Friendly Town.

KFOA—SEATTLE, WASH.
The Gateway to the Orient. (Pacific Northwest Station.)

KFON—LONG BEACH, CALIF.
Where Your Ship Comes In.

KFOR—DAVID CITY, NEBR.
The Voice of David City.

KFPM—GREENVILLE, TEXAS.
The New Furniture Co. (Biggest Little 10 Watts on the Air.)

KFPW—CARTERVILLE, MO.
Keeping Pace With Christ Means Progress.

KFQW—NORTH BEND, WASH.
At the Western Entrance of Snoqualmie Pass.

KFRW—OLYMPIA, WASH.
Make the World a Brotherhood.

KFUJ—BRECKENRIDGE, MINN.
Where the Red River of the North Finds Its Source.

KFUM—COLORADO SPRINGS, COLO.
Known for Unsurpassed Mountain Scenery.

KFUS—OAKLAND, CALIF.
The City of Opportunity.

KFUU—SAN LEANDRO, CALIF.
The Voice of Automobile Row. (Voice of the Cherry City.)

KFVE—ST. LOUIS, MO.
You Will Always Know KFVE by the Tick of Her Clock.

KFVH—MANHATTAN, KANS.
Kansas Fans Very Happy.

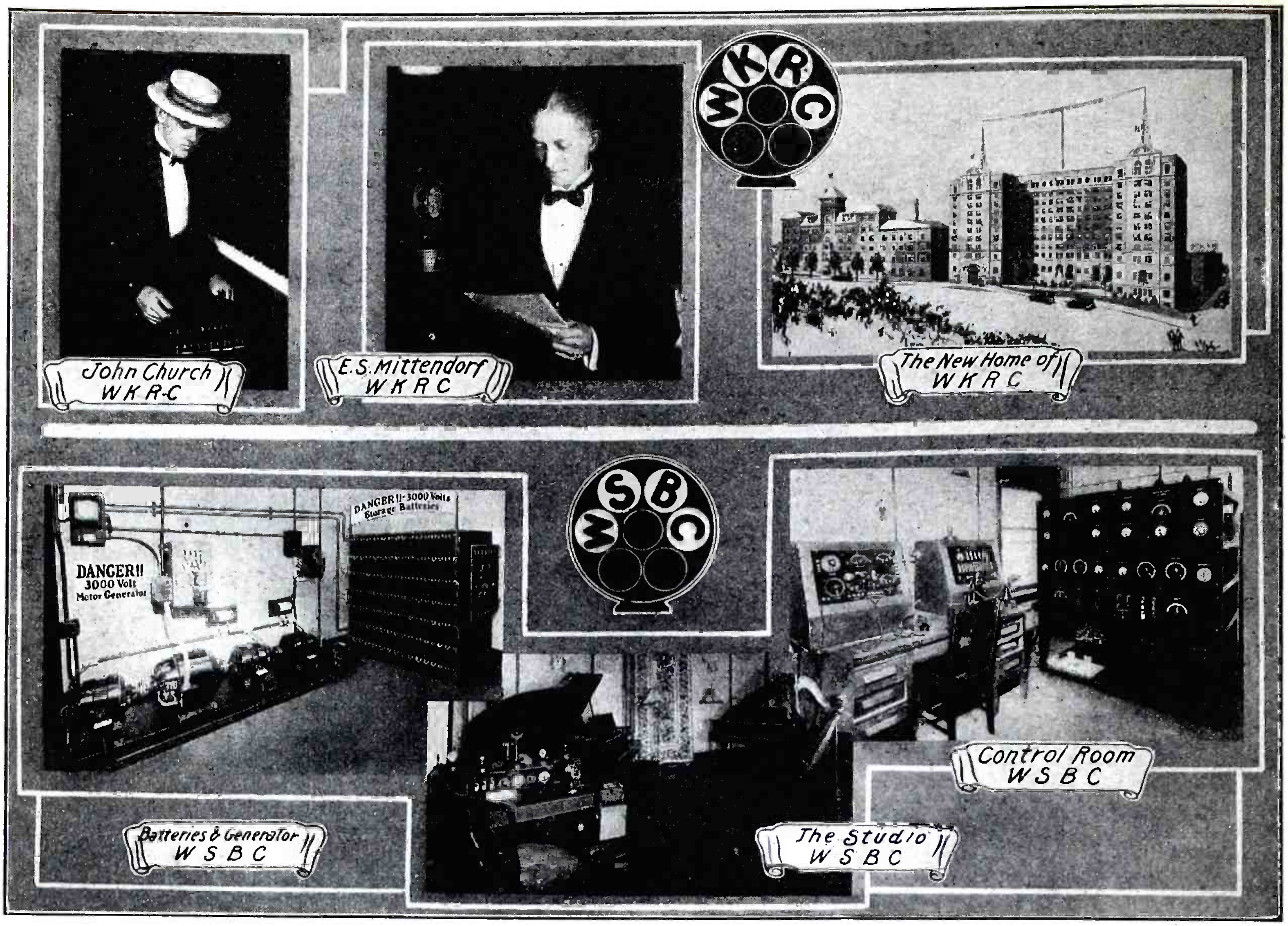
KFVN—WELCOME, MINN.
The Voice of Martin County.

KFVU—EUREKA, CALIF.
On the Redwood Highway. (Eureka on the Redwood Highway, the End of the West.)

KFWA—OGDEN, UTAH.
Keeping Friends With All.

KFWH—CHICO, CALIF.
Kind Friends We're Here.

KFWO—AVALON, CATALINA ISLAND, CALIF.
Katalina for Wonderful Outings.



John Church WKRC

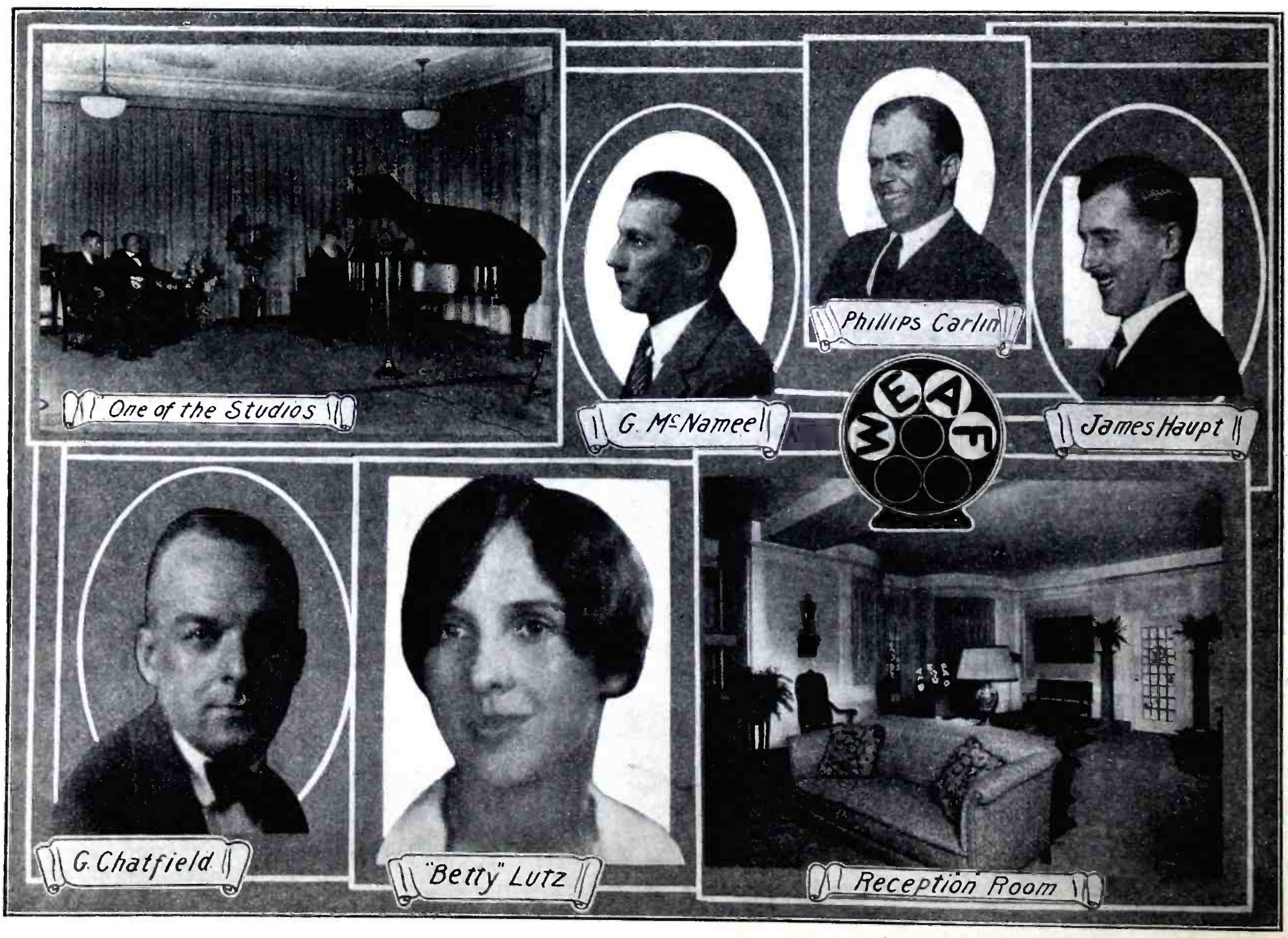
E. S. Mittendorf WKRC

The New Home of WKRC

Batteries & Generator WSBC

The Studio WSBC

Control Room WSBC



One of the Studios

G. McNamee

Phillips Carlin

James Haupt

G. Chatfield

"Betty" Lutz

Reception Room

SLOGANS OF BROADCAST STATIONS IN UNITED STATES AND CANADA (*Continued*)

KFXB—BIG BEAR LAKE, CALIF.
Rim of World Super Station.
KFXF—COLORADO SPRINGS, COLO.
The Pikes Peak Station.
KFXH—EL PASO, TEXAS.
The Voice of the Rio Grande.
KGB—TACOMA, WASH.
This is KGB in Tacoma, Wash., the Lumber Capital of America and the Gateway to Mount Tacoma. (The Lumber Capital of the World.)
KGW—PORTLAND, OREG.
KGW Keep Growing Wiser.
KGY—LACEY, WASH.
Out Where the Cedars Meet the Sea.
KHJ—LOS ANGELES, CALIF.
Kindness, Happiness, and Joy.
KJBS—SAN FRANCISCO, CALIF.
Royal Order Smoked Herring. (Kleen Jokes, Better Songs.)
KJR—SEATTLE, WASH.
Radio Headquarters.
KMOX—ST. LOUIS, MO.
Voice of St. Louis.
KPO—SAN FRANCISCO, CALIF.
The City by the Golden Gate.
KPRC—HOUSTON, TEXAS.
Kotton Port Rail Center (Post).
KQP—PORTLAND, ORE.
Hood River Apples from Portland, Oreg.
KTCL—SEATTLE, WASH.
Know the Charmed Land.
KTHS—HOT SPRINGS, ARK.
Kum to Hot Springs.
KTW—SEATTLE, WASH.
Hear Ye, Hear Ye, the Gospel.
KUO—SAN FRANCISCO, CALIF.
The Voice of the West.
KUSD—VERMILLON, S. DAK.
South Dakota University for South Dakotans.
KWG—STOCKTON, CALIF.
Voice of the San Joaquin Valley.
KWKC—KANSAS CITY, MO.
Keep Watching Kansas City.
KWWG—BROWNSVILLE, TEXAS.
Kum to the World's Winter Garden.
KZRQ—MANILA, P. I.
Radio Manila.
WAAW—OMAHA, NEBR.
Where Agriculture Accumulates Wealth.
WABY—PHILADELPHIA, PA.
Quaker City Sleep Dodgers.
WABZ—NEW ORLEANS, LA.
The Station with a Message.
WAFD—PORT HURON, MICH.
Gateway to the Great Lakes. (We Are Ford Dealers.)
WAHG—RICHMOND HILL, N. Y.
Wait and Hear Grebe.
WAMD—MINNEAPOLIS, MINN.
The Voice of the Great Northwest.
WBAV—COLUMBUS, OHIO.
We Broadcast a Variety.
WBAX—WILKES BARRE, PA.
In Wyoming Valley, Home of the Anthracite.
WBBM—CHICAGO, ILL.
World's Best Broadcasting Medium.
WBBS—NEW ORLEANS, LA.
The Gospel Wave.
WBBW—NORFOLK, VA.
The School You'd Like to Go to.
WBCN—CHICAGO, ILL.
World's Best Community Newspaper.
WCAC—MANSFIELD, CONN.
From the Nutmeg State.
WCAD—CANTON, N. Y.
The Voice of the North Country.
WCAL—NORTHFIELD, MINN.
The College on the Hill.
WCAO—BALTIMORE, MD.
The People's Store.
WCAR—SAN ANTONIO, TEXAS.
Royal Order of Prevaricators.
WCAX—BURLINGTON, VT.
The Voice of the Green Mountains.
WCBD—ZION, ILL.
Where God Rules. (Where God Rules Man Prospers.)
WCBE—NEW ORLEANS, LA.
Second Port in U. S. A. (Strongest 5 Watt Station in the World.)
WCCO—ST. PAUL—MINNEAPOLIS, MINN.
Service to the Northwest.

SLOGANS OF BROADCAST STATIONS IN UNITED STATES AND CANADA (*Continued*)

WCLS—JOLIET, ILL.
Will County's Largest Store.
WDAD—NASHVILLE, TENN.
The Athens of the South.
WDAG—AMARILLO, TEXAS.
Where Dollars Always Grow.
WDAY—FARGO, N. DAK.
The Biggest Little City in the World.
WDBE—ATLANTA, GA.
We Distribute Better Equipment.
WDBJ—ROANOKE, VA.
Roanoke, Down in Old Virginia.
WDBO—WINTER PARK, FLA.
Wander Down by Orlando.
WDOD—CHATTANOOGA, TENN.
Wonderful Dynamo of Dixie.
WDWF—CRANSTON, R. I.
Quality First.
WEAF—NEW YORK, N. Y.
The Voice of the Millions.
WEAM—PLAINFIELD, N. J.
America's Pioneer Municipal Broadcasting Station.
WEAR—CLEVELAND, OHIO.
Goodyear Tires WEAR.
WEAU—SIOUX CITY, IOWA.
The Heart of the Corn Belt.
WEBA—HIGHLAND PARK, N. J.
Wonderful Evenings by Air WEBA.
WEBH—CHICAGO, ILL.
The Voice of the Great Lakes.
WEBK—GRAND RAPIDS, MICH.
The Furniture Capital of America.
WEBQ—HARRISBURG, ILL.
Bluebird Station.
WEBR—BUFFALO, N. Y.
We Extend Buffalo's Regards.
WEBT—DAYTON, OHIO.
Worthy Effort Brings Triumph.
WSM—NASHVILLE, TENN.
We Shield Millions.
WSMK—DAYTON, OHIO.
The Home of Aviation.
WSOE—MILWAUKEE, WISC.
In the Land of Sky-blue Waters.
WSRO—HAMILTON, OHIO.
We Sell Radio Only.
WTAG—WORCESTER, MASS.
The Voice from the Heart of the Commonwealth.
WTAM—CLEVELAND, OHIO.
The Voice from the Storage Battery.
WTAR—NORFOLK, VA.
Down in Old Virginia.
WTAW—COLLEGE STATION, TEX.
The Voice of the Wilderness.
WTAX—STREATOR, ILL.
Tappa Kegga Nails.
WTIC—HARTFORD, CONN.
The Insurance City.
CFCH—IROQUOIS FALLS, ONT.
The Call of the North.
CFCN—CALGARY, ALBERTA.
Voice of the Prairies.
CFCT—VICTORIA, B. C.
The Mecca of Tourists.
CFQC—SASKATOON, SASK.
The Hub City of the West Where No. 1 Northern Hard Wheat Grows.
CFXC—NEW WESTMINSTER, B. C.
Voice of the Fraser River.
CFYC—BURNABY, B. C.
Canada's Flourishing Young City.
CHCM—CALGARY, ALBERTA.
Western Canada's Leading Leather Goods Store.
CJCA—EDMONTON, ALBERTA.
The Sunniest Spot in Sunny Alberta.
CKCD—VANCOUVER, B. C.
Canada's Western Gateway.
CKCO—OTTAWA, ONT.
Ottawa's Radio Voice. The Community Voice of Canada's Capital.
CKOC—HAMILTON, ONT.
In the Garden of Canada.
CKY—WINNIPEG, MAN.
Manitoba's Own Station.
CNRA—MONCTON, N. B.
Voice of the Maritimes.

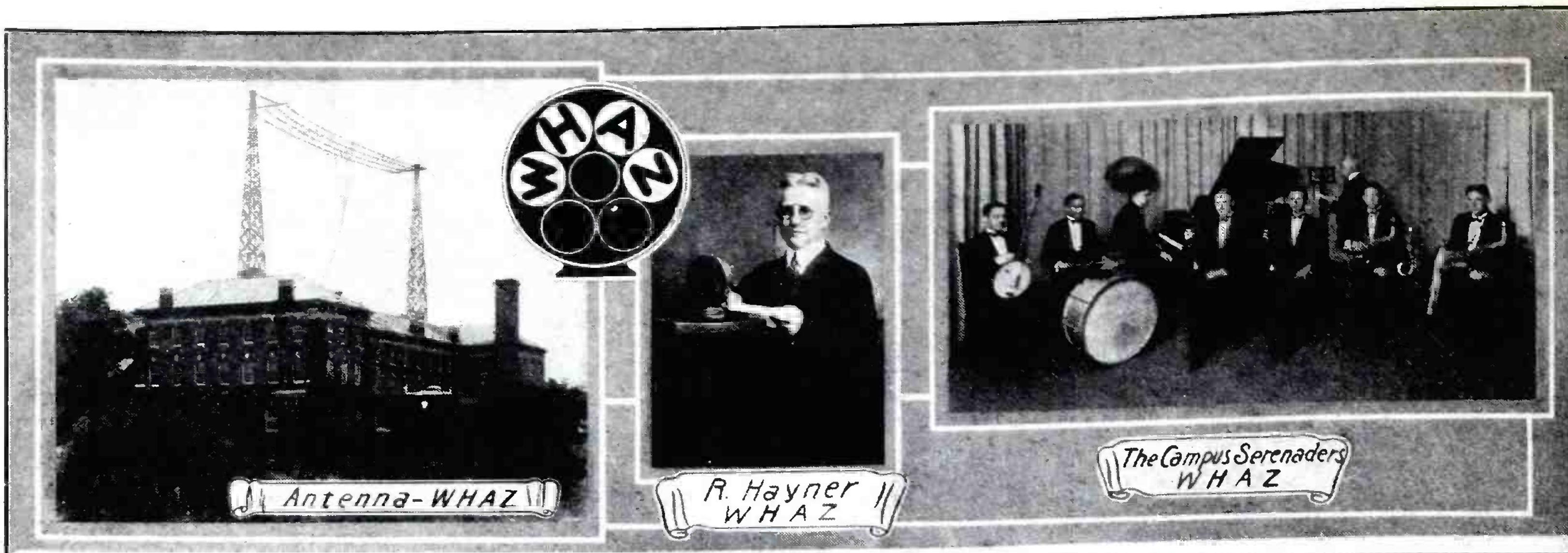
Kilocycle-Meter Conversion Table

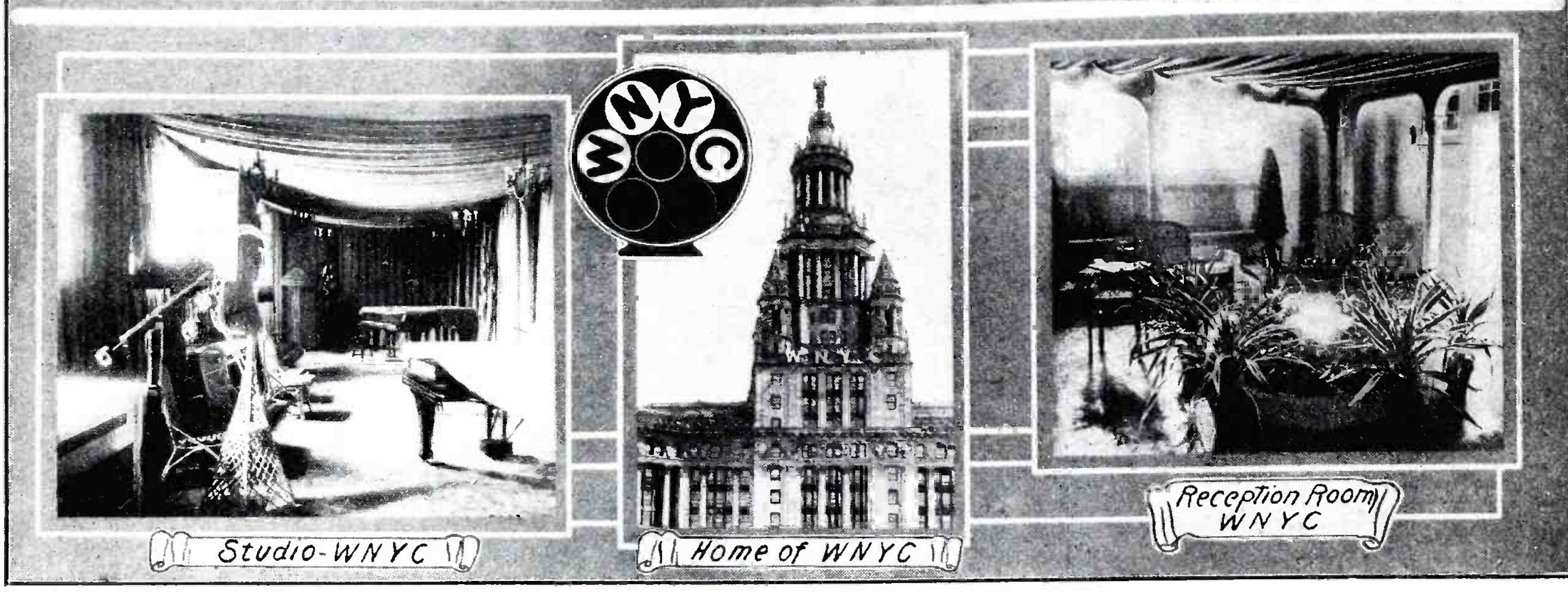
The Department of Commerce specifies radio station assignments in both kilocycles and meters. The tendency of radio engineering practice is to use and express frequency in kilocycles rather than wave length in meters. "Kilo" means a thousand, and "cycle" means one complete alternation. The number of kilocycles indicates the number of thousands of times that the rapidly alternating current in the antenna repeats its flow in either direction in one second. The smaller the wave length in meters, the larger is the frequency in kilocycles. The numerical relation between the two is very simple. For approximate calculation, to obtain kilocycles, divide 300,000 by the number of meters; to obtain meters divide 300,000 by the number of kilocycles. For example, 100 meters equals approximately 3000 kilocycles, 300 m equals 1000 kc, 1000 m equals 300 kc, 3000 m equals 100 kc.

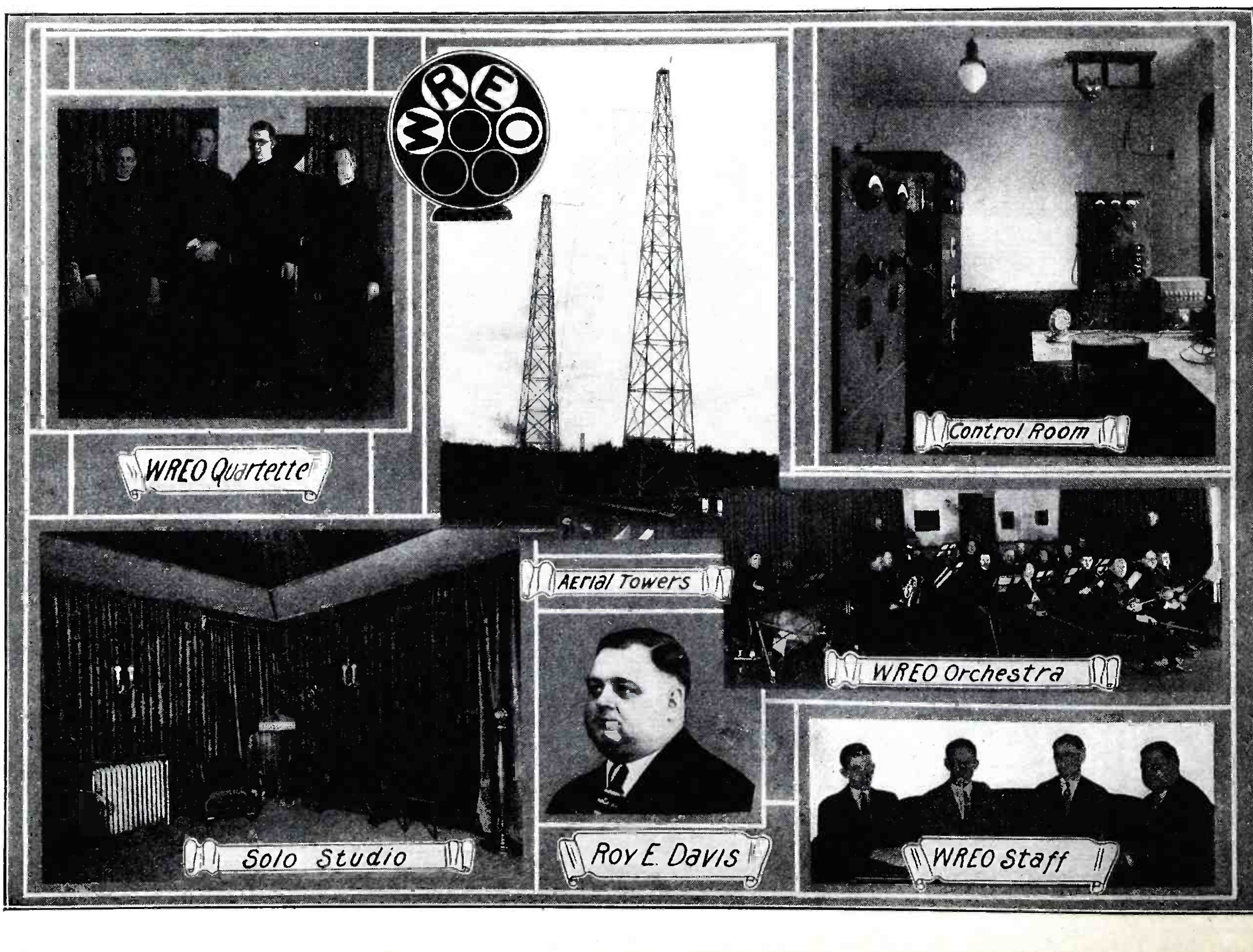
For highly accurate conversion the factor 299,820 should be used instead of 300,000. The table below gives accurate values of kilocycles corresponding to any number of meters and vice versa. The table is based on the factor 299,820, and gives values for every 10 kilocycles or meters. It should be particularly noticed that the table is entirely reversible; that is, for example, 50 kilocycles is 5996 meters, and also 50 meters is 5996 kilocycles. The range of the table is easily extended by shifting the decimal point; for example, one can not find 223 in the first column, but its equivalent is obtained by finding later in the table that 2230 kilocycles or meters is equivalent to 134.4 meters or kilocycles, from which 223 kilocycles or meters is equivalent to 1344 meters or kilocycles.

KILOCYCLES TO METERS, OR METERS TO KILOCYCLES

Meters	Kilocycles	Meters	Kilocycles	Meters	Kilocycles	Meters	Kilocycles	Meters	Kilocycles	Meters	Kilocycles	Meters	Kilocycles
10	29980	720	416.4	1430	209.7	2140	140.1	2850	105.2	4120	72.77	6400	46.85
20	14990	730	410.7	1440	208.2	2150	139.5	2860	104.8	4140	72.42	6450	46.48
30	9994	740	405.2	1450	206.8	2160	138.8	2870	104.5	4160	72.07	6500	46.13
40	7496	750	399.8	1460	205.4	2170	138.1	2880	104.1	4180	71.73	6550	45.77
50	5996	760	394.5	1470	204.0	2180	137.5	2890	103.7	4200	71.39	6600	45.43
60	4997	770	389.4	1480	202.6	2190	136.9	2900	103.4	4220	71.05	6650	45.09
70	4283	780	384.4	1490	201.2	2200	136.3	2910	103.0	4240	70.71	6700	44.75
80	3748	790	379.5	1500	199.9	2210	135.7	2920	102.7	4260	70.38	6750	44.42
90	3331	800	374.8	1510	198.6	2220	135.1	2930	102.3	4280	70.05	6800	55.09
100	2998	810	370.2	1520	197.2	2230	134.4	2940	102.0	4300	69.73	6850	43.77
110	2726	820	365.6	1530	196.0	2240	133.8	2950	101.6	4320	69.40	6900	43.45
120	2499	830	361.2	1540	194.7	2250	133.3	2960	101.3	4340	69.08	6950	43.14
130	2306	840	356.9	1550	193.4	2260	132.7	2970	100.9	4360	68.77	7000	42.83
140	2142	850	362.7	1560	192.2	2270	132.1	2980	100.6	4380	68.45	7050	42.53
150	1999	860	348.6	1570	191.0	2280	131.5	2990	100.3	4400	68.14	7100	42.23
160	1874	870	344.6	1580	189.9	2290	130.9	3000	99.94	4420	67.83	7150	41.93
170	1764	880	340.7	1590	188.6	2300	130.4	3020	99.28	4440	67.53	7200	41.64
180	1666	890	336.9	1600	187.4	2310	129.8	3040	98.62	4460	67.22	7250	41.35
190	1578	900	333.1	1610	186.2	2320	129.2	3060	97.98	4480	66.91	7300	41.07
200	1499	910	329.5	1620	185.1	2330	128.7	3080	97.34	4500	66.63	7350	40.79
210	1428	920	325.9	1630	183.9	2340	128.1	3100	96.72	4520	66.33	7400	40.52
220	1363	930	322.4	1640	182.8	2350	127.6	3120	96.10	4540	66.04	7450	40.24
230	1304	940	319.0	1650	181.7	2360	127.0	3140	95.48	4560	65.75	7500	39.98
240	1249	950	315.6	1660	180.6	2370	126.5	3160	94.88	4580	65.46	7550	39.71
250	1199	960	312.3	1670	179.5	2380	126.0	3180	94.28	4600	65.18	7600	39.45
260	1153	970	309.1	1680	178.5	2390	125.4	3200	93.69	4620	64.90	7650	39.19
270	1110	980	305.9	1690	177.4	2400	124.9	3220	93.11	4640	64.62	7700	38.94
280	1071	990	302.8	1700	176.4	2410	124.4	3240	92.54	4660	64.34	7750	38.69
290	1034	1000	299.8	1710	175.3	2420	123.9	3260	91.97	4680	64.06	7800	38.44
300	999.4	1010	296.9	1720	174.3	2430	123.4	3280	91.41	4700	63.79	7850	38.19
310	967.2	1020	293.9	1730	173.3	2440	122.9	3300	90.86	4720	63.52	7900	37.95
320	936.9	1030	291.1	1740	172.3	2450	122.4	3320	90.31	4740	63.25	7950	37.71
330	908.6	1040	288.3	1750	171.3	2460	121.9	3340	89.77	4760	62.99	8000	37.48
340	881.8	1050	285.5	1760	170.4	2470	121.4	3360	89.23	4780	62.72	8050	37.25
350	856.6	1060	282.8	1770	169.4	2480	120.9	3380	88.70	4800	62.46	8100	37.02
360	832.8	1070	280.2	1780	168.4	2490	120.4	3400	88.18	4820	62.20	8150	36.79
370	810.3	1080	277.6	1790	167.5	2500	119.9	3420	87.67	4840	61.95	8200	36.56
380	789.0	1090	275.1	1800	166.6	2510	119.5	3440	87.16	4860	61.69	8250	36.34
390	768.8	1100	272.6	1810	165.6	2520	119.0	3460	86.65	4880	61.44	8300	36.12
400	749.6	1110	270.1	1820	164.7	2530	118.5	3480	86.16	4900	61.19	8350	35.91
410	731.3	1120	267.7	1830	163.8	2540	118.0	3500	85.66	4920	60.94	8400	35.69
420	713.9	1130	265.3	1840	162.9	2550	117.6	3520	85.18	4940	60.69	8450	35.48
430	697.3	1140	263.0	1850	162.1	2560	117.1	3540	84.70	4960	60.45	8500	35.27
440	681.4	1150	260.7	1860	161.2	2570	116.7	3560	84.22	4980	60.20	8550	35.07
450	666.3	1160	258.5	1870	160.3	2580	116.2	3580	83.75	5000	59.96	8600	34.86
460	651.8	1170	256.3	1880	159.5	2590	115.8	3600	83.28	5050	59.37	8650	34.66
470	637.9	1180	254.1	1890	158.6	2600	115.3	3620	82.82	5100	58.79	8700	34.46
480	624.6	1190	252.0	1900	157.8	2610	114.9	3640	82.37	5150	59.22	8750	34.27
490	611.9	1200	249.9	1910	157.0	2620	114.4	3660	81.92	5200	57.66	8800	34.07
500	599.6	1210	247.8	1920	156.2	2630	114.0	3680	81.47	5250	47.11	8850	33.88
510	587.9	1220	245.8	1930	155.3	2640	113.6	3700	81.03	5300	56.75	8900	33.69
520	576.6	1230	243.8	1940	154.5	2650	113.1	3720	80.60	5250	57.11	8950	33.50
530	565.7	1240	241.8	1950	153.8	2660	112.7	3740	80.17	5400	55.52	9000	33.31
540	555.2	1250	239.9	1960	153.0	2670	112.3	3760	79.74	5450	55.01	9050	33.13
550	545.1	1260	238.0	1970	152.2	2680	111.9	3780	79.32	5500	54.51	9100	32.95
560	535.4	1270	236.1	1980	151.4	2690	111.5	3800	78.90	5550	54.02	9150	32.77
570	526.0	1280	234.2	1990	150.7	2700	111.0	3820	78.49	5600	53.54	9200	32.59
580	516.9	1290	232.4	2000	149.9	2710	110.6	3840	78.08	5650	53.07	9250	32.41
590	508.2	1300	230.6	2010	149.2	2720	110.2	3860	77.67	5700	52.60	9300	32.24
600	499.7	1310	228.9	2020	148.4	2730	109.8	3880	77.27	5750	52.14	9350	32.07
610	491.5	1320	227.1	2030	147.7	2740	109.4	3900	76.88	5800	51.69	9400	31.90
620	483.6	1330	225.4	2040	147.0	2750	109.0	3920	76.49	5850	51.25	9450	31.73
630	475.9	1340	223.7	2050	146.3	2760	108.6	3940	76.10	5900	50.82	9500	31.56
640	468.5	1350	222.1	2060	145.5	2770	108.2	3960	75.71	5950	50.39	9550	31.39
650	461.3	1360	220.4	2070	144.8	2780	107.8	3980	75.33	6000	49.97	9600	31.23
660	454.3	1370	218.8	2080	144.1	2790	107.5	4000	74.96	6050	49.56	9650	31.07
670	447.5	1380	217.3	2090	143.5	2800	107.1	4020	74.58	6100	49.15	9700	30.91
680	440.9	1390	215.7	2100	142.3	2810	106.7	4040	74.21	6150	48.75	9750	30.75
690	434.5	1400	214.2	2110	142.1	2820	106.3	4060	73.85	6200	48.36	9800	30.59
700	428.3	1410	212.6	2120	141.4	2830	105.9	4080	73.49	6250	47.97	9850	30.44
710	422.3	1420	211.1	2130	140.8	2840	105.6	4100	73.13	6300	47.59	9900	30.28
										6350	47.22	9950	30.13


WHAZ
Antenna-WHAZ
R. Hayner
WHAZ
The Campus Serenaders
WHAZ


WNYC
Studio-WNYC
Home of WNYC
Reception Room
WNYC


WREO
WREO Quartette
Aerial Towers
Control Room
WREO Orchestra
Solo Studio
Roy E. Davis
WREO Staff

1926 CALENDAR 1926

1926 JANUARY 1926

SUN	MON	TUE	WED	THU	FRI	SAT
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24/31	25	26	27	28	29	30

1926 FEBRUARY 1926

SUN	MON	TUE	WED	THU	FRI	SAT
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28						

1926 MARCH 1926

SUN	MON	TUE	WED	THU	FRI	SAT
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31			

1926 APRIL 1926

SUN	MON	TUE	WED	THU	FRI	SAT
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	

1926 MAY 1926

SUN	MON	TUE	WED	THU	FRI	SAT
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23/30	24/31	25	26	27	28	29

1926 JUNE 1926

SUN	MON	TUE	WED	THU	FRI	SAT
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30			

1926 JULY 1926

SUN	MON	TUE	WED	THU	FRI	SAT
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	31

1926 AUGUST 1926

SUN	MON	TUE	WED	THU	FRI	SAT
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

1926 SEPTEMBER 1926

SUN	MON	TUE	WED	THU	FRI	SAT
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30		

1926 OCTOBER 1926

SUN	MON	TUE	WED	THU	FRI	SAT
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24/31	25	26	27	28	29	30

1926 NOVEMBER 1926

SUN	MON	TUE	WED	THU	FRI	SAT
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30				

1926 DECEMBER 1926

SUN	MON	TUE	WED	THU	FRI	SAT
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	

TIME IN ALL PARTS OF THE WORLD

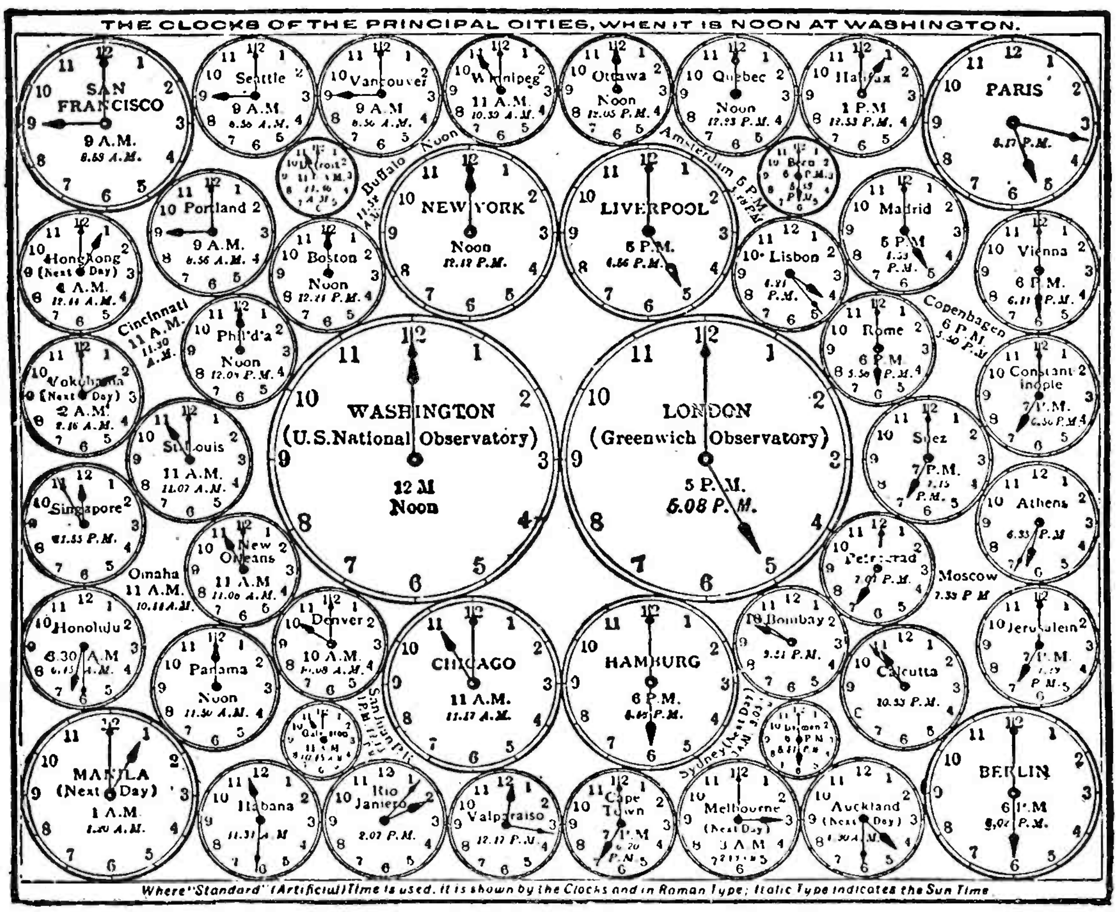
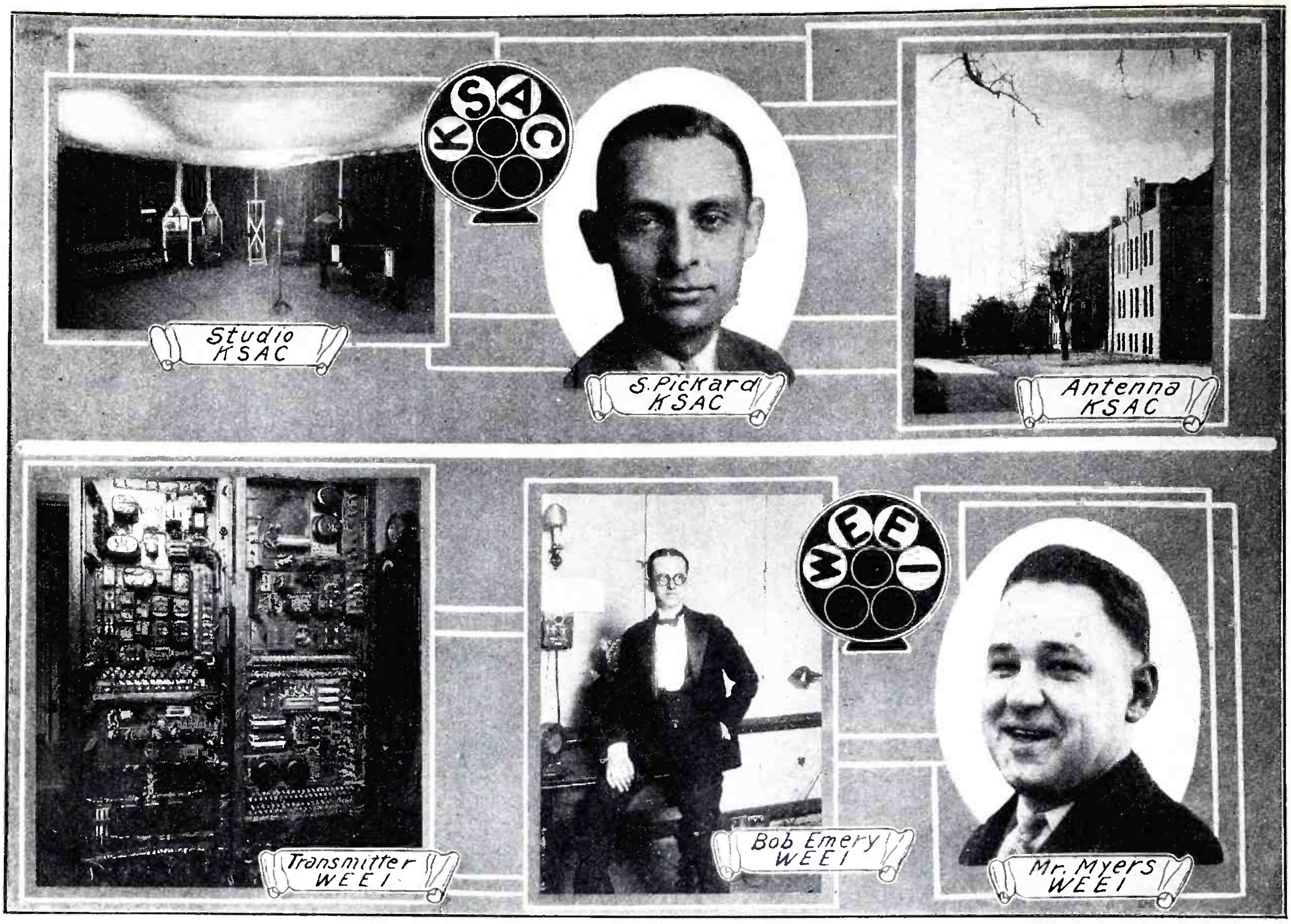


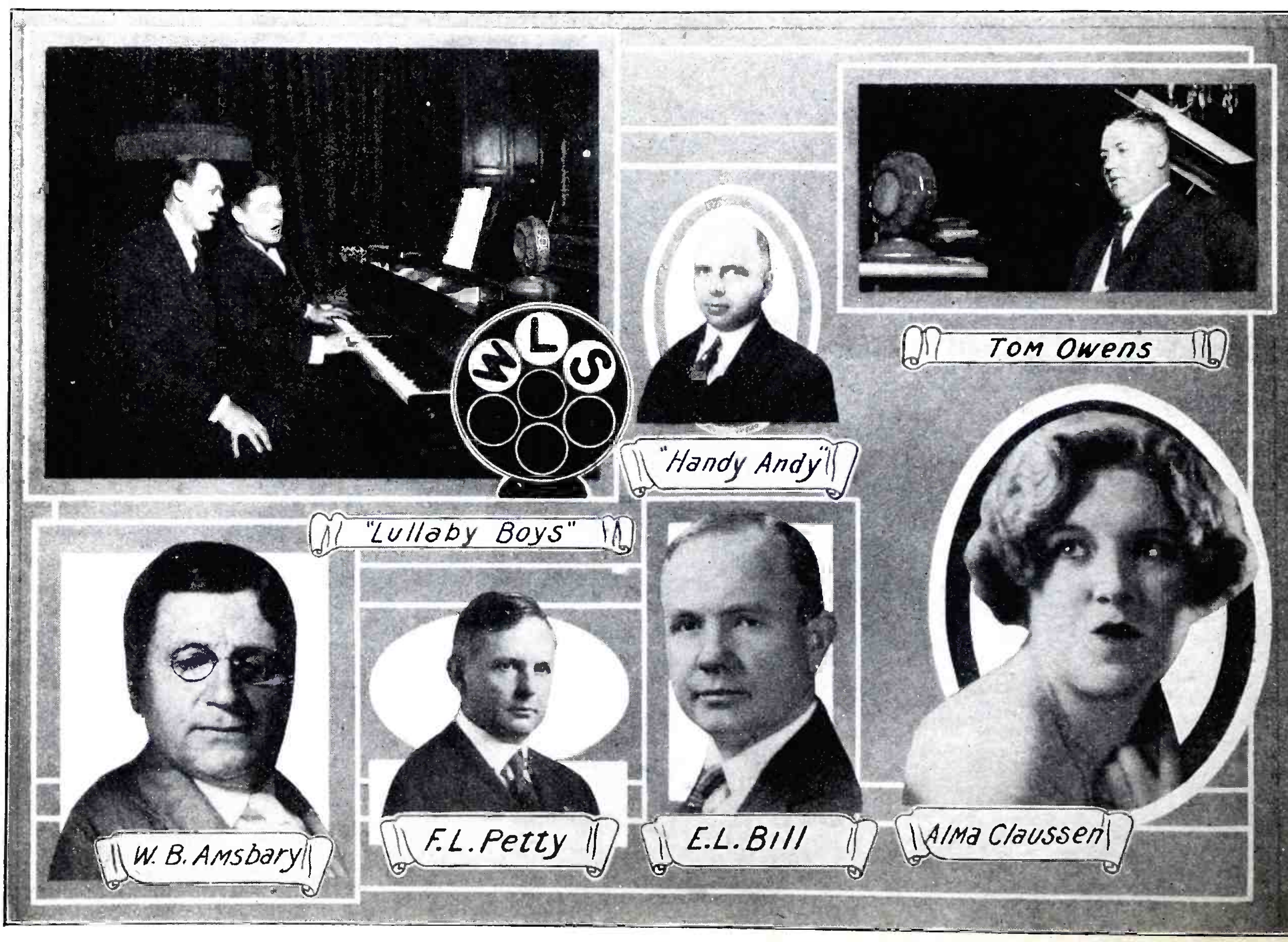
Table For Making Time Transitions

Eastern Standard Time	1	2	3	4	5	6	7	8	9	10	11	12
Central Standard Time	12	1	2	3	4	5	6	7	8	9	10	11
Mountain Standard Time	11	12	1	2	3	4	5	6	7	8	9	10
Pacific Standard Time	10	11	12	1	2	3	4	5	6	7	8	9

HOW TO USE TIME TRANSITION TABLE

If a station is giving a program at 8 o'clock Mountain time and you wish to find what this is equivalent to in Central time, find 8 o'clock in the third or Mountain time row. Then immediately above it in the same vertical column will be found the figure 9 in the Central time row. This indicates that the program would be heard at 9 o'clock Central time.


KSAC
Studio KSAC
S. Pickard KSAC
Antenna KSAC
Transmitter WEEI
Bob Emery WEEI
WEEI
Mr. Myers WEEI


Tom Owens
WLS
"Handy Andy"
"Lullaby Boys"
W. B. Amsbary
F. L. Petty
E. L. Bill
Alma Claussen

AMERICAN RADIO RELAY LEAGUE

This organization was formed in 1910 by Mr. H. P. Maxim, the inventor, and is purely an "amateur" organization in that it exists for the benefit of the art and is not in any way a profit-making organization. The primary purpose of the League is the relaying of messages to all parts of the country. To accomplish this end a traffic department is in existence by which the United States and Canada are divided into a number of divisions as shown, each having a Division Manager in charge. Each state is under the jurisdiction of an Assistant Division Manager who has in turn District Superintendents under him in such number as the population and size of the state warrants. Cities of 25,000 or more have City Managers and smaller cities have official relay stations. By means of this organization it is possible to transmit messages throughout the country without any charge to the sender.

DIRECTORY

OFFICERS

President
HIRAM PERCY MAXIM
Hartford, Conn.

Vice-President
CHAS. H. STEWART
St. David's, Pa.

Traffic Manager
F. H. SCHNELL
Hartford, Conn.

Canadian Gen. Manager
A. H. K. RUSSELL
6 Mail Bldg.,
Toronto, Ont.

Treasurer
A. A. HEBERT
Hartford, Conn.

Secretary
K. B. WARNER
Hartford, Conn.

DIRECTORS

President
HIRAM PERCY MAXIM
Drawer 4,
Hartford, Conn.

Vice-President
CHAS. H. STEWART
St. David's, Pa.

Canada
A. H. K. RUSSELL
6 Mail Bldg.,
Toronto, Ont.

Atlantic Division
DR. EUGENE C. WOODRUFF
243 West Fairmont Ave.,
State College, Pa.

Central Division
CLYDE E. DARR
137 Hill Ave., Highland Park,
Detroit, Mich.

Dakota Division
C. M. JANSKY, JR.
Dept. of Elec. Eng., U. of M.,
Minneapolis, Minn.

Delta Division
BENJ. F. PAINTER
424 Hamilton Nat'l Bank Bldg
Chattanooga, Tenn.

Hudson Division
DR. LAWRENCE J. DUNN
480 East 19th St.,
Brooklyn, N. Y.

Midwest Division
PORTER H. QUINBY
Box 134-A, Route 6,
Omaha, Nebr.

New England Division
DR. ELLIOT A. WHITE
Apt. K, The Parker, N. Park St.
Hanover, N. H.

Northwestern Division
K. W. WEINGARTEN
3219 No. 24th St.,
Tacoma, Wash.

Pacific Division
ALLEN H. BABCOCK
65 Market St.,
San Francisco, Cal.

Roanoke Division
W. TREDWAY GRAVELY
424 Main St.,
Danville, Va.

Rocky Mountain Division
PAUL M. SEGAL
c/o District Attorney
West Side Court Bldg.,
Denver, Colo.

Southeastern Division
HARRY F. DOBBS
c/o Dobbs & Wey Co.
Atlanta, Ga.

West Gulf Division
FRANK M. CORLETT
2515 Catherine St.,
Dallas, Tex.

ADVISORY TECHNICAL COMMITTEE

STUART BALLANTINE
LEO C. YOUNG
LEROY M. E. CLAUSING
FRANK CONRAD
WM. C. BALLAD. Jr.
GERALD M. BEST
MINTON CRONKHITE
J. H. DELLINGER
C. L. FARAND
PAUL F. GODLEY
F. C. BLAKE
MELVILLE EASTHAM
D. G. McCAA
L. A. HAZELTINE
C. D. TUSKA
R. H. G. MATHEWS
S. KRUSE

TRAFFIC DEPARTMENT OF THE AMERICAN RADIO RELAY LEAGUE

ATLANTIC DIVISION

Manager,	3DW	E. B. Duvall, Box 317, Edmonston, Md.
A.D.M.	D. of C., 3AB	A. B. Goodall, 1824 Ingleside Ter., Washington
A.D.M.	Maryland, 3HG	G. L. Deichmann, Jr., Chapel Gate Lane, Ten Hills, Baltimore
A.D.M.	So. N. J., 3EH	H. W. Densham, 140 Washington St., Collingswood
A.D.M.	West N. Y., 8PJ	C. S. Taylor, 598 Masten St., Buffalo
A.D.M.	East, Pa., 3FM	J. F. Rau, 2085 E. Kingston St., Philadelphia
A.D.M.	West, Pa., 8ZD	P. E. Wiggin, 714 Johnston St., Wilkinsburg
A.D.M.	Delaware, 3AIS	H. H. Layton, 805 Washington St., Wilmington

CENTRAL DIVISION

Manager,	9ZN	R. H. G. Mathews, 2747 Hampden Court, Chicago, Ill.
A.D.M.	Michigan, 3ZZ	C. E. Darr, 137 Hill Ave., Highland Park, Detroit
A.D.M.	Ohio, 8AA	C. E. Nichols, 739 Weadock Ave., Lima
A.D.M.	Illinois	
A.D.M.	Wisconsin, 9VD	C. N. Crapo, 443 Newton Ave., Milwaukee
A.D.M.	Indiana, 9CYQ	D. J. Angus, 310 N. Illinois St., Indianapolis
A.D.M.	Kentucky, 9EI	J. C. Anderson, Glengary Farm, Lexington

DAKOTA DIVISION

Manager,	9ZT-9XAX	D. C. Wallace, 54 N. Penn Ave., Minneapolis, Minn.
A.D.M.	Minnesota, 9EGU	C. L. Barker, Henning
A.D.M.	So. Dak., 9CJS	M. J. Junkins, Bryant
A.D.M.	No. Dak., 9CSI	M. L. Monson, E. 12th St., Grafton

DELTA DIVISION

Manager,	4MM	B. F. Painter, 424 Hamilton Nat. Bank Bldg., Chattanooga, Tenn.
A.D.M.	Mississippi, 5AKP	J. W. Gullett, 819-29th Ave., Meridian
A.D.M.	Arkansas, 5XAB	Dr. L. M. Hunter, 207½ Main St., Little Rock
A.D.M.	Tennessee, 4KN	L. K. Rush, 4 Second St., Bemis
A.D.M.	Louisiana, 5UK	C. A. Freitag, 8520 Forshey St., New Orleans

HUDSON DIVISION

Manager,	2BRB	E. M. Glaser, 845 E. 13th St., Brooklyn, N. Y.
A.D.M.	No. N. J., 2WR	A. G. Wester, Jr., 1075 Chancellor St., Irvington
A.D.M.	N. Y. C., 2CWR	F. H. Mardon, 1309 W. Farms Rd., Bronx
A.D.M.	East. N. Y., 2PV	H. N. Ammenheuser, 178 Quail St., Albany

MIDWEST DIVISION

Manager,	9DXY	P. H. Quinby, Box 134A, Rt 6, Omaha, Nebr.
Asst. Secy. to D.M.,		B. Diehl, 3006 So. Ave., Omaha
A.D.M.	Iowa, 9ARZ	D. E. Watts, 116 Hyland Ave., Ames
A.D.M.	Mo., 9RR	L. B. Laizure, 8020 Mercier St., Kansas City
A.D.M.	Kansas, 9CCS	C. M. Lewis, 312 E. Rutledge St., Yates Center
A.D.M.	Nebraska, 9CJT	H. A. Nielson, 4708 N. 39th St., Omaha

NEW ENGLAND DIVISION

Manager,	1AWW	T. F. Cushing, 78 College St., Springfield, Mass.
A.D.M.	R. I., 1BVB	D. B. Fancher, 86 Franklin St., Westerly
A.D.M.	N. H., 1GL	C. P. Sawyer, 11 Stark St., Manchester
A.D.M.	Vt., 1AJG	Charles T. Kerr, Poultney
A.D.M.	W. Mass., 1ASU	C. V. Green, 6 Airlie St., Worcester
A.D.M.	E. Mass., 1KY	Miss Gladys Hannah, 3 Sumner Rd., Cambridge
A.D.M.	Conn., 1BM	H. E. Nichols, 60 Benham Ave., Bridgeport
A.D.M.	Maine	

NORTHWESTERN DIVISION

Manager,	7EK ex 7ABB	Everett Kick, 3802 Hoyt Ave., Everett, Wash.
A.D.M.	Montana, 7NT	A. R. Willson, Ramsey
A.D.M.	Wash., 7FD	Otto Johnson, 4340 30th West, Seattle

NORTHWESTERN DIVISION (continued)

A.D.M.	Oregon, 7IW	Paul R. Hoppe, P. O. Box 8, Eugene
A.D.M.	Idaho, 7OB	K. S. Norquest, Weather Bureau, Boise
A.D.M.	Alaska, 7DE	Leo H. Machin, Box 452, Cordova, Alaska

PACIFIC DIVISION

Manager,	Southern Section, 6ANL-6LJ	M. E. McCreery, 317 Central Ave., Los Angeles, Ca.
A.D.M.	Dist. 1, 2, 3, 6CTO	E. H. Burgman, 1200 Tamarind Ave., Hollywood
A.D.M.	Ariz., 6ANO	D. B. Lamb, 229 W. First St., Mesa
Manager	Northern Section. 6ZX	P. W. Dann, 562-35th St., Oakland
A.D.M.	Dist. 4, 6NX	F. J. Quement, 51 Pleasant St., San Jose
A.D.M.	Dist. 5—6A.W.T.	B. Molinari, 653 Union St., San Francisco
A.D.M.	Dist. 6,	St. Clair Adams, Eureka
A.D.M.	Nevada, 6UO	C. B. Newcomb, Yerrington
Manager,	Hawaiian Section, 6TQ	K. A. Cantin, 1593 Piioki St., Honolulu, T. H.
A.D.M.	Hawaii, 6BCG	W. H. Friedly, 1825 Dole St., Honolulu, T. H.

ROANOKE DIVISION

Manager,	3BZ	W. T. Gravely, 424 Main St., Box 245, Danville, Va.
A.D.M.	West Va., 8BSU-AKZ	C. S. Hoffman, Jr., 126 Chantal Court, Wheeling
A.D.M.	Virginia, 3CA	J. F. Wohlford, 118 Cambridge Ave., Roanoke
A.D.M.	No. Carolina, 4JR	R. S. Morris, 413 S. Broad St., Gastonia

ROCKY MOUNTAIN DIVISION

Manager,	7ZO	N. R. Hood. 1022 S. Ash St., Casper, Wyo.
A.D.M.	Colo., 9CAA	C. R. Stedman, 1641 Albion St., Denver
A.D.M.	Utah, 6ZT	Art Johnson, 247 E. 7th South St., Salt Lake City

SOUTHEASTERN DIVISION

Manager,	A.D.M., Ala. 5AJP	A. D. Trum, 217 Catoma St., Montgomery, Ala.
A.D.M.	S. C. 4RR	A. Dupre, 290 Wofford Campus, Spartanburg
A.D.M.	Ala., 5AJP	A. D. Trum, 217 Catoma St., Montgomery, Ala.
A.D.M.	Fla.	
A.D.M.	Ga. 4IO	J. Morris, 58 Frederica St. Atlanta
A.D.M.	Porto Rico, 4OI	Louis Rexach, Box 319, San Juan

WEST GULF DIVISION

Manager,	5ZC	F. M. Corlett, 2515 Catherine St., Dallas, Texas
A.D.M.	Oklahoma, 5APG	K. M. Ehret, 2904 N. Robinson St., Oklahoma City
A.D.M.	So. Texas, 5YK	E. A. Sahm, Box 569, New Braunfels
A.D.M.	No. Texas, 5AJT	W. B. Forrest, Jr., 502 Royal St., Waxahachia

MARITIME DIVISION

Manager,	1DD	W. C. Borrett, 14 Sinclair St., Dartmouth, N. S.
A.D.M.	P. E. I., 1BZ	W. Hyndman, Charlottetown
A.D.M.	N. B., 1EI	T. B. Lacey, c/o N. B. Power Co., St. John

ONTARIO DIVISION

Manager,	9BJ	W. Y. Sloan, 167 Close Ave., Toronto, Ont.
A.D.M.	Cen. Ont., 3VH	A. R. Williams, 56 Madison Ave., Toronto
A.D.M.	East Ont., 3APP	F. A. C. Harrison, 181 Hopewell Ave., Ottawa
A.D.M.	So. Ont., 3XI	J. E. Hayne, 303 N. Brock St., Sarnia

QUEBEC DIVISION

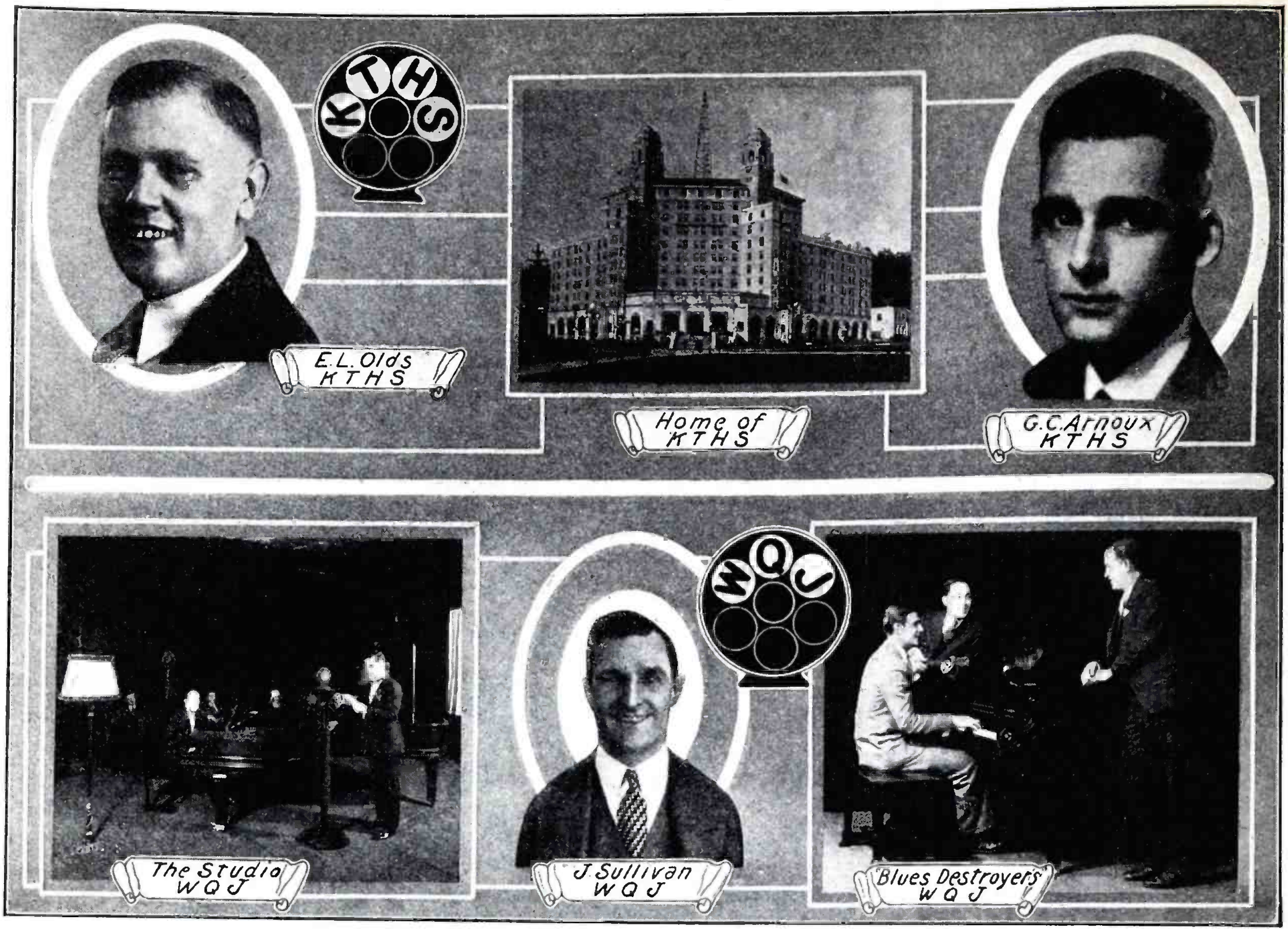
Manager,	2CG	J. V. Argyle, 493 Decarie Blvd., Montreal, Que.

VANCOUVER DIVISION

Manager,	5CG	Wm. J. Rowan, 1928 Pender St., E., Vancouver, B. C.

WINNIPEG DIVISION

Manager,	4AO	W. R. Pottle, 1164 Willow Ave., Moose Jaw, Sask.
A.D.M.	Sask., 4CB-9BX	E. L. Maynard, Morse
A.D.M.	Manitoba, 4DE	F. E. Rutland, Jr., 452 St. John Ave., Winnipeg


KTHS
E. L. Olds
KTHS
Home of
KTHS
G. C. Arnoux
KTHS
The Studio
WQJ
WQJ
J. Sullivan
WQJ
Blues Destroyers
WQJ


WOC
Solo Studio
P. J. Vipperman
Dr. F. W. Elliott
"Aunt Jane"
Erwin Swindell
Dr. B. J. Palmer
Peter MacArthur
Towers & Antenna

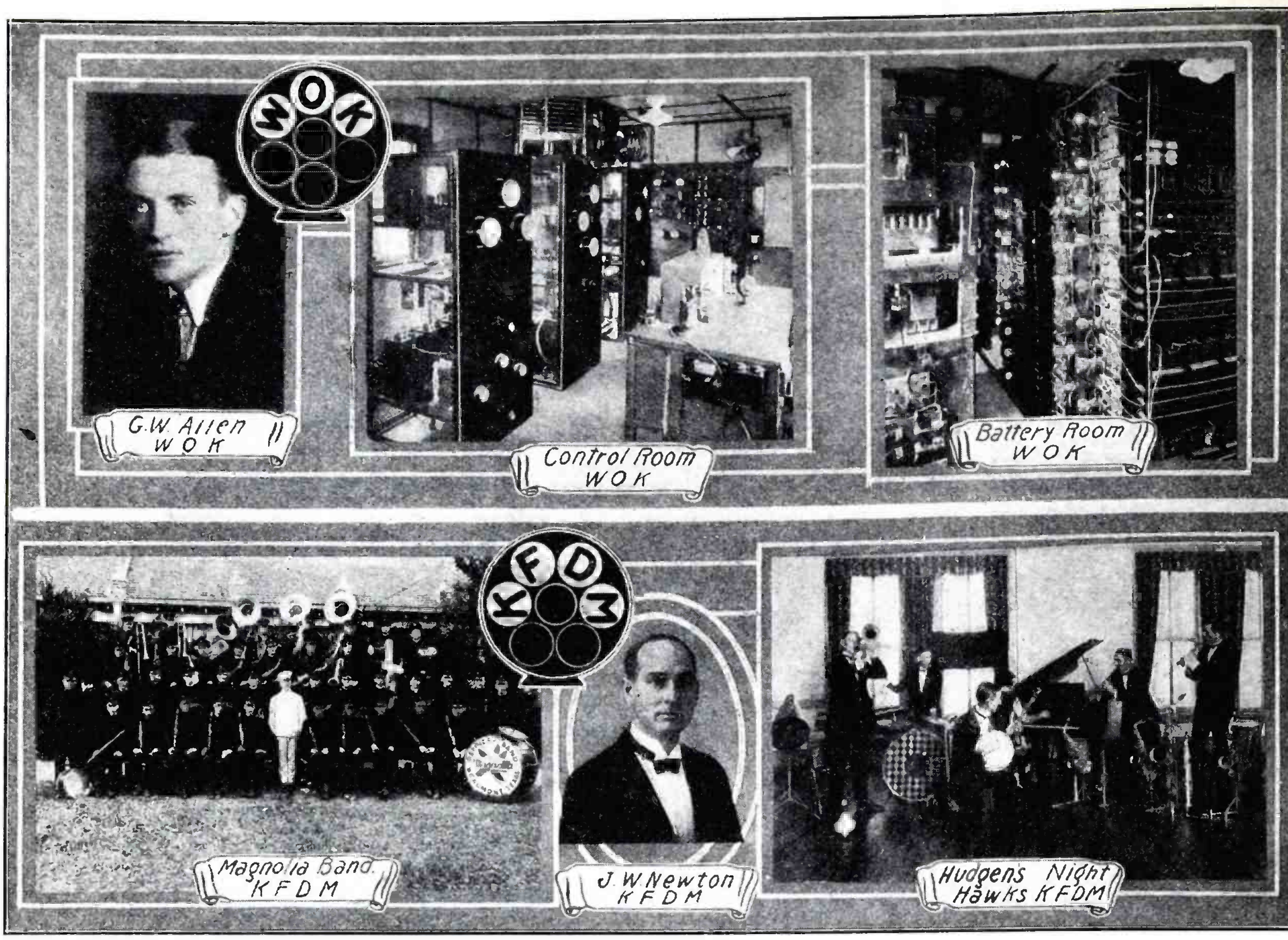
Canadian Radio Broadcast Stations

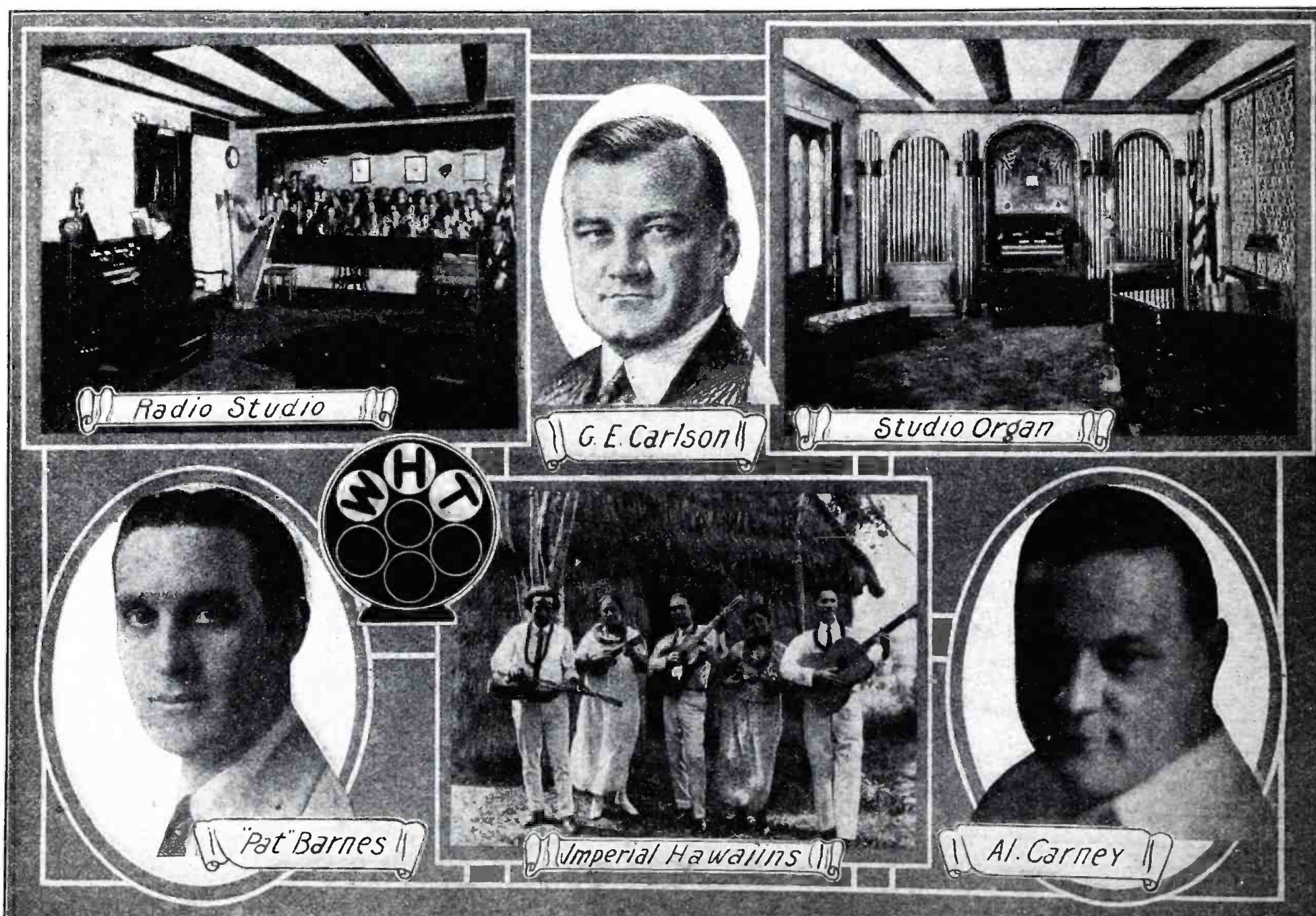
States and Cities	Owner	Call Letters	Wave Length (Meters)	Power (Watts)	Date	Time Received	Dial 1	Dial 2	Dial 3
NOVA SCOTIA—									
Glace Bay	Marconi	**DO**	3,000						
Halifax	Marconi	**CFCF**	440						
"	Radio Engineers	**CHAC**	400	500					
"	Eastern Telegraph & Telephone Co.	**CJCS**	410						
NEW BRUNSWICK—									
Moncton	Canadian National Railways	**CNRA**	313	1,000					
St. John	Jones Electric Co.	**CKCR**	400						
"	Maritime Radio Corporation	**CJCI**	400						
QUEBEC—									
Bellevue	Semmelhaack-Dickson (Ltd.)	**CFCQ**	450	40					
Gouin Dam	Shawaningin Water & Power Co.	**DW**	1,900						
Iroquois Falls	Abitibi Power & Paper Co.	**DS**	1,590						
Mont Joli	Dr. J. L. P. Landry	**CJCM**	312	500					
Montreal	University of Montreal	**CFUC**	400						
"	A. Contiore	**CJCL**	270						
"	Northern Electric Co.	**CHYC**	410	500					
"	Canadian National Railways	**CNRM**	341	2,000					
"	Bell Telephone Co.	**CKCS**							
"	La Presse Publishing Co.	**CKAC**	430	2,000					
"	Depuis Freres	**CJBC**	420						
"	Marconi	**CFCF**	440	500					
Quebec	Shawaningin Water & Power Co.	**DX**	1,900						
"	La Soliel Publishing Co.	**CKCI**	295	200					
"	La Cie. d'Evenement	**CFCJ**	410						
Thetford Mines	Shawaningin Water & Power Co.	**DY**	1,900						
Victoriaville	Shawaningin Water & Power Co.	**DV**	1,900						
ONTARIO—									
Hamilton	Wilkenson Electric Co. (Ltd)	**CKLC**	400						
"	Hamilton Spectator	**CHCS**	410	2,000					
"	Wentworth Radio Supply Co.	**CKOC**	410	100					
"	Jack V. Elliott (Ltd.)	**CFUC**	410						
Iroquois Falls	Abitibi Power & Paper Co.	**CFCH**	400	500					
Kingston	Queens University	**CFRC**	450	1,500					
Kitchener	The News Record (Ltd.).	**CJCF**	295	300					
London	Charles Guy Hunter	**CFCL**	430	100					
"	Free Press Printing Co.	**CJCG**	430	200					
"	London Radio Shop	**CHCO**	410						
"	Radio Supply Co.	**CKQC**	410						
"	London Radio Co.	**CFCW**	430	600					
Ottawa	Canadian National Railways	**CKCH**	435						
"	Canadian National Railways	**CNRO**	435	500					
"	J. R. Booth, Jr.	**CHXC**	400	1,200					
"	Dr. G. M. Geldert	**CKCO**	400	200					
Markham	Marconi	**DQ**	3,300						
Sudbury	Laurentide Air Service	**CFCR**	410	200					
Thorold	D. J. Fendell	**CFKC**	295						
Toronto	Northern Electric Co.	**CHIC**	350						
"	Simons Agnew & Co.	**CJCN**	410						
"	Metropolitan Motors	**CHVC**	410						
"	Marconi	**CHCB**	440						
"	T. Eaton Co.	**CJCD**	410	100					

States and Cities	Owner	Call Letters	Wave Length (Meters)	Power (Watts)	Date	Time Received	Dial 1	Dial 2	Dial 3
Toronto	Canadian National Railways (under construction)								
"	Jarvis Street Baptist Church	CJBC	312						
"	Toronto Radio Research Society	CHNC	350	200					
"	Canadian National Railways	CNRT	400	2,000					
"	Bell Telephone Co.	CFTC							
"	Evening Telegram	CJSC	430	500					
"	Star Publishing & Printing Co.	CFCA	400	2,000					
"	Canadian Ind. Tel. Co.	CKCE	450	2,000					
Twin Falls	Abitibi Power & Paper Co.	DT	1,590						
MANITOBA—									
Winnipeg	Manitoba Free Press	CJCG	410						
"	Canadian National Railways	CNRW	450	2,000					
"	Tribune Newspaper Co.	CJNC	400						
"	Manitoba Telephone System	CKY	450	500					
"	Radio Engineering Co.	CKZC	420						
SASKATCHEWAN—									
Regina	Canadian National Railways	CNRR	420	2,000					
"	G. M. Bell and Leader Pub. Co.	CKCK	420	2,000					
Saskatoon	Canadian National Railways	CNRS	400	500					
"	International Bible Students Asso.	CHUC	400						
"	The Electric Shop	CFQC	400	200					
ALBERTA—									
Calgary	Albertan Publishing Co.	CHBC	410	500					
"	Canadian National Railways	CNRC	440	1,000					
"	W. W. Grant Radio (Ltd.)	CFCN	440	1,750					
"	Calgary Herald	CFAC	430	2,000					
"	E. Taylor	CJCY	420						
"	Western Radio Co.	CHCQ	400						
"	G. Melrose Bell	CGAC	430						
"	H. Birks & Sons	CFHC	440	1,000					
"	Riley & McCormick	CHCM	440	1,000					
"	Radio Corporation of Calgary (Ltd.)	CJCK	316	500					
"	P. Burns & Co.	CKCX	440	1,000					
Edmonton	Edmonton Journal	CJCA	450	500					
"	Canadian National Railways	CNRE	450	500					
"	Radio Supply Co.	CFCK	410	250					
Olds	Percival Wesley Shackleton	CJCX	400						
BRITISH COLUMBIA—									
Lulu Island	Canadian National Railways	CNRV							
Nainamo	Sparks Co.	CFDC	430	50					
Nelson	J. G. Bennett	CJBC	400						
New Westminster	Westminster Trust Co.	CFXC	440						
Ocean Falls	Pacific Mills (Ltd.)	CD	600—1,600						
Vancouver	Canadian Westinghouse Co. (Ltd.)	CHOC	400						
"	Canadian National Railways								
"	First Congregational Church	CKFC	385						
"	Victor W. Odlum	CFYC	400	20					
"	Radio Specialties Co.	CFCQ	450	40					
"	Marconi	CFCD	440						
"	Vancouver Merchants Exchange	CNCL	440						
"	Daily Province	CKCD	410	2,000					
"	Sprott Shaw Radio Co.	CJCE	400	150					
Victoria	Western Canada Radio Supply Co.	CHCE	400	20					
"	Centennial Methodist Church	CFCL	400	500					
"	Victoria City Temple	CFCT	410	500					

Log for Additional Broadcast Stations

Radio Call Letters	BROADCAST STATIONS Location and Name	Power Watts	Wave Length (Meters)	Frequency (Kilocycles)	Time at Station	Date	Time Received	Dial 1	Dial 2	Dial 3


WOK
G.W. Allen WOK
Control Room WOK
Battery Room WOK
KFDM
Magnolia Band KFDM
J.W. Newton KFDM
Hudgens Night Hawks KFDM


Radio Studio
G.E. Carlson
Studio Organ
WHT
"Pat" Barnes
Imperial Hawaiins
Al. Carney

Foreign Radio Broadcast Stations

Including U. S. Possessions

States and Cities	Owner	Call Letters	Wave Length (Meters)	Power (Watts)	Date	Time Received	Dial 1	Dial 2	Dial 3
ALASKA									
Juneau	Alaska Electric Light & Power Co.	KFIU	226	10					
ALGERIA									
Algiers	Colin & Fils	8DB	180-200	100					
ARGENTINA									
Buenos Aires	Argentine Ass'n of Broadcasters	LOR	350-410	*500					
" "	Radio Nacional	LOY		*1,000					
" "	Francisco J. Brusa	B1							
" "	Falcutad de Ciencias Medicas	C1							
" "	Departmento Nacional de Higiene	C3							
" "	Departmento Nacional de Higiene	C2							
" "	Sociedade Radio Telefonico	A1							
" "	Radio Cultura	LOX	375	*500					
" "	Grand Splendid Theater	LOW		*1,000					
" "	Francisco J. Brusa	LOV		*1,000					
" "	Senores Bocci Hermanos	AI1							
Tucuman	Radio Club			*100					
AUSTRALIA									
Adelaide	Central Broadcasting Co.	5CL	395	*5,000					
"	F. J. Hume	5DN	313	*500					
"	Marshall & Co.	5MC	273	*500					
Brisbane	Queensland Government Bureau of Agriculture	4QG	385	*5,000					
Hobart	Associated Radio Co. (projected)	7ZL	390	*3,000					
Melbourne	Associated Radio Co.	3AR	484	*5,000					
"	Broadcasting Co. of Australia	3LO	371	*5,000					
"	Wangaratta Sports Depot	3HW	300	*100					
Mildura	R. J. Egge	3EO	520	*100					
Newcastle	Broadcasters Sydney (Ltd) (proj.)								
"	H. A. Douglas	2HD	333	*50					
Perth	Westralian Farmers (Ltd.)	2WF	1,250	*5,000					
Sydney	Electrical Utilities Supply Co.	2UE	293	*250					
"	Burgin Electric Co.	2BE	316	*100					
"	A. W. A.	2WA	462	*500					
"	Farmer & Co., (Ltd.)	2FO	1,100	*5,000					
"	Labor Party (projected)			*3,000					
"	Broadcastings Sydney (Ltd.)	2BL	353	*1,500					
AUSTRIA									
Bregenz	Projected (relay)								
Graz	Oesterreichischer Radioverkehrs Gesellschaft		404	*500					
Innsbruck	Projected (relay)								
Klagenfurt	Projected (relay)								
Linz	Projected (relay)								
Salzburg	Projected (relay)								
Vienna	Oesterreichischer Radioverkehrs Gesellschaft	ORV	530	2,000					
BELGIUM									
Brussels	Radio Belgique Co.	(1)	265	1,600					
Haeren		BAV	900-100	4000					
BRAZIL									
Bahia	Cia. Radiotelegraphica Brasiliera (projected)			*500					
"	Radio Sociedade do Bahia		250-450	*500					

(*) Preceding the power of the station indicates that there is doubt as to whether power given is input or antenna measurement.

(1)—Radio Belgique.

When no mark precedes figures in column headed "Power-Watts" the figures indicate antenna measurement.

States and Cities	Owner	Call Letters	Wave Length (Meters)	Power (Watts)	Date	Time Received	Dial 1	Dial 2	Dial 3
Bello Horizante	National Telegraph Service			*500					
" "	Cia. Radiotelegraphica Brasiliera (projected)								
" "	Radio Sociedade de Minas Geraes		370	*500					
Ceara				*50					
Curityba	Radio Club Paraneanse (under construction)								
Goyanna	Benedicto Rabello (projected)								
Para	Radio Club de Para (projected)			*50					
Parnahyba	Soc. Algodoeira (projected)								
Parana				*300					
Penedo	A. G. de Oliveira (projected)								
Porto Alegre	Radio Sociedade Rio Grandense	RSR	381	*80					
Recife	Radio Club, Pernambuco		310	*300					
"	Cia. Radiotelegraphica Brasiliera (Projected)								
"	Sociedade Algodoeira (projected)								
"	Tito de Araujo Firmo Xavier (projected)		105	*500					
Ribeiro Preto	Radio Club de Ribeiro Preto (projected)								
Rio de Janeiro	Radio Sociedade do Rio de Janeiro	SPE	380						
" " "	Radio Club de Brazil	SPE	312-325	*500					
" " "	Cia. Radio telegraphica Brasiliera (projected)								
Rio Grande do Sul	Sociedade Rio G. Radiocultura (projected)								
Sao Paulo	Radio Club de Sao Paulo		380-420	*100					
" "	Radio Educadora Paulista		350	*10					
" "	Radio Educadora Paulista (under construction)			*1,000					
"	Cia. Radio telegraphica Brasiliera (projected)								
CANARY ISLANDS									
Teneriffe			120	*100					
Santa Cruz	Projected								
CEYLON									
Colombo	Ceylon American Wireless Association (projected)								
CHILE									
Santiago	Sociedade de Broadcasting de Chile	CRC	400-460	*600-250					
"	Mercurio (projected)								
Valparaiso	Antonio Cornish Besa	ACB	400	*50					
CHINA									
Kowloon	Radio Communication Co. (under construction)			*50					
Mukden	Government (projected)								
Peking	Government			*500					
Shanghai	The Evening News								
Tientsin	Gesho Electric Road (projected)			*500					
Victoria	Radio Comunication Co.			*10					
"	Hongkong Hotel Co.			*100					
"	Government (projected)			*1,500					
COSTA RICA									
San Jose	Government (under construction)								

States and Cities	Owner	Call Letters	Wave Length (Meters)	Power (Watts)	Date	Time Received	Dial 1	Dial 2	Dial 3
CUBA									
Caibarien	Maria J. Alvarez	6EV	250	50					
Camaguey	Pedro Nogueros	7AZ	225	10					
"	Salvador Rionda	7SR	350	500					
Central Tuinicu	Frank H. Jones	6KW	340	100					
Central Tuinicu	Frank H. Jones	6JK	275	100					
Camajuani	Diego Iborra	6YR	200	20					
Ciego de Avila	Eduardo V. Figuerca	7BY	235	20					
Cienfuegos	Eligio Cobelo Ramirez	6JQ	275	10					
"	Jose Ganduxe	6BY	300	100					
Habana	Credito y Construcciones Co.	2HP	295	100					
"	Julio Power	2JP	270	20					
"	Antonio A. Ginard	2XX	150	5					
"	Frederick W. Borton	2CX	320	10					
"	Alberto S. Bustamente	2AB	235	10					
"	Cuban Telephone Co.	PWX	400	500					
"	Jose Leiro	2JL	275	5					
"	El Pais	2EP	355	400					
"	Humberto Giquel	2CG	350	15					
"	Bernado Barrie	2BB	255	15					
"	Manuel y Guilliermo Salas	2MG	280	20					
"	Mario Garcia Velez	2OK	360	100					
"	Oscar Collado Orta	2OL	300	100					
"	Salvador de la Torre	2RY	170	5					
"	Roberto E. Ramirez	2TW	230	20					
"	Roberto E. Ramirez	2UF	265	10					
"	Raoul Karman	2RK	310	20					
"	George A. Lindeaux	2PK	195	10					
Matanzas	Leopoldo T. Figueroa	5EV	360	10					
Nueva Gerona	Isle of Pines Telephone Co.	8JQ		20					
Puerto del Rio	Antonio Sarasola	1AZ	275	5					
Sagua la Grande	Santiago Ventura	6HS	200	10					
Santiago	Andres Vinent	8FU	225	15					
"	Alberto Ravelo	8BY	250	100					
"	Guillermo Polanco	8HS	200	20					
"	Ceferino Ramos	8IR	190	20					
"	Jose Fernandez Heredia	8JQ	130	20					
CZECHO-SLOVAKIA									
Bratislava	Projected (relay)			500					
Brunn		OKB	1,800	1,000					
"	Projected, to replace above station	OKB	1,800	1,000					
Prague-Strasnice		OKP	550	500					
"	Projected, to replace above station	OKP	513	5,000					
Kosice	Projected			500					
Ushorod	Projected (relay)			500					
DENMARK									
Hjorring	Relay		1,250						
Lyngby	Danish State Telegraph System	OXE	2,400	2,500					
"	Danish Government		775	500					
Odense	Relay		950						
Ryvang	Ministry of War		1,150	1,000					
ECUADOR									
Guayaquil	El Telegrapho (projected)								
EGYPT									
Alexandria	Projected								

States and Cities	Owner	Call Letters	Wave Length (Meters)	Power (Watts)	Date	Time Received	Dial 1	Dial 2	Dial 3
FINLAND									
Helsingfors	Civil Guards of Finland								
"	Youth's Society		300	*250					
Skatudden	Military Station	(²)	420	*1,000					
Tammerfors	Nuoren Voiman Liiton Radioyhdistys	3NB	300	*250					
FRANCE									
Abbeyville			900						
Agen									
Bordeaux	Lafayette Station								
Dijon		FND	900						
Issy-sur-Moulineaux	Ministry of Posts		1,600						
Lille	Coupleux Freres								
Lyon	Ministry of Posts	YN	550	*500					
"	Societe Lyonnaise de Radiophonie		287	*2,000					
Montepellier	Societe Languedocienne de T. S. F.		186	*100					
Nice	Ministry of Posts		362-460						
Paris	Ecole Superieure de P. T. T.	ESP	458	*2,000					
"	Eiffel Tower, army	FL	2,650	*5,000					
"	Radio Electrique	SFR	1,780	*10,000					
"		8AJ	1,780						
"	Petit Parisien		345	*500					
"			1,780	*15,000					
Pic du Midi			350						
Toulouse	Aerodrome	MRD	1,525						
Tours	Ministry of Posts	YG	2,500	*500					
GERMANY									
Berlin	Konigswusterhausen	LP	330-680	†5,000					
"	Telefunken Co.		290-750	†2,000					
"	Vox Haus	H	425-505	†1,500					
"	Magdeburger Platz (under const.)								
Bremen			330						
Breslau	Schlessischer Rundfunk	GPU	418	†1,500					
Cassel			292						
Dresden			280						
Eberswalde									
Frankfort	Sudwest Deutscher Rundfunk Dienst	LP	470	†1,500					
Gleiwitz				†1,500					
Hamburg	Nordischer Rundfunk	EG	395	†1,500					
Hanover			296						
Koenigsburg	Ostmarken Rundfunk	LP	463	†1,500					
Leipzig	Mitteldeutscher Rundfunk	MR	454	†1,500					
Munster			410	†1,500					
Munich	Deutsche Stunde in Bayern	WM	485	†1,500					
Norddeich		KAV	1,800						
Nuremburg	Relay		340						
Stettin	Relay (projected)								
Stuttgart	Suddeutscher Rundfunk	OKP	443	†1,500					
Waldenburg				†1,500					
HAWAII									
Honolulu	Marion A. Mulrony	KGU	270	500					
HUNGARY									
Budapest	Post Office	MTI	950	*250					
"	Post Office	HB	950	*1,100					

(†) Indicates input.
(²)—Radio division.

States and Cities	Owner	Call Letters	Wave Length (Meters)	Power (Watts)	Date	Time Received	Dial 1	Dial 2	Dial 3
INDIA									
Bombay	Bombay Presidency Radio Club	2FV	400	*1,500					
Calcutta	Radio Club of Bengal	2BZ	800	*500					
"		5AF	425						
Madras	Radio Club of Madras (projected)								
Rangoon	Radio Club of Burma (projected)								
IRISH FREE STATE									
Cork	Projected								
Dublin	Projected								
ITALY									
Milan	Proj., Union Radiofonica Italiana		384	1,600					
Naples	Projected		392	1,600					
Rome	Unione Radiofonica Italiana	IRO	425	1,600					
JAPAN									
Nagoya	Nagoya Radio Broadcasting Co.	JOCK	360						
Osaka	Osaka Radio Broadcasting Co.		385	500					
"	Osaka Radio Broadcasting Co. (projected)		385	1,500					
Tokyo			375	1,000					
KWANGTUNG Leased Terr.									
Dairen	Projected								
LATVIA									
Riga	Projected			*2,000					
LITHUANIA									
Kovno	Lithuanian Sales Corporation			5					
"	Under construction								
MEXICO									
Chihuahua	Telephone Company	CZF	325	250					
"	Federal Military Command	FAM	490	1,000					
Guadalajara	Radio Club-Degollado Theatre		280	10					
Mazatlan	Castulo Llamas	CYR	475	250					
Mexico City	Elfrian R. Gomez	CYA	300	500					
" "	Jose J. Reynosa (El Buen Tono)	CYB	275	500					
" "	Miguel S. Castro (La High Life)	CYH	375	100					
" "	Raoul Azcarra (Universal Casa del Radio)	CYL	400	500					
" "	Martinez y Zatina	CYO	425	100					
" "	El Excelsior Parker	CYX	325	500					
" "	Department of Education	CZE	350	500					
Monterre	Roberto Reyes	CYM	275	100					
Oaxaca	Federico Zonilla	CYF	265	100					
Puebla	Augustin del P. Zaenz	CYU	312	100					
Tampico	Cipriano Sagaon	CYQ	322	100					
Yucatan	Partido Socialista del Sureste	CYY	548	100					
MOROCCO									
Casablanca	Radio Club de Moroc	CNO	250	*500					
NETHERLANDS									
Amsterdam	W. Bosman	PX9	1,050	60					
"	Vas Dias Press Office	PCFF	1,950	100					
Bloemendaal	Church		340	100					
Hilversum[3]	Nederlandische Seintoellen Fabriek	HDO	1,050	1,000					
" (3)	Hilversum Draadlooze Omroep	HDO	1,050	1,000					
NEW ZEALAND									
Auckland	Newcombe (Ltd.)	1YL	260	*500					
"	Auckland Radio Service	1YA	260	*200					
"	La Gloria Gramophone Co.	1YB	260	*50					

(3)—Separate stations.

States and Cities	Owner	Call Letters	Wave Length (Meters)	Power (Watts)	Date	Time Received	Dial 1	Dial 2	Dial 3
Christchurch				*500					
Dunedin	Otago University	4XO	140						
"	British Electrical & Enginering Co.	4YA	310-370	*500					
"	Radio Supply Co.	4YO	370	*500					
Gisborne	Gisborne Radio Co.	2YM	335	*500					
Wellington	Broadcastings (Ltd.)	2YB	275	*15					
"	Dominion Radio Co.	2YK	275	*500					
NORWAY									
Oslo		OSLO	340-500						
PERU									
Lima	Peruvian Broadcasting Co. (Ltd.)	OAB	360	*1,500					
PHILIPPINE ISLANDS									
Manila	Far Eastern Radio (Inc.)	KZRQ	222	500					
"	F. Johnson Elser	KZUY	370	500					
"	Electrical Supply Co.	KZKZ	270	500					
POLAND									
Warsaw	Government		365	*300					
PORTO RICO									
San Juan	Radio Corp. of Porto Rico	WKAQ	340	500					
PORTUGAL									
Lisbon	Grandes Armazens de Chiado	P1AA	320						
RUSSIA									
Baku	Under construction			2,000					
Chiva	Under construction			2,000					
Elliset	Under construction			2,000					
Erivan	Under construction			2,000					
Tiflis	Under construction			2,000					
Voronezh	Under construction			2,000					
Moscow	Popov		1,010						
"	Trade Union		450						
"	Lubovitch		365						
"	Union of Soviet Workers		675						
"	Comintern		1,450	†12,000					
"	Comintern (under construction)		1,450	50,000					
Leningrad									
Kiev									
SALVADOR									
San Salvador	Projected			500					
SENEGAL									
St. Louis	Radio Club Senegalaise (project.)		300	*100					
SPAIN									
Alcoy									
Barcelona	Radio Barcelona-Hotel Solon	EAJ1	325	*1,500					
Bilbao									
"									
Cadiz		EAJ3	360	*1,000					
"				*100					
Catagena		EBX	1,200						
Madrid "	Under construction	EGC	1,650 2,200	*2,000					
"	Radio Iberica	RI	392	*1,500					
"	Radio Madrid	PTT	310	*1,000					
"	Radio Espana	EAJ2	350						
San Sebastian	Projected								
Seville	Radio Club	EAJ5	350	240					
"	Radio Club (under construction)	EAJ5	350	*1,000					

States and Cities	Owner	Call Letters	Wave Length (Meters)	Power (Watts)	Date	Time Received	Dial 1	Dial 2	Dial 3
Valencia	Radio Club (projected)			1,000					
"	Reina Victoria Hotel								
Zaragoza	Radio Club (projected)								
STRAITS SETTLEMENTS									
Singapore	Projected			*100					
SWEDEN									
Boden	Radiotjanst	SASE	2,500						
Falun	Radiotjanst								
Goteborg	Radiotjanst	SASB							
Jonkopings	Jonkopings Rundradiostation	SMZD	265						
Karlstad	Karlstads Rundradiostation	SMXG	355						
Malmo	Radiotjanst	SASC	270	*1,500					
Stockholm	Radiotjanst	SASA	470-440						
Sundsvall	Radiotjanst	SASD	680						
Trollhattan	Trollhattans Rundradiostation	SMXQ	345						
Varberg	Varberg Radio Club (projected)								
SWITZERLAND									
Basel	Under construction								
Geneva	International Esperanto Association (projected)								
"	Cointrin	HBI	1,100	*300					
Hoengg	Swiss Radio Association		515-650	*500					
Kloten		HBK	1,100						
Lausanne	Champ de l'Air	HB2	780-1,100	*500					
Zurich	Zurich University	RGZ	515-650	*500					
TUNISIA									
Tunis	French Army								
UNION OF SOUTH AFRICA									
Cape Town	Cape Publicity Association	WAMG	400	*500					
Durban	Town Council		350	*500					
Grahamstown			400						
Johannesburg	Associated Scientific and Technical Societies	JB	450	*500					
UNITED KINGDOM									
Birmingham	British Broadcasting Co.	5IT	479	1,000					
Bournemouth	British Broadcasting Co.	6BM	385	1,000					
Daventry	British Broadcasting Co.	5XX	1,600	16,000					
Hull	British Broadcasting Co.	6KH	335	150					
Leeds-Bradford	British Broadcasting Co.	2LS	346-310	150					
Liverpool	British Broadcasting Co.	6LV	315	150					
London	British Broadcasting Co.	2LO	365	2,000					
Manchester	British Broadcasting Co.	2ZY	378	1,000					
Newcastle	British Broadcasting Co.	5NO	408	1,000					
Nottingham	British Broadcasting Co.	5NG	326	150					
Plymouth	British Broadcasting Co.	5PY	338	150					
Sheffield	British Broadcasting Co.	6FL	301	150					
Stoke-on-Trent	British Broadcasting Co.	6ST	306	150					
Cardiff	British Broadcasting Co.	5WA	353	1,000					
URUGUAY									
Montevideo	Crandon Institute			500					
"	El Dia								
VENEZUELA									
Caracas	Coronel Arturo Santana (project.)								
YUGOSLAVIA									
Belgrade	Cie. Generale de T. S. F.	HFF	1,625	*5,000					
Rakovitza			1,650						
Zagreb	Radio Club (under construction)								

How Uncle Sam is Clearing the Air

By ARTHUR BATCHELLER*

IN the ship service the United States Government has dispensed with the use of the 300 and 450 meter waves entirely, and has limited to calling and distress messages (SOS) the use of the 600 meter wave. The latter was in use previously for routine communication purposes. We had to provide new channels for ship radio communication to replace those which were thus closed to them, and in addition to take care of the constantly increasing radio telegraphic business of this country, and in fact of the world, as ships at sea are continually communicating with our shore stations. Accordingly there have been assigned for ship use the following wavelengths: for distress calls and messages relating thereto—600 meters; for regular marine traffic 706, 750 and 900 meters; for naval radio compass service—800 meters. In the long wave marine bands the following waves have been assigned, 1800, 1900, 2000, 2100 and 2400 meters. This gives for marine radio telegraph service ten wavelengths, the lowest of which is 600 and the highest 2400 meters.

In addition to the above the steamers plying on Long Island Sound have been authorized to use the wavelength of 875 meters, while the shore station at New London, Conn., which works with these steamers has been authorized to use a wavelength of 920 meters. All of these ship stations and all shore stations are required to maintain a listening-in watch on 600 meters for distress calls and messages relating thereto. All shore stations in the Second Radio District except three are equipped with tube or arc (continuous wave) transmitters and have been given new long and short wave assignments so that they are free to operate simultaneously without conflicting with one another.

By a reciprocal agreement entered into between the Governments of the United States, Great Britain and Newfoundland, the ships of these countries are restricted from the use of the 450 meter wave when within 250 miles of their respective shores.

There is still considerable interference caused by the testing of ship radio transmitters at the Port of New York. This testing is necessary, however, in order to determine that the transmitter is operating on its proper wavelengths. It is quite generally recognized that the only reliable means for determining whether or not a radio transmitter is in proper working order is to test it out on a radiating antenna. While it is true that this is a source of considerable interference, it results in an improvement of the general situation because it provides means for adjusting the transmitters to the exact wavelengths on which they are required to operate, and makes it possible to check up and correct decrement, and other discrepancies which may be found. Every effort is being made to adjust each and every American ship entering the Port of New York.

In order to minimize interference from this source, these testing periods are restricted to the last ten minutes of each half hour, that is, from 20 to 30 minutes past the hour, and from the 50th to the 60th minutes of the hour, thus allowing but 20 minutes in each hour to carry on this important work, although it does not forbid an operator to test his transmitter to determine that it is operating properly just before putting out to sea. However, plans are now under way to restrict ship radio operators from testing their transmitters prior to the vessel's departure for sea, to the 20 minutes allowed under the testing regulations of the port.

Other sources of interference affecting reception are those which emanate from electric railways, transmission lines, smoke precipitators, tree grounds, electric signs, battery charging apparatus, telephone ringing systems, x-ray equipment, curling irons and other domestic electrical equipment. The policy of this office is that when complaints are filed by the broadcast listeners which concern interferences emanating from systems not radio, and not under the control of the Department of Commerce, the matter is always reported directly to the Company controlling the system from which the disturbance originates. In this way a large number of the more serious disturbances have been eliminated through the co-operative efforts of the operating companies and the Supervisor of Radio.

With the abolition of the amateur spark transmitters there has been a decided improvement in the situation, and a great reduction in the interference which has heretofore been experienced from amateur spark transmitters. For some time past the amateurs have been voluntarily replacing their spark transmitters with continuous wave tube transmitters, and at the recent Radio Conference at Washington, it was recommended that no more licenses for spark transmitters be issued to amateurs. This substitution of continuous wave tube transmitters has not completely eliminated amateur interference, for there are many cases where the broadcast listeners reside in close proximity to amateur transmitting stations and are using receiving apparatus which is supersensitive but not superselective to the same degree. Such receiving apparatus is bound to respond to the amateur signals no matter how sharply defined these signals may be. In such cases we recommend that the broadcast listener employ a wave trap, and I am glad to say that these are being used to good advantage. We occasionally encounter a broadcast listener who is more or less skeptical of the use and value of such a wave trap, because of his belief that it will prevent his receiving D.X. (distant) signals. This is, of course, an erroneous idea.

If we stop for a moment and make a mental survey of the area in and around New York, for instance, the large amount of radio telegraphic and radio telephonic service being constantly carried on, together with the tremendous amount of electrical activity going on in connection with the operation of electric railways, power lines, elevator service in tall buildings, electric signs, etc., we will find it is remarkable that we are able to get such splendid service and enjoyment from broadcasting with such a minimum of interference from local sources.

In summing up we could, with propriety, make a comparison between the radio broadcast service and our great transportation systems, motor vehicular traffic and foot traffic. No one expects to have a train all to himself on the railroad or in the subway, or to have the highway to himself when he goes out with his car on a week-end trip, or to have the full freedom of the sidewalks when we go out to enjoy our noonday lunch. We find obstacles of various degrees and kinds in our way everywhere we go, and we find the same when we come to sit down before our radio sets in the solitude of our homes to enjoy the evening programs. Some interference is bound to ensue, but in the United States we are known as a nation of engineers, and under such regime, broadasting is going to develop rapidly to its highest point of technical efficiency.

*Supervisor of Radio, Second District.

What the Beginner Should Know About Radio

By A. M. POWERS*

I'M sit-ting on top of the world, —Just roll-ing along,—Just roll-ing a-long,"—comes the voice of your favorite radio artist from your loud speaker or from the head-set clamped to your ears. You hear his voice and so do perhaps many hundreds of thousand others at precisely the same time.

But how does the voice reach you? Newspapers, magazines and casual conversations overheard in public places give the newcomer the impression that the music comes out of the air since they refer to "air" as the medium through which radio waves travel. This, of course, common sense tells us is wrong, for if it did how would Jack Smith be able to get Los Angeles on that super-heterodyne of his with a little loop, and all closed up in the library of his home. Why he would hardly be able to "smell" a local station, outside of getting a program from Los Angeles loud enough to be heard on his loud speaker.

When a tuning fork is struck it sends out sound waves which our ear responds to and we hear the tone. The frequency of these tone waves are low and therefore vibrate at an audible frequency. Various size forks give different pitches which vary the frequency of sound waves.

How would Jack Smith be able to hear a Los Angeles broadcast station on his Super-Heterodyne with a loop aerial if radio waves travel on the "air"? Here we see Jack tuning in on his set in the library of his home with the loop on top of the set and the loud speaker on the table at the left.

To answer this question we are going to try as our first endeavor to explain in as few words as possible how the radio waves travel through great spaces. We might start out by comparing radio waves to that of the old analogy of light and water waves with which we all are probably more or less familiar.

Light and Water Waves Similar to Radio Waves

Some years ago when scientists attacked the problem of light, they found that it did not travel through air. What it did travel through was not apparent, so they decided that there must be some all-pervading substance, and they called this intangible something "ether." Ether at the time was a product of resourceful imagination, but today we find that some of our eminent scientists have somewhat of a further understanding as to what this medium is, particularly in regards to the transmission of radio waves, while on the other hand we have others contradicting these theories. Therefore, we can hardly say that we are to any great measure more informed than we were years ago. However, we are told that ether is everywhere, the world is surrounded and soaked in it. It is all-pervading. It is neither a gas, liquid nor a solid. It is invisible and odorless.

Now that we at least have some idea as to the ether, let us go back to the subject of waves.

How does ether act to transmit light? It must be pushed, shaken or displaced in some way or another to produce waves. Thus, atoms vibrate in the sun, send out waves in the ether, and when they strike our eyes we say we can see. If we throw a stone into a quiet pond of water, little waves spread out from the source of disturbance in all directions on the surface. (See Figs. 1 and 2.) The size or length of these waves depends on the size of the stone dropped into the pond which may be compared to the varying wave-lengths as referred to in radio. The length of the wave is measured from the peak or crest of one wave to the peak of the next immediately preceding or succeeding wave which in radio is measured in the metric term of meters.

* Written specially for Radio Specialty Co., New York.

In radio we deal also with waves in the ether—waves which resemble the light and water waves. The voice that comes to you from the broadcast station is a voice which has first been

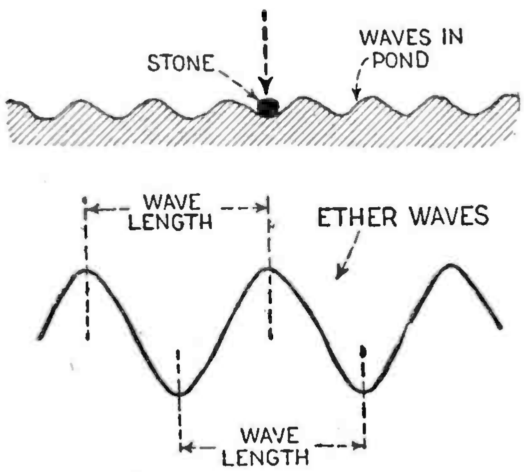


Fig. 1. Above are shown waves produced in water and ether. The wave length of a wave is the distance from the crest of one wave to the crest of another immediately preceding or succeeding it

transformed into ethereal waves, and then back into a voice by means of the receiver.

What Is Meant by "Wave Frequency"

From the foregoing we learn that the length of waves will depend upon the number of waves passing a given point per second, or, we may say their length depends upon their frequency. Small waves may have frequencies as high as ten to fifteen or more a second, while long waves may have a frequency of but one or two per second. We can understand then that the more waves crowded within a certain area the shorter the waves will be, and we therefore must impress upon our minds that wave-lengths depends upon frequency.

We can now assume that waves are produced in the ether just as they are produced in light or water. An electrical disturbance in the ether also results in waves just as do disturbances caused by the stone dropped in the pond.

Our understanding of ether waves brings us to many byways. It is now necessary to consider "alternating" and "direct" current such as we speak of them in electrical terms. Many of us use alternating current for lighting purposes in our homes, while others use direct current. The difference between an alternating and direct current is simple. A direct current flows continuously in one direction like water flowing through a pipe while alternating flows first in one direction and then in the other, in a to-and-fro

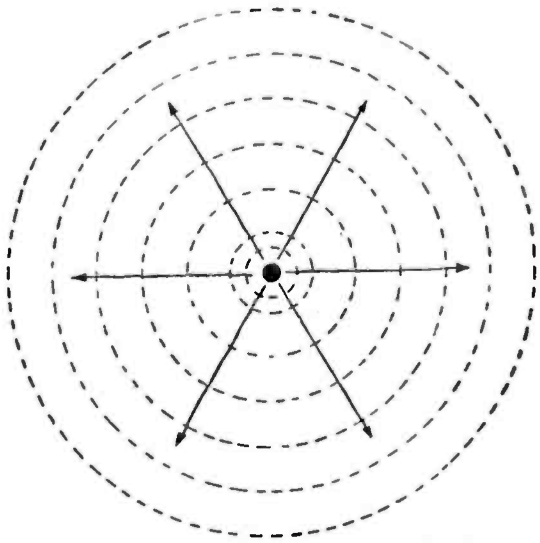
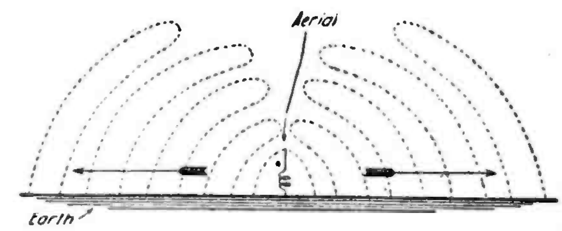


Fig. 2. Looking down from directly above a radio station. The waves are found to spread outward in all directions as indicated by the arrows. This also applies to water waves when a stone is thrown into a pond.

motion. An alternating current can be said to vibrate and when a thing vibrates it always does so at a certain rate or "frequency," another term which means much in radio. If a small cork were floating in the pond of water in which we caused the disturbance by the stone, the cork would bob up and down a certain number of times per second according to the frequency of the waves. Alternating current used for lighting purposes is said to be of "low frequency." In some cases it goes back and forth as many as 120 times per second, while in others only 50 times. This frequency may be increased by suitable means, and as a frequency mounts higher and higher, the current grows wilder and wilder in its action until it is rushing back and forth several hundred thousand times per second. When this condition is reached, the current is said to be of "high frequency." Radio waves are generated by such high frequency currents, and it is these currents which form the waves in the ether. The frequency of the number of waves passing a given point in one second as mentioned before in this article is equal to that of the current that produces them, as we will learn later.

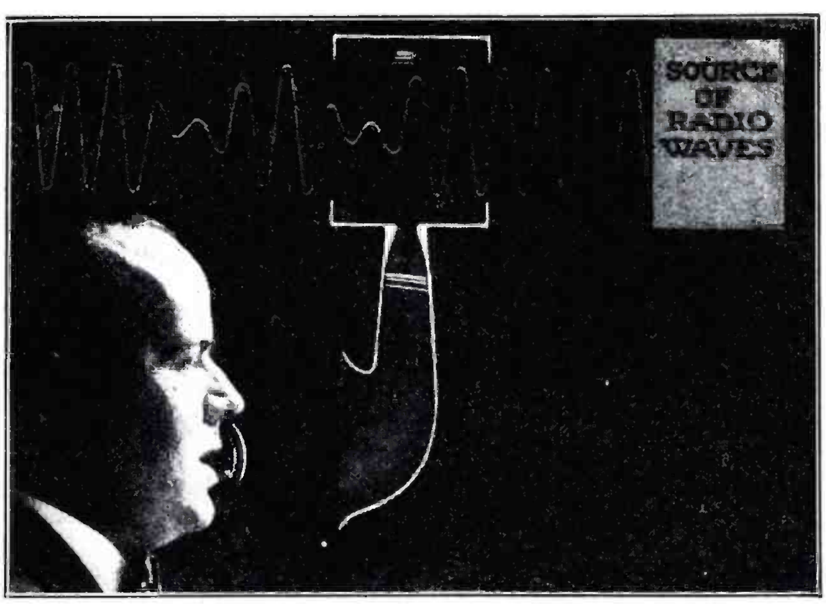
High frequency alternating currents vibrate or oscillate rapidly, flowing into the antenna and there setting up radio waves.



This illustration shows how the radio waves are imagined to pass out over the earth's surface from a transmitting aerial.

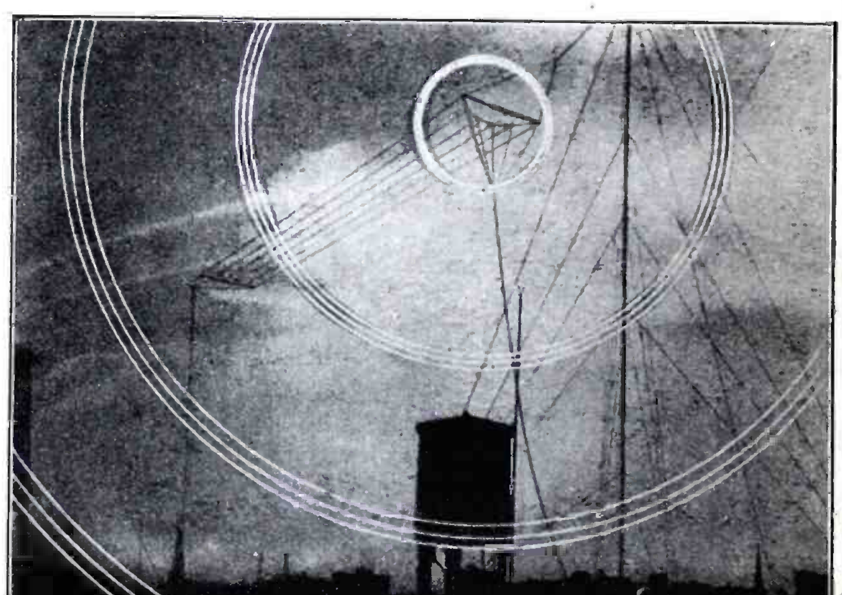
How Inductances, Resistance and Capacity Affect Electric Circuits

It has now been shown that the length of the wave created in the ether depends upon the frequency of the current producing it. If the frequency is extremely high, the resulting ether waves will be short, and if the frequency of the current is low the waves produced will be long. When a condenser is discharged in a closed circuit, the frequency of the oscillating current will be governed by the inductance, resistance and capacity of the circuit. In general, the greater the inductance and capacity of such a cir-



Visualization of modulation of radio waves by sound waves produced through the transmitter. At the right of the sound chamber is shown the unmodulated waves and at the left the modulated voice waves.

Illustrations by The Brady Productions, Inc.



Visualization of radio waved spreading out from the transmitting aerial in all directions. The possibility of showing these waves in their absolute form is of course limited.

cuit, the lower the frequency. Inductance is a property of every electrical circuit, but it only shows itself when current is changing. Its action is always such as to oppose the change. Thus, if the current is increasing, the inductance tends to prevent further increase, while if the current is decreasing the inductance tends to oppose further decrease. Therefore, inductance in a circuit would naturally tend to slow up oscillations and reduce the frequency.

"Resistance" is another property of an electric or radio circuit which is equally as important as inductance. Every moving thing, even electricity, meets with some resistance. To roll down a hill, a ball must overcome a certain amount of resistance. A stone thrown through the air also meets with some resistance. And so does electricity meet with resistance when flowing through an electric circuit. The resistance met with here depends upon the nature of the metal making up the wire, the length and size of the wire and other similar electric conductive materials of certain kinds which are in the circuit. The size of the wire is important, because electric currents will flow with greater freedom through a large wire than through a small one, just as in the case of water which flows more rapidly and easily through a large pipe than a small one. If the wire is small the resistance will be high. High-resistance wire is therefore undesirable for conducting electric currents. However, in certain cases high resistance in a circuit is made to perform many important

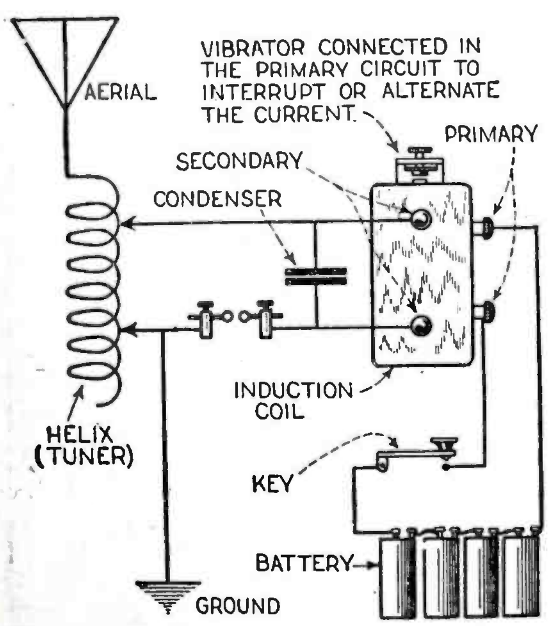


Fig. 3. A simple radio wave producing apparatus as used in transmitting radio telegraphic signals.

duties. When the resistance in a circuit is too great the current loses its force and cannot flow as strongly as under other conditions. Thus it can be easily reasoned why certain resistances are used in electrical and radio circuits to regulate the flow of current by means of introducing or omitting resistance.

Electric and radio circuits have still another property which influences the current flowing through them. This is called "capacity." But for the time being we will not attempt to enter deeply into this subject as it will be found more appropriate to discuss it in connection with matters later, so let us now consider an elementary arrangement of apparatus for producing radio waves.

The Simple Method of Producing Radio Waves

Before going into this angle of the subject, let us study the accompanying diagram in Fig. 3, showing a simple arrangement of apparatus which is probably better known as a wireless telegraph transmitting set which our proud amateurs of yesteryear employed to send their dot and dash signals between one another. Here we will see what is known as a key, an induction coil, a condenser, a spark gap, a helix or tuner, a battery, an aerial and a ground. The key is merely a hand-operated switch or a

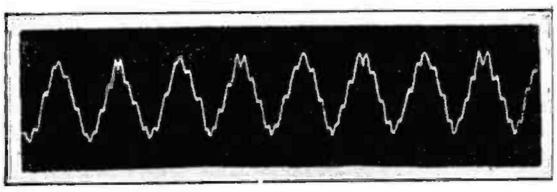


Fig. 4. Sound waves as emitted by a tuning fork and recorded in graph form.

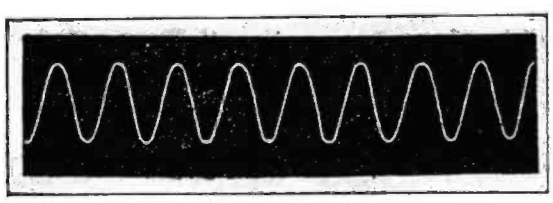


Fig. 5. Sound waves of the vocal sound "ee" as in "seen" recorded in graph form.

means of opening or closing the circuit of the battery and primary of the inductance coil. It is so arranged that dots and dashes can be made with it. By pressing the lever down the circuit is closed and current from the battery flows into the primary of the induction coil or "transformer," a device to increase the voltage of an electric circuit. A presure of 6 volts may be increased to 60,000 volts. Thus, an induction coil might be regarded as a pump producing a high electrical pressure. When the current issues from the high voltage side or secondary of the induction coil, it has a good deal of sting to it.

The current produced by the induction coil passes into a receptacle called the "condenser" which will hold just so much electricity at a given pressure, in other words, it has a definite "capacity." This brings us to a better understanding of capacity. The capacity depends, among other things, upon the size of the condenser since a large one takes longer to fill than a small one. When a condenser is "filled" it acts in a peculiar manner. It fills up and discharges. The stored up electricity then rushes across the spark gap from one side of the circuit to the other. This process of rushing back and forth

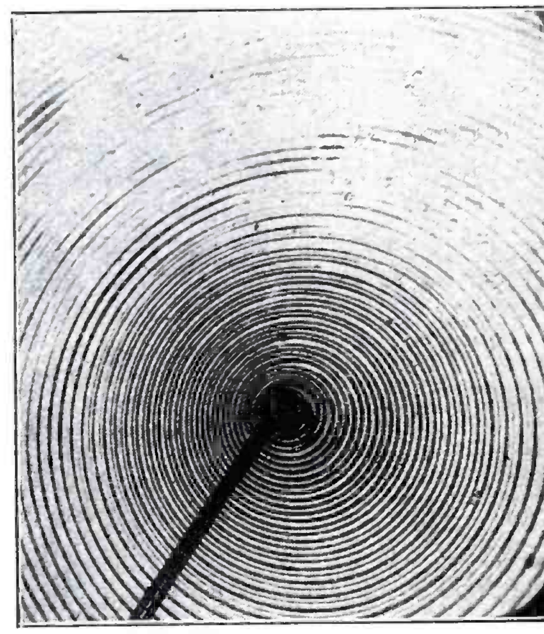


Photo by J. H. Vincent

A photo showing ripples or waves on mercury created by impact of prongs of a tuning fork. This will give the reader a visual idea of how waves spread out from a point of disturbance.

is continued until all the energy stored up in the condenser is used up. When once the condenser is fully "filled" or charged, it can discharge and recharge itself many thousand times in the space of a single second. Each successive charge becomes weaker than the preceding one. However, all this action takes place at a very rapid rate and when the key is pressed, the spark rushes across the spark gap and flows continually until the key is released. When this is done, the current passes through the helix or coil of wire and is emitted through the aerial to generate waves in the ether in all directions.

How We "Tune In" on the Wave-Length

Wave-length in radio corresponds with pitch in sound and with color in light. Sounds are transmitted through the air by bodies that move back and forth or vibrate and thus create a train of waves. If the waves come through the air regularly, we hear a musical note which may be shrill or high-pitched or deep or low-pitched. The pitch depends on how many waves reach our ears in a second, and this in turn depends on how many times the sounding body vibrates the air. When we tighten or loosen the string of a violin we raise or lower its pitch. We call this "tuning." In radio we also speak of "tuning" and when we do we mean simply that we are adjusting the radio pitch of the receiver to the pitch of the transmitting station. In our simple wave producing apparatus previously described, tuning is accomplished by means of adjusting the inductance or introducing a greater or lesser amount of inductance in the circuit. This is done by making contact with a desired number of turns of wire on the helix or tuner from the

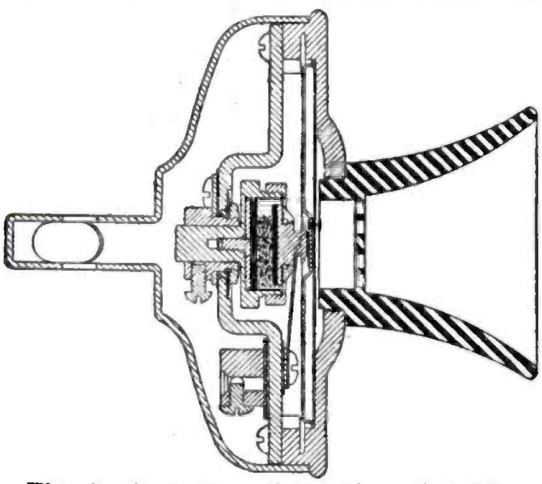
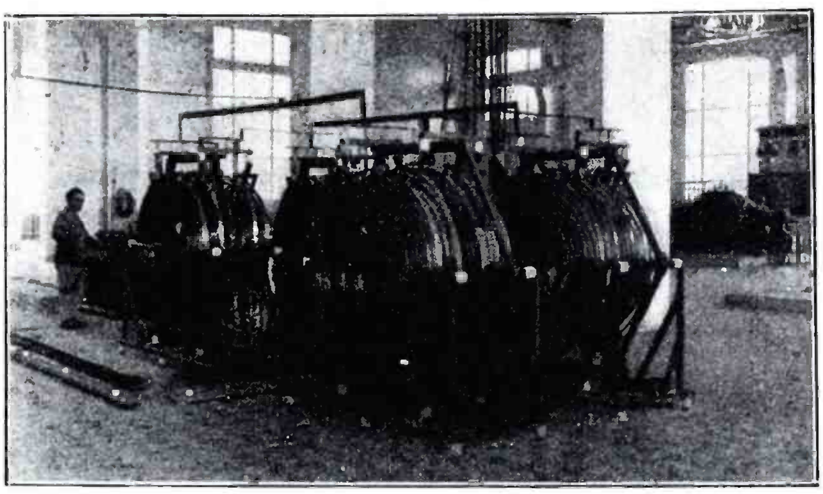


Fig. 6. A cross sectional view of a telephone transmitter showing details of construction.

circuit connected to the "secondary" of the inductance coil in Fig. 3.

Pitch is a matter of wave-length. The smaller the waves and the smaller

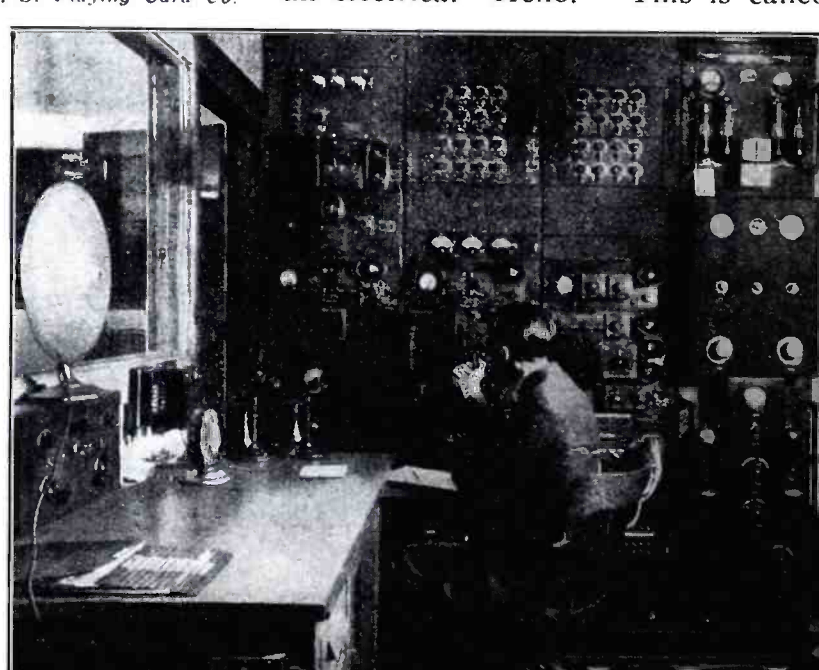


The tuners of a powerful transcontinental radio station. The inductances consist of large spirals of copper ribbon wound on insulating frames. Note the porcelain insulators at different points on the tuners.

Photo by A. N. Mirzaoff

The concert studio of radio broadcast station WSAI. Fixtures, draperies and furnishings are so arranged to give the best acoustic properties. Note the two microphone transmitters on the pedestal.

Photo by Courtesy of U. S. Playing Card Co.



Control room of radio station WOC showing the complicated panels on which the apparatus for transmitting programs is easily accessible

Photo by Courtesy of The Palmer School of Chiropractic

their length, the more of them strike the receiver, whether it be an eye, an ear or a radio detector. Hence when we "tune in" on a wave-length of three hundred meters in radio we simply adjust the receiving instrument to receive waves of that length, just as a violinist tunes his instrument to agree in pitch with the piano that his accompanist plays.

Wave-length can also be explained in terms of light. When we say that one color is "red" and another "blue," we mean that the pitch of the color we call red is lower than the pitch of the color we call blue. In other words, red has a greater wave-length than blue. When we look at the things through a piece of red glass our eyes see with light of one wave-length. When we look through a piece of blue glass, we see things with light of another wave-length. Hence we "tune in" on definite wave-lengths of light when we wear red, yellow or blue spectacles. A radio broadcast station which makes the ether ripple with the voice of our favorite radio tenor on a wave-length of three hundred and sixty meters is like a lighthouse or beacon which send forth beams of red light only. A normal eye can detect all the colors in the rainbow; a color-blind eye cannot. Hence, a tuned receiver is color-blind, in a radio sense. The human eye is a far better "tuner" than any we have yet devised for radio reception.

A tuning instrument is wanted which will be as marvelously sensitive as the eye. Between deep red (400 billion vibrations a second) and red-orange (437 billion vibrations a second) is a difference of wave-length far less than between 360 and 361 meters in radio; yet our receiving devices are still so made that we cannot "tune in" more closely than seven meters. A highly trained eye can distinguish about one thousand different tints in the visible spectrum. Far more extensive is the invisible radio spectrum, and radio is still so young that we cannot yet make use of all its tints or wave-lengths.

Turning the Voice Waves into Radio Waves

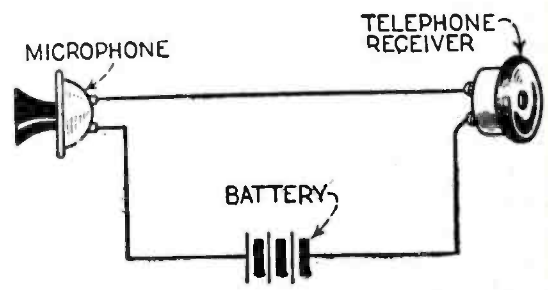


Fig. 7. A simple telephone circuit. The words are spoken into the microphone transmitter cause corresponding variations in the electric current of the circuit and the variations of the current are reproduced by the telephone receiver as sound.

With the invention of methods of generating radio waves such as that based upon the simple apparatus described previously, telephone transmission by radio became not only a possibility but a reality. When you telephone from one part of the city to another you know that your voice is not literally carried over the wire. A current passes through the wire, and in talking the current is varied as the voice rises and falls. When you say the single word "Hello" you modify the current in perhaps a thousand different ways; you mold the electric waves that pass through the wire into an electrical "Hello." This is called "modulation." In radio telephoning the same process occurs. The waves that are constantly radiated into space are molded or modulated by the voice. The molded or modulated waves strike the receiver. The telephone translates the modulated waves into modulated sound waves, exactly like those of the singer's voice at the broadcast station.

Why the Aerial Is Used

We now have seen that energy is transmitted in waves whenever anything "vibrates," "alternates" or "oscillates," and that a big alternating or vibrating object will set up bigger waves than a small object. A little rocking boat produces smaller waves than a big rocking boat.

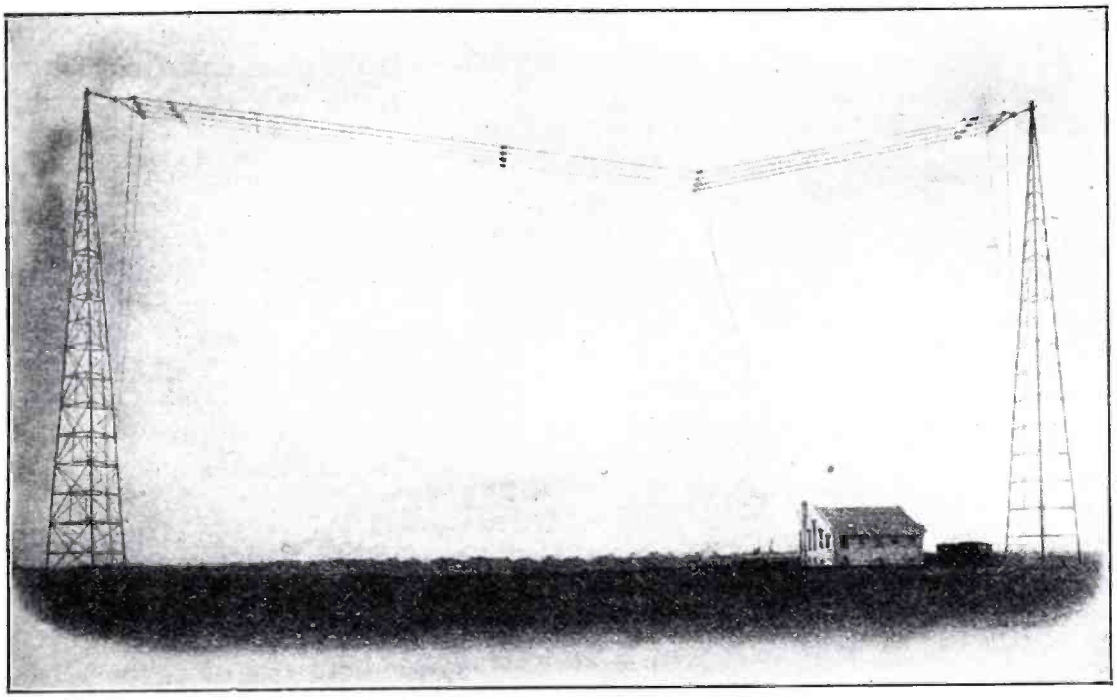


Photo by Courtesy of Washburn-Crosby Co.
A typical broadcast station aerial. This photo shows the aerial of radio station WCCO. The towers are each 200 feet high and 400 feet apart. The building at the right contains the generators and control equipment. Programs transmitted through this station are sent over private telephone lines from studios located several miles away.

It was Marconi who first realized that this applied to radio as well as to boats in water. His tiny spark formed part of a circuit like in our simple wave producing apparatus. As the spark oscillated there was also an oscillation in the wire of that circuit. He discovered that if the wire were stretched between poles or masts it would come in contact with more of the ether and thus shake more of it into waves. The longer the wire the better, for there would be a better chance for the oscillating or alternating current to produce big waves. He

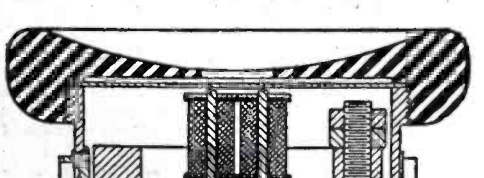


Fig. 8. Cross section of a telephone receiver. A radio phone has the same general construction but is a great deal more sensitive to electric current.

found, too, that the higher the wires, strung between poles or masts, the more effective was the sending and the receiving. This is due to the fact that fewer obstructions are encountered by the waves at a height than at the ground. Although the radio or electromagnetic waves pass through glass they meet some resistance. For that matter even the most transparent glass does not transmit all the light that strikes it.

After a while it became the general practice to hang the conductors from tall masts or towers and to call them "aerials" or "antennae." The term was borrowed from entomology. It is applied to the long feelers of insects. And the tall antenna of a great radio station with wires stretched between look for all the world as if they were reaching out and trying to feel something in space. They do feel radio waves.

Since amateur stations or broadcast stations are not intended to send sig-

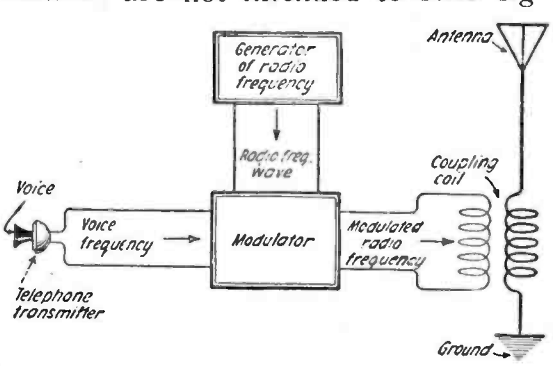


Fig. 9. Diagram of radio telephone transmitting circuit. The telephone transmitter delivers a current having variations of the voice frequency. The current of voice frequency and radio frequency current from the generator are both fed into the modulator which combines the two frequencies and delivers modulated radio frequency currents to the antenna.

nals over distances measured by thousands of miles (although the amateurs have actually been heard in Scotland and further points) their aerials are not so long or tall as those of the great stations that telegraph radio messages to Europe or Japan and have towers several hundred feet high. It is easy to see why the big stations must have such high aerials. They must shake a great deal of the ether in order to form tremendous billows measuring ten and twenty miles from crest to crest. A large tuning fork will be heard farther than a small tuning fork

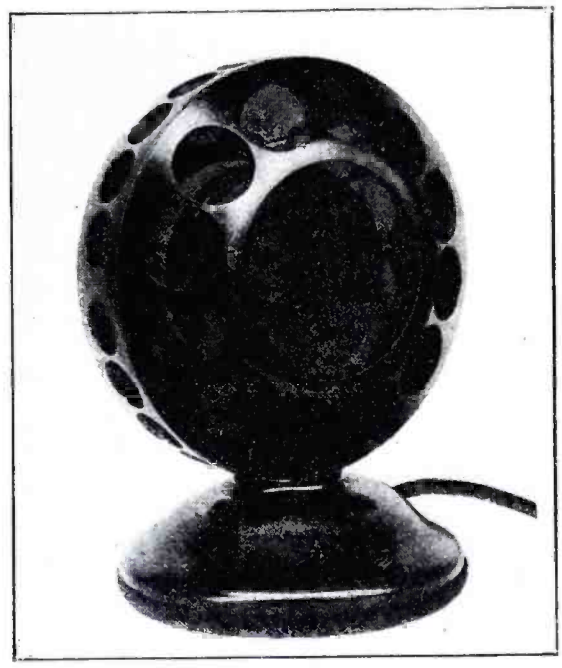


Photo by Western Electric Co.
A microphone transmitter as used in radio broadcast stations.

and similarly, high power sent through a large antenna will send waves farther than a small one.

For the same reason the receiving aerial must be large if the detection is to be good. The bigger the waves that beat against a distant receiving aerial, the more powerful are the oscillations received.

In the foregoing explanation the nature of different kinds of waves have been discussed. Every wave has certain characteristic properties, and these are length, frequency, velocity, height, and form. All of these properties may be noted in a water wave. The length is the distance between successive crests; the frequency is the number of crests that pass a given point in a given interval of time; the velocity is the speed with which the wave transmits a disturbance from one point to another; the height is the vertical distance between crest and trough; and the form is the shape assumed by the sides of the wave. The greater the amount of energy that it is transmitting and the greater the amount of work that it can be made to perform.

As a wave spreads out from the point from which it starts, its height becomes less and less, and at a sufficiently great distance it becomes so feeble as to be imperceptible. Thus in the pond of water waves die out as they spread, and so a sound quickly dies out as the listener moves away from its source. The distance to which a wave of a given kind will travel before dying out depends to a certain extent on its frequency.

Sound waves travel in air with a velocity of about 1,090 feet per second. Waves, including light, heat, and radio waves, travel with a velocity of about 186,000 miles per second.

Sound waves are caused by vibrations or to-and-fro motions of some sounding body that creates waves in the air. The vibrating body may be a piano wire, an anvil, a vocal cord, or any one of an almost infinite variety of objects. The waves sent out by different kinds of vibrating bodies differ greatly in form. Probably the "purest" sounds that we ever hear are emitted by tuning forks, such as piano tuners use. Fig. 4 shows the form of a sound-wave emitted by a tuning fork. Another photo shows waves of a tuning fork as produced in mercury to show the effects of sound.

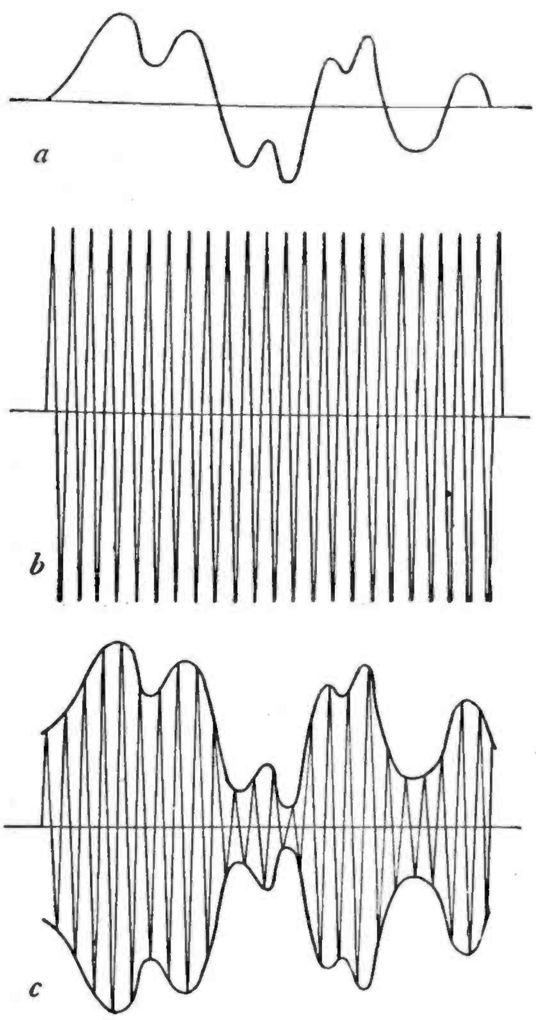


Fig. 10. The wave forms of radio. "a" is the voice frequency from the telephone transmitter. "b" is the radio frequency wave from the generator unit (see diagram of transmitter). "c" is the resultant modulated radio frequency wave delivered to the aerial by the modulator unit.

The waves produced by a piano or a violin are very irregular in shape and not like those produced by a tuning fork. These irregularities, however, are important. They are characteristic, as identifying, as the features of our faces, and make it possible for us to distinguish one musical instrument from another. The frequency of vibration is the number of times that the sounding body vibrates to and fro in a second. As the frequency of vibration increases, the pitch of the sound becomes higher.

Waves Produced by Speech Vibrations

The sounds of the voice are produced by the vocal organs, including the vocal cords, and the throat, mouth and nose cavities. The vibrations of the vocal cords are similar to those of the strings of a violin, but are more complicated. The air in the throat, mouth, and nose cavities vibrates like the air in a very small organ-pipe. For producing each distinct sound, our vocal organs are used in an entirely different way. The vowel sounds, such as A, E, I, O, U, are produced by different combinations of the vibrations of the vocal cords, and vibrations of the air in the cavities of the throat, mouth and nose. The consonant sounds such as "s," "c," "b" and "f" are hissing, breathing and explosive sounds caused by air rushing past the tongue and lips. Speech waves are even more irrigular in shape than most of the sounds of music.

With suitable apparatus we can take a picture of the sound waves corresponding to a particular sound. Fig. 5 shows the vibrations that constitute the vowel sound "ee" as in "seen." Each word that we speak consists of a whole series of irregular waves like this. If two people speak the same word, there is sufficient difference in the sound waves so that the two voices can be distinguished. The pitch of the voice is determined by the nature of the vocal cords. The pitch of a woman's voice is usually higher than that of a man's. The average pitch of the voice is perhaps as low as 200 vibrations per second, but some sounds like "s" involve frequencies of several thousand.

Hearing the Sound Waves

Sound waves that reach the ear cause the ear-drum to vibrate just as the source of the sound vibrates, and thus the sound is reproduced. The movements of the ear-drum are transmitted through the little bones of the inner ear and finally reach the hearing center of the brain through the nerves.

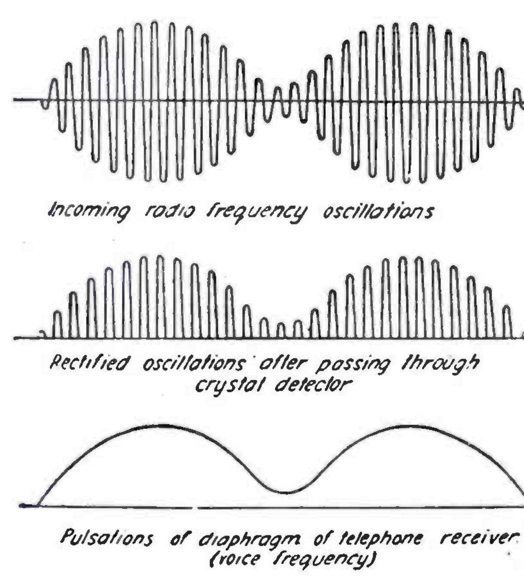
The ear can best hear sounds that have frequencies varying between 1,000 and 4,000 per second. Sounds can be heard, however, which have frequencies between the extreme limits of 16 vibrations and 32,000 vibrations per second, but for these extreme limits it takes a great deal more energy to make a sound wave audible. The ear cannot hear sounds having frequencies greater than 32,000. Some of the vibrations produced by crickets have frequencies so high that they cannot be heard by the human ear. The frequency of the radio waves employed in radio broadcasting greatly exceeds 32,000. In radio work it is very convenient to differentiate the two classes "radio" frequencies and "audio" frequencies. The "audio" frequencies or voice frequencies are the frequencies which can be heard; that is, the ones that are audible; the "radio" frequencies are the higher frequencies that cannot be heard.

The Telephone's Role in Radio

Sound waves die out rapidly and cannot be heard at a short distance from the source. By using devices such as a speaking mouth-piece and a horn, the distance can be somewhat increased, but it is still small. Sound waves are absorbed by the many objects that lie in their paths; these objects are set into vibration as the sound waves beat upon them. To transmit or communicate over any but very short distances, it is necessary to make use of means other than sound waves. Electric transmission is the most important means of communicating over long distances. The ordinary electric telephone is the most important means of carrying the voice over such distances.

Ordinary speech is a kind of sound telephony with air as the transmitting medium. Telephony over wires is so like radio telephony which, of course, is the same as radio broadcasting, and the fundamental principles involved are so much alike, that it will be worth while to consider the operation of the ordinary telephone, and see just what each part of the system does. The problem in any form of electrical telephony is to reproduce electrically at the distant receiving station the complex sound wave spoken into the transmitter.

The essential parts of a simple telephone system are a device called a "transmitter," by means of which sound vibrations cause corresponding variations of an electric current, a device called a telephone "receiver" for changing the electric current variations back into the corresponding sounds, and an electric circuit for connecting the two devices. The microphone transmitter or "mike" as it has been called, into which our radio artist sings is simply an extremely sensitive telephone transmitter.



Wave forms in the receiving circuit. The detector allows only the top half of each oscillation to pass and the bottom is cut off. The rectified oscillations are smoothed out and cause the diaphragm of the telephone receiver to pulsate at voice frequency.

How the Microphone Transmitter Operates

The telephone transmitter into which we speak is merely a speech-controlled valve that turns the electric current on and off. Fig. 6 shows the construction of a transmitter. The sound waves beat upon a thin piece of metal called the "diaphragm," and cause vibrations of the diaphragm corresponding to the voice. Back of the diaphragm is mounted a "transmitter button," which is really a little cup containing small granules of carbon. At the back of the cup is a carbon plate, called the "back electrode." The front wall or cover of the cup is movable, but fits tightly in the cup. The front electrode is attached to the diaphragm, and moves in accordance with the motions of the diaphragm. A low voltage, as from a few dry cells, is connected with the front and back electrodes. The mass of carbon granules has this property: when the granules are pressed somewhat together by a little pressure, their electrical resistance decreases to a marked degree. As the diaphragm and the front electrode move back and forth in response to the voice, the pressure on the carbon granules varies; hence the resistance varies, and the current flowing through the transmitter varies accordingly. When the diaphragm is in its normal position of rest, a certain unvarying current will flow in the circuit. When a sound causes the diaphragm to vibrate, the current flowing in the line varies exactly in accordance with the wave form of the sound. The process may be thought of as a moulding of the normal unvarying current to the form of the impressed sound wave. It is important to note that the sound waves beating on the diaphragm do not themselves generate any electric current, but simply control and vary a current which is already flowing.

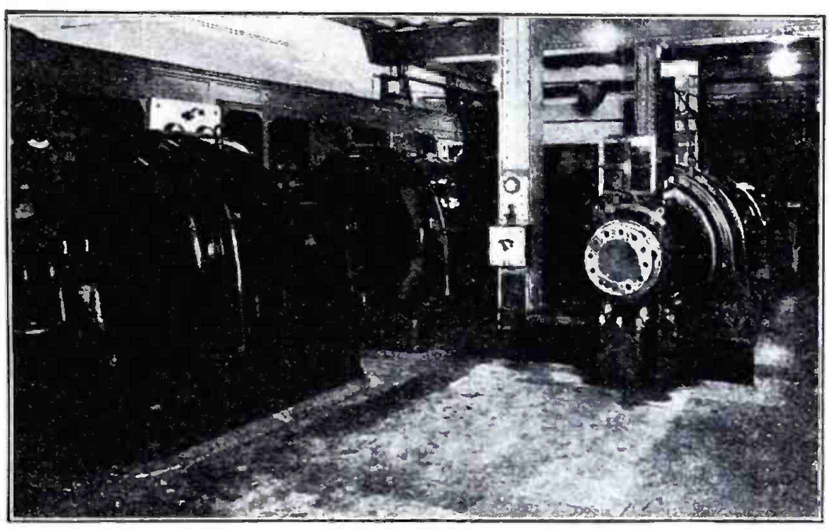
A circuit connecting the telephone transmitter with a telephone or radio receiver is shown in Fig. 7 and is given here in order to illustrate more clearly the transmitter's operation as well as the receiver which will be taken up later

At the receiving end of the circuit we must have a device for changing the variations of the electric current back into sound waves. This is the telephone receiver. The telephone receiver is essentially an electromagnet, that is, a magnet the magnetism of which is controlled by an electric current.

The ordinary telephone receiver, as shown in Fig. 8 consists of two coils of wire wound around the poles of a permanent magnet, and an iron diaphragm held in place near the poles of the magnet by its magnetism. If the two coils are connected in the circuit in the right way, the magnetic field of both coils will act in the same direction, and the effect of a current flowing in one direction will be to increase the normal magnetism of the magnet, and the effect of a current flowing in the opposite direction will be to decrease its magnetism. When the current flows in the one direction, the diaphragm will be pulled closer to the poles from its normal position, and when the current flows in the other direction the pull will be decreased and the diaphragm will assume a position not so close to the poles as its normal position, when no current is flowing. The diaphragm will move in and out as the current in the coils varies, and in a telephone receiver the diaphragm will respond very promptly and accurately to the variations in the current. The motion of the diaphragm causes a sound in the air, which corresponds with the variations in the electric current and hence with the sound impressed upon the transmitter or microphone. The voice at the transmitter end of the circuit in Fig. 7 is thus reproduced in the receiver at the other end. The process of this transmission is almost instantaneous.

Photo by Courtesy of The Experimenter Pub. Co.

The operating room of radio station WRNY. The aerial lead-in and lighting switch can be seen above the window. An operator is constantly on watch at the receiving set for "SOS" call to cease broadcasting.



The powerful generators of a transcontinental radio station. These generators produce the necessary energy required to project radio waves across the Atlantic ocean.

Photo by A. N. Mirzaoff

Voice Transmission by Radio

By this time the reader will question

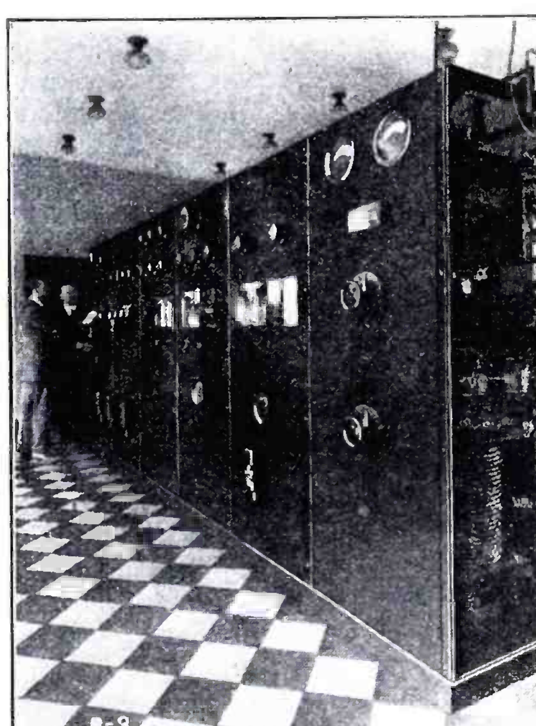
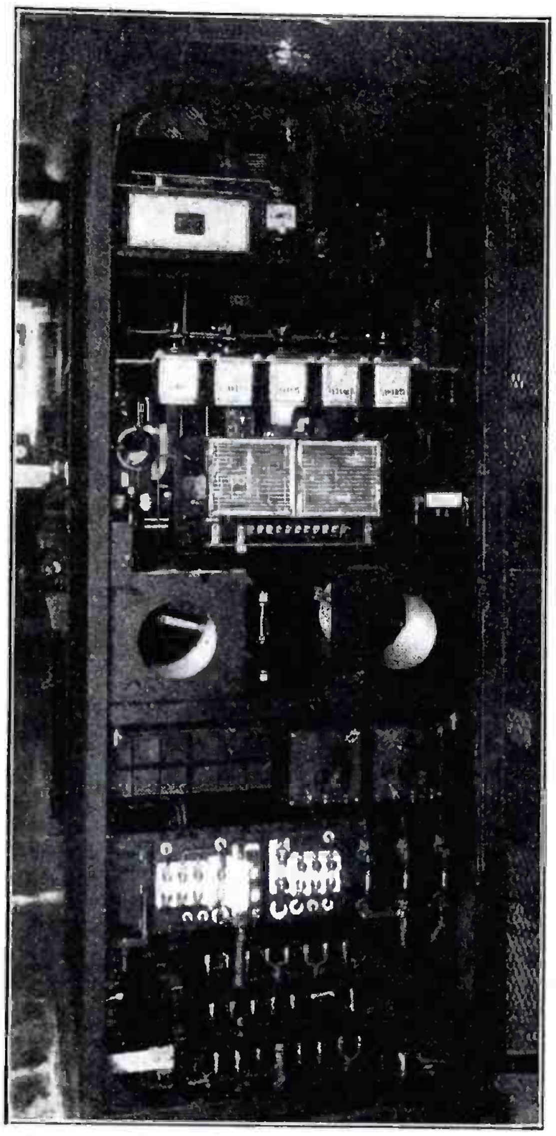


Photo by Courtesy of The Palmer School of Chiropractic.

Seven and a half tons of apparatus are used to produce the powerful radio broadcasting waves from radio station WOC. The large vacuum tubes can be seen through the glass fronts of the center panels.

the fundamental difficulties of producing voice waves at low frequencies into high frequency radio waves. However, let us consider what we



A rear view of a 1000-watt transmitter equipment at station WWJ. The tuning inductance can be seen in the uppermost part of the unit. Condensers and other incidental parts are arranged below.

have already learned about the production of high frequency currents and note the circuit shown in Fig. 9. We will shortly reach the point where we will have a complete understanding as to how the voice vibrations are converted into high frequency radio waves and then radiated out into the ether by way of the aerial.

We have seen that low frequency current can be readily boosted into a high frequency current suitable to produce radio waves by means of the simple radio telegraph apparatus in Fig. 3 and also how tuning is affected. The problem now simply resorts itself into the process of "modulating" the high frequency radio wave. The familiar vacuum tube usually accomplishes this. The sizes of the vacuum tubes used in radio broadcast stations, of course, greatly exceed the proportions of those used in your radio receiving set. An explanation of vacuum tube principles and operation will be discussed later.

The arrangement for producing the modulated wave is shown in Fig. 9. To go into details of the actual apparatus employed here would be too complicated and confusing for the layman, therefore only a general diagram of units is given. Into the modulator there is fed both the unmodulated high radio frequency current from the "oscillator," another vacuum tube device, and the current from the telephone or microphone transmitter which is varying at low voice frequencies. These two currents are combined in the modulator unit, from which results the modulated radio frequency wave which is radiated out into space. The telephone transmitter used may be the same type that is employed in telephony over wires, as has been described before.

The three wave forms are shown in Fig. 10. The voice wave produced by the transmitter is shown at a. The modulated radio frequency wave produced by the oscillator is shown at b, and the modulated radio frequency wave which is radiated out into space is shown at c. It is evident that the effect of the process of modulation has simply been to vary the height or amplitude of the radio frequency wave to correspond with the voice wave, the

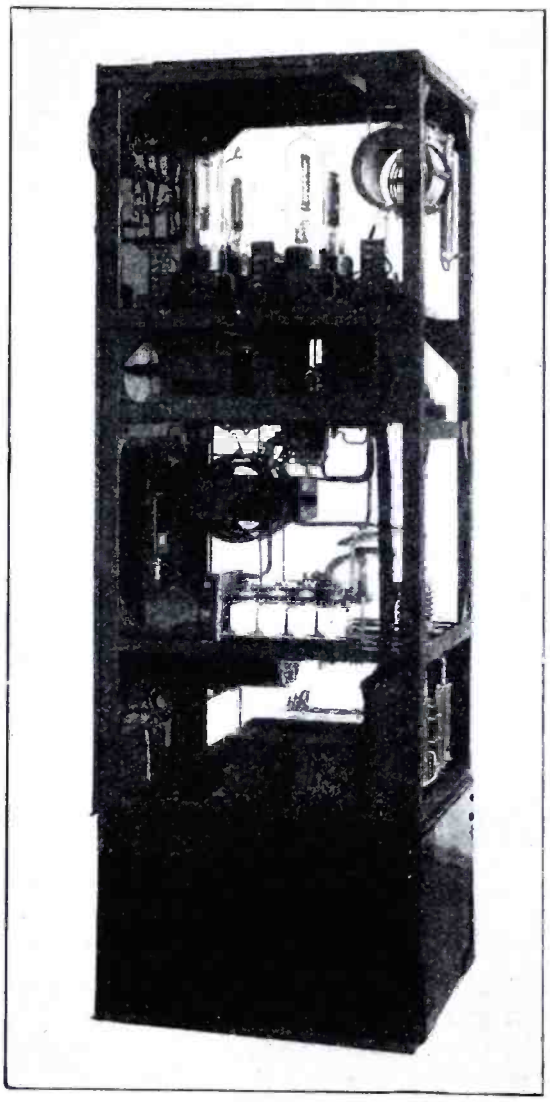


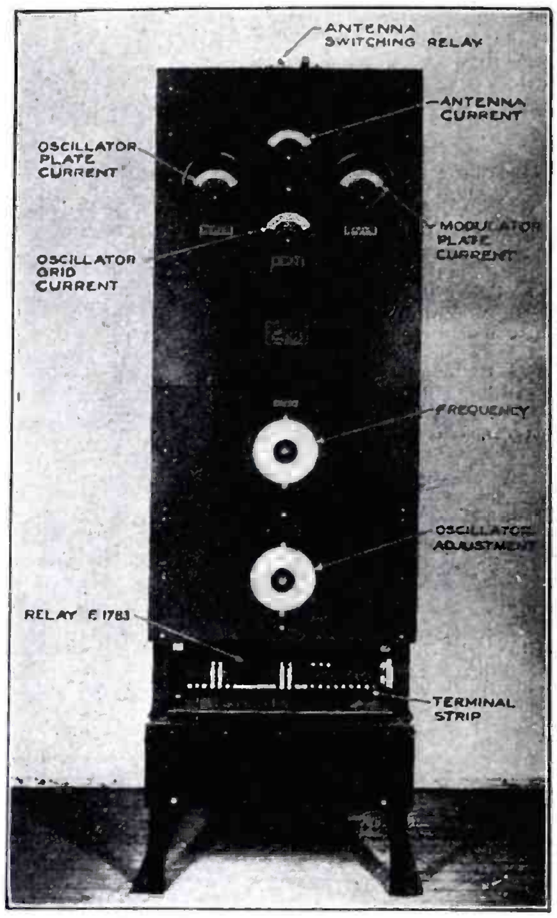
Photo by Courtesy of Western Electric Co.

A side view of the 500-watt transmitter unit shown at the right. In the top compartment are the twin 250-watt oscillator and modulator tubes, and a 50-watt speech amplifier tube; and the antenna tuning coil. In the third compartment are the coils and condensers for the oscillating circuit, and a variable condenser in the oscillator plate circuit. Resistances, choke coils and transformers make up the rest of the apparatus.

mountains of voice wave corresponding with the large amplitudes of the modulated radio wave, and the valleys of the voice wave corresponding with the small amplitudes of the modulated radio frequency wave.

In order to secure the most effective radiation of the radio waves into space, it is ncessary to use an antenna, which has been briefly described before.

Let us summarize what we have learned thus far. We speak. The particles of air in our vicinity vibrate back and forth. For each back-and-forth motion there is a mountain and a valley in the modulated radio waves



Front view of a 500-watt broadcast transmitter such as used at radio station WRNY. See opposite page for diagram of complete 500-watt broadcast equipment.

which are radiated. Between the crests of successive radio waves there is a distance of perhaps 300 meters, or less than a quarter of a mile, but the distance in space from one of our voice-wave mountain peaks to the next will probably be between one hundred and one thousand miles.

It has not yet been explained how we can detect these radio waves which have been radiated into space, and how to reconvert them into sound waves which will produce the words spoken at the transmitting station. It is first necessary to tune the receiving circuit as previously explained, and make use of a crystal detector or vacuum tube detector which rectifies the modulated radio waves and thus makes them audible in the telephone receiver or amplified to operate a loud speaker.

How the Radio Waves Are Received

The radio waves are intercepted at any given point within range of the transmitting station. If we throw a small cork into the pond of water as described for our analogy on the production of waves, the cork will naturally bob up and down on the surface in no matter what location it is when waves are produced by a stone thrown into the pond. Obviously, the waves become weaker and weaker as they travel out from the transmitter. Thus a receiving set will respond to waves in all locations. The method of tuning in on the wave-length or selecting a desired station may be likened to tuning in on light and sound waves.

The Crystal Detector and the Telephone Receiver

All that is needed to receive radio waves is an antenna connected with a circuit tuned to the radio frequency wave which it desires to receive, and means for making the radio frequency current audible. In a foregoing article "tuning-in" on the waves has been explained. The antenna used for reception may be any one of the various forms, the most popular being a single wire suspended in the air between two insulators. The radio wave which arrives at the receiving station causes a corresponding alternating current to flow in the antenna and the circuit connected with it.

Suppose that the telephone receiver and the tuning coil are connected directly in series between the antenna and the ground, and that the tuning coil is tuned to the wave-length of the wave which it is desired to receive, but that no other apparatus is present. The incoming wave will have a frequency of perhaps a million cycles per second. If there were an extremely light and sensitive device which could vibrate a million times a second, it could be connected in the circuit and would respond to the incoming wave and vibrate at the wave's frequency. But the diaphragm of the telephone receiver is not nearly light enough to respond to so high a frequency. During one-half of each radio frequency wave the diaphragm is subjected to an outward force and during the other half it is subjected to an inward pull, but the duration of these forces is so short that the diaphragm does not have time to get started moving in one direction before it is pulled in the other direction. And even if the diaphragm were so light that it could accurately follow these very rapid changes in the magnetic force acting on it, the ear would not perceive any sound because the frequency is far above the highest audible frequency.

If the incoming wave is a high frequency radio frequency wave having a frequency of a million cycles per second, which is modulated by a sound having a frequency of three hundred cycles per second, the sound cannot be made audible in the telephone receivers with the apparatus mentioned above. But if we could devise some kind of valve which would pass only the halves of waves acting to pull the diaphragm in one direction, and would prevent the other halves of the waves from acting on the diaphragm, we could accomplish our result. During each three-hundredth of a second, the diaphragm would be acted upon by over three thousand impulses acting in the same direction, and the effect of these impulses would add up and pull the diaphragm, and the sound transmitted could thus be made audible.

There are several devices which act as such an electrical valve. The most important of these are the crystal detector and the vacuum tube.

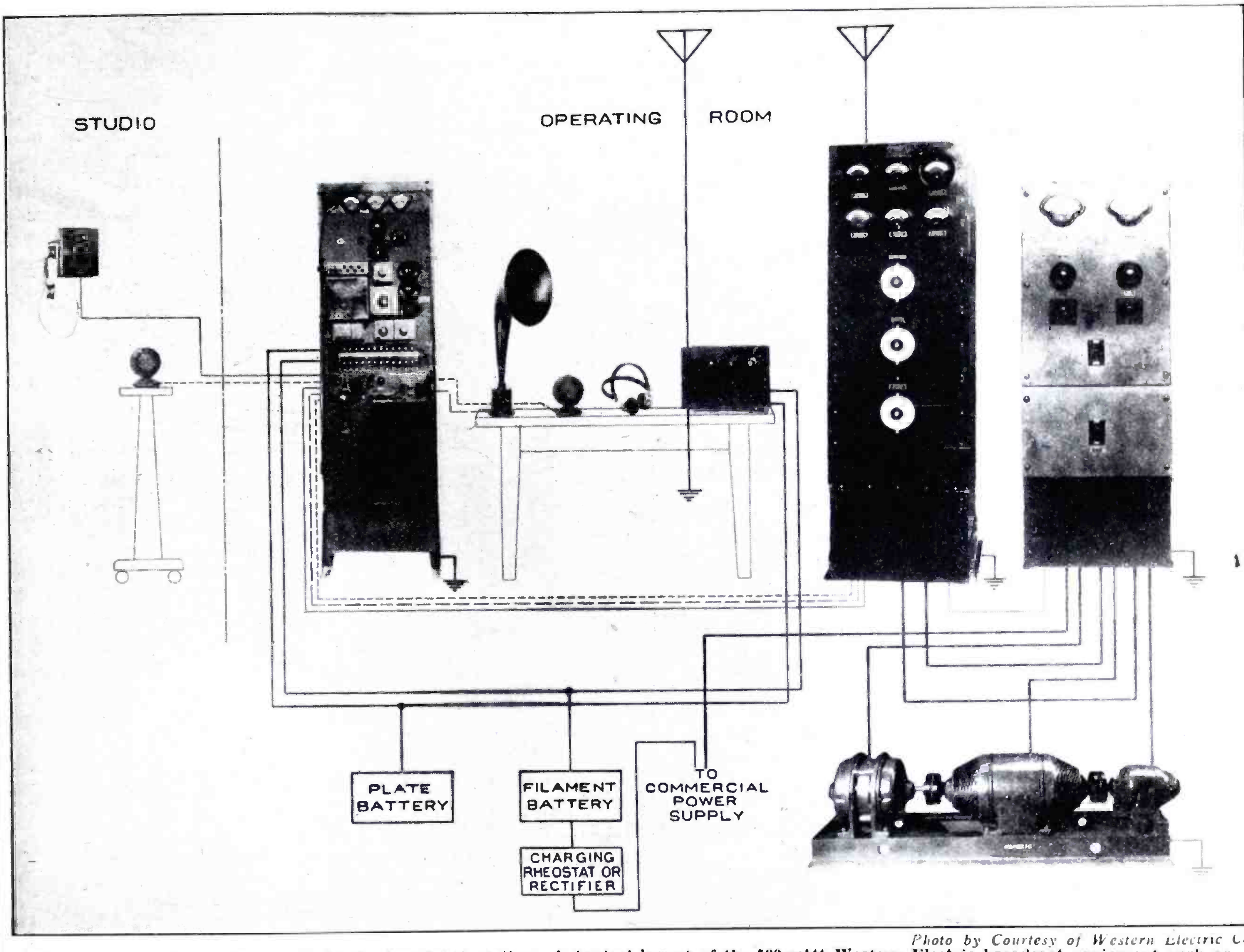


Photo by Courtesy of Western Electric Co.

Here you see what really counts in the broadcast station. A typical layout of the 500-watt Western Electric broadcast equipment such as installed at radio broadcast station WRNY. At left is the announcer's local telephone set, and the "mike" that picks up the program. Then comes the speech amplifier panel, with its control dials, meters, etc. On the operator's table is the monitoring loud speaker, another microphone, the headset and radio receiver for "listening in" at 600 meters. At the right are the 500-watt radio transmitter with its three dials for antenna tuning, wave length and oscillator adjustment; and the power control panel. Below is the motor-generator set which delivers current for filament and plate circuits in the transmitter.

Crystals for Use as Detectors of Radio Waves

Galena is a native mineral, and is an important lead ore. It has been

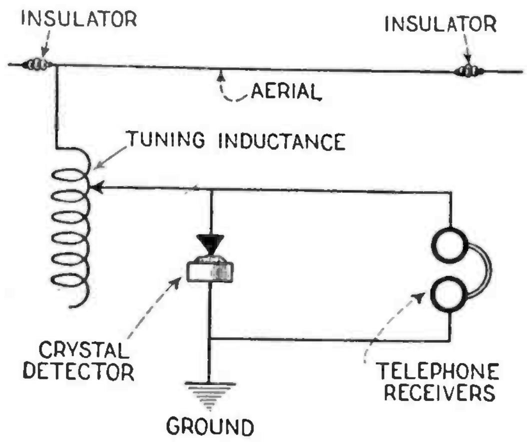
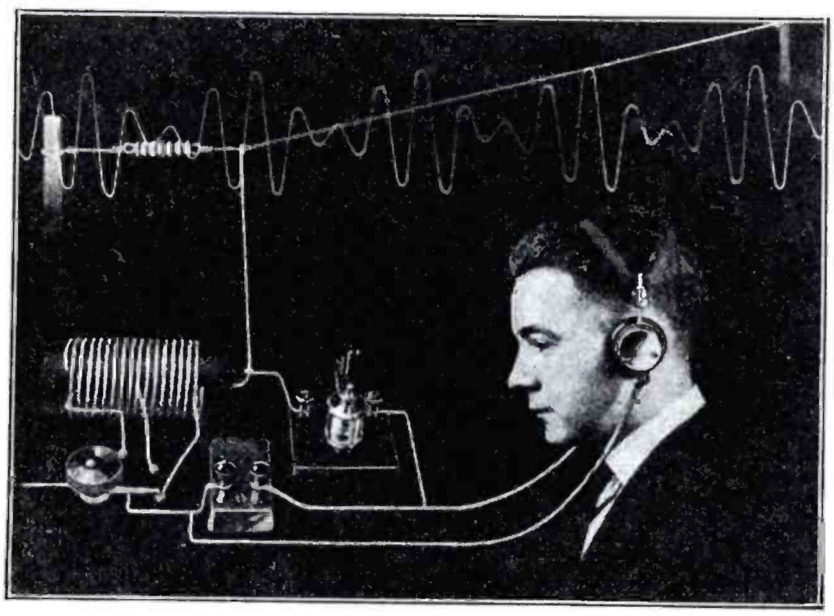


Fig. 11. A simple radio set for receiving incoming radio waves.

found that if a fine wire is placed in contact with the surface of a selected crystal of galena, an electric current will flow in one direction through the fine wire and the contact and the crystal, but that practically no current will flow in the opposite direction. The contact between the fine wire and the surface of the crystal acts like a flap valve which lets water pass in one direction only in a pipe. Iron pyrites or "fool's gold," also acts in this way. Such minerals are called "crystal detectors." It is by no means every specimen of either of these minerals that will act as a crystal detector, and it is not every spot on the surface of a given crystal that will give a contact that will act as a detector, and pass current only in one direction. A good crystal must be selected, and then the surface of the crystal must be searched with the fine wire to find a spot which is satisfactory.

A short distance away the waves may be intercepted or detected by means of the simple receiving set shown in Fig. 11; but at greater distances when the waves are considerably weaker the more elaborate vacuum tube arrangements are usually employed.

The first step is to tune in on the incoming wave so as to bring it in harmony or "resonance" with the wave-length of the broadcast station like that of tuning in on a desired color or tone pitch. When this is done, the intercepted waves flow down from the receiving aerial to the ground. They may be diverted into the receiving apparatus as illustrated. However, even when they are diverted in this manner these wave energies are still of frequencies several hundred thousand vibrations per second corresponding to the wave-length of the transmitter, and will not produce any sounds in the usual telephone receiver (Fig. 8), which will only respond within a range of audible or considerably lower frequencies. By making use of a detector that can "rectify" or convert these electric waves into a direct current (current flowing in one direction), we secure a series of vibrations or impulses flowing in one direction. The current flowing from the detector to the telephone receiver is smoothed out into impulses at a frequency within the range of the telephone receiver and causes vibrations of its diaphragm that can be heard by the human ear. When the proper adjustments of the tuner are made to correspond with the wave-length of the desired station the sounds as transmitted are distinctly heard.



Pictorial illustration of a simple receiving outfit, showing an arrested visualization of the modulated radio waves reaching the receiving aerial.

Photo by The Brady Productions, Inc.

The Vacuum Tube and Its Use in Radio

Vacuum tubes are used in every station that broadcasts programs as described in connection with "modulation" of waves. The tubes are used to strengthen the music before it is broadcast, and at the receiving end they are again used for detecting and amplifying the waves after their journey through the ether. The question now arises how does the vacuum tube work. To answer this it will be necessary to start with the smallest particles of matter known as "atoms."

Atoms, which are minute particles of matter so small as to be invisible even with the most powerful microscopes, are made up of even smaller portions called electrons, and it is with these electrons that we are concerned. As an electron is so small that it is almost impossible to conceive of its minuteness, it is best to think of it as a charge of electricity.

It is also fitting at this point to explain the nature of a charge, when speaking about electricity. When the

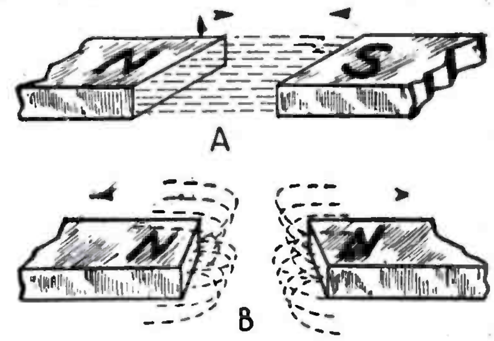


Fig. 12. At "A" the magnetic process of opposite poles attract, and at "B" the like poles repel.

ends of two bar magnets are touched together they will sometimes have a tendency to cling to each other and sometimes they will push each other away. If this little experiment is tried, it will be found that when the north pole of one magnet and the south pole of the other are in proximity, the magnets will tend to attract each other, but if the two north poles or the two south poles are brought in contact, then the magnets will repel one another. This experiment will show us, that unlike polarities attract and like polarities repel. (See Fig. 12.)

So it is with electrons. We say that some electrons are charged positively, and some have a negative charge. The electrons that have the positive charge are the more stable and those that are negatively charged may be considered to be wanderers. The atom, mentioned before, is composed

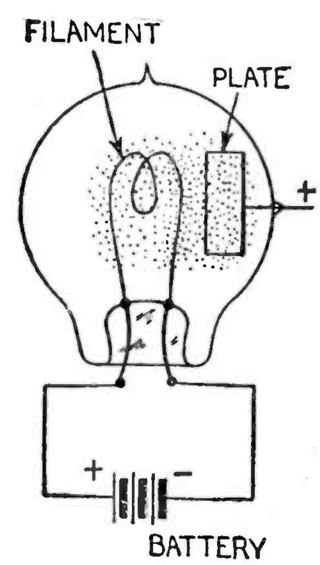


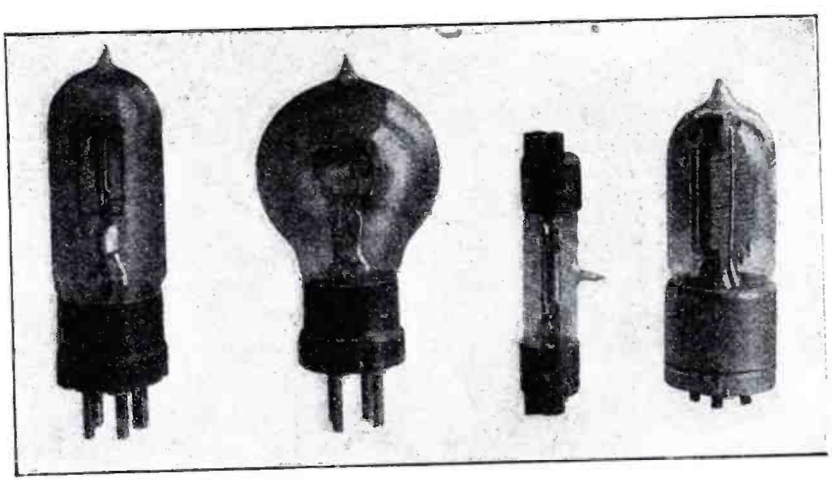
Fig. 13. A diagram showing how the electrons flow from the filament to the plate of a two-element vacuum tube.

of electrons that have either positive or negative charges. There are, at the center of each atom, electrons that have a positive charge of such a strength that they hold negatively charged electrons that are revolving about them in regular orbits. In other words, the structure of the atom may be compared to the solar system of which the earth is a part. The sun may be thought of as the positive nucleus at the center of the atom and the negative electrons as the planets that revolve in their orbits about the sun. The attraction of the sun which holds the earth in its path may also be likened to the force that the positive nucleus exerts on the traveling negative electrons.

However, under certain conditions, when outside forces are brought to bear on the atom, the force holding the negative electrons in place is overcome and they fly away to some object that has a greater positive charge than the positive nucleus.

The Filament Employed to Emit Electrons

This characteristic of electrons was first applied to vacuum tubes by an English scientist, Prof. Fleming, in 1904. He suspended a fine wire attached to a battery near a metal "plate," which could also be attached to a battery, and enclosed the two elements in a glass tube from which the air was removed. When the battery



Various types of vacuum tubes as used for receiving purposes. As seen these tubes differ as to their size and shape. However, they all incorporate the same principle.

was attached to the thin wire, which he called the "filament," the wire grew warm. As the positive terminal of another battery was connected to the plate, he discovered that there was a flow of current between the filament and the plate as in Fig. 13.

This current flow was caused by the heating of the filament to a temperature at which the positive nucleus could no longer exert sufficient attraction upon some of the negative electrons and they flew off into space. As we have seen above, unlike charges attract each other, the negative electrons thrown off from the filament went across the intervening space to the positively charged plate. Also, as the plate was always charged positively with respect to the filament, the electrons always flowed in one direction, *i.e.*, from the filament to the plate.

In 1907 Dr. Lee DeForest, while experimenting with the two-element Fleming tube, found that by placing another element in it more wonderful things than ever could be performed. This third element was another wire strung spirally between the filament and the plate and was named the grid. The function of this discovery of Dr. DeForest's is to act as a control for the electrons that flow from the filament to the plate. (Fig. 14).

The Action of a Tube Likened to a Water Pump

If we compare the action of the vacuum tube to the valve of a water-pump, it will doubtless make matters clearer. In a water-pump, there is a valve which permits water to flow in one direction only. That is, when the stroke of the pump plunger is downward, the valve opens, allowing the water to flow into the chamber. When the pump plunger is started on its up-stroke the pressure of the water is exerted on the valve, which closes, the water then being lifted to the top of the pipe. There might also be a gate-valve in the pipe between the pump plunger and the outlet, which would regulate the flow of water. (Fig. 15).

These parts of a pump and their functions may easily be compared to the three elements of a vacuum tube. The one-way action of the pump may be compared to the unidirectional flow of electrons from the filament to the plate, which may be thought of as the outlet of the pipe. The gate-valve mentioned between the pump and the outlet may be considered as the grid of the tube, because the function of the grid is to regulate the flow of elec-

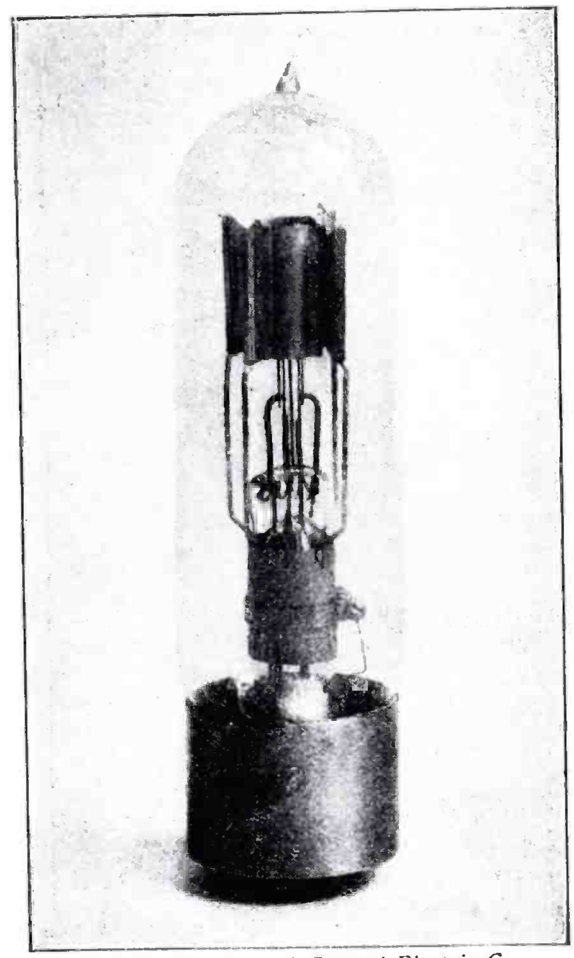
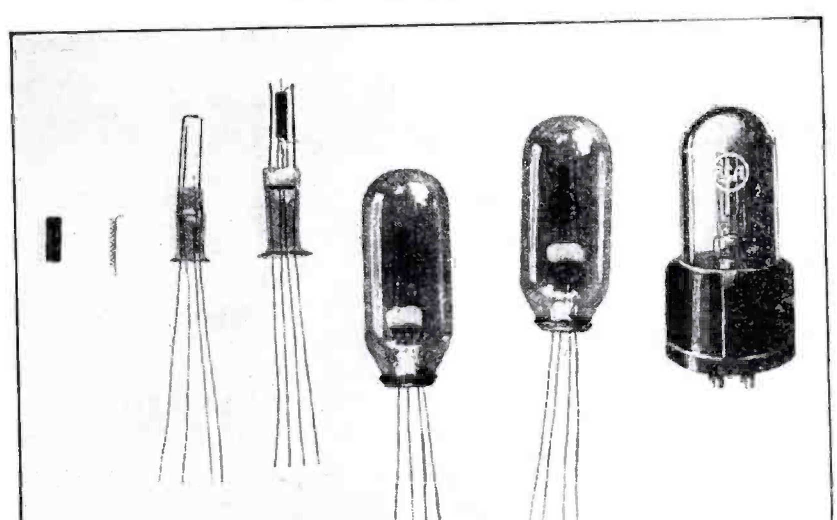


Photo by Courtesy of General Electric Co.
One type of transmitting vacuum tube as used in connection with medium power transmitting sets.

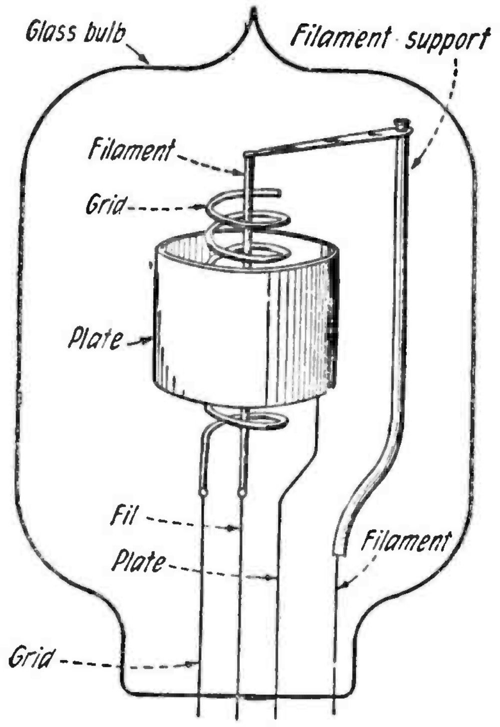
trons, as the gate-valve regulates the flow of water.

This regulation or control of the electronic stream is easily understood if one considers the relative electric charges on the grid and plate elements, *i.e.*, the plate being charged positively with respect to the filament, attracts electrons when they are shot off into space from the filament. However, as the grid is between the filament and the plate and as this element, too, may be given an electric charge, it influences the electronic stream in the following manner: If the grid is charged positively with respect to the filament and negatively with respect to the plate, then it will attract to itself a certain number of electrons, the rest of the electrons in the stream continuing their journey on to the plate. Now



Successive stages in the manufacture of a dry cell vacuum tube showing how the elements are arranged with the glass vacuum bulb. From left to right are the plate, grid, filament on support, assembled elements, elements within tube and finally the completed tube.

Photo by Courtesy of Radio Corporation of America if the grid is charged negatively with respect to the plate and has the same charge as the filament it will allow the electronic stream to pass unchanged,



Within the vacuum bulb of the tube are the filament, grid and plate elements. The wires connected to them are brought out to leg contacts on the bottom of the tube base.

or the number of electrons reaching the plate will be greater. If the grid and the plate are identically charged the electrons will stop at the grid, not continuing their journey any farther.

This may seem confusing, but if the reader will remember that like charges repel and unlike charges attract, then he should have no trouble in understanding the part the grid plays in the vacuum tube. Of course, there are many variations that enter into the grid and plate function that are entirely too technical to be discussed here. However, it might be fitting to explain a few of the uses of vacuum tubes in receiving circuits.

The Vacuum Tube as a Detector

Primarily there is the vacuum tube that is used as a detector. If a circuit diagram of a receiver is considered, it will be found that there are always two wires on the input side of the detector tube, one of these leading to the grid and the other to one of the two filament terminals. In most cases, these two wires are connected to the ends of some form of inductance, whether it be the secondary side of a radio frequency transformer or the secondary of coupling coils.

Superimposing Currents

The current passing through these wires is an alternating current varying its polarity, or direction of flow, thousands of times per second. Superimposed on this alternating current is a second current, which is irregularly alternating, whereas the first current is uniform. The variations in the second current, which are caused by words or music being projected into the microphone at a broadcast station, are the components of the whole that cause the detector to function. They cause the first-mentioned current, which is commonly called the carrier wave, to vary in intensity. That is to say, at some instant the carrier wave will have a greater positive (or negative) value than at some other instant. This variation of the carrier wave is called "modulation," as previously described.

When this modulated carrier wave is impressed on the grid of the detector tube, it will cause the charge of the grid to vary, making it more or less

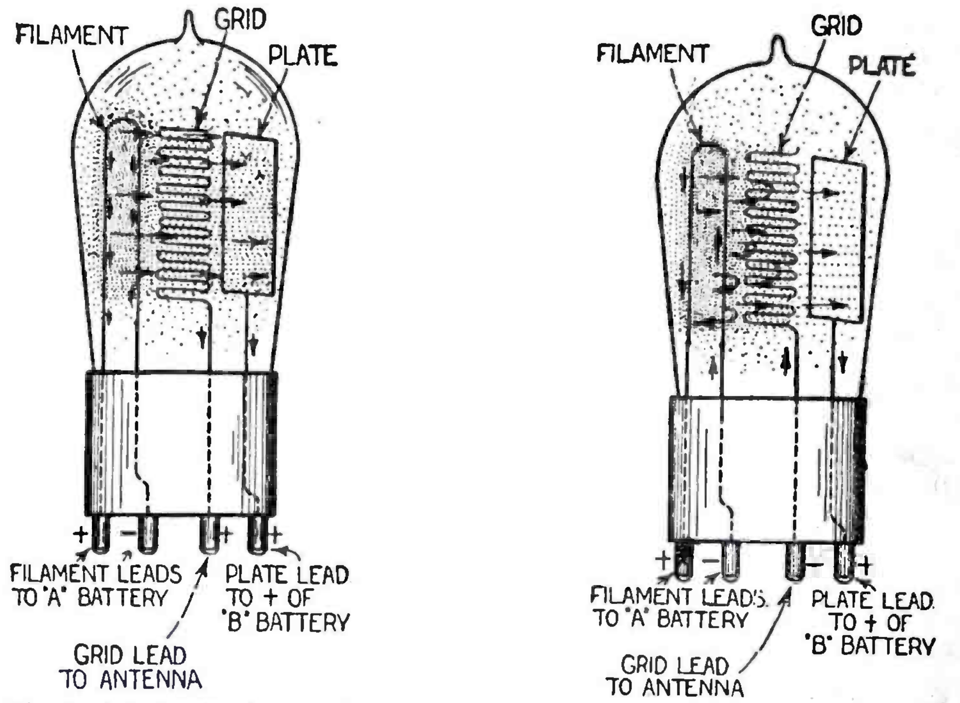


Fig. 14. A pictorial illustration showing what happens in a vacuum tube when the polarities of the batteries are connected to allow the electrons from the filament to flow to the plate and at the right shows what the reversal of the battery polarities does.

negative (or positive, as the case may be) with respect to the filament. As has been explained above, the grid of the tube acts as a control valve for the electronic stream flowing from the filament to the plate, according to the nature of the charge upon the grid. So if the value of the charge of grid varies as the modulated carrier wave, then the electronic stream will vary in exactly the same manner. In other words, the function of a detector tube is to convert the modulated carrier wave, which is alternating at radio (high) frequency, to the modulated audio frequency current that we are able to hear in the headphones or loud speaker as voice or music, etc.

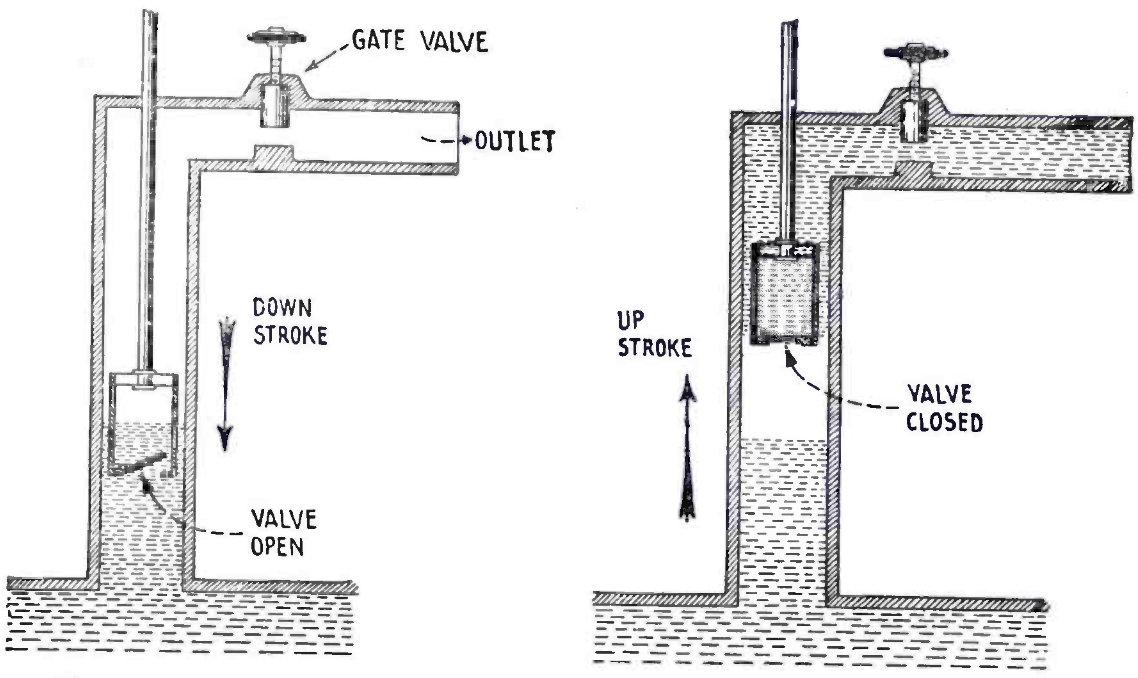


Fig. 15. In a water pump there is a valve which permits water to flow in one direction only. Thus this action is likened to that of the vacuum tube which permits currents to flow in one direction.

The Vacuum Tube in Amplifier Circuits of the Receiver

When vacuum tubes are used either in the radio or audio frequency amplifiers, their purpose is entirely different. The tubes are then employed because it is possible, by their use, to make a small amount of energy control a large amount of energy, in

(*Continued on page* 158)

The How and Why of Radio Code

By GILSON V. WILLETS*

WERE you ever listening-in to some beautiful concert when suddenly the program was interrupted with a most annoying noise coming with symmetrical regularity consisting of long and short impulses that seemed to fairly wreck your delicate receiver? "Dit-Dah-Dit-Dah-Dit-Dah," it goes in a series of dots and dashes which you've learned are radio code signals presumably emanating from a ship at sea. You probably frown and try to tune the offending signals out by seeking another station on a lower wave-length. Sometimes you are able to do this and sometimes the code seems to be everywhere on your dials. Should it be everywhere you may probably close up your set for the evening and go to the movies telling your friends the set is no good or that you advocate a new law to suppress this distraction from your radio enjoyment. Many, very many, have written their senators and representatives in Washington urging just such a measure. In 1922 a man in Maryland organized a nation-wide society, the object of which was to force the government to either remove radio from all ships or to compel them to use radiophone so what they said could at least be understood by "intelligent" people. The man in question sent his propaganda to several of the prominent broadcast stations and much to his surprise his idea was displeasing to them and in many instances he was severely criticised.

In time the problem of code interference will be eliminated and the air will be free for the complete enjoyment of radio programs, but this will take some time. Meanwhile, let us seek the reason for this interference and why it hinders uninterrupted reception in our homes.

Contrary to whatever statements have been made by manufacturers today there are no receiving sets made to operate on the regular broadcast wave-bands that do *not occasionally* pick up code signals. This is because in localities near powerful ship-shore stations or where ships pass using their transmitters, *forced oscillations* will be heard on every wave within the range of your receiver. This is because the power is so strong at the transmitter that "Spark," signals leaks through everywhere. In New York harbor during the day, the U. S. Department of Commerce has radio inspectors adjusting the radio transmitters of ships in the harbor. In order to properly adjust the waves of these ships to avoid *future* interference it becomes necessary to throw the power on the air for periods of as long as a minute or more at a time while adjustments are made. In most sections of the city these signals drown out everything in the upper broadcast bands and cause dealers the loss of many sales during the daylight hours. The government will not itself, nor will it permit anyone else to, thus test during the regular evening broadcast periods.

There are several kinds of radio transmitters that employ the "Code" which is absolutely necessary because

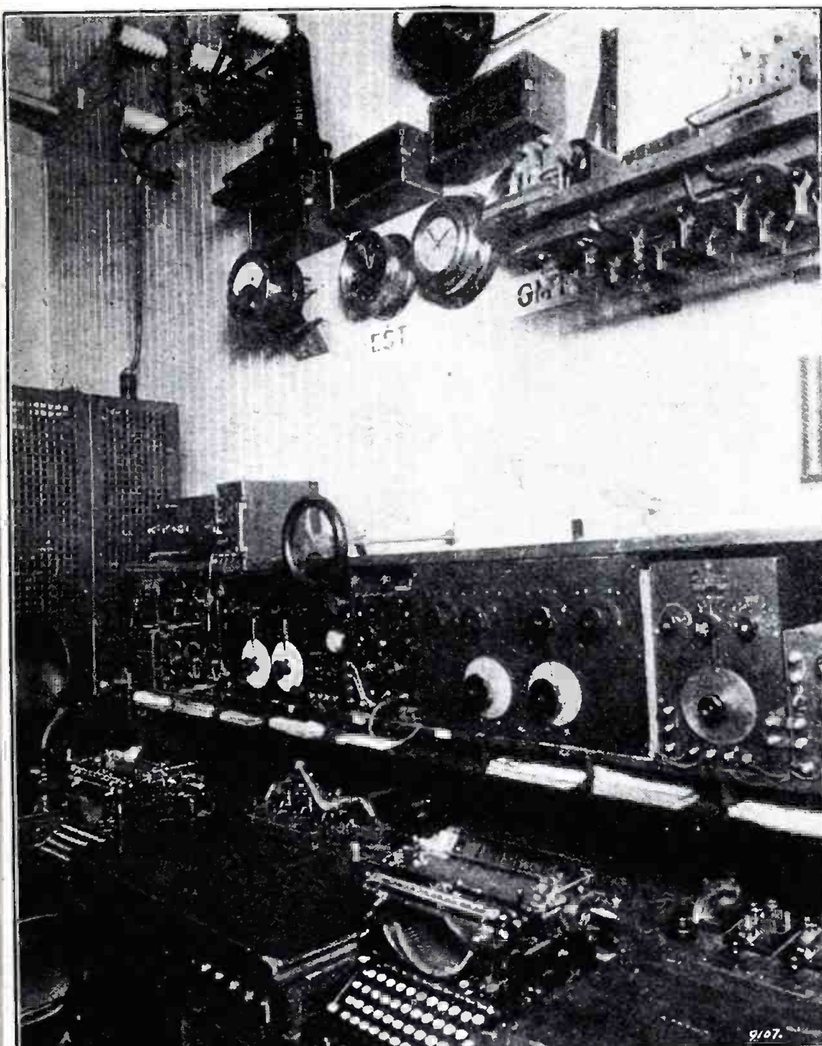


Photo by Thomas Cook Knight

The S.S. Leviathan is probably the most completely equipped steamship in the world and here we have a glimpse of a corner of her transmission room. Particular attention is called to the fact that the installation consists of three transmitters.

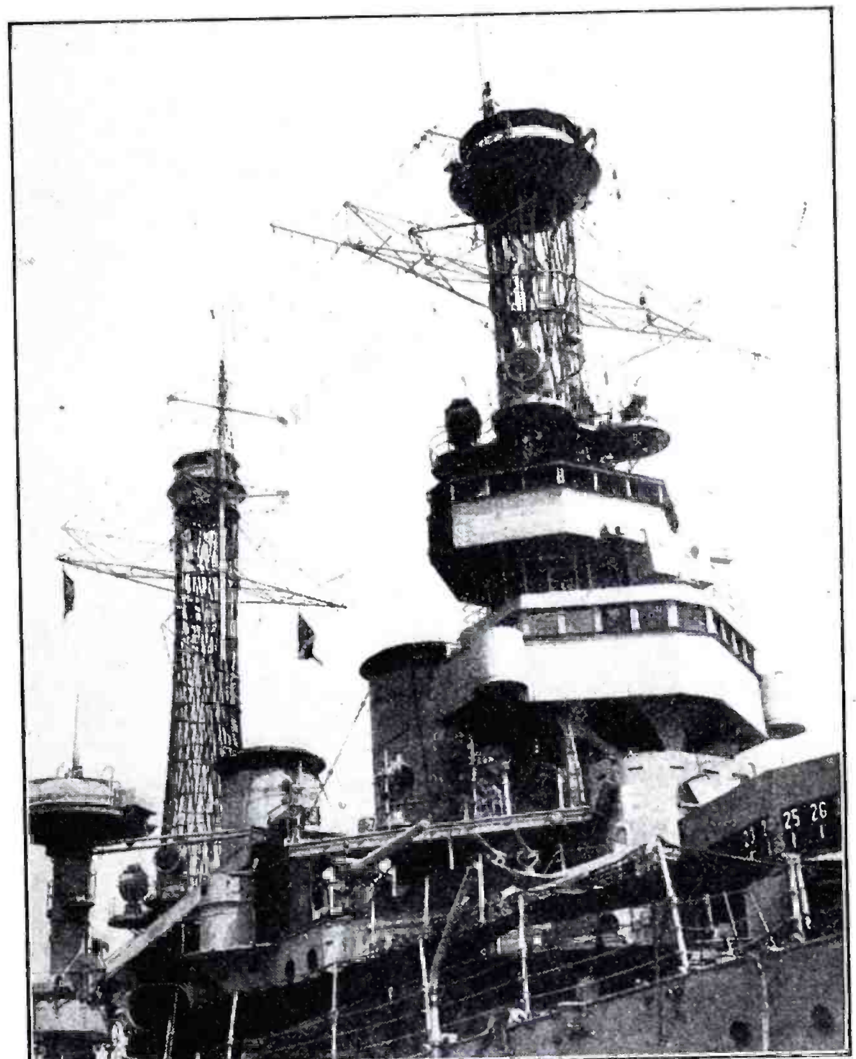


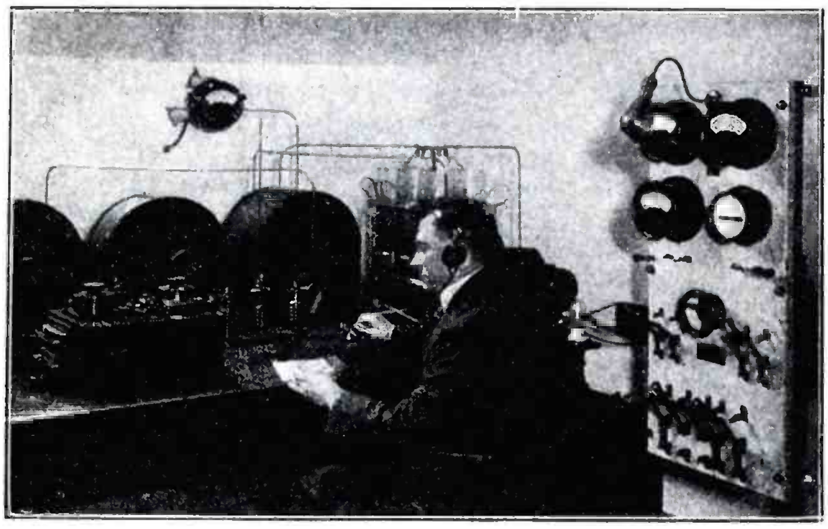
Photo by K. and H.

Here we see the antenna system on one of Uncle Sam's battleships. It will be interesting to note that like the mighty Leviathan, Uncle Sam's battleships are equipped with the last word in modern methods radio communication.

*Former Engineer, Stations WOS, WOC and WRNY *voice* is impracticable: The possibility of phonetic error is too great and besides code is the most accurate method we have today, next to the written word, of exchanging intelligence. Could you imagine a code message like this "XXSDG, QWTRX, SQZXC, DFGJK," being sent in static-filled air and bad interference in *voice?* No! The code must positively be used and we owe our thanks to Samuel F. B. Morse for its inception although the radio code was not all conceived by him as the Morse code is only used on the railroad and telegraph systems of the country and an evolution of it, known as the Continental Code, is used by all cables of the world, by all the telegraph land lines of continental Europe and by all the radio stations of the world by international agreement. In the early days of wireless when Marconi was conducting his tests and for a few years afterwards, the Morse code was used, but it was supplemented by the more practical Continental code because it has no spaces in the characters comprising the letters. See the two codes as outlined on the code chart on page 95 and note the "O." In Morse it is "Dot space Dot," but in Continental it is "Three Dashes." This is more simple and easy to receive through bad static and also there is no possibility of mistaking the Morse "O" for the Morse "I" which is "Two Dots" without spaces between.

Another thing of interest is the types of transmitters used today by ships and land stations. They are divided into the following classes: *spark* (using damped waves which are very interfering), *arc* and *tube* (which are both very sharply tuned and cause but little interference when properly adjusted), and *chopper systems* (which utilize a method for breaking up the undamped waves of the *arc* or tube transmitters, making them audible for non-oscillating receivers and which are not quite as interfering as sparks and much more desirable). The governments of the world co-operating with private interests are gradually changing all spark type sets over into tube or arc sets and within a score of months the interference from that source wil lbe practically nil.

However, the arc and tube transmitters have greater range and reliability and are far more desirable in every way in addition to being non-interfering.



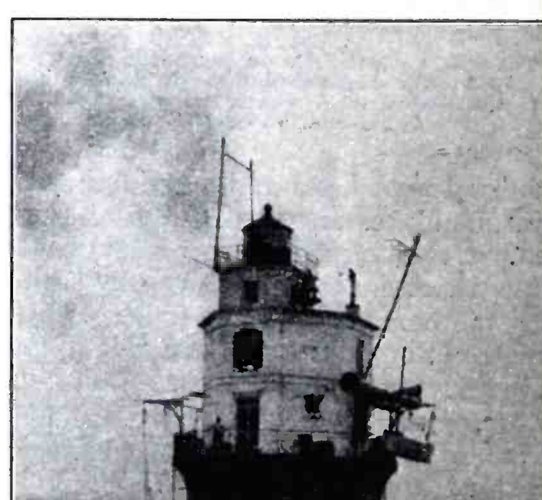
Here is an old-fashioned spark type transmitting station which has been for years outclassed by modern tube transmitters. This station which at one time operated in Binghampton would cause interference for miles around whenever it operated, and was such a station to be used today, it would completely ruin broadcasting reception in its vicinity. *Photo courtesy D. L. & W. Railroad.*

One of the most important things to be considered is that no matter how much the broadcast listener may consider his own importance in the matter, that same person sings a far different tune should he be a passenger aboard a ship at sea that meets with accident, for then the radio becomes a vastly important thing in his eyes. Big business men that roast the interfering ships turn and beg the operators on these same ships to keep them in touch with their home interests when they take a "hop abroad." While the broadcasting of entertainment has been of great benefit to thousands of people and has also been responsible for the sudden and rapid growth of a vast industry, still no lives depend upon it. The most important thing in broadcasting is the radio market news in the mid-west and there the farmer depends upon it and still he is very puny compared to the importance of radio communication in the marine world, the trans-oceanic field and the aircraft and inter-city radio traffic.

A certain man once spent an evening at the writer's elbow cursing the "Damfool" ships that ruined his evening on a rather poorly constructed broad tuning receiver of a well-known make. Later, an SOS call was received from the S.S. *Lenape,* and the writer copied for him the various messages sent in connection with the disaster. His daughter was on board the *Lenape.* At once the ship's radio assumed the greatest importance. He was so happy that the broad undamped wave of the KVL (call of the *Lenape*) was audible to thousands of vigilant land and ship stations. When sending an SOS call a ship tranmitter is always tuned as broad as possible to enable the greatest number of listeners to hear the call. The anxious father watched with longing eyes, filled with love and horror, the grim messages copied from the *Lenape* and the rescue ships and when he learned, via his own radio, that his beloved daughter was safe along with all the other pas-

(*Continued on page* 95)

And here we have a radio installation on board an airship which of course is the only means they have of communicating with the world below, and therefore we must admit is of more importance than a simple broadcasting station. *Photo by P. and A.*



Even lighthouses in lonely spots are equipped with radio in this modern day.

What to Expect of Your Radio Set

By H. G. CISIN, M.E., Assoc. A.I.E.E.

AN old proverb states that he who expects little will not be disappointed. While this ought not to apply to radio, still there have been so many exaggerated claims made regarding radio receiving sets that the man who buys his first radio set usually expects performance far better than he actually gets.

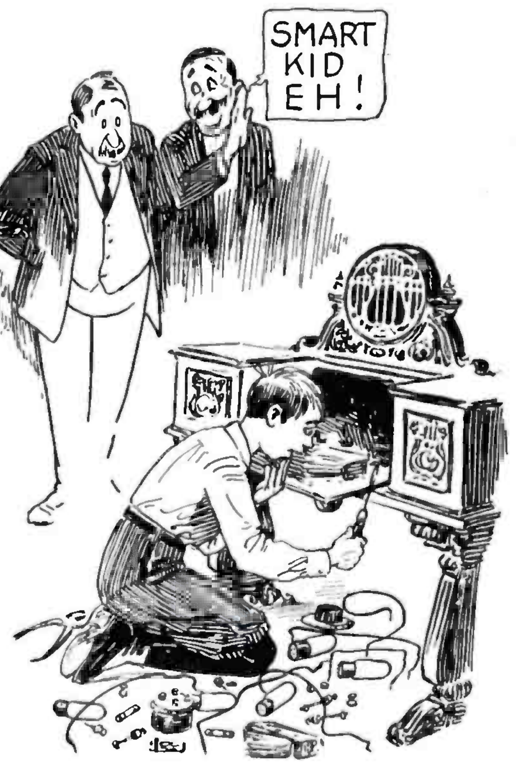
The purchaser of a motor car knows in advance how fast the car can go, how many miles to the gallon, how much oil it will require, the probable life of the tires, and so forth. When he buys a radio set he cannot understand why he does not get similar hard and fast specifications. When he asks what distance the set will bring in, he is given what he thinks is an evasive answer. He asks how long this accessory will last, or that, and each time the dealer puts him off with the answer "that depends—". Finally he buys the set anyway, hoping for the best. When the new set arrives, the local stations are tuned in for a while and then a search is made for distant ones. If these are not immediately forthcoming there is a hue and cry. The set is condemned, the dealer is hastily summoned and there is a great amount of excitement.

The set is condemned, the dealer is hastily summoned and there is a great amount of excitement.

Possibly you yourself have gone through this same experience. If not, and you are just purchasing your first set, there are a number of points which should be of particular interest to you. In addition to the radio set, the antenna installation and the batteries, there are a number of other factors upon which distance getting depends. For instance, in most cases it is practically impossible to get distance in the daytime. Morover, on many evenings, atmospheric conditions are such as to preclude getting any distance at all. On the other hand certain cool, clear winter nights seem to give ideal reception and at such times it is often possible to get results far above the average.

Keep in mind the fact that even the best broadcasting stations are not always up to the mark in the quality of their broadcasting. Thus a station which ordinarily sends out clean-cut, sharply tuned, powerful waves, may at any time send out broadcasting lacking in power and not properly tuned. As a result the reception will not have the customary volume and the receiving set will not tune as sharply as usual. It is obvious that such a condition has nothing whatsoever to do with the receiving set. Certain broadcasting stations are unable to send out waves which will give satisfactory reception, due to lack of power, imperfections in transmitting equipment or other causes. Naturally you will never be able to receive these stations as perfectly as you get the more powerful ones. In some localities, reception is always poor and in fact, certain places are known as "dead spots," due to the difficulties in obtaining even fair radio reception. Fortunately, such "dead spots" are seldom encountered. You should have considerable patience with your new set, studying it carefully under varying conditions and not attempting to condemn its performance, at least in respect to distance, before three or four weeks. During this interval of time, if the set is used each night, you will discover another important fact—namely, that a radio set will yield results in proportion to your skill in operating it. In this respect the radio set resembles a musical instrument. The more you practice with it the more you will be able to coax out of it. The tuning, on distant stations, is usually extremely sharp and the rheostats must be carefully manipulated to bring these stations in. Many sets will not bring in distant stations while the local stations are on, since they do not tune sharply enough. If your set is not selective, you will be able to get distance only after the local stations have signed off.

Do not expect to get more than you pay for. If one radio sells for $60 and another one has a wide sale at $210 you cannot expect to get the same results from the cheap set which you would get from the more expensive outfit. It is true that both sets may have the same number of tubes. They may even operate on exactly the same principles and utilize the same type of circuit. But in one case, only the finest materials are used and these are assembled carefully and tested again and again. In the other case, the set is often made from the cheapest parts obtainable, put together in a slip-shod way and not really tested at all. If you have picked up your set at a bargain counter there are many things you have no right to expect from it—especially distance reception while locals are on. If you have purchased an expensive set you have every right to expect the set to cut through the locals and bring in dis-



The neighbor's boy improves the radio set.

tance, subject of course to the exceptions mentioned above and with particular emphasis on the point that atmospheric conditions must be favorable.

The writer recalls one case where a man bought a high-grade high-priced radio set but made his own installation. He complained to the dealer that he was unable to get any distance whatsoever. An investigation revealed the fact that his aerial and lead-in were both grounded in a number of places and in fact it is doubtful if he would have been able to get even the local stations if not for the high sensitivity of the set. Another radio enthusiast tuned in five Chicago stations from his Long Island home on his new set the first night the set was installed. Several nights later he set the dials for Chicago again but was unable to get a whisper. He immediately telephoned the dealer who explained that as it happened to be Monday night, that night was silent night in Chicago!

Do not expect distant stations to come in clear as a bell, or just as good as the locals. There is bound to be more interference on the former than on the powerful local stations. A dealer was recently called out to service a set which had been in use about two weeks. He found a log sheet on which had been recorded at least forty stations, including many distant ones, all received on the loud speaker. The purchaser's wife explained that the reason she had sent for the dealer was that the distant stations were neither as loud nor as clear as the locals, so she felt sure the set was defective in some way.

Radio manufacturers and dealers are often to blame for the lack of knowledge on the part of the public as to what a set should do. We are all familiar with the type of advertising which boldly claims "coast to coast" range under all conditions. Such advertising is misleading to say the least and should be toned down. Last winter, a Chicago set manufacturer had this brought home to him in a very striking way. He ran an advertisement in one of the Chicago newspapers with big headlines which read as follows: "Hear the Happiness Boys Every Friday Night on your ———Set." It happened that on the next Friday night there was a great deal of static so that it was impossible to tune in any New York stations. On Saturday the complaints started to pour in. Letters and telephone calls by the score and every purchaser of that particular set who had expected to hear the Happiness Boys felt that he had been swindled.

In tuning in for distant stations make sure they are broadcasting and also be certain to take account of the difference of time in different sections of the country. It is impossible to make the set perform when there is no broadcasting on, as thousands of fans in the vicinity of New York discovered several months ago, when local broadcasting was discontinued for an entire evening because of an SOS call. According to International law, all broadcasting must be discontinued when an SOS or distress call is sent out by a ship. Many fans, who missed the announcement of the distress call, immediately came to the conclusion that there was some trouble in their sets, and as a result the dealers were kept busy answering telephone complaints.

If you allow the neighbor's fourteen-year-old boy to "improve" your set, do not be surprised if it suddenly stops working. There has been so much tinkering of this sort that many manufacturers have sealed up their sets and only guarantee them with the proviso that the seals remain unbroken.

If you use your set every evening, as you probably will, and other members of the family use it during the day, be prepared to have the storage battery recharged often. This is the battery which lights the filaments of the vacuum tubes. It is a simple matter to figure out just how long the battery will last. If you have an 80-ampere hour battery, and a five-tube set using standard storage battery tubes, each tube draws one-quarter of an ampere or the five draw a total of 1¼ amperes. Dividing the 1¼ into 80 gives 64 hours as the time which will be taken to completely discharge the battery. This means that if the set is used on an average of 5 hours per day, the battery will be completely discharged in about 13 days. Using a 100-ampere hour battery under the same circumstances, the battery will be discharged in 80 hours or, if used 5 hours a day, in 16 days. However, your battery should never be allowed to become completely discharged as this shortens its life and otherwise spoils it. Hence in the case of an 80-ampere hour battery, used as above, it would be necessary to recharge in about one week, while in the case of the 100-ampere hour battery, recharging would be necessary in less than two weeks. The only correct way to determine exactly when the battery needs to be recharged is to use a hydrometer, testing at least as often as once a week. It is well to follow explicitly the instructions given by the battery manufacturer as to operation. Some batteries are fully charged when the hydrometer shows a reading of 1280, and manufacturer's directions usually recommend that battery be recharged before the specific gravity falls to 1150.

If your new battery loses its charge only a few days after the installation has been made, do not jump to the conclusion that the battery is defective. Batteries have to be "seasoned" before they will hold a charge properly. This usually means that the new battery will require recharging in from two to seven days. Thereafter it will hold its charge and only require recharging in proportion to its capacity and the

When going away on a week-end trip lock the door and switch off the radio set.

length of time it is used. In some cases, however, it is necessary to subject a new battery to two or three cycles of discharge and charge before it starts to function properly.

If you leave your storage battery

(known also as the "A" or filament lighting battery) standing for a long time, it may become greatly reduced in efficiency. During the process of discharge, a white crystal substance called lead sulphate is formed at both the positive and negative plates of the cell. When the battery is neglected for any considerable period of time, this sulphate gradully hardens and it becomes much more difficult for the charging current to reduce it. In this condition the battery is said to be "sulphated." As a general rule, if your battery becomes sulphated, this has happened through neglect on your part. To avoid this trouble, have a storage battery charged promptly as soon as it is discharged. Many people have a battery charged and then do not use it for a long time. When they finally decide to operate the set, they are much surprised to learn that the battery has lost most of its charge. This loss of capacity is due to local action within the battery.

From the above, it is obvious that the most effective method of doing away with battery trouble is to invest in a charger, and charge the battery regularly every week or oftener if necessary. If you buy a 2-ampere charger don't expect to charge a fully discharged 100-ampere hour battery in a hurry. Figure it out for yourself. It will probably be worth your while to pay the difference and buy a 5- or 10-ampere charger. It is well to remember that the oxygen and hydrogen liberated when a storage battery is being charged form an explosive mixture. For this reason, you should use especial care not to bring an open flame into the room where a battery is being charged and also not to cause a spark by short circuiting the connecting leads, as a dangerous explosion may result. In adding water to a battery to replace that which has evaporated, be sure to use distilled water.

When your set is installed, mark the date on each of your "B" batteries. These are the dry cells used to supply the proper voltage to the plates of the vacuum tubes. Of course, where a storage battery or "B" eliminating device is used to supply plate voltage this does not apply. Medium sized 45-volt batteries used on an average of three hours per night with a five-tube set should last three or four months. It should be noted that "B" batteries deteriorate even when not in use. In general, the smaller sizes deteriorate more rapidly than the larger sizes. If your batteries go dead in three or four weeks, they are probably old or defective and you should be entitled to replacement. Of course, there are many cases where "B" batteries may go dead through your own fault. In one instance, a woman placed a metal tray on top of the "B" batteries, thus short circuiting them and rendering them worthless. In another instance, the filament switch was left on for over 24 hours, thus running down the "A" battery, shortening the life of the tubes and permanently weakening the "B" batteries. Neglect of this sort should not be blamed on the manufacturers or the dealers, although many people seem to think that a radio set is absolutely fool-proof.

He can't understand why it stopped working.

Your set has a way of notifying you when its batteries are not up to the mark. When the "A" or storage battery starts to get weak you will notice a diminution in the volume of the local stations and you will probably be unable to get any distant stations at all. Further weakening of the "A" battery will result in a sudden cessation of reception. Sometimes the music or speech fades out and stops. Thereafter if the switch is turned off and then turned on a little later, sounds can again be detected, and these also die out rapidly. If the rheostats must be turned on full in order to get sufficient volume, this is a very good sign that the "A" battery needs recharging.

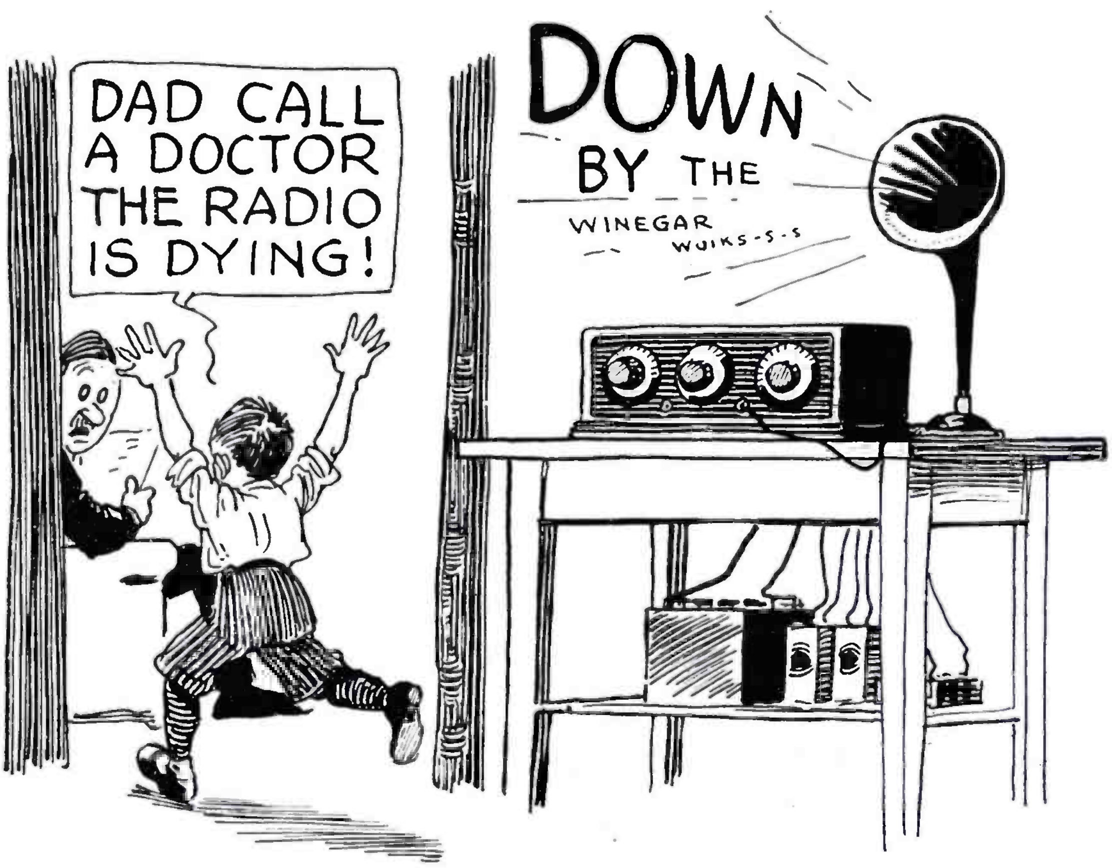
Weak "B" batteries often cause noisy reception and they also may be responsible for reduced volume. Many good loud speakers will not operate correctly unless the "B" battery voltage is correct. Such speakers often rattle when the voltage of the "B" battery is too low. The best way to test "B" battery voltage is by means of a small voltmeter. This test should be made about once a month or any time when the set is not operating properly. When a 45-volt "B" battery falls below 35 volts it should be discarded. Many people think they are being economical when they save their old "B" batteries and connect four or five run-down batteries in series, thus getting a total of the 90 volts required. This method usually results in noisy reception and it is quite usual for a poor battery when used with good ones to cause the latter to run down rapidly also.

If you treat your tubes with consideration, they should last a long time. If they are handled carelessly you may have to purchase new ones in a few weeks. The rheostats are put on your set for definite purposes. One of the most important of these is to enable you to cut down the filament current. The rheostat should be turned on slowly. The tube filament is delicate and when cold it has a low resistance. If the current is applied at full voltage to the cold filament, the tube may burn out in a flash before it has had a chance to warm up. The rheostat cuts down the voltage and thus enables the filament to warm up before full voltage is applied. One per cent. more voltage than the tube is rated at can cut down the life of the tube 25 per cent., and just a little more cuts the life of the tube in half.

It should be remembered that a tube

may light and still not operate. A tube in this condition is said to fail to oscillate. Such a tube is defective and should be replaced without question, by the dealer.

If you slam down the cover of your set and jar the tubes badly you may ruin them. If you have been obliged to disconnect the set from the batteries in order to change its location or for any other reason, do not connect it and turn on the switch as you may in this way burn out all the tubes if you have made a wrong connection. After the wires have been connected and you have carefully checked over each connection twist the tubes in their sockets so that they no longer make contact. Then put back one tube so that this makes contact and turn on the switch, using the single tube as a final test. Proceeding in this way you eliminate the possibility of burning out all your tubes at once.



Your set has a way of notifying you when its batteries are not up to the mark.

In putting tubes back into their sockets, be sure that the prongs are making contact. Sometimes the socket prongs become bent. It is then necessary to remove the tube and pull the prongs upward with the finger. Tubes may be of exactly the same type and apparently indentical in every way and still will vary considerably in their characteristics. This especially applies to the tube used as the detector tube. Most sets are now constructed to use the same type of tube for a detector as that used for amplifying. By changing the tubes around and trying each one in the detector socket, you will usually be able to find one tube which will give much better results than the others. This test should be made with the set operating and with the volume as low as possible. The better the tube, the louder and clearer will be the reception. Many sets are marked for a detector voltage of 45 volts. It should be understood that this is not essentially a fixed requirement of the set but varies with each particular detector tube. The soft detector tubes, formerly used, usually gave best results with a plate voltage around 22½ volts. A good many of the standard tubes, when used as detectors, operate best at 45 volts on the plate. Many tubes, however, show a decided improvement when a plate voltage either higher or in some cases lower, than 45 is used. This is a condition that can only be determined by test, while broadcasting is being received on the set.

If for any reason, a tube must be replaced, do not assume that any tube of the same type can be substituted. In many sets, the tubes are carefully matched so as to have the same operating characteristics and unless the new tube is matched to the others, poor results are likely to follow. It may be necessary to try out a number of tubes before the right one is found. The writer recalls an acquaintance in St. Louis who tested out 100 tubes in order to properly match eight tubes for his super-heterodyne. This man claimed that the remarkable results which he obtained from his set were largely due to the perfect matching of the tubes. Inasmuch as he was the manager of a large radio and electrical jobbing concern, he had facilities for obtaining tubes which are not available to most of us. However, a selection from half a dozen tubes will often greatly improve results. Matching of tubes is especially necessary in sets which use automatic filament control.

The loud speaker should be given the same care as any other part of the set. If it is dropped, it will probably be thrown out of adjustment and it may be permanently ruined. Where an adjustment is provided for bringing the diaphragm and the magnets closer together, great care should be taken not to tighten this adjustment too much as this may result in bending the diaphragm and thereafter reproduction will be very poor. In such a case, the only remedy is to obtain a new diaphragm. Many cone speakers are provided with a thumb screw at the point where the rod connects to the parchment. This is not an adjustment of the ordinary type, but is for use only in case atmospheric conditions alter the tension of the diaphragm. If the tension of the diaphragm is too great, due to a change in the temperature or to other causes, it is simply necessary to loosen the thumb screw, thus allowing the diaphragm to assume a normal tension, and then to tighten the screw again. The terminals of the loud speaker should be reversed at the plug and the speaker tested and the reproduction should be compared with the terminals in the original position. Many loud speakers give greatly improved results by thus reversing the terminals. Very annoying trouble will sometimes result from unexpected causes. In a case where a phonograph unit was used in connection with a Victrola, the set suddenly stopped working, even though the tubes were properly lit and all the batteries were in perfect condition. A thorough test revealed the fact that the cover of the phonograph had cut through the connecting cord due to the fact that each time the cover was closed the cord was under pressure. After a while the insulation was removed from both wires leading to the unit and a short circuit resulted, thus rendering the set inoperative.

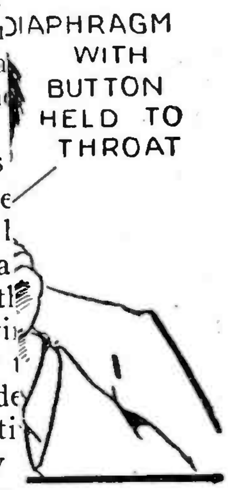
This article would not be complete without a few words about the various squeals and noises which are heard from time to time but which have nothing to do with the set itself. First of all, there is static to contend with. This is a crackling noise which often comes in, in a series of crashes. While various static eliminators have appeared on the market, this problem seems to be one which is still to be solved. However, static does not interfere with the local broadcasting of powerful stations and moreover it is not of frequent occurrence except in the summer months. Another exraneous noise which you will soon earn to distinguish is that of the ode transmitter. Inasmuch as both hip and land stations are now con- ned to higher wave-lengths than hose used in broadcasting, this cause f interference is rapidly disappear- ng. Sometimes in tuning in a sta- ion, a steady whistle, similar to the vhistle on the iterant peanut stand, s heard. This does not change in itch and cannot be tuned out. It is robably caused by the action of an- ther broadcasting station operating pon a wave-length close enough to he first station to cause this trouble. The technical name for this type of nterference is called "heterodyning." What actually happens in this case is hat the frequencies of the waves being ent out by the two stations overlap, differing by just enough to produce a new wave or note, called a "beat" note, which has an audible frequency. This trouble is seldom serious and is noticed more frequently on the lower wave-lengths, which are more crowd- ed. Many receiving sets will set up a steady singing hum if the loud speaker is placed on top of the set. To stop this trouble it is simply necessary to move the speaker away from the set until a position is reached where the hum ceases. In certain instances a bell-like tone may be due to a detector tube which vibrates at an audible fre- quency whenever the set is jarred and which then continues to vibrate for some time, producing this particular note. Such a tube is said to have a "microphonic" action. The remedy is to use one of the other tubes as the detector.

Some of the most annoying noises are due to the improper tuning of a regenerative set in the neighbor- hood of a receiver. "Dial twisting" on the part of you neighbor who owns a may cause most objec to come out of your s tion of elevators may a nearby set and som are affected by being located near a telephone. The operation of an X-ray machine or even a vacuum cleaner will often cause a steady hum in the receiving set. An aerial running parallel to a nearby trolley wire or to a wire carrying high-tension current will usually cause serious interference.

From the foregoing, it would appear that the perfect operation of your radio set is not as simple a matter as many people believe. Nevertheless, if you give your set a reasonable amount of care and attention, even a great deal less than you give your car, it will repay you with long continued and satisfactory service.

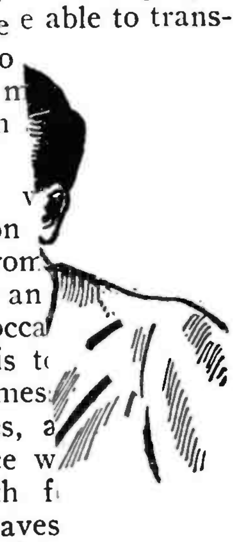
The How and Why of Radio Code

ster should have belonging to his to attend Sun- sengers off Delaware made a prayer of that invention that safegua those who travel th CODE interference different aspect in his



The writer has se men and women in a l tion studio red with a SOS call compelled tl of broadcasting, leavi for messages relating t ternational law provide sion of all radio acti that relating directly call and that is why tune in on your rece nothing on the broadca such times, if you sho highest point on your hear plenty of code anyone is around who an interesting—far m than music—program its true-life drama.

le for him to ll microphone n in the pulpit. e able to trans-



The interfering v mostly from ships on cast receivers come from band used for calling an communication and occa the sending station is t 700 meters, where mes changed. Sometimes, a rare, the interference w on 800 meters, with f tions on the lower waves ics. Here the wave is u to get their position. Th compass wave and it is a ant wave to the navigato as statistics have shown t compass stations of the wo

his sermon o listen and h in going a few wires e talk takes

FIG 7

thus transmitted to the inner ear and brain in a much stronger manner than if the voice were merely heard in the usual manner. For transmitting the sound of a violin to persons hard of hearing and also for the production of various stage effects, the microphone

MATCH BOX DETECTOPHONE

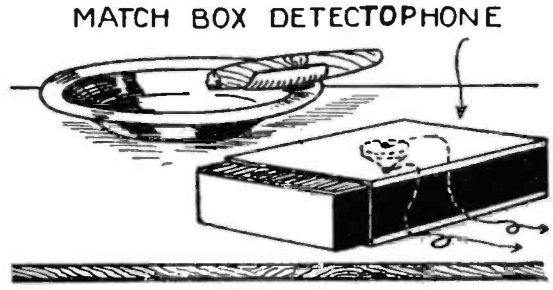


FIG. 8

button can be screwed fast to the body of the violin, or preferably to the bridge, as this latter position in no way damages a valuable instrument. In this manner all the tones of the

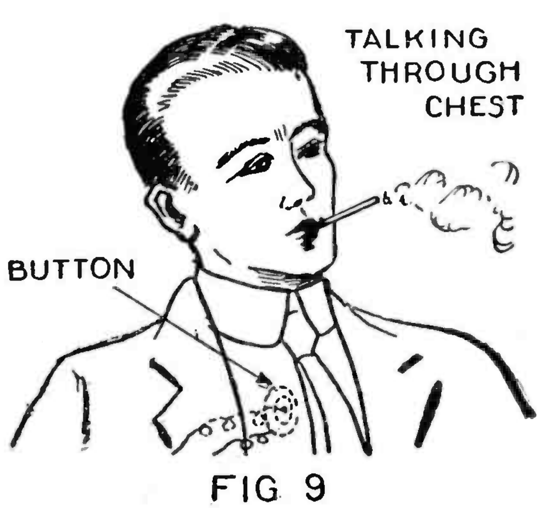


FIG 9

FIG. 11

could be made to fill the largest hall with music. The band itself need not necessarily be very large. This particular hook-up is illustrated in Fig. 11.

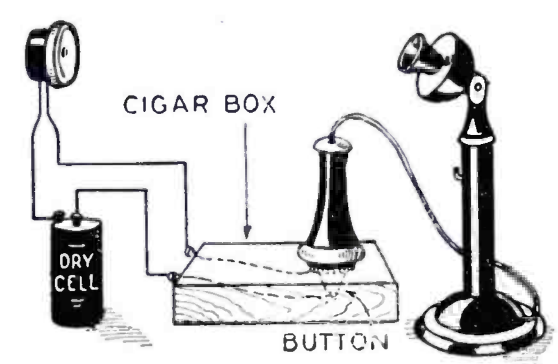


FIG. 12

Fig. 12 shows how the sounds from a telephone receiver can be made to travel to a distant receiver. Here the microphone button is mounted inside

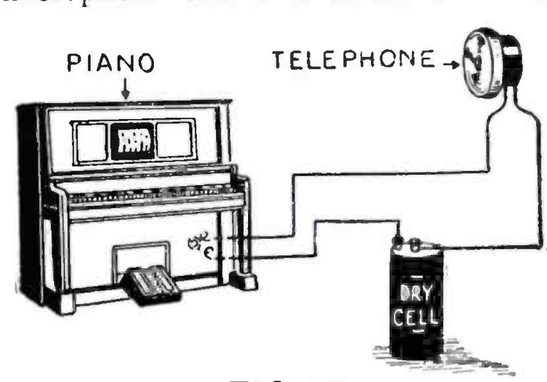


FIG. 13

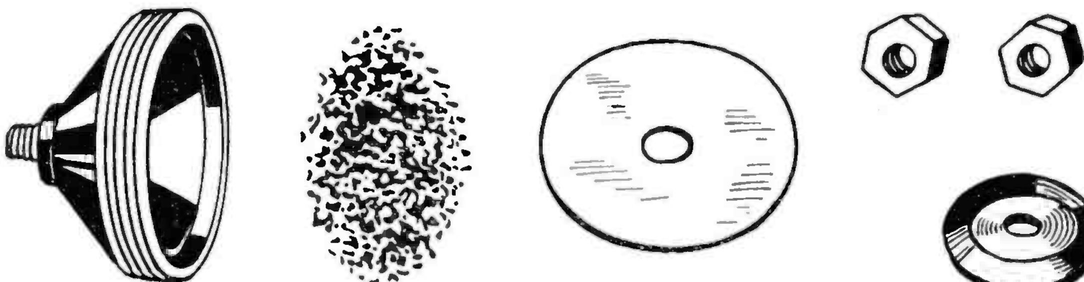
of a cigar box and the receiver is then placed right on top of the position of the button.

may
in

Experiments with Transmitter Buttons

By JOSEPH H. KRAUS*

ONE of the most interesting little pieces of electrical apparatus is what is known as a transmitter button. This particular device lends itself admirably for use in radio and electrical circuits, and in view of the fact that many do not realize to what either horizontal or vertical. It is so small that it can be readily concealed in any of a dozen or more places, and thus serves as an admirable detectophone. For instance, it can be placed in a watch case; an old watch case is used and a tiny hole drilled in the transmission is possible. If a tiny hole is drilled into the side of a glass and a person should talk towards the glass, as indicated at Fig. 5, it will be found that speech can easily be transmitted in this manner. This makes a very nice little experiment for electrical clubs.


1 4 5 6

Music from a phonograph can be transmitted to distant places by employing the hook-up illustrated in Fig. 6 wherein a small hole is drilled in the side of the tone arm of the phonograph, and the screw of the transmitter button is inserted in that hole. There are several other means for doing this perhaps a little more efficiently than indicated here, and these will be

Your set has a way of notifying you when its batteries are not up to the mark.

in the temperature re in the article.
it is simply nece tter buttons can be
thumb screw, thu hones for conveying
phragm to assum ves or operatives sta-
and then to tight in a hotel or in the
The terminals o e methods illustrated
should be revers In the former case
the speaker teste ton is mounted in the
tion should be co ure. The tiny screw
minals in the orig of the picture is not
loud speakers gi casual observer and
results by thus re asily be detected. It
Very annoying tr wever, in placing mi-
result from unex
case where a p
used in connect
the set sudden
even though the
lit and all the ba
condition. A t
the fact that th
graph had cut th
cord due to the
the cover was
under pressure.
insulation was
wires leading to
circuit resulted,
inoperative.
This article v
without a few w

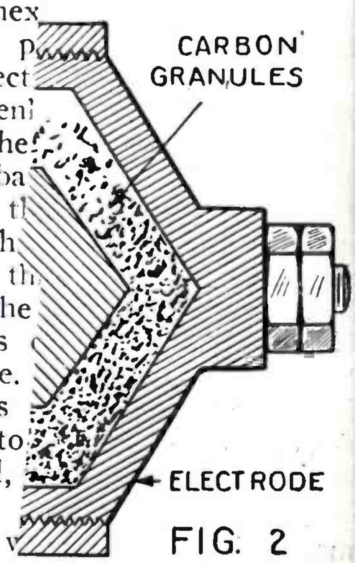


FIG. 2

squeals and no suspected positions, to
from time to of them in the same
nothing to do w different sets of wires
of all, there is ing each pair out of the
This is a crack different exits. In event
comes in, in of these detectophones
While various there are still two or
appeared on th in the room which re-
seems to be co vered. Most criminals
solved. Howe at when they have once
terfere with th detectophone that they
powerful stati further interference on
not of freque his silent watchman. If
the summer

In putting tubes back into their sockets, be sure that the prongs are making contact. Sometimes the socket prongs become bent. It is then necessary to remove the tube and pull the prongs upward with the finger. Tubes may be of exactly the same type and apparently indentical in every way and still will vary considerably in their characteristics. This especially applies to the tube used as the detector tube. Most sets are now constructed to use the same type of tube for a detector as that used for amplifying. By changing the tubes around and trying each one in the detector socket, you will usually be able to find one tube which will give much better results of the same type can be substituted. In many sets, the tubes are carefully matched so as to have the same operating characteristics and unless the new tube is matched to the others, poor results are likely to follow. It may be necessary to try out a number of tubes before the right one is found. The writer recalls an acquaintance in St. Louis who tested out 100 tubes in order to properly match eight tubes for his super-heterodyne. This man claimed that the remarkable results which he obtained from his set were largely due to the perfect matching of the tubes. Inasmuch as he was the manager of a large radio and electrical jobbing concern, he had facilities for

for Press Guild Co., New York.

several detectophones are placed in the room a complete transcription can readily be taken by the reporting stenographer.

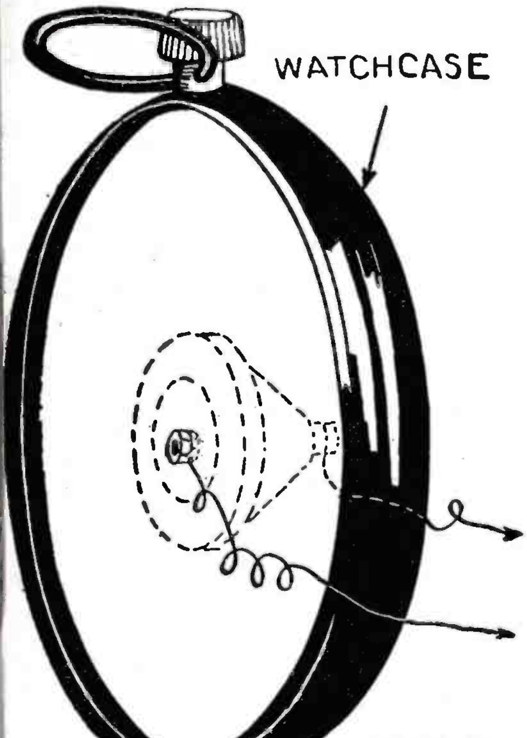


FIG. 3

In event that a minister should have several sick members belonging to his parish who are unable to attend Sunday services, it is possible for him to place one of these small microphone buttons in front of him in the pulpit. In this way he would be able to transmit the complete text of his sermon to any of those who care to listen and who are interested enough in going to the expense of stringing a few wires from the point at which the talk takes place to their homes.

FIG. 4

FIG 5

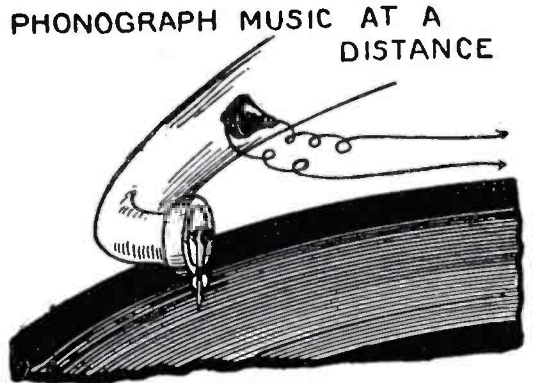


FIG. 6

For those hard of hearing such a device would be of particular benefit, as the church could be fitted with several sets of ear phones and the speech, greatly amplified, would be impressed upon the diaphragm of the ear, and thus transmitted to the inner ear and brain in a much stronger manner than if the voice were merely heard in the usual manner. For transmitting the sound of a violin to persons hard of hearing and also for the production of various stage effects, the microphone button can be screwed fast to the body of the violin, or preferably to the bridge, as this latter position in no way damages a valuable instrument. In this manner all the tones of the violin are faithfully reproduced in the distant receiver, or they may be amplified by means of a regular vacuum tube amplifier, such as you have in your radio set, and then transmitted to the crowds in the dance hall. Several of these microphone buttons attached to the various instruments in the band and all connected to a good amplifier, could be made to fill the largest hall with music. The band itself need not necessarily be very large. This particular hook-up is illustrated in Fig. 11.

FIG 7

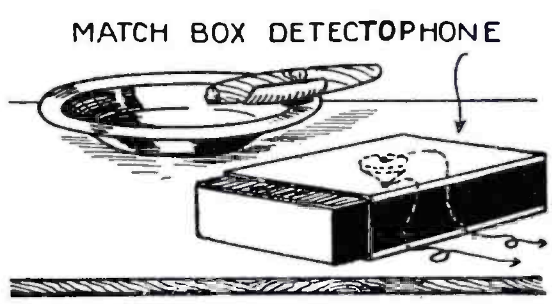


FIG. 8

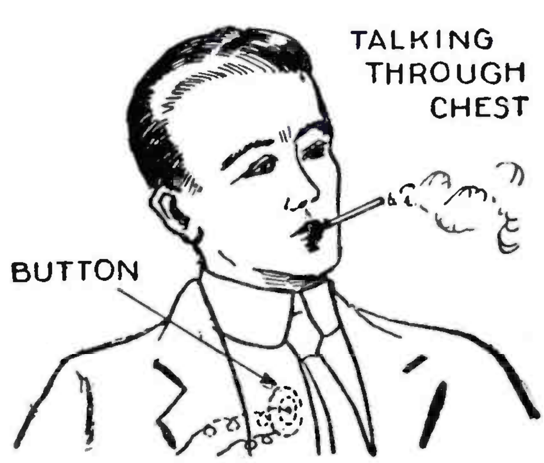


FIG 9

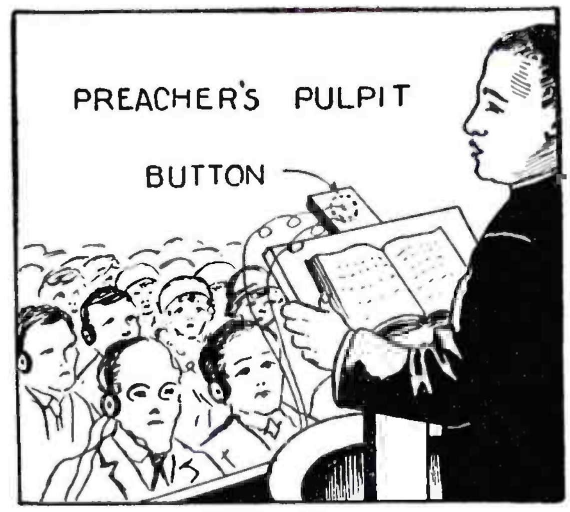


FIG. 10

FIG. 11

Fig. 12 shows how the sounds from a telephone receiver can be made to travel to a distant receiver. Here the microphone button is mounted inside of a cigar box and the receiver is then placed right on top of the position of the button.

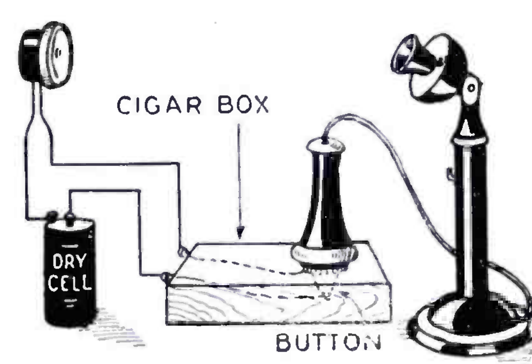


FIG. 12

FIG. 13

Fig. 13 shows how the microphone button can be used to transmit the sound of a piano to a distant room. The button is preferably fastened to the sounding board in a piano, but it

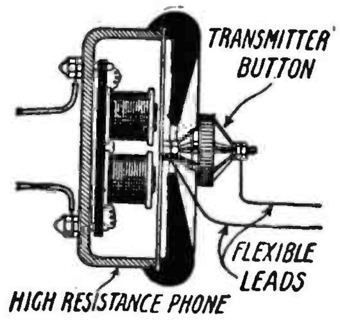


FIG. 14

may be fastened to any convient place on the piano to accomplish this work. This is of value where there may be a sick patient in a home on the second or third floor far remote from the piano, and who would like to listen to any music played on the piano by some of his friends.

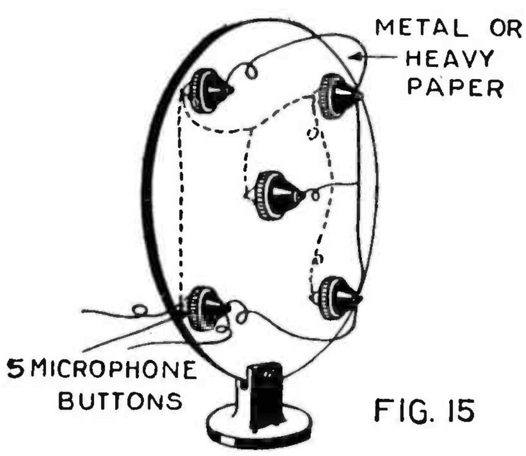


FIG. 15

In Fig. 14 we show how radio music can be transmitted to distant points and incidentally amplified at the same time. Here the microphone button is soldered to the diaphragm of the receiver as indicated, and then the leads connected in series with several dry cells and a low resistance phone.

For experimenters desiring to get greater sensitivity and volume for either radiophone transmitting stations or for ordinary phone transmission, the particular system illustrated in Fig. 15 will be found highly suitable. Here five or six microphones are mounted upon a thin metal or a heavy cardboard disk. The screws projecting through the cardboard are then all connected by means of flexible copper wires, or in event that a metal disk is used, the metal disk itself will serve as the means for making connections between the

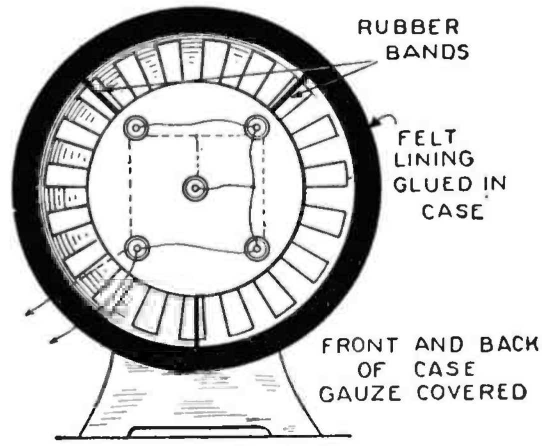


FIG. 17

screws and one thin lead soldered to the disk will suffice. In order to make a more classy job of the device, an old molded variometer makes a fine microphone case. The wire is removed from the variometer and then the case is packed with felt lining which should be glued to it, as illustrated in Figs. 16 and 17. The disk with the five microphone buttons mounted thereon is then supported in the center of the variometer case by

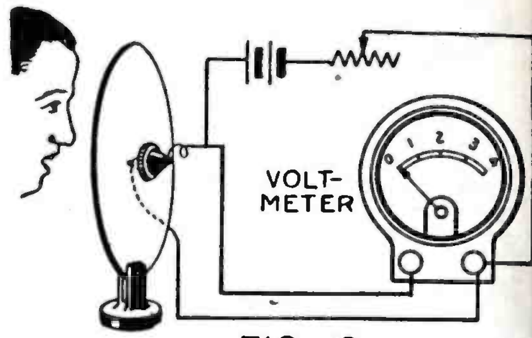


FIG. 19

means of three rubber bands, as indicated. The front and back of the case are then covered with fine silk gauze. This makes a very presentable instrument which looks very much like those microphones used in our broadcasting stations.

In Fig. 18 we show the construction of a hand microphone for transmitting sets or for inter-departmental telephone circuits. A very simple circuit closer is mounted in the handle of the microphone which in this particular case is an ordinary piece of wood hollowed out to receive the switch and the wires. This wooden handle is then

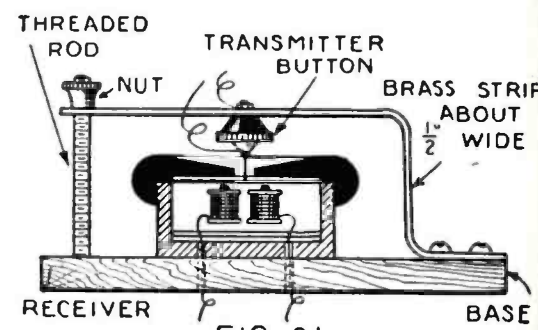


FIG. 21

fastened to the rubber case of a telephone receiver. The coils and magnets in the telephone receiver are removed, a small hole is drilled or punched into the diaphragm, and the transmitter button is fastened as indicated in the diagram.

In making transmitters using multiple transmitter buttons, as illustrated in Fig. 15, 16 and 17, it is frequently desirable to use buttons which have a resistance almost identical. For this purpose the method outlined in Fig.

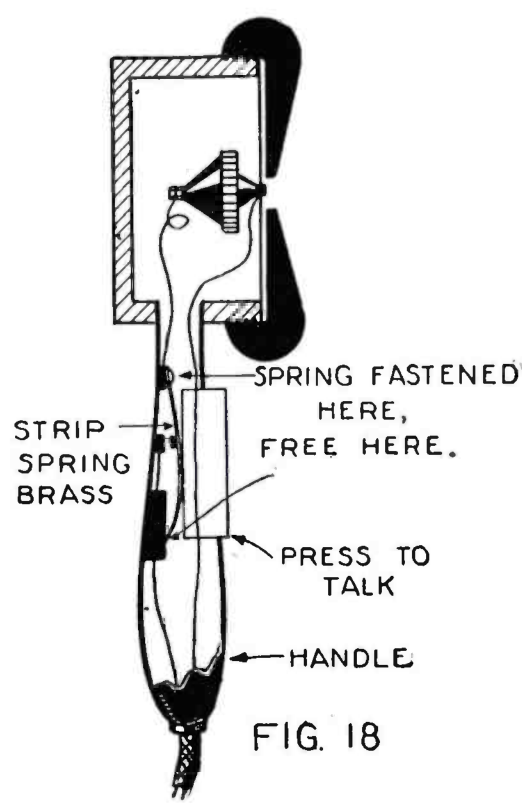


FIG. 18

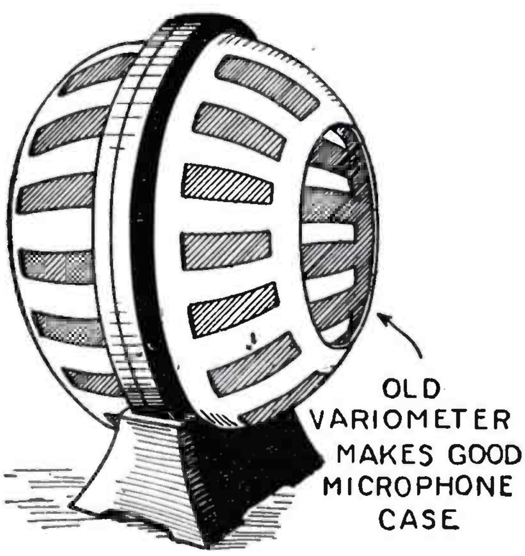


FIG. 16

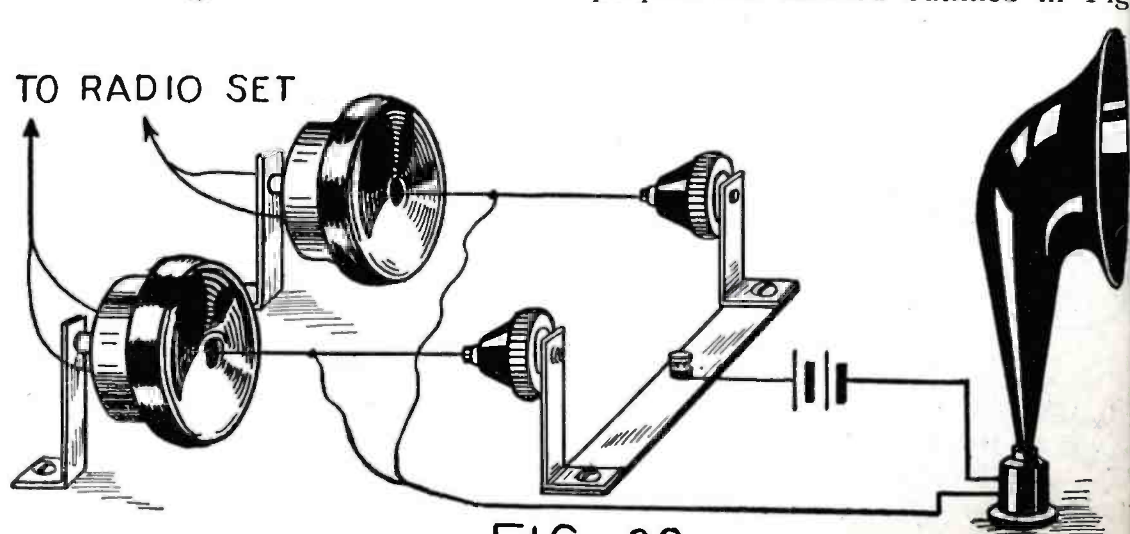


FIG. 20

19 will be found quite satisfactory. An ordinary voltmeter is placed across the terminals of the microphone and then the batteries and rheostat are connected in parallel with the voltmeter. By measuring the voltage drop across the microphone when a certain sound is uttered, and making three tests to obtain an average, it is possible to de-

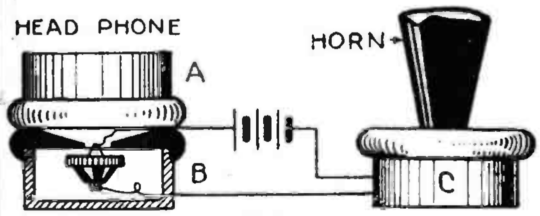


FIG. 22

termine exactly what the voltage drop across the microphone will be. One transmitter button is then substituted for another and the same procedure followed. When five transmitter but-

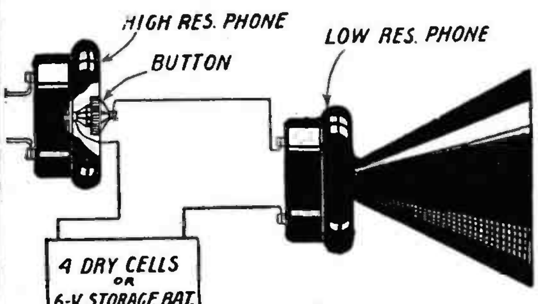


FIG. 23

tons have been tested, and they all give the same voltage drop, they may be used in a sensitive transmitter without fear that one of the buttons will heat

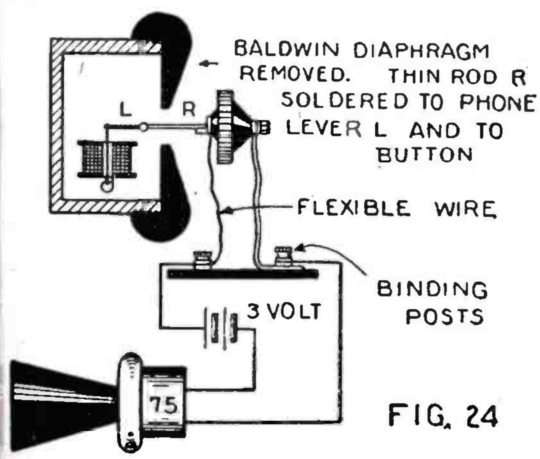


FIG. 24

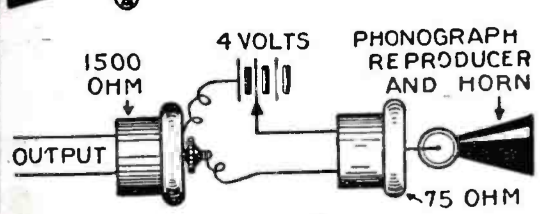


FIG. 25

more than the other and produce a possible frying noise.

Amplifying Radio Music

Any of the microphones described in the first part of this article may be used for amplifying radio music when the telephone receivers are placed in close proximity to the transmitter buttons and when the batteries and one or more low resistance receivers are put in series with the transmitter buttons, but there are several ways of improving even these results, and they will be described now.

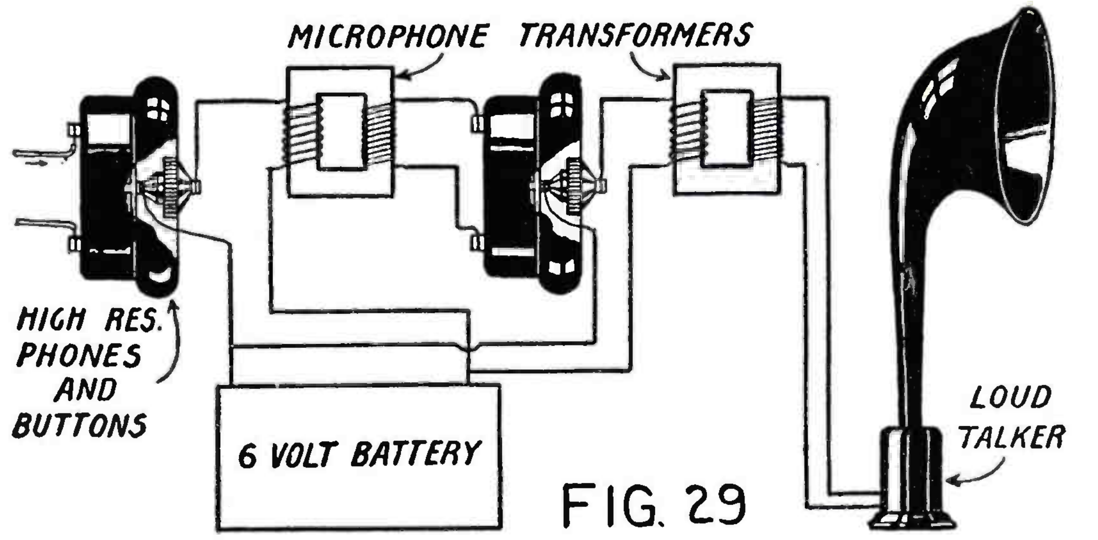


FIG. 29

In Fig. 20 we show how two radio receivers are fastened to a piece of wood. These receivers are naturally connected to the receiving set which

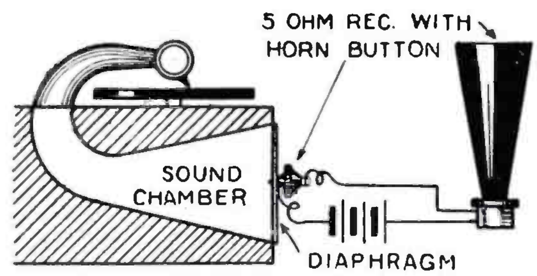


FIG. 26

in this case we may assume to be an ordinary one-tube receiver not giving very much power. A thin steel wire is soldered to the center of the diaphragm of both the receivers, care being taken that the wires are not bent during the soldering process. These wires then lead to the transmitter buttons and are fastened to them as illustrated. The other side of the buttons are secured to a brass plate, or a couple of small brass angles which

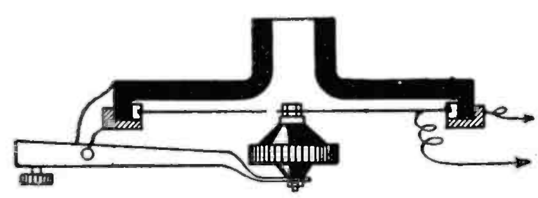


FIG. 27

should be adjustable so that proper regulation may be made. Two flexible leads then connect with the steel wires, as indicated, and a wire is fastened to the two brackets. The wires are connected in series with the battery and a low resistance phone, which is

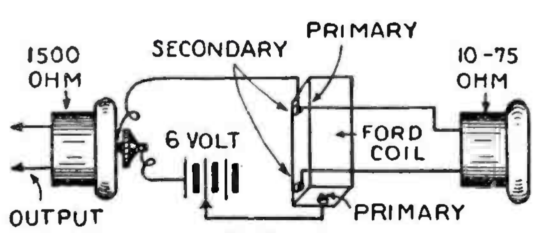


FIG. 28

mounted in the base of the horn, as the illustration clearly shows.

Another method of fastening a transmitter button to a receiver is illustrated in the diagram in Fig. 21. Here the transmitter button is mounted on a brass strip which is bent so that the center of the button will rest upon the diaphragm of a telephone receiver fixed to the base. A threaded rod and nut regulate the pressure of the button against the diaphragm. In event that it is not desired to make any changes to a pair of receivers, the transmitter button can be fastened in the shell of an old receiver, B in Fig. 22, and the head phone may be rested

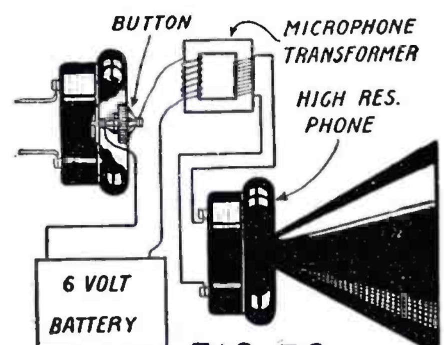


FIG. 30

upon the shell. As indicated, or as previously shown, the hook-up in Fig. 23 may be employed.

In event that the owner of the receiving set has a Baldwin receiver, a microphone transmitter button is fastened to it in the following manner: The diaphragm of the Baldwin receiver is first removed and a thin rod is soldered to the lever, as indicated in

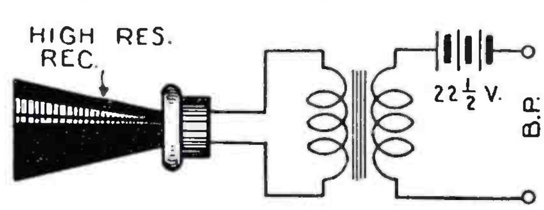


FIG. 30-A

Fig. 24. The transmitter button is then soldered to the rod as shown.

Another way of making a loud speaker from an ordinary one-tube receiving set is illustrated in Fig. 25. In event that you have a phonograph at home, you merely employ the hook-up there illustrated and then place the reproducer of your phonograph on the receiver which should be placed in a suitable position on the turntable. Inasmuch as the movement of the diaphragm of the seventy-five-ohm re-

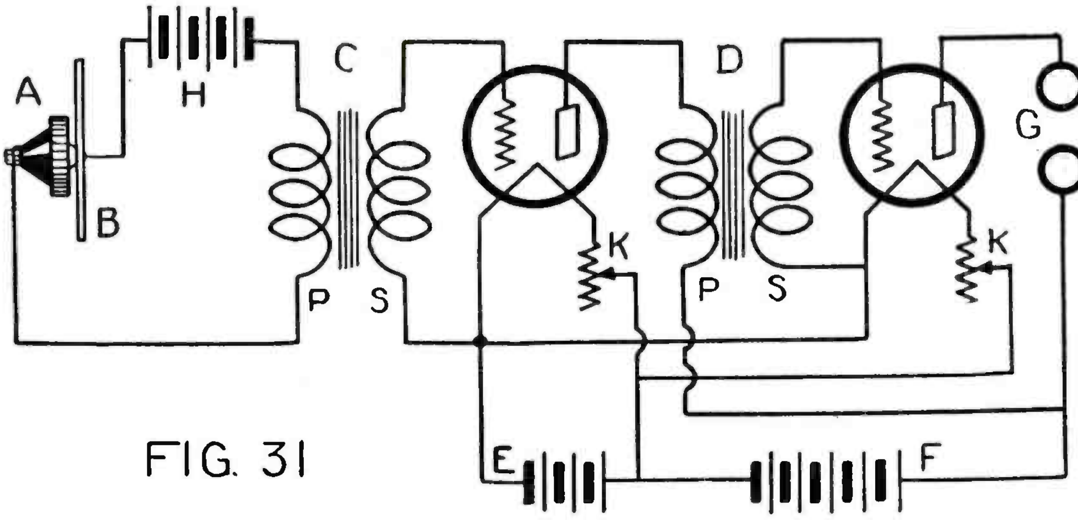


FIG. 31

ceiver is an up and down one, the reproducer of the phonograph should be turned as it would be for "hill and dale" records. A tiny drop of solder

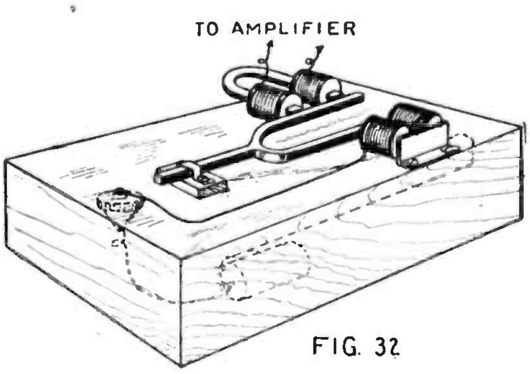


FIG. 32

could be dropped upon the diaphragm of the seventy-five-ohm receiver, and a small nick should be placed into the center of the solder for receiving the needle of the phonograph reproducer.

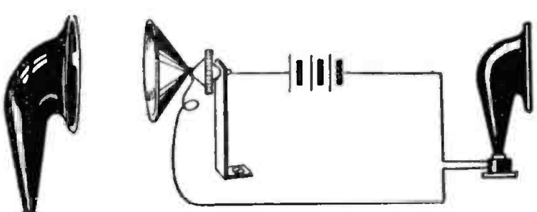


FIG 33

In Fig. 26 we show how the music from a phonograph can be picked up and amplified by means of the transmitter button. In event that an outdoor fete is to take place, it will frequently be found that the sound of a phonograph is too weak to carry. For this reason the hook-up illustrated in Fig. 26 will be found very serviceable. Several microphone buttons and several horns may be connected as illustrated, and the horns should be placed about on the lawn, so that the music will appear to come from all directions at one time. Even one transmitter

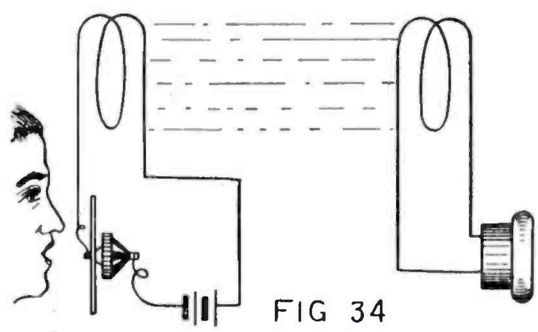


FIG 34

button would serve the purpose if the music were amplified by means of a standard amplifier. The best method of transmitting phonographic music, however, will be found in Fig. 27, wherein the transmitter button forms an integral part of the reproducer.

Amplifiers

Very often it is desired to further amplify the music or sounds picked up by a transmitter button. For this reason microphone transformers or as they are better known, modulation transformers, are employed. In Fig. 29 this instrument and the circuit for its use, is illustrated. Here the incoming radio signals are made to operate the microphone fastened to the receiver. The current which the microphone passes then goes through the primary of the microphone transformer, the secondary of which is con-

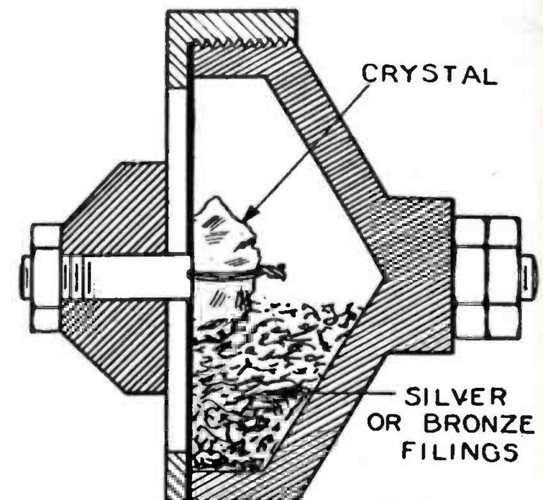


FIG. 35

nected to another receiver similarly fitted with another transmitter button. The output of the second microphone transformer is then connected to a loud

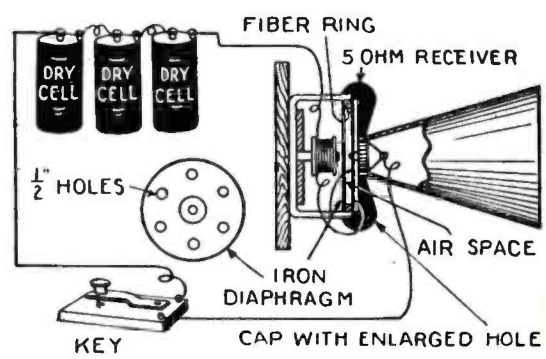


FIG. 36

talker. Of course several more stages of amplification could be connected together in this manner. It is obvious

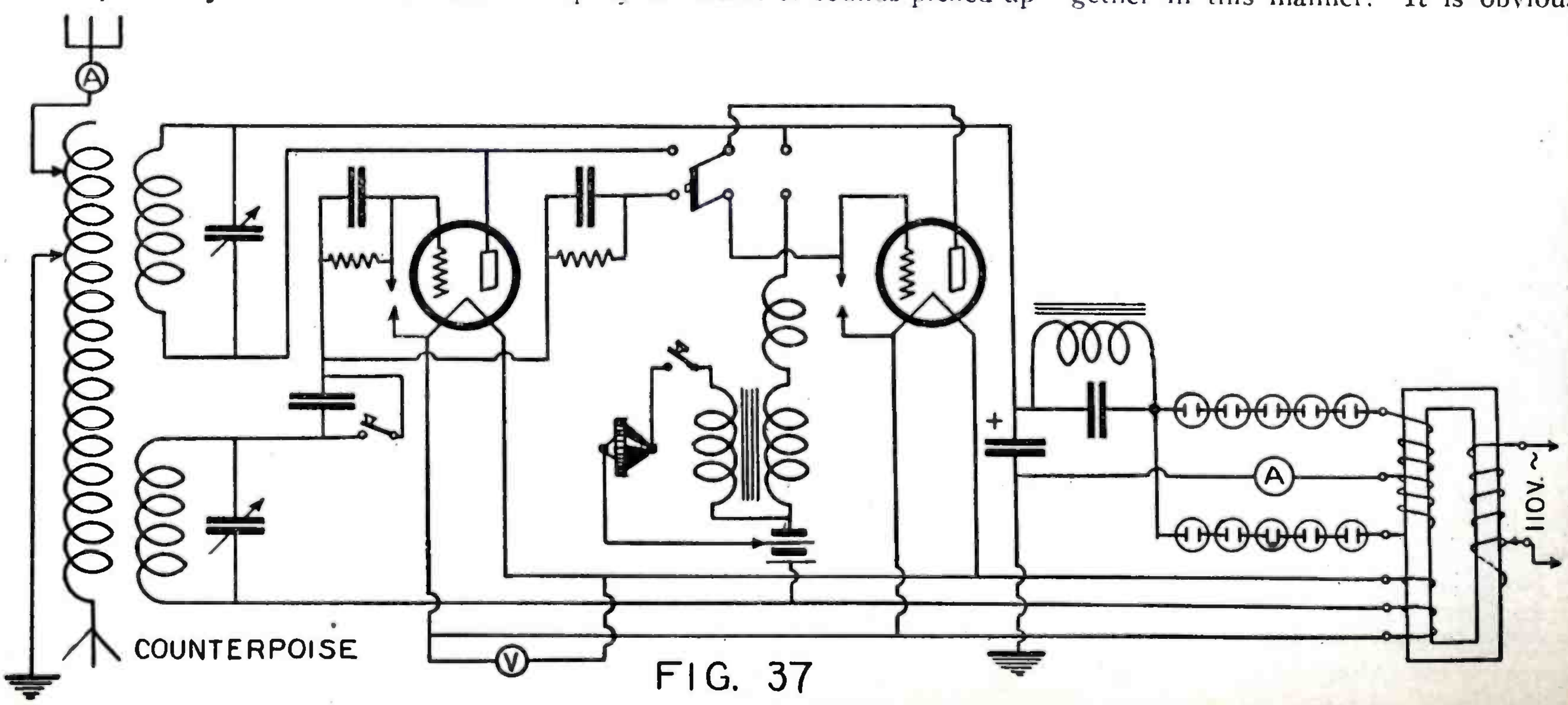


FIG. 37

TRANSMITTER BUTTONS

"Amplifier Units"

BUTTON
One-half
Actual Size →

Here's a marvel of Engineering design—a practical miniature transmitter, used by thousands of radio fans and experimenters for amplification purposes.

Among the many hundreds of interesting uses are the following everyday applications —

- LOUD SPEAKERS
- SPEECH AMPLIFIERS
- TELEPHONE TRANSMITTERS
- DETECTOPHONES
- Etc., Etc.

SPECIALLY PRICED

85c PER UNIT

WHILE THEY LAST OR TWO FOR $1.50

THIS is a most novel unit, having hundreds of uses. Every amateur should have two or three of these amplifiers in his laboratory.

With each unit is mailed a four-page instruction pamphlet. It shows how to use these units.

Our supply is limited, avoid disappointment by ordering today. The coupon below is for your special convenience—just fill in your name and address, mark in the number of units you desire, enclose the necessary amount and we will ship them to you at once postpaid.

COUPON

THE PRESS GUILD
66 West Broadway, New York, N. Y.

Enclosed find 85c / $1.50 for which send me postpaid one / two amplifier units as advertised.

Name ....

Address ....

City, State ....

that the installation should be placed in a box of a sound-proof nature, so that extraneous noises will not effect the microphones. If the box is sound-proof no howl will be experienced. If a howl is noted, it is plain to see that the output of the loud speaker is effecting the microphones, and thus the characteristic audio frequency sound will constantly be heard.

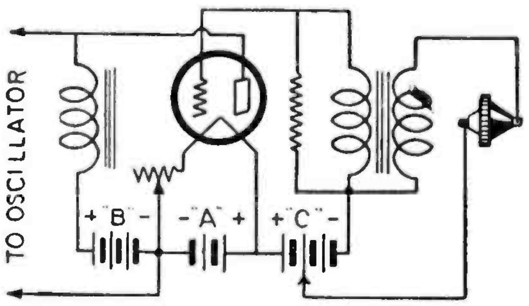


FIG. 38

The use of a Ford coil as a transformer is illustrated in Fig. 28. A Ford coil. if you have an old one, which is of no practical use, but is not burned out, will serve the same purpose as a modulation transformer, possibly not as efficiently as the aforementioned device, but will certainly give the results and is worth experimenting with. The schematic hook-up for either of the two systems is illustrated in Figs. 29 and 30A.

A diagram for using but one stage of amplification through transformers is illustrated in Fig. 30. For the better class of work, however, it is desirable to use a standard vacuum tube amplifier, as illustrated in Fig. 31. Here the microphone button is placed in series with the primary of a modulation transformer, and in series with several dry cells or flashlight batteries. The secondary of the modulation transformer then connects to the grid and filament the same as it would in a standard vacuum tube amplifying circuit. The music from the output is, of course, very loud.

A very splendid oscillator is illustrated in Fig. 32. Here a tuning fork of standard frequency is mounted on a suitable holder in a cigar box. Two low resistance coils about five to seventy-five ohms, are then placed under one prong of the tuning fork. These are connected in series with a transmitter button fastened in the cigar box which serves as a base for mounting the tuning fork. The batteries may be concealed in the cigar box. Thus when the tuning fork is struck, it will continue to vibrate as long as the current is applied to the microphone. To use this as an oscillator, a pair of magnets from a receiver and the permanent magnets are mounted near the other vibrating prong. The current constantly being changed by means of the vibrating bar of steel produces a standard frequency, which when amplified can be used for making radio measurements of different kinds. Fig. 33 shows how a transmitter button may be fastened to a cone placed in front of a loud speaker, so as to transmit the sounds of the loud speaker to a distant loud speaker.

In Fig. 34 we show how experiments with an induction telephone may be made. Here a microphone button is connected in series with a coil of wire and the batteries. Several feet away another coil of wire is mounted parallel to the first coil and this is connected to a low resistance receiver.

It may be interesting to note that the writer used this same principle in a magical act some years ago. A coil

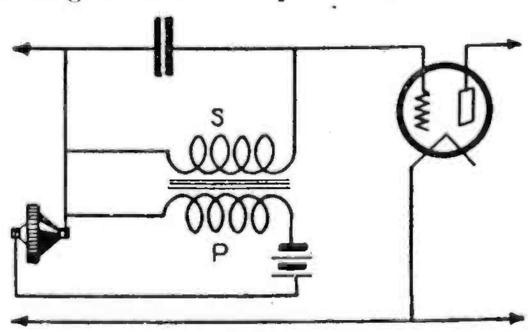


FIG. 39

of wire was wound into a carpet and a transmitter placed in series with this coil of wire. Another coil of wire was wrapped around the waist of a supposed medium who walked into the room and sat down. A tiny receiver fitted into the ear of the medium and was concealed by a Hindu head-dress. The assistant in back of the stage then

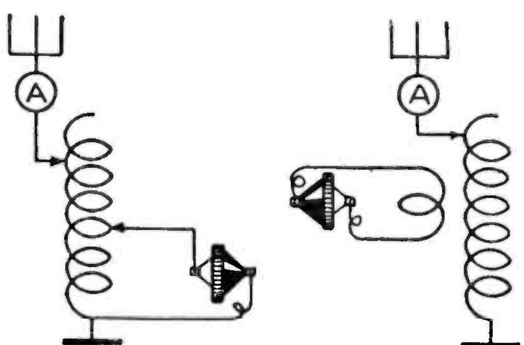


FIG. 40

telephoned the questions written on slips of paper, which were heard in the telephone receiver and answered by the medium. The medium naturally could move about and hear the questions as she was walking. She must not get too far away from the coil of wire concealed beneath the carpet. For better results the voice transmitted to the coils was amplified by means of a vacuum tube amplifier in a circuit similar to that illustrated in Fig. 31, except that the coil of wire was placed in the position now occupied by the phones in that diagram.

Fig. 35 shows how the transmitter button can be used for making a "crystalloy" detector. This is a crystal detector which is constantly adjustable. A regular galena or silicon crystal is mounted at the diaphragm end of the shell and the same is half filled with silver filings. Rotating the shell picks out sensitive spots in the receiver. Copper filings also make very good contact points as do phosphor bronze filings.

Fig. 36 shows a method of making a code practice device. An audio frequency howl is produced which will enable the instructor to teach an entire classroom the radio code. Sometimes the key, instead of interrupting the circuit, merely shunts a small portion of the current passing through the transmitter button, and for this purpose the key would have to be placed directly across the transmitter button and in series with a small resistance.

Fig. 37 shows how the transmitter button may be adapted to the Meissner circuit. Fig. 38 shows how it may be used in Heising modulation. Fig. 39 indicates its adaptation to the variation of grid voltage of the oscillator tube, and Fig. 40 how the transmitter button may be hooked up to modulate the output current. These last four figures indicate the use of transmitter buttons in vacuum tube transmitters. Fig. 41 shows a transmitter button used as a grid leak in a regenerative circuit.

Very often the experimenter would like to build his own modulation or input transformer. Considerable experimenting may be done along this line. Cover a straight iron core about 5 in. long and composed of a bundle of No. 20 iron wire about ½ in. thick, with a thin layer of tape or paper. Upon this wind approximately four layers of No. 22 wire along a space of 4½ in. This is the primary of the transformer. The secondary should be composed of about twenty-five layers of No. 30 enamel covered wire. Each layer may be insulated from its preceding layer

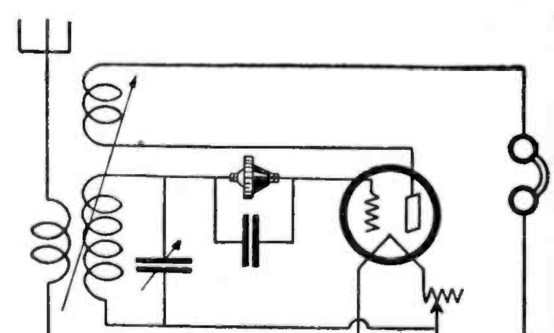


FIG. 41

by thin wax paper, or the wire may be wound upon the iron core without insulating the individual layers. The beginning and end of the wiring should be soldered to small flexible leads, because the No. 30 wire breaks quite easily.

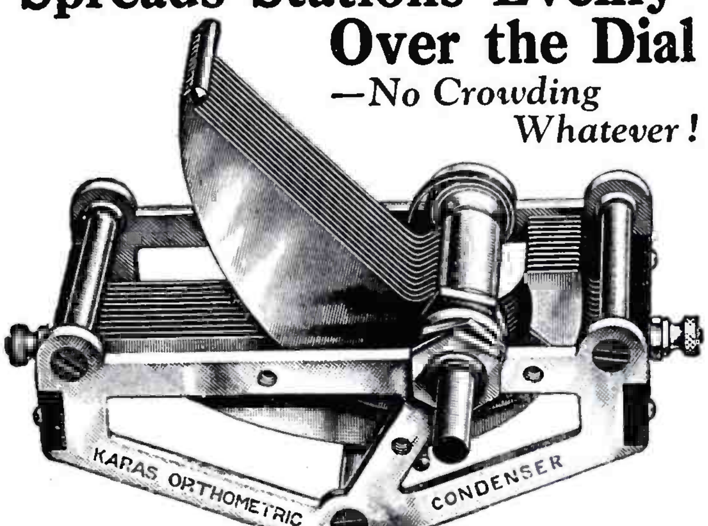
Modulation transformers are the amplifying transformers for circuits using the microphone buttons for the various stages. These particular transformers should not be used wherever a vacuum tube is employed as the amplifying means, but regular audio-frequency transformers, such as used in any radio set, should be here inserted.

No matter what circuit—
Far, Far Better Results
with
KARAS
Orthometric Condensers *and* Harmonik Transformers

KARAS instruments have been tested and recommended by leading technical editors for use in all types of sets from the most elaborate supers to the simplest low loss 3-tube receivers. The most exacting homeset builders, the country over, demand Karas Transformers and Condensers—and will use nothing else. Nothing can take the place of these scientifically designed, precision instruments. Use them in your next set—or improve your present set by installing them. It's easy to do—the results will be worth many times the cost.

"The Best Transformer Money Can Buy"

Spreads Stations Evenly Over the Dial
—No Crowding Whatever!



The Karas Orthometric Condenser positively separates all adjoining wavelengths by EQUAL distances on the dial—giving you full benefit of the 10 Kilocycle frequency separation fixed by the government. Ordinary condensers jam 70 of the 100 Government alloted wavelengths into the first 30 points on the dial—even straight-line-wavelength condensers crowd 57 of them below 30. But with Karas Orthometrics, each point on the dial corresponds to one of the 100 alloted wavelengths. The result is marvelous simplicity in tuning—and better, clearer reception—all side bands without interference.

For Long Distance with Big Volume and Keen Musical Quality

Karas Harmoniks deliver perfect music with loads of volume from stations one to two thousand miles distant. DX broadcasting becomes really enjoyable. "Fishing" for distant stations is only a matter of finding programs you want to hear—not straining to catch only the bare announcement and making up a list of call letters.

Even from far away points, Karas Harmoniks bring out full, round musical tones. All the vital harmonics and rich overtones are fully retained. Low bass notes pour forth, rich, sweet, sonorous. If you want music like this, you must have Karas Harmoniks in your set. Get a pair TODAY!

Brings in KDKA at 53

Not at 17—or 28, but at 53 where it belongs, leaving lots of room for the 52 wavelengths that must come in below it. The Karas Orthometric is a "precision job"—entirely of brass. Every joint soldered. Plates patent-levelled and securely bridged.

If your dealer is out of Karas Instruments

Order Direct on This Coupon

Most good dealers everywhere sell Karas parts. If your dealer happens to be one who doesn't, we will supply you direct at no trouble on your part—on our 30-day money back guarantee. Just fill in and mail this coupon at once. Send no money. You can pay the postman on delivery.

KARAS ELECTRIC CO., 4061 North Rockwell Street CHICAGO, ILLINOIS

For more than 30 years makers of PRECISION Electrical Apparatus

Karas Electric Co.,
4061 N. Rockwell St., Chicago

Please ship me the instruments checked below. I will pay the postman prices listed; plus postage upon delivery. It is understood that I have the privilege of returning these goods. for full refund, within 30 days, if they do not prove entirely satisfactory.

........Karas Harmonik Audio Transformers. **($7.00 each)**

........Karas Orthometric Condensers: Size..............
(23 plate $7 ea.; 17 plate $6.75 ea.: 11 plate $6.50)

Name..

Address..
If you send cash with order, we'll send package postpaid

How Many Radio Circuits Are There?

By SYLVAN HARRIS

In spite of the fact that there have been published here, there and everywhere, a multitude of radio circuits, under as many different high-sounding names, the fact remains that there are very few fundamentally different circuits. In this article I will endeavor to outline these fundamental circuits for my readers, and will show how these are combined in various ways to produce the many "dynes," "plexes" and what not.

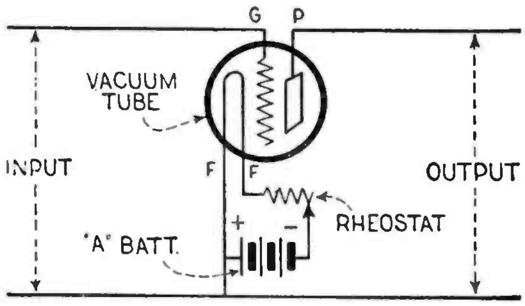


FIG. 1

Elementary circuit of a vacuum tube.

The fundamental circuit of the three-electrode vacuum tube is shown in figure 1. No matter what kind of circuit is used in the radio receiver, and no matter what name may happen to be given it, this fundamental circuit still forms the basis of the receiver.

In this circuit the input of the tube is, as marked on the illustration, between the grid and filament, and the output is between the plate and filament. No sources of voltage have been shown on this fundamental diagram for they may be applied in various ways, as shall be explained. The only battery shown is that which is used for lighting the filament, which is always applied in the same manner, and to tell the truth, this application is not subject to much variation.

Fundamentally, the action of the electron tube is much the same, no matter whence or how the various electromotive forces which operate it are derived. For instance, in figure 2 we have shown several methods of applying the input voltage to the electron tube, which is to act in the capacity of an amplifier or a detector of the high frequency oscillations which constitute the radio signals. Three methods of obtaining the high frequency voltage to apply to the input of the tube are shown. Even these three do not constitute all the methods that are in use, but are only the most generally used methods. The main thing to remember is that we must obtain somehow, somewhere, a high frequency electromotive force to apply to the input. Where or how we obtain it is a secondary consideration, as far as the operation of the tube is concerned; this does not affect the operation of the tube fundamentally, although it may affect the method of tuning the circuits considerably.

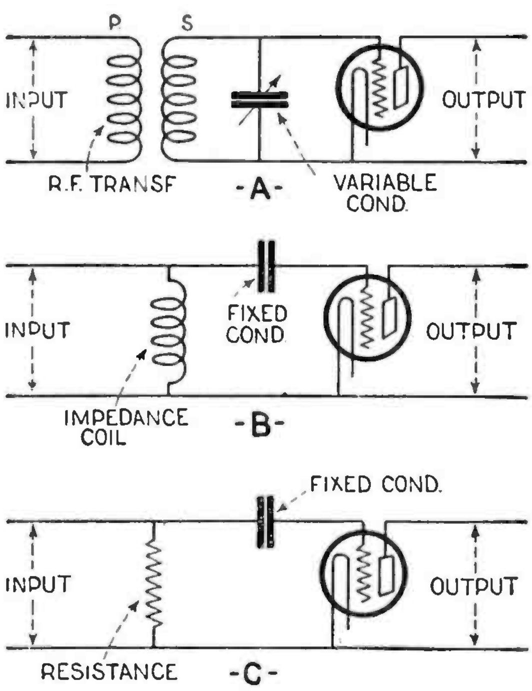


FIG. 2

Three different methods of applying input voltage to the vacuum tube.

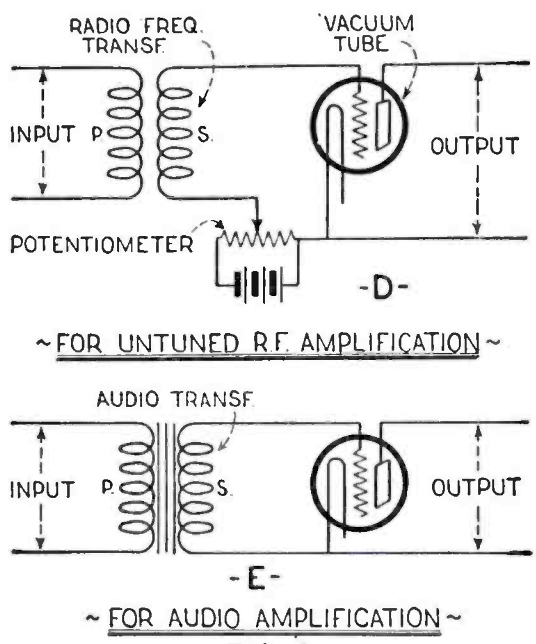


FIG. 3

Additional methods of applying input voltage.

In A of figure 2 we have the most generally used method, viz., the input voltage to the tube is obtained from the potential difference established across the terminals of the variable condenser by the high frequency current flowing in the tuned circuit. This tuned circuit has an electromotive force induced in it by being coupled to another circuit carrying a high frequency current, as for instance the antenna circuit of a radio receiver. In B of figure 2, we have what is commonly known as impedance coupling, that is, the potential difference to be applied to the input of the tube is that which is set up across the terminals of an inductance or impedance coil, which may or may not have an iron core, depending upon whether it is to be used for amplifying high or low frequency voltages. The ends of this impedance coil are connected to another circuit carrying a high frequency current, just as in the preceding case; this other circuit may be the output of a preceding amplifier tube, or, again, the antenna circuit.

In C of figure 2 we have shown what is called resistance coupling; here the input voltage is obtained as the difference of potential between the terminals of the resistance indicated, in just the same manner as the potential difference is obtained in the case of the impedance coupled tube.

There is one remaining system,

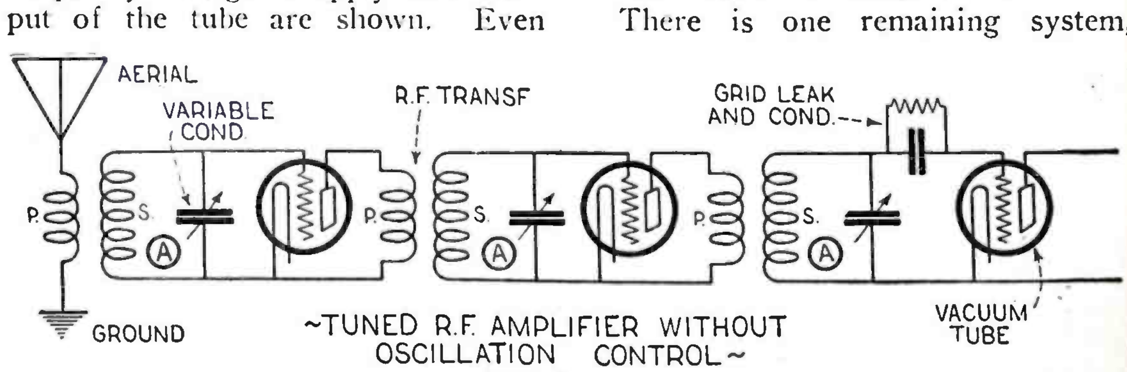
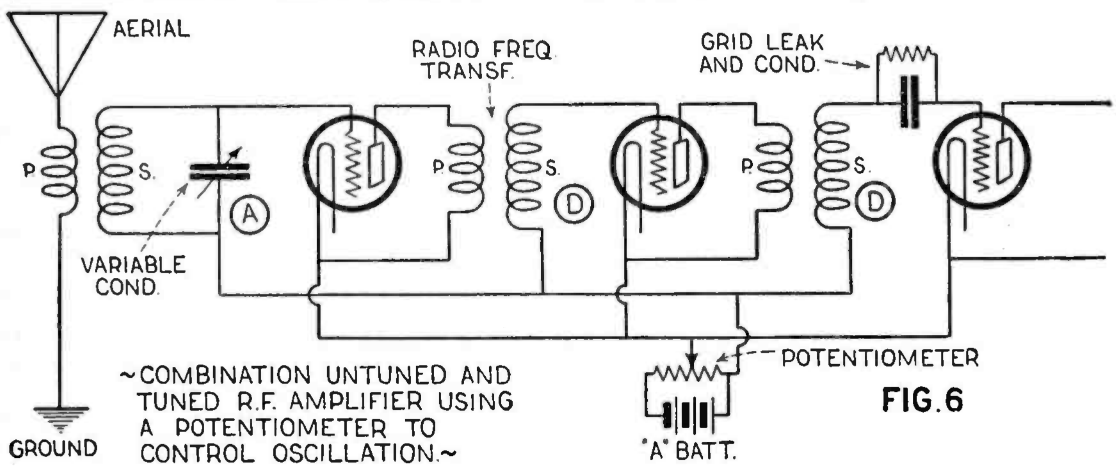


FIG. 4

The above circuit must be made inefficient in order to insure stability.

shown in figure 3, which is practically the same in effect as that of A, figure 2. This is the untuned transformer system. The tuned transformer system (A of figure 2) is tuned by the condenser indicated. In the untuned system this transformer may or may not have an iron core, depending upon whether it is required to amplify high or low frequency voltages. It is generally used with an iron core for amplifying audio frequency voltages, but the untuned transformer, without an iron core, has often been used for amplifying radio frequency voltages, in which case a potentiometer is used to control the tendency toward self-oscillation. In figures 4, 5 and 6 we have the complete circuit diagrams of high frequency amplifiers using these various systems. In each of the stages in each of the diagrams a capital letter indicates the fundamental upon which the circuit is based, corresponding to the letters used to identify the systems of figures 2 and 3.

In figure 4 we have the tuned r. f. amplifier, without any provision made for controlling the tendency toward self-oscillation. Generally stability is secured in this system by making it so inefficient that it cannot oscillate.

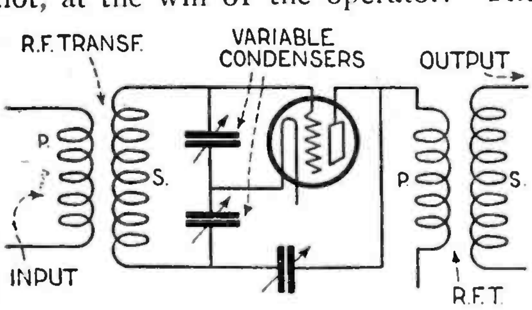


~COMBINATION UNTUNED AND TUNED R.F. AMPLIFIER USING A POTENTIOMETER TO CONTROL OSCILLATION~

FIG.6

The first stage must be tuned to allow stations to be tuned in or out.

In figure 5 we have the same tuned system, but this time we have added a potentiometer, by means of which the system can be made to oscillate or not, at the will of the operator. The



THE ISOFARAD SYSTEM

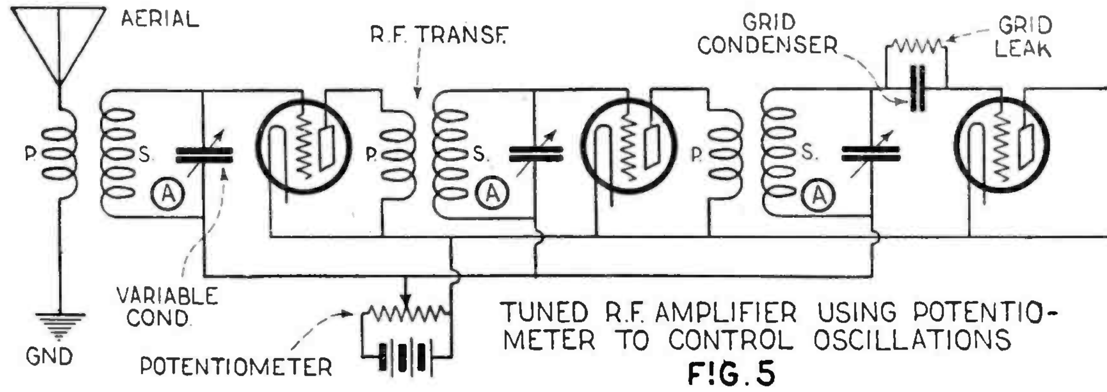
FIG.8

Tendency towards self-oscillation is here automatically controlled.

advantage of being able to make the system oscillate is very great, as the greatest amplification is obtained when the circuits are operated just at the point before self-oscillation starts. This condition is easily found in operation, since the instant self-oscillation starts a whistle is heard in the phones when tuned to any station it is desired to receive.

In figure 6 we have the untuned system, with the exception of the first stage which is required to be tuned, so as to be able to tune stations in or out. The tendency to oscillate is likewise controlled by means of a potentiometer.

These are the three main systems for amplifying high frequency volt-



TUNED R.F. AMPLIFIER USING POTENTIOMETER TO CONTROL OSCILLATIONS

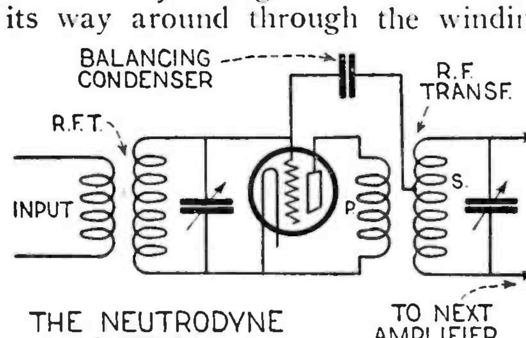
FIG.5

This circuit is more efficient than one shown in Fig. 4.

ages, but there are often added to these various other things which may or may not facilitate the operation and control of the receiver. Often these adjuncts to the receiver are useless, and are merely added to it so as to make it appear new to the uninitiated, and provide sales talk for the manufacturer or salesman. One of the most valuable of these additions is a system for automatically controlling the tendency toward self-oscillation. The most prominent of these systems are Neutrodyne and the Isofarad. The diagrams of these two systems are shown in figures 7 and 8. Obviously these may be extended to several stages of amplification.

Both of these systems work on what is known as the "bridge" principle. We will not discuss this principle here as it is rather complicated. The circuit diagrams are presented so that my reader will be able to identify them.

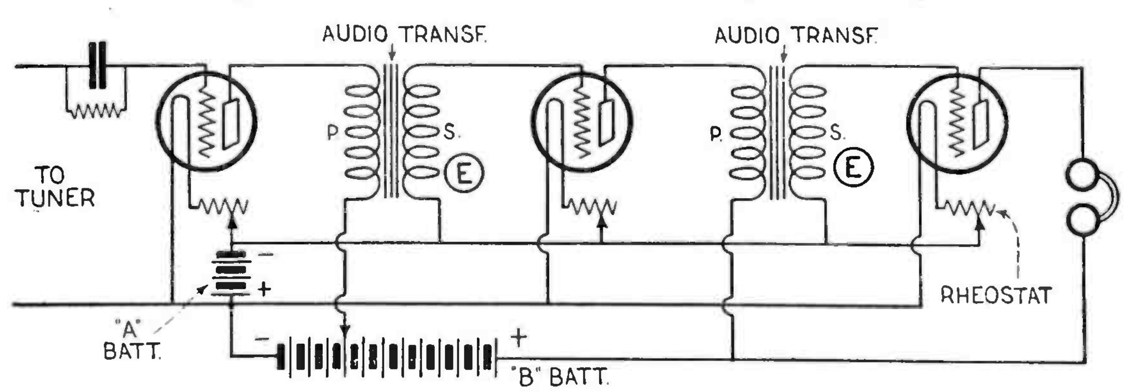
In figures 9, 10 and 11 we have three systems of amplifying audio frequency voltages. In figure 9 we have the ordinary transformer coupled amplifier, which, of course, is untuned. The detector tube is shown connected to the amplifier in all three illustrations, as this is generally found to be the case in the usual radio receiver. In figure 10 is shown an impedance coupled amplifier connected to the detector. It will be seen that this does not differ essentially from the case of the transformer coupled amplifier, for in this case, the one winding of the transformer acts as both primary and secondary winding. The condenser shown connected to the grids of the two last tubes is for the purpose of blocking off from the grids the high "B" battery voltage which would find its way around through the winding of the coupling impedance and on to the grid. If this should go all the way to the grid the tube would not act properly.



THE NEUTRODYNE SYSTEM

FIG.7

Here self-oscillation is automatically controlled by the balancing condenser.



A.F. TRANSFORMER AMPLIFIER & DETECTOR

FIG.9

The ordinary transformer coupled amplifier is, of course, untuned.

Figure 11 shows the resistance amplifier, which also is seen to not differ much in essentials from the impedance coupled amplifier. The connections are in every respect the same

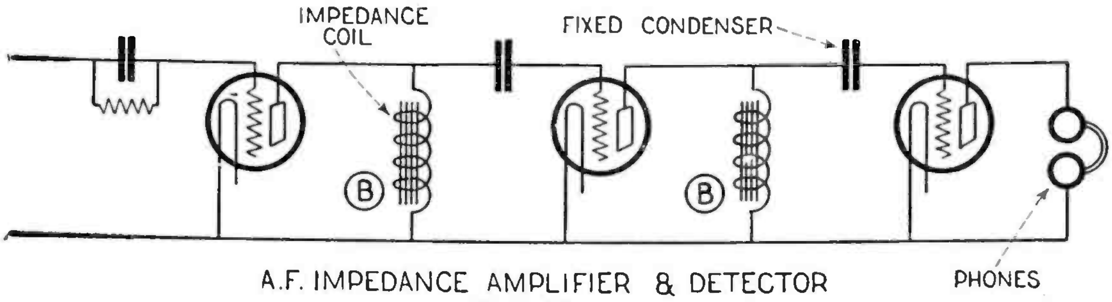


FIG. 10

This circuit is similar to Fig. 9 except that the one winding of the impedance coil acts both as primary and as secondary.

The next important part of the radio receiver to consider is the circuit of the detector tube, which is perhaps more susceptible to variations than the amplifiers. The tube circuit as we have shown it in figure 1 is the unregenerative circuit. There are several methods of obtaining regeneration in this circuit, of which the three most usual methods are indicated in figure 12.

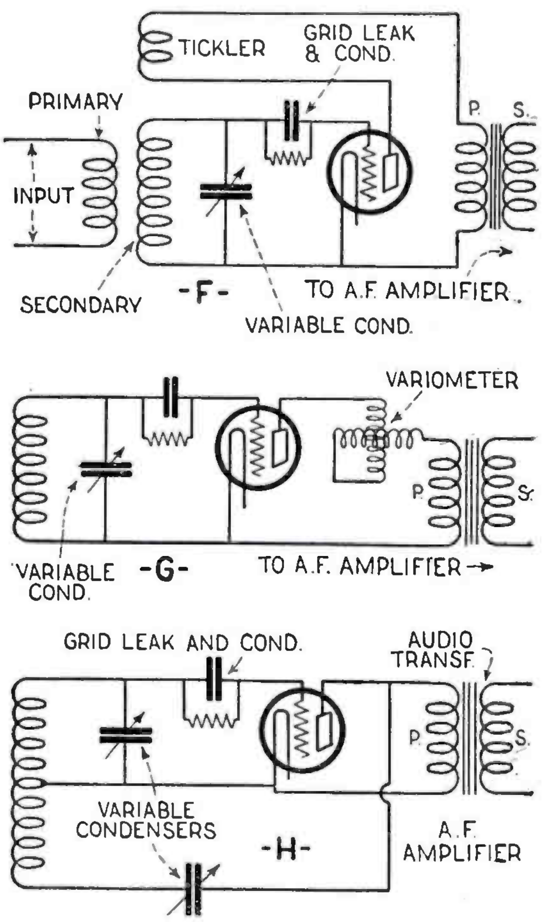


FIG. 12

Three methods of obtaining regeneration with detectors.

The first method, F of figure 12, is the tickler method, in which a coil in the output circuit is coupled inductively to the input circuit. The second method, G of figure 12, is called the tuned plate circuit method, in which there is included in the output circuit of the tube a variable inductance of some kind, as, for instance, a variometer. The third method, H of figure 12, is an adaptation of the Hartley oscillator, sometimes called the Reinartz system, which is essentially the same as the tickler method. In all cases a by-pass capacity is required across the terminals of the device which couples the detector to the A.F. amplifier, whether it be a transformer, impedance or resistance. In many cases it is not necessary to add a special condenser to furnish this capacity, as there may be already sufficient capacity in the windings of the transformer or impedance to by-pass the high frequency currents.

The tickler method may also be used to control the tendency toward self-oscillation by reversing the feed-back and extending it to one of the R. F. stages in advance of the detector. This is the system employed in the Superdyne circuit, which was greatly in favor during the past few years.

There are many other variations of these systems possible, but study and the knowledge of the fundamental systems which the reader will gain from this article, he should have no difficulty in identifying them.

The reflex systems are often difficult to trace out because of the maze of wiring required in them, and also because of the failure of most radio writers to draw the circuits properly. In figure 13 we have the principle of the reflex system, in which the output of one of the stages is made to pass into the input of a previous stage, so that the latter tube is made to perform two operations simultaneously, viz., first that of amplifying the high frequency voltages, and second, that of amplifying the audio or low frequency stages. The high frequency signal currents enter the R. F. amplifier at the input, as indicated, and the passage of the signal is as indicated by the broken line and arrows. The high frequency voltages are amplified in the first tube and rectified in the detector. They then pass on from the output of the detector to the input of the first tube again, which now acts as an A.F. amplifier. The phones or loud speaker are included in the output circuit of

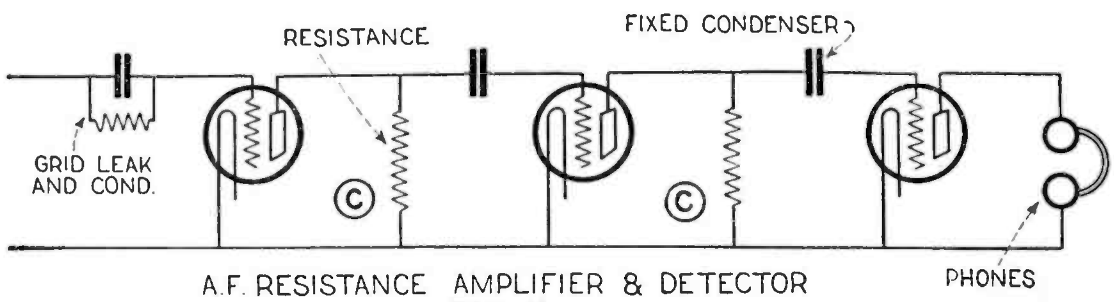


FIG. 11

Resistances are substituted here for the impedance coils.

the first tube. By-pass condensers are required across the terminals of the reflexing transformer and the phones, so that the high frequency currents can pass by them on into the detector. These by-pass capacities are too small to affect the low frequency or audio frequency currents being reflexed, and the tuning of the radio frequency amplifier input circuit does not in any way affect the low frequency currents. The first tube is thus made to act in two capacities and the two-tube system acts like a three-tube circuit. All reflex circuits act upon these fundamental principles, and the whole system is easily seen to consist of nothing more than a combination of the elementary systems shown at the beginning of this article.

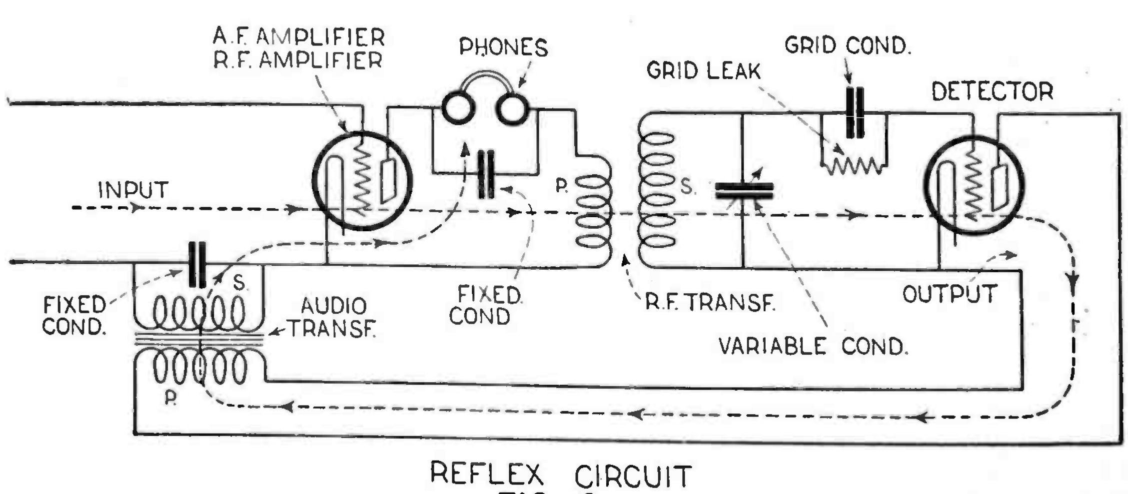


FIG. 13

In the reflex system the tube is called upon to perform two functions simultaneously.

RADIO REVIEW READERS' BUREAU

Time and Postage Saver

IN every issue of RADIO REVIEW AND RADIO LISTENERS' GUIDE AND CALL BOOK you undoubtedly see numerous articles advertised about which you would like to have further information.

To sit down and write an individual letter to each of these respective concerns, regarding the article on which you desire information, would be quite a task.

As a special service to our readers, we will write the letters for you, thus saving your time and money.

Just write the names of the products about which you want information, and to avoid error, the addresses of the manufacturers, on the coupon below and mail it to us.

If the advertiser requires any money or stamps to be sent to pay the mailing charges on his catalogue or descriptive literature, please be sure to enclose the correct amount with the coupon.

We will transmit to the various advertisers your request for information on their products.

This service will appear regularly every month on this same page in RADIO REVIEW AND RADIO LISTENERS' GUIDE AND CALL BOOK.

If there is any Manufacturer not advertising in this month's issue of RADIO REVIEW AND RADIO LISTENERS' GUIDE AND CALL BOOK, from whom you would like to receive literature, write his name, address and the product in the special section of the coupon below.

TEAR ALONG THIS LINE

READERS' SERVICE BUREAU, RR-3-26

The Consrad Co., Inc., 64 Church Street, New York, N. Y.

Please advise the firms listed below that I would like to receive detailed information on their product as advertised in the .... issue of RADIO REVIEW AND RADIO LISTENERS' GUIDE AND CALL BOOK.

DO NOT USE THIS COUPON FOR TECHNICAL QUESTIONS

NAME	ADDRESS (Street—City—State)	List here specific article on which you wish literature.	If Catalogue of complete line is wanted check in this column.

Use this space if you desire information from a manufacturer whose advertisement does not appear in this month's issue.

NAME	ADDRESS (Street — City — State)	

Your name.. Dealer's name ....

Your address.. His address..

☐ If you are a dealer, check here. City.............................. State.............. City.............................. State..............

How To Get the Most Out of Your Storage "A" Battery

By RAYMOND A. KLOCK, Associate I.R.E.*

MUCH of the information generally current on the care of the radio storage battery is perfectly applicable to the auto starting battery but is misleading when applied to the Radio Storage "A" battery. It is the purpose of this article to tell, in a simple way, how to get the most out of the lead acid type of radio storage "A" battery as used for broadcasting reception in the home of the radio set owner.

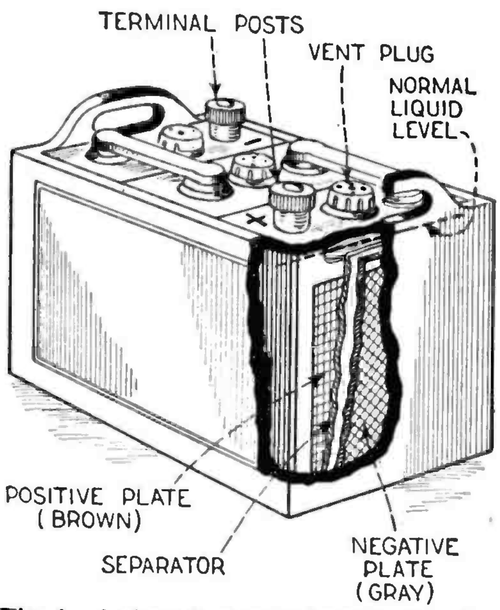


Fig. 1. A six-volt storage battery showing arrangement of its plates.

It is assumed that the reader has selected a storage "A" battery of sufficient capacity to properly operate his radio set. Except for Gould Unipower or other equipments involving the newly developed continuous or trickle charge, a standard five-tube radio set in use in the ordinary home should be equipped with a storage battery of at least 80 ampere hours' capacity. If the nameplate on the storage battery indicates a capacity of 80 ampere hours or more and bears the name of a responsible manufacturer, a five-tube radio set is correctly equipped.

The storage "A" battery is usually accompanied by a nameplate or instructions indicating its charge rate and its specific gravity when fully charged. The charge rate is not of vital importance as the rate marked on the nameplate is usually the maximum normal charging rate employed by service stations. There is no objection to a lower charge rate than the rate indicated on the nameplate, but the battery should not be charged at a higher rate except under the supervision of an expert batteryman.

Addition of Water

Fig. 1 shows the interior of a storage battery cell of the type generally used in radio. It will be observed that the liquid level is normally well above the plates and separators of which the battery cell is made up. *The plates and separators must be kept covered by the addition of distilled water from time to time.* The liquid level should never be permitted to fall to a point that will expose the separators, which are the topmost parts visible through the vent opening. However, in filling, the liquid level must not be permitted to rise into the vent opening itself. If a cell is filled so full that the electrolyte enters the vent opening, in the course of charging it may seep up through the opening and actually exude over the top of the battery to the floor.

With a properly designed storage "A" battery, filled to the correct water level a few minutes after charging, it should not be necessary to add water again until it is charged a second time. Very little evaporation occurs in a radio storage battery except while

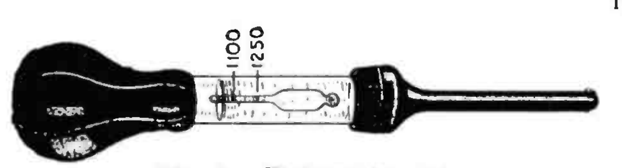


Fig. 2. Hydrometer set.

charging but considerable evaporation occurs in the last stages of charging. *When first connecting the battery or when reconnecting the battery after charging always make sure that the water level is correct.* Assuming that the battery is installed in your set, fully charged and with electrolyte at the correct level, we will now consider how to keep it in best condition.

Testing with the Hydrometer

The testing instrument most commonly employed in storage battery work is the hydrometer, shown in Fig. 2. The purpose of the hydrometer is to determine the state of charge of the battery as indicated by the *relative* specific gravity of the electrolyte. The specific gravity of a fully charged battery is not a fixed value but depends entirely on the standard specific gravity employed by its manufacturer which may be anywhere from 1.250 to 1.300. The user should always ascertain the correct specific gravity for the make of battery he is using before attempting to test it with a hydrometer.

Fig. 3 shows how the hydrometer float checks specific gravity and, it should be noted, that *the hydrometer employed for testing the specfic gravity of the radio "A" battery should be clearly marked in figures.* No dependence can be placed on a hydrometer marked "charged," "half-charged" and "empty."

When water is first added to the battery cell the upper layer of electrolyte remains mostly water for several hours so that a hydrometer reading taken on a fully charged battery to which water has recently been added may appear to indicate a discharged battery. The hydrometer reading is, accurate only after sufficient time has elapsed for the water to mix with the electrolyte, then giving a true reading.

Assuming that the solution of the battery cell has had time to fully mix, a hydrometer reading under 1.200 indicates a half-charged condition of the battery and, in general, a hydrometer reading below 1.150 indicates a fully

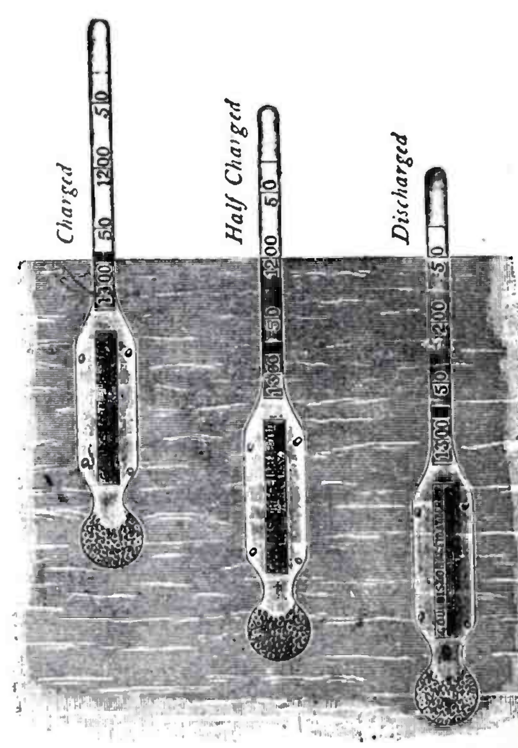


Fig. 3. How the hydrometer float checks the specific gravity of the battery solution.

discharged battery. If you employ a device for charging the storage battery at home *the battery should be put on charge sufficiently often to keep it above the half-charged state.*

** Gould Storage Battery Co., Inc.*

Testing with a Voltmeter

A voltmeter may be employed as a means of testing a storage "A" battery if a voltmeter of the proper type is selected and is used in the manner described following.

The voltmeter must be accurate with a sufficient length of scale to read tenths of a volt clearly. Voltmeters are obtainable which may be used for both the "A" and "B" batteries, whether dry or storage, making an invaluable instrument to the radio user. It is not possible to test the storage "A" battery with cheap types of so-called pocket voltmeters.

Bear in mind that a voltmeter reading on a storage "A" battery is of value only when the battery is either charging or discharging, except when the battery is practically dead. A voltmeter reading taken when the battery is not connected to the circuit, either charging or discharging, may be misleading. Fig. 4 shows voltmeter scale readings which are taken at the *battery terminals*. With the radio set filament switch turned on and the tubes lighted, so long as the voltmeter indicates a full six volts the battery is charged, but, under the same conditions, if the voltmeter lags appreciably below six volts the battery should be charged in order to keep it in the best condition. When it falls to 5.4 volts the battery is discharged and cannot possibly operate the set with any degree of satisfaction more than an hour or two. When the battery is connected to the charger and the voltmeter shows from 7.5 to 7.8 volts the battery is fully charged.

Testing without Instruments

If one has neither a hydrometer nor a voltmeter it is possible to recognize the necessity for charging by the fact that the amplifying rheostats have to be moved forward of the normal working position, indicating low voltage, and the battery should be charged whenever this becomes necessary. When on the charging line, at the ordinary charge rate of the usual commercial charger, and all of the cells of the battery are bubbling, it is charged.

Charging Equipment

For reasons of both economy and convenience a device for charging the storage battery in the home is quite as essential as the storage battery itself. An additional reason, however, of equal importance is the necessity for keeping the battery in a charged condition in order to insure a satisfactory battery life. If a storage battery is kept normally less than half charged it deteriorates approximately three times as fast as a storage battery that is kept normally well above the half-charged condition. Furthermore, if a storage battery is permitted to stand for any length of time in a fully discharged condition it is permanently damaged and cannot be brought back to normal capacity.

If the home of the user is located in an area supplied by direct current a direct current type of battery charger is necessary. This charger consists of a resistance unit and a meter with plug and cord for attaching it to the lamp socket. In charging from direct current it is always necessary to completely disconnect the storage "A" battery from the radio set when charging, to avoid trouble from the grounded direct current power line. The instructions of the maker of the charger should be followed closely.

If the home of the user is located in an alternating current area, usually 60 cycles, 115 volts, but sometimes 25 cycles, 115 volts, several types of commercial charging devices are available to him. It is always necessary to select a device designed by its maker to operate on the exact type of alternating current employed.

In order of simplicity of maintenance the electrolytic rectifier using the Balkite principle, the bulb rectifier using the vacuum tube principle, and the mechanical or vibrator type, are generally available.

The electrolytic rectifier requires the occasional addition of water in the same way that water is added to the battery but, in the lead acid-tantalum type it has no adjustments or wearing parts. The bulb rectifier requires the replacement of the bulb, from time to time. These two types of rectifier are of approximately the same efficiency, that is to say, cost about the same in current consumed.

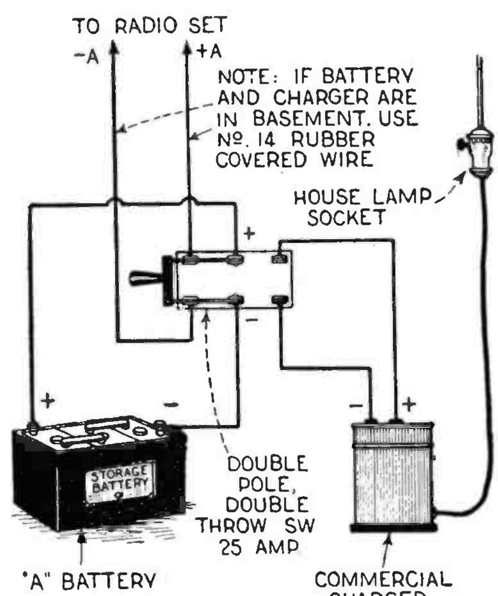


Fig. 5. A switching arrangement for charging the "A" battery of a radio set.

The mechanical rectifier requires routine adjustment of the vibrating element and occasional replacement of the contact point and is inclined to be more or less noisy. The mechanical rectifier, when at correct adjustment draws somewhat less current from the house lighting line than the other types, but it requires much more routine attention and its efficiency is dependent on the accuracy of its adjustment.

The bulb type of rectifier is usually audible at a short distance from the rectifier. The electrolytic type of rectifier is silent.

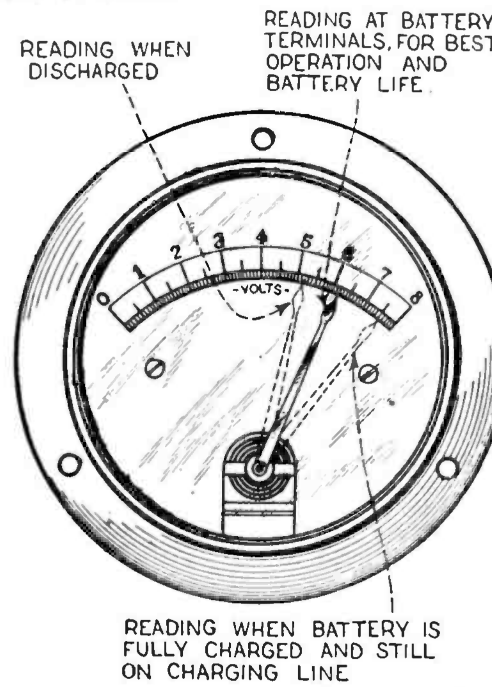


Fig. 4. Showing voltmeter scale readings taken at battery terminals.

Whatever type of rectifier you employ, follow closely the instructions accompanying it in its installation and care.

Bear in mind that for longest battery life and best radio reception the battery should not be permitted to become more than half discharged. It is desirable, therefore, to simplify the operations necessary to charging as much as possible. A convenient arrangement is shown in Fig. 5. This installation should be made with the same care that is employed in house wiring and is preferably located in the basement. It will be found that the switch can be thrown over at regular intervals between periods of use of the radio set, usually from one evening to the next, keeping the battery up with a minimum of testing and manipulation.

How to Tell When Battery Is Charged

When the battery is fully charged, as noted under "Testing" a hydrometer shows its full rated specific gravity (which may be any value between 1.250 to 1.300), it registers 7.5 to 7.8 volts on the voltmeter and all its cells are bubbling (gassing) freely.

Caution in Handling

Whether you install the switch or whether you attach the charger to the storage battery, each time you desire to charge, particular attention should be paid to the storage battery terminals. These terminals oxidize rapidly and should be scraped bright, all contacts thoroughly cleaned and binding posts screwed tight. A coating of pure vaseline should be placed over the terminals after the connection has been

(*Continued on page* 158)

An Improved Super-Heterodyne

A New Super-Heterodyne Which Incorporates Plug-In Inductances

WITH the advent of a new radio season, bringing with it receiving conditions differing immeasurably from those encountered last year, the time seems most opportune to present a description of an improved super-heterodyne, designed to meet existing American or foreign broadcast conditions.

Aside from the increased number of broadcasters, and their increased power, there is the extension of wave-length ranges to be considered. Last year 250 meters was the low limit in practical use. Today it is 300,000 cycles higher, or 200 meters. Few of last year's receivers will efficiently reach this new low limit. Rebroadcasting brings in an even lower limit, so that our really practical receiver must go down to 50 meters and up to 550. If it is desired to listen to the high-powered European stations, then this range must be extended to 2700 meters.

Specifications

Possibly the first features to strike the eye are the interchange oscillator and antenna coil systems. Plug-in coils are used in each circuit, arranged to cover the desired wavelength range. Three coils are used in either oscillator or antenna circuit to tune from 50 to 550 meters. They are wound upon moulded bakelite forms.

If a loop is to be used, it is merely necessary to remove the antenna coil from its six-contact socket and connect the loop to three binding posts on the socket. For different wave-length ranges, both oscillator and antenna coils are merely plugged in or out, exactly as a tube would be. The oscillator coupling coil is connected in the filament return of the first detector rather than in the grid lead, which gives somewhat greater selectivity and permits of greater efficiency at short wave-lengths.

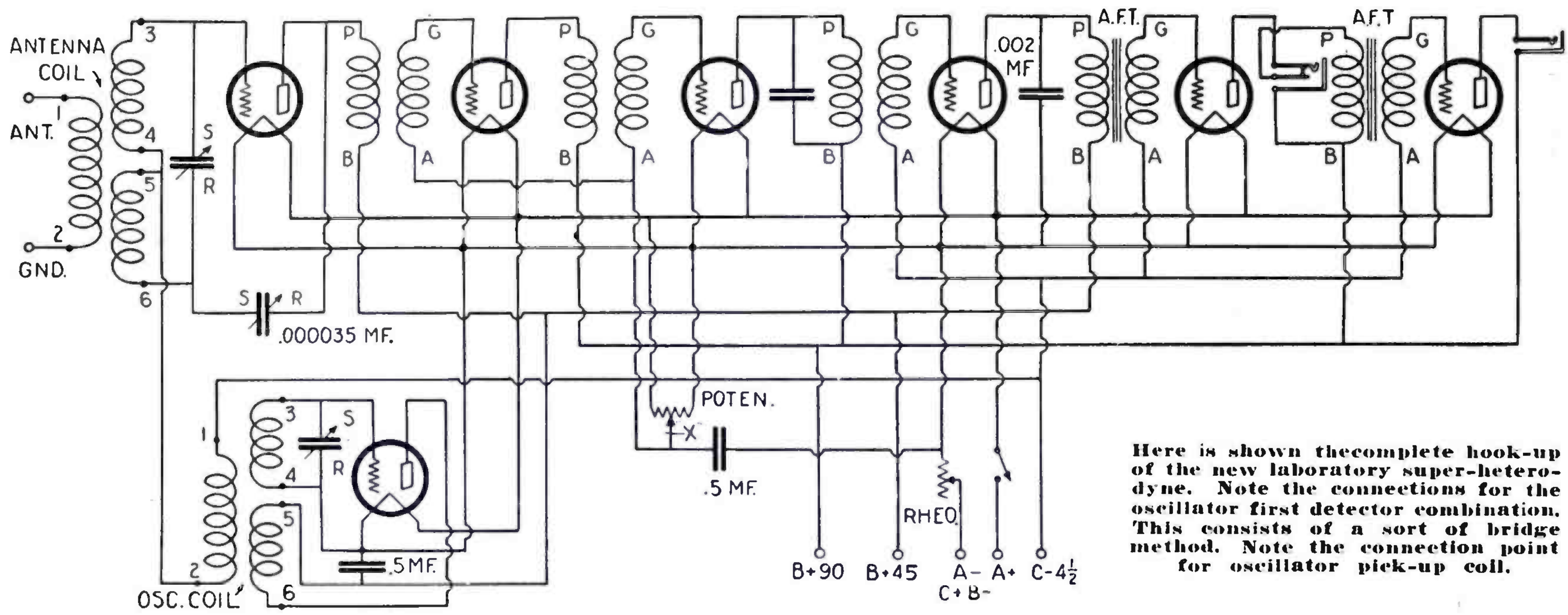
Straight-line frequency condensers are recommended, in order that maximum ease of tuning may be experienced upon the short waves.

Vernier dials may or may not be used, as desired, but it will be found somewhat difficult to tune the receiver without them. Some friction type should be used if it is desired to take advantage of the single-control feature, which will be considered further on.

Most intermediate amplifying transformers and filters are carefully tuned at the factory to exactly the same operating frequency, the filter being provided with a measured tuning condenser of exactly the correct value. The iron-core type is recommended. With controlled regeneration these will give as great amplification as it is possible to obtain. The over-all amplification curve of the two-stage amplifier is very similar to that of an extremely good band-pass filter as used in carrier telephone work. This means that a band only wide enough to pass the desired signal receives amplification. In this particular amplifier, the width of the band may be varied by the volume control from a width so great that selectivity and amplification are poor up through a good operating condition, and on to a point where the frequency band passed is so narrow that little or nothing but the low notes of a station come through.

The audio amplifier suggested employs 3½:1 transformers. The size of the baseboard is great enough to permit the addition of an extra tube, so that a three-stage resistance coupled amplifier might be used, or a three-stage choke coupled amplifier, to be selected by the individual builder.

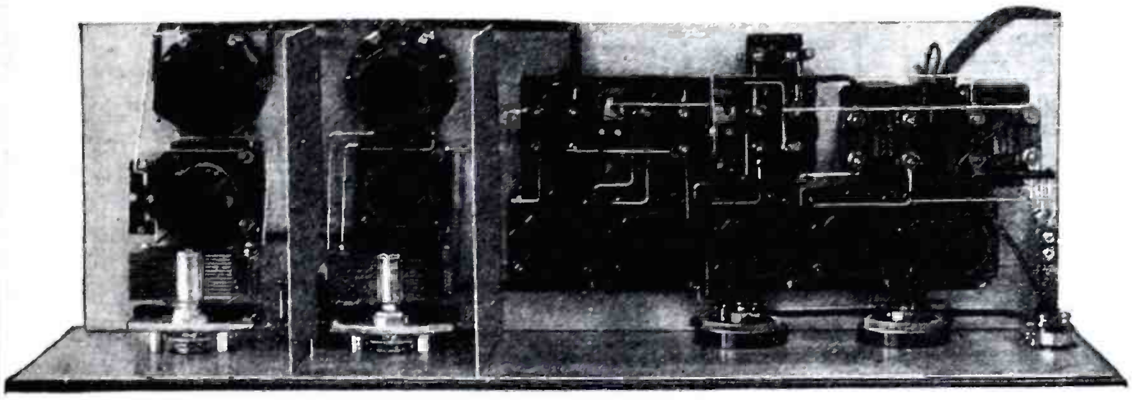
The circuit is not at all new, except for the use of a grid bias upon both detector tubes rather than the grid condenser and leak generally used. The reason for this is primarily one of convenience, since practically the sensitivity for either system appears substantially equal. However, a grid condenser and leak suited to broadcast reception with the first detector would be too large for good results on low waves. Further, regeneration control and selectivity improved slightly through the use of a grid bias.



Here is shown the complete hook-up of the new laboratory super-heterodyne. Note the connections for the oscillator first detector combination. This consists of a sort of bridge method. Note the connection point for oscillator pick-up coil.

The positioning of the oscillator coupling coil is evident from a reference to the circuit. It will also be noticed that only the oscillator grid circuit is tuned, thus bringing one side of the oscillator tuning condenser at ground potential, and eliminating any tendency toward hand capacity effect.

The mechanical features of the set are quite simple. Photos are shown of the shielded model. An aluminum sub-base, together with an aluminum panel shield is used. If the back, ends, and top of the cabinet in which the set is placed are also shielded, the selectivity obtainable will be remarkable. The choice between the shielded and unshielded methods of construction is quite simple. If the receiver is less than a mile from a broadcaster, then the shielded model should be selected, by all means. Though its assembly may appear a task for a tinsmith, it is really quite simple, since the aluminum works as easily as bakelite, and may be obtained cut to size. The unshielded model is entirely satisfactory for use outside a one-mile radius of a powerful broadcaster.



This view of the new super-heterodyne shows the parts with two of the inductances in place in the receptacles. It also shows the method of building.

Results

Generally, writers of constructional articles feel that their work is incomplete without a glowing tale of the wonderful results obtained from their particular circuit. The writer is no exception, nor is it assumed that the reader would wish to remain uninformed of what may be expected from the sets. During August a test was run in a building adjacent to a new steel frame hotel in the Chicago loop district. Some twenty out-of-town stations were logged between nine and twelve o'clock including coast stations. More were heard, but could not be logged, due to terrific static and elevated railway interference—located less than 75 feet away. However, the important fact is that within a radius of but a few miles, some ten local stations were operating — three of them not half a mile distant. Yet the selectivity was such that no trouble was experienced in working.

Parts for this set should be selected which will co-ordinate properly, and are of equal quality, since the results obtainable are dependent, in a large measure, upon the use of parts selected.

A list of material is given in the accompanying box.

If the completely shielded model is to be built, additional aluminum shielding will be required. The sub-base should be No. 8 gauge, while the balance may be No. 20 gauge, cut to fit the desired cabinet.

No specifications for the oscillator coils have been given. It is possible to use standard six-contact forms for these coils, which can be procured on the market, as these will plug into the sockets listed very nicely and are completely provided with hardware. They may be procured wound or unwound, as desired. The winding specifications are given below.

For the antenna coil, the stator tube should be wound with two equal sections, and the rotor tube with one section split for the rotor bearings as listed:

2	.00035 SLF condensers.
2	4" moulded dials, vernier preferably.
1	6-ohm rheostat.
1	200- to 400-ohm potentiometer.
1	2-Spring jack.
1	11-Spring jack.
2	Charted intermediate transformers.
1	Tuned filter with condenser.
7	Spring sockets, UX or UV.
2	3½:1 audio transformers.
1	On-off switch.
3	.5 mf. bypass condensers.
1	.002 bypass condenser.
1	.000025 mf. balancing condenser.
1	7x24x½" bakelite panel.
1	7½x23 oak or aluminum sub-base.
2	Coil sockets, screws, lugs, nuts, solder, spaghetti, etc.

190—550 meters:

Stator .... 43 turns per coil
Rotor .... 40 turns per coil

90—210 meters:

Stator .... 16 turns per coil
Rotor .... 10 turns per coil

50—110 meters:

Stator ...... 7 turns per coil
Rotor ...... 6 turns per coil

For the oscillator system, the top stator coil is much larger than the bottom one, the larger being used in the grid circuit, the smaller in the plate circuit. For the rotor and pick-up coil, the winding specifications are as follows:

190—550 meters:

Large stator .... 84 turns
Small stator .... 25 turns
Rotor .... 40 turns

90—210 meters:

Large stator .... 32 turns
Small stator .... 14 turns
Rotor .... 10 turns

50—110 meters:

Large stator .... 14 turns
Small stator .... 10 turns
Rotor .... 6 turns

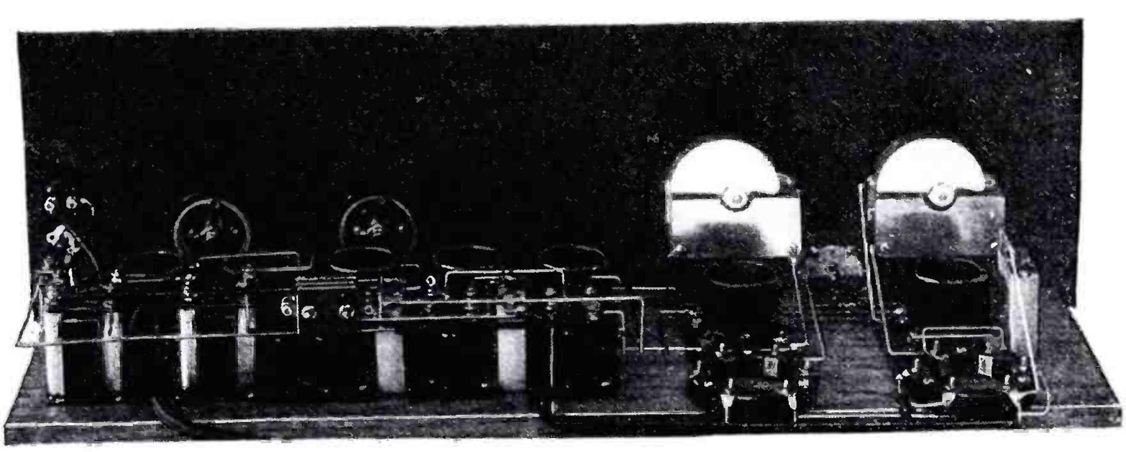
In all cases, the stators are wound as one continuous winding, the top end being No. 3, the bottom end of this winding being No. 4, the top end of the next winding being No. 5, and the bottom end of this winding being No. 6. The rotor numbers are 1 and 2. These coils may be clipped in at will and adjusted to any desired position. After being once set, they need never be disturbed.

Any standard type of tube may be employed. The writer prefers UX-199 tubes up to the second audio stage with UX-120 for the last stage. UX-201As, with the last stage UX-112, will give slightly greater handling capacity, higher "B" battery consumption and possibly, a little more volume.

Construction

Should the aluminum shield be used, holes must be drilled in it to correspond with those in the panel, but so over-sized that no instrument will short on it, except the oscillator condenser, the frame of which goes to the negative filament line, which is also the shield.

If the sub-base is of wood, wood-screws will serve to fasten all parts to it, and it, in turn, to the panel. If an aluminum sub-base is used, machine screws (6/32) and nuts will be required.



This view of the new super shows the arrangement of the parts with the two receptacles for taking the inductances. The model picture is the unshielded type.

The wiring is quite simple, requiring only the usual bus-bar, spaghetti, well-tinned soldering iron, non-corrosive paste and rosincore solder. No battery binding posts are provided, the short ends of the color cable being terminated directly at instrument binding posts, while the long ends go directly to the batteries.

The preliminary testing of the set is quite simple. It should first have only the "A" battery connected to it, and the tubes inserted in their sockets They should, of course, light, and have their brilliancy controlled by the rheostat. The negative "A" battery lead should be left connected and the plus lead removed and touched first to the "B" 45 and then to the "B" 90 leads. The tubes should not light with either of these connections. If they do, an error has been made in wiring and must be corrected before proceeding further.

The tubes being in their sockets, the rheostat should be turned about seven-eighths on for storage battery tubes. The proper adjustment for UX-199 tubes (dry cell) may be arrived at by the use of a filament voltmeter, which is vitally important for use with this type of tube.

Two of the larger size oscillator coils and antenna coils should be put in their respective sockets, and the balancing condenser turned all out. Then, if the potentiometer is turned from its positive to its negative side, a "plunk" will be heard, followed by squeals if the oscillator dial is rotated. The potentiometer should be turned back far enough so that no squeals will be heard in which position it should be left unless it is desired to vary the signal volume with it.

If the oscillator and antenna dials are rotated slowly, varying the oscillator through a range of 10 degrees above to 10 degrees below the antenna setting for each 2-degree step with the antenna dial, signals will be heard if any local stations are operating. An antenna not over 40 to 60 feet long, indoor or outdoor, and a ground may be connected to terminals 1 and 2 of the antenna coil socket, or one just behind the antenna condenser and first detector tube. Selectivity may be regulated by adjusting the position of the rotor coil with the fingers. Once set it need not be disturbed. This is true for all sizes of antenna coils, for the different wave-length bands.

The oscillator coupling is not generally critical and the oscillator rotor should have its axis coinciding with that of the stator tube to start with. Selectivity may be improved by turning it slowly out. It will be found, however, that turning it a full 180 degrees around may increase signal strength on weak stations. In some extreme cases it may even be necessary to connect it in the first detector grid lead rather than in the filament return. This should be tried at once, should the receiver fail to operate properly.

In first tuning the set a few signals will be heard, due to the extreme selectivity. Therefore, it may be well to do away with the regenerative first detector circuit temporarily by reconnecting the circuit as suggested in the circuit diagram. This will render the antenna tuning quite broad, with consequent ease of handling, but at the expense not only of selectivity, but of a considerable degree of sensitivity.

Single Control

Using the non-regenerative first detector connection, the antenna tuning will be broad enough so that if the two tuning condensers are geared together, one knob may be used for tuning, thus simplifying control. This is as practical an arrangement as can be used in any super. The antenna tuning being broad, it is impossible to vary both condensers at once, keeping them a uniform number of degrees apart, and yet still obtain the best setting for all waves on both condensers.

In view of the single-control feature, the use of a loop has not been seriously considered. However, it may be used with perfect satisfaction as on any super, by removing the antenna coil and connecting the loop with its inside end to post 6 of the coil socket, its center tap to post 4 or 5, and its outside end to post 3. This assumes a spiral loop, of 18 turns, about 20 inches mean diameter with turns spaced one-half inch between centers. Stranded loop wire should be used—not Litz. For shorter waves, fewer turns will be required—say about eight for the 100- to 200-meter band and about four for the 50- to 100-meter band.

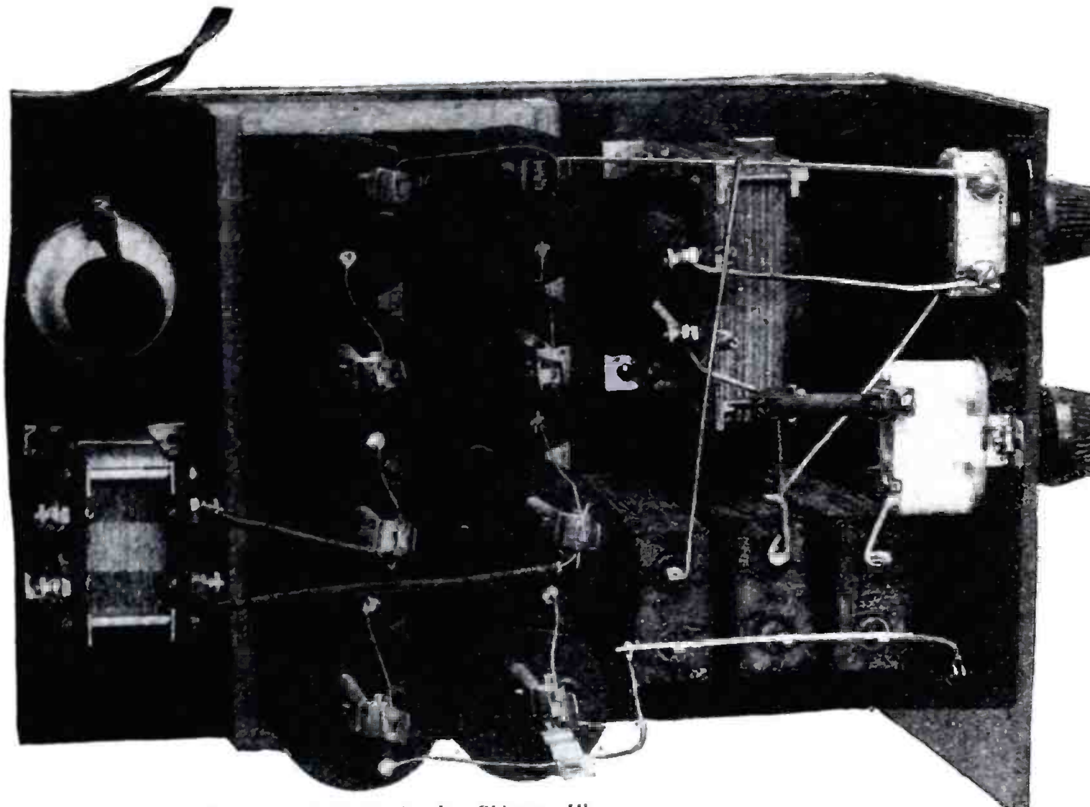
In the case of some standard loops, wound with few turns, it may be necessary to add a turn or two to cover the desired maximum range up to 550 meters.

A Practical "B" Battery Eliminator

By C. E. JACOBS

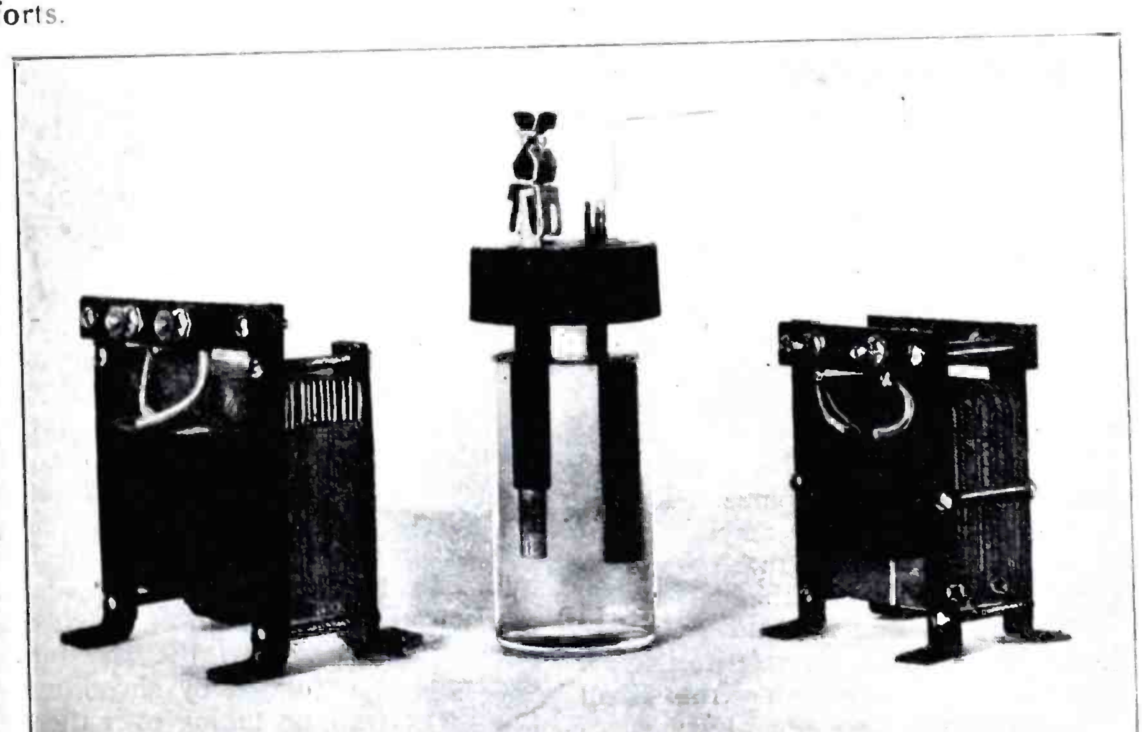
How to Build a Smooth and Flexible "B" Eliminator Using Electrolytic Rectifiers

WITH present day receiving sets, using as high as 10 tubes the question of B batteries becomes an item of a good deal of bother and expense. In 90 per cent of all cases of poor signals, loss of selectivity and sensitivity, it is either the fault of the A or the B batteries, mostly the latter. Then, too, there is the expense. On the average five tube receiver a set of dry cell B batteries of a good make will last about three to four months, while on larger sets they will not work well after a month's use. No wonder, the average fan, after having operated his receiver for some time, turns to some substitute for B batteries, but it is equally surprising that not more B battery Eliminators are being built when it is comparatively easy to do so. The parts may be readily obtained and any fan that can assemble a crystal receiver can wire up a B Eliminator in a short time. It is not necessary to be very particular about the layout of the wiring, as we are not dealing with any tricky high frequency currents, and if a little care and caution is used in the choice of the material and parts, the builder will be amply rewarded for his efforts.



Illustrations by Courtesy of C. E. Jacobs, Chicago, Ill.

Photo showing a top view of the "B" battery eliminator.

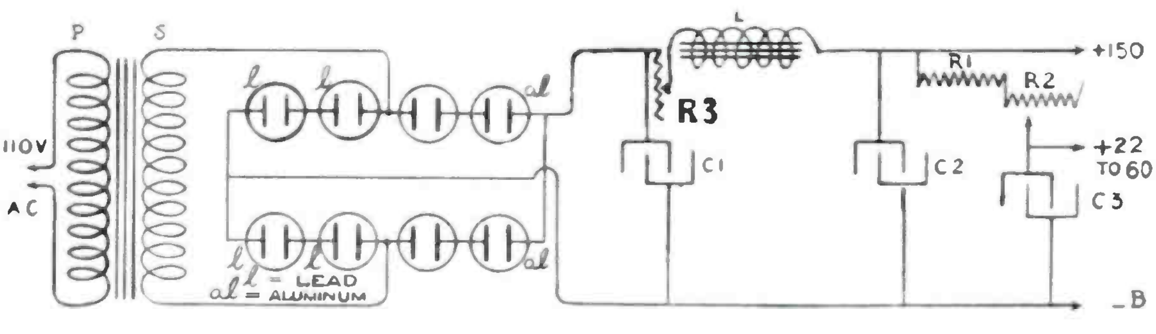


Here is shown one of the electrolytic cells and choke coils as used in the eliminator described herewith.

In the following article a B current Supply Unit is described which is not only very smooth in action, but also flexible enough so that it can be used on a variety of receiving sets. It is low in first cost as well as in upkeep. The current consumption of such a B Unit is, as a rule, not more than 7 or 8 watts, or far less than an ordinary light bulb would consume. The wearing part of this B Unit which is the chemical rectifier can be replaced at nominal cost. In this respect the chemical rectifier has the advantage over rectifying tubes whose average efficient life is not more than 600 hours. Every B Supply Unit that is to be used with alternating house current consists essentially of four sections. These are, the power transformer which steps up the house current to a higher voltage, the rectifier system and the output voltage regulation.

In the B Unit to be described herewith, a 25 watt transformer is used which steps up the 110 volts of the house current to 155 volts. This figure has been found to deliver about 40 milliamperes of current at 90 volts on the output side of the Eliminator. For the construction of the power transformer we can take any convenient toy transformer, that has a rating of around 25 watts. Unwind the primary winding which is next to the core and count the number of turns thus unwound. Divide this number by 110 which is the line voltage and we now have the number of turns per volt. Carefully rewind the primary on the core, taking care that no open or short-circuit creeps in. Wrap a layer of

Empire cloth around the primary and bring out the free ends to suitable binding posts. These will be connected to the house current. Now in order to find the right number of turns for the secondary we multiply the number of turns per volt with the secondary voltage desired. For instance, if we have 8 turns per volt on the primary winding and we want 160 volts on the secondary, we must wind on 1280 turns. The wire must be wound in even layers and each layer should be insulated with thin paraffined paper. The whole assembly should then be wrapped in Empire cloth and can be soaked in molten beeswax or left as it is.



Wiring diagram of the electrolytic "B" battery eliminator as shown in the photos.

In the accompanying schematic wiring diagram of the B Current Supply Unit, it will be noted that 8 rectifier cells are used. These are arranged in what is called a bridge circuit which provides full wave rectification with but a single secondary winding on the transformer. The number of rectifier cells is determined by the secondary voltage and it is a rule to have one jar for every 40 volts. With a full wave rectifier this means twice the number as each cell rectifies only one half of the A C wave.

The current in passing through the rectifiers is changed from alternating to direct but pulsating current. Now, this current would cause a strong buzzing sound in the receiver if it were used just as it is. It must, therefore, be smoothed out to a steady flow of pure direct current, so that there will be no fluctuation in its supply. Any fluctuation of the supply would have a tendency to modulate the received signal, and the result would be a choppy or "ragged" signal. The smoothing out of the pulsating current is effected by the filter system. This consists essentially of a large reactance coil, commonly called a choke coil, and large capacity filter condensers. It has generally been suggested to use a choke coil of 30 henries, but for real good results on a receiving set a much higher value should be used. Sixty henries is none too much and 100 to 125 henries will work better. In fact, the heavier the inductance, the better, providing, of course, that the DC resistance does not exceed a certain value. The use of audio transformers as choke coils is to be discouraged. They have neither the proper inductance, and as a rule where a high ratio instrument is used, the DC resistance as well as the distributed capacity of the windings are far too high to get good results. In connection with the choke coil we also require large capacity filter condensers. These should be high grade and must stand a high voltage test. For the B Unit in question condensers made by the larger Telephone Companies or filter condensers made for B Eliminators should be selected. In the diagram shown, C1 and C2 are 2MF each, while C3 is 1MF. These values are not critical, but should not be smaller. On the contrary, the larger the condensers, the better will be the filtering. In order to get the proper voltage taps, either fixed or variable resistances should be used. Fixed resistors are probably better, but the variable ones are more convenient. In selecting the latter, make sure that they are able to carry the currents which they are intended for without burning out or losing their operating characteristics. Referring to the diagram, R1 is a fixed resistance of 125000 ohms while R2 is a Bradleyohm, No. 10 which varies from 10,000 ohms to 100,000 ohms. This arrangement is used to cut down the voltage for the detector tap. The fixed resistor R1 can be used without the Bradleyohm if a hard tube is used for a detector, or if the detector voltage is not critical, but R2 should always be used in series with R1. The variable resistor R3 which is put in ahead of the choke coil is also a Bradleyohm No. 5 which has a range of from 1,000 to 10,000 ohms. This is used for regulating the amplifier voltage. On sets requiring more than two positive plate voltages, this may be arranged by tapping into the amplifier line with another variable resistance and by-passing its output with a fixed condenser. (This is not always necessary, as the by-pass condenser of the receiver will take care of this).

The heart of the B Supply Unit is the rectifier element. In the Unit described herewith, the electrolytic type in which aluminum serves as the rectifying element is made use of. Heretofore, the average experimenter has always used a combination of lead and aluminum in a solution of ordinary borax. However, during the past few years when considerable research work has been done with this type of rectifier in connection with its use as a B battery charger, various defects have shown up and these have now been eliminated. For instance it has been found that borax would eat away the aluminum electrodes very quickly. This required frequent renewal of the electrodes and also of the solution. Various chemicals have been found which did not possess this disadvantage and if they are procured in the chemically pure state, the aluminum electrodes will show an unusually long life. A few of these chemicals are sodium phosphate, ammonium phosphate, to which has been added a slight amount of potassium phosphate, sodium acid tartrate, and ammonium borate. A good many of the battery charger manufacturers are putting out chemicals which can be used in the rectifier cells.

An improvement has also been made in the choice of the cathode material. While, this, as a rule, consisted of lead, a few manufacturers are now using specially made graphite electrodes which are similar in appearance to the carbons used in dry cells. Graphite does not undergo oxidation or electrolysis while used as a cathode in the rectifiers and, therefore, does not rob the solution of its active elements. At the same time it will always stay clean and makes good contact with the electrolyte, while lead, due to its corrosion sets up a high resistance with a consequent drop in the output of the rectifiers.

It is also important to have the proper amount of aluminum exposed to the solution. This is referred to as the current density. For a B Eliminator to be used on a receiver where about 40 milliamperes of plate current is consumed, no more than one square inch of the aluminum should be immersed in the solution. For the average five-tube receiver an immersion of half inch using a rod ¼" in diameter works out very well. Too large a surface exposed, where only a small amount of current is consumed, means poor rectification with a resultant difficulty in filtering out the hum. In the photograph of the single rectifier cell, it will be noted, that the area of immersion of the aluminum electrode is regulated by shrinking a piece of pure gum tubing over the aluminum rod. This at the same time prevents the sparking at the surface of the solution, which, in time, corrodes the electrode to such an extent that it will be useless.

The aluminum used in the rectifiers should be of the highest purity obtainable. Chemically pure metal should be procured. Ordinary aluminum will ot work at all, or only fair. Most of he larger chemical houses can supply C. P. rods, but for the best results this hould be bought from manufacturers f B battery chargers or rectifiers for B Units.

It is also important to use nothing ut distilled water for the solution and he latter should be saturated. Do not se a hydrometer for filling the rectifier cells, if it has ever been used for esting a storage A battery. There will be enough acid sticking to the lass wall of the hydrometer to spoil he solution and the electrodes.

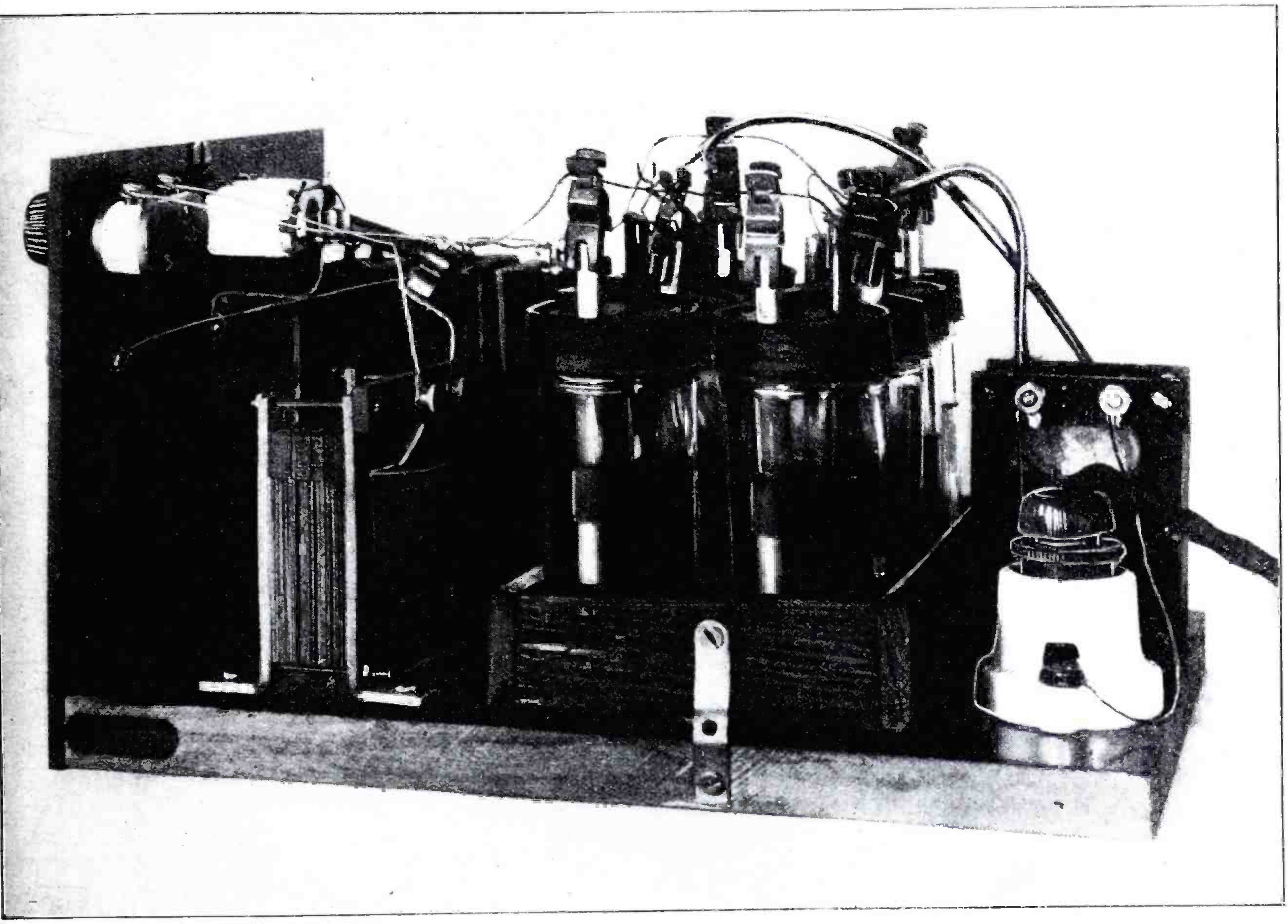
same cabinet without experiencing any hum on the loud speaker. On loop operated receivers it is sometimes necessary to ground minus B.

The evaporation of the solution in the cells is very slow. As a rule adding a few drops of distilled water twice a year will take care of this. The life of the solution itself will vary considerably. In some cases it might be as short as 6 months, while in others it is good for two years or more. This is the great advantage of the chemical type of rectifier over any other system. The total costs, both

1 Bradleyohm No. 10 (10,000 to 100,000 ohms).

1 Bradleyohm No. 5 (1000 to 10,000 ohms).

The construction of the choke coil is rather tedious and is a job not recommended for the average experimenter. A good many fine points will have to be observed which space forbids to mention here, but for those fans who have sufficient knowledge of coil windings and transformer assembly, it is suggested to use a core of one inch square cross section with a winding of 9000 turns of No. 32



Another view of the "B" eliminator. Note the socket at the right for connecting the unit to the lighting supply line.

With the B Current Supply Unit assembled, we now turn on the house current and form the electrodes. With the bridge arrangement of the rectifier cells, this will be done in 5 or 10 minutes or sufficiently well to operate the receiver. The forming will get better after the B Unit has been operated a few days, but the Unit can be used on a receiver almost at once.

There should be no perceptible hum, even when the headset is used, but any residual hum can be eliminated by increasing the capacities of condensers C1 and C2, preferably the latter. The B Supply Unit itself should not be very near the receiver itself, but in some cases it can be set into the

operating and replacement of the chemical B Unit for 1000 hours operation should not be more than $1.50 to $2.00. In a good many cases it is even less than $1.00 per year.

To summarize, the parts required for the building of the Electrolytic B Eliminator are:

1 power transformer with a secondary of 150 to 170 volts?

1 choke coil of 125 henries at 60 cycle no load.

8 rectifier cells.

2 filter condensers of 2 M F capacity.

1 filter condenser of 1 M F capacity.

1 fixed resistor R1 (125,000 ohms).

wire. The wire should be wound in even layers and the distributed capacity must be kept low. One leg of the core should be assembled with a butt joint while the others are interleaved as in regular core assembly.

The B Current Supply Unit constructed after above instructions is exceptionally smooth and very flexible. The detector voltage can be regulated to a point where a soft tube can be used with good success, while the amplifier voltage can be varied from 75 to as high as 135 volts with a current draw of 20 to 25 milliamperes. This will handle a Tuned Radio Frequency receiver with resistance coupled am-

(*Continued on page* 119)

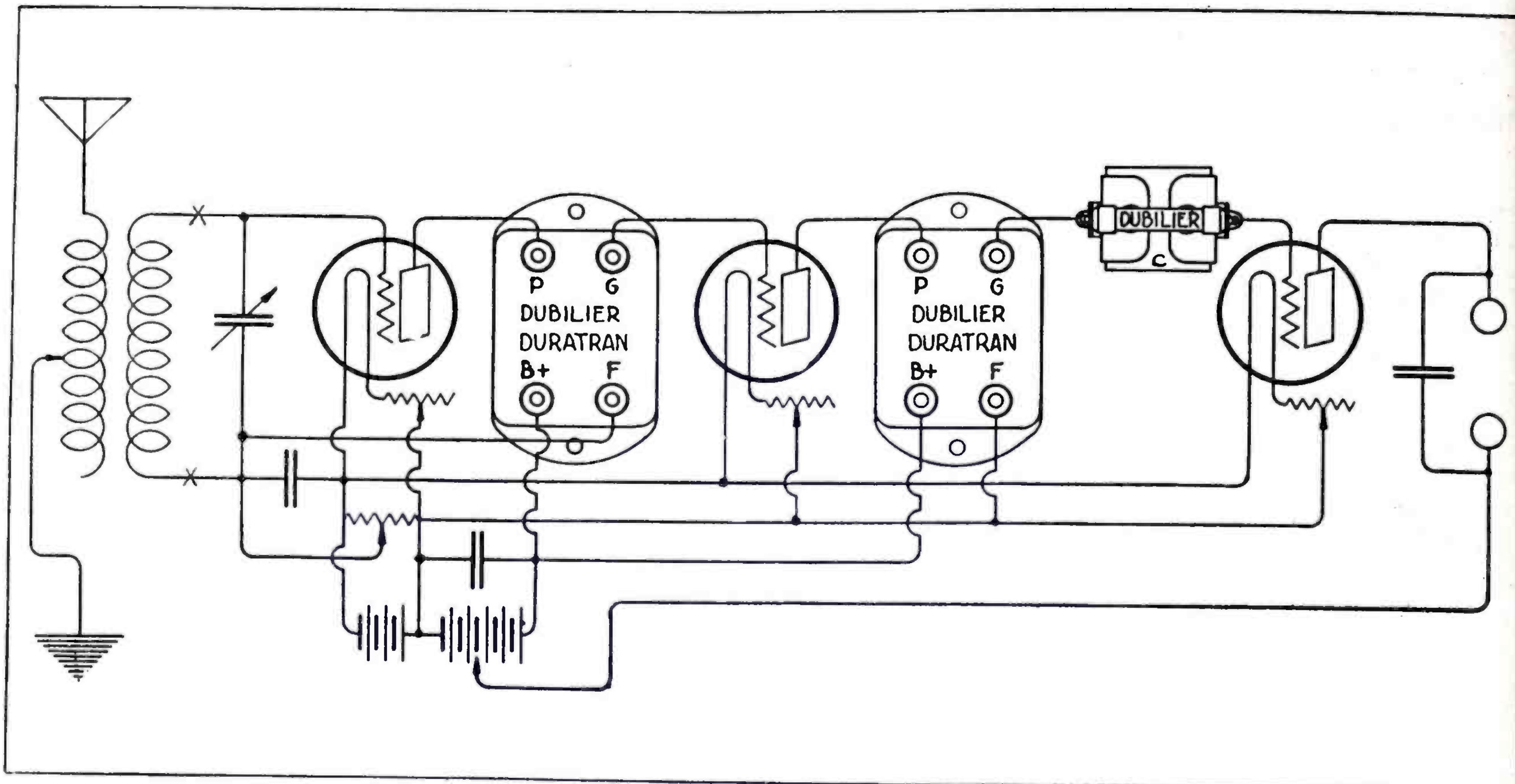
Fixed Condensers

By M. KEVELSON*

Their Position and Function in a Receiving Set

IN every radio set, a fixed condenser is a practical necessity. The diversity of uses to which it is put, and the part played electrically in each of its positions, make it important for the manufacturer and builder of radio sets to know the why and wherefore of fixed condensers.

It is difficult to classify these uses in the order of their relative importance because in practically every instance, if the condenser is properly located in the circuit, the part that it plays electrically is so important, that it is almost indispensible. In fact, in



Illustrations by Courtesy of Dubilier Condenser and Radio Corp., New York.
Fig. 1.—Fixed condenser at C used as a grid condenser in the detector circuit.

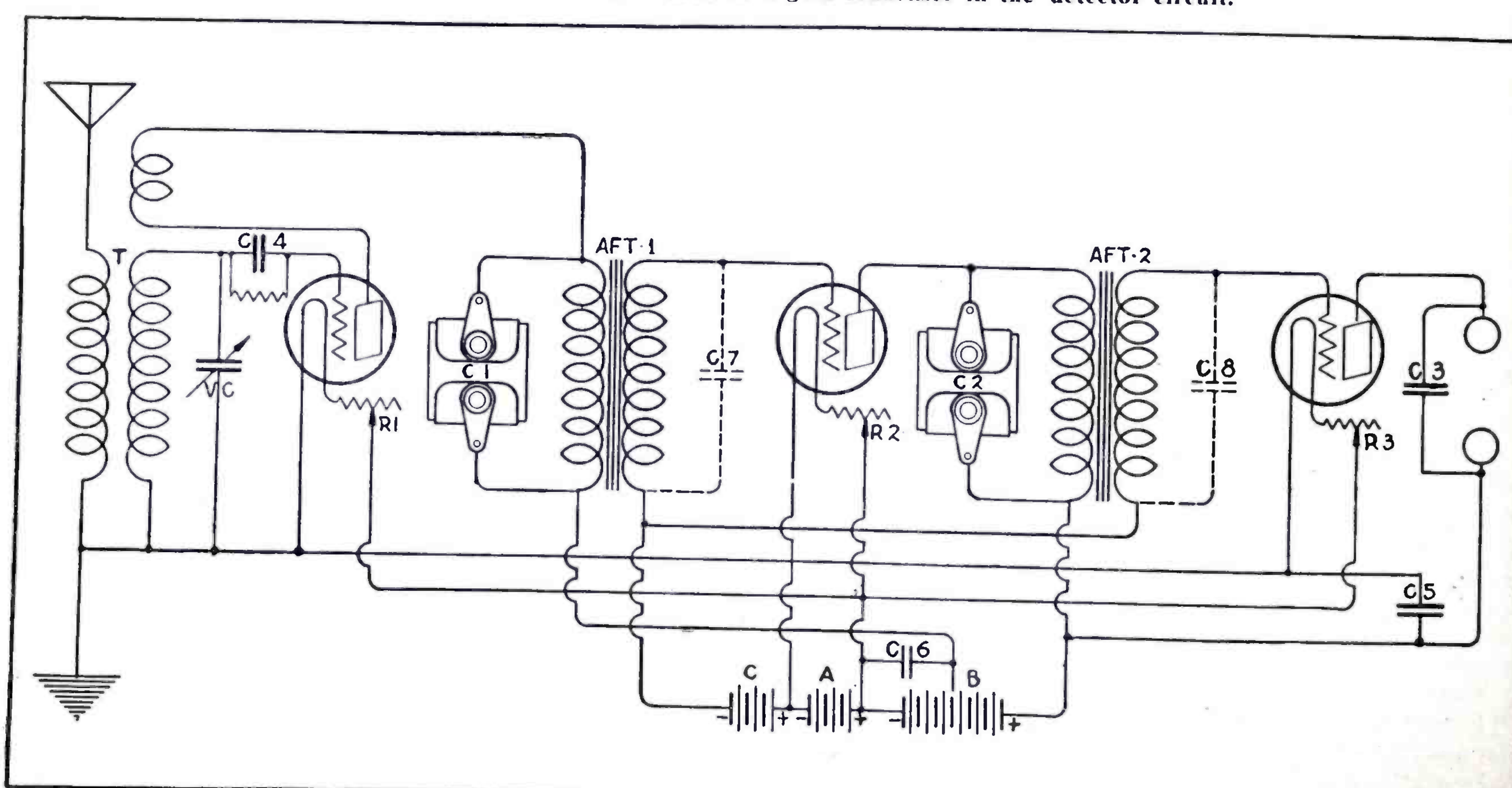


Fig. 2.—Fixed condenser at C_1 and C_2 used as a by-pass for radio frequency currents.

*Dubilier Condenser and Radio Corporation.

any cases it is an absolute necessity. The most important use of fixed ndensers is in the position of grid ndenser (Fig. 1) in the detector rcuit where it so modifies the action the vacuum tube, which is normal- an amplifier, as to make it a very perior form of rectifier; in fact, t only a rectifier, but a very effi- ent form of audio detector. Radio aves as sent out by a broadcasting ation are continuous waves modu- ted according to the speech or music gnal. These modulations consist of aggregation of frequencies from bout 25 to 5,000 cycles per second, ving various amplitudes and phases. he continuous waves, known as car- er waves, are of such high fre- uency, that they are not directly au- ble. Even if it were possible for e human ear to respond to such pid vibrations, we could find no echanical contrivance, such as a lephone diaphram capable of vibrat- g at this rate. It becomes neces- ry, therefore, to take these high equency currents and convert them to currents of audible range, for hich purpose it is necessary to rec- fy the incoming pulses, that is to y, make them uni-directional. Var- tions in these uni-directional pulses e of audible frequency and can, erefore, be heard in the head-set. here are several methods of recti- fying these radio frequency pulses, he most efficient of which is by means of the grid condenser. It must not be supposed that the grid con- denser of its own accord acts as a rectifier, since from the electrical nature of a condenser this is impossible. The effect of a grid condenser used with a vacuum tube is to allow the tube to rectify the incoming pulses and amplify them at the same time. This is really the chief advantage of the grid condenser rectification scheme. It permits of simultaneous rectification and amplification by one tube. The size of the condenser used for this purpose is either .00025 mfd., or .0005 mfd., depending on the characteristics of the vacuum tube used, and the range of frequencies being received.

Another use to which fixed condensers are put is as a by-pass for radio frequency currents (Fig. 2 & 3). In practically every circuit, such as the regenerative, neutrodyne, reflex, etc., it is absolutely necessary to pass currents of two different frequencies simultaneously from the output of one tube to the input of a succeeding tube. Audio frequency transformers when placed in the plate circuit of a vacuum tube, cannot pass currents of a very high frequency because of the choking effect they exert on such currents. This choking effect is caused primarily by the iron core in the transformer. Since it is necessary to pass radio frequency currents in this same circuit, the only means by which this can be accomplished is by placing a small fixed condenser across the primary of an audio frequency transformer. This condenser will allow currents of radio frequency to pass through it, but will deny the passage of audio frequency currents. Conversely, the primary of the audio frequency will pass audio frequency currents and prevent the passage of radio frequency currents. Thus, the necessity of a condenser across iron core inductances is apparent.

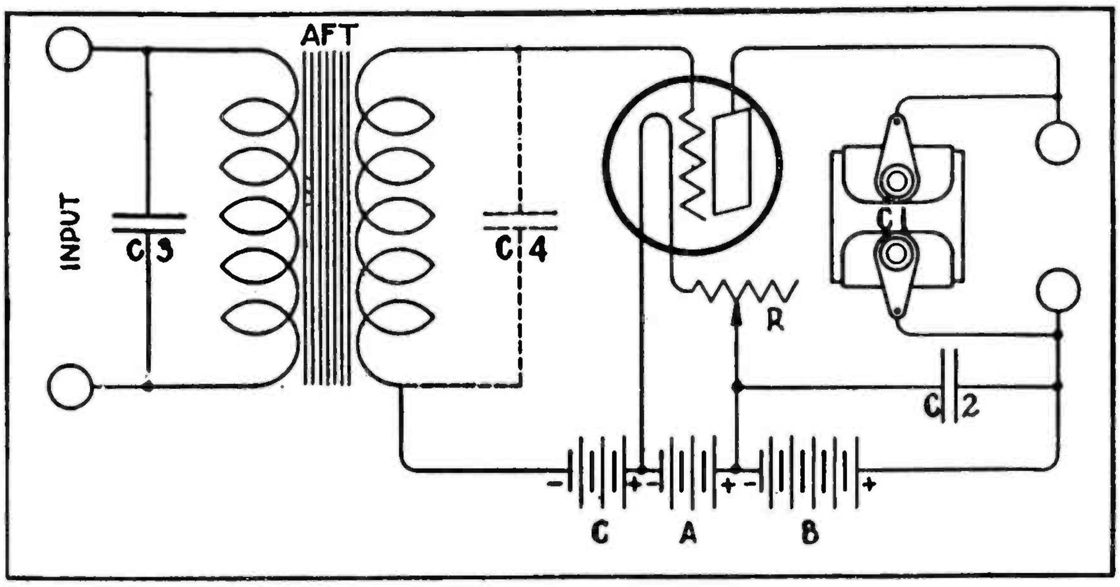


Fig. 3.—Another example of a fixed condenser, shown at C_1, used as a by-pass for radio frequency currents.

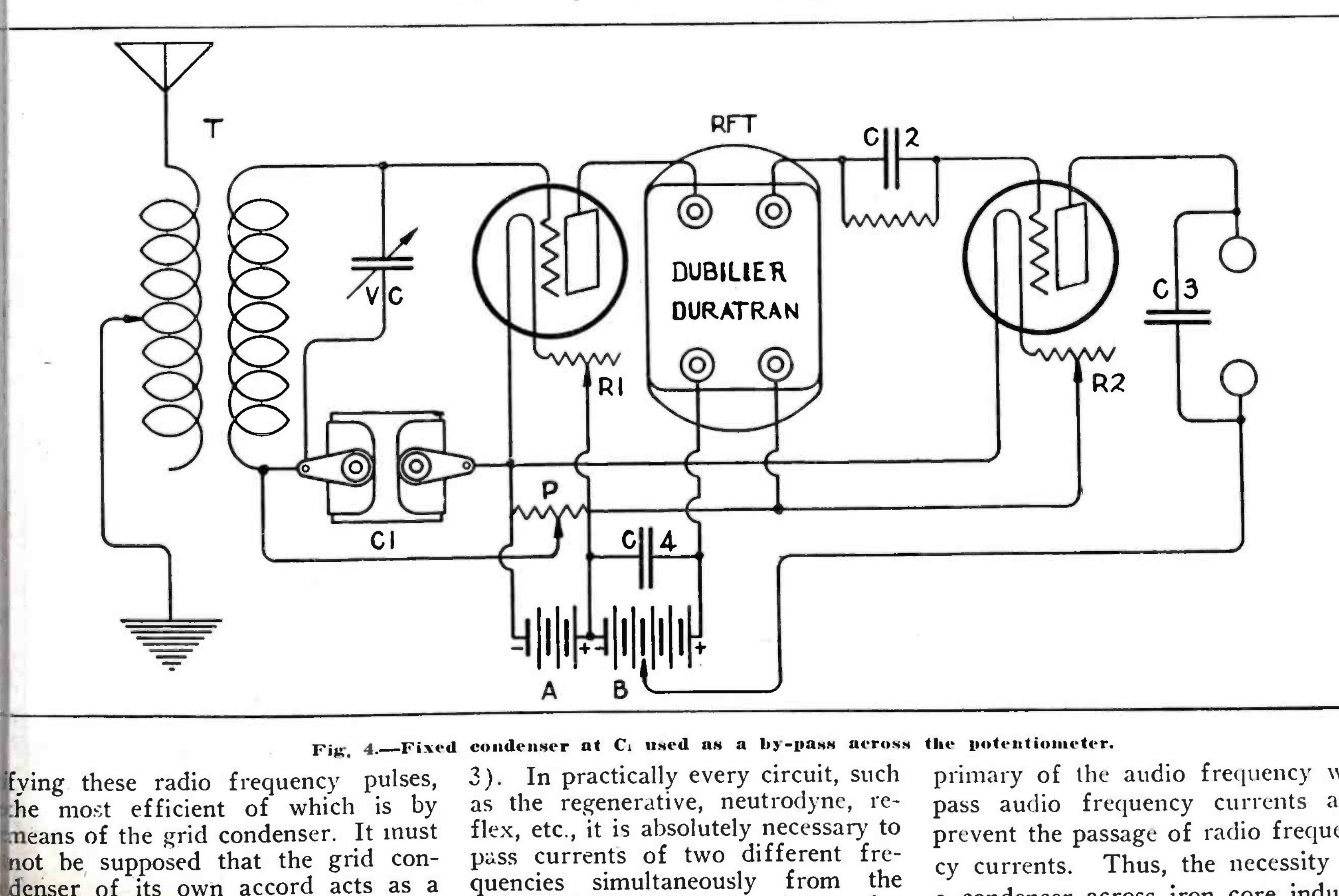


Fig. 4.—Fixed condenser at C_1 used as a by-pass across the potentiometer.

In addition to this use of fixed condensers across inductances, there are other uses, such as by-pass across resistances and batteries. An example of the former use would be as by-pass across a potentiometer, (Fig. 4) while an example of the latter would be as by-pass across the "A" battery; this latter connection being for the purpose of shunting out the radio frequency resistance of the battery leads when the batteries are situated at some distance from the set.

An important use of fixed condensers which is of economic value rather than electrical, is in the position of by-pass across a "B" battery. When a "B" battery is new, its internal resistance is very low and it is devoid of all internal local action. After it has been in use for some time, the chemical action within it has resulted in the formation of substances of very high resistance and there results continual minute fluctuations in voltage due to local action on the electrodes. By the use of a 1 Mfd. condenser across the battery, (Fig. 5) are smoothed out, giving a steady these minute fluctuations in voltage flow of current devoid of all noise.

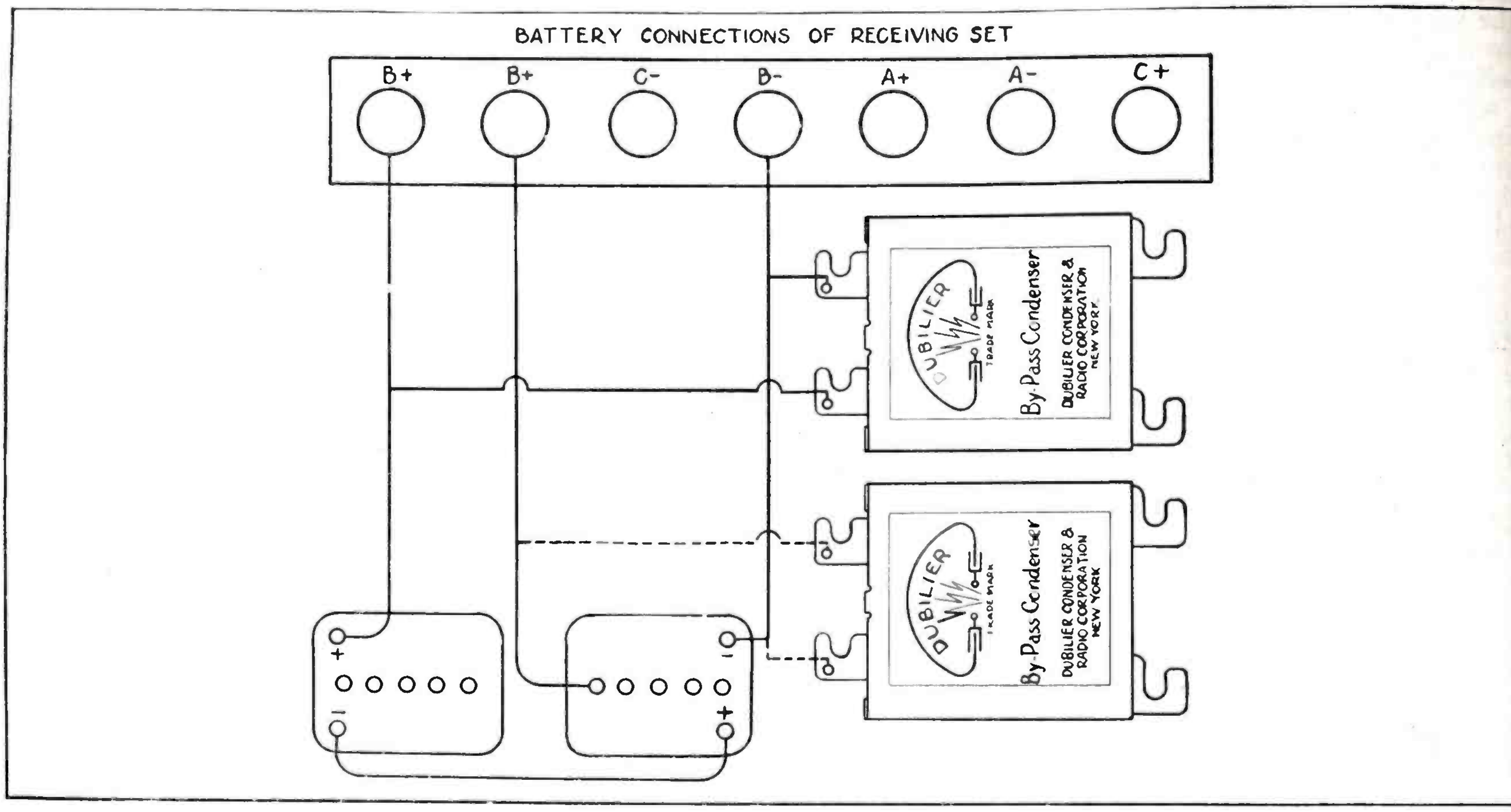


Fig. 5.—Diagram showing the use of 1 mfd. condensers across "B" battery.

In transformer coupled amplification it is possible by the judicious use of a fixed condenser across the secondary of the transformer, to improve the quality of reception. Such use would be advisable where a transformer is of very high ratio, and in consequence the voltage amplification

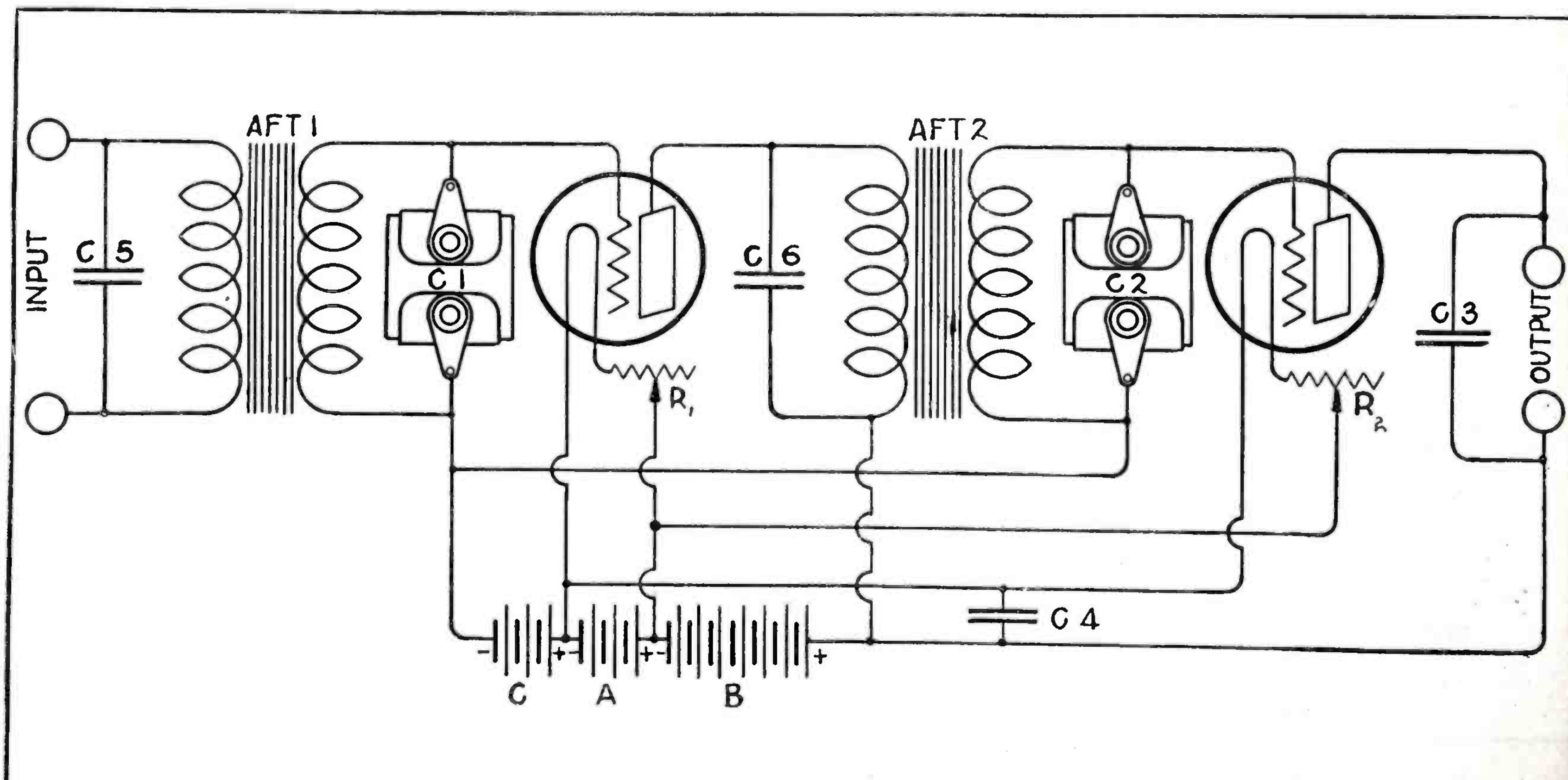


Fig. 6.—Condensers placed across the secondaries of the audio frequency transformers at C_1, and C_2 for the purpose of improving the quality of reception.

very high at high frequencies giving peaked amplification curve. It is en possible by placing a condenser ross the secondary (Fig. 6) to atten out this upward characteristic, d thereby reduce the distortion at e higher frequencies.

The proper use of fixed condensers operating point of a tube is for a slightly negative or normal grid potential, the simplest remedy lies in the use of blocking condensers in the grid leads. This solution, however, introduces a difficulty, for regardless of the size of condenser used, its reactance will vary with the frequency. It is the .006 Mfd may be used without any appreciable distortion. However, for best results, a capacity of .02 Mfd. is recommended. With a well constructed amplifier the grid resistance should not be less than 1-2 megohm, and the negative bias of the last tube should be considerable. The faithful-

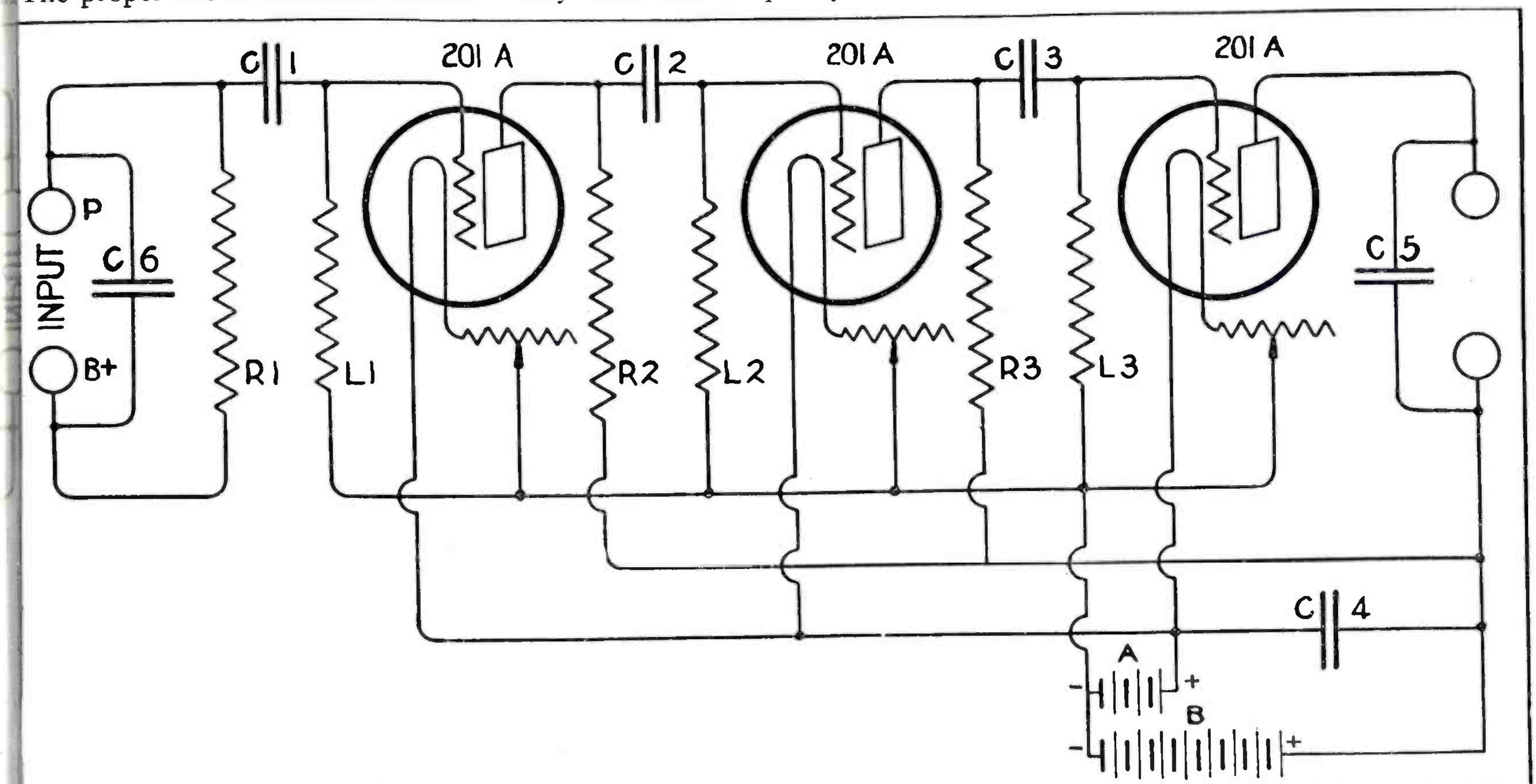


Fig. 7.—Diagram showing the correct use of fixed condensers in a resistance coupled amplifier.

a resistance coupled amplifier (Fig.) makes this type of amplifier, without doubt, the most faithful of reproducers. This item is so important in e design of resistance coupled amplifiers that the use of an incorrect apacity will result in this form of mplifier distorting to even a greater xtent than transformer coupled amification. One of the most important problems in the design of resistance coupled amplifiers is the avoidance of communicating the "B" battery voltage drop across the external ate circuit resistance to the grid of e succeeding tube; for under these onditions, the grid will have a very rge positive potential. Since the best real cause of distortion in any resistance coupled amplifier. The larger it is made, the less the distortion. The reason for the distortion is that since the voltage drop through the condenser varies with the frequency, the voltage impressed on the succeeding grid is different with different frequencies from the voltage output across the plate resistance. It is entirely possible by the use of a very small condenser to cut off nearly all of the voltage at the lower frequencies, thus causing considerable distortion. The proper blocking condenser to use in a radio frequency amplifier is not necessarily as high as 1 or 2 Mfds. Condensers as small as ness of reproduction of this type of amplifier is about as perfect as it is possible to obtain at the present time. It is quite apparent therefore, that the blocking condenser in this type of amplifier is of paramount importance.

In choke coil amplification the blocking condenser serves the same purpose as in resistance coupled amplification and it should be of approximately the same size.

There are many special circuits in which fixed condensers may be used as coupling condensers, such as the Browning Drake, super-heterodyne, super-regenerative, reflex, and the like. In most of these circuits they serve as by-pass condensers.

A Practical "B" Battery Eliminator

(Continued from page 115)

lification very nicely. For a Super voltage of 90 to 100 is available ith a current draw of 40 mils. The hole assembly can be mounted on baseboard 9x12 inches and the panel an be a strip of rubber or bakelite x9 inches. The various views show he assembly from different angles, hile a separate view shows the transormer and choke coil, also one of the rectifier cells. The jars used for the latter should be fairly large. The standard storage battery jars will do very well for this purpose, but all traces of acid must be removed from the jars and the rubber caps.

In conclusion the writer wishes to state that the construction of this B Unit will amply reward the builder for his efforts. Many a receiver that performs only in a mediocre way when B batteries are used will deliver a much clearer tone and crisper signals when current is supplied with the B Unit. Local stations can be tuned down for fine tone shadings and distant stations will be loud and clear by adjusting the amplifier voltage to the best point for the particular receiver.

The Passing Fallacy of Matching Tubes

By JACOB HOLENSTEIN*

with a power tube

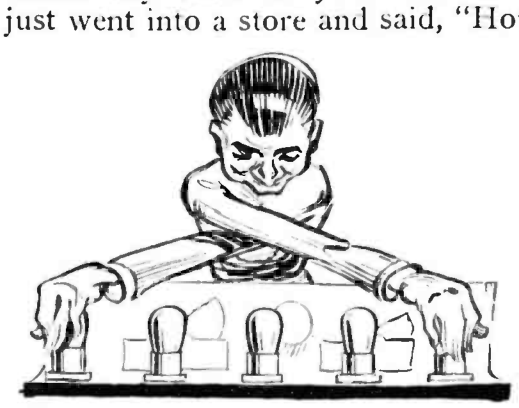
AS ever, in watching the fascinating developments in radio, I have been intensely interested in the recent demand for tubes of specialized charteristics for specific purposes. I use the pronoun in the first person because this is meant to be, not a solemn discourse on an abstract technical subject, but rather an informal conversation on some items of interest to the ordinary lay student of his receiving set. A one-sided conversation, 'tis true, but then the reader can tune out in self defense at any time, and no one will be the wiser.

Those of us whose activities in radio have been principally concerned with the design, development, and manufacture of tubes, have long foreseen, and long advocated this new point of view, this idea of specialized tubes, each designed for a particular purpose, and that is why we find it so gratifying that our ideals are beginning to bear fruit.

There are many things going on in your set while you sit there listening to your favorite orchestra, more things, Horatio, than you wot of. And nearly all of those things are being performed by your tubes. Not quite all. Because although the tubes are the heart of the set, yet neither can function without the other. The tubes are an integral part of the circuit. Their functions, and the manner in which they carry them out, are in part dependent upon their own characteristics and for the rest dependent upon the characteristics of the circuit. Your set with different tubes will behave differently. That is why when you change only one tube you will nearly always have to readjust your tuning, rheostats, and potentiometer. And your tubes in a different set will act differently, do different work, and do it differently. Nay, more, your tubes, if rearranged in your own set, will display these differences.

In a more or less vague way you have known this all along. And when somebody said to you, "Look here, see how differently these tubes behave when you change 'em around? You ought to get tubes that won't behave that way. You want tubes that are all alike so you can change 'em around carelessly, without spoiling your reception. Get matched tubes,"—when somebody told you that, it sounded good, didn't it?

Matched tubes—what magic was in those words And what a fallacy. What do you mean by matched tubes? Do you mean that the tubes should be matched to your set, to each socket in your set? Or do you mean that the tubes should be all alike in every jot and tittle, without reference to your set? You meant the latter, didn't you. Fess up. It never occurred to you to match any tubes to your set. You just went into a store and said, "How about matched tubes?" And the man said to you, "Yes, sir, how many?" And you said "Five," or "Three," or "One" (don't laugh—I've seen it happen) as the case may be. And you took your tubes home and maybe you got a little better results, and maybe you got poorer. If you got better results you said "That's good dope; matched tubes are the cat's." And if you got worse results, you said the tubes weren't properly matched.

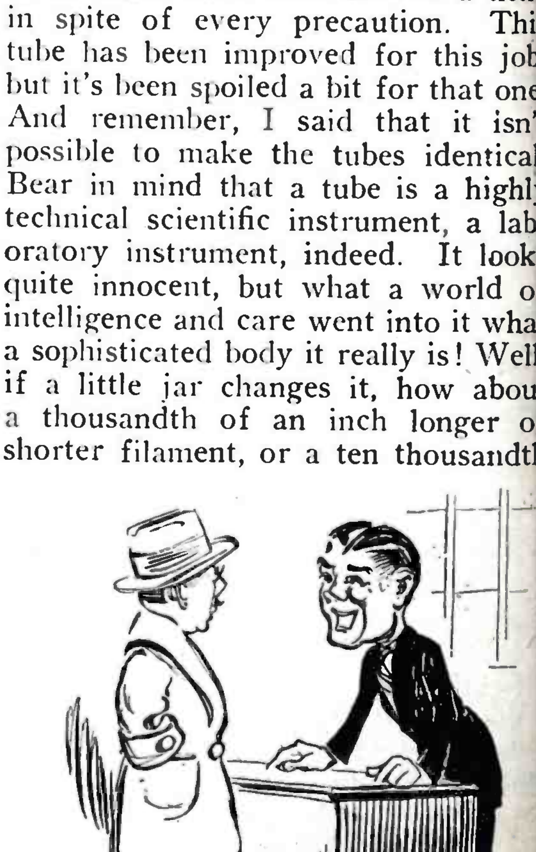


the gentle art of switching tubes

Now how did this idea of matching tubes originate? In a perfectly sensible and legitimate way. You know how our entire civilization is a constant struggle between two great principles, a constant effort to adjust two great opposing tendencies, namely: "Standardization" vs. "Specialization." Well, here's how it worked out. Leaders of the tube manufacturing industry decided to put out just a few types of tubes, let's say one type for dry cells and one for storage batteries. Take one of these, the three volt tubes for example. Those tubes were to be made with the utmost possible uniformity, so that you could go into a store and buy one like you would buy a bar of laundry soap, for instance. You go home, put it into your set, push your switch, and you're through. Or you buy five tubes, put them in, and that's all. Whatever result you get, that's what you get, and you can't change it. The thing's simple and easy, requires no special knowledge or intelligence, and thus avoids all kinds of trouble and difficulty. Really, you can't find fault with the people who thought this way, can you? Their intentions were of the best.

But what happened? You bought five tubes, put them in, and got fair results. Perhaps you had an extra tube around. You took one out and put the extra one in. Fine. Then you took the tube now left over and tried it in another socket. Here worse, here better. You soon found that this tube worked better in this socket and that tube in that socket. Why? Lots of reasons.

Here are a few. I told you about the different functions of each socket. We'll pass that over for the present. There are other reasons. Even if it were possible to make a million tubes, identical in every respect, and believe me, it isn't, if you take a few of them, and ship them from factory to distributor, from distributor to dealer, and then carry them home, you will shake them a bit and the internal spacing of the elements will be deranged a little. Just a little,—but enough to make your twin tubes quite unlike. Your tubes have been altered a little in spite of every precaution. This tube has been improved for this job, but it's been spoiled a bit for that one. And remember, I said that it isn't possible to make the tubes identical. Bear in mind that a tube is a highly technical scientific instrument, a laboratory instrument, indeed. It looks quite innocent, but what a world of intelligence and care went into it what a sophisticated body it really is! Well, if a little jar changes it, how about a thousandth of an inch longer or shorter filament, or a ten thousandth



"gimme one matched tube"

*Sales Manager, Conneway Elec. Laboratories.

f an inch difference in the diameter f the grid wire. You ain't heard othin' yet, as Jolson sings, but you now what I mean. No, indeed. The est we can do, and it's a lot, really, to use a very rigid standards, and ery narrow requirements, paying attention to two things,—first, that the verage values shall be such and such, nd second, that the tube must be ithin so much of the average. That's atching, properly done. Anything urther than that is really not representative of sound knowledge of the anufacture of tubes.

So that's how this "Specialization" ea began to get the upper hand in adio. If this tube makes a better adio frequency amplifier than that ne, how come? And if my pet audio mplifier tube burned out, how could ever replace it? I was pretty lucky catch this one.

The technical end of all this readjustment of ideas kept progressing in he laboratories. We worked out what detector should be and do, what an f. tube should be and do, and what e audio tube should be. The oscillator, the rectifier, the various stages f amplification have all been carefully studied, and while we do not et know all there is to know about ubes, we've certainly been making onderful and rapid strides. After all, ond reader, who does know all there to know? Take all the knowledge at every first class tube engineer as about tubes, today, and put into ook form and you'll have a dozen olumes or so. But come back to that helf in the library next year and ount the volumes. And the year after nd the next generation. Really, we've ardly scratched the surface. Yet I might mention, with justifiable pride ou will agree, that it is incontrovertible that America's knowledge of ubes, and American tubes, excel reatly those of the rest of the world.

But let's get back to the plot. I promised not to get technical, and I won't. But we must look at tubes little more closely for a moment. And then if you want to follow the echnical side of this discussion a little urther, perhaps in a subsequent article we can take that up.

What does a detector do? It takes minute alternating electrical impulses of extreme complexity and of great requency and irons them out a bit and sifts them a bit, side-tracking part, and giving you the rest in agreeable audible form. It has to be extremely sensitive. What does that mean? Why, simply that an extremely faint impulse should be able to stir t, make it step. We'll not, at this time, go into the relative values of hard and soft detectors. That's on the table for future discussion. But, hard or soft, the detector should certainly have a low internal impedance, by which we mean that it should offer small resistance to the passage of plate current through itself. Its grid control should be great, but within such limits that it will not distort the signals it gets. Enough for that.

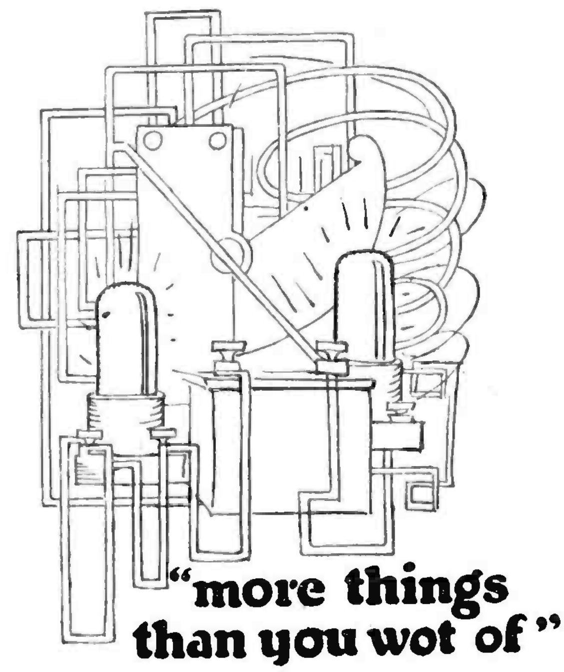
What does the radio frequency amplifier do? It takes this very faint and very complicated alternating impulse and magnifies its every convolution, so that it can be more easily handled by the detector. That's why r. f. gives you distant signals. Your detector might not be able to do its stuff, until the r. f. amplifier has enlarged the radio wave. So the r. f. tube must be sensitive, but low impedance isn't as important as a high voltage amplification, called the amplification constant. That should be great, very great. And the tube should be extremely hard so that no distortion can enter. The tube doesn't have to pass much current, but must pass along the impulses it gets with no change of any kind except to magnify them exactly, or pep them up as much as possible.

Now how about the audio frequency amplifer? That tube gets the rectified impulses that the detector is sending out. The frequency is low, and the current is comparatively heavy, but direct, not alternating. It has to magnify those impulses, but its job is a little easier in one way, though harder in another. It doesn't have to dance to such extremely complicated measures as its predecessors. But it has to handle much more power, and increase that power. So its impedance must be low to pass as much

current as possible, while its amplification constant must be somewhat lower so as to avoid any possibility of distortion under its heavy load. And the second audio tube, handling a still heavier load, should have a still lower impedance and a still lower amplification constant. So many second audio tubes are overlooked in the sets now in use. Yours very likely is. And if you are using ordinary tubes, you either have distortion, or cannot use all the volume the set is capable of, or perhaps a little of each is present.

What other tubes do in specialized circuits we will leave for future discussion because not so many such circuits are in use, for one thing, and the appropriate tubes are not yet available, anyhow.

"Well," you say, "suppose I agree with you that I ought to have specialized tubes for each socket in my set, what am I going to do about it? Can I get any?" Yes, indeed you can. Not, perhaps, everything you need. But you can make a start.



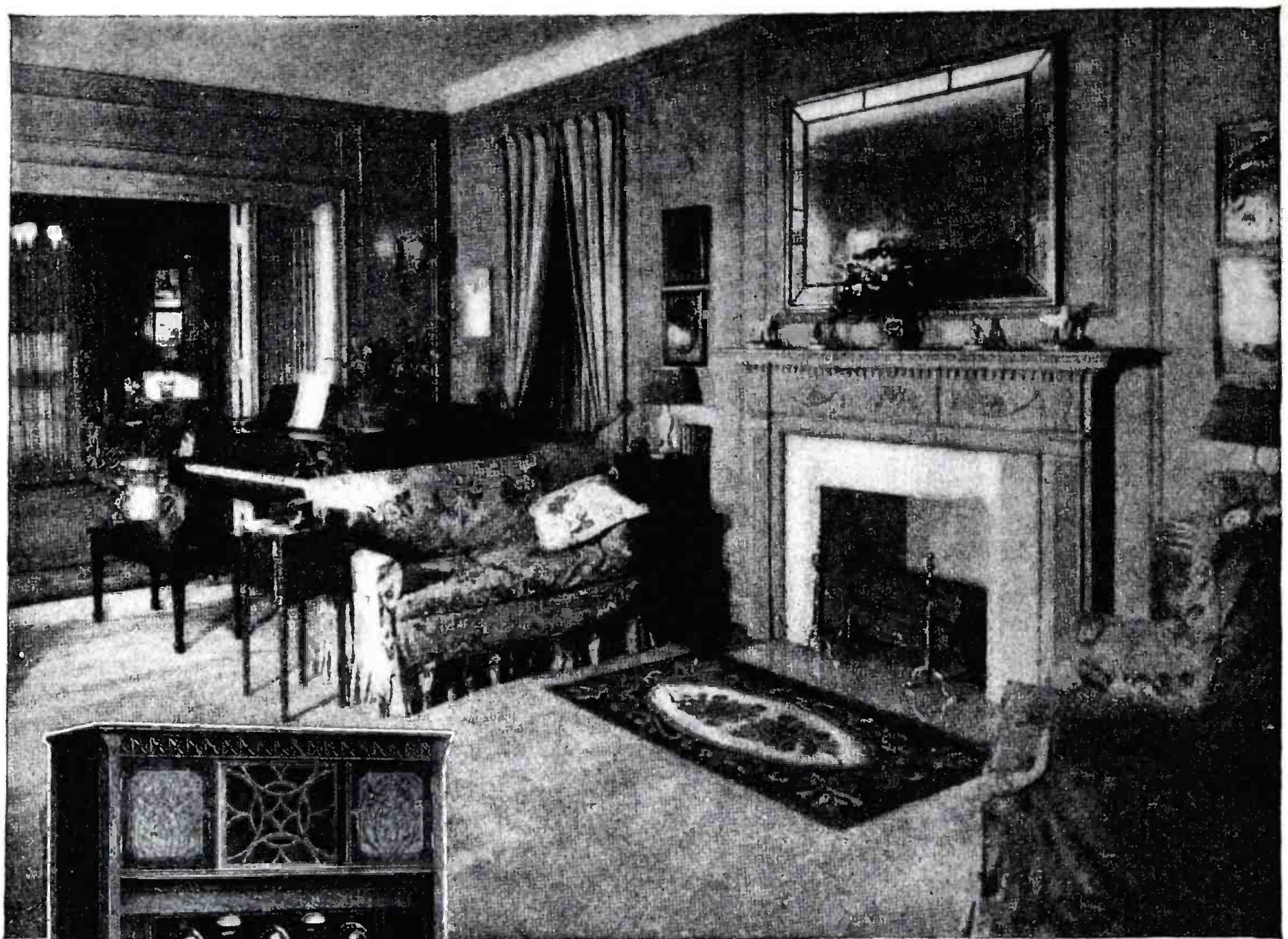
Since it is pretty generally the fact that receiving sets now in use, yours too very likely, are capable of delivering more power than they do, some of the more enlightened and more progressive tube manufacturers have begun by tackling the neck of the bottle. And that is the last tube, the second audio tube, the tube that delivers the stuff to your loud speaker.

Take a three volt, or one ninety nine set, for example. Your r. f. tubes, and your detector, are functioning beautifully. You plug your head phones into your detector jack and you get splendid quality, and very gratifying DX. Then you plug your head phones into your first audio jack and you get all of that with very nice volume, sometimes too loud for your comfort. When, however, you plug your loud speaker into the last jack you find that there's too much noise. There's volume, but not of music,—of all sorts of racket. So you adjust your dials until you get more satisfactory results. Now, when you have done that, you have either cut down your volume below the point that satisfies you, or you still get distortion.

What's wrong? Simply this, that your last tube is overloaded. It can't handle the load it gets, smoothly. A special tube, built for the purpose, is necessary— a power tube.

The Magnatron DC-120 is one of a few tubes that is built for the last audio socket of that 199 set. It is a 3-volt tube. It has a low amplification constant, so that the swing of the grid

(*Continued on page* 175)



The Counterphase Receiver

By J. T. CARLTON

An Exceptionally Efficient Broadcast Set Employing Toroid Type Coils

THE circuit described herewith is one that has attracted an un-ual amount of attention during re-nt months, and at various radio ows through the country has been iled as one of the most popular cir-its of the season. It is noticeable o for the further reason that it is e of the comparatively few circuits ng manufactured at this time that covered by patents, the same hav-g recently been issued to Harry A. emer and assigned to the Bremer-lly Mfg. Company.

The Counterphase Circuit as de-gned is particularly adapted for the e of "toroidal" or so-called dough-t coils, the Torostyle transformers ed therein also being an item on ich the constructional and design atures are likewise covered by tents granted to Mr. Bremer a ort time ago. Particular mention made of this toroidal coil for the ason that it differs from any other milar coil on the market, being de-gned particularly for the Counter-ase circuit which makes use of an cillation control method employing additional winding.

Oscillation Necessary

As the principles explained herein come better understood the neces-

underlying the Counterphase method are along the same lines as used in the B-T Nameless Circuit of the past

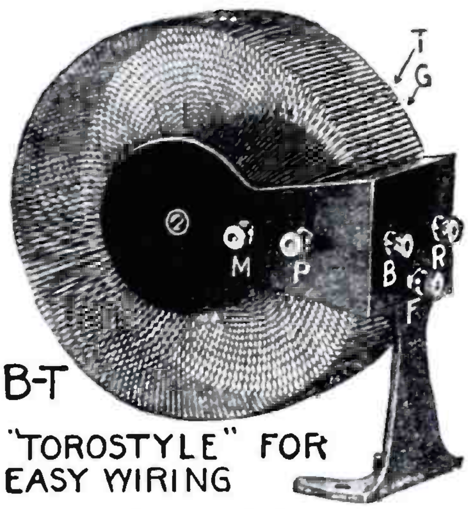


Illustration by Courtesy of Bremer-Tully Mfg. Co., Chicago, Ill.

This is the toroid type of coil used in the Counterphase Receiver. It is especially designed to simplify wiring and to eliminate interactive effects that generate noises in receivers.

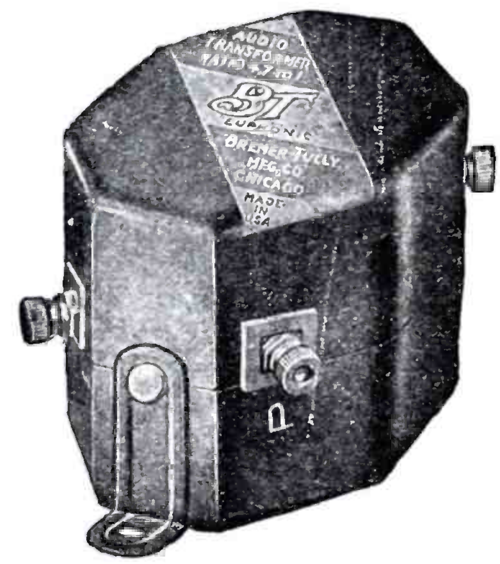
two years but with further added refinement made possible thru the development of apparatus which permits greater simplicity of operation and more efficient results.

Selectivity is one of the greatest of present requirements and also the ability to shut out local disturbances. A great aid in accomplishing this ob-

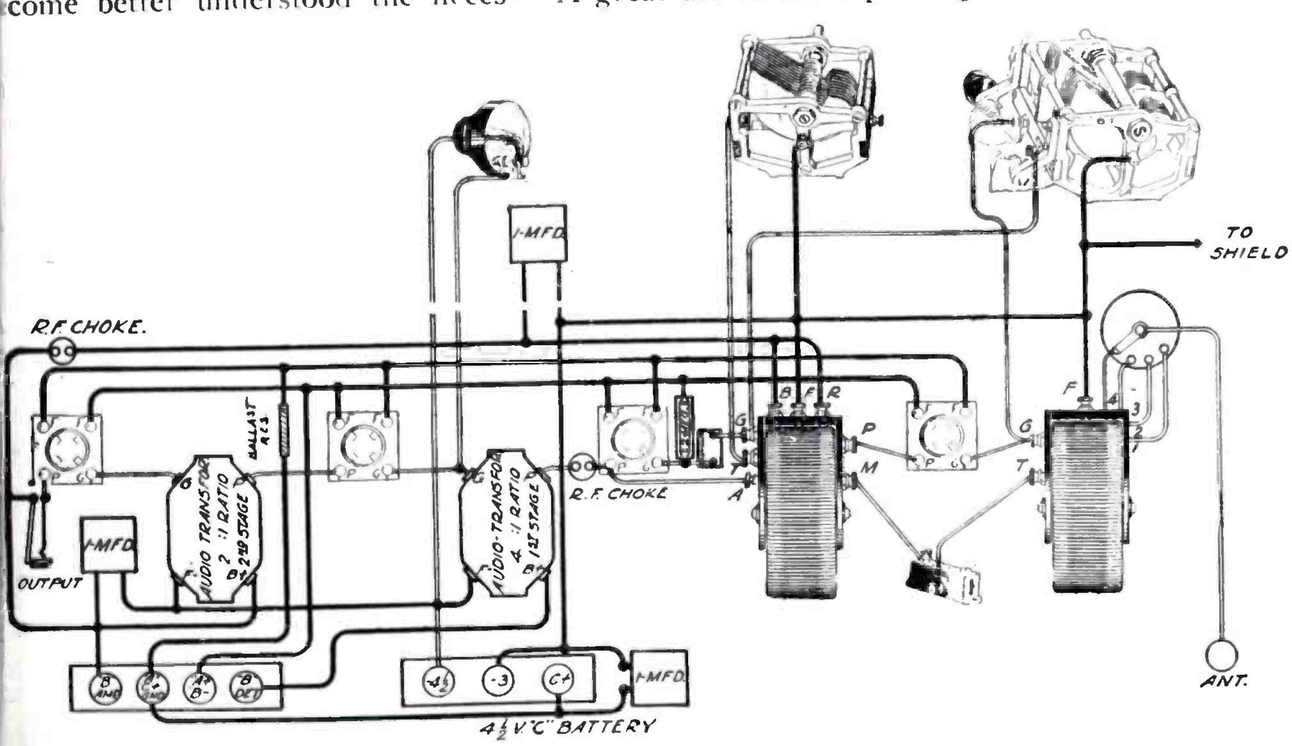
efficiency which would result from the enclosing of the open type of coil.

Counterwise Theory

Theoretically the B-T Counterphase method employs a "bridge" between output and input circuit. Counter potential is derived from a coil inductively coupled to the plate circuit and sent thru an adjustable capacity to a coil inductively coupled to the grid circuit. The use of such coupled coils either as such or when



Audio frequency transformer used in the Counterphase Receiver.



Picture wiring diagram of the Counterphase set.

used with inductance, resistance or capacity, in series, is covered by the Bremer patents. To secure the greatest results from the use of this method extremely careful design is necessary to avoid such an increase in grid-to-plate capacity as to prevent neutralization at the lower wave lengths. This has been worked out in the Torostyle transformers by the use of the main outside winding as a secondary with an interior supporting member on which is placed a primary winding and also the special or Counterphase winding.

ity for such method of oscillation ontrol becomes more and more apparent. The elementary principles

ject is to be able to fully shield a receiver and the closed style of coil permits shielding without the loss in

Oscillation control method

The general methods in use for stopping oscillation at this time are fairly well known, one of the most simple and common being the addition of sufficient resistance to prevent the possibility of oscillation. The fallacy of such method is at once apparent when we consider the efforts that have been made to reduce losses in coils and condensers.

Among the other methods, those of direct resistances, absorption coils and eddy current losses secured by placing condensers within the field of a coil are more or less generally used in the circuits referred to as "self-neutralizing"; while still another method is that of slightly detuning or de-resonating the plate circuit by reducing the plate load or number of turns in order to cut down the coupling.

Control Must Be Variable

The weaknesses of these various methods lie in the fact that the energy transfer between tubes is reduced where the coupling is cut down sufficiently to stop oscillation on the lower wave lengths and this same unsufficient coupling results in very unsatisfactory response on the longer waves. In other words, the method answers only for part of the range,—and this brings up immediately the question of a variable control.

It is pretty generally understood that in operating a regenerative set some method is necessary whereby the feed-back is brought just below the point of oscillation. In other words a variable tickler is necessary.

In the Counterphase there is likewise a variable control of oscillation ni irder to secure the same efficiency on both high and low wave lengths, an opposite method however being used, which prevents or eliminates regeneration instead of producing it.

Dual Resistance Control

The method employed to secure this control is quite ingenious. Consider a condenser with a variable resistance in series. If the resistance is changed the capacity of the circuit is changed without turning the condenser. Now picture two condensers using this common resistance. A variation in the latter will change the capacity of both circuits simultaneously. The condensers in question are the small neutralizing condensers which are first adjusted, after which they can be controlled by means of the resistance knob which at the same time is also used for the other part of the resistance in series with the B battery circuit.

Where it is desirable to cut down volume, sensitivity is not required. Where sensitivity is what we are after we also want as much volume as can be secured. The dual resistance has two separate arms, one of which is always at zero when the other is operating; tuning in one direction increases both sensitivity and volume; turning in the other direction decreases both of them.

There is still further fortunate factor operating to our advantage in the fact that this method does not introduce losses into the grid circuit or interfere with selectivity and in addition to that it does not effect dial readings by detuning the circuit.

External Circuit Great Improvement

It would seem that this solution of using an external circuit designed to feed back energy of opposite potential in such manner and amount as to overcome or break down the regenerative action of the tube is in itself of considerable importance, but when it also adds a surprising increase in the transfer of energy per stage there is a consequent great increase in amplification.

(Continued on page 175)

Notes on Wavetraps

Their Theory, Construction and Method of Operation

WAVE TRAPS aid considerably in the tuning of radio receiving sets that are not inherently selective and in *The Irish Radio Review* an article entitled, "All About Wave-traps" gives many details on the construction of these instruments that will be interesting to everyone. The article follows:

Every serious amateur needs a wave trap sooner or later; and it is for those radio workers who wish to increase the selectivity of their sets that this article has been written.

If it is necessary to write with the strictest degree of truth, it must be said outright that the title of this article is, perhaps, a little in the nature of a misnomer. It would be impossible to write down within the confines of these pages *everything* concerning the theory and working of interference eliminators or wave traps, as they are more commonly and happily called. For one thing, space in this journal, like life, is not exactly unlimited, and again, there are quite a number of things concerning the mathematical theory of wave traps which the radio amateur, and more especially the beginner in the science and pastime of radio, does not ordinarily require to study.

But, nevertheless, it is proposed in these columns to put into a concise form that which may well be called the applied theory of wave traps and rejector circuits, and also to give brief instructions for the making and operation of one of these almost indispensable instruments.

Wave traps are used at the present time simply because in all radio sets there exists a deficiency which has not yet been overcome by radio inventors and scientists. That deficiency is to be seen in the fact that very few practical wireless circuits are really selective in the strictest sense of the term. With an ideally selective receiver, it would be possible to operate the set under the nose, so to speak, of a broadcasting station, and to receive far distant transmissions at will without being "jammed" by the local station. A really selective receiver would pick out a station transmitting on, let us say, a wave length of 500 metres from stations transmitting wave lengths of 495 and 505 metres respectively. But with an ordinary radio set such a feat is impossible, or almost so at any rate, and it is only with the assistance of a carefully tuned and operated wave trap that such a feat is placed within the bounds of possibility.

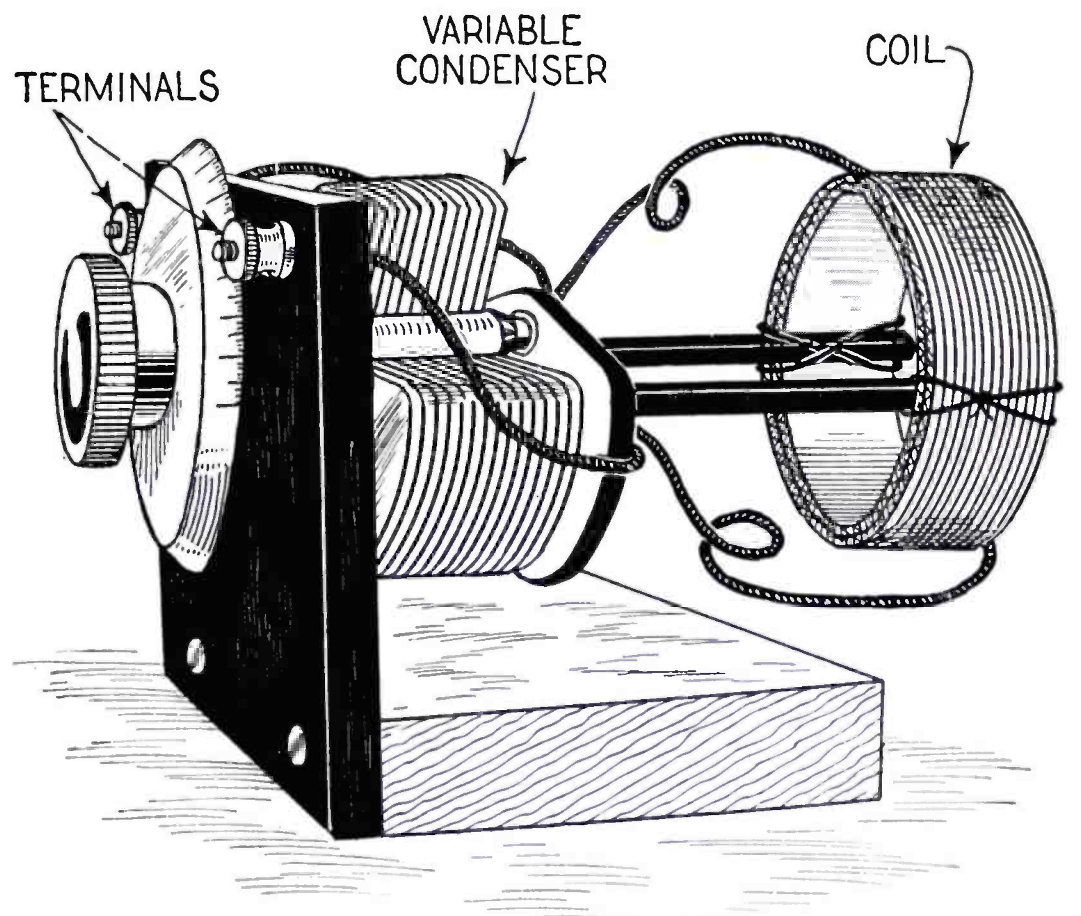
The Fundamental Principle

A wave trap, or an interference eliminator — call it what you will — is merely a simple little instrument which is attached to a radio set, or else included bodily in its circuit, and by means of which any interfering station can be cut out at will. With an efficient instrument of this type it becomes possible to cut out completely the broadcast from a local station and to receive other and more distant stations. Without the use of a wave trap, it is generally impossible to attain this end, and this characteristic non-selectivity of any ordinary radio circuit is more greatly in evidence the closer the receiver is to the interfering transmitting station.

In theory, all a wave trap consists of is a device by which an extra amount of inductance and capacity in a controllable form can be introduced into the circuit of the receiving set, or, more strictly, into the aerial circuit of the receiving installation. There are many different ways of arranging the extra inductance and capacity in the aerial circuit of the set, but they all operate the same way, i.e., by absorbing the unwanted radio energy from the aerial and by allowing to pass that which is required by the operator.

The extra "rejector" circuit must be placed in parallel or in series with the aerial circuit of the receiver. This rejector circuit, which comprises the wave trap, is separately tuned, either by altering the amount of its inductance or its capacity, to the wave length of the interfering station, and the interfering signals are absorbed by the trap and passed to earth, whilst the wanted signals are passed on to the set, very little weakened, if any, in strength and initial intensity.

There are two main types of wave trap circuits in use at the present time. The first contains two separate circuits arranged in parallel with the aerial and ground of the receiving set. One of these circuits is tuned slightly above the wave length of the station it is desired to receive; the other is tuned slightly below that wave length. Such a rejector circuit is illustrated in diagram at Fig. 1.



Illustrations by Courtesy of The Irish Radio Review (Ireland).

Fig. 3. A simple wave trap for ordinary use in connection with broadcast receivers.

It is somewhat difficult to operate, however, and by far the most simple form of wave trap or rejector circuit is the one which is illustrated at Fig. 2.

This circuit, as will be seen from the diagrammatic illustration, consists of an inductance coil and a variable condenser arranged in parallel, and this arrangement of inductance and condenser is placed in series with the aerial of the receiving set. The amounts of inductance and capacity may be made variable by means of employing a tapped inductance and a variable condenser. Generally speaking, however, it is more practicable, and more efficient, for most purposes, to employ a variable condenser and a fixed coil, the necessary tuning being effected by means of the condenser.

How to Make a Wave Trap

A simple home-made wave trap, working on this principle, is shown in the photograph, Fig. 3. In this instance, it will be noticed that the instrument consists merely of a small panel mounted vertically on a wooden base. The size of the panel is approximately 5 by 3½ inches, while the base measures 5 by 4 inches, the latter being about 1½ inches thick.

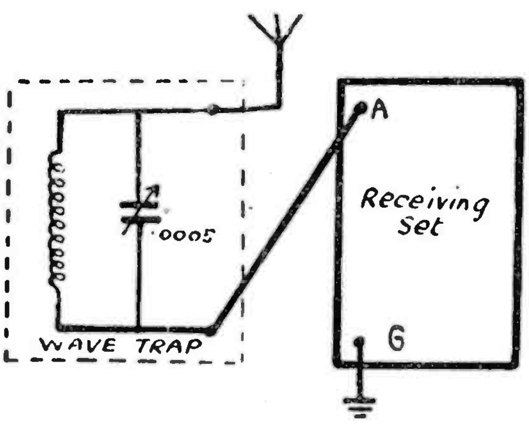


Fig. 2.—Diagram of simple one circuit wave trap showing method of connection to receiving set.

The condenser is mounted on the panel in the usual manner, and two binding posts are provided, one for the aerial lead and the other for the lead to the receiving set.

The matter of mounting the inductance coil in the wave trap is a process of individual preference. The instrument illustrated was constructed in a few moments, and therefore the necessary coil is merely tied on to two projecting strips of metal about two inches in length.

If a very neat wave trap, however, is required, a coil holder may be mounted on the wooden base of the instrument behind the condenser, and the coils will be rapidly and conveniently changeable.

The wiring of the wave trap will readily be followed from a glance at the diagram, Fig. 2, and the mode of attaching the wave trap to the receiving set will also follow from a study of that diagram.

How to Operate the Trap

The wave trap, made as above, is connected up in series with the aerial and the aerial binding post of the receiving set. Before connecting up the wave trap to the set, however, the latter should be tuned as far as possible to the wave length of the signals which it is desired to receive without interference from any local stations. After this end has been attained, attach the trap to the set, and tune the trap by means of the condenser knob to the wave length of the interfering transmission. Finally, de-tune the receiving set. The unwanted signals will now be found to be cut out, and the desired transmission may be tuned in on the receiver.

It is important to note, in passing, that the wave trap is tuned in to the unwanted signals. It thus "accepts" them and passes on the desired signals (to which it is not tuned) to the receiving set.

The operation of the wave trap is simplicity itself. One cannot fail to get good results from its use, and to any radio amateur who has never experienced the freedom from interference which such a simple little instrument affords, the realization of the fact will come as a pleasant surprise.

Points to Note

In order to obtain the best results with any type of wave trap, however, there are several important points which should be carefully borne in mind.

The first of these is that the coil, or coils, which are employed in the wave trap should be composed of thick wire, about No. 20 or, better still, No. 18 D.C.C. wire. This cuts down the resistance losses in the circuit which forms the wave trap, and therefore there is no noticeable decrease in strength of the signals obtained from the receiving set.

It should also be remembered that it is better to have a greater amount of inductance than capacity in the aerial circuit. Accordingly, therefore, it is advisable to make use of the largest coil possible in the wave trap in order that a minimum amount of capacity may be introduced by the condenser.

Generally speaking, for the purpose of eliminating interference from local broadcasting stations, a coil containing about 50 turns of wire gives satisfactory results, although, of course, it is not easy to generalize on this question. The best results will be obtained by employing a coil of such a size that it allows the wave trap to be tuned up to the wave length of the unwanted signals with the minimum amount of capacity from the condenser.

The condenser itself should have a capacity of about .0005 microfarads.

Every connection in the wave trap should be well soldered in position, for it should be remembered that the instrument is placed in series with the aerial of the set, and thus if any energy is absorbed by loose contacts in the trap, the signal strength obtained in the 'phones will be decreased in consequence.

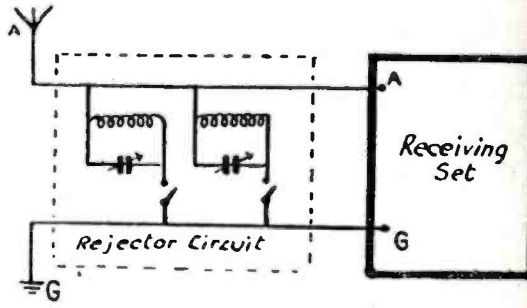


Fig. 1.—A two-Circuit wave traps diagram.

Any form of wave trap can, of course, be included in the actual cabinet of a radio set, and in this form it can be put out of action by means of a switch, but, generally speaking, the amateur will generally prefer to construct his wave trap as a separate unit which can be readily attached and detached from the receiving set. By adopting this procedure, many different types of wave traps may be experimented with until the most satisfactory one is found.

But, in conclusion, however, it may be remarked that, for all general purposes, and especially for cutting out local transmissions, a wave trap built on the lines indicated in this article will always afford real satisfaction to the amateur from the threefold point of efficiency, portability and inexpensiveness. A neater and a more handsome instrument may easily be made, but not, for general purposes, a more efficient one.

The Importance of the Loudspeaker for Radio

By S. B. TRAINER*

AS a result of the development of the radio industry which has brought into use radio sets that can receive long distance broadcasting with considerable volume, it has become possible now to use a loud speaker for almost all ordinary radio reception. Ordinary radio reception is now of such volume on a receiving set as to make headphones uncomfortable to use, so that the development of the use of the radio loud speaker has been very fast.

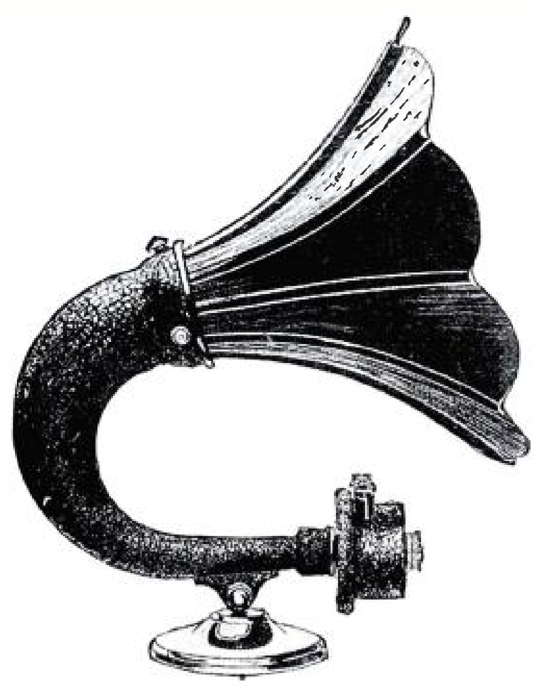
It has been necessary therefore to give greater consideration to the loud speaker as a part of a radio set than ever before and the manufacturers of loud speakers have been engaged in a mass of research work, in order to develop the loud speaker to the point of good radio reproduction where radio broadcasting can be reproduced from a receiving set of a quality to do justice to the excellent sets that are now on the market.

Many points have had to be investigated in connection with the manufacture of loud speakers in order to accomplish the desired results. In order to obtain better radio reproduction, it has been necessary to perfect, not only the reproducing Unit of the loud speaker, but the acoustic part of it, which is commonly called the horn.

The Unit of a loud speaker that will reproduce radio reception well must be so constructed as to meet certain requirements to get proper results. As a loud speaker is naturally bought by the user with a view to long and constant use, it is naturally important that the reproducing Unit, so far as the internal parts are concerned, should be ruggedly constructed and not subject to being put out of order by mishandling. Ruggedness of construction of the Unit therefore is important. As the diaphragm of a loud speaker is the part which activiates the air column in the horn to produce sound, it is natural that the diaphragm must be made of a material to receive the impulses from the magnets so as to reproduce in all fineness the variations of the electrical impulses. The size of the diaphragm of a loud speaker Unit is also an important factor, as a diaphragm of the proper thickness and of the proper diameter will produce results superior to the results to be obtained by the use of a diaphragm of improper thickness and diameter. As the diaphragm reproduces what is transmitted to it from the receiving set through the magnets and pole pieces, the method of fastening the diaphragm in the Unit is a most important factor. When a diaphragm is so held in the Unit as to be permitted to bend from edge to edge and to be allowed to flex freely, greater sensitivity and greater volume and greater clarity of reproduction are the results.

As sound from a loud speaker is produced by varying frequencies or air waves in the air column, it is desirable to have such air waves transmitted through the horn without being affected by cross vibrations of the horn itself.

As the reproducing Unit produces sound by vibrations of the diaphragm, naturally the Unit as a whole vibrates. In order to eliminate interfering vibrations of the horn, the best results in sound reproduction can be obtained only by insulating the vibrating Unit or mechanism from the horn of the loud speaker. A common method of doing this is by having a rubber bushing or insulator between the Unit and the small end of the horn. Even this does not overcome the air waves in the horn, causing vibration in the horn and the flare or the bell of the loud speaker. To eliminate this interfering vibration or resonance, the flare or bell is made of a material which does not naturally vibrate. Either wood or hard rubber or fibre are materials commonly used to obtain this result. By the use of a rubber insulator or bushing between the flare and the elbow of the loud speaker, further interfering vibration or resonance is avoided.



A modern type of loud speaker.

Illustration by courtesy of The Amplion Corporation of America.

A reproducer unit for use in connection with a phonograph.

The acoustics of a loud speaker have come to be one of the most important factors that makes the difference between a good loud speaker or radio reproducer and one that is not so good.

Length of air column in relation to the taper of the horn from the small end to the outlet must be scientifically worked out. The relation of the size of the small opening to the size of the large opening of the loud speaker must also be in proportion to the taper of the horn.

From the above it can easily be seen therefore, that the manufacture of a satisfactory loud speaker or radio reproducer must be based upon certain scientific factors which are known to make the difference between a good loud speaker and one not so good. If a loud speaker is constructed so as to embody the various features above described, the user can depend upon getting satisfaction using the loud speaker in connection with his radio set.

Because of the importance of the loud speaker for present day radio reception, those who give attention to the points above described and who, while doing so, employ quality materials and quality workmanship can be expected to have their product popular with radio set users.

(*Continued on page* 130)

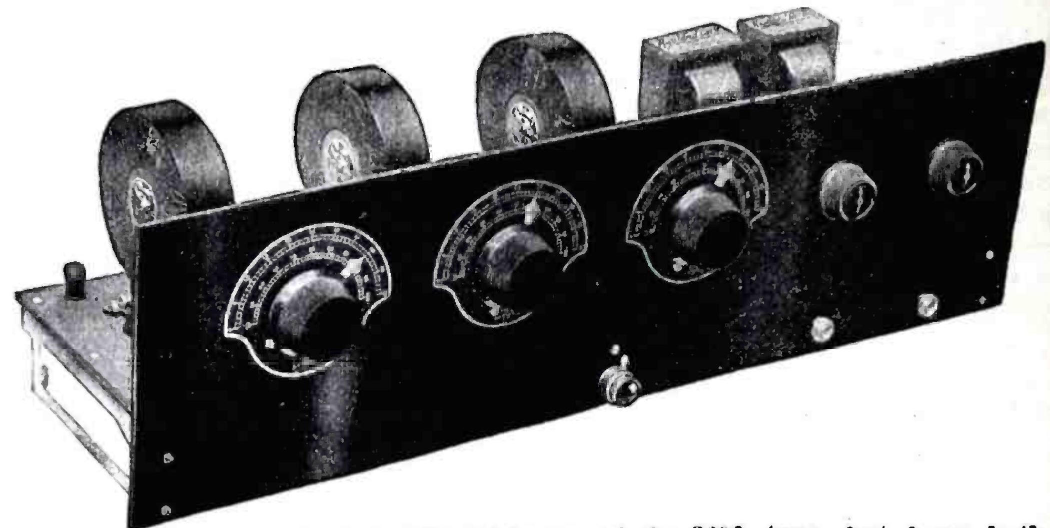
President, The Amplion Corporation of America.

A Simple But Powerful Toroid Set

By H. K. RANDALL, M. E., in E. E. Assoc., Member I. R. E.

BY far the best circuit developed this year are to be found embodied in receivers which are being turned out in complete set form by some of the larger manufacturers. Not all of these manufacturers look with favor on the publication of the circuits they are using, and in some cases these circuits are difficult for the home builder to follow exactly.

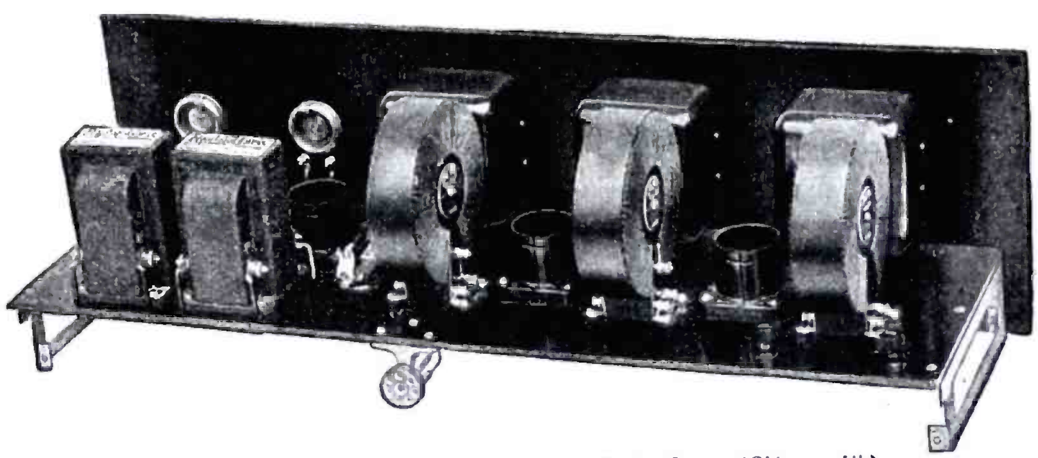
Radio Review is, however, enabled to present on this page a circuit which is exactly that used in one of the most interesting of the new sets, the All-American Model R, with the exception of a few changes which we have made, so that the set can be readily built from parts easily obtainable on the market. These slight changes are not such as to affect the performance of the receiver in any way, and if the set is laid out as indicated on the photographs, and is carefully wired in accordance with the diagram, its performance should equal in every way that of the manufactured set.



Panel view of the 5-Tube Set. The Dials are of the 360° type, but have both halves of the scale on upper part of dial, for visibility.

There is nothing very unusual in the diagram itself, except the way in which three fixed condensers, shown in the diagram as C4, C5, and C7, are used to by-pass the B battery and attendant wiring. As seen in the diagram, these three condensers are all in parallel with each other. In fact, however, the 1 mfd. condenser C7 is connected across the B battery at a point near the battery terminals, while the .002 condensers are placed so as to run directly from the post on the Toroid Coil marked -F to the -F post on the tube socket. Together with the natural tendency of good Toroid Coils to exclude extraneous signals, these fixed condensers have a remarkable effect in making for quiet and clear reception.

The unusually clean-cut appearance of this set in the photographs is due to the effective use of the sub-panel



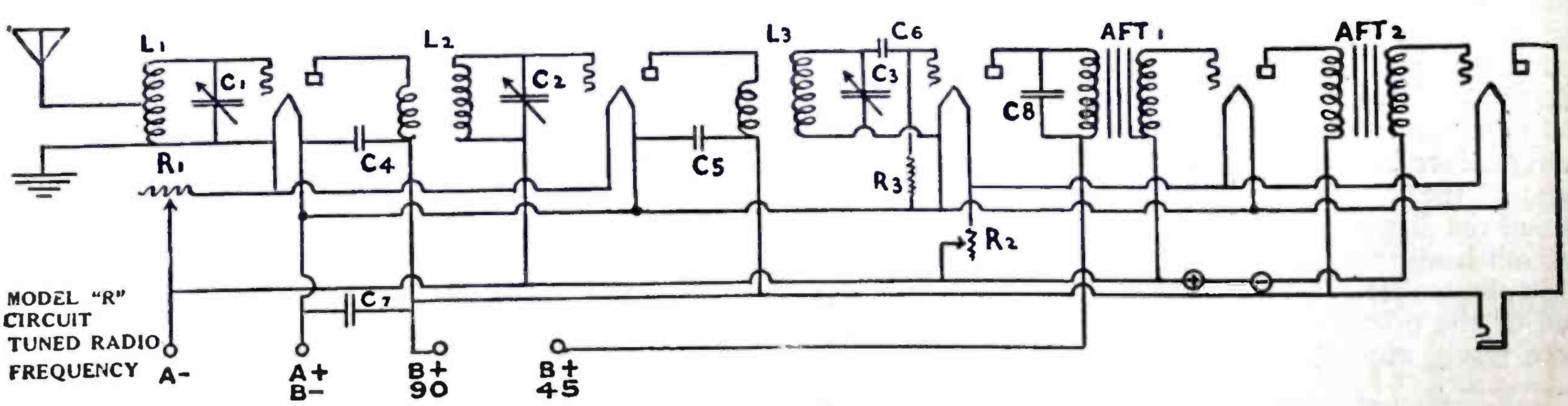
Illustrations by Courtesy of All-American Radio Corp., (Chicago, Ill.)

The rear view brings out the clean-cut appearance, due to the well-shielded condensers and audio transformers, and keeping wires below and close to the sub-panel.

Parts Required for the Set

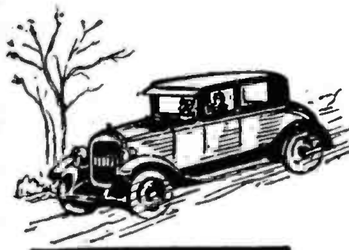
- L1-All-American Toroid Coil Type T 1.
- L2-All-American Toroid Coil Type T 2.
- L3-All-American Toroid Coil Type T 2.
- AFT1-Rauland-Lyric Audio Transformer Type R 500.
- AFT2-Rauland-Lyric Audio Transformer Type R 500.
- C1-All-American S-L-F Condenser Type C 35.
- C2-All-American S-L-F Condenser Type C 35.
- C3-All-American S-L-F Condenser Type C 35.
- C4-002 Fixed Condenser.
- C5-002 Fixed Condenser.
- C6-00025 Fixed Condenser.
- C7-1 Mfd. Fixed Condenser.
- C8-002. Fixed Condenser.
- R1-6 Ohm Rheostat.
- R2-6 Ohm Rheostat.
- R3-1 Meg. Grid Leak.
- Panel Size 7 x 24"
- 5 tubes, 201-A type.
- 5 All-American Sockets, Type R-25. (These sockets take either the regular 201-A or the "UX" base.)

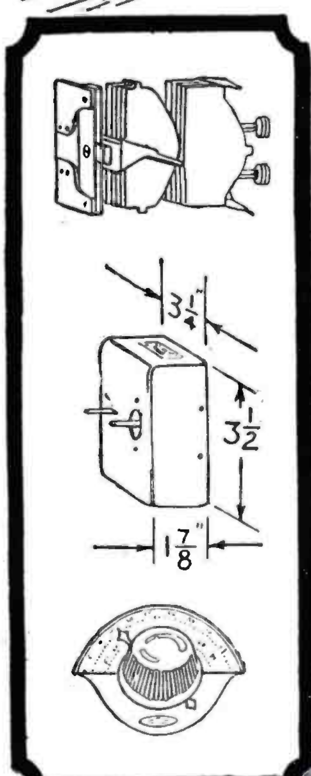
NOTE—When using new U X Power Tubes break grid return at points marked ┼ — and insert "C" battery of voltage recommended by manufacturer.



Circuit Used in the new All-American Receiver (Model R)

Straight-Line-Frequency Tuning Without the Brakes!

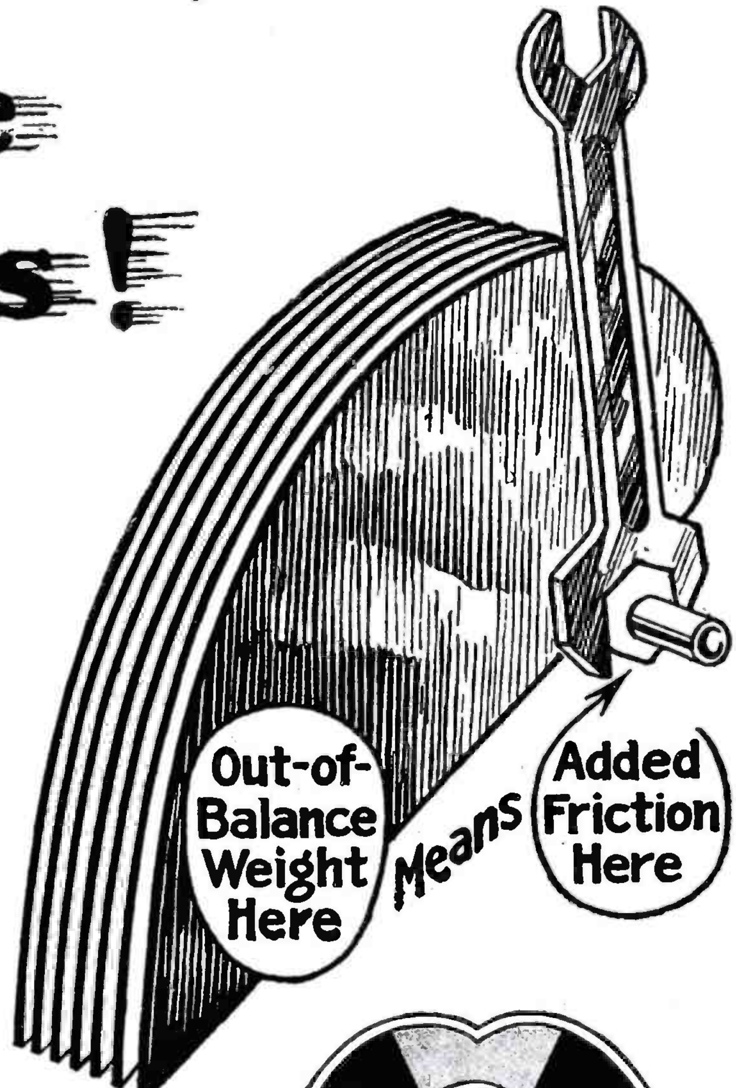




ALL-AMERICAN Condensers, with their smooth-*sliding* plates, (see sketch at left) *require no tensioning*. There is no sensation of raising a *weight* or letting it fall. *Compactness*, also, far exceeds that of rotor types. (See dimensions on sketch.) Efficient shielding *prevents* the touch of the fingers from affecting the tuning, and *protects* the plates permanently from dust or damage.

Taking full advantage of the 360° rotation, there is an ALL-AMERICAN Dial with *two scales*, both on the *upper half*, where they are always visible.

Used with the ALL-AMERICAN Toroid Coils, these Condensers space out *equidistant* on the dial *all* wave-frequency channels from 550 meters down even to 175 meters. Power and selectivity are greatly improved through the absence of stray magnetism



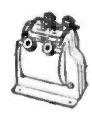
ALL-AMERICAN Straight-Line-Frequency CONDENSERS

Type C-35 Max. 350 micro-microfarads (Min. 10.5 mmf. at 400 meters) . . . $4.50
Type C-50 Max. 500 micro-microfarads (Min. 11.8 mmf. at 400 meters) . . . $5.00
Type C-40, 360° Dial 1.00

ALL-AMERICAN TOROID COILS

Type T-1 Antenna Coupler . $3.50
Type T-2 R.F. Transformer. 3.50
Set of 3 coils complete 10.50
The R. F. Transformer has a small primary, closely coupled to the secondary, entirely air-insulated. The coupler has taps for long and short antenna. All bases are of bakelite.

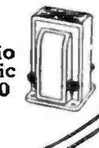
ALL-AMERICAN
TRADE MARK
Famous Audio Transformers



Standard Audio Transformers
3 to 1, R-12 . . . . . $4.50
5 to 1, R-21 . . . . . 4.75
10 to 1, R-13 . . . . 4.75

Power Amplifying Transformers (Push-Pull)
Input Type R-30 . . . . $6.00
Output Type R-31 . . . . 6.00

Rauland-Lyric
A laboratory-grade audio transformer for music lovers. R-500 . . . . . $9.00



ALL-AMERICAN RADIO CORPORATION, 4227 Belmont Avenue, Chicago, Illinois
E. N. Rauland, President

MEMBER RMA

OWNING AND OPERATING STATION WENR—266 METERS

ALL-AMERICAN

Pioneers in the Radio Industry

construction, with parts of a type suited to it. The sockets have their binding posts inverted so that filament wiring is all brought underneath the sub-panel, and the Toroid Coils as well as the audio transformers have their binding posts so placed that short leads can be run through holes in the sub-panel.

Laboratory-grade transformers are used in both audio stages. These instruments can be relied on to give tone quality not exceeded by any other type of coupling, and five tubes in this kind of a set may therefore be said to do the work of six in sets where a smaller amplification per audio stage is obtained. The condensers used give a strictly straight-line-frequency characteristic with 360° rotation, rendering entirely unnecessary the use of any vernier mechanism, and thus simplifying the set still further.

The Importance of the Loudspeaker for Radio

(*Continued from page 127*)

No factor is quite so important today in the radio field as the need for better quality and better workmanship.

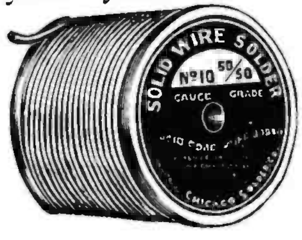
If radio users will insist upon buying only loud speakers of known merit and high quality, they will not only obtain greater satisfaction in the use of loud speakers but will help to encourage the continued efforts on the part of manufacturers to make their products better in order to be successful in business.

How to Solder Properly

By P. C. RIPLEY*

N the construction of a practical and efficient radio receiver, sol- r is indispensible. It is that sub- ınce which binds the mechanical nts of your set, making them im- rvious to oxidation. Oxides, we ow, are the very poorest sort of nductors for electrical energy, and echanical joint, no matter how cure, cannot prevent the encroach- ent of our ever present friend oxy- n.

That solder is indispensible will, no ubt, be assailed by some; yet, if u will take the trouble to examine ts made by the leading manufac- rers and radio engineers of the day, u will find more than 95 per cent ly on solder to protect their joints. assured, that if there existed a tter method, it would be adopted, d the ratio would be reversed. In compact radio receiver there exists ly a limited amount of space in ich to manipulate pliers or other ols to tighten terminals or binding sts, giving rise to the chance for in- cure electrical connections. Couple is with the fact that these will in short time oxidize, you can readily e why a soldered joint is imperative. egardless of whether you use a flex- le, insulated, wire or the more com- on tinplated bus bar, to properly otect your joint or connection



Solid Wire Solder Spool

lder must be used. You, who want istance and the strongest and purest nal qualities, can readily appreciate e obstacles a few insecure or oxi- ized connections present to the travel f those feeble radio currents. Do ot confuse oxidation with common orrosion or rust—such as you have oted on articles of iron, for the etals of which your radio will be onstructed, will not present any such tartling evidence of oxidation. Yet, will be present just the same, offer- ng its resistance to the radio cur- ents.

The mere fact that a radio joint as some solder melted on it, will not e a guarantee that it is a perfect joint or radio conductivity. To be effective, it must be properly applied and suitable materials must be used in forming it. For the novice to successfully solder, it is essential that he know something of the composition and characteristics of solders and fluxes. Also, as an aid in their application, he should be acquainted with the correct tools and their uses. Soldering, in the minds of many, constitutes an accomplishment akin to the black arts of mediaevalism, but if they will take the pains to secure the correct materials, with a minimum of practice, they will find such is not the case.

Rosin Core Solder Spool

So, for you, who wish to build an efficient radio receiver, it will be advisable to follow the accepted and proven methods of our leading radio authorities by using solder bonded joints.

Solder

Solder is an alloy, composed usually of the two metals, tin and lead. These two metals are combined in variable proportions, which reflect certain well defined characteristics in the alloy, and are a controlling factor in the selection of the solder for specific purposes.

One of the vagaries of nature is manifested in solder, for it possesses a lower melting point than either of its component metals. Other metals may be added which will bring about a further lowering of the melting point; but, in doing this, we effectually destroy some of the desirable attributes ordinary tin and lead mixtures manifest. So, we may at once dismiss from our consideration solders of a lower melting point than are obtainable with tin and lead combinations.

In your purchase of solder, it will be wise to select a product that the manufacturer endorses for radio use, as he has conducted exhaustive experiments to determine the correct proportions of tin and lead which will give you good results. Beware of cheap solders, for, oftentimes, they are made from reclaimed metals, and may contain metals other than tin and lead. These may raise the melting point, render the alloy brittle, detract from its flowing quality, or give an increased resistance to the flow of your delicate electrical currents.

Illustrations by Courtesy of Chicago Solder Co., Chicago, Ill.

Bar Solder

The more common forms in which this commodity is offered for sale are: bars, wire and ribbon. The bars usually weigh from a pound to a pound and a half per bar, and present a form that is not readily adaptable to the uses of the radio set builder. We would not recommend the purchase of solder in this form for the average radio construction. Next, we have solder in the form of a wire, and this type will be found much more convenient to handle than the bar. The ribbon type will probably meet with the approval of every enthusiast, and is a most adaptable form of solder for radio construction. One advantage in the purchase of the wire or ribbon type is, that, it may be secured in smaller amounts when purchasing solder. Both wire and ribbon solder may be purchased which contain their own flux (rosin), and offer a most convenient solution in the procurement of these two essentials for your soldering.

So, the wise procedure for you, who know nothing of solders, is to demand a trade-marked article, made of virgin metals, carrying the manufacturer's endorsement as being suitable for radio use. Then, you will be assured of securing a correctly made article.

Fluxes

Under the heading of fluxes comes one of the most important factors of success or failure in soldering. Flux is that substance, whose duty it is to dissolve the oxides which occur on the surface of the parts to be joined with solder. When these oxides are dissolved, it enables the solder to enter the minute pores of the metal surface, effectually sealing it against the penetration of oxygen.

Fluxes range in character from very strong acids to very mild acid bearing substances. For radio use, we must have a flux which is non-corrosive, and which in its use will leave a residual matter that will have

Research Engineer, Chicago Solder Co.

no tendency to collect moisture, dust or other foreign material. *This is imperative.* There have been some ineffectual efforts to neutralize the stronger acids and use them, but to do this is to court disaster. Simply because you incorporate alcohol or ammonia in these stronger acids to the point where they appear neutral, does not assure that the residual matter will be neutral after the heat of the soldering operation has driven off the alcohol or ammonia. So, let us, at once, forget the stronger acids as

Rosin Core Solder in roll form.

being entirely unsuited to radio use. Next, we come to the pastes or semi-viscous fluxes, which are another form of compromise in an effort to use the sharp acids. These contain a more or less limited amount of the strong fluxing materials, suspended in some organic grease or wax. The popular idea is, that the presence of these greases, will prevent corrosion on the work. Unfortunately, this is not true, as the acid content of these compounds will corrode even if enveloped in grease, as the heat of the soldering operation does not change their chemical structure. Some manufacturers of these acid bearing pastes, have been so bold as to advertise their wares as being absolutely non-corrosive and adaptable to radio use. This is misleading, and the radio enthusiast should view all pastes with suspicion when purchasing a flux for radio work. Should he care to test the manufacturers' claims regarding the corrosive action, simply heat a small amount of the paste and some solder on a piece of German silver and set aside for thirty days. The result will be startling.

Still another bad feature in the use of paste, is the fact that the organic greases or wax that are universally employed in its manufacture, over-run when heated onto the insulating material of parts and wires. This breaks down or rots these insulations, and will manifest itself in no uncertain manner at a later time. The active acids in these pastes usually have an affinity for moisture; and, as they are deposited in a thin film over your parts in the soldering operation, they will induce dielectric losses. To attempt to remove them with alcohol, simply tends to spread them over a greater area, often into the parts themselves. *Grease also forms a very efficient collecting agency for dust and foreign matter, which may bring about still further losses through leakage of these radio currents.*

The leading manufacturers and radio engineers have spent large sums in experimental work, and have conducted exhaustive tests to determine the best flux for radio use; and, they are almost unanimous in acclaiming rosin the safe and sure radio flux. Contrary to popular belief, rosin is acid—or rather contains acid in its natural structure; yet, its physical characteristics are such, that, it is non-corrosive in action. Rosin is a rather complex mixture of a number of different substances, and these undergo certain changes when subjected to heat, light, age and atmospheric contact. The action of these forces will materially alter, or destroy entirely, the good fluxing qualities of a rosin. The United States Department of Agriculture recognize some twelve standard grades of rosin. Of these, there are only a few which have the necessary qualities to make them efficient fluxes. This of course, presents a problem to the novice in the selection of a rosin which will serve as a flux.

Here is where a rosin-cored solder will lead the way out of the difficulty. The manufacturer of this solder, in

Phantom View, and Description

either the ribbon or wire type, carefully tests all rosins which enter into his solder, and uses every precaution to maintain and insure the retention of its highest fluxing qualities. Should the radio enthusiast purchase bulk rosin, he must remember that age is detrimental and should demand fresh rosin. Also, that the darker grades are the least active as fluxes.

Now, to enumerate the distinct advantages of rosin as a flux, they are briefly these: Non-corrosive and the residual matter exhibiting no tendency to gather moisture, dust, or foreign substances; and, if proper grade is used, and while not quite as rapid in action as the stronger acids, it will prove to be a very efficient fluxing material.

Selection of Tools

In the selection of tools with which to transmit heat to the work to be soldered, we have three, more or less, distinct types as follows: A torch throwing an open flame, the conventional type of soldering iron which absorbs heat from some source and acts as a conveying agent to the object to be soldered and the electrically heated iron.

The torch is more or less impractical, as it is too hard to confine the flame to the area to be soldered without damage to the surrounding parts. Also, it produces excessive oxidation and is apt to carbonize the work as well, unless it is operated by an experienced operator.

The ordinary iron, with which we are all more or less familiar, offers the most inexpensive and efficient means of heating our work. For the set builder, who has only an occasional use for a soldering tool, we will recommend this type of iron.

An electrically heated iron has the advantage of holding a more or less constant heat, but its initial cost is considerably higher than the ordinary type of iron. Those of you who care to invest in one of these, will find that you possess a very handy tool. There are electrically heated irons on the market today that fail to generate enough heat for the heavier soldering, and we want to caution you to be sure that in purchasing you secure one of ample capacity. This, too, will apply in the purchase of an iron of the ordinary type.

A long or slender point on an iron must be avoided, as it will not transmit the heat with enough rapidity to give good soldering results. Failures in soldering where a good solder and flux are used, are often traced to the lack of heat in the object to be soldered, thereby, failing to allow the solder to flow properly.

So regardless of what type tool you employ, the prime factor in securing a properly soldered radio joint is to bring the work to a temperature where it will melt solder itself.

Application of Solder, Flux and Tools

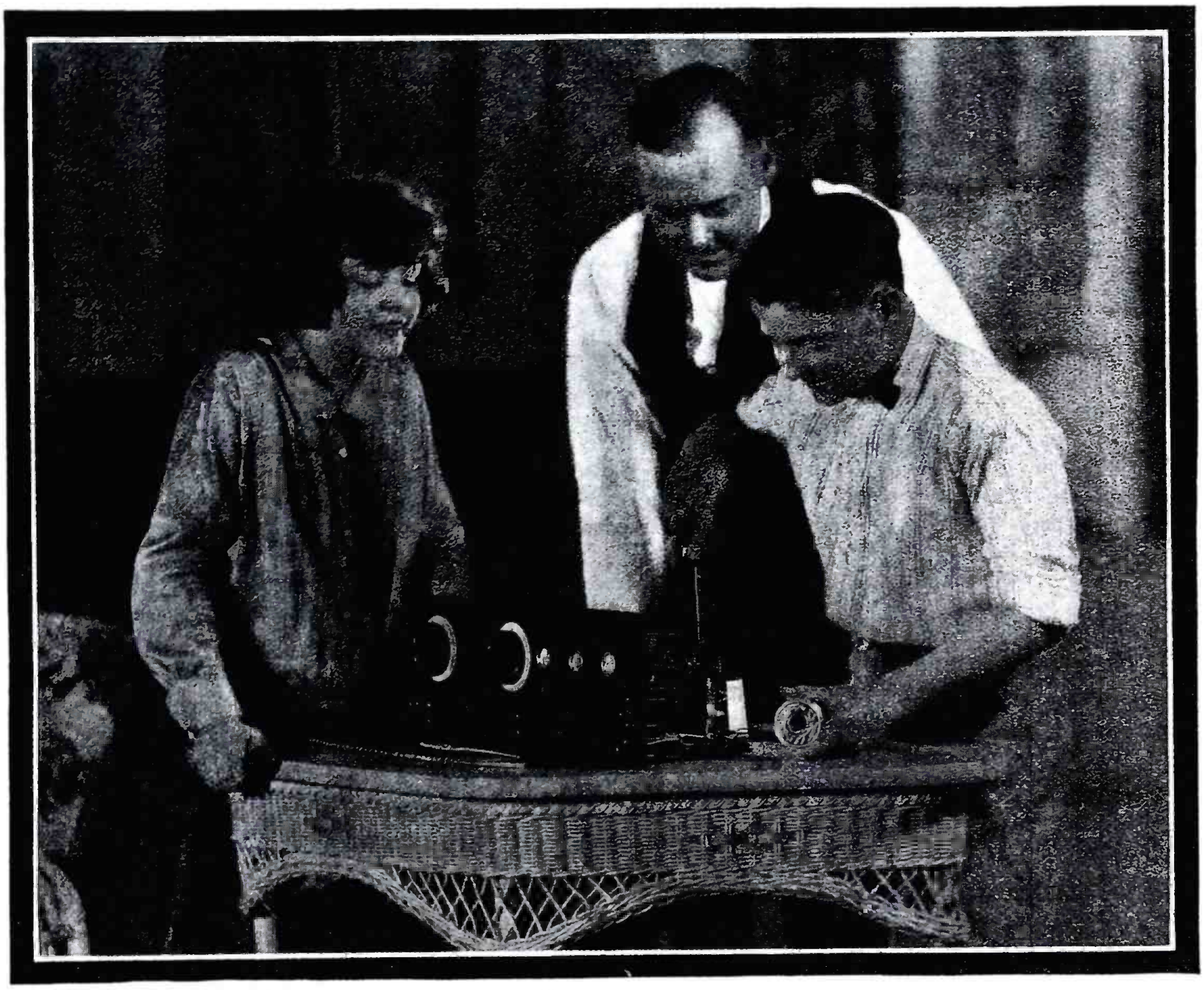
Now, we come to the application of our solder and flux with the aid of our soldering tools and skill. If we will bear in mind this one very important fact, we cannot fail to accomplish a perfectly solder bonded joint; and, that is, *our work must be hot enough to flow solder.*

First, let us give some serious attention to our iron shape as this has a very important bearing, altho, it seldom is given much consideration by one not experienced in the use of solders. In the following illustrations Fig. 1 shows a correctly shaped iron point, while the one in Fig. 2 should be avoided.

The iron in Fig. 1 having a more or less blunt point, will present a maxi-

KESTER *Radio* SOLDER

(Rosin Core)



Oh boy! It Sure is Safe and Simple

"Requires Only Heat"

Approved by Radio Engineers

IF YOUR DEALER CANNOT SUPPLY YOU

Chicago Solder Company
4252 Wrightwood Ave., Chicago, Ill.

Gentlemen: Send me one can Kester Radio Solder, for which I enclose 25c in stamps.

(Postpaid anywhere in U. S. A.)

Name..

Address..

City.. State..................

Dealer..

mum of surface to the work through which it can deliver its heat and bring about a suitable temperature in the object to be soldered, before radiation has come to carry the heat away. The iron in Fig. 2 with its longer and slenderer point, will only make a limited contact with the work, and radiation may be so rapid as to defeat our object of heating the work to a solder melting temperature. The result will be an insecurely soldered joint, and what is commonly termed, a rosin joint.

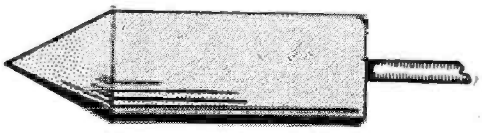


Fig. 1.

After we have secured a properly shaped point, we must next see that it is solder coated to prevent the formation of oxide on its working faces. Oxides not only being bad electrical conductors, are also poor conductors of heat, and their presence on the working faces of our iron may defeat our efforts to heat our work properly. When solder is coated or tinned, the solder has a tendency to web between the iron face and the the work, and will take care of the irregular surface of either. This assures us of a maximum contact for the flow of our heat. To secure this solder coating, heat the iron; and, with a file, smooth the faces. When you have removed all of the oxides, and the metal shows that it is clean and bright, apply your rosin-core solder to the faces until they are coated. Should your iron later become overheated and this film of solder destroyed or oxidized you will observe, that it loses its efficiency in heat transmission. Before attempting to use it further, it will be necessary to renew this film of solder, following the method outlined above.

Next, let us consider the proper handling of our iron. We must bring it in contact with the work in such a manner that a maximum of surface is presented for heat transmission. Fig. 3 illustrates a correct contact, while Fig. 4 shows a poor one.

In Fig. 3 the iron face lies flat on the work, giving a maximum contact for the flow of its heat. In Fig. 4 only the extreme point of the iron is in contact. This limited contact cannot allow for a great enough flow of heat to overcome the radiation in the work. So, remember, we must give the iron a chance to transmit the heat that is stored up in it, to the work, by bringing in contact all of the face surface our work will permit.

When applying solder and flux to the article to be soldered, *the flux must come in actual contact with the joint or object to be soldered.* The sole reason for the flux is to dissolve the oxide film that is on the surface of the work, and if we destroy our flux before we have accomplished the soldering operation, we are certain to fail in securing a well soldered joint. Now, rosin is disintegrated with heat, so you see there is a time limit which must not be overlooked in applying our flux and solder. Do not apply solder and flux to the iron; apply it directly to the work after it has attained a temperature where it will melt the solder. We are not interested in melting solder and flux on the iron; what we want is a securely soldered piece of work, and the easiest way to secure this is to apply the solder and flux directly to the heated joint. If the work is of a nature that demands we carry our flux and solder to the work on our iron, let us so arrange it, that a minimum of time elapses between the picking up of these and their application to the work. When melting these onto the iron, be sure that

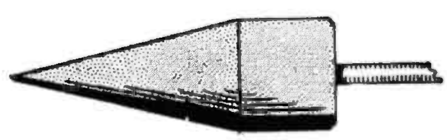


Fig. 2.

the iron point is directed more or less downward, so that, they will have no tendency to run up the body of the iron. Both flux and solder must be concentrated at the point in order to

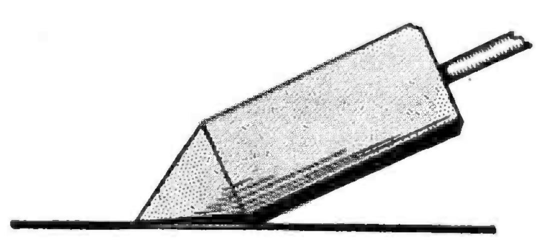


Fig. 3.

secure the best results. Also, instead of picking the solder off the coil with an upward stroke, do this with a downward stroke; and, then, your rosin will not have to run around the entire point to get to the bottom face where we must have it. As a suggestion to the set builder, we would discourage this as being more or less impractical. However, if he wishes to use this method, let him first do a little practicing and carefully note the action in this method. Take a scrap of tin or copper, and with a hot iron try carrying the flux and solder from your spool of rosin-core solder. You will note that the instant the solder and flux have melted onto your iron, a film of white smoke is produced. Your rosin has started to disintegrate, and when this stops, you will find that the residual matter on the iron possesses no fluxing power at all. So, if you wish to use this method, you must get your solder and flux to the work before disintegration is complete.

Next, try heating the scrap of metal with the iron, and as soon as it reaches a temperature where it will melt solder, apply your rosin-core solder directly to the work at the point of its contact with the iron. Do not remove the iron from the work until the solder has spread out evenly and smoothly. After a little practice with this method, make a comparison of the two methods outlined and you can readily see the merit of applying the solder and flux directly to the joint.

Still another method, which we would suggest as a substitute for the first one mentioned, would be to tin or solder coat the two parts to be joined at their point of contact. Then, bring the two solder coated surfaces in contact with each other, and apply the iron until enough heat is transmitted to knit, or flow, the two together. There is usually enough rosin clinging to the surfaces to successfully flux the operation.

Parts presenting nickel-plated or brass soldering contacts, should be avoided as much as possible, as the oxides of these metals do not respond to rosin flux readily. In the case of nickel-plating, this may be removed with a file, and then, you will find that the base metal will solder much easier. Should it be necessary to solder on these metals, remember, that it will require a great deal of patience to make a good joint. Often, you will be presented with the problem of soldering enameled, lacquered or rubber insulated wires. Before making any attempt at soldering these, we must first clean them thoroughly. In the case of the enameled or lacquered wires, all that is necessary is to scrape or sandpaper until all the covering material is removed, and the surface is bright and clean. For rubber insulation, simply cut this away and treat as you did the enameled wires.

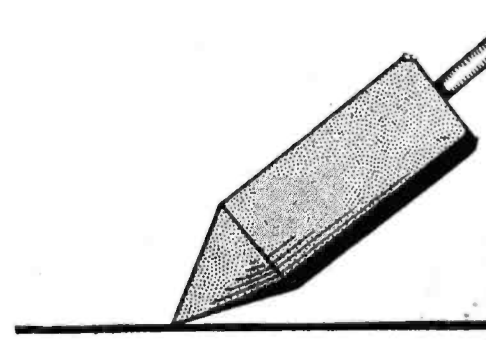


Fig. 4.

Another point which might be well to bear in mind is the activity of copper as a conductor for heat. This metal is one of the best heat conductors we have; and, as the wiring of our radio receivers is always of this metal, we must take into consideration the greater, proportionate amount of heat we must apply to overcome radiation.

Variable Resistance in Radio Circuits

By ARNOLD E. PFEIFFER

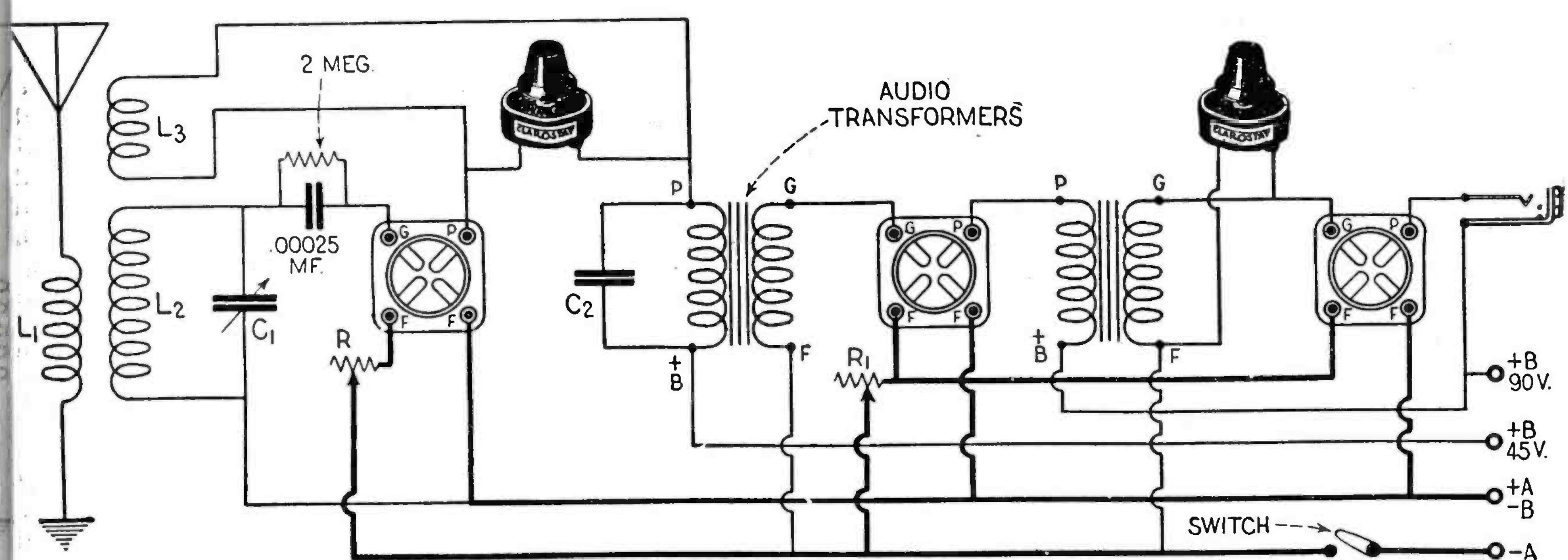
SO common is the knowledge that resistance in radio circuits makes for inefficiency that even the rankest layman has learned to scrape the end of his aerial lead-in before connecting it to the set, but the rankest layman has yet to learn that resistance, properly applied, will also increase the efficiency of a receiver. Resistance in radio circuits is altogether undesirable, in certain parts of circuits, in other parts it is indispensible.

Take, for example, the condition known as distortion, the condition that manifests itself in slurred words and ragged music and which is characteristic of almost every commercial receiver on the market today. Resistance will remedy that!

Radio set manufacturers—excepting those that make extremely expensive sets—do not, for some unaccountable reason, incorporate in their sets certain refinements that would add greatly to the fidelity of reproduction, and which would enable you to hear the broadcast offering in all the beauty of its original delivery—not the way you hear it now, often distorted to frightfulness. And as the set manufacturers do not take the trouble to add these refinements, it is our purpose in this article to tell you how to do it yourself, so that you, too, may enjoy to the fullest extent the art that stands alone in its possibilities for pleasure and entertainment.

see two devices called "audio frequency transformers." They are easily distinguishable from the other apparatus in the set because of the large iron cores which are a part of them. These audio frequency transformers function in the circuit to step up the signal strength after the signal is detected or rectified by the detector, and therein lies the trouble. Set manufacturers use this system of amplifying the signal to loud speaker proportions for no other reason than that it is the cheapest and because every other set manufacturer uses it! The system is all wrong.

Transformer coupled audio frequency amplification, when carried



Wiring diagram showing Clarostats shunted across the tickler and the secondary of the last audio frequency transformer.

Take the condition known as "squealing" in tuned R.F. circuits, a condition caused by the tubes becoming saturated as frequency resonance is approached, and which drives the listener-in frantic because he can't clear the signal. Resistance will remedy that!

How often have you felt that you could get a louder and clearer signal from your three-circuit tuner if only it would not "plop" in self-oscillation so suddenly, if only it were possible to approach the "spilling-over" point more gradually. Resistance will remedy that!

One could fill pages with the ills of radio that can be remedied by the proper application of resistance, but the three subjects mentioned are those most common and most likely to be encountered. Let us, to begin, consider the subject of distortion.

The First Requisite

Does any one take issue to the statement that the first and prime requisite of a radio set should be the fidelity with which it reproduces broadcast song, speech and music? I think not. Hunting for distant stations is fascinating, hair splitting selectivity is desirable, but after all a set's ability to reproduce music clearly and without distortion is the greater achievement. Kings and emperors of a generation ago had not at their command the singers, the orators, the musicians and the entertainment that the average American has today at the flip of a dial. These singers, orators, musicians and all the host who serve you, serve you to the best of their ability—why should you not hear them from a set that does justice to their efforts?

If you look into your set you will

through to two stages, cannot give distortionless reproduction, because transformers amplify some frequencies to a greater degree than others. One stage of transformer coupled amplification, howeer, will not distort, or rather its distortion will not be audible to the average unpracticed ear, but where amplification is carried through to two stages, the distortion produced by the first transformer, little as it is, will be built up to greater proportions by the second, owing to the increased distorting qualities of successive stages of transformer amplification.

Suggesting a Remedy

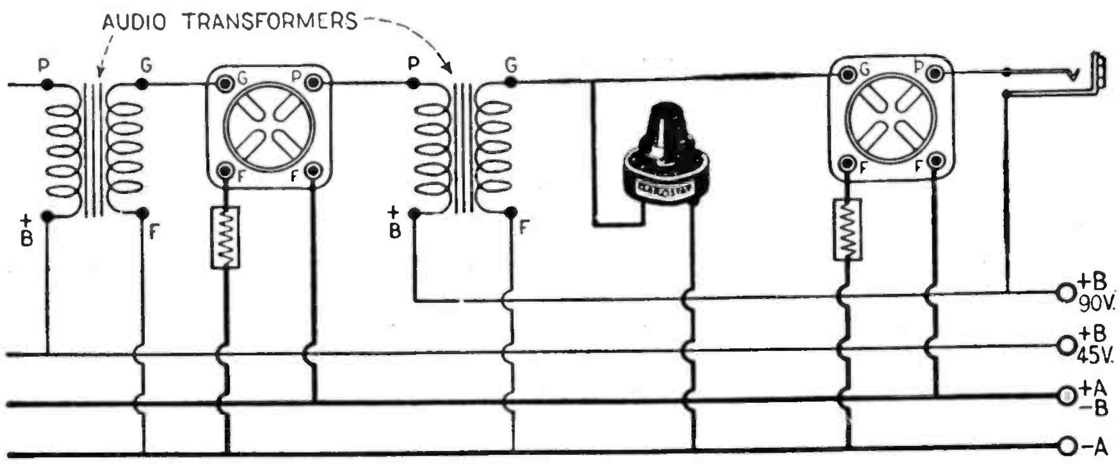
How are we going to remedy the matter? We can, of course, rip out the last transformer and substitute two stages of resistance or one of impedance coupling—two stages would be necessary for sufficient volume—but not only would this entail considerable expenditure of time and effort and a knowledge of wiring not possessed by the average person, there is also the possibility that lack of space in your set precludes incorporating another tube. Also, if you substitute resistance coupling, it would be necessary for you to employ just double the "B" battery voltage you are now using.

These radical changes, however, are not at all necessary. It will surprise you how simply and effectively your set can be changed from one that gives poor reproduction to one that will rank with the best. The simple addition of a Clarostat, together with a few minutes' time, will end your distortion troubles, and at the same time give you a volume control that will stand in good stead late at night, when it is imperative that the neighbors are not disturbed.

By shunting a Clarostat across the secondary of either audio frequency transformer, we obtain, in effect, a stage of impedance coupling, but with this difference. It would be extremely difficult for the average layman to adjust a stage of conventional impedance coupling, *i.e.*, a choke coil and grid leak, to the point of maximum amplification, and even were it so adjusted, volume from the combination of transformer and coupler would not give sufficient volume for our purpose. This is true because impedance coupling, like resistance coupling, is equal only to the amplification factor of the tube used, there being no step-up action as in transformer coupling.

However, we may, through the agency of a Clarostat, obtain not only distortionless reproduction of all voice frequencies, but sufficient volume as well, because by adjusting the Clarostat to the proper point we are able to strike a balance where all distortion is eliminated and at the same time preserve some of the step-up value of the transformer. The Clarostat can be added to your set without disturbing or disconnecting a single wire, and the benefits to be derived will repay you a hundredfold for the small expenditure necessary.

Obtain a Clarostat, and either a phone cord or a few feet of double conductor lamp cord. Attach one set of terminals of the cord to the spring clips of the Clarostat. Slip the other end of the cord through one of the holes in the back of the cabinet. Raise the cover of the set and determine which transformer is nearest the hole admitting the cord. Connect one terminal of the cord to the post marked "G" and the other terminal to the post marked "F," or if one side of the transformer is simply marked "secondary," connect from post to post. And that's all there is to it!



A two-stage audio frequency amplifier circuit showing how the transformers are matched with the Clarostat.

Before tuning in a signal turn the knob of the Clarostat all the way out, that is, to the left. After the signal is tuned in, turn the knob of the Clarostat slowly to the reverse, and note the difference!

Tuned radio frequency receivers employ a circuit known as "radio frequency amplification," which is a system of amplifying the high or radio frequencies to a considerable degree before they are changed to the lower or audio (audible) frequencies. The radio frequencies can be amplified in two ways, by the untuned interstage method and by the tuned interstage method. The only untuned methods are those employing interstage resistance coupling or interstage impedance and resistance coupling, both of which are inefficient and unsatisfactory on broadcast wave-lengths because of the internal capacity existing in vacuum tubes, especially those of American make, between grid and filament and plate and filament.

It is the contention of some that radio frequency amplification by the interstage transformer method is also in the category of untuned systems, but this contention can hardly merit credence in light of the facts involved. A potentiometer is absolutely necessary to the proper functioning of this system of amplification, and this potentiometer is the tuning device in the system. A radio frequency transformer has not yet been designed that will function properly on all broadcast wave-lengths, favoring none, without the aid of a supplementary tuning device. All in all, the transformer method is generally considered inefficient, principally for reasons which will be given later in the part of this article devoted to the control of oscillations by the grid bias or potentiometer method.

In the conventional and popular tuned radio frequency receiver the successive stages are tuned and amplified by either a variable inductance or a fixed inductance tuned by a varying capacity or variable condenser. Of the two the latter system is most widely in favor, and it is upon this that we shall concentrate our attention.

Radio frequency amplification is effected, in tuned radio frequency circuits by tuning the antenna circuit to the desired frequency and succeeding circuits to the same frequency, making a narrow path for the desired frequency to reach the detector, to the exclusion of other frequencies, and at the same time amplifying it considerably on the way. The system is efficient, in so far as we have attained efficiency in radio receivers; admits of satisfactory selectivity and is highly sensitive to weak and distant signals. But there never was an ointment without a fly, and in tuned radio frequency receivers we have the fly of self-oscillation, or "squeals." This self-oscillation is caused by energy being fed back from the plate of the tube to the grid when the grid circuit and the plate circuit are tuned so that they are resonant to the same frequency. Magnetic coupling between the grid coil and plate coil will also cause self-oscillation on certain wave-lengths, but this has been largely minimized by mechanical development.

By tuning both the grid and the plate circuit to the frequency of the incoming signal we would get maximum amplification were it not for the fact that self-oscillation takes place considerably before frequency resonance and maximum amplification are effected. Therefore it is necessary for us to sacrifice a considerable degree of amplification which we would otherwise obtain in order to prevent self-oscillation, which causes the tonal quality of the signal to suffer.

There are several ways of overcoming this tendency to self-oscillation, though no matter what method is used it has the effect of limiting amplification, some methods to a greater degree than others. The oldest scheme is that which employs a potentiometer in the grid circuits of the tubes, where it functions by introducing losses. The system is inefficient, however, because the applied potential on the grids of the tubes changes with the frequency or wave-length, whereas the applied potential should always be constant in amplifier circuits. Also its adjustment is critical and in some forms it broadens the tuning considerably.

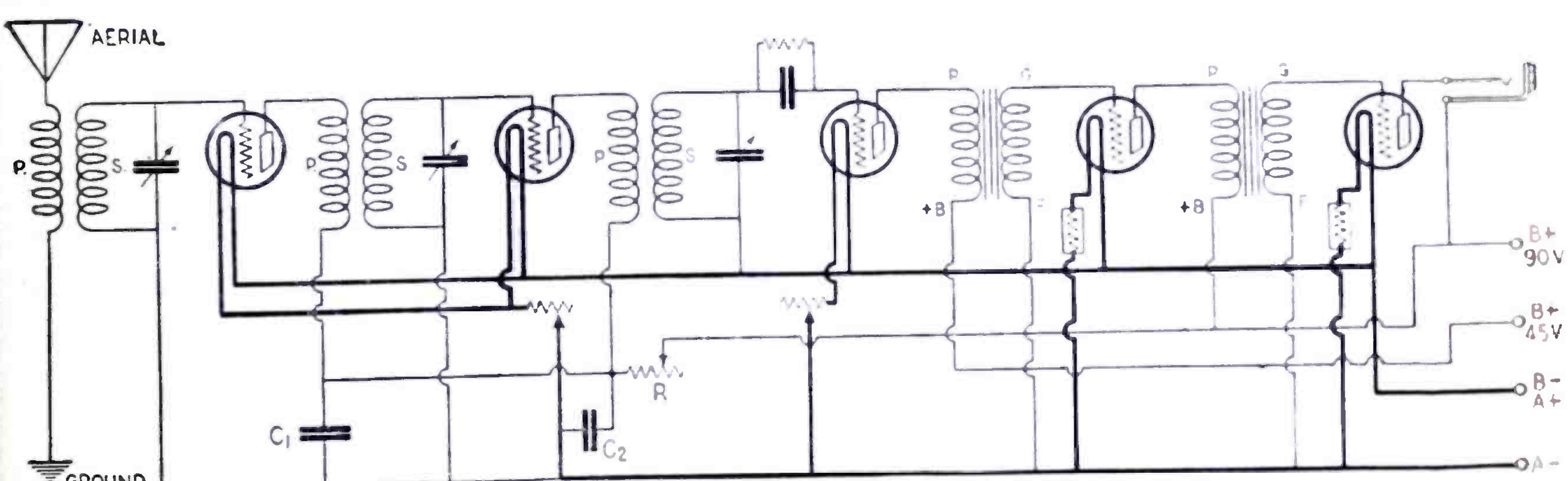
Another method, and one in popular favor, is that which neutralizes the capacity existing between the grid and plate of the tube, thus preventing the feed-back which produces self-oscillation. There are several ways of doing this—the Hazeltine method, the Rice method and the superdyne method. The last employs a reversed tickler arrangement that feeds back counted E. M. F. to the grid circuit, offsetting the E. M. F. fed back through the internal capacity of the tube. This system, however, is very unstable and difficult to tune.

The Hazeltine system is basically the same as the superdyne, differing only in application, in that counter E. M. F. is generated to balance and neutralize the E. M. F. that feeds back through the capacity of the tube when tuning approaches resonance. In the neutrodyne or Hazeltine system the means for feeding back this counted E. M. F. is fixed, and therein lies its disadvantage. The tendency to self-oscillation is more pronounced on the lower wave-lengths than on the high, and it therefore becomes evident that a circuit adjusted down to favor the low wave-lengths in the matter of self-oscillation will certainly not do justice to the reception of high wave-lengths.

And so we must find an efficient means that can be used to limit the radio frequency voltage that builds up in the plate circuit and avoid the feed-back through the capacity of the tube, which causes oscillation. A most effective way of doing this, and a way that is rapidly coming into favor, is by controlling the tendency to oscillation by a variable resistance in the plate circuits of the radio frequency tubes, where it serves to vary the voltage applied to those tubes. When the direct plate voltage is reduced the instantaneous voltage differences between the plate and the grid are reduced, curbing oscillation. As two large by-pass condensers lead the radio frequency current from the primary of the coil back to the negative filament of each tube, the resistance is not in the radio frequency circuit and therefore will not broaden tuning.

It is well at this time to mention a type of tuned radio frequency receiver which sold in such large numbers that it is safe to assume that a very considerable number are in use. That is the type that employs no method of controlling oscillations, depending for stable operation on so-called self-neutralizing coils and upon the radio frequency and detector rheostats. As all who possess one of these receivers will bear witness, they oscillate, and oscillate violently, on the lower wave-lengths. The self-neutralizing coils, although they tend to minimize self-oscillation, do by no means overcome it, and turning down the rheostats to overcome the trouble not only does not help but would be an inefficient way if it did.

It is particularly in sets of this kind that a variable resistance in the plate leads of the radio frequency circuit would aid materially in stabilizing operation and bringing in those stations that are now obscured by squeals and whistles. If you are the possessor of such a set or any other type of tuned radio frequency receiver that is not giving satisfactory operation use this system for stabilizing operation and you will find a new joy in the greatest of indoor sports. Secure a good variable resistance, one that has a working range of from zero to five million ohms, is mechanically sturdy and one which, once set, will not change its resistance. Get a good one or get none at all. The writer uses a Clarostat, and after months of dependable service it still responds nicely to the will of the operator.



Complete wiring diagram of a five-tube tuned radio frequency receiver employing Clarostat resistance controls.

In a convenient part of the panel mount the resistance, which is R in the drawing, marking carefully the position of the holes, or if a Clarostat, the hole, before drilling. Disconnect the primaries of your radio frequency coils from the 90-volt lead, connect together and connect to one terminal

(*Continued on page* 142)

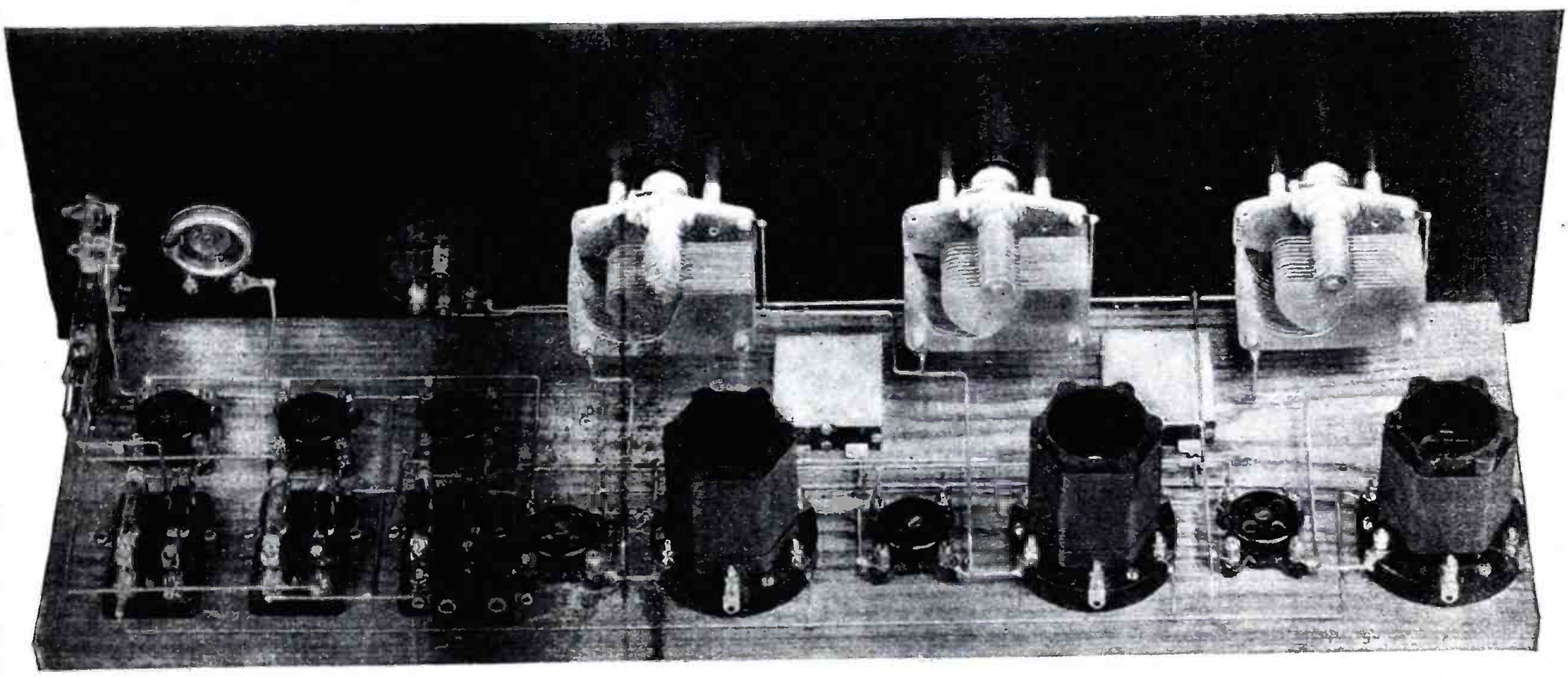
How to Build the Silver Six

By McMURDO SILVER, A.I.R.E.

FOR some time past, the writer has felt that it should be possible to design a radio receiver possessing all of the valuable features of the best superheterodynes, yet going a step beyond by dealing with the present season's radio problems in a manner not possible with any previous systems, since none of the present aggravated reception conditions were even imagined during the past year.

Last year about this time, the entire range of available broadcasting channels may have been occupied by transmitting stations, but any listener of a running up to several thousand meters. Of what value, then, is last year's receiver, with its satisfactory operating range generally from 1330 to 520 kc. (225 to 575 meters)? This year's, and future years' sets must be capable of covering a wide wavelength range—far wider than any existing sets will cover.

The receiver to be described made its initial bow to the radio public thru the columns of *Radio Broadcast* magazine during the fall of 1925 under the title of "A 1926 Receiver." Of it, Arthur H. Lynch, Editor said: "It has inductances for different wavelength bands. This made necessary the designing of interchangeable coil forms possessing a form factor suitable for all frequencies to be handled. For the higher frequency bands, the turns are spaced, while on coils for waves longer than the present broadcast band, the turns may be bank wound. Six contacts are provided on a reinforced ring at the bottom of each coil upon which are mounted six studs in which the ends of the windings terminate, and which in turn make contact with springs in a special six-con-



A back panel view of the Silver Six showing how the parts are mounted on the panel baseboard.

year's standing knows that in actual operation this was not so. Channels could often be found where stations were not transmitting and it was seldom indeed that a fan could pick up the full quota of approximately 95 stations that would be required to fill properly the broadcast wavelength range of 200 to 546 meters, a range of some 950 kilocycles. Obviously, there are far more stations operating simultaneously than there were last year. Equally obviously, we require far more selective receivers this year than last.

Today the range of the broadcast frequencies is from 1500 to 551 kc. (200-546 meters). Rebroadcasting goes down to 5996 kc. in some cases, and it is quite possible that the regular broadcasting range may be extended below 1500 kc. (200 meters). Foreign super power broadcasting takes place in many instances on long waves, well nigh perfect selectivity." This comment is most gratifying, as in designing the receiver but two aims were in view—super-heterodyne sensitivity and selectivity, and the finest quality obtainable from any receiver.

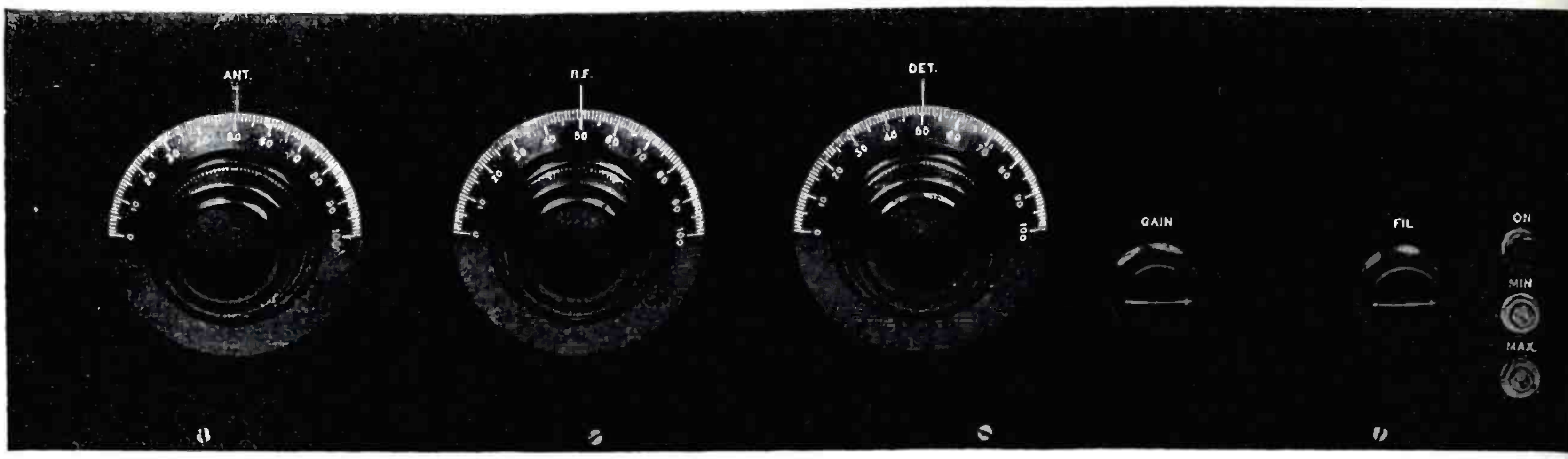
At first glance, the set does not seem at all original, since it consists merely of two stages of tuned radio frequency amplification, followed by a detector tube and two audio amplifiers. The circuit is a combination of the best points of all receivers, carefully executed with regard for the most recent discoveries, and the fund of information gained by the writer and his assistants through contact with many thousands of experimentors—men whose judgment of receiving equipment was based solely upon one thing, performance.

Since one of the first requirements was wavelength flexibility, it was necessary to devise a method of shifting tact socket, so keyed that a coil cannot be inserted incorrectly. In order to change a wavelength band, it is necessary only to remove the coils from their sockets and insert ones of different inductance values—an operation consuming about 10 seconds.

The condensers used with these inductances are of the type giving an approximately straight line frequency variation, or a uniform kilocycle variation for each dial division.

Neutralization and Loss of Sensitivity

Neutralization, which is nothing more than fixed oscillation or regeneration control, could not be used. This is because the r. f. amplifier, for a given frequency band, would have to be neutralized at the shortest wave to be received in that band so that the amplifier would not oscillate. Sensitivity would be obtained then only at the lower end of the wavelength band, while the receiver would be as inefficient and as little sensitive as the average neutrodyne at the longer waves. In this connection, the now popular circuits employing a stage of tuned neutralized r. f. amplification and a regenerative detector were considered. In them, due to reaction, regeneration in the detector circuit tends to assist the neutralized r. f. amplifier. This being at best an indirect solution of the problem, the r. f. amplifier in this design was made highly regenerative, with an increase in sensitivity, since a much stronger signal could then be delivered to the detector tube, the efficiency of which varies with the square of the applied voltage. This means that, with a given signal applied to the detector, doubling the strength of the signal will increase the detector response four times. In the new receiver, due to reaction, the detector circuit is rendered practically as sensitive as if direct regeneration were employed, through the reactive effect of regeneration in the r. f. amplifier.



How the front of panel appears. The three large dials are used for tuning while the twoknobs at the right are the rheostat and potentiometer.

New Regenerating Control

The actual method of regeneration control employed is now, practically, and consists of a variable high resistance in shunt with the grid circuit of the second r. f. tube. Customarily, a grid biasing potentiometer is employed which is extremely inefficient at short waves although satisfactory at long waves as in a super-heterodyne; or a series B battery resistance. The latter, the most popular method, is extremely unsatisfactory, as it merely controls oscillation by reducing the effective amplifier plate voltage. This process is bound to detune the set in a measure, as well as throw the amplifier tubes entirely off their proper operating characteristic if a C battery is employed, as should be done. In the system used, a variable resistance of 500,000 ohms is shunted across the tuned circuit feeding into the second tube's grid circuit. The probable average operating resistance of the tube is about 150,000 ohms, so that the resistance is so far in excess of this that selectivity is not affected. Due to careful design of the circuit, it is only necessary to decrease the value of shunt resistance to not less than 300,000 ohms to get excellent oscillation control. Obviously, this method will not affect selectivity to the detrimental extent that any other method would.

Due to the extremely low losses of the three tuned circuits, the overall amplification curve resembles that of a band-pass filter, such as is used in carrier telephone work; in some cases for separation of carriers—not 10kc. apart as in radio—but only 3 kc. apart. This is the ideal response curve and can only beo btained by other systems after they have gone beyond the limits of practicability.

The Audio Amplifier

Three stages or resistance coupled audio amplification are responsible for a fidelity of reproduction which cannot be improved upon. Not only is this method of amplification economical in initial as well as upkeep cost, but the volume obtained is greater than that resulting from the use of a standard two stage transformer amplifier, with loss B battery consumption.

The current consumption of the receiver is astonishingly low. With six tubes, three in the resistance amplifier operating on 135 volts, it was but seven milliamperes as against the general 15 to 25 for neutrodynes and 15 to 40 for supers. Despite the fact that storage battery tubes were used thruout, this was made possible by biasing the grids 4½ volts negative. Thus, the r. f. amplifiers all have the correct bias for 90 volts; the A. F. tubes for 135 volts while the detector is correct for 90 volts. This practice, unusual in the case of the detector, results in an increase in overall efficiency due to the lower detector input losses, plus the greater handling power for strong signals, unobtainable with the customary grid-condenser-leak method of rectification.

Single, Double, or Triple Control

The receiver may be tuned either as a single, double or triple control outfit at will. Each condenser is provided with a policy collar, on its shaft, which may be connected with all the others by means of fish-line. This season this method of control will be found on the Bosch, Grebe and Zenith receivers, not to mention others. It is, to the writer's mind, the most practical single-control scheme yet devised, because of its flexibility. Thus, the builder of a set may test it out carefully, determine just how it logs, then put the fish-line in place and realize a true uni-control set without the fear that all the circuits may not be properly adjusted, as in the case of gang condensers. The use of external compensating capacities, often suggested with gang condensers, is not particularly to be recommended.

Further, a multiple range, uni-control receiver cannot be built practically. It might be possible to build it for one frequency range, but if coils must be interchanged, the circuits must be compensated for errors that cannot be overcome. This is where the beauty of the fish-line control comes in—it is merely necessary in logging at first to determine how many degrees apart the three dials may run for one set of coils, then when they are used, adjust the dials to this relation and go ahead tuning with but one or two controls as desired, since holding one or two dials with the fingers and turning the other merely causes the fish-line to slip, only to grip tightly again when but one dial is turned alone.

Flexibility

One feature of the set is its flexibility. It may be used on antenna or loop with either only a detector, one r. f. or two r. f. amplifiers. Suppose an antenna is to be used, the antenna coil with its adjustable rotor for maximum selectivity is inserted in the socket at the left end of the set. Then the r. f. coils are put in their sockets and the antenna and ground connected to posts 1 and 2 of the left or antenna socket. Thus, we have a detector and two r. f. stages. If only one r. f. stage is desired, the first tube is removed together with the antenna coil, with antenna and ground connected to 5 and 6 of the middle socket, and the set tuned with the two right-hand dials. To use only the detector, the antenna and ground leads are moved to the socket nearest the detector, and all tuning is done with the right-hand condenser. If a loop is to be used, the antenna coil is removed, and the loop leads connected to 3 and 6 of the socket from which the coil is removed, depending upon the number of r. f. stages desired. The a. f. amplifier is controlled by jacks, one for the first and one for the second stage. Thus the set may be changed from a three to a six tube set at will. The volume resistance serves as a smooth, even control of loud-speaker volume, by means of which any desired intensity of sound may be obtained at will.

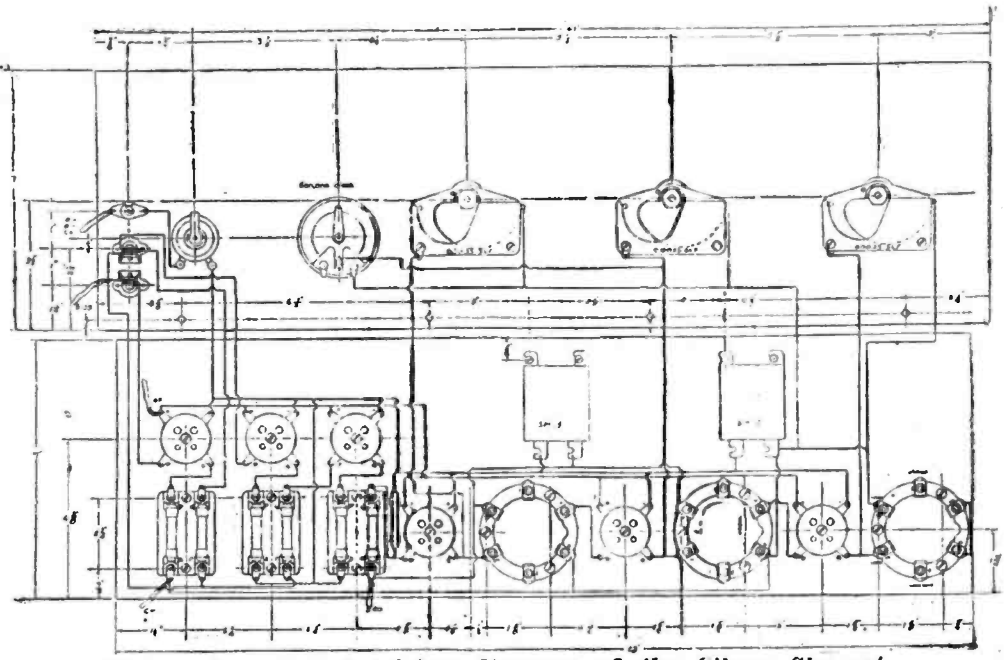
Tubes

But one rheostat is used, which will be correct for either dry cell or storage battery tubes. UX201A tubes with a UX112 are recommended for storage battery use. If the builder wishes to use the best tubes available then Musselman charted tubes, type 5VA with type 5VC in the last audio stage, will be found excellent. For dry cell operation, UX199 tubes with a UX120 in the last stage are OK. For maximum power using dry cells, Musselman 3VA tubes should be used, as they are more powerful than UX199s. Dry cell tubes will give about 10% less volume than storage battery types, but the sensitivity and selectivity of the set will be the same with either type.

Results Obtained During August

During the latter part of August, the receiver was tested in the center of the Chicago loop district, among steel buildings, and in comparison with a completely shielded seven-tube super capable of cutting side-bands, a neutrodyne and several other types of commercial tuned r. f. sets. The "Super" gave, using a loop, slightly greater sensitivity. This could be made up by attaching a 20-foot wire to the grid side of the loop on the r. f. set. This was seven tubes against five of similar types. The other receivers were practically worthless on a loop. On a 40-foot antenna, the r. f. set and "super" were even—the point had been reached where the additional sensitivity of the "Super" was useless. The other sets tested failed signally to equal the "Super" or r. f. set—even to the point of the number of stations heard. Frequently DX stations would operate a speaker on the super or r. f. set, yet could not be heard on the other factory-built sets. The results in selectivity were similar. Either the "Super" or r. f. set would eliminate some ten local broadcasters, a few less than 500 yards distant, which completely blanketed the other sets. Side-bands could be cut on any station at will with either "Super" or r. f. set, but not with the others. On local broadcasters within one mile, the "Super," shielded, was more selective than the r. f. Shielding the r. f. set evened things up. This would never be necessary, however, except where the set was but a few yards from a transmitter.

Then a sample receiver was tested in the Radio Broadcast laboratory at Garden City, Philadelphia was brought in in daylight with plenty of volume to be heard all over the house.



Picture layout and wiring diagram of the Silver Six set.

PARTS REQUIRED

- 3 S-M 311 .00035 S. L. F. Condensers.
- 3 4" Naald Molded Dials.
- 3 S-M 515 Coil Sockets.
- 2 S-M 112-A Inductances
- 1 S-M 1110-A Inductance.
- 6 S-M 510 Sockets.
- 1 Carter 6-ohm Imp. Rheostat.
- 1 Central Laboratory 500,000-ohm Modulator.
- 3 Daven Resisto-Couplers.
- 3 1/10 meg. Leaks.
- 1 ¼ meg. Daven Leak.
- 1 ½ meg. Daven Leak.
- 1 1 meg. Daven Leak.
- 1 Carter 101 Jack.
- 1 Carter 102-A Jack.
- 1 Benjamin On-off Switch.
- 1 .002 M. F. Condenser.
- 2 S-M .5 M. F. By-pass Condensers.
- 1 7x24" Drilled, Sanded and Engraved Panel.
- 1 7x23 Oak Base Board.
- 1 Belden 5-Lead Color Cable.
- 15 Bus-Bar Lengths.
- 12 ¾-inch No. 6 R.H.N.P. brass wood screws.
- 10 ½-inch No. 6 R.H.N.P. brass wood screws.
- 6 ¼-inch No. 6 R.H.N.P. brass wood screws.
- 1 Rosin Core Solder.
- 1 Spaghetti.
- 27 Tinned Lugs.

Tools required: Screw-driver, side-cutting pliers, soldering iron and non-corrosive soldering paste and hand drill with drills and countersinks.

Construction of the Set

To build the receiver, the following material is required. It is suggested that substitution be not indulged in, since many of the items have been designed for the set—to substitute without proper knowledge of the electrical details would be to court disaster with the finished receiver.

Assembly

The assembly of the receiver is quite simple, it merely being necessary to mount the parts on the base-board and panel as shown in the photos. The wiring diagram and layout is to scale for the base-board, and the sockets, coils and resisto-couplers may be screwed down in accordance with the diagram.

The dials should be put on the SLF condensers so that they read zero against their indicating marks when the plates are entirely interleaved. This is just the opposite of the manner of attaching dials on SLW condensers. In assembling the set, the panel should not be screwed to the baseboard until all possible wiring has been put on each separately.

Wiring

The wiring of the set is the simplest of assembly operations. The soldering iron should be heated, the point filed bright, rubbed in paste, and then in solder so that it will acquire a coat of tin, without which it would be impossible to solder. Each lug to be soldered should have the point of a pin carrying a little paste rubbed on the lug itself not the iron. Resin on a joint does not hurt it, providing there is solid solder underneath. Do not try to wire with anything but perfectly straight bus bar rolled flat between two boards. Then measure it carefully, cut and bend it to size, tin the ends, and finally solder it in place.

Many constructors prefer to use flexible wire in connecting up sets. In this particular receiver, this is permissible only for the filament battery, and audio amplifier sections. All r. f. amplifier wiring should be of stiff bus bar, as illustrated, in order not to interfere with the satisfactory operation of the simplified control feature.

Inductances

For the broadcast wave-length range, a 110A coil will be required in the left or antenna socket, and two 112A coils in the two right hand sockets. For the 90 to 210 meter band, one 110B and two 112B coils are needed, with one 110C and two 112C coils for the 50 to 110 meter wave-length band.

Testing

After the receiver has been completed, and the wiring checked against the circuit diagrams, it may be connected up, using one standard A battery as required, say a 6-volt, 90-ampere storage battery for UV201A's, one 4½-volt C battery and 135 volts of B battery consisting of large 22½ or 45 volt blocks. The ends of the color cord are terminated at the batteries, with the exception of the B45 and B90 leads. With those unconnected, a tube inserted in a socket should light, if the switch is on, and the rheostat is turned on. If this happens, remove the A-plus lead from the A battery, and substitute for it the B135 and then the B90 leads.

The tube should not light—if it does, the circuit is incorrect and should be checked for errors. Assuming the tube not to light all batteries should be connected properly to the set. A Bakelite "B" eliminator will work out very nicely, and entirely eliminate troubles frequently due to poor "B" batteries.

With a water-pipe ground connected to either 1 or 2 of the left coil socket, and a 25- to 40-foot single wire indoor or outdoor antenna connected to whichever post (1 or 2) the ground has not been connected to, the set may be tuned, using the three dials. It should first be operated with headphones. The modulator or volume control should be turned all the way to the right, or at maximum. The antenna coil rotor should be so adjusted that its axis is paralel to that of the stator coils. All three dials will read practically alike—that is, they will all be set at within one or two degrees of each other for a given station. Since each dial division may be assumed to represent approximately 10 kc. with S.L.F. condensers, a station might be located approximately as follows:

Locating Stations

For simplicity, let us assume that zero on the dials equals 500 kc. and 100 degrees equals 1500 kc. Thus, we have 10 kc. per dial division. Suppose we want WHT. 750 kc. (400 meters). (we get this information from the call book or daily paper). Then 500 kc., our lower limit, subtracted from 750 kc.—WHT's frequency—gives us 250 kc., which divided by 10 kc.—the frequency variation per dial degree—gives us 25. Thus, setting the dials at 25 degrees plus or minus one or two divisions will tune the set to 750 kc. (400 meters).

Suppose we were using straight line wave-length condensers. The process is different. Our wave-length range covered by 100 dial degrees may be assumed to be 200 to 550 meters, or a range of 350 meters. Thus, each dial division represents 3.5 meters. Suppose we want WHT again, at 400 meters. Then 200—our low wave-length limit—subtracted from 400—WHT's wave—gives 200, which, divided by 3.5—the number of meters per dial division—gives us approximately 57—the setting at which the set will be tuned to 400 meters.

It must be remembered that these figures are at best but approximate, due to unavoidable variation in individual receivers and tubes.

It is hardly necessary to say that the builder will be well repaid for this effort in building the set—he will be, since it is about impossible to build a practical receiver, equally simple, capable of delivering better results. A hundred stations will not be heard the first night of operation—the set is far too selective for that. It will require several nights of patient tuning before the builder will realize that he really has a better set than his friends.

Variable Resistance in Radio Circuits

(*Continued from page* 137)

of the variable resistance. Connect the other terminal of the variable resistance to the 90-volt binding post. The fixed condensers C1 and C2, which are .5 mfd. each, are connected as shown in the drawing, one each from the battery side of the primary to the negative filament of the tube.

The majority of manufacturers follow the practice of using two rheostats for a five-tube set, principally from the standpoint of either summetry or economy, and this system, using one rheostat for the detector and one for both the radio and audio tubes, is detrimental to getting the best results out of any radio detector and audio combination and should be rectified. Another rheostat is not necessary; simply disconnect the audio frequency tubes from the rheostat that controls them and connect Amperites in the leads from the negative terminals of the sockets to the switch. It is surprising what a difference this will be found to make in increased selectivity, in eliminating noises and in added sensitivity.

These two simple changes, a variable resistance in the plate circuits of the R.F. tubes and separate filament control for those same tubes, will make of any receiver now giving unsatisfactory, or not altogether satisfactory, results a thing of intense personal gratification to him who makes the changes when distant stations are pulled in smoothly and noiselessly.

The three-circuit tuner, which has been popularized under various commercial titles, has the instability common to regenerative circuits working at peak efficiency in that they oscillate whenever the circuit is disturbed.

It has been found that this deficiency can be overcome by controlling the feed-back with a Clarostat, which not only makes the circuit more stable, but also increases the volume because close coupling can be maintained between the tickler and secondary on all wave-lengths.

The function of the Clarostat across the tickler or plate coil is to strengthen or weaken the magnetic field produced by this coil without disturbing the constants of the rest of the circuit, which invariably accompanies a change in the position of a movable tickler coil. With the Clarostat, coupling between the secondary and tickler is always fixed and at maximum and therefore a signal of much greater volume can be obtained, together with a still more important advantage, one that appeals to everyone—a greater freedom from distortion in voice and music.

In the drawing L1, L2, and L3 are respectively the primary, secondary and tickler of the conventional three-circuit tuner. C1 is a .0005 mf. variable condenser, R is a 30-ohm rheostat, and R1 a 20-ohm rheostat. C2 is a .001 by-pass condenser.

Analyzing the "Diamond of the Air"

By JOHN F. RIDER, Member I.R.E.

MUCH is said and written about the various receivers that make their appearance before the constructively inclined radio fan and it must seem strange to the fan who is really interested in the art of radio that very few of these producers really supply any data to substantiate the claims made for the receivers. The reason for this is a matter of conjecture. Some no doubt do not care to publish this information, realizing that it would not be beneficial to their cause. Then again others do not care to go through all the trouble entailed. But be that as it may, those who do supply this information, and prove that their product does possess the merits claimed are compensated accordingly.

Now, would it not really be better for all concerned if some standard were developed whereby the prospective purchaser or constructor would be guided before making his investment in a receiver or a kit with which to construct a receiver? To assert that any one receiver will receive signals emanating from a station 2,000 or 3,000 miles distant is making a claim that will be very hard to fulfill. Would it not be more sagacious advertising to state that the receiver possesses certain amplifying powers in the radio frequency side and in the audio frequency side? And with a set standard, a receiver with a certain value of amplification under normal conditions would be responsive to signals of a certain intensity, which values could again be interpreted into distance and power of the transmitter. With the values of amplification specified for each receiver it would be very easy for the non-technical man to decide upon the receiver he desired. And it is an admitted fact that with the receivers advertised as they are at present one well versed in the art must hedge before arriving at a decision.

The Diamond Under Test

With the above in mind and for the edification of the fan who may be interested, the writer conducted extensive experiments upon the 1926 Model Diamond of the Air to determine just what degree of amplification is being obtained in each of the stages; furthermore to ascertain the general degree of efficiency from the aerial binding posts through the various parts in the receiver to the loud speaker terminals. The findings will be described in the following paragraphs. But before entering into the actual discussion it is necessary to consider for a short while some factors governing the design of radio receivers.

The complete constructional details of the "Diamond of the Air" appeared in the January issue of *Radio Review*.

In the first place the design of a good radio receiver is not what most fans imagine it to be. It is not the selecting of certain coils, condensers, sockets, rheostats, transformers and resistances, followed by certain wiring up of the parts until the receiver is completed, to be then vivisected and rejuvenated until the final product is produced. The cut and try method is an extremely expensive proposition, as many manufacturers have found to their disillusionment. To design a receiver one must know his requirements beforehand. The frequency spectrum or wave-length band to be covered, the most efficient inductance to capacity (L to C) ratio for that wave-length band and the type of coil used are factors of great importance, since they control the wave-length amplification curve, that is, the amount of amplification obtainable upon the various wave-lengths within the wave-length band. The design of the radio frequency amplifying side must be independent of the audio side. The amount of amplification to be obtained in the radio frequency tubes must be decided beforehand, since an overloaded detector tube is just as bad as some other defect in the design.

The Distortion Factor

The extent of regeneration in the radio frequency side, and its control, are of paramount importance, because they have a tremendous effect upon the distortion possible in the radio frequency side. The same is true of the degree of selectivity. Excessive selectivity invariably results in distortion, hence that must be excluded. Proceeding deeper into the receiver the designer encounters another multitude of requirements in the detector and audio frequency amplifying circuits which must be conquered. The choice of transformer, resistance, or impedance coupling lies before him. Perhaps a combination would be best; but that is for him to decide. So we see that a job well done is a gratifying accomplishment.

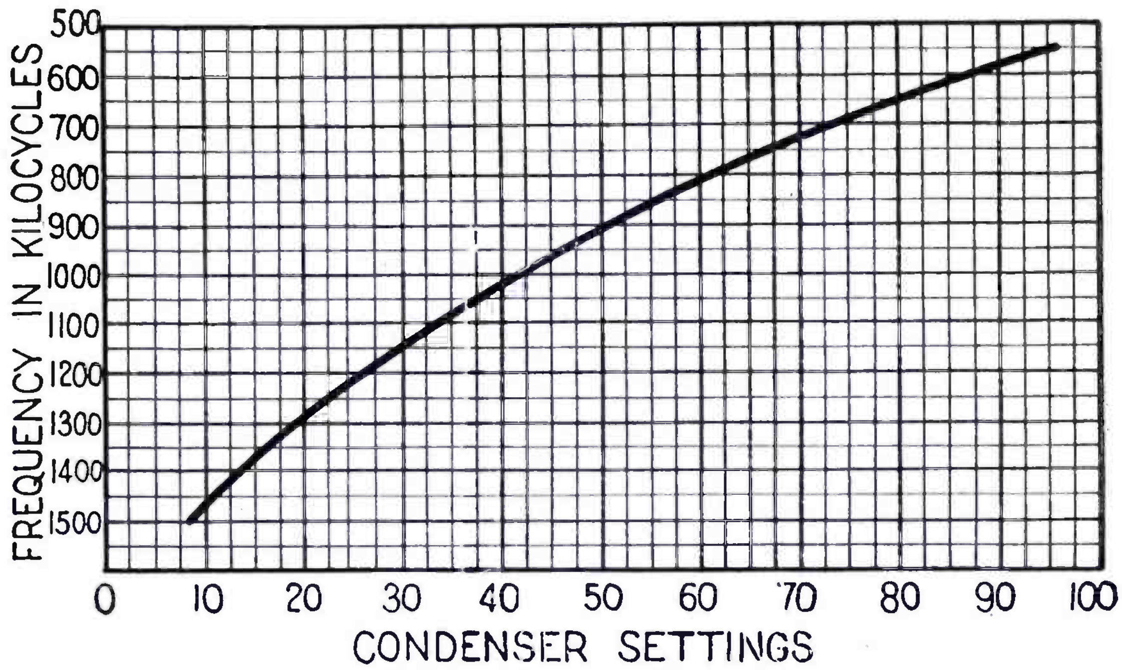


FIG. 1

The tuning curve of the Streamline straight line frequency condenser, used in conjunction with the Bruno R.F. coil in the 1926 Model Diamond. The slight drop in the lower part of the curve is due to the distributed capacity of the coil, since no coil can be made with zero distributed capacity. The curve shows how closely actual SLF tuning is approximated.

Wave Range, 175 to 560 Meters

Turning back to the laboratory tests, the first determination is the wave-length range of the receiver. This result is independent of amplification, oscillation, distortion in any circuit, etc. The receiver must cover the present broadcast band, from 200 to 550 meters, and to accomplish this effectively, so as to permit satisfactory tuning on both ends of the scale it must reach below 200 meters and above 550 meters. A calibrated modulated radio frequency oscillator was used in the tests of the Diamond. The Precision Wave-meter with a wave-length band of from 75 to 24,000 meters was beside the oscillator. In substance the oscillator is a miniature broadcasting station. The energy from the oscillator is picked up by the coupling coil, acting as a portion of the phantom antenna (condenser and the resistance box) whose constants approximate an average receiving aerial. Passing through the "dummy" aerial the energy is fed into the receiver, amplified, detected and then amplified again and passed into a measuring circuit made up of a calibrated crystal detector and a special microammeter (200 microamps full scale). By means of a switch the output side of the receiver can be linked to either the measuring circuit or the loud speaker.

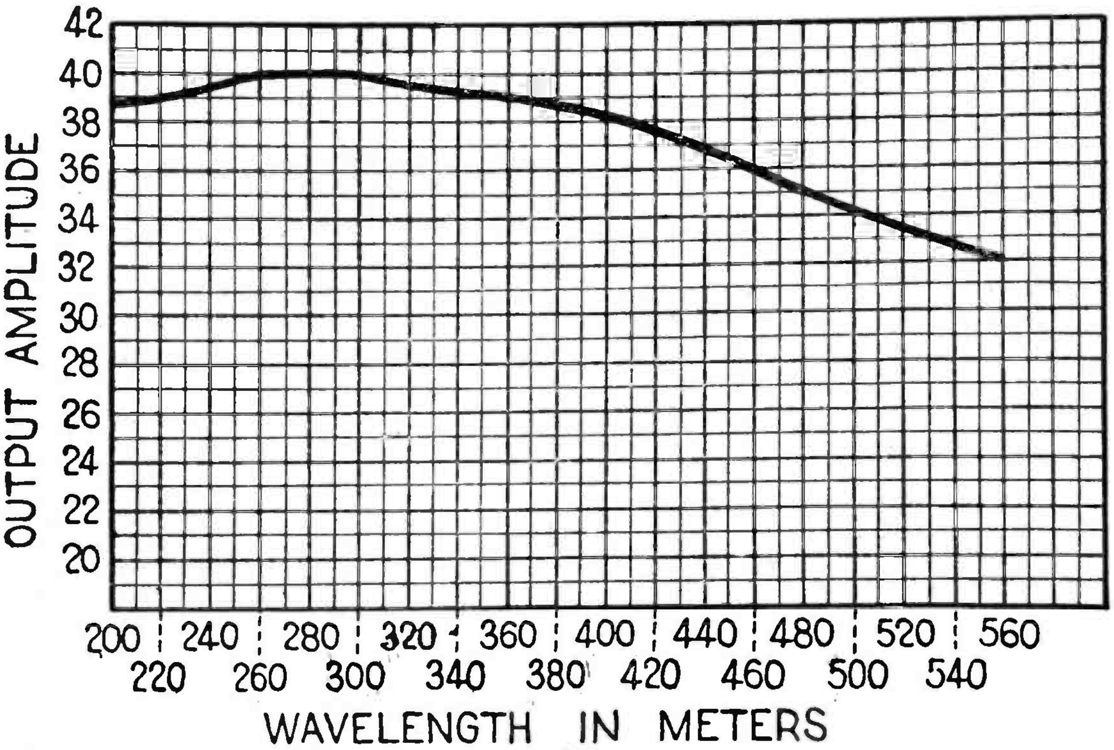


FIG. 2

The amplification of the unaided R.F. circuit in the Diamond is highest at 280 meters, as this curve shows. The curve was made in a test in which no regeneration was employed, except that inherent in the tube. The result with the tickler playing its important part will be disclosed in a later issue. The above curve compares favorably with that of other tuned R.F. receivers. At the higher capacity settings (higher waves) there is a decided drop in every tuned R.F. circuit.

The wave-length range was found to be excellent, being from 175 to 560 meters, affording a wave-length ratio of 3.2.

The next move is to ascertain how close the variable condensers come to straight line frequency tuning. Being of this design, frequency settings of even steps should be distributed uniformly over the dial periphery. If this is the case station settings will be spread evenly over the dial, that is, with uniform separation between stations. This should not be construed as meaning that a straight line frequency condenser will eliminate any interfering stations. All it does is to separate the station settings uniformly. The resultant curve, frequency against dial settings, is shown in Fig. 1. When making these determinations the tickler control setting is fixed at 0 as we are concerned solely with the action of the condensers as tuning media, the operating characteristics of the tickler being considered in a separate paragraph, which will follow later in this text.

The Amplification Curve

The next item is the amplification vs. wave-length in the radio frequency system. The results obtained in this test are really of the greatest importance, since they indicate the actual efficiency of the design of the receiver. By this token we can observe the points of efficiency or deficiency. Fans may not be aware of it, but tuned radio frequency amplifiers, too, have points of greatest efficiency, that is, greatest amplification, although it is possible to tune each circuit to resonance with the incoming wave. The shortcomings of the old and now obsolete untuned transformer coupled radio frequency amplifiers were easily comprehended, insofar as amplification vs. wave-length was concerned, since every transformer has a peak, usually located on the mean wave-length of the band covered by the unit. And it was assumed that the inception of the tuned circuits would completely eliminate this fault. That, however, is impossible, as the operating characteristics of a tuned circuit are dependent to a large extent upon the applied frequency; therefore when the circuit is tuned to various wave-lengths the degree of response is altered each time. Furthermore, the physical construction of the circuit is of great importance. By this is meant the physical design of the inductance; its winding form, shape factor, the wire used, etc. It is therefore obvious that even a tuned circuit cannot afford maximum response over the entire band, but despite that inherent handicap, the designer of the receiver has it in his power to strive for the utmost amplification through the band. And the designer of a tuned radio frequency receiver will strive to effect a straight line for the wave-length vs. amplification curve, for by so doing he attains the much-desired objective—uniform efficiency over the entire band. To some this may seem a simple task; a few experiments will prove the reverse.

Results Without Regeneration

The curve showing the amplification of the radio frequency signal on the various wave-lengths within the operating band of the Diamond of the Air is illustrated in Fig. 2. This curve was plotted without regeneration other than that due to the capacity within the tube. It shows clearly the degree of efficiency obtained on the various wave-lengths in the radio frequency circuits. When viewing this graph one must bear in mind that all artificial regeneration has been omitted. The effects of the regeneration control, as was mentioned previously, will be considered in detail subsequently.

As to the interpretation of the curve, it is apparent that the amplification falls off as the wave-length is increased beyond a certain point. This cannot be avoided and is an inherent defect in absolutely every tuned radio frequency receiver utilizing fixed primary circuits, and is attributable to the natural phenomena encountered in radio transmission. This peculiar action is the greater penetrating and carrying power of the signals on the lower bands. In addition, the number of turns in the primary circuit cause a greater reaction within the tube on the shorter wave-lengths, resulting in greater amplification. Furthermore, the greater inductive effect upon the lower wave band causes a greater voltage to be built up in the inductance and applied to the grid. And last, but not the least, the greater capacity used to tune the circuit to resonance on the higher wave-lengths also results in a slightly decreased grid voltage. Considering all the factors it is impossible to obtain as high a degree of amplification on the higher wave-length as is obtained on the lower band. So we observe that when the amplification on the higher wave-lengths is only slightly below that on the lower wave band the work of designing the circuits has been very effectively carried out.

Control Is Perfect

In the following we shall consider two items of paramount importance, in fact, the two most significant details in the 1926 Model Diamond of the Air. These are the voltage amplification factor of the stage of radio frequency amplification and of the regenerative detector. If these values are high and the associated circuits possess low values of effective resistance a high degree of amplification will be obtained in each tuning unit carrying radio frequency currents, resulting in good sensitivity and volume.

What the Amplification Factor Is

No doubt many fans are wondering about the voltage amplification factor of the tuned radio frequency stage and also of the detector. Just what is this voltage amplification factor? In simple language it is the amplifying power of the tube and coil combination. If a transformer is used in conjunction with the tube, it is the amplifying power of the tube and transformer combination. In other words it is the ratio between the voltage applied to the grid of the tube under test, and that applied to the grid of the subsequent tube. In a regenerative detector it is the increase in amplification, due to the regenerative effect, and is determined by measurement of the output of the detector tube alone, no other tube entering into this consideration, unless it be that of a vacuum tube voltmeter, utilized as the output indicating device.

Now, as the stage of tuned radio frequency amplification is for all measurement purposes entirely remote from the regenerative detector, each will be considered separately. Accordingly we will forget for a short while the regenerative detector and delve into the facts pertaining to the stage of tuned radio frequency amplification.

An Analysis of TRF

Tuned radio frequency amplification has during the past two years received so much exploitation and publicity that it is without a doubt the most widely known topic of the entire radio art among the vast host of radio fans. And correspondingly the majority of the fans, if not all, are thoroughly familiar with its function, it being to amplify the radio frequency currents before they reach the detector tube and are rectified and passed into the audio amplifiers. Now, as the stage of tuned radio frequency is intended as an amplifier of radio frequency currents, thereby augmenting the degree of sensitivity of the receiver, it is best to obtain the highest power of amplification, thereby obtaining the maximum efficiency. In technical language this would be the highest voltage amplification factor. Unfortunately, however, there are decided limits to this value, due to the amplifying characteristics of the tube itself, the tendency towards over-oscillation, which action would render the receiver unstable in operation, and the design of the various circuits comprising the tuned radio frequency stage.

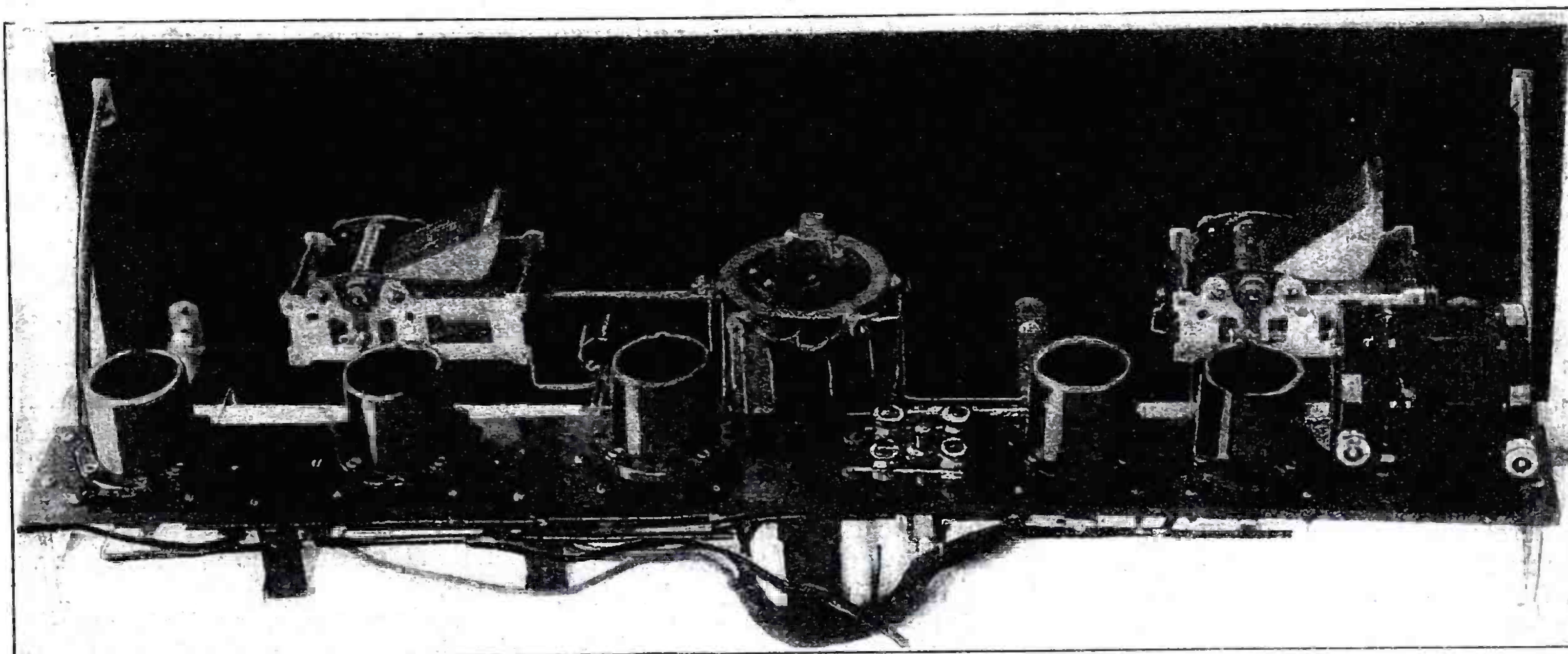
This design factor includes the primaries, secondaries and inductances values of the two and also the capacity value between the two sets of inductances. Therefore when designing the radio frequency circuits to have a certain amplification factor it is necessary to strike a value consistent with the desired stability of operation and the general design of the receiver, that is, whether or not neutralization is to be employed, an independent oscillation control included, etc. These precautions are necessary because of the increased tendency toward over-oscillation as the voltage amplification factor is increased, although it is true that there is a gain in signal intensity with each gain in the amplifying factor.

Varies for Number of Stages

The number of stages of tuned radio frequency amplification also governs the voltage amplification ratio factor of each stage. That is, each stage is designed to afford a certain value. This is unfortunate, but nevertheless true, it being necessary to reduce the amplifying power of each additional stage of radio frequency, or to use a uniform but decreased value throughout, when more than one stage are utilized. Hence the amplifying power of a well-designed single stage of radio frequency in a receiver employing only one, is invariably greater than that of any single stage in a multi-stage radio frequency amplifying unit. And the design of the Diamond of the Air has been well carried out, since the stage of tuned radio frequency amplification has an average voltage amplification factor of slightly more than 6 on wave-lengths within the broadcast band, from 200 to 560 meters. To some this value may appear small, in that the amplification constant of the tube is greater than that figure, but 6 is a very satisfactory value of voltage amplification for a stage of radio frequency, bearing in mind that the stage is perfectly stable.

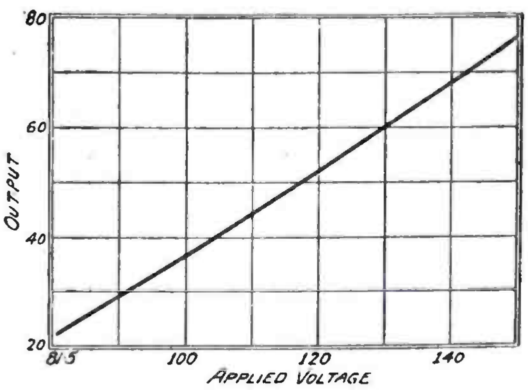
The Regenerative Effect

Delving deeper we arrive at the other important item, the amplifying power of the regenerative detector. It is unnecessary to discuss the advantages accruing through the use of regeneration in every receiver, in so far as increased distance and receptivity are concerned, but the design of a unit that will provide a high value of amplification with perfect control warrants careful consideration. In the



The rear view of the Diamond. Note the binding posts at right of the socket strip center. To the left two nuts and screws protrude. These are terminals of the audio-transformer. This method of mounting the transformer makes it fit snugly and serve as a support for the socket shelf.

first place, the attainment of regeneration is by no means difficult, but so that it be satisfactory it must be under perfect control from the minimum to the maximum wave-length covered by the tuning circuit. Furthermore, it must be a stable control with low loss circuits in the primary and secondary. This last mentioned factor has been neglected by many, but it is of importance, and many will be surprised to hear that regeneration control with a tickler or plate variometer is more difficult with a low loss secondary circuit than with a high loss system. This



Curve showing the output as measured on the basis of various applied voltages (81.5 to 150) on the 100,000-ohm plate resistors in the Diamond. This curve holds good wherever such voltages and resistors are used. The 20-to-80 scale represents arbitrary figures that show accurately the proportional increase.

should not be construed to mean that it is more difficult to obtain, but more difficult to control. This is so because there is less positive resistance to be removed from the grid circuit. And when there is a smaller value of resistance in the grid circuit each movement of the regenerating unit has an augmented effect. Apparently this is a defect, but such is not the case, because a reduction in the necessity of regenerating minimizes distortion caused by excessive regeneration and there is no loss in volume, because the low-loss secondary permits a greater inductive voltage to be built up in the secondary winding and applied to the grid of the detector tube. In the Diamond of the Air the regeneration control is perfect from 0 to 100 on the control dial. Tests to determine the regenerative amplification showed an increase in output with regeneration to be 49 times that without regeneration, affording a voltage amplification ratio of 7. Again a very satisfactory value of amplification.

25% Above Two TRF Stages

Now we have two radio frequency amplifying circuits, one with an amplifying factor of 6 and the other of 7. If we assume for one moment a non-regenerative detector, it will possess a factor of unity (one) and with the single stage of radio frequency the combination will be 6 and 1. However, by virtue of the 7 for the regenerative detector, this is of greater amplifying power than the stage of radio frequency amplification, and in reality we have the equal of two stages of tuned radio frequency amplification and non-regenerative detector, since the average tuned radio frequency receiver utilizing two stages of tuned radio frequency amplification has non-regenerative rectification. And in the Diamond of the Air the regenerative detector is more than equivalent to an extra stage of tuned radio frequency amplification and non-regenerative detector, in amplifying powers, not in the filtering effect. This must not be overlooked. The regenerative action of the detector, while increasing the degree of selectivity to a small extent, cannot increase that factor to equal the filtering effect of another stage of tuned radio frequency amplification. The increased amplification gained by the high voltage amplification factor of the regenerative detector over the non-regenerative detector and two stages of tuned radio frequency amplification approximated fully 25 to 30%, when measured against several popular 5-tube conventional type tuned radio frequency receivers.

Action of the Bretwood Leak

Another item of interest is the variable grid leak, and it is unfortunate in every respect that radio fans do not realize the importance of variable grid leaks in this day of many and various powered stations. Many discussions have been provoked by the grid leak, and many articles written about it, but very few have made mention of the fact that the value of a fixed leak is governed by other factors than the recommendation of one person. In substance, the value of the leak with a fixed condenser is dependent upon the intensity of the impressed signal, the kind of signal and last but not least the tube used. Now, if these three factors are encountered in every receiver at all times, it is quite apparent that the choice of a value of fixed leak recommended by one person is not always the correct one. The same value of leak will not permit the leakage from the grid of charges of various intensities, nor will it permit the complete discharge of the grid condenser within the required time. Hence the necessity of a variable leak. The advantages of a variable grid leak need not be described to one who has had occasion to use it at some certain time. But the fan who has never used a variable leak should by all means incorporate such a unit in his receiver.

Advice on "B" Battery Voltage

Many experimenters are prone to overlook entirely the importance of the plate voltage applied to the various tubes in a receiver, considering it as a necessary accessory, without any real significance. But the plate voltage is a paramount item when the maximum efficiency and output are desired. Without the proper values of plate voltage, the trouble taken in the design of a receiver has gone for naught, and satisfactory results cannot be expected.

Take for instance the 1926 Model Diamond of the Air. One tube is utilized as a radio frequency amplifier, one as a detector and three as audio frequency amplifiers. This makes five tubes in all. Two plate leads are furnished. One supplies both the radio frequency tube and the detector and one the three audio tubes. Now, the design of the radio frequency stage took into consideration the value of plate potential that was to be normally applied to that tube, since the plate voltage is a controlling factor in the extent of oscillations in the radio frequency system, by virtue of its effect upon the tube characteristics. Therefore if operation, as intended by the designer, is to be achieved the specified plate voltage should be used. This of course applies to all receivers, even though no definite value was recommended for a set.

The Conjunctive Plate Voltage

In the Diamond the radio frequency tube is supplied with the potential that is applied to the plate of the detector tube, which practice is entirely satisfactory in a receiver of this type, since the tendency towards oscillation in a single stage of radio frequency is very small.

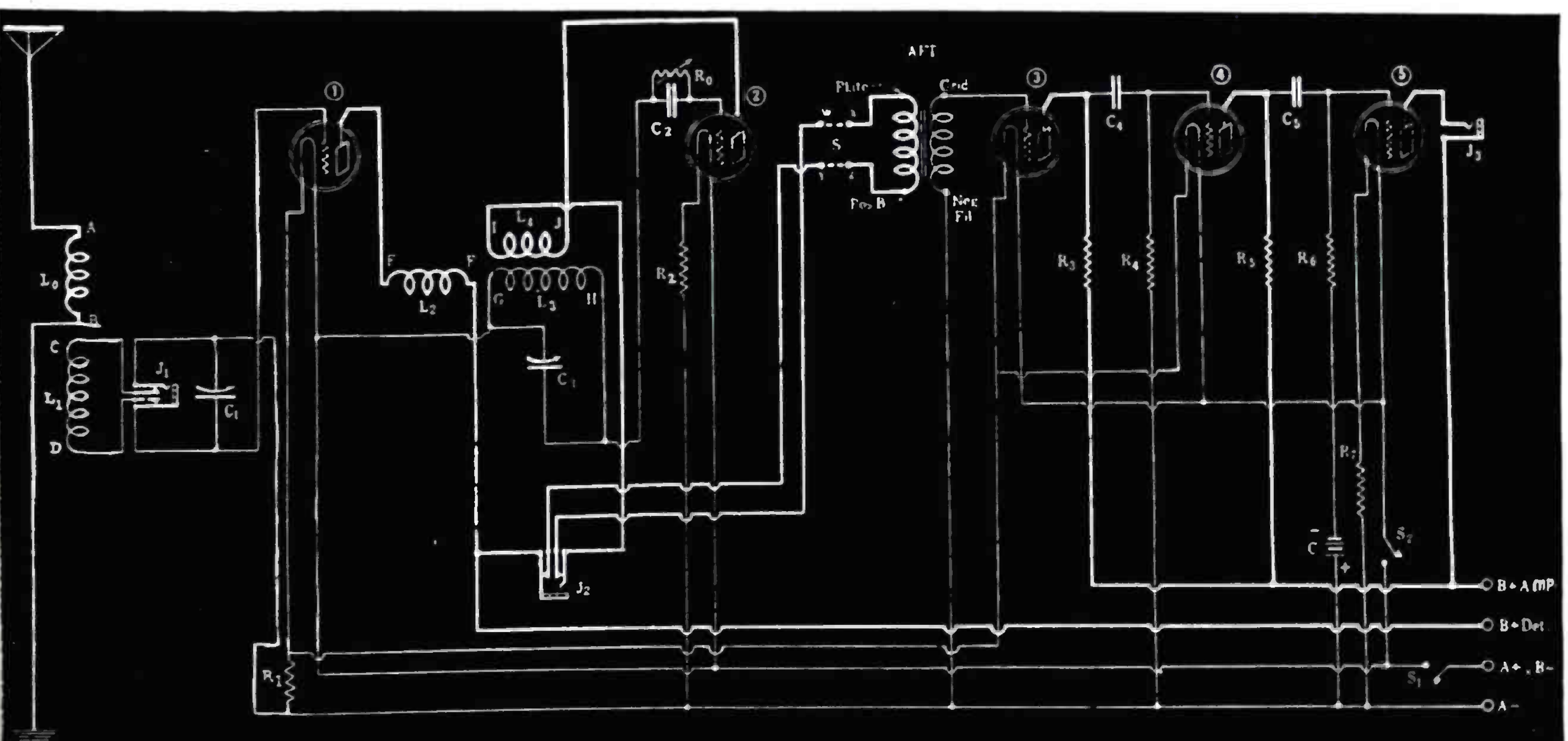
Furthermore, very little amplification is gained by applying more than 67½ or 75 volts to the plate of the radio frequency amplifying tube, since the input grid voltage fluctuations as compared with the audio tubes are very small, and it is really unnecessary to lengthen or straighten the characteristic curve beyond that obtained with 67½ volts on the plate. And since the design of the detector circuit is such as to permit the application of a plate potential of 67½ volts, without causing the detector tube to be critical in operation, it is a very feasible plan to supply both the radio frequency and detector tube plates from one source. With 75 volts upon the plates, the plate current drain of these two tubes is 11 milliamperes, divided equally between the two, each tube drawing 5.5 mils. The tubes used during tests were R. C. A., Cunningham and Musselman Certified, and the values quoted are averaged.

As to the operation of the detector tube, one can say very little, unless the particular tube used is at hand. The functioning of a tube as a detector is a peculiar action. Not that the rectifying action is different in the various tubes, but rather that the degree of sensitivity is a very uncertain item. Some fans, due to the use of resistance coupling in some of the audio stages, may forget that the detector is coupled to the first stage of audio by means of a transformer, and accordingly apply an excessive plate voltage, in order that the effective voltage be sufficient. This high voltage will cause very poor rectification, because of the complete saturation of the tube, and in additon the regeneration control will not be very stable on the lower wave band. The fan should therefore observe that the coupling medium between the detector tube and the first stage of audio frequency is a transformer.

The Audio Plate Voltages

The selection of the plate voltage for the audio amplifying tubes is slightly more complicated, in that it should be higher than is normally used for audio amplification. This is brought about by the different coupling media used. It was customary with transformer coupled audio amplifying systems to use 90 volts as standard. But the growth in popularity of resistance coupling necessitated a change in this value, that is, an increase. This is necessary so that the proper effective voltage be applied to the tube plate, since the additional resistance of the coupling resistor causes a very large voltage drop. In the average audio frequency amplifying system, using transformers, the resistance of the complete plate circuit is the sum of the tube impedance and the resistance of the transformer primary. In actual figures this approximates 14,000 to 16,000 ohms (DC). But in resistance coupled system the transformer primary is replaced by the coupling resistor, and in place of 1,500-ohm primary resistance we have a 100,000 to 120,000-ohm resistance unit, hence the total resistance is many times that previously resulting. Now, if the same plate potential is separately applied across both values of resistance it is obvious that the drop across the higher

(*Continued on page* 173)

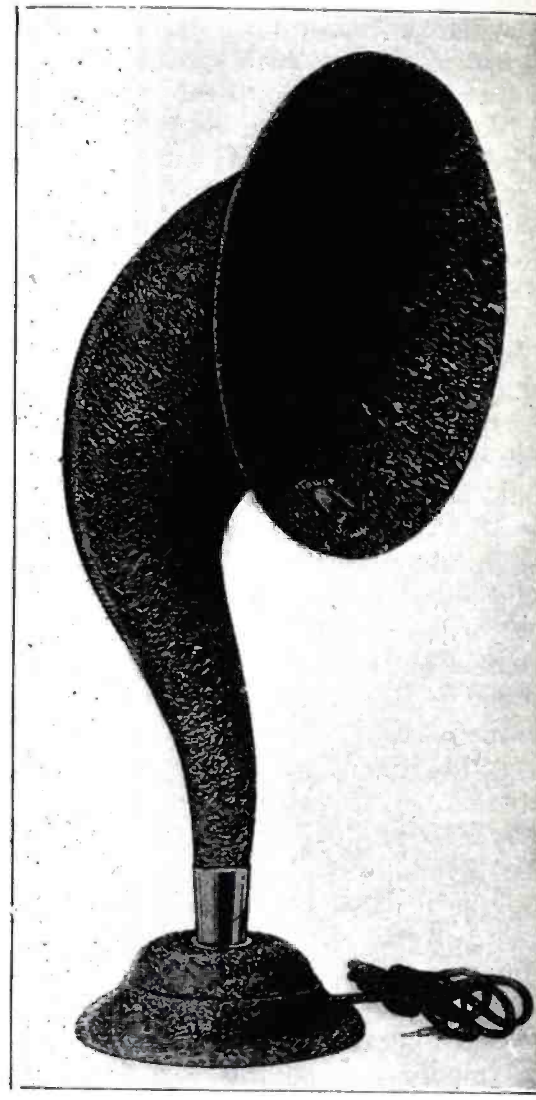


The plate resistors, shown in the above diagram of the 1926 Model Diamond of the Air, are R3 and R5, each 100,000 ohms. The curve on the opposite page shows that a B battery voltage of 140 gives about 1.75 as great an output as a voltage of 105 (the proportion of 70 to 40).

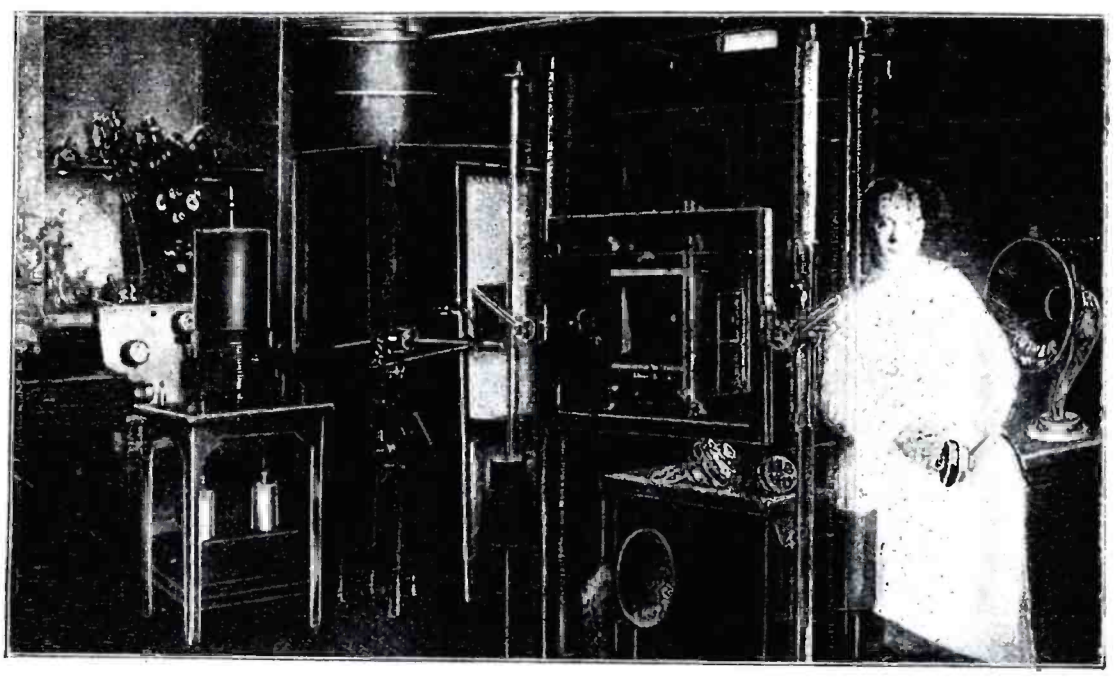
Loud Speaker
Uses Newly Discovered Principle

WITH the possible exception of the development of the cone type loud speaker, this particular branch of the radio field has been singularly devoid of any real advances in the past few years. The reproduction of the majority of speakers is faithful over only a portion of the frequency band used in music. The cone speakers, when properly made, have a deep, resonant tone and bring out the lower register with unusual clarity. However, while they represent a distinct improvement in this respect they undoubtedly require some further development. It remained for a Russian scientist, Dr. Herman Fisher, to introduce a radical improvement in this direction.

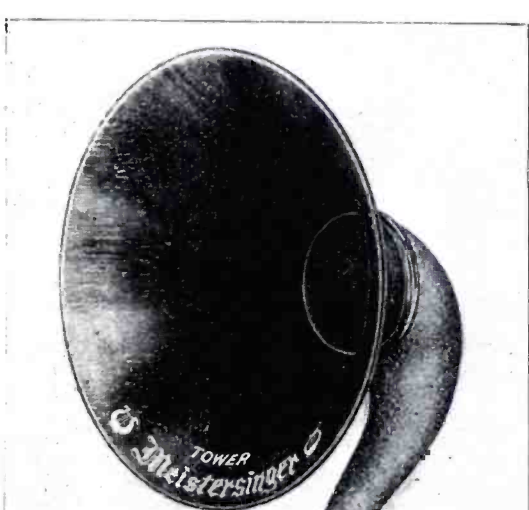
About a year ago Dr. Fisher startled the Paris Conservatory of Music and the entire musical world by producing violins which not only rivaled the famous Stradivarius instruments, but according to an unprejudiced, comparative test vote, actually exceeded the quality of what have always been regarded the ultimate in violins. Dr. Fisher solved the age old secret of the old violin craftsmen—a secret which has baffled acoustic experts and musical instrument experts for years.



Fibre horn speaker equipped with new-type unit.



Dr. Herman Fisher in his laboratory where he developed his unique loud speaker.



A speaker which utilizes Dr. Fisher's recent development.

The discovery brought to light the fact that instead of being in the geometric center of the violin back, the greatest thickness of wood in the Stradivarius is actually under the foot of the sounding post rests.

Upon his arrival in America, Dr. Fisher was at once impressed with the need of improvement in the reproducing units for radio, and accurately located the source of the greatest difficulty. He realized that true reproduction of tone qualities could not be obtained without careful regard for the diaphragm. It was therefore quite an interesting source of experiment for the discoverer of the violin secret. During the summer of 1925, the discoveries of the scientist, Dr. Fisher, were brought to the attention of Mr. F. S. Tower, president of the Tower Mfg. Corp., makers of loud speakers and head sets. Realizing the importance of the developments, Mr. Tower immediately arranged with Dr. Fisher for the application of the principle to the improvement of loud speaker units.

After several months of careful research along these lines, Dr. Fisher perfected a new type of diaphragm, utilizing the same essential principle of varying thickness that made the old violins produce such marvellously pure notes. The new diaphragm is a composite, made by welding together two separate diaphragms of different materials, the resulting diaphragm having varying thicknesses. The diaphragm is thus quicker at one portion of its surface, much as is the case with the violins referred to. It is claimed that this proper placing of the thickest part of the diaphragm results in a diaphragm capable of producing, in conjunction with the proper loud speaker, a remarkably faithful reproduction of all tones.

One portion of the diaphragm is metal—to bring out high notes. The

(*Continued on page* 168)

The Hammerlund-Roberts Set

An Improved Five Tube Receiver

By HARRY J. MARX

THE judgment of radio fans is final in deciding the efficiency of a circuit. What better proof of the value of a circuit than the continued popularity, What better proof of the value of a circuit than the continued popularity, extended to the Robert's Knockout receiver? Still, every circuit is in a state of continuous evolution. The greater the popularity the more there will be experimenting with it. This has been the case with the Roberts which has now been crystalized in its final form as the Hammarlund-Roberts circuit.

The circuit as it is shown in its final form, Fig. 1, is the result of painstaking experimental work and final judgment of ten of our foremost engineers. It has been designed and balanced and in addition so simplified that the layman or radio fan need only to follow the simple details of instruction in order to build a set that will absolutely duplicate the original just like a manufactured set.

The Circuit

Here is a circuit employing tuned, neutralized radio frequency amplification of unusual efficiency, a regenerative detector, then a stage of normal audio frequency amplification, followed by a new form of power amplifier that employs a Lyric audio transformer but requires two tubes in parallel connection. This last arrangement is the best method in which the volume that is delivered from the second stage can be utilized with absolute clarity of reception and the high degree of tone quality which is so desired by the more critical fan.

It is apparent that the circuit embodies and incorporates every important and worth-while refinement of control and accuracy of design that is known. But all this careful attention of design is based on the importance of using the apparatus as specified and around which the entire receiver is designed.

The reflex feature of the old Roberts Circuit has been eliminated because of the difficulties that every fan has encountered in the construction of reflex sets. This elimination has also been instrumental in the unusual improvement in selectivity of the set.

Although a home-constructed receiver, it resembles the best of manufactured sets in appearance and surpasses them in performance. A sloping panel, regularly engraved and with gold finish marking will make the

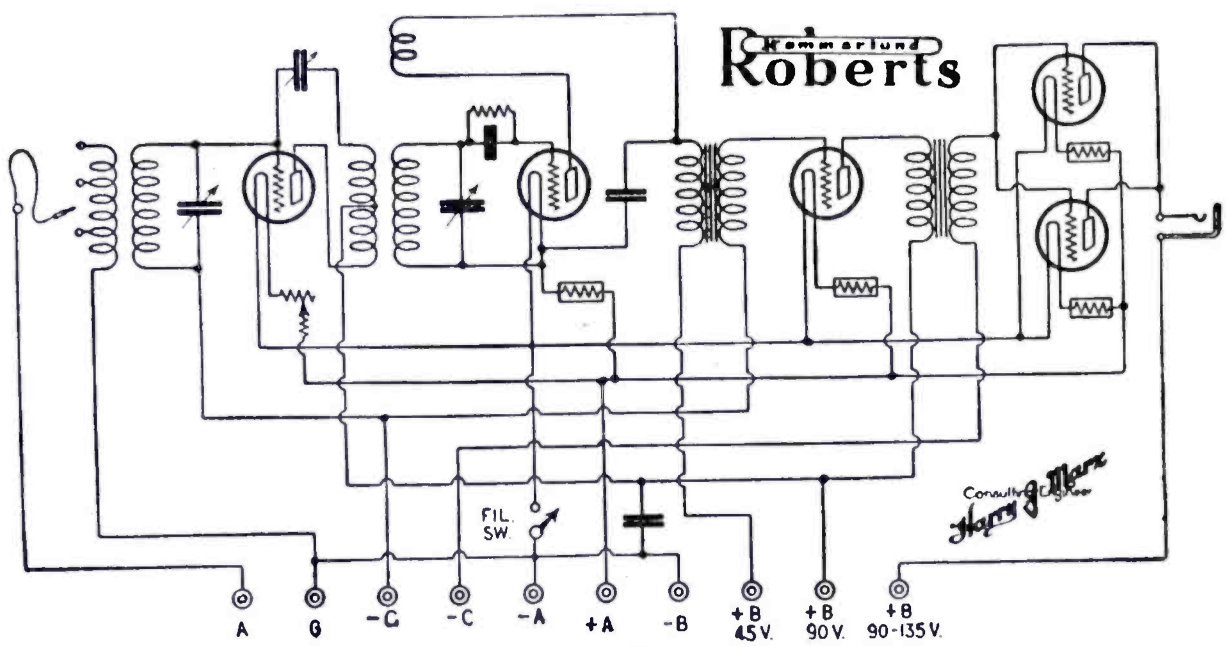


Fig. 1. Schematic wiring diagram of the Hammarlund-Roberts receiver.

most skeptical fan prone to boast of his set.

Circuit Operation

The coils are of exceptionally low loss type, designed especially for this circuit. This provides for tuning over the entire broadcast wave-length range and with that degree of selectivity necessary in order to eliminate powerful interference from local stations in order to bring in the long distance ones.

Straight line frequency condensers provide for proper separation of stations on a basis of uniform spacing of dial graduations. Because of the elimination of the reflex features the first tuning circuit is much more effective in separating the stations than before. The efficiency of the detector circuit tuning is obvious when we stop to consider the regenerative feature. The little tickler control is the guardian of selectivity and at the same time it builds the volume to all that is to be desired on long distance stations.

Volume is controlled by means of a rheostat for the radio frequency tube. put tube and, therefore, avoids the distortion due to overloaded detector and audio tubes.

There are two major controls—the condenser tuning dials, and two minor —the tickler for selectivity and the rheostat for volume. What could be simpler and more desirable for the home where all members of the fam-

This controls volume right at the in-
ly wants to know how the set works so as to use it themselves?

Comment on Apparatus

In the usual set construction article —the fan must lay out his panel, drill and countersink the holes, rarely has he the opportunity of owning an engraved panel. In this case the drilled and engraved panel, with a drilled subpanel and even brackets for mounting can be purchased as a unit. The products are all nationally known, so there is no difficulty in obtaining them anywhere. The complete parts for building the set but without a cabinet will run a few cents over sixty dollars.

Considering the individual variations in set construction as described in various publications, and the difficulties encountered by the fans in altering layouts and circuits to suit their fancies, it is not hard to appreciate the attractions of a plan which minimizes the dimensioning, layout and assembly of a set.

The List of Parts and Assembly

The important item in a receiver is not only the circuit, but the selection of apparatus used. Contrary to what many think, you cannot substitute anything on hand or that can be bought cheap. A nationally recognized product is one that has earned its reputation. Many a circuit has been condemned simply because substitutes failed to produce.

The panel and sub-panel are drilled for the parts as listed. Others will not fit—terminals will not be properly located—coupling and interference introduced and results will be lacking.

The foundation unit contains the drilled and engraved front panel, a drilled sub-panel and brackets. In addition it contains a coil mounting plate, grid condenser mounting posts, wire, fixed 4 ohms resistance and all the necessary lugs, screws and nuts for assembly.

The Hammarlund-Roberts coils consist of two units—with a special primary winding, a standard secondary and a variable coupling tickler coil. These units must be efficient low loss apparatus in order to perform their functions properly.

The variable condensers must be of similar quality so as to eliminate losses and keep the selectivity which is characteristic of the set. The audio transformers were selected because of their ability to step-up the voltage passsed through them without distortion. They are important factors when clear and beautiful reception is desired. The amperites control the filaments of four tubes and eliminate rheostats with the exception of the Carter Imp which is used as a volume control. The capacity of the neutralizing condenser is important as has been predetermined by the design of the neutralizing system. All the mounting holes, and holes for the wires through the sub-panel are drilled in exactly the proper place for mounting Na-Ald sockets. The grid and also the fixed condensers must be accurate and high quality, for this reason Dubilier has been specified. The mounting holes for the grid condenser have been drilled in the sub-panel for this type. The Union phone tip jacks mounted along the edge of the sub-panel facilitate battery connections and make a neat looking job.

No value is given for the grid leak as it differs for various tubes—but as it is important that the resistance remains fixed and not susceptible to atmospheric changes, ink impregnated paper strip types cannot be used. The Durham is a metallized filament leak which remains fixed regardless of changes in temperature.

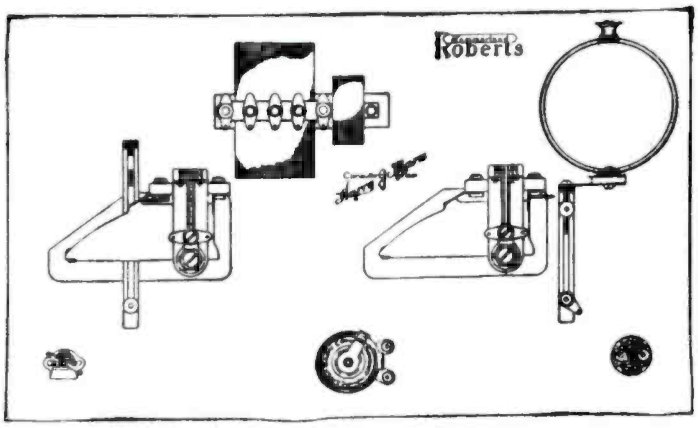


Fig. 2. Assembly of parts on the front panel.

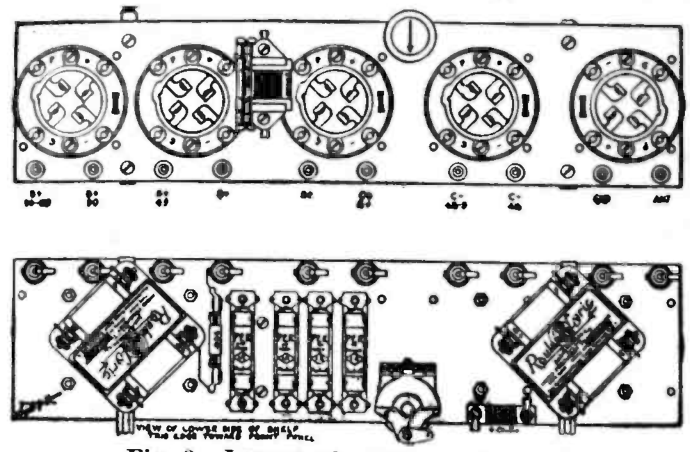


Fig. 3. Layout of parts on sub-panel.

Front Panel Assembly

The assembly of apparatus on the front panel is shown in Fig. 2. The brackets are shown but cut off so as to avoid any confusion. The shield plates of the condensers are against the panel. The one on the left in the illustration goes behind the bracket. It is best to mount the condensers and shield plates before fastening the brackets to the panel.

The coil with tickler should be mounted in the position illustrated. It is important that units be fastened with terminals located as shown. The antenna coil mounts on a brass plate, which is fastened with two screws into tapped holes in the right-hand bracket.

LIST OF PARTS REQUIRED

- 1 Hammarlund - Roberts Foundation Unit.
- 1 set Hammarlund-Roberts coils.
- 2 Rauland-Lyric transformers.
- 2 Hammarlund S.L.F. condensers .0005 mfd.
- 1 Hammarlund "Midget" condenser 16 mfd.
- 5 Na-Ald "De-Luxe" sockets.
- 1 Na-Ald 1¾-inch dial K-3844.
- 2 Na-Ald "Super De-Luxe" 4-inch dials.
- 1 Carter 25-ohm "Imp" rheostat.
- 1 Carter single-circuit jack No. 101.
- 1 Carter "Imp" battery switch.
- 1 Durham metallized resistor (grid leak).
- 4 Radiall Amperites No. 1-A.
- 1 Dubilier grid condenser .00025 mfd.—Type 640G.
- 1 Dubilier fixed condenser .002 mfd.—Type 640.
- 1 Dubilier fixed condenser .006 mfd.—Type 640.
- 10 Union phone tip jacks.

Sub-Panel Assembly

In the sub-panel assembly, there are two sides to be considered, Fig. 3, the top or upper half of illustration, should be assembled first.

The four sockets on the left have their terminals facing the same but the one on the right is reversed from these. The center socket is fastened with two screws that go into tapped holes in the sub-panel, but the others require screws and nuts as clearance holes are drilled for these. The grid leak is mounted on two brass supports, furnished with the foundation unit.

The lower half of Fig. 3 shows the sub-panel mounted on the brackets with the transformers in place. The ten Union phone tip jacks should be fastened as shown. The amperites are fastened by means of screws which go into tapped holes in the sub-panel. The four ohm fixed resistance and the .006 by-pass condenser are shown in place but are not fastened, the wiring holds them in place.

Wiring and Operation

It must be kept in mind that the tubes in this receiver are not laid out as in the conventional set. That is, the radio frequency tube first, the detector next and then the audio frequency tubes. For simplicity and short leads in wiring, the first audio tube was placed on the extreme right, Fig. 4. The second from the right is the radio frequency amplifier, the one in the center the detector and the two on the left are the parallel connected tubes of the second audio stage.

Wiring

In wiring this set these points are important—all leads are to be kept short as possible and all points should be well soldered. This doesn't mean slap solder all over everything. Make it hold—use a hot iron. The filament wiring goes in first. In the picture wiring diagram a loop, where wires cross, indicates no connection—while a black dot means they are connected and soldered.

Alongside some of the socket terminals are shown holes through which the wires are intended to pass in order to connect to units on the lower side. These holes are also shown in the view of the lower side. The wires are shown disappearing into these holes in the upper view and should be followed up from the respective holes in the lower view. Where wiring disappears under some unit such as a transformer it is shown in dotted lines in order to complete the connection.

Most of the filament wiring can be completed before the sub-panel is mounted on the brackets and the transformers put in place.

In the lower right corner there is a note "This wire is connected to the screw and bracket." Before the transformer is mounted, a terminal plug is passed over the screw on the rear edge fastening the sub-panel to the right bracket. The lead from the B—, A— and C+, and the ground phone tip jacks, is connected to this terminal. This puts the bracket in the negative filament circuit. Where this bracket is fastened to the front panel a terminal lug is shown under the nut on the lower screw of the bracket. This lug is wired to the battery switch which closes this negative circuit to the switch.

The Antenna Coil

This negative filament and ground lead must be connected to the first lug near the front panel on the upper terminal strip of the antenna coil. This is done by fastening a lug under one of the screws that hold the mounting plate on the aluminum bracket.

The antenna coil unit has six terminals, two lower ones for the secondary circuit and four on the upper strip—the one of which is grounded as explained. The other three are antenna terminals and are placed there so the fan can try all of them with the set in operation, to find which gives the best results. The antenna lead can be flexible with a clip on the end so the connection can be altered as desired. This is the reason for the note "see instructions."

Operation

Turn the volume control on full and advance the sensitivity dial to its maximum position. Now, by simultaneously rotating the two tuning dials at approximately the same settings, a squeal should be heard in the loud speaker, provided any stations are "on the air." Adjust the dials for maximum squeal and then reduce the setting of the sensitivity dial. This wil eliminate the squeal and result in reception of music or whatever is being broadcast at the time.

Perhaps on local stations the advancement of the volume control to its limit will produce distorted reception because of tubes overloading. If this is the case it is only necessary to reduce on the setting of the volume control, or else reduce the amount of "B" battery voltage applied to the last audio amplifier tubes.

Regeneration should be obtained smoothly by advancing the sensitivity control, that is the tube should go in and out of oscillation quite evenly and slowly. If this is not the case reduce on the detector B voltage applied to the B positive 45 jack.

Neutralization

Tune in some moderately strong station, and, listening in with headphones or loud speaker, turn out the radio frequency tube by means of the volume rheostat. Adjust the midget condenser setting until signals either disappear entirely or at a decided minimum. It will be necessary to retune slightly after this and then the tube should again be turned out and the condenser readjusted slightly to a more exact position. There is a distinct minimum of sound when the neutralizing condenser has been correctly set.

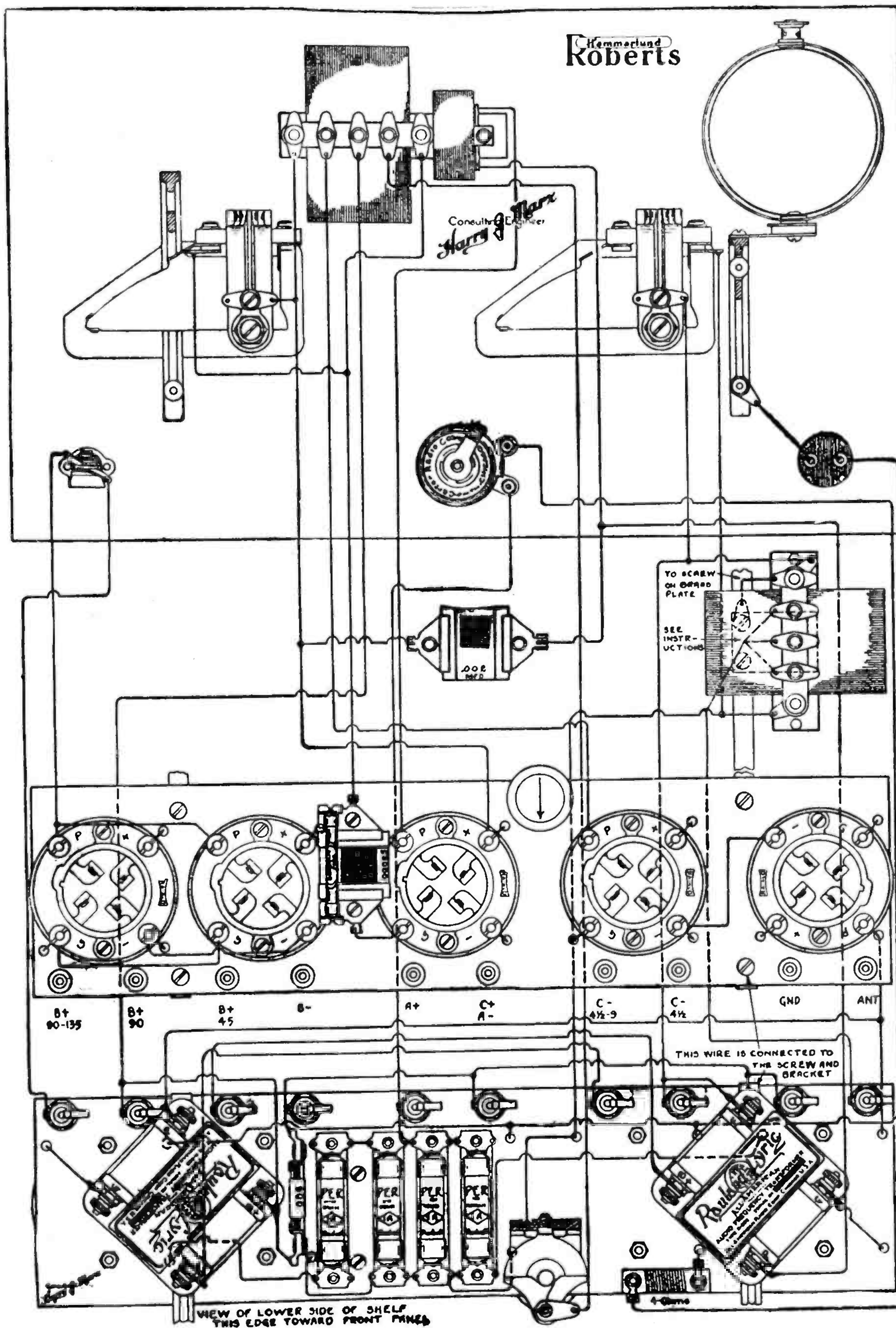


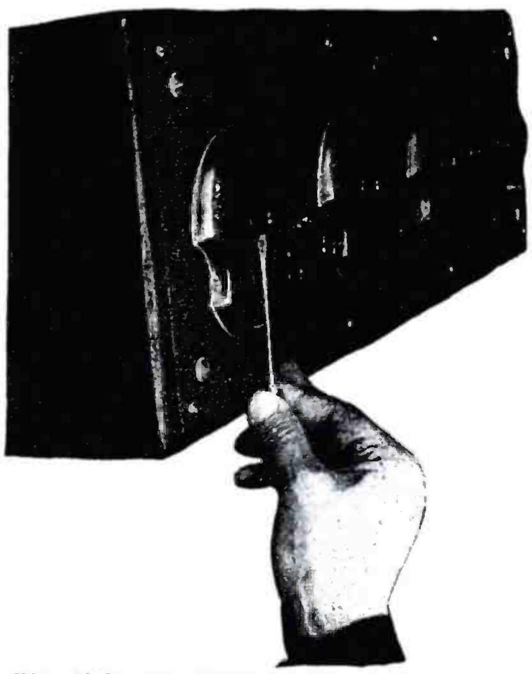
Fig. 4. Complete wiring diagram and layout of the Hammarlund-Roberts set.

Your Set May Be Down, But It's Never Out

By ARNOLD E. PFEIFFER

MY set worked so well a year ago when I bought it, but now, I don't know what's the matter." The writer has heard this complaint so often that through sheer desperation he needs must write this article and tell the radio public why a set that worked well a year ago need not necessarily work well now, and how it can be made to work just as well again.

First, the tubes. Of course they still light, but that doesn't mean a thing.



The dials can easily be attached to your present set with the aid of a screwdriver.

Tubes seldom burn out now-a-days, they just wear out, and although the tubes in your set may light with the brilliancy of Liberty enlightening the world, still they may be deader than the conventional door nail in-so-far as ability to relay high frequency impulses are concerned.

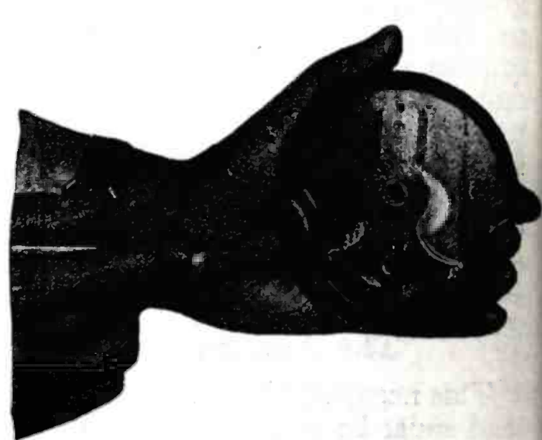
So, look to your tubes. Try them in a friend's set that's working up to snuff, and if they are dead, bury them. You can, of course, have them rejuvenated at small cost, but what's the sense? They'll only go dead again in a short time and you'll have to buy new ones anyway. If the tubes in your set have gone the way of all earthy things, buy a complete new set. Buy them from a dealer who will test each one before he gives it to you—who will test them on the meters. In this way only can you be sure you are getting good tubes.

In the new sets coming on the market arrangements are made to prolong the life of tubes by employing self adjusting rheostats for controlling the filament temperature. Automatic filament controls actually do this because they allow only the proper current to pass from the time the switch is closed until it is opened. With rheostats there is always a certain time phase during which the filaments heat at an improper temperature, *i.e.*, while turning up and turning down the rheostats, and nothing is so detrimental to the life of tubes as this.

The grid leak in your set may have changed its value since you've had the set—grid leaks do—and the grid leak, when its value is not correct, can raise more Cain in a radio set than a bull in a china shop. Obtain a range of grid leaks—1, 2 and 3 megohms and try them in the circuit. Look to your ground connection and see that it isn't corroded. See that the prongs of the tube sockets aren't loose. Go up on the roof and see that no one has hooked on to your aerial—it's being done, you know. Your "B" batteries should read at least 34 volts each.

And now, selectivity. You had no trouble a year ago separating the stations. Now, on the lower wave-lengths you are finding it more and more difficult. Certainly! There are twice as many stations to separate now as there were a year ago, and it is becoming increasingly difficult to separate them at the lower wave-lengths. This is caused by the fact that broadcasting wave-lengths are assigned according to frequencies, and every station, in order not to interfere with other stations in the vicinity, needs a frequency band of 10,000 cycles or 10 kilocycles of its own. Now, in tuning at the lower dial settings a small change in condenser capacity will cause a great variation in the frequency to which a tuned circuit responds, while a considerable change in condenser capacity is needed for the same frequency variation at the higher dial settings.

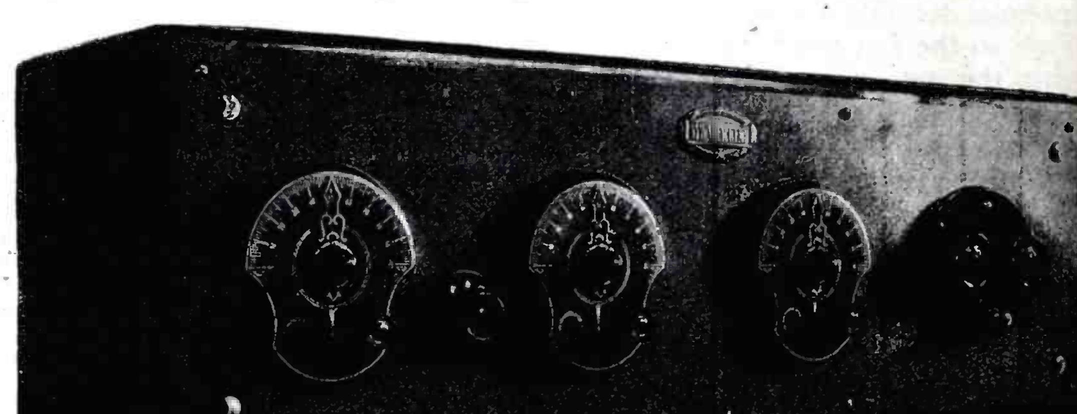
Hence, with the condensers in your set, the readings of the dial will not correspond to the variation in frequency, which means that at the lower settings of the dial, stations are crowded together, while at higher readings of the dial the stations are scattered. This problem will become more acute when space will have to be allotted to more stations, because this space can be allotted only by assigning to these stations wave-lengths below 200



The mechanism is all enclosed within the dial.

meters, which means along the lower numbers on the dial.

As a result of this confused condi-
of the dial the stations are scattered. This problem will become more acute when space will have to be allotted to more stations, because this space can be allotted only by assigning to these stations wave-lengths below 200



A typical radio receiving set fitted with Tune-Rite vernier dials.

condenser is the so-called straight-line frequency condenser, which when well

(*Continued on page* 155)

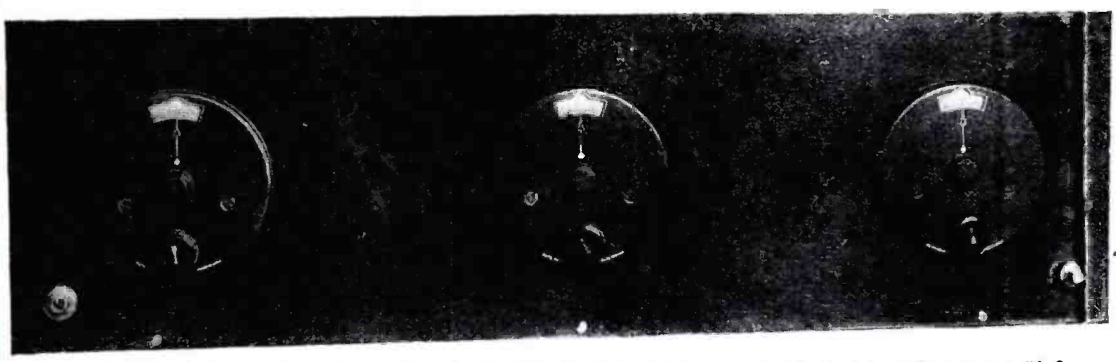
The Gen-Win Lemnis Coil Receiver

By EDWARD SPIEGLER

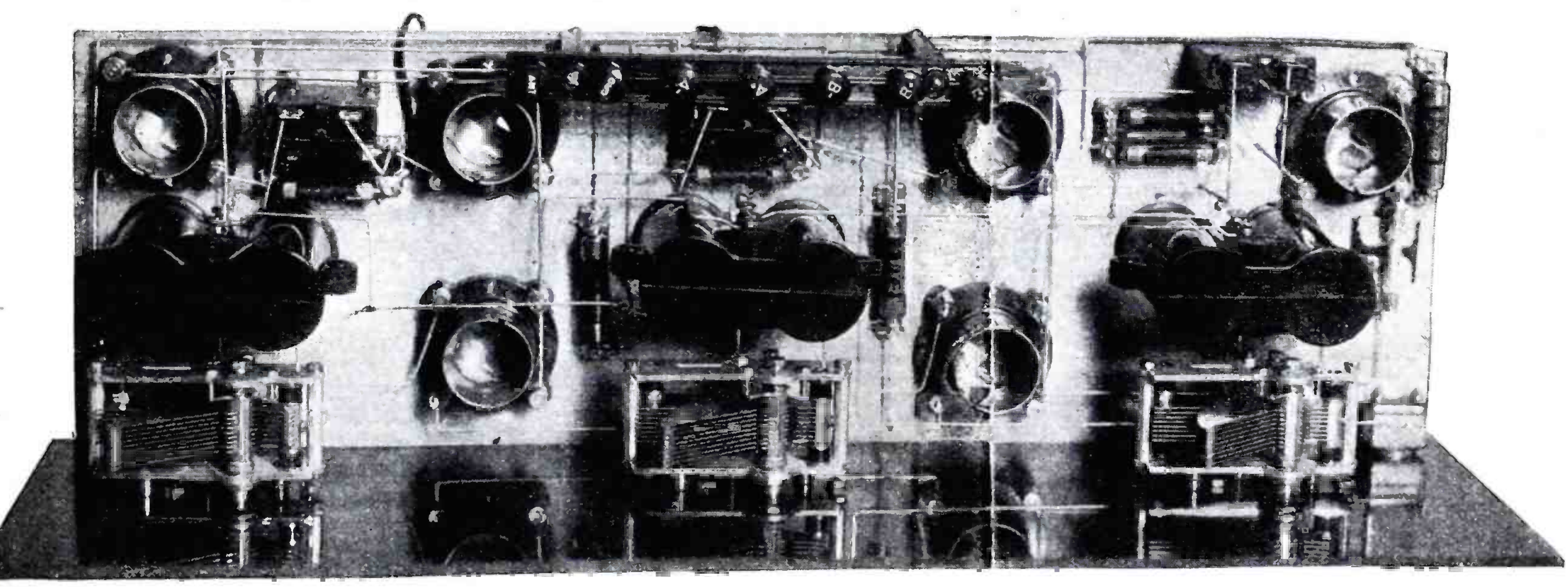
The author is shown here pointing to the Daven Mu-6 power tube in the last stage.

THE statement to the effect that the success of most radio frequency receivers depends on the particular coils used in them can be made with a comfortable degree of safety. Any radio fan who has tried straight tuned R.F. circuits with different types of transformers will willingly verify it, for he knows that efficient coils, possessing confined magnetic fields that remain in the coils and that do not cause troublesome feed-back between R.F. tubes, are what make the difference between a stable, selective receiver, and a squealingly troublesome and broadly tuning one.

It was with these facts in mind that the Gen-Win "Lemnis-Coils," a new type of radio frequency transformer, were designed by the engineers of the General Winding Company, Inc., the well-known coil manufacturers. The new transformers, wound according to the "lemniscate" principle, incorporate many features, foremost among which is its confined magnetic field. The magnetic lines of force are prevented from straying by the peculiar design of the winding that produces them, so there is no direct coupling between the stages of a radio frequency receiver using the inductances. The coils use an elongated reverse curve of extraordinary length, which gives them the desirable characteristics of the solenoid with none of the latter's inherent bad features. The coils, by the way, are decidedly not of the "binocular" type; the latter employs two separate windings, whereas the Lemnis-Coils use only one.



The front of panel is well balanced as can be seen above. The latest vernier type dials are used to obtain careful tuning adjustment.



The top view of the receiver showing how the parts are arranged.

An excellent all-around receiving set incorporating three "Lemnis-Coils" as the main tuning units can be constructed by the radio fan with little difficulty. The coils can, in fact, be connected in any standard radio frequency circuit and will work in an extremely satisfactory manner, but a definite set is described here so that the constructor will have something definite to work on. The outfit has actually been made as the photographs show, so no one need fear he is going to try something that has never graduated from the drawing board stage.

This Lemnis-Coil set involves two stages of tuned radio frequency amplification, detector, and three stages of resistance coupled audio amplification, which means six tubes in all. It is highly selective and sensitive, and because of the resistance amplifiers, boasts of absolutely perfect tone quality. The parts required are all standard, and can be purchased without trouble in any radio store. They are:

Three Gen-Win "Lemnis-Coils" (they come packed in laboratory tested kits of three); three .00035 mfd. straight line frequency condensers, with suitable dials to fit their shafts; a 7 by 24 inch panel, with an 8 by 24 wood baseboard; six standard tube sockets; three .5 mfd. fixed condensers; three resistance coupling units; five .1 megohm and one .5 megohm resistances; grid condenser and leak; one ¼, one ½, and one ¾ ampere amperites; battery switch; single circuit telephone jack; binding post strip; and the usual odds and ends of screws, busbar wire, etc.

The set is assembled in two units, the panel and the baseboard. On the panel are mounted the three variable condensers, the battery switch, and the telephone jack. The condensers are spaced along the horizontal center line, one in the exact center of the panel and the other two 3½ inches from the sides. The switch goes in the lower right hand corner, the jack in the lower left. This part of the work is simple, as it involves the drilling of only a few holes.

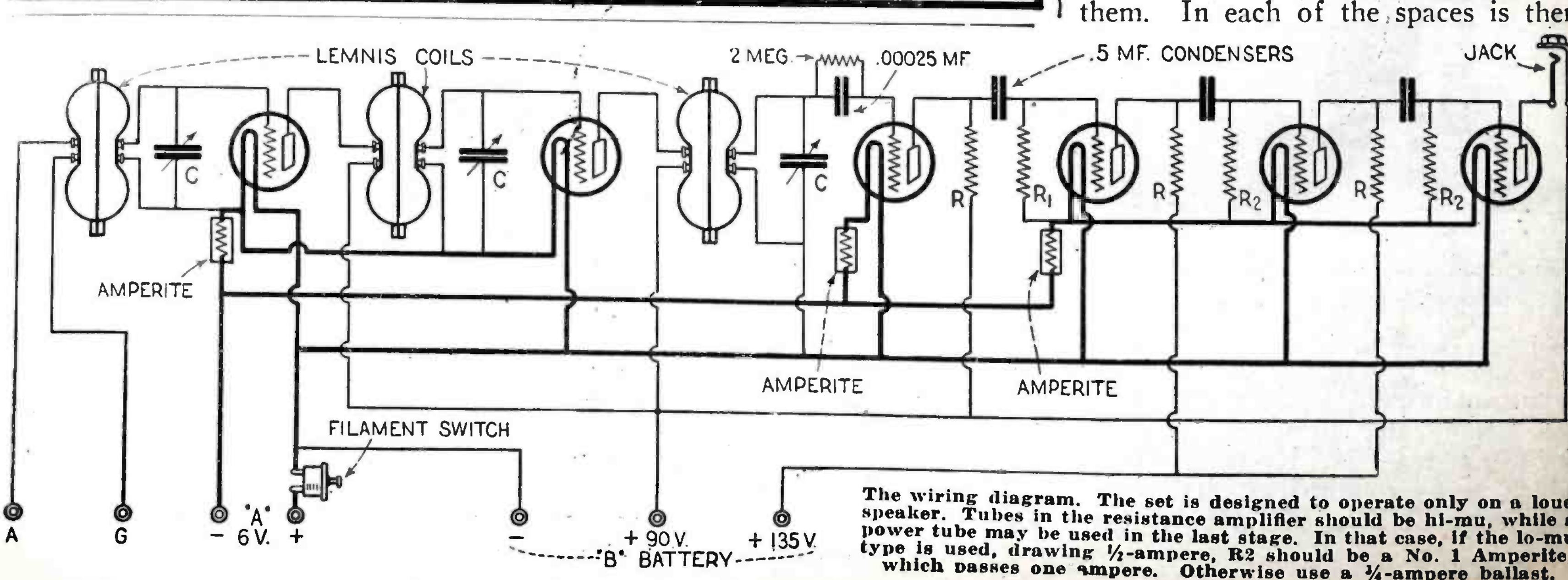
Four additional holes should be drilled along the bottom edge of the panel, ¼ inch up from the edge itself; these are for the screws that hold the panel against the edge of the wood baseboard.

After the panel instruments have been mounted, the unit should be laid aside and work started on the baseboard. The arrangement of the parts is plainly shown in the various accompanying photographs.

The three Lemnis-Coils are screwed to the board so that they will fit comfortably behind the three variable condensers on the panel. One tube socket is placed so that it will fit between the first and second condensers and another between the second and third. These are for the radio frequency bulbs, and occupy positions that make their connection wires very short.

In the extreme upper right hand corner of the baseboard a third socket, for the detector tube, is fastened down, with the ¼ ampere amperite on its right hand side. The grid and plate binding posts of this socket should be faced toward the panel, and the wires to them will fall naturally in place.

The three remaining sockets are then placed along the back edge of the baseboard, with even spaces between them. In each of the spaces is then



The wiring diagram. The set is designed to operate only on a loud speaker. Tubes in the resistance amplifier should be hi-mu, while a power tube may be used in the last stage. In that case, if the lo-mu type is used, drawing ½-ampere, R2 should be a No. 1 Amperite, which passes one ampere. Otherwise use a ¾-ampere ballast.

placed one of the .5 mfd. fixed condensers and one of the resistance coupling units. As will be noted in the photographs, a little room must be left along the middle section of the back baseboard edge for the binding post strip, which is raised above the wood about three inches by means of simple brass brackets. The strip should have its aerial and ground posts on the left (looking at the baseboard from the panel) side, and its "B" posts to the right.

The ½ ampere amperite is now screwed down a little to the right and in front of the middle Lemnis-Coil, and the ¾ ampere one in the corresponding position on the left of the same coil.

With all this done, work can be now started on the actual wiring. By way of suggestion, the baseboard parts should be wired as completely as possible before the panel is screwed permanently in place, for if the panel is fastened first and the wiring attempted later, the job will prove a decidedly awkward one. About 90 per cent. of the wiring must be done on the baseboard instruments, and only a few connections will require installation on the panel once the baseboard has been disposed of.

The wiring diagram is very plain, and needs little explanation. It will be seen that the ¼ ampere amperite controls the filament of the detector tube, the ½ ampere one the filaments of the two R.F. tubes, and the ¾ ampere one the three audio amplifiers at once.

The variable condensers are connected directly across the secondaries of the three Lemnis-Coils. Care must be taken that the stationary plates of the variables go to the grid posts of the tubes, and the rotary plates go to the filament. If the reverse order is used, the set will display "hand capacity" effects; that is, the movement of the operator's hands near the dials will affect the reception.

Standard six-volt tubes, working on a regular six-volt storage "A" battery, may be used throughout, though it is recommended that high Mu tubes like the Veby be employed in the first and second stages of the resistance amplifier. A regular 135-volt "B" is also needed, it being tapped at 90 volts for the last audio, R.F., and detector bulbs.

The great uniformity of the Lemnis-Coils makes the dials of the three condensers read almost exactly alike for any particular station. Their overall efficiency makes the set as a whole work beautifully, especially on DX. To select several DX stations of some thirty-six tuned in during two nights of listening, the dial readings were 70½, 71, 70 for WMBF, Miami Beach, Fla.; 69½, 69, 69 for WGY, Schenectady; and 89, 89, 89 for WIP, Philadelphia. It is actually possible to hear a station on each dial setting, because of the wave channel allocations and the straight line frequency characteristics of the receiver.

This set was made in the laboratory of Walter J. McCord, at 57 Dey Street, New York City, and although the particular location is known to be an extremely poor one, being surrounded by skyscrapers and the elevated railway, the outfit brought in one out of town station after another. As for the purity of the tone quality and the faithfulness of reproduction—well, you simply must hear the set to really appreciate it.

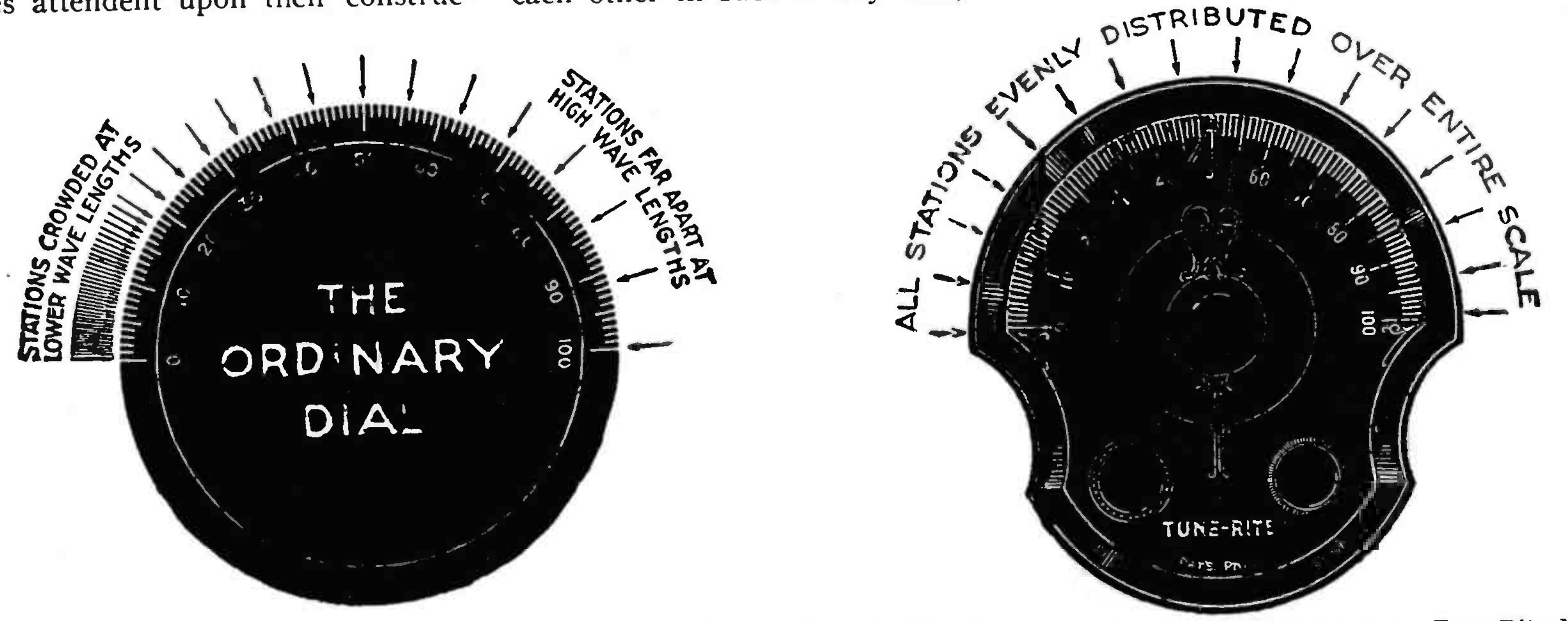
Your Set May Be Down, But It's Never Out

(Continued from page 152)

made, actually does space the stations evenly over the entire dial scale, a highly desirable feature. But here is a point of great importance. These condensers are expensive, due to the difficulties attendent upon their construction, and above all they are very bulky.

There is now, however, on the market the Tune-Rite straight-line-frequency dial which, when applied to any existing radio receiver equipped with ordinary condensers, converts it in such a way that the stations are separated evenly over the dial scale, being otherwise possible only with straight-line frequency condensers.

This conversion is made possible by means of an ingenious arrangement of two sets of gear trains. The two gear trains move independently of each other in such a way that, while one moves a pointer at a uniform rate over the graduated scale of the dial, the other train rotates the condenser. This latter gear train comprises eccentric gears, which work in such a way that at the lower readings of the pointer the condenser moves slower than the pointer. This, as can be readily seen, causes the stations at low wave-lengths to be separated on the scale and to bring stations of higher wave-lengths closer together. This dial is easy to mount, no drilling of holes being at all necessary and it is indeed fortunate for those who desire selectivity that there is in existence such a device, that can accomplish with little expenditure and in a few minutes' time all that rebuilding a set would accomplish. We thus see that there is a cure for every ill that radio is heir to and far from any set being down and out it can easily be brought up to top notch.



At the left shows how stations are crowded on the ordinary dial and at the right shows how stations are received when using a Tune-Rite dial.

A Plain Talk on Tone Quality

By GEORGE V. ROCKEY*

FROM the beginning of broadcasting until the past eighteen months, the demand of the broadcast listener has been for distance and volume. Tone quality was practically unheard of. Today distance has been relegated to the background—85% of the owners of receiving sets tune in on "local" stations within a few hundred miles of their homes. Radio has long since ceased to be a toy, it has become an almost necessary adjunct to American home life, supplying Inspiration, Education, Entertainment. The wonder that music could be caught out of the spaces and translated into music has become commonplace—the question of distance has become secondary—tone quality and appearance have taken the places of distance and volume.

The Meaning of Tone Quality

In all musical selections the melody or theme is carried by one or a group of instruments; the harmony, which brings out the true beauty of every selection, is carried by the other instruments of the orchestra, particularly the instruments of low pitch. Alone the melody sounds thin, is without depth, and, while it "tells the story," it lacks the depth of feeling which characterizes the rendering of the complete orchestra.

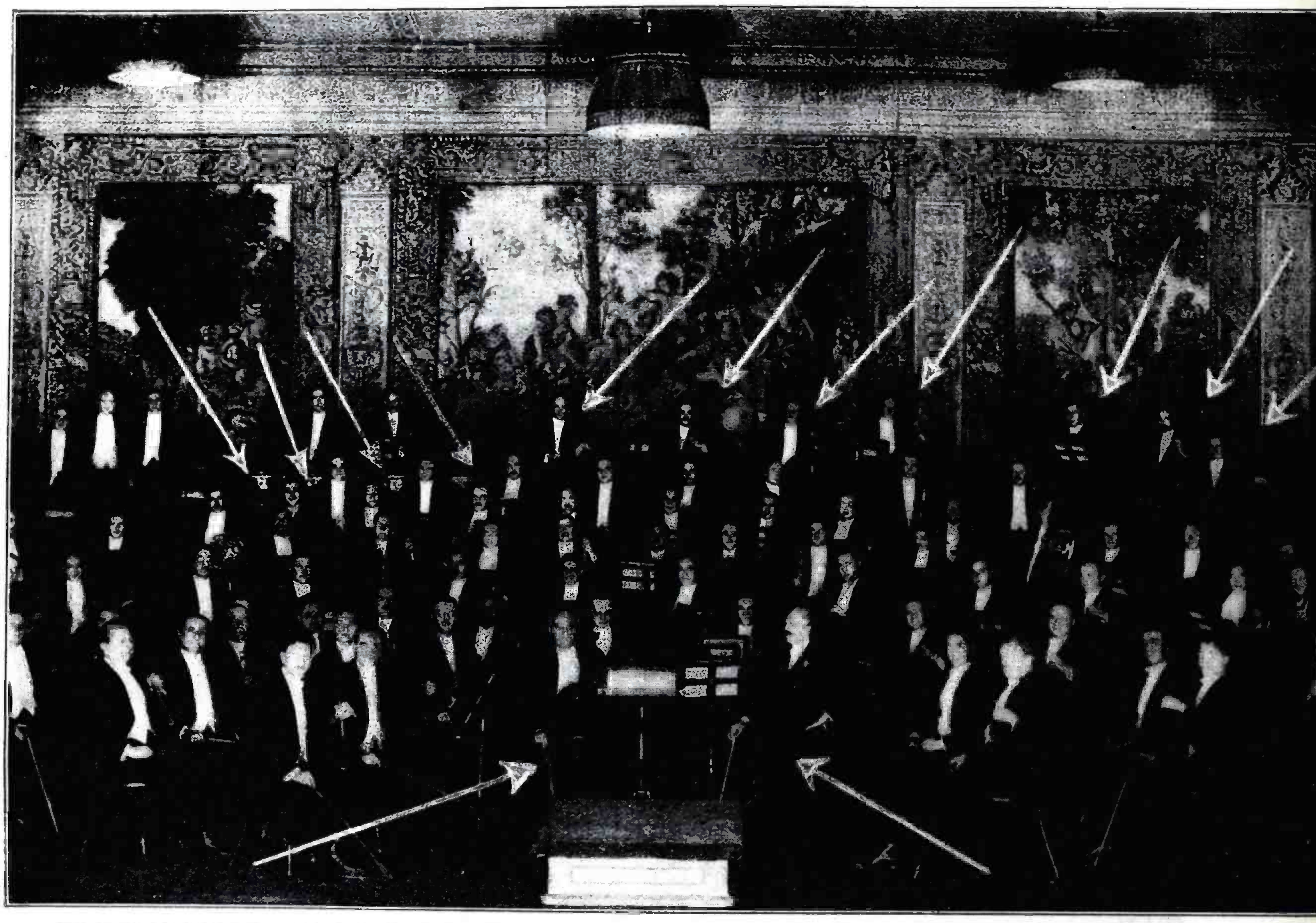
Most radio sets on the market today reproduce the melody without distortion—they also reproduce the higher notes without appreciable distortion, but the bass notes, which give the true harmony, are badly distorted, slurred over, or lost entirely.

Thus the real beauty of orchestra and band selections are lost. How many times does a piano recital sound flat? How many times have you heard the deep, resonant, pealing notes of the organ? How many times have you been able to hear the bassoon—the kettle drums?

Lost Music from Poor Amplification

To illustrate just what is being lost in many radio receiving sets now on the market, as indicated in the photograph shown herewith. Every instrument in this orchestra is needed for the portrayal of perfect music. As far as the reproduction from a majority of sets is concerned the musicians indicated with arrows might as well not be in the orchestra—you will never hear them. And many other musicians in this orchestra might also better not be there for the beautiful notes from their instruments are slurred and distorted.

This is why there have been complaints against the tone quality of the present receivers. A receiver which



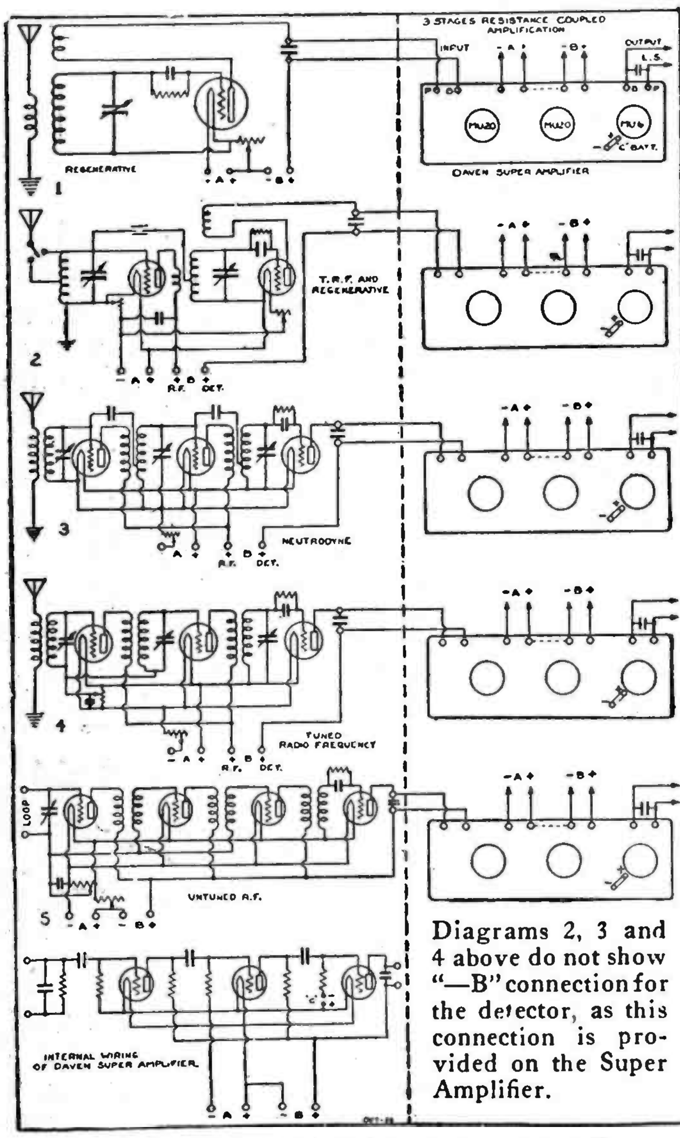
The arrows point to the musicians whose instruments are not or barely heard when the ordinary type of transformer coupled audio frequency amplification is used.

*Daven Radio Corporation

will reproduce all of the bass notes without distortion will solve the question of tone quality. And this is not only possible, but is a reality.

The Audio Amplifier the Seat of the Trouble

Every radio set may be divided into three parts: the tuning circuit, which receives the radio waves; the detector which changes them from high, inaudible frequencies to low frequencies which can be heard by the human ear and, the audio circuit, which amplifies the audible waves and transmits them to the loud speaker where they are translated into music. Any properly constructed tuning and detecting circuit brings into the radio set all of the music as it has been broadcast from the studio. It is what happens to the radio impulses *after* it has left the detecting circuit that makes or mars the reception. The audio circuit is the troublemaker—and must be improved if radio is to have the popular success it deserves.



Diagrams 2, 3 and 4 above do not show "—B" connection for the detector, as this connection is provided on the Super Amplifier.

Wiring diagram showing how to connect a Daven resistance-coupled amplifier in your set.

Years ago when inventors were making their experiments to improve the reception of code, they discovered the method of Resistance Coupled Amplification. This method brought the signals in clear and sharp, but with the growing demand for more and more distance—and with it naturally more and more volume, this method was dropped, without being developed or refined, and another transformer-coupled system was used. The only thing that transformers had to recommend then was more volume. The question of distortion meant nothing. To the dot and dash listener, distortion made no difference—a dot was a dot, and a dash was a dash, no matter how they were distorted. So the first method of audio amplification, the resistance coupled method, was forgotten and disregarded.

When broadcasting came into being, transformers were known, they had been improved and so naturally enough they were used for amplifying the audio waves.

Three years ago, realizing that, if radio was to achieve the same popularity as the phonograph, the engineers resurrected the old resistance coupled method and started to improve and perfect it.

Last year resistance coupled amplification again made its bow to the general public in a new guise—an audio amplifier which amplifies *all* of the music without distortion. It is now possible, by the use of resistance coupled amplification to hear broadcast programs just as they are played in the studio—all of the bass notes come through without being distorted or slurred, the true harmony is preserved, giving any musical selection that depth of tone which is produced by the broadcasting orchestra.

The Use of Special Power Tubes

Engineers who had been conducting experiments with resistance coupled amplifiers were fully acquainted with the fact that ordinary 201-A tubes were not suitable for resistance-coupled amplification. After years of effort, they succeeded in perfecting a new tube such as that now known on the market as the Daven MU-20. This tube has an amplification factor of 20, which is greatly in excess of the usual all purpose tubes such as 201-A tubes. With resistance amplification, it is absolutely necessary to use the MU-20 tubes in order to get the best results. This cannot be stressed too strongly.

Just as it is so necessary to use these special tubes in the first two stages of a three-stage amplifier, it is equally important to use the special power tube such as the MU-6 power tube in the last or output stage.

Most people have the idea that a power tube will give more volume than an ordinary tube. This is absolutely erroneous. The term "power tube" means just what the phrase implies—a tube to handle more power. If an ordinary tube is used and the power turned on, the tube will load up and the loud speaker will produce a series of squeals and grunts. The power tube, on the other hand, will take care of this excessive power and will feed the audio waves to the loud speaker clearly and without distortion.

How to Get the Most Out of Your Storage "A" Battery

(*Continued from page* 109)

fastened in place. If these contacts are not perfectly made, charging may not be normal and the operation of the set may be irregular from this cause.

The wires leading to the storage battery should be rubber covered without braid. Braid is attacked by the storage battery spray and is destroyed in a short time whereas the rubber covering is immune.

While the gases that escape from the storage battery in charging, particularly at the end of charging, are hydrogen and oxygen which are not in themselves harmful, the higher rates of charge draw up also a fine spray which leaves a coating about the vent tubes at the end of charge. The eye of the operator should never be held close to the vent opening during charging for this reason.

Hydrogen gas is, of course, inflammable and explosive as it leaves the battery cell and an open flame should never be held over the storage battery vent at any time. Use an electric bulb held so as to illuminate the interior of the cell when you are adding w ter, with the eye at least two feet away from the cell.

The electrolyte is dilute sulphuric acid which is harmful to fabrics and to the finish of furniture. Should it exude or be spilled in any way it may be neutralized by throwing baking soda on the dampened surface and when the bubbling ceases, wiping off the surface with an old cloth. An old cloth dipped in ammonia water should also be used for drying the top of the battery after filling with water and after charging.

Routine Charging

Assuming that the user is supplied with a normal 80 ampere hour battery and a commercial charger of standard make usually charging at either 2½ amperes or 4 to 4½ amperes; on a five tube set in the average home, the battery should be charged at least overnight once in ten days. If the charger is rated at 2½ amperes it should remain on charge about 20 hours. If the charger is rated at 4 to 4½ amperes it should remain on charge about 14 hours. This is, of course, not a fixed schedule and must be adjusted by the user to meet his conditions of service.

Keep Your Battery Charged

Actual experience of manufacturers and dealers in radio "A" storage batteries clearly indicates that a very large per cent. of battery troubles are due to undercharging and that only in rare instances is the storage battery damaged by overcharging. Users should always bear this in mind and understand clearly that if they charge infrequently the very slight economy in current consumed is more than offset by unsatisfactory radio reception and a short-lived radio storage battery.

What the Beginner Should Know About Radio

(*Continued from page* 88)

other words, greatly amplify a weak impulse.

A small variation of the potential in the grid circuit causes a large variation in the plate current. However, it should be noticed that these two circuits are quite separate and it should also be borne in mind that the energy in the plate circuit is not supplied by the incoming grid voltage, but merely controlled by the latter. The energy in the plate circuit comes from the battery and is only released by the action of the grid of the tube.

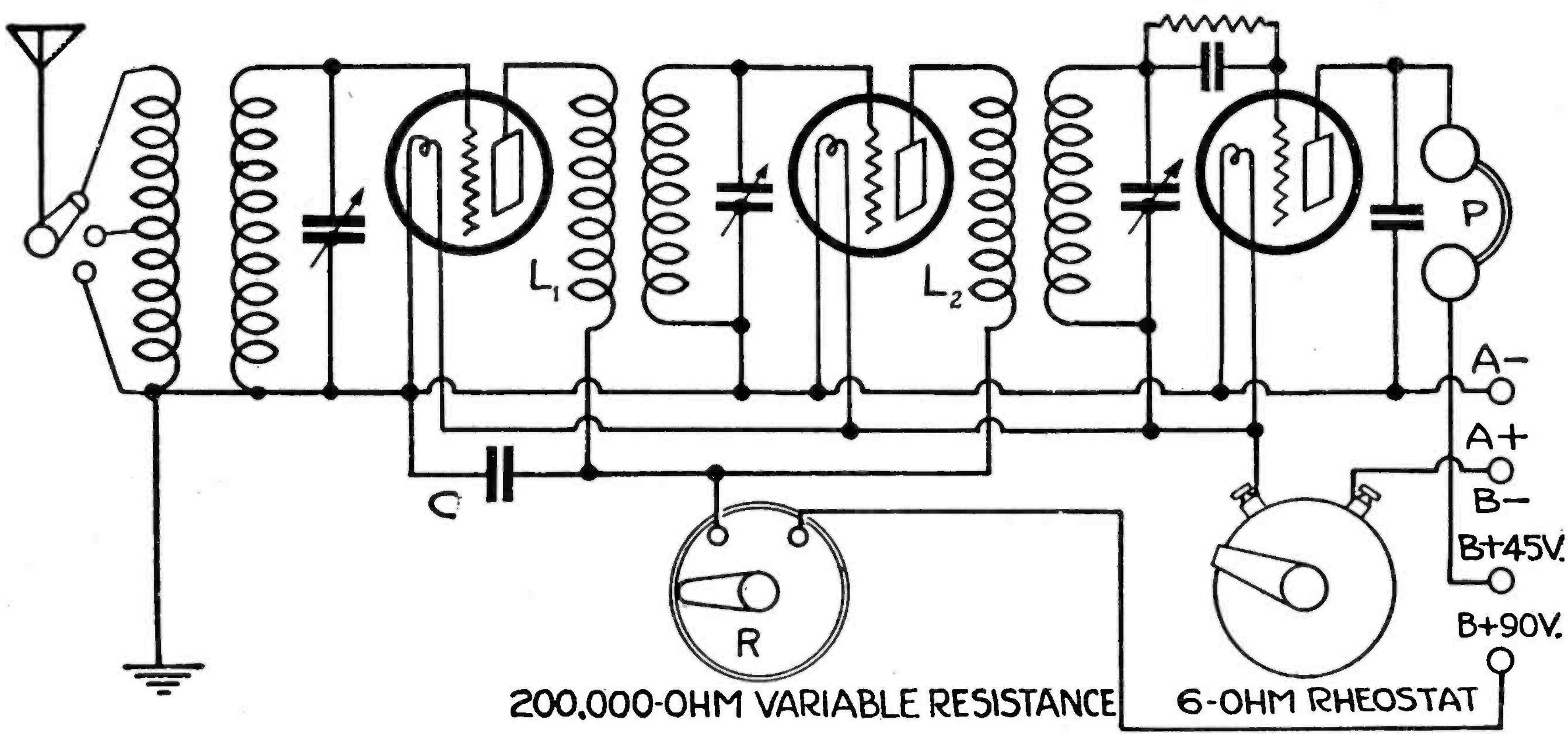
By a relaying system the small amount of energy in the grid circuit releases a much greater amount of energy in the plate circuit, which is then utilized instead of the smaller amount of energy that is coming to the tube. Of course, the amount of energy that can be controlled by one tube has a limit, but if greater amplification is desired several tubes can be connected together by suitable means and each one can add its own part to the building-up process, until finally we have a huge amount of energy resulting from a small initial input. This is the manner in which an amplifier system operates.

The Use of Resistance in Radio Sets

By E. R. STOCKLE, Ph.D., Member A.I.E.E.*

IT is well known that a circuit including a coil and a condenser is capable of electrically oscillating, provided that its resistance is low enough. If an electromotive force is suddenly applied to such a circuit, the current which flows will not immediately reach a definite value, but will over-shoot its final value and oscillate back and forth a number of times before reaching a steady flow. If the resistance of the introduced by the vacuum tube is equal to or greater than the positive resistance of the circuit then the circuit will generate sustained oscillation.

This very valuable property of the vacuum tube becomes a great source of trouble in radio receiving circuits, which are made up of a number of tubes capable of supplying energy to a number of tuned circuits. It is the chief cause of the oscillation control anced to avoid oscillation prevents the nice adjustment of the vacuum tubes which will give enough regeneration to compensate for resistance losses in the circuit at all frequencies. This seriously decreases the efficiency of the receiver, particularly in getting distant stations. If the counter electromotive force of this method were adjustable at the will of the operator, so that the set could be operated close



A portion of a five-tube tuneu radio frequency circuit snowing the use of plate voltage control to prevent the vacuum tubes from generating uncontrolled oscillations.

circuit could be reduced to zero, the electrical oscillation thus started would continue for a very long time and would die out slowly as energy is radiated from the circuit in the form of radio waves. It is therefore apparent that resistance is a detriment when inserted in an oscillating circuit, since it dissipates the energy of the oscillating current.

One of the chief purposes of the vacuum tube in modern radio circuits is to compensate for the resistance losses in the oscillating circuits. The vacuum tubes supply energy from the plate battery at the proper frequency and phase to make up for the resistance losses in the circuit. For this reason the vacuum tube is often called a negative resistance device, since its effect is the same as though resistance were subtracted from the circuit. If the energy supplied by the tube to the circuit more than compensates for the loss of energy in the circuit, or in other words, if the negative resistance problem with which all designers of tuned radio frequency circuits must contend. Many schemes have been provided to prevent the vacuum tubes in a tuned radio frequency circuit from generating uncontrolled oscillations. These schemes may be divided into three classes.

1—The introduction of proper counter electromotive forces through inductance or capacity coupling.

2—Introduction of losses sufficiently great to prevent their compensation by the vacuum tube.

3—The method of limiting the supply of plate voltage to the vacuum tubes so that they cannot furnish enough energy to generate oscillations.

The first of the above mentioned classes is exemplified by Neutrodyne and so-called Reversed Feed-Back circuits. It has had a great popularity for about two years, but as generally put into practice sacrifices one of the great advantages of the vacuum tube. A circuit which is permanently bal- enough to the oscillation point to give maximum efficiency at all wavelengths, this method would be one of the very best. As commercially produced, however, this is not accomplished.

The second of the above methods has a large number of representatives, among which are the introduction of resistance into the grid circuit, absorption circuits, the potentiometer control, etc. This method, while not necessarily decreasing the efficiency of the receiver, usually results in broader tuning. The introduction of a resistance loss into a freely oscillating circuit is generally not good radio practice, even when vacuum tubes are included to compensate for this loss.

The third of the above methods has been given commercial attention only within approximately the last year, and it is the purpose of this article to set forth the ideas underlying this circuit. In this method the resistance used for oscillation control is not electrically a

*Chief Radio Engineer, Central Radio Laboratories.

part of the freely oscillating circuits, but is simply used to govern the voltage which is supplied to these circuits.

A diagram of a five-tube tuned radio frequency receiver employing plate voltage control method is shown in the diagram. In designing this circuit, all the well-known precautions for positioning the coils and otherwise eliminating feed-back between successive stages, should be used. If this is not done the amount of resistance which is necessary in the plate circuit might be so great as to decrease somewhat the efficiency of the radio frequency tubes. In general, the type and arrangement of coils used in the Neutrodyne and other tuned radio frequency circuits makes a very satisfactory design. It will be noticed that the distinctive feature of this circuit is that the primaries L1 and L2 of the radio frequency transformers are brought together and a resistance R connected in series with them and the positive "B" voltage. This resistance must have a high value in order to provide the required range of control for the voltage. It further must have a wide range of variation, that is from maximum value down to practically zero. It is also desirable that this resistance be so tapered in value that the resistance per unit length of the element be less at the low resistance end than at the high resistance end. When two radio frequency tubes are controlled by this method a resistance of 200,000 ohms is the preferred value.

Another very important element is the by-pass condenser which is connected from the Positive "B" side of the radio frequency transformers to the filament. This condenser should have a value of about one microfarad or a one-half microfarad condenser may be connected across each of the R.F. tubes. It will be observed that this condenser provides a path for the oscillating plate current so that this current is not obliged to pass through the high resistances. In other words, the primary of the radio frequency transformer, the vacuum tube, and the condenser C provide a closed circuit whose greatest impedance is that between the plate and the filament of the vacuum tube itself. The D.C. voltage applied to the plates of the radio frequency tubes is governed by the value of the resistance R and at any given frequency just enough voltage is applied to the plates of the tubes to compensate for resistance losses in the oscillating plate circuit. As the frequency to which the receiver is tuned increases, the energy fed back through the grid to plate capacity of the tubes, and also through the inductive coupling between stages, increases. This .auses an increase of energy compensation to the point where the receiver will go into uncontrolled oscillation unless additional resistance is inserted at R. It is thus possible for the operator to adjust the energy supplied to the radio frequency tubes by means of the resistance R so that the set will operate at its most sensitive regenerative condition. This will permit the greatest range of reception and also will provide adjustment for best quality.

It should be noted that this circuit, unlike many of the resistance controlled circuits, does not introduce any loss into the tuned circuits. It therefore does not interfere with the efficiency nor the sharpness of these circuits. This is one of the outstanding advantages of this method of oscillation control.

Another advantage is in the economy of "B" battery consumption of the radio frequency tubes. When the circuit is properly designed it will be found that at frequencies below three hundred meters the resistance in the plate circuit of the radio frequency tubes will be of the order of 100,000 ohms.

Under these conditions the plate current taken by these tubes will be as low as one-half milliampere, compared to the eight or ten milliamperes normally consumed by these tubes. The large volume obtained on the shorter wave-length stations with this very small plate current consumption is one of the surprising characteristics of this circuit. It results directly from he fact that the control resistance does not dissipate the radio frequency energy but supplies just enough direct current voltage to the oscillating circuits to allow the tubes to operate at their greatest efficiency.

This circuit has been discussed at ome length because it is an illustration of the proper use of resistances in radio circuits. In conclusion it may be stated that in order to obtain maximum efficiency from a radio receiver, resistances should not be included in any of the circuits which carry oscillating current, since this generally results in broadening the tuning and lowering the efficiency of the receiver. Variable resistances used as a means of governing the energy supplied to the oscillating circuits in a receiver are among the most satisfactory devices for accurately controlling the regeneration and oscillation of vacuum tubes, and when properly designed they give the operator perfect control over the tubes in his receiver.

structure and any slight vibration breaks it. On the other hand, if the tube is operated above the proper temperature, the filament is rapidly vaporized and the tube may be burned out. It is evident, therefore, that the temperature and current must be kept within a very narrow range.

There are, however, certain kinds of wire, consisting of metallic alloys, which possess the quality of increasing their resistance under heat to such an extent as to exactly counterbalance a voltage across the filament. If then a voltage applied to such a filament is increased, the wire simply heats up a little more and increases its resistance, so that, even with a higher voltage, only the required amount of current can flow and no more.

It is a filament of this kind of metallic alloy of which Amperite consists and which adjusts the current automatically. It is contained in a hermetically sealed glass tube, filled with an nert gas, which prevents damage to he tender filament operating under the foremented thermo-electric prin- ple. It has, as already indicated, the nique property of automatically anging in resistance as the "A" bat- y voltage changes, thereby main- ning an even flow of current in the e filament.

his is most clearly demonstrated ve the current passing is operated on a rrent

Fig. 1 is a typical illustration of the proper way to install an aerial, using a standard steel "Hercules" Aerial Mast.

Note how the mast places one end of the aerial well above the roof and treetops. The other end of the aerial is secured to the gable of the house, by a screweye.

The lead-in is a continuation of the aerial wire—this eliminates a splice. Energy is lost at all splices, try not to make any.

It will be noted that the antenna is double insulated from the top of the mast and also the gable roof.

The Mast should be equipped with a mast-head pulley so the antenna may be raised or lowered at will. The mast-head pulley should be galvanized and the pin on which the pulley wheel turns should be brass so it will not rust or wear.

The guy wires should be galvanized and about 1/8" in diameter. The mast should be of substantial construction, preferably of steel. The Hercules Aerial Mast for instance uses a special high strength pressed steel section to give proper strength and at the same time reduce the weight—so it can be erected easily.

(*Continued on page* 172)

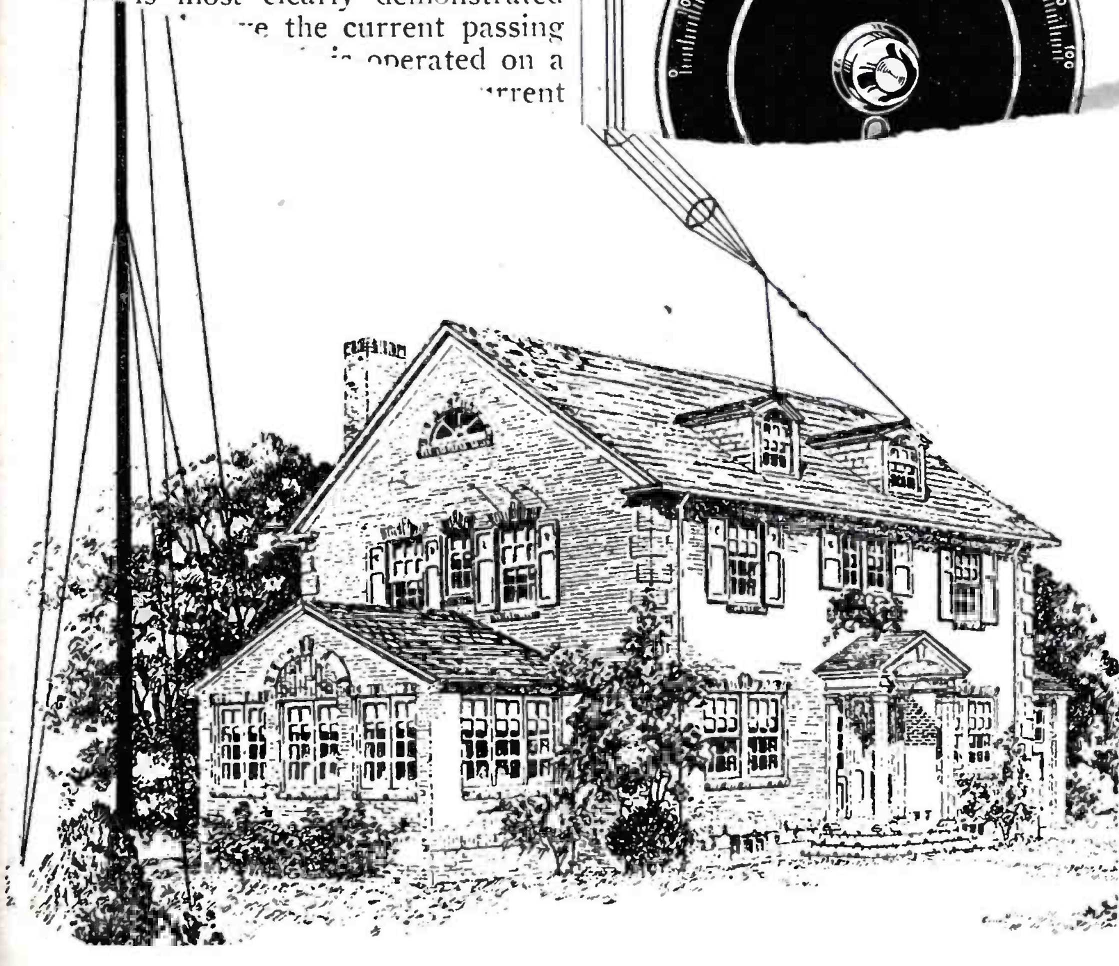


Fig. 2

A typical installation of a cage antenna.

away, whose wave energy has become weakened by travel over great distances.

The ideal aerial for such work is a single No. 14 stranded copper wire

sition to get the full energy of the radio wave, before it has lost energy through absorption due to treetops or other interference.

The fact that all objects absorb

**President S. W. Hull & Company*

part of the freely oscillating circuits, but is simply used to govern the voltage which is supplied to these circuits.

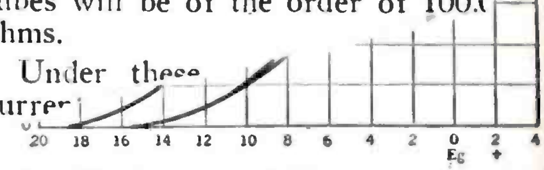
A diagram of a five-tube tuned radio frequency receiver employing plate voltage control method is shown in the diagram. In designing this circuit, all the well-known precautions for positioning the coils and otherwise eliminating feed-back between successive stages, should be used. If this is not done the amount of resistance which is necessary in the plate circuit might be so great as to decrease somewhat the efficiency of the radio frequency tubes. In general, the type and arrangement of coils used in the Neutrodyne and other tuned radio frequency circuits makes a very satisfactory design. It will be noticed that the distinctive feature of this circuit is that the primaries L1 and L2 of the radio frequency transformers are brought together and a resistance R connected in series with them and the positive "B" voltage. This resistance must have a high value in order to provide the required range of control for the voltage. It further must have a wide range of variation, that is from maximum value down to practically zero. It is also desirable that this resistance be so tapered in value that the resistance per unit length of the element be less at the low resistance end than at the high resistance end. When two radio frequency tubes are controlled by this method a resistance of 200,000 ohms is the preferred value.

quency to which the receiver is tuned increases, the energy fed back through the grid to plate capacity of the tubes, and also through the inductive coupling between stages, increases. This causes an increase of energy compensation to the point where the receiver will go into uncontrolled oscillation unless additional resistance is inserted at R. It is thus possible for the operator to adjust the energy supplied to the radio frequency tubes by means of the resistance R so that the set will operate at its most sensitive regenerative condition. This will permit the greatest range of reception and also will provide adjustment for best quality.

It should be noted that this circuit, unlike many of the resistance controlled circuits, does not introduce any loss into the tuned circuits. It therefore does not interfere with the efficiency nor the sharpness of these circuits. This is one of the outstanding advantages of this method of oscillation control.

Another advantage is in the economy of "B" battery consumption of th radio frequency tubes. When the circuit is properly designed it will b found that at frequencies below thr hundred meters the resistance in t plate circuit of the radio frequen tubes will be of the order of 100,0 ohms.

Under these curre



Amplification curve of MU6 compared with two other well known power tubes when used in resistance coupled amplifier.

Above is shown three tubes which are especially designed for use in a resistance coupled amplifier. The one standing upright is a power tube for the last stage.

without touching the controls, put in a power tube—the music comes through clear and full without distortion or oscillation—the volume hasn't increased—the ability to handle the power without distortion has been improved. That's the purpose of the power tubes.

It's the same principle as putting a high powered automobile engine in a jitney chassis and stepping on the gas; the light chassis will shiver and vibrate. Now put that engine in a sturdy chassis and use the same amount of gas—the same horsepower is being generated, but the sturdy chassis remains firm without vibration.

ed out feeling friendly toward the store, but mighty unfriendly toward power tubes.

After he had gone out, I engaged the clerk in conversation and after we had talked condensers for a little while, I said, "What was the matter with the tube that man returned a little while ago?" The clerk's answer made me sit up and take notice—if that's a fair example of the general misinformation on power tubes, some-very little which the layman could understand.

Power Tubes Do Not Increase Volume

Power tubes were properly named in the first place—they are tubes designed to carry more power or juice or whatever you want to call it, without distortion. If power tubes were designed to give more volume, they would be called volume tubes. That's

Use Power Tubes Only in the Last or Output Socket

Power tubes were designed for one purpose—to improve reception by permitting more power to be used without distortion. They should be used only in the last or output stage of the audio frequency end of your receiver. They are not a cure-all, but when used prop-

(*Continued on page* 174)

*Daven Radio Corporation

structure and any slight vibration breaks it. On the other hand, if the tube is operated above the proper temperature, the filament is rapidly vaporized and the tube may be burned out. It is evident, therefore, that the temperature and current must be kept within a very narrow range.

There are, however, certain kinds of wire, consisting of metallic alloys, which possess the quality of increasing their resistance under heat to such an extent as to exactly counterbalance a voltage across the filament. If then a voltage applied to such a filament is increased, the wire simply heats up a little more and increases its resistance, so that, even with a higher voltage, only the required amount of current can flow and no more.

It is a filament of this kind of metallic alloy of which Amperite consists and which adjusts the current automatically. It is contained in a hermetically sealed glass tube, filled with an inert gas, which prevents damage to the tender filament operating under the forementioned thermo-electric principle. It has, as already indicated, the nique property of automatically hanging in resistance as the "A" battery voltage changes, thereby maintaining an even flow of current in the has)e filament.

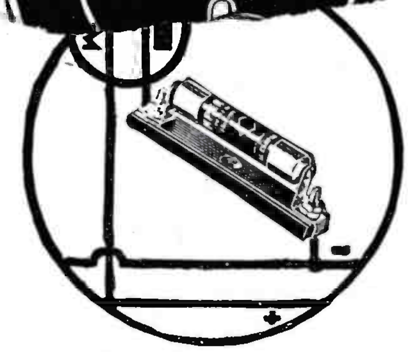
mosT'his is most clearly demonstrated automobile ob-erve the current passing

Be it remembered' tis operated on a upon an unsuspecting public current rush such as had never been seen before or since. Radio, which constitutes the greatest achievement of the present century, found millions of people ready to enjoy it—but a comparatively small number sufficiently trained to operate a radio set. Not before the handling of a radio set could be made so simple that even a child could operate one, could the industry hope to attain that degree of popularity which it is just beginning to reap.

Hence simplicity of operation became the guiding star of everybody connected with the radio industry, and tremendous strides have been made in this direction.

One of the most vexed questions was "how to safeguard the tubes," the correct operation of the tubes being, of course, the very essence of proper reception. Many are the perils to which the tubes are exposed at the hands of the inexperienced operator. Rheostats, to control the tubes, which are all right in the hands of experts, though experts often experience difficulty with them, proved a source of unending trouble in the hands of the layman. Consequently, a great deal of effort has been directed toward the elimination of hand-rheostats.

It would be underrating American ingenuity to assume that this difficulty



Schematic diagram showing how Amperite is connected in the filament circuit of a vacuum tube.

it takes over in its entirety the function of the ordinary rheostat.

The tubes are the most important fact in the set, and to operate them at their highest efficiency it is essential that the tube filament gets neither too much current, which would damage it, nor too little, which would impair its efficiency. To achieve perfect tube-performance it is necessary to introduce a variable resistance in the filament circuit, *i.e.*, either a hand-rheostat, by means of which the operator can increase or decrease the current at will, or a variable resistance such as Amperite, which is self-adjusting and exercises this function automatically.

By way of demonstration let us first take an ordinary kind of wire and see how it acts under the influence of elec-

...electric characteristic of the wire, and the change of resistance when heated differs considerably in all kinds of metals or alloys. Look at the tungsten vacuum lamps burning in your home. Irrespective of their wattage or voltage all burn at the same temperature. This is not merely a coincidence. Every tungsten vacuum lamp is carefully designed to operate at that definite temperature. Why?

The life of any vacuum tube depends upon the life of the filament. The best scientists and metallurgists in the world spent many years in trying to develop a method to make tungsten into fine filaments. The difficulty lay in the fact that tungsten is very hard and brittle; it was like trying to draw an eggshell into wire.

Nevertheless a process was finally developed which changed the eggshell-like structure of tungsten into tungsten that could be drawn into wire of less than one-thousandth of an inch in thickness. It is this kind of tungsten, which is used in modern radio tubes, and in order to keep this tungsten-filament in the proper ductile form for giving best results it must be operated at a definite temperature.

Contrary to popular conception the lamp will not last longer if burned at a lower temperature. Doing this in fact changes the filament to the eggshell

part of the freely oscillating circuits, but is simply used to govern the voltage which is supplied to these circuits.

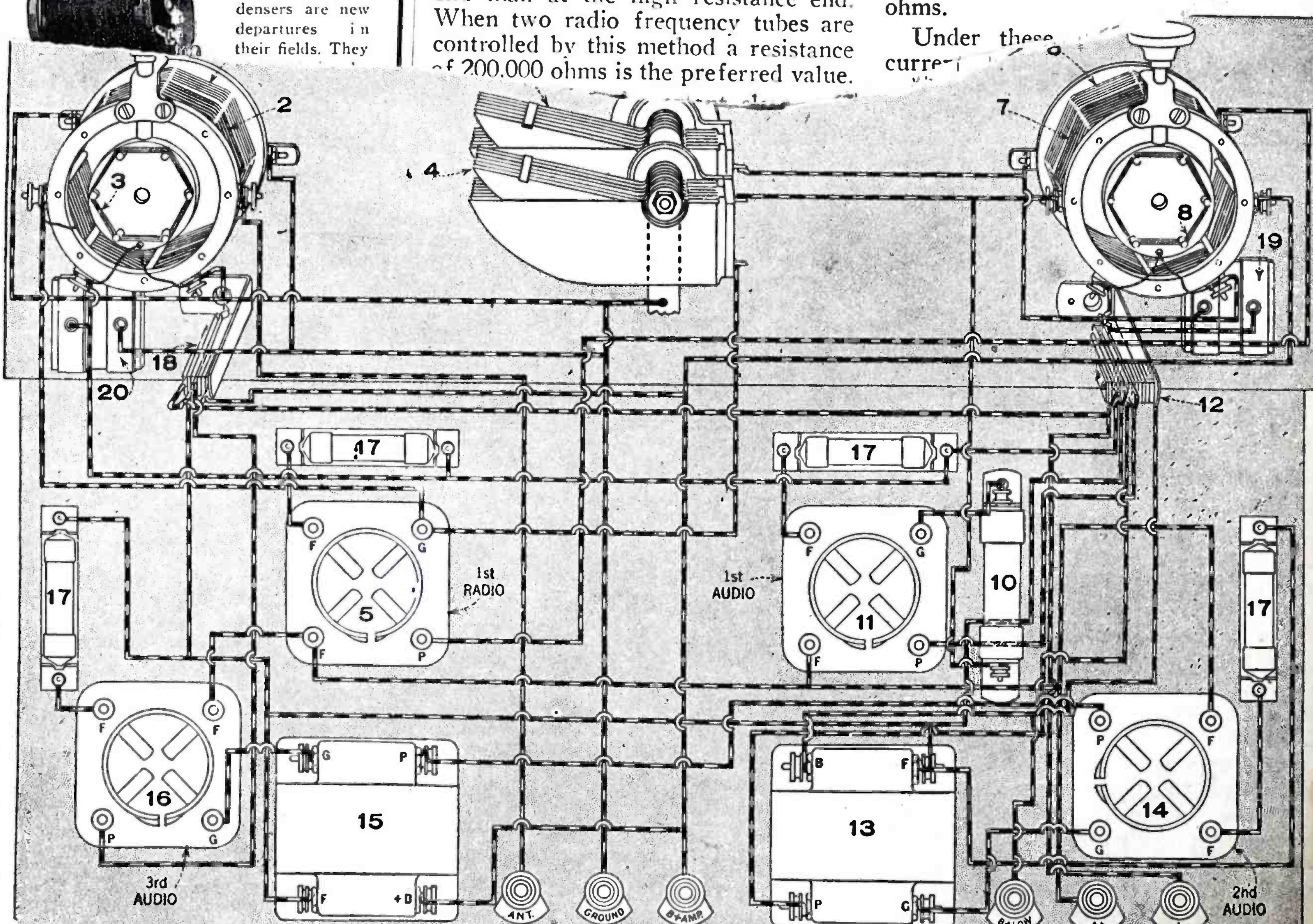
A diagram of a five-tube tuned radio frequency receiver employing plate voltage control method is shown in the diagram. In designing this circuit, all the well-known precautions for positioning the coils and otherwise eliminating feed-back between successive stages, should be used. If this is not done the amount of resistance which is necessary in the plate circuit might be so great as to decrease somewhat the efficiency of the radio frequency tubes. In general, the type and arrangement of coils used in the Neutrodyne and other tuned radio frequency circuits makes a very satisfactory design. It will be noticed that the distinctive feature of this circuit is that the primaries L1 and L2 of the radio frequency transformers are brought together and a resistance R connected in series with them and the positive "B" voltage. This resistance must have a high value in order to provide the required range of control for the voltage. It further must have a wide range of variation, that is from maximum value down to practically zero. It is also desirable that this resistance be so tapered in value that the resistance per unit length of the element be less at the low resistance end than at the high resistance end. When two radio frequency tubes are controlled by this method a resistance of 200,000 ohms is the preferred value.

quency to which the receiver is tuned increases, the energy fed back through the grid to plate capacity of the tubes, and also through the inductive coupling between stages, increases. This causes an increase of energy compensation to the point where the receiver will go into uncontrolled oscillation unless additional resistance is inserted at R. It is thus possible for the operator to adjust the energy supplied to the radio frequency tubes by means of the resistance R so that the set will operate at its most sensitive regenerative condition. This will permit the greatest range of reception and also will provide adjustment for best quality.

It should be noted that this circuit, unlike many of the resistance controlled circuits, does not introduce any loss into the tuned circuits. It therefore does not interfere with the efficiency nor the sharpness of these circuits. This is one of the outstanding advantages of this method of oscillation control.

Another advantage is in the economy of "B" battery consumption of the radio frequency tubes. When the circuit is properly designed it will be found that at frequencies below three hundred meters the resistance in the plate circuit of the radio frequency tubes will be of the order of 100,0[illegible] ohms.

Under these [illegible] curre[illegible]



Picture wiring diagram of the Balanced Interflex Receiver showing the employment of Amperites to control the filaments of the tubes. The Amperites are indicated at 17.

structure and any slight vibration breaks it. On the other hand, if the tube is operated above the proper temperature, the filament is rapidly vaporized and the tube may be burned out. It is evident, therefore, that the temperature and current must be kept within a very narrow range.

There are, however, certain kinds of wire, consisting of metallic alloys, which possess the quality of increasing their resistance under heat to such an extent as to exactly counterbalance a voltage across the filament. If then a voltage applied to such a filament is increased, the wire simply heats up a little more and increases its resistance, so that, even with a higher voltage, only the required amount of current can flow and no more.

It is a filament of this kind of metallic alloy of which Amperite consists and which adjusts the current automatically. It is contained in a hermetically sealed glass tube, filled with an inert gas, which prevents damage to the tender filament operating under the aforementioned thermo-electric principle. It has, as already indicated, the unique property of automatically changing in resistance as the "A" battery voltage changes, thereby maintaining an even flow of current in the tube filament.

This is most clearly demonstrated when we observe the current passing through a set, which is operated on a freshly charged battery. The current tends to rise above the point for which the tube is designed, a condition which calls for adjustment. It is effected automatically by the self-adjusting rheostat, whose filament at once heats up. It thus increases its resistance and decreases the current that can flow through its filament to the tube with which it is connected. It is obvious, therefore, that a tube, which is connected to the right kind of filament resistance, never becomes overheated or gets out of commission. In this connection it is well to remember, what has already been indicated, that, if a tube filament draws only a very small overload of current, its life will be considerably shortened and replacement of the tube becomes necessary long before its due time.

On the other hand when, in course of operation, the battery potential becomes weaker, as the charge of the battery decreases, the self-adjusting rheostat again takes care of this by decreasing its resistance through cooling off. It thus once more allows the proper amount of current to flow through the tube filament, until the battery becomes exhausted, when the tube naturally won't function.

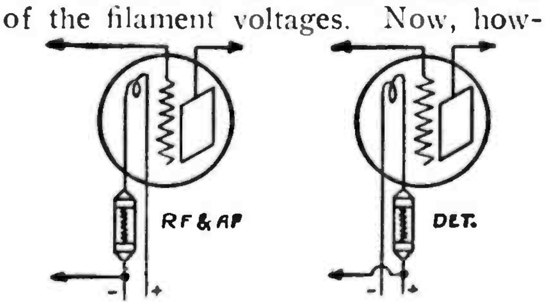
Simplified operation of radio sets has at all times been the principal aim of all radio experimenters, and the self-adjusting rheostat is one of the biggest steps towards that goal.

The Elkay Tube Equalizer System

A Method Which Uses Any Combination of Tubes

By JOSEPH KAUFMAN*

RADIO tubes have undergone numerous changes in the past few years and as a result there has been no standardization of the sockets or of the filament voltages. Now, however, with the advent of the new Radio Corporation UX types, a definite step has been taken in the direction of a universal mounting. This system will obviate the necessity of making radical socket changes in the receivers built to accommodate former types of tubes.

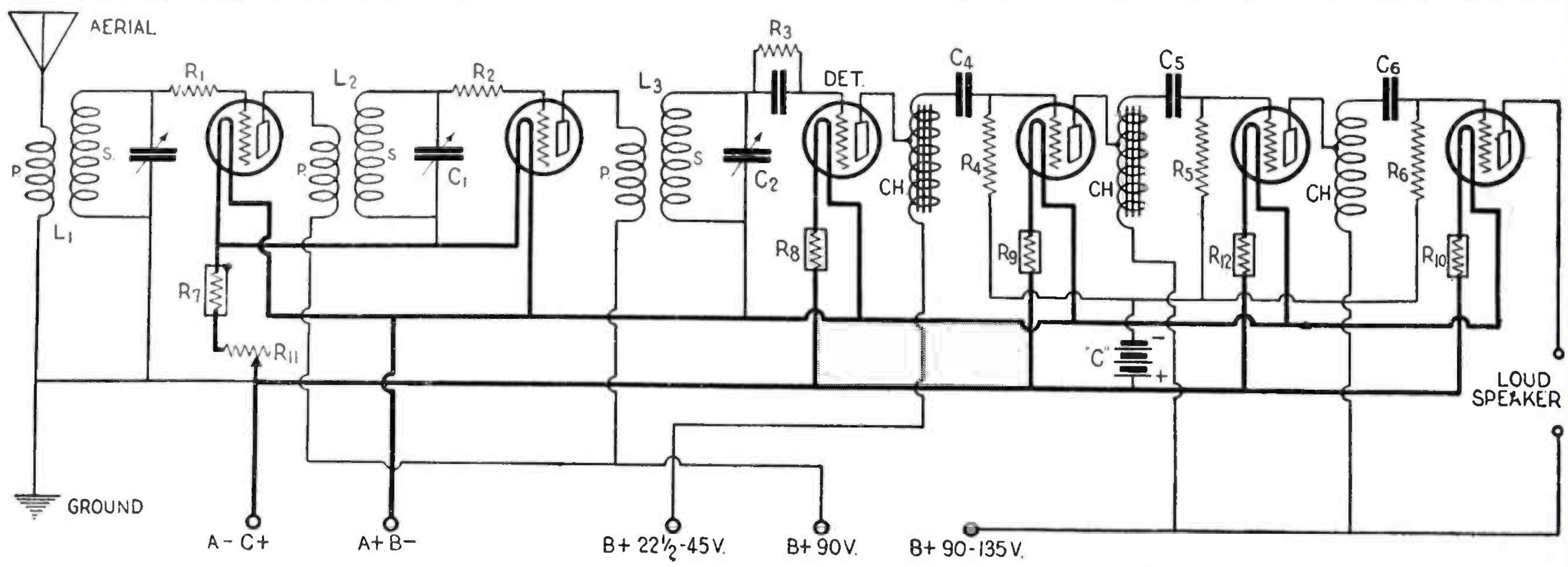


The diagram at the left shows an Elkay Resistor in an audio frequency circuit, while the one at the right shows the resistor used to control the filament of a detector tube.

In addition to the movement toward standardization of the bases used with vacuum tubes, the tendency is to arrive at a universal input voltage. Irrespective of the input voltage, if we adopt a standard source of current such as the six-volt storage battery—assuming that the maximum required voltage is slightly below that point—a system of resistors can be used to adapt any tubes according to their operating voltage and filament current requirements. With these pre-adjusted resistors in the positive or negative filament lead, no rheostats are required and tubes can be changed at will without any of the former difficulties regarding rheostat values by merely adapting the proper Elkay Resistor.

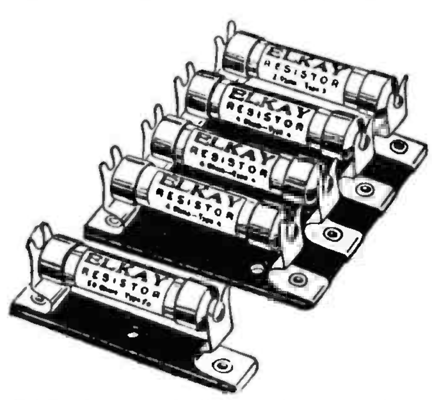
The arbitrary selection of the storage battery is due to obvious causes. In the first place it is estimated that 90 per cent. of all filament supply is from this source; then again, it is the logical source from the standpoint of economy. It is not only a very expensive practice to operate the five-volt tubes from dry cells, but it is actually impractical. It is, therefore, only natural that the six-volt source should have been adopted by the large tube manufacturers.

As an example of the development of such resistors, the Elkay Tube Equalizer System assumes a six-volt storage battery source and provides suitable resistors to adapt any of the tubes to any circuit. Among the various types are units for a single tube of the UX-201A, UX-199, UX-112, UX-120, MU-20, MU-6 types, or for several tubes of either type, as for instance, two tubes used as radio frequency or audio frequency amplifier. In the latter instances they are particularly advantageous, eliminating a rheostat control and permitting the tubes to operate at their rated current and voltage.



Here is shown a circuit diagram of a six-tube radio frequency set using the Elkay Equalizer System. The types of resistors used for various types of tubes are as follows: R-7—(2-UX199 tubes)—type 25 Elkay Resistor. R-8—(1-UX199 tube)—Type 50 Elkay Resistor. R-9—(1-UX201A)—type 4 Elkay Resistor or (Mu 20 tubes)—type 0. R-10—(Mu 6)—type 0, or UX112—type 2 Elkay Resistor. R-12—(Mu-20)—type 0, or (UX201A)—type 4 Elkay Resistor.

The Elkay Resistors will prove a great convenience with the new UX-112 tubes. This new tube operates at one-half ampere and five volts. One of the Elkay units can be used with this tube in the last stage of an audio amplifier and if the tube should be changed, it is merely necessary to change the type of resistor.



A single Elkay Resistor is shown at the left and a bank of four of these resistors is shown at the right.

Radio enthusiasts who are continually trying new circuits will find these resistors a great aid as several different types of tubes can be used to obtain the benefit of their particular characteristics, permitting them to be changed at will. The receiver is thus not limited to any particular type of tubes. If, for example, two standard radio frequency stages are used, a resistor can be obtained for regulating the current and voltage to any of the tubes best fitted to this kind of amplification; the detector tube can be controlled by another unit; the amplifier for the audio frequency currents can be of the resistance coupled type, using three tubes. Two of these may be the MU-20 or other similar tubes operating from individual resistors, and the output tube may be the MU-6 or similar type controlled by a separate automatic resistor. It is then possible to change to any other tubes without loss of time or change in the receiver.

(*Continued on page* 168)

**The Langbein-Kaufman Radio Co.*

To illustrate the flexibility of this method of filament control we are giving a schematic diagram of a six-tube receiver employing the latest methods of balancing the R.F. stages and of audio frequency amplification. Coils L1 and L2 are the customary tuned radio frequency coils in conjunction with variable condensers C1 and C2. The resistances R1 and R2 may be set —generally about 600—800—ohms to control oscillating; R3 is the grid leak shunted across a condenser of .00025 mfd. capacity; R4, R5 and R6 are the standard resistances used in impedance coupled amplifiers; R7, R8, R9 and R10 are Elkay units according to the tubes used; (UX-199 for R.F. stages or UV-199 for detector and 3UV-201A's for audio amplifier will make an excellent combination). R11 is a rheostat of about 10 ohms to vary the R.F. voltage below the operating level, giving control of volume; C4, C5 and C6 are stopping condensers and CH, CH, CH, are the chokes or auto transformers. An arrangement of this sort is very economical to operate and offers exceptional quality of tone.

If the builder wishes to employ resistance coupled amplification for the audio stages, few changes will be necessary. The chokes CH, CH, CH, can be replaced by resistances and Elkay Resistors of the proper value to control respectively, two MU-20 and one MU-6 tubes.

Loud Speaker Uses Newly Discovered Principle

(*Continued from page* 148)

other portion is a special impregnated parchment for the low notes. The metal, being harder, is better able to reproduce the rapid variations while the parchment reacts to the slower vibrations which produce the low notes —thus combining the basic principle of the finest violins, cone type speakers and basic laws of sound reproduction.

One of the most noteworthy features of the loud speakers using this diaphragm is their reproduction of notes of the extreme lower register such as the low notes of an organ or bass drum. The same is true of the high notes of the violin. Loud speakers using this new type of diaphragm appear to strike a new and better note in reproducing apparatus.

The Three Circuit Tuner

By REUBEN H. GROSS

The Old Reliable Radio Set for Broadcast Reception

FATE has been kind to us throughout the several years of broadcast listening-in to which we plead guilty, and still remain the simon-pure B.C.L. as of yore. What a blessing it is to continue along without trying to delve into the innermost secrets that lurk behind the whole "mystery" of delivering entertainment via ether. We are quite satisfied to learn our lesson by what comes out of the horn of the loud speaker or thru the phones. Doing sufficient of this will eventually teach the veriest tyro enough to enable him to form an opinio as to which circuit has the best punch and which brings in the elusive DX stations. So has it been with us. We have turned dials on all types of receivers from the simple crystal set to the complicated super "what-not'—have burned the early morning oil both winter and summer and have met with old man static in all of his varying moods.

Please don't be mislead. This recital will contain no lengthy discussion on the scientific phases of radio. The reasons are simple. Primarily, we know nothing about the radio laboratory and like millions of others are not keenly interested therein, except where theories promulgated by laboratorians fail to check up with experiences in front of the dials. Secondarily, we are willing to admit our mental deficiencies (along these lines only however) and concede that the language of microfarads, millihenries and fractions thereof is foreign and most difficult to learn, except perhaps in its barest fundamentals. Again we are like millions of others and must learn our lessons from nothing more than the set as it functionates before us.

How well do we remember the first experience with the crystal set. What a thrill it was when the strains of what seemed to be the most beautiful music in the world came over, and we were entranced. And so, too, there still rings in our ears the laughs of friend wife, who thought it so ridiculous and said so, to see a big, fat, grown-up man playing with a toy that almost fit the palm of his hand. So too, there lurk pleasant memories of the single circuit squealer which was followed by the three-honey-comb coil set that brought in the elusive DX stations and which later still reposes intact upon a shelf in the "shop."

Of course, we had a neutrodyne. Who didn't own one about two years ago? We thought we had the utmost tube affair which we succeeded in getting into a 26-inch panel and over which fact we gloated with keen delight. We thought that the greatest thrill in radio had come to us when we owned this giant. Not alone did we get a station on plenty of places on the dials, we also blew all eight tubes at once when a screw-driver accidentally slipped into the works while the batteries we connected. What a thrill!

Funny influence this radio disease has on one, what? Almost like telling

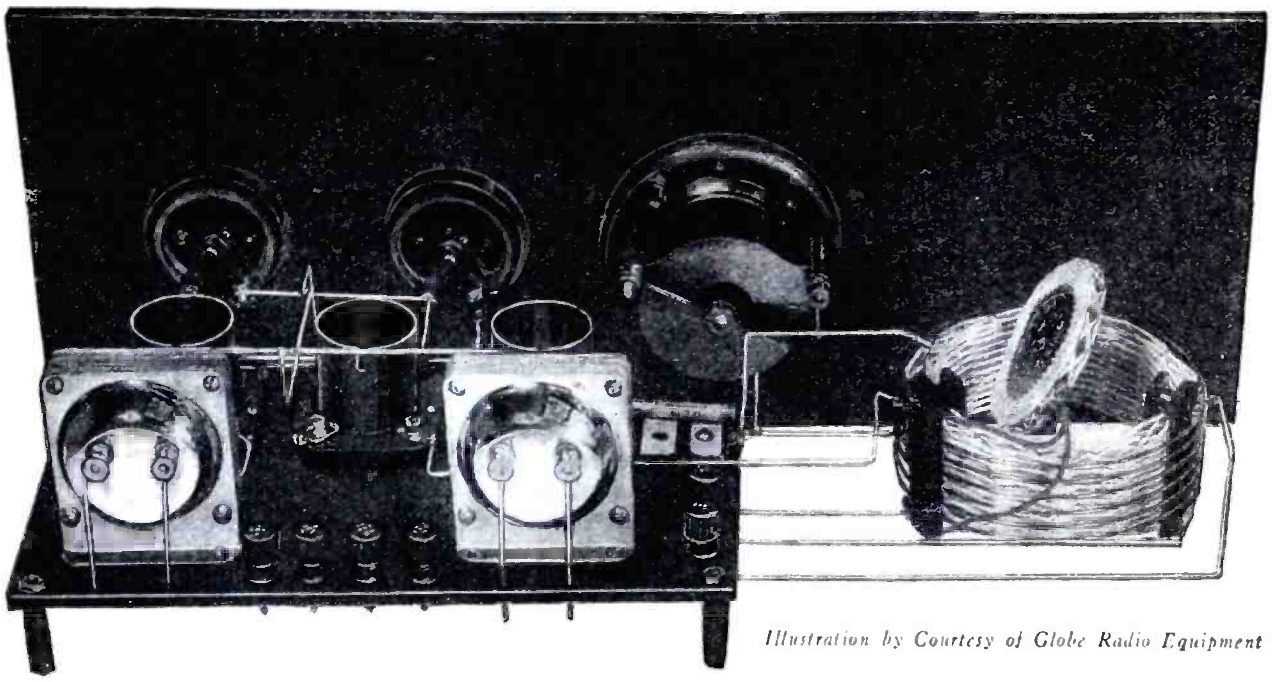


Illustration by Courtesy of Globe Radio Equipment Co.

A back panel view of a three circuit tuner employing a transformer coupled audio frequency amplifier.

in receivers at that time and rejoiced accordingly. By the way, our first one still lives and is doing daily service for a friend who refuses to become infected with the virus of the radio bug, and continues satisfied with what he has. What a strange creature! How diligently we followed instructions in how to "neutralize," and how eloquently we cussed when the darned thing wouldn't "Neut." We even tried striking the same pose as did the man in the book during this most difficult operation, and finally admitted our inferiority.

How many failed to get het-up with the super-het? To you fellow bugs, who admit the failing, we say go back and try it. The sport of matching tubes and deciding whether it shall be air-core or iron-core transformers is something that you cannot afford to have missed, else the cycle will have been broken and your radio biography differ from ours. Ours was an eight

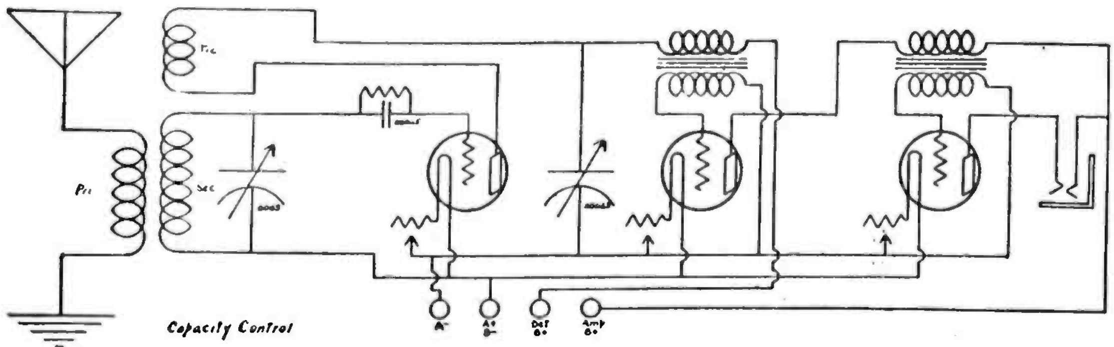
a new listener about the operation in which you nearly but not quite died. The point of this tale is almost lost in the length of the story. Incidentally we built a three circuit tuner and hence the title of this most valuable contribution to the infant science. Economy must be practised, even by the radio bug, and having enriched the tube manufacturer through the medium of the super-het, the exchequer demanded immediate retrenchment. What a vast difference in the size of the bill when we purchased the three tubes necessary to put life into the plot of this narrative. And speaking of economy, isn't it remarkable how gallopingly the "B" battery juice is consumed with a multi-tuber.

As may be readily deducted, by this time in our radio experience, we had learned the lesson of cheap parts. To the neophyte, let us admonish you to learn this lesson and thus avoid suffering the experiences for which we paid so dearly and so often. There is no such thing as a good, cheap radio part, and it is well we know it. Now that we have preached, back to the story. Out we went and bought, "Low loss" parts and built us a "Low Loss" set. At this stage, it again becomes necessary to preach. Look to the laboratory for help in securing real "Low Loss" material. How much junk has been foisted upon poor, unsuspecting victims as "Low Loss," no one will ever know. Don't buy anything that has not met the tests of the experts engaged in doing this service for you, through the medium of the laboratory, and your "shop" will never have to tolerate the pile of stuff that has accumulated in ours.

No, there's nothing new about the hook-up used in the three circuit tuner. Look over the diagram that accompanies this and you will see much the same as when you first built the three honey-comb coil set. The values of the coils and the wave length range is fixed in the new outfit, otherwise, the resemblance is apparent. The use of an aperiodic primary in this circuit is excellent and if you are careful about the size of your antenna, it is as selective as could be desired, even by the most critical. Don't get it over 100 feet, including the lead in and all will be well. In large apartment houses found in big cities, those living on the lower floors are compelled to use longer lead-ins and thus will have an aerial longer than this. Sharpness of tuning can be maintained by placing a low capicity fixed condenser (.0001 to .00025 mfd.) in series with the antenna lead. This will do the trick nicely.

The choice of a coil or tuner was the next problem which we finally overcame. Not being a radio expert, we are permitted to express our opinion frankly, so here goes. The ethics of radio authorship demands that details of coil building be furnished to the amateur from the method of insulating the wire to the threading of the screws used therein. Not being bound by this code let us say that we have yet to see the amateur who could do justice to such a job, unless perhaps he had the facilities of the coil maker's factory, and even then we still question. Our advice is to go out and buy a ready-made, factory-built coil, but make sure that you are getting one that will do all that is claimed for it. That's exactly what we did, and while we had some slight disappointments, we finally got what we wanted, and at last we are, or we think we are, riding on top of the radio world.

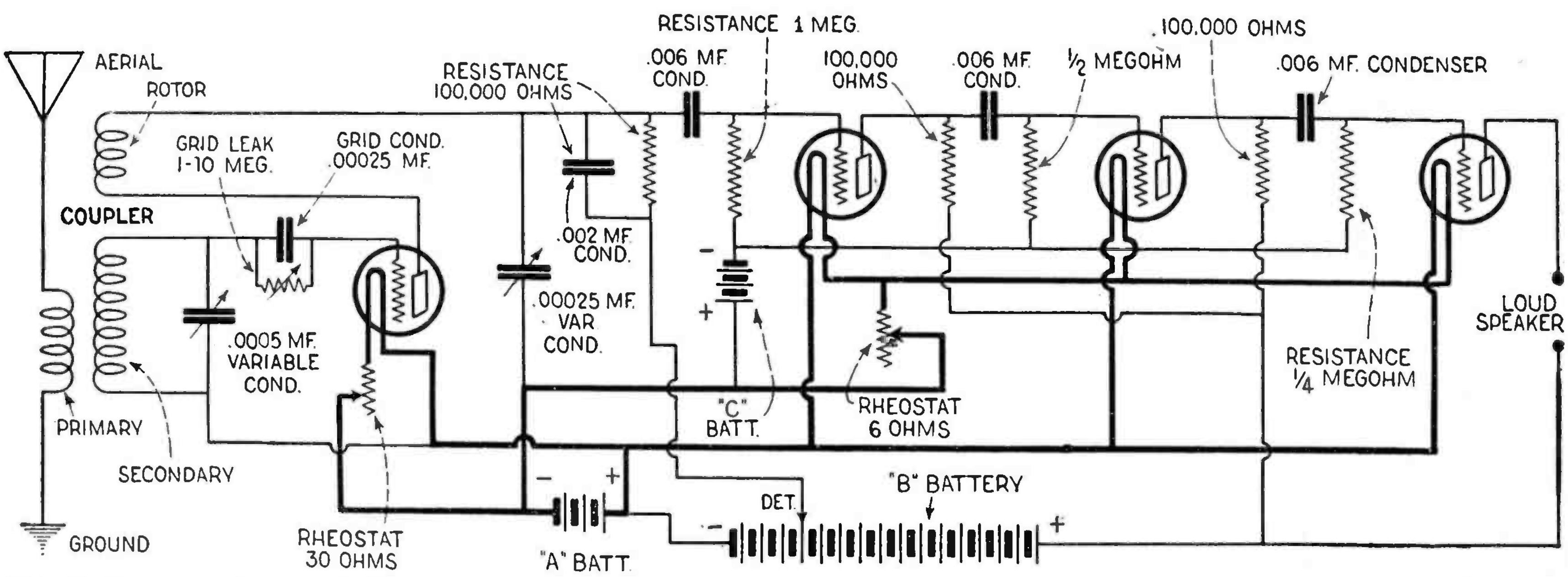
There are two types of three circuit tuners. One has a tuned tickler and the other has a fixed tickler which is tuned by a variable condenser. Both coils have their advantages, with a slight inclination to the latter type. We find that it is more easily controlled than the movable coil, but perhaps it is our lack of skill more than the coil.



Schematic wiring diagram of the three circuit regenerative set with two-stage transformer coupled audio amplifier.

Study the photograph which shows the coil wired into the set. You will notice that the primary is made of bare copper wire and surrounds the secondary. This wire is gold plated which makes it immune to the action of the elements and eliminates corrosion of the metal. This feature means little or nothing when tuning locals, but when the elusive DX station remains elusive, it is often the factor which brings in the music or voice.

The secondary of the tuner is tuned by a .0005 mfd. variable condenser. This too is of the "low loss" type and should have a vernier other than the plate variety. We have found that plate verniers are not as efficient as the others and are a means of increasing losses in the operation of the set. A vernier dial of good make is excellent. We have discovered something about insulated wire which we, in our big-hearted manner will reveal to the world. Look at the wire on a new coil and notice how bright and shiny it is. Now take a piece of insulated wire which has been used in a coil during one summer in a climate such as is found in and around New York City. Carefully unwind the insulation. The bright sheen on the metal is gone and instead we have a dull piece of copper covered by oxide or sulphide as the case might be. We are told in the primers on radio that the minute electric currents which go to make up our infant, move over the surface of the wire. Inasmuch as the new coating on the metal is a non-conductor, the surface of the wire is no longer available for carrying impulses. Thus there are more losses with which to contend. This is easily overcome however, by using enameled wire which is covered by both cotton and silk. We have found such a coil and are now using it. Our hopes for increased efficiency are hastened.

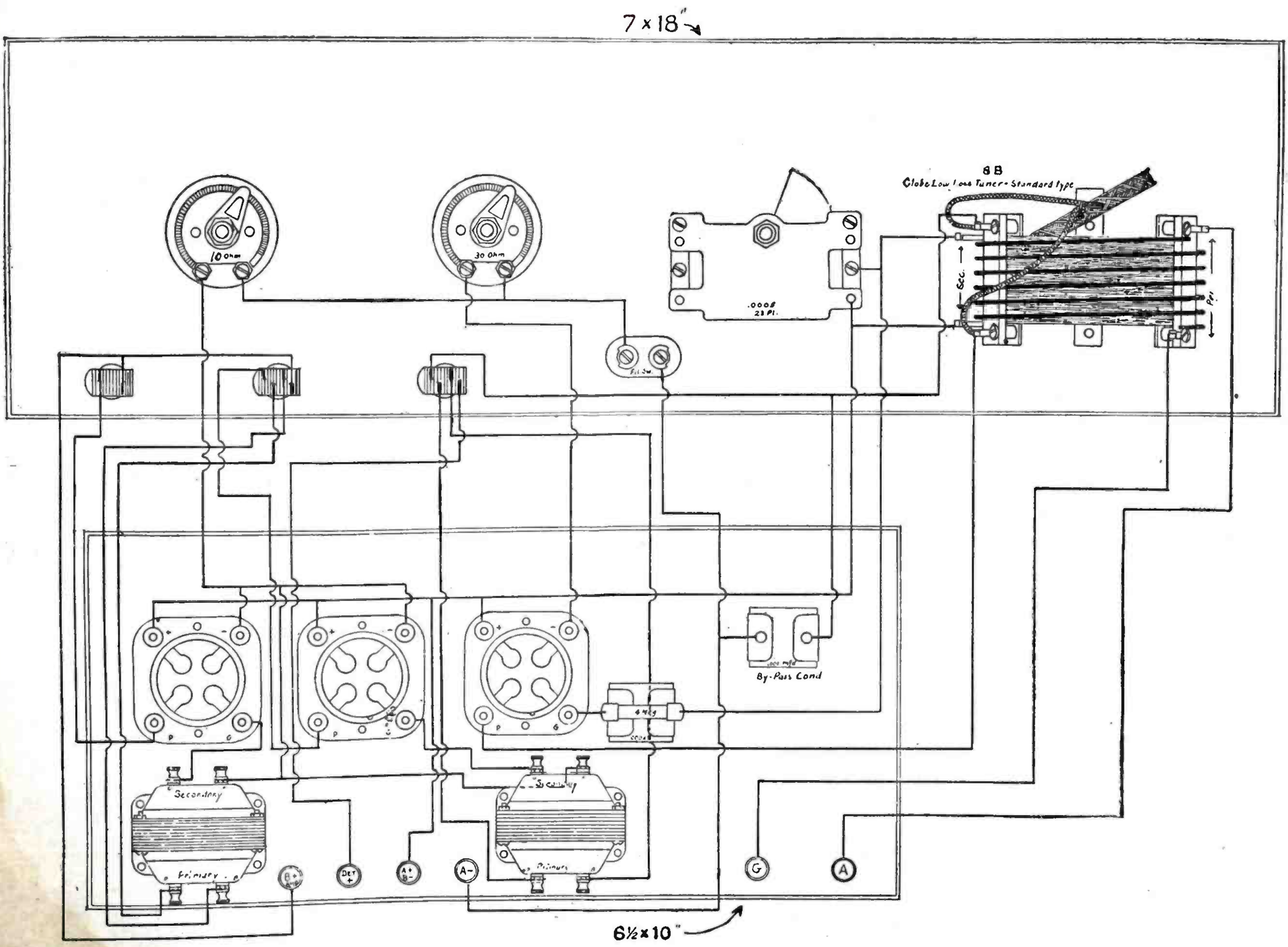


Schematic wiring diagram of the three circuit tuner showing how a three stage resistance coupled amplifier can be employed. This arrangement is ideal for tone quality reproduction.

A word about the tickler in the 3-circuit tuner and then our tale nears its end. This part of the coil is the means of controlling regeneration and since regeneration is the principle on which the circuit is based, the tickler is deserving of much more attention than is usually accorded it. The variable tickler with its small diameter wire surely gives the punch to the set, and if properly used, brings in the DX stations so that the family can really hear the concert without having you act as interpreter or conductor. On the other hand, this innocent looking bit of apparatus is responsible for more annoyance to neighbors than even old man static himself. If you must tune a station by the whistle of the carrier wave, then do so as quickly as possibly. Don't keep the set howling while you make your adjustments. Remember that while you are doing this, all others listening on the same wave-length in your neighborhood are being cheated out of hearing the program. This nuisance has caused many a cuss word to be heaped upon the head of the offender, and matters reach their most horrible state when some other fellow starts squealing back for revenge. This often leads others into the scrimmage and the first thing you know, the entire community shuts down their sets and radio is again blackened, with special emphasis on regenerative sets.

The advantage of the fixed tickler which is tuned by a .00025 mfd. var-

(*Continued on page* 174)



Complete picture layout and wiring diagram of the three circuit tuner as shown in the accompanying photo. This set employs a standard transformer coupled audio frequency amplifier.

Correct Aerial Installation

(*Continued from page* 163)

It is desirable to use a good grade of black graphite paint—and to give the mast at least three coats to insure against rust. Pipe is not desirable because of the possibility of filling with water at the base and rusting on the inside, unless a cup is provided at the top.

Earth anchors for fastening the guy wires are best made by cutting off a piece of 2 x 4 lumber 12" long and wrapping a piece of the guy wire around it, leaving a stem about 4 feet long with a loop on the end. This block should be buried about 3 feet below the surface, with the loop above the earth. The guy wires are fastened to this loop.

The earth anchors are usually spaced away from the mast a distance equal to 1/3 the height—for instance on a 40-foot mast they are spaced 13 feet 4 inches out. Three anchors are sufficient, generally two back of the mast and one in front.

The mast itself is set in a hole about 18 inches deep. The bottom of this hole should be lined with stones to prevent the mast from settling in damp weather.

Fig. 2 shows a cage antenna. This presents greater area and more surface to the radio wave and will therefore gather more energy than one wire.

Such a cage should be about 75 feet long. It is generally made of six No. 14 stranded copper wires. The ends are soldered together and securely attached to insulators at the end nearest the mast.

The rings should be about 12 inches in diameter and made of 1/4 inch round brass rod, soldered neatly at the splice.

These rings are spaced about 6 to 8 feet apart. The aerial wire is soldered to the rings—taking care to have the wires spaced equally about the rings before soldering. The best way is to fasten them first with a little wire.

Slow and careful, neat and thorough is the way to go about this work—and you will be satisfied with your finished aerial.

A good aerial is well worth the trouble it takes to make it. For where the average radio fan gets l ng range occasionally—the man with a first-class aerial gets it consistently. That's the difference.

High priced radio sets often may prove disappointing or even a total loss to a would-be radio fan, if his aerial is not properly put up.

Of course an indoor aerial "will work" and it is even found convenient in many cases to depend entirely upon the small portable aerials that come with some of the higher priced receivers.

But when you stop and consider that the antenna is the big hand that "reaches out" into the air and captures the radio waves for you, you will realize that the loop antenna can no more be compared with a large outside antenna than a rowboat can be compared with a modern ocean liner.

In the first instance the loop antenna will "catch" things for you, and so will the outdoor antenna. But the comparison stops about there, just like the row boat will keep you on top of the water and so will the ocean liner.

Analyzing the "Diamond of the Air"

(*Continued from page* 147)

value would result in a lower effective voltage. To compensate to a certain degree for this additional resistance and increased drop, the applied plate voltage is increased to 150 volts, wherever it was 90 volts with transformer coupling. In fact, if it is desired to apply identical effective voltages it is necessary with resistance coupling to use approximately 200 per cent. higher applied voltages.

What the Curve Shows

A graph showing how the output is increased when the applied plate voltage is increased is shown herewith. From this curve one may observe the difference between an applied voltage of 90 and 150. And fortunately with this type of amplification the increase in plate current is not proportional to the increase in plate voltage, being very much less. The following values are cited:

At 100 volts the output of the unit was rated as 72 and the drain was .8 of one mil. At 150 volts applied, the output was increased to 172, but the current advanced only .315 of one mil to a total drain of 1.15 mils. With 150 volts applied to the audio tubes the total plate current drain of the entire audio amplifying system was 13.9 mils. Of this 11.5 mils was the drain of the output tube, and 1.2 mil for the first and second audio stages. It should be remembered that no biasing batteries were used when these values were ascertained. This high rate for the last tube is due to the replacing of the plate coupling resistor by the loud speaker, whose winding has a resistance value about one-tenth of that of a resistor and the effective voltage is higher. Thus the total drain of the receiver is 24.9 mils. Proper design, however, calls for a biasing battery in the grid circuit of the output audio tube. The accompanying diagram embodies this. The grid biasing voltage value as determined by best response was 6 volts negative and the plate current thus was reduced by 5 mils, to 8.9 mils for the last tube. The total drain of B current in the whole set, with "C" battery used, is 19.9 mils, not at all excessive for a 5-tube receiver of this design. This value of bias is used with a plate potential of from 145 to 150 volts with 5-volt tubes, other than the hi-mu type.

Plate Voltage in Resistance

Experiments conducted with various values of plate potential upon audio amplifying tubes utilized in resistance coupled units showed that 90 volts applied was not sufficient to provide satisfactory, distortionless amplification of loud signals. The advantages that should have accrued due to the use of resistance coupling were lost entirely, through insufficient effective plate voltage. With 90 volts applied to the plates of tubes coupled with 100,000-ohm resistors, the effective voltage is about 25 to 30, depending upon the tube impedance, and experimenters have generally found that 25 or 30 volts are anything but sufficient for the plates of an audio amplifier. This is the reason for the poor operation of many resistance coupled amplifiers. The lower the effective voltage, the shorter the operating characteristic curve, and the more tendency for the grid to swing positive, at which time distortion cannot be avoided. By increasing the effective plate voltage, this characteristic curve is lengthened, until grid voltage fluctuations cannot swing the grid positive, and distortion from that angle is eliminated.

Resistors Stand 150 Volts

It would be well at this time to consider an item found in the audio circuit that is closely allied with the plate voltage. This is the plate resistor. Being of the graphite type it is limited in the value of potential that may be applied across it, due to the disintegrating action of the voltage upon the carbon granules. If the voltage is excessive this deteriorating action takes place and the resistance of the resistor decreases, resulting in a decrease in the total voltage amplification obtainable with the tube-resistor combination. Experiments with the resistors used showed that 150 volts was the maximum potential which could be applied without causing rapid voltage and resistance fluctuations.

Now, as to the life of the "B" batteries when the potential is increased.

One is very likely to forget that when the plate potential is increased, the plate current drain is increased, because the higher the plate voltage, the greater the current drain of the tube, and when this action is applied to a receiver it is at once obvious that when the output is increased by the application of increased plate voltage, the life of the "B" battery is correspondingly decreased, due to the increased current drain. And this action occurs despite the "C" battery, for the biasing battery is limited in its scope when a modulated input and output are concerned.

This additional drain is of great importance when the "B" batteries are of the dry, non-rechargeable type, since their design does not permit of a heavy overload; nor is the decrease in life proportional to the increase in drain. Doubling the load on a battery of this type will not decrease the life in proportion, the advance towards death being much more rapid as the load is increased. So we see that the plate potential is not as small an item as we might imagine.

Power Tubes for Audio Amplification

(*Continued from page* 162)

erly, will improve the tone quality and relieve you of many of the distortions of radio.

How to Protect Your Power Tube

Whether you are using transformer-coupled audio amplification or resistance coupled amplification, you should never use power tubes without the proper amount of "C" battery bias. This is not only to protect your "B" battery consumption, but also to help prevent the rapid deterioration of the tube due to the high "B" battery voltage passing through the tube and tearing down the electrons of the plate.

With 45 volts of "B" battery, you should use not less than 4.5 volts of "C" battery. With 90 volts of "B" battery, you should use 4.5 volts of "C." With 135 volts use 7½ to 9 volts of "C" battery.

Resistance Coupled Amplification and Power Tubes

Resistance coupled amplification, without question the finest method of amplification known for tone quality, can be made to equal transformer-coupled in volume if the proper and high mu tubes are used. Hi-mu means that the tubes have a high amplification constant. The power tubes combined with the hi-mu tubes have made the method, now generally known as resistance amplification, the peer of all audio amplifiers in every respect. Superior tone quality, not approached by any other method, was always conceded for resistance coupling amplification, as it is now popularly termed. The question of volume is now answered by using two MU-20s in the first two stages and a MU-6 power tube in the last or output stage. This combination will give as much volume as any two-stage transformer-coupled amplifier and without distortion.

So the power tube has given to radio not only an improvement for reception —it has helped give radio the answer to its greatest problem, tone quality. Perfect music, just as it is broadcast from the studio, is now possible, without sacrificing volume.

If the power tube had nothing else to recommend it except that it helped, with the Hi-Mu tubes, to put resistance coupled amplification in the place it deserved, it has served its purpose.

Use power tubes, they will improve your reception; but use them correctly —do not expect to get something they were not designed to deliver.

The accompanying chart shows the efficiencies of the power tubes now on the market. This chart was compiled by Mr. G. F. Usman, a prominent radio engineer, and appeared in the September 25th issue of the *New York Sun*.

The Three-Circuit Tuner

Continued from page 171)

The coils we used were the two types manufactured by the Globe Radio Equipment Co., and known as Globe Tuners. The variable condensers were the SLF type made by the General Instrument Co. While these instruments are larger than most others, their efficiency is unquestioned. We used resistance coupled audio frequency amplification through the medium of units made by the Polymet Mfg. Co. Three stages of this form of amplification will give sufficient volume for the most critical and the tonal qualities must satisfy even the fan who insists that he has an aesthetic sense. At one time we were satisfied that transformers were quite good enough but after our recent experience we have learned better.

A word about the grid leak would not be amiss at this time. It is quite remarkable how much this harmless looking bit of apparatus influences reception. The correct resistance in this part of the circuit is essential else you are not getting all that you should into the horn. Try out several from one to ten megohms and you will find that one gives the loudest signals. Bear in mind that when you change your detector tube, the grid leak will have to be matched again.

When you buy tubes, buy only those that are known to be made by reliable makers. "Bootleg" tubes may work, for a while, but their life is short and in the end you are stung even if they cost much less than the genuine article. The O1A type is satisfactory both for detector and amplifiers. We are using X tubes and find them O. K. Have your tubes tested before you buy them and if they meet the standards, you run very little risk of loss. A reliable dealer stands behind anything he sells, including the tubes. A thirty-ohm rheostat controls the detector and a ten-ohm rheostat is used for the amplifiers. Polymet rheostats are in one of our sets and General Instrument in the other. Both serve their purpose very well.

Tuning is simple. The condenser shunting the secondary of the coil finds the stations according to their wavelength and the other dial controls regeneration and volume. Nothing could be simpler than this and if you are patient and willing to study the characteristics of your set, you will soon learn how to handle it. A set, even with the identical parts found in another, will vary slightly from its fellow, and these variations must be noted and used in tuning. After the locals have been mastered, and you have learned to find them easily, then start fishing for DX. Don't expect to do wonders the first time you try. Experience is the best teacher, and time will see you improve. Keep adjusting the grid leak and try various voltages on the plate of the detector tube. This may vary from 22½ to 45 volts depending on the tube. Ninety to 135 volts are used on the plate of the amplifiers. When you learn to hear the faint whistle of the carrier wave of the DX station, it will require delicate adjustment of the dials to bring it in with volume. Having attained the knack, it is remarkable how far out you will reach with this circuit. Don't expect all that you would from a multi-tuber.

The Counterphase Receiver

(*Continued from page* 124)

One, Two or Three Radio Stages

While the Counterphase method is applicable to one stage of radio frequency, giving a very excellent four tube set with practically a single control, and may also be used with two stages for a five tube set, the height of its usefulness comes into play with three stages of radio frequency. In this case the use of Tandem condensers make a two control unit possible. The Tandem condensers have so-called "trimmers" which are used to bring the two circuits into resonance with each other after which they are left in that position for all ordinary tuning but are available when necessary on distant or weak signals in order to bring the same up to full volume.

Great Volume on First Audio Stage

The great advantage of the third stage of radio frequency of course is that long distant stations may be brought in with only a short indoor antenna. Loud speaker operation on stations up to 500 miles is readily obtainable with an antenna not more than three or four feet long and the fact that the Counterphase method eliminates losses from the grid circuit gives an astounding increase in volume. The result is that the second stage audio is used only on very weak signals; at Chicago for example, it is nothing unusual to tune in Pacific Coast stations on the loud speaker with only one stage of audio, and a consequent increase in quality which cannot be expected when more stages of audio amplification are employed.

All in all it would seem that the Counterphase circuit is one about which a great deal will be heard in the days to come and that any one who is qualified to construct a circuit using one or more stages of radio frequency will be able to secure exceptional results from its use.

Nine-Color Diagrams Furnished

The manufacturers furnish the same in kits for either five or six tube circuit with a very excellent and instructive set of diagrams, one of the features of which is that nine different colors are employed using a color for each wire and the kits include wire of the same color as that shown on the diagram.

These coils are built in three different styles, one as an Antenna coupler, the other intermediate and the four-circuit style for four tube sets, all coils also being obtainable individually.

The Passing Fallacy of Matching Tubes

(*Continued from page* 121)

changes will not distort. It has a very low impedance so that the current and lots of it, will flow freely. If it is put into the set without any other changes, not much diference will be noticed. The music you get may come through more smoothly, but you may not now have the volume. You need more plate voltage on the tube. I take it for granted that you've been using ninety volts on all your amplifier tubes. That seems to be most satisfactory. And another 22½ volt block to the special tube., making it 112½ volts on that plate. Now, to smooth it out a bit, and economize on plate current, put a separate C battery on that tube alone, of 13½ volts. You will have increased your volume, and greatly cleared up your reception. You'll really be delighted with the results. If you want more volume make the plate voltage higher still. Add another 22½ volt block, making it 135 volts on the plate. Your C battery should now be 22½ volts. If your set gave you poor quality before, sit back and enjoy it to the full now. If you didn't hear it across the room, you'll sure hear it now.

Now, for your five volt, 201A set you can do exactly the same thing. Your special tube is the Magnatron DC-112.

You will never complain about quality or volume again, I'll wager.

A word about your B battery eliminator, if you have one. You will not deny, I am sure, that a special tube is necessary there, too. Your 201A tube cannot give you the results you want. It was never designed to. How many tubes have you used and thrown away? There are tubes, such as the Magnatron Rex, which are built for that job, and which do it right, though they can't do anything else. They are power tubes with a heavier filament that can stand the gaff. Don't forget that your eliminator tube is handling the current, all of it, that all the rest of your tubes and your loud speaker taken together, are handling after it. It has to be a heavy duty device. Eliminator tubes like the Rex have a very very low impedance so as to carry lots of current, and at the same time with as low a voltage drop as possible. And they have to be very hard so that they will rectify completely and constantly, without ionizing, choking, over-heating or back-firing.

And that's about enough, just now, don't you think? After a little while we'll be taking up special r. f. tubes. But we haven't quite got round to that in this country yet.

But we will. Sufficient unto the day. Let us all, you and I, keep ourselves informed. Let us take advantage of every new advance that takes place in radio. Let us install into our sets these new ideas and principles as they prove themselves. No need to discard our sets for new ones. No need to be technical experts, either. It's really simple after it's been properly explained. Have I?

Index of This Issue

Additions to, Changes in, and Eliminations from list of United States Broadcast Stations.

New Stations

Call Signal	Location of Station	Owner	Power (Watts)	Wave Length	Frequency (Kilocycles)
KFIO	Spokane, Wash.	North Central High School	100	265.3	1,130
KFXR	Oklahoma, Okla.	Classen Film Finish Co.	15	214.2	1,400
KMMJ	Clay Center, Nebr.	M. M. Johnson Co.	500	228.9	1,310
WDAH	El Paso, Tex.	Trinity Methodist Church (South)	50	267.7	1,120
WQAC	Amarillo, Texas	Gish Radio Service	100	234.2	1,280

Changes

KFAU—(Boise, Idaho) W. L. 280.2, frequency 1,070 kilocycles.

KFCF—(Walla Walla, Wash.—Call signal changed to KOWW; power 500 watts; Owner of Station, Blue Mountain Radio Ass'n. (Frank A. Moore).

KFDJ—(Corvallis, Ore.)—Call signal changed to KOAC wave-length 280.2, frequency 1070 kilocycles.

KFOB—(Burlingame, Cal.)—Owner of Station, KFOB (Inc.).

KFQB—(Fort Worth, Tex.)—Power 1,000 Watts.

KGO—(Oakland, Cal.)—Power 4,000 Watts.

KGTT—(San Francisco, Cal.)—Wave-length 206.8; frequency 1,450 kilocycles.

KYW—(Chicago, Ill.)—Power 3,500 Watts.

WAAM—(Newark, N. J.)—Call signal changed to WBPI.

WAGM—(Royal Oak, Mich.)—Wave-length 225.4, frequency 1,330 kilocycles.

WBAL—(Baltimore, Md.)—Wave-length 245.8; frequency 1,220 kilocycles.

WDAF—(Cranston, R. I.)—Call signal changed to WDWF and WLSI; Owner of Station, Dutee W. Flint and Lincoln Studios (Inc.).

WEAH—(Wichita, Kan.)—Call signal changed to KFH.

WEBK—(Grand Rapids, Mich.)—Call signal changed to WOOD.

WMAQ—(Chicago, Ill.)—Power 1,000 Watts.

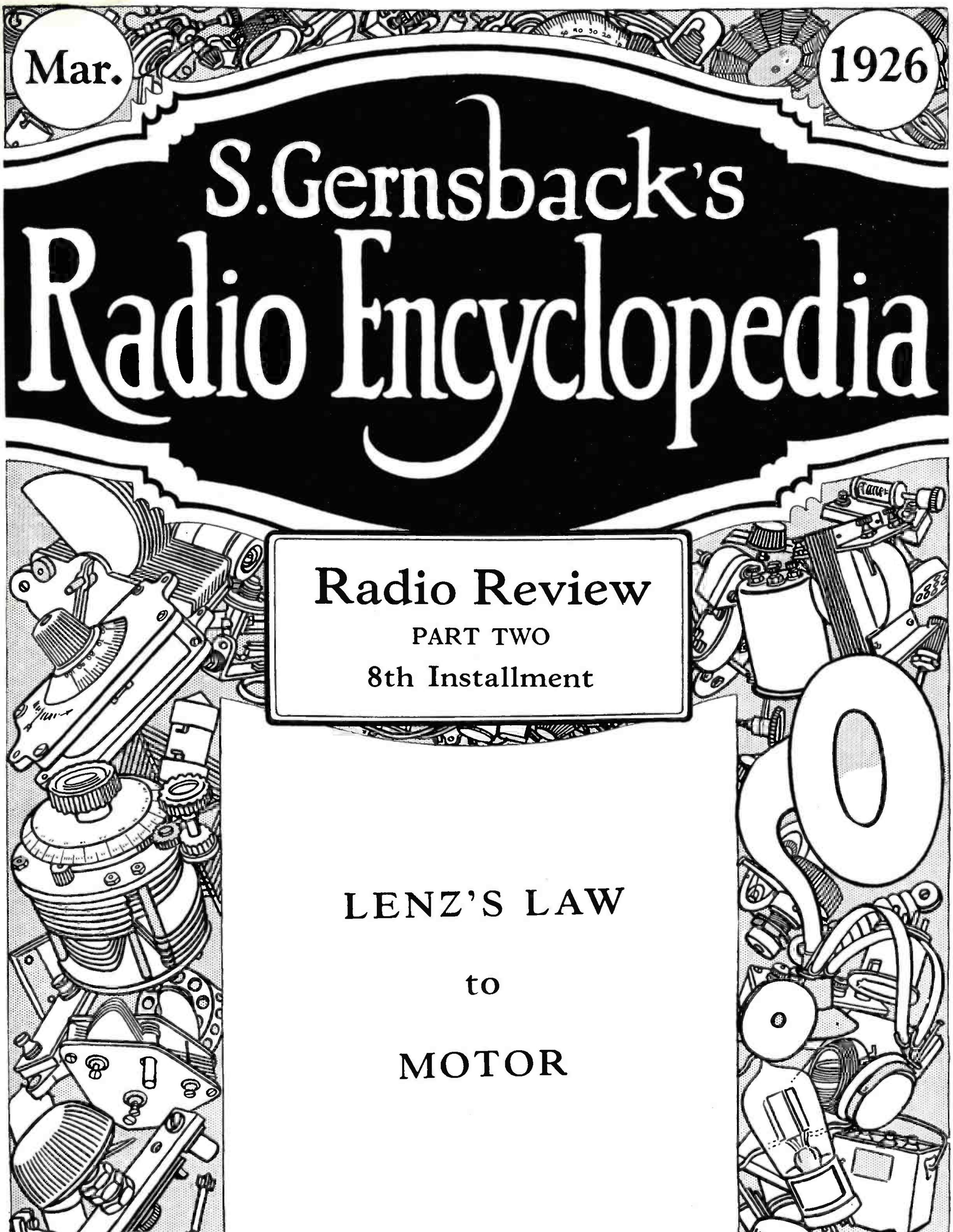
KNOX—(Knoxville, Tenn.)—Power 1,000 Watts.

Eliminations

KFBG—Tacoma, Wash.
KFVU—Eureka, Cal.
WCAH—Columbus, O.
WEBT—Dayton, O.
WHBR—Cincinnati, O.
WOAC—Limo, O.
KFRM—Fort Sill, Okla.
KFWP—Brownsville, Tex.
WCBG—Pascagoula, Miss.
WGBQ—Menomonie, Wis.
WJD—Granville, O.
WPDO—Buffalo, N. Y.
KFRY—State College, N. M.
KFXE—Waterloo, Iowa.
WCUW—Worcester, Mass.
WHAG—Cincinnati, O.
WLAX—Greencastle, Ind.
WTG—Manhattan, Kans.

Mar. 1926

S. Gernsback's Radio Encyclopedia



Radio Review

PART TWO

8th Installment

LENZ'S LAW

to

MOTOR

PREVIOUS INSTALLMENTS

FIRST INSTALLMENT	Consisting of definitions from "A" BATTERY to ARC OSCILLATOR, contained in May 1925 issue of Radio Review, Vol. 1, No. 1.
SECOND INSTALLMENT	Consisting of definitions from ARC SPARK to CAPACITY OF CONDENSERS IN PARALLEL, contained in July 1925 issue of Radio Review, Vol. 1, No. 2.
THIRD INSTALLMENT	Consisting of definitions from CAPACITY OF CONDENSERS IN SERIES to COUPLING COEFFICIENT, contained in September 1925 issue of Radio Review, Vol. 1, No. 3.
FOURTH INSTALLMENT	Consisting of definitions from COUPLING, DEGREE OF to EDISON, THOMAS A., contained in October, 1925. issue of Radio Review, Vol. 1, No. 4.
FIFTH INSTALLMENT	Consisting of definitions from EDISON EFFECT to GALVANI, LUIGI, contained in November, 1925, issue of Radio Review, Vol. 1, No 5.
SIXTH INSTALLMENT	Consisting of definitions from GALVANOMETER to INDUCTANCE, ANTENNA, contained in the December, 1925, issue of Radio Review, Vol. 1, No. 6.
SEVENTH INSTALLMENT	Consisting of definitions from INDUCTANCE COILS to LENGTH OF AERIAL, contained in the January, 1926, issue of Radio Review, Vol. 1, No. 7.

The Consrad Co. has the above back numbers in stock and to accommodate readers, we will sell these seven numbers of Radio Review at $1.00, prepaid. Please use the coupon below:

THE CONSRAD CO., INC.
64 Church Street, New York City.

Enclosed find $1.00 for which please send me the seven back numbers of Radio Review containing the first seven installments of the Radio Encyclopedia.

Name ....

Address ....

ENZ'S LAW—An induced current always tends to stop the motion which produces it. Stated in another way, whenever current flows in a conductor, due to electromagnetic induction, the action between the magnetic field which is being cut and the field around the conductor is always such as to tend to oppose further motion of the conductor. The following is still another way of stating *Lenz's Law*: The field due to the induced current always acts to prevent a change of the original field.

EYDEN JAR—A condenser consisting of a glass jar with an outer and an inner coating of tinfoil covering the bottom and the sides nearly to the neck.

A small leyden jar.

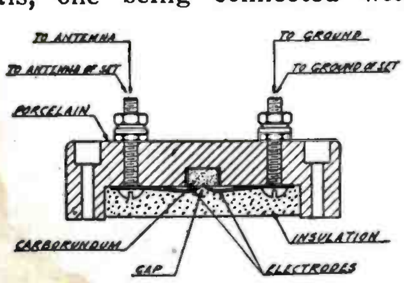
A brass rod terminating in an external knob passes through a wooden stopper and is connected to the inner coating by a loose chain. This condenser received its name from Leyden, the city in Holland in which it was invented.

. F. C.—Abbreviation for *Low Frequency Current*. (See *Frequency, Low*, also *Frequency*.)

IGHT—Radiant energy or visible *radiation* which affects the eye so that objects become visible. Light consists of *ether* vibrations varying between 400 billions per second producing waves 271 ten-millionths of an inch in length and giving red light, up to 750 billions per second producing waves of 165 ten-millionths in length, giving violet light. Faster or slower vibrations produce waves not visible to the human eye. Shorter waves are called *ultraviolet rays*, while those immediately above the red rays are known as *infra-red rays*. The speed of light waves is identical with that of other electromagnetic waves and electricity and is 186,000 miles or 300,000,000 meters per second.

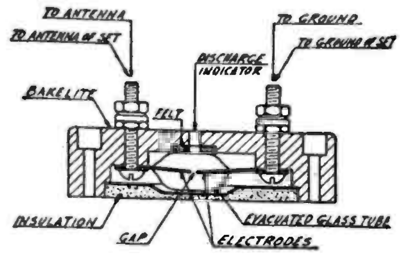
IGHT LINE AERIAL—A device which acts as an aerial for a radio receiving set and which utilizes the electric lighting system by means of a plug to which a condenser is attached. The plug is inserted in any lighting socket and the aerial connection of the receiving set it attached by means of a flexible lead to one terminal of the condenser. (See *Adapter, Aerial*.)

IGHTNING ARRESTER—(Also called *lightning protector*.) A device for protecting radio or other electrical apparatus from lightning or from atmospheric discharges. Radio *lightning arresters* are provided with two terminals, one being connected with the



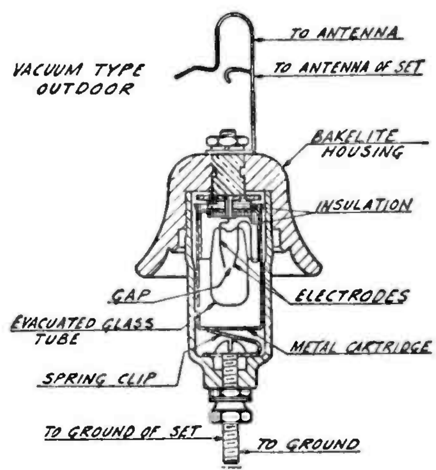
A carborundum type lightning arrester consisting of a block of carborundum held between two pieces of high resistance carbon.

aerial and the other directly to a ground. Between these terminals is a medium which offers practically no resistance (or technically speaking, which offers low *impedance* (q.v.)) to the flow of very high frequency currents such as lightning discharges. However, this medium acts as an insulator to the normal operating currents. Hence, during the ordinary re-



Vacuum type of lightning arrester for indoor work.

ception of radio signals, the currents flow past the *arrester* to the receiving instrument but they are unable to pass through the insulating medium of the *ligtning arrester* to the ground. When there is a lightning discharge, the arrester offers the shortest and most direct path to the ground and hence the dangerous current never reaches the apparatus but proceeds directly to the



Sectional view of vacuum type lightning arrester used for outdoor work.

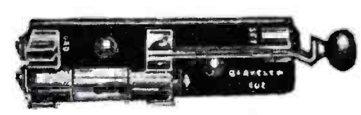
ground through the *lightning arrester*. The more popular designs of lightning arresters are of three types: vacuum, non-air-gap and air-gap. The vacuum type is the more sensitive of the three, due to its having a low functioning voltage. In a usual form, it consists

Outdoor vacuum type lightning arrester shown above in sectional view.

of two terminals in a sealed glass chamber from which air has been partially exhausted. This type of arrester can be discharged repeatedly without impairing its efficiency. The non-air-gap type of arrester involves the use of a carborundum stone, with a special clay binder. This type of arrester has a rectifying action similar to that used in a carborundum detector. The air-gap type of *lightning arrester* depends for its efficiency on a closely spaced air-gap which offers a low break-down voltage. The Underwriters requirements call for the use of an approved lightning protective device on all radio receiving sets where outside aerials are used. Further requirements are that such arresters shall operate on 500 volts or less. (See *Arrester*.)

LIGHTNING GAP—This refers to the *air gap* or *vacuum gap* in a *lightning arrester* (q.v.). This gap is connected across the aerial and ground leads to the receiving set. When the potential in the aerial rises above a certain value (usually 500 volts or less) a spark jumps the gap, discharging the excessive energy to the ground without damage to the radio apparatus. (See *Gap Arrester*.)

LIGHTNING SWITCH—A single pole, double throw knife *switch* (q.v.) used for grounding the antenna during a storm, or in some cases at all times when the apparatus is not in use. The



Lightning switch combined with vacuum type lightning arrester.

upper terminal of the switch is usually connected to the aerial, the central terminal to which the switch arm is connected, leads to the radio set and the lower terminal is connected to the ground. In most installations, the *lightning switch* is mounted outside the building in which the radio apparatus is located. (See *Ground Switch*.)

LIKE CHARGES—Bodies which carry like *electrostatic charge* (q.v.) exert a repulsion against each other.

LIKE POLES—Like magnetic poles repel one another. This is one of the *laws* of *magnetism*. (See *Magnetism, Laws of*.)

LIMITING VOLTAGE OF BRUSH DISCHARGE—The potential at which a brush discharge passes into an arc or spark. Brush discharges and arcs may be reduced in radio transmitting apparatus by eliminating sharp points or edges on conductors and by coating the edges of metal plates with paraffin. (See *Brush Discharge*, also *Corona*.)

LIMITING VOLTAGE OF GLOW DISCHARGE—The potential at which the glow gives place to the *brush discharge* (q.v.) in a high tension line or in a radio transmitting aerial (q.v.). (See *Corona*.)

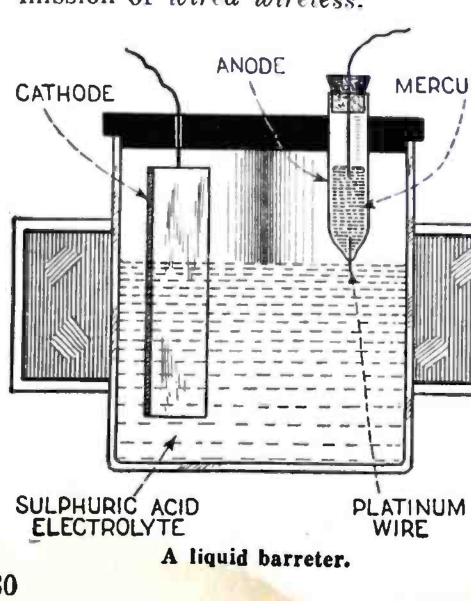
LIMITS OF AUDIBILITY—The limiting *frequencies* (q.v.) at which audible sounds are produced. These range from 500 to 1000 cycles per second up to as high as 10,000 cycles per second. *Audio frequencies* (q.v.) are sometimes defined as those conveniently heard in the telephone. (See *Frequency, High*, also *Frequency, Low*.)

LINE—A conducting wire between terminals in a system of electric communication or distribution. The positive wire is sometimes specifically referred to as the *line* and the return wire as *earth*. In many cases the earth or ground is used in the place of a return wire.

LINE OF FORCE—A theoretical conception used to map out a magnetic field and to show the direction along which the magnetism acts. *Lines of force* are conceived as forming closed loops and the path they traverse is called the *magnetic circuit* (q.v.) The positive direction of the *lines of force* is arbitrarily taken as that in which the north-seeking end of a compass moves. *Lines of force* are represented in diagrams by curves so drawn that the direction of the tangent at any point is the direction of the *magnetic force* (q.v.) at that point. The closeness of the lines is used to indicate the intensity of the force. The *line of force* is also used to indicate and map out an *electrostatic* (q.v) field in the same way as it is used for the magnetic field. The *line of force* is also called the *line of flux* or the *line of induction*. This latter term is used especially where the line of force is being considered in respect to its electrical effect. In some cases it is simply referred to as a *line*. Thus a line (*of force*, or *of flux*, or *of induction*) is an electromagnetic unit of magnetic flux and is equal to 10^{-8} *webers* (q.v.). In the practical system of measurements, the *maxwell* (q.v.) equal to one *line*, is the unit of *magnetic flux* (q.v.). When 100,000,000 *maxwells* are cut by a single conductor, in one second, one *volt* (q.v.) will be induced. (See *Law of Electromagnetic Induction*, also *Electromagnetic field*.)

LINEAR OSCILLATOR—See *Oscillator, Linear*.

LINE RADIO—Also known as *Wired Wireless*—A system of communciation devised by Major General George O. Squier which permits the transmission of electromagnetic waves along a wire or conductor. Instead of the waves spreading out in all directions, as in ordinary broadcasting, the waves travel along a predetermined path, viz: the conductor. It is possible to transmit either code or speech by *wired wireless*. Vacuum tubes are used as oscillators at the transmitting end and a specially designed vacuum tube set is used as the receiver. When code transmission is desired, a telegraph key is inserted in the circuit to intermittently stop and start the oscillating waves. This produces dots and dashes and in this way it is possible to send code using undamped radio frequency waves. When it is desired to telephone, the key is omitted and the radio frequency or *carrier waves* (q.v.) are produced continuously except when they are varied or modulated in amplitude corresponding to the voice of the speaker at the transmitting end. The wave which passes from the transmitting end of the wire to the receiving end is of radio frequency and is called the *carrier wave*. In a way, this wave is analogous to the wire which carries the voice current in wire telephony. *Line radio* can be transmitted over ordinary telephone or telegraph lines at the same time as these lines are being used for their ordinary purposes and without any interference whatsoever. High-tension lines are also used for transmission of *wired wireless*.



A liquid barreter.

LIQUID BARRETER—An electrolytic detector which utilizes a very fine platinum wire dipped to a small depth in nitric or sulphuric acid. These detectors were formerly used to some extent in receiving wireless code messages. The electrolytic detector of the *barreter* type was invented and named by *Fessenden* (q.v.). The illustration shows a liquid barreter. In the glass jar is a platinum glass-anode, lead cathode and sulphuric acid electrolyte.

LITZENDRAHT—abbreviated Litz—A German word, meaning braided wire. A high frequency conductor built up of a number of very fine conducting strands. The individual strands are enameled and the conductor is usually so constructed that each strand comes to the surface or very near the surface at regular intervals. In the most effective form of conductor the strands are braided so as to form a woven tube. The strands are usually covered by a single braided silk wrapper. The use of *litz* tends to reduce *skin effect* (q.v.). This type of wire has been found to be especially effective when used in the construction of *loop antennas* (q.v.).

LOADSTONE—also spelled *Lode-stone*—Iron ore which shows magnetic properties. The name loadstone is derived from a word meaning leading stone and refers to the property of a compass of pointing to the north magnetic pole. The loadstone is also referred to as a *natural magnet*. (See *Magnetite*, also *Magnet*.)

LOADING—Adding capacity or inductance to a circuit. *Inductance coils* (q.v.) called *loading coils* are used to increase the inductance and condensers are used to increase the capacity. A loading coil may be used to increase the *wave length* (q.v.) of an antenna by placing it in series between the *lead-in* (q.v.) and the receiving set. In the case of a transmitting antenna, the loading coil may be used to tune the aerial for *resonance* (q.v.) at a desired frequency. An example of the use of loading, is that of the addition of a loading coil to a receiving set for the purpose of enabling the set to receive higher wave lengths.

LOADING INDUCTANCE—An inductance coil used to increase the wave length of a circuit. This term usually refers to an inductance coil used in connection with a radio receiving set for increasing its receptive wave length range. Sometimes the term *loading coil* is applied to a unit consisting of an inductance coil, mounted beneath a panel in a small cabinet. On the outside of the panel is a contact arm and a number of studs. These latter lead to taps taken from the inductance coil. By moving the contact arm from one stud to another it is possible to vary the loading of the circuit as desired. A loading coil connected in series with the aerial will increase the natural wave length of the aerial. (See *Loading*, also *Inductance, Antenna*.)

LOCAL ACTION—Electrochemical action within a cell, usually at the positive plate, which does not add to the useful output. In primary cells, zinc is the material usually employed for the positive plate. This zinc practically always contains impurities such as carbon, iron, etc. When the zinc is immersed in the electrolyte, there is a difference of potential between the zinc and the impurities and small local currents flow from the zinc through the electrolyte to the impurities and back to the zinc again. These currents serve no useful purpose and moreover use up the zinc and the electrolyte. *Local action* can be practically eliminated by coating the surface of the zinc with mercury. This is called *amalgamation*. In secondary cells or *accumulators* (q.v.) local action is due to the action which takes place between the lead of the positive and the coating of lead sulphate.

LOCAL OSCILLATIONS—Oscillations set up in the vicinity of a receiving set for test purposes or within the set, as in the *super-heterodyne*, to produce oscillations differing in frequency from the incoming oscillations so as to establish a beat frequency. *Local oscillations* may be produced by means of a buzzer. This is a method frequently used in testing. The use of such oscillations enables a manufacturer of radio receiving sets to test these sets for selectivity, etc., without waiting for actual broadcasting. In the *super-heterodyne* (q.v.) local oscillations are produced by a suitably arranged vacuum tube. (See *Driver*.)

LOCUS—The path of a movement graphically represented by a curve. In mathematical language, the *locus* of an equation is the curve that contains all the points whose co-ordinates satisfy the equation. The circle is defined as the *locus* of all points in a plane equidistant from a fixed point in the plane called the center.

LODGE, SIR OLIVER—British Physicist and radio pioneer. Born at Penkhull, near Stoke-upon-Trent, June 12th, 1851, Oliver Lodge went to the Newport Grammar School at the age of eight, but at fourteen was taken into business to help his father. He worked in the evenings for the intermediate examination in science at the University of London, and eventually took first-class honors in physics. In 1872 he went to University College, London, and in 1877 took his D.Sc. in electricity and became demonstrator, and afterwards assistant professor in physics at University College.

Sir Oliver Lodge.

In 1881 he was appointed first professor of physics at Liverpool, and in 1887 he was made a Fellow at the Royal Society. In 1888 he received the honorary L.L.D. of the University of St. Andrews, the first of a long series of such distinctions. In 1900 he was appointed the first principal of the University of Birmingham, a post from which he retired in 1920. In 1902 he was knighted. Sir Oliver Lodge is one of the foremost physicists of his time, and his brilliant series of researches into electrical phenomena, which he has made his special study have had a profound effect in all branches of that subject. To him, indeed radio owes as much as to any man, for he dealt with fundamentals when the whole subject of electromagnetic radiation was in its infancy. He was led to study the surging and oscillating character of an electrical discharge along wires as a result of his investigations as to the best means of protection against lightning.

One very remarkable experiment of his is now well known under the name of Lodge's resonating jar, now used as a measurer of wave length. In these experiments Lodge was really dealing with the electromagnetic waves discovered by Hertz in 1888. Lodge early recognized the vast importance of the discovery by Hertz, which so brilliantly confirmed the theories of Clerk-Maxwell, and he threw himself into work of investigating these ways with an energy which made him the foremost British physicist on the subject at the time. All this was pioneer work before Marconi and others came along and built upon the solid foundations which Lodge had prepared.

It was during this early period that Lodge discovered his coherer, and with this detector devised the first practical wireless telegraph, sending signals over a distance of several hundred yeards. In May, 1897, Lodge took out his fundamental patent for tuning—a patent that was successfully upheld in the law courts, and extended for seven years by Lord Parker. The patent was acquired by the Marconi Company in 1911. Sir Oliver Lodge has been a pioneer in many other directions. His theories and experiments in connection with the ether, of which he is the leading exponent, are well known, and he has carried out a number of interesting researches on the passage of electricity through liquids. Sir Oliver was the first to devise a simple and direct experiment to show the speed and direction of travel of the constituents of a salt in solution when broken up by a current of electricity. For his researches on electric waves and the passage of light through a moving medium, Sir Oliver Lodge received in 1898 the Rumford Medal of the Royal Society, one of the highest honors the society bestows.

Sir Oliver Lodge has won a well-deserved reputation for the clearness and simplicity with which he is able to explain many of the difficult and fundamental truths of physics, and this clarity of expression is well shown in the many articles he has written.

LODGE DISC DETECTOR—An imperfect contact detector consisting of a steel disc rotating with its sharp knife edge just touching some mercury having a film of oil on it. When an oscillation passes through the circuit, momentary cohesion sets in between the disc and the mercury, but this is immediately broken by the revolving motion of the disc. In this way, oil re-insulates the disc at the completion of each passage of oscillations. Using this type of detector, code signals can be recorded with great precision on a *Morse* tape using a syphon recorder. The *disc detector* is in reality a specialized form of *coherer* (q.v.).

LOG—A list of dial readings of a radio receiving set with corresponding call letters of the broadcasting stations received at these readings. A radio set is said to *log* when the same stations always come in at exactly the same dial readings. Thus on a three dial set, if WEAF comes in at 61, 60 and 60 and always comes in at these identical readings using the same aerial, the set *logs*. All present day sets are constructed so that stations can be accurately logged. Sometimes the term log is used to refer to a graph or chart on which dial settings are plotted against wave lengths of stations recorded. A graph is a diagrammatic representation by means of lines, of the relation between several quantities. Figure 1, gives a simple illustration of this. Suppose it is desired to obtain a general idea of how the radio business varies from year to year or from season to season. On a piece of paper, ruled both vertically

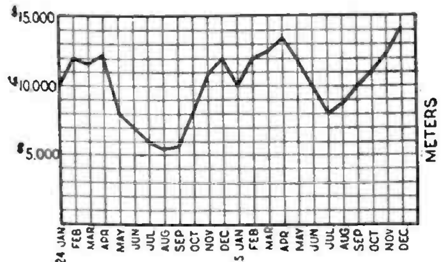


FIG. 1

Log showing variation of a business.

and horizontally, as in Figure 1, the months and years are marked at the bottom horizontally. The vertical lines then represent the months and the bottom horizontal line is called the *axis* of *time*. These vertical lines are known technically as *ordinates*. The vertical line to the extreme left is called the axis of ordinates and after it has been marked as shown in Figure 1, to represent dollars, it may be

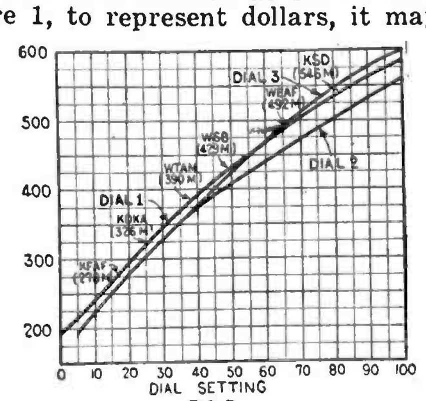


FIG. 3

A three-dial radio log using only one chart.

referred to as the *axis of dollars*. The horizontal lines are known as *abscissas*, the bottom horizontal line being the *axis of abscissas*. Assume that a certain radio concern did $10,000 worth of business in the month of January, 1924. Looking upward along the vertical line representing this month, until the horizontal line representing $10,000 is reached, a point is put at the intersection of these two lines. Suppose that in the following month, February, 1924, the firm does $12,000 worth of business. The point is found as before by following the line February, 1924, up to the line indicating $12,000. Each horizontal line in the figure represents $1,000, so that this point should be found two lines higher than the one marked for $10,000. This can then be continued indefinitely, plotting the amount of business for each month. Assume that in the summer there is a lull in business. The decline starts, say, in the month of May. The business done amounted to $8,000. By glancing at the chart it is possible to ascertain a number of facts which stand out much clearer than where columns of figures are given. Thus the seasonal character of the business is apparent at a glance. It can also be seen readily that the business was better in 1925 than in 1924, etc. Radio logs are plotted in exactly the same way. Each point must be obtained individually in order for the curve to be absolutely accurate, although in many cases a few well chosen points are

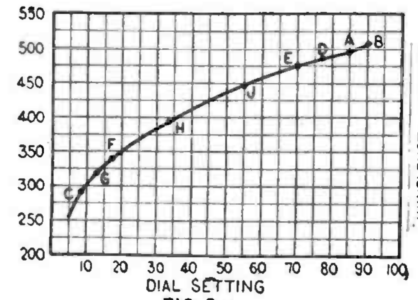


FIG. 2.

A radio log.

sufficiently satisfactory. In Figure 2, the dial setting is marked along the bottom of the chart. The scale is here chosen at one division on the chart equal to 5 divisions of the dial. If preferred the scale could be chosen so that one division on the chart would equal one division on the dial as shown on chart on the following page, which is a typical log of an actual set. Proceeding, it is first necessary to find

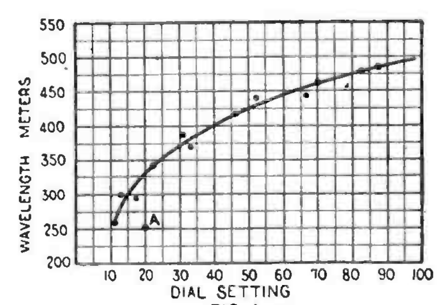


FIG. 4

Radio log showing curve drawn so as to touch as many points as possible.

out the limits of the chart. The limits of the horizontal scale are already known, i.e., zero to 100 on the dial. Looking over the list of broadcasting stations, it is found that they all have wave lengths which fall, roughly between 200 and 600 meters. Therefore it is not necessary to make the vertical scale include wave lengths outside of this range. Consequently the vertical scale is started at 200. Counting upward, two divisions on the chart are taken, for convenience, as equal to 50 meters. Having done this, actual readings are next taken on the radio set. Suppose that the first station tuned in is WEAF and that this is tuned in at 85 on the dial. This station has a wave length of 492 meters. Looking along the bottom of the chart for 85, the vertical line is then followed until the position of 492 meters is reached. This is slightly below the 500 line on the chart, Figure 2, and is indicated by the letter A. Next suppose that WOO, having a wave length of 509 meters is tuned in at 90 on the dial. This, then gives the point marked B. Then another station is tuned in, indicated by the point C.

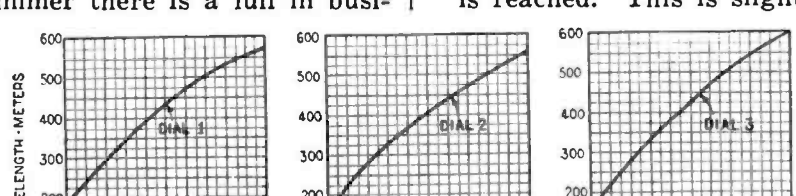


Fig. 5—A three-dial radio log using three separate charts.

Various stations are thus located by points on the chart until enough points are obtained to draw the curve. If the points do not give a smooth curve, it is necessary to approximate a curve, that is to draw it so as to pass through as many of the points as possible. This has been done in Figure 4.

Sometimes points are obtained that do not seem to have any meaning, such as the point A in Fig. 4. This point may have been subject to inaccuracies in reading the dial, or perhaps the operator did not read the wave length correctly from the list of stations. There is always the possibility, also, that he did not plot the point properly. He has plotted the point A as 251 meters at a setting of 20 when it might have been 335 meters at 20 on the dial, in which case it would have fallen directly upon the curve. If none of these difficulties can be found with the point A it can be discarded, however, because it is an absurd point, as the 12 other points, which determine the curve, will testify. Generally it is not good practise to discard points, but the experimenter must learn to use his good judgment.

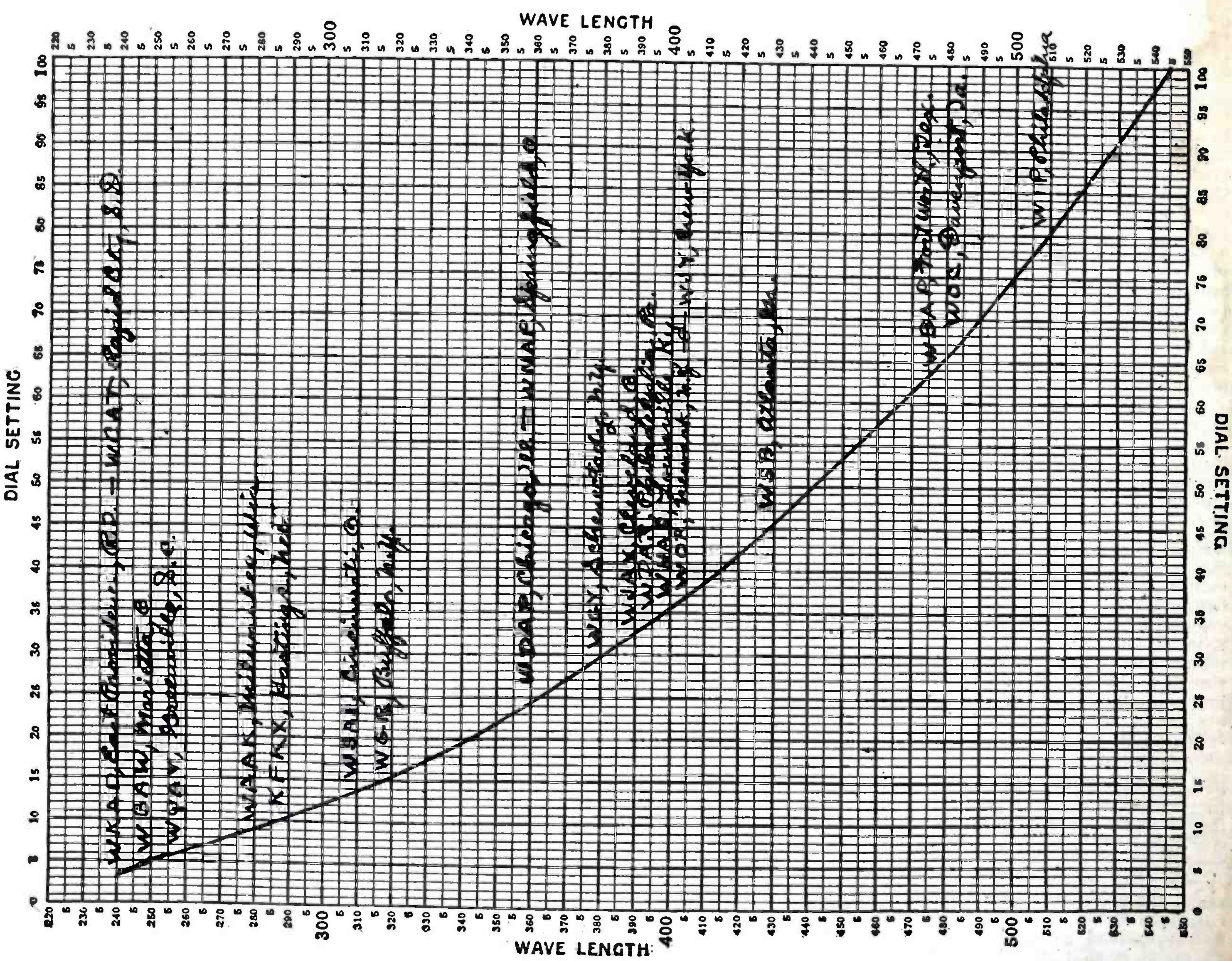
In single-control sets, where only one dial is employed it is only necessary to have one of these radio log curves. In receivers, such as the Neutrodyne or any two-stage radio frequency amplifier, where three dials are employed, it is generally necessary to log each dial separately. The reason for this is, that although these sets are supposed to tune to stations with identical dial settings, many of them do not do so, a difference as great as 10 divisions on the dial often being found. A three dial log is shown in Fig. 5. Separate charts may be used for each dial, or, for convenience, as has been done in Fig. 3, the three charts may be combined into one. If the difference between the dial settings is very small, say only a division or two, one curve will be sufficient.

Many things can be learned from studying the curves obtained. Take for instance, Fig. 2. This is practically a straight line at the higher wave lengths, changing from about 500 meters to about 400 in 55 divisions of the dial. In the remaining 35 divisions of the dial the wave length changes from 400 to 250. In the first case there was a range of 100 meters for 55 divisions and in the latter case a range of 150 meters in 35 divisions. This is because the curve bends downward. At the low dial settings a small change in the dial reading means a relatively large change in wave length, while at the upper end of the dial the same change in dial reading will mean a relatively small change in wave length. The reason why the stations are so crowded at present, at the small end of the dial, is then very apparent, i.e.:

To illustrate, a station operating on a 200 meter wave corresponds to a frequency of 1500 kilocycles (1 kilocycle equals 1000 cycles), and a station on 200 meters corresponds to a frequency of 1,363.5 kilocycles. In other words the difference in wave length is only 20 meters whereas the difference in kilocycles in 136.5. These two wave bands are at the low end of the present broadcast wave band. Now at the high end of the band we find a wave length of 600 meters corresponds to 500 kilocycles, and a wave of 580 meters corresponds to 517.2 kilocycles, or a difference of but 17.2 kilocycles for the 20 meter difference in wave length. At the lower end of the broadcast band between 200 and 220 meters we found a difference of 20 meters equalled 136.5 kilocycles. This indicates that as the wave length becomes lower the difference in frequency becomes very high.

To bring this most strongly to the mind, go down to the extremely low wave of 5 meters. Here the frequency is found to be 60,000 kilocycles. Going up to 25 meters, this corresponds to 12,000 kilocycles, so that for this difference of 20 meters there is the tremendous difference of 48,000 kilocycles.

The accompanying illustration, Fig. 6 will explain the matter very clearly. In changing the dial setting from 100 to, let us say, 90, the wave length is changed roughly from 600 to 580 meters. This is a change from 500 to 517 kilocycles. On the other end of the dial from zero to about 10 we have a change of wave length of roughly 200 to 220 meters, an approx-



An example of a station log chart.

mate change of from 1500 to 1363 kilocycles. In the first case on the upper part of the dial we have only made a change of 17 kilocycles in the frequency. On the lower end of the dial we have made a change of 137 kilocycles.

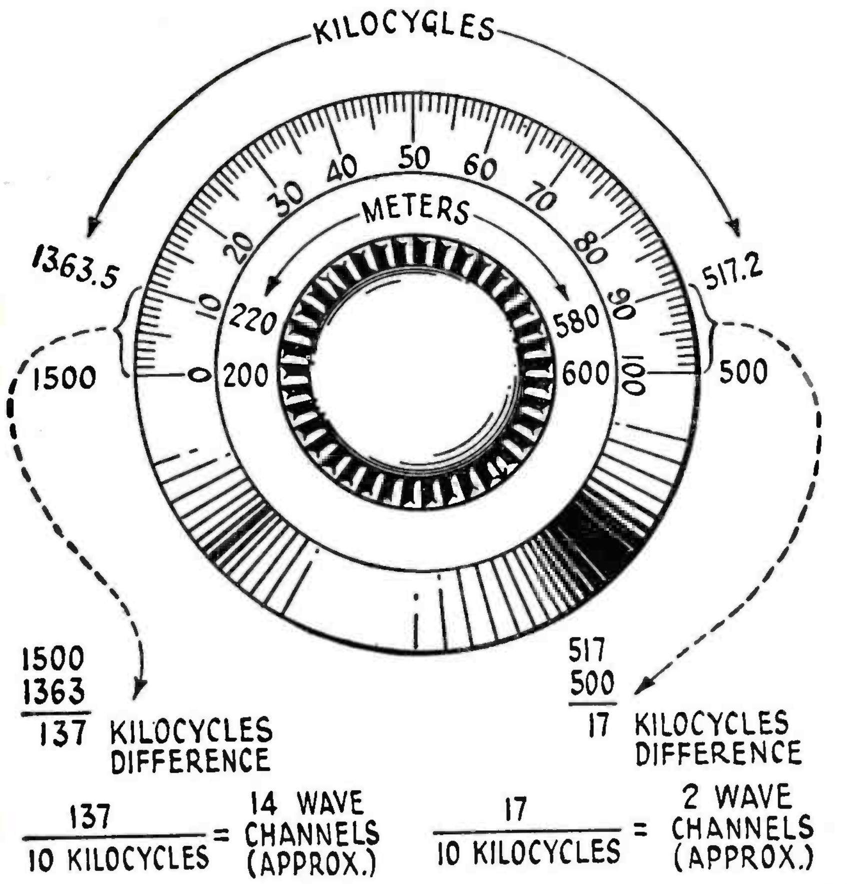


Fig. 6—This illustration shows clearly why stations are crowded on the dial at the lower wave lengths.

According to the frequency allocation as made by the Government, which places broadcast frequencies 10 kilocycles apart, on the upper 10 divisions of the dial there is room for approximately 2 frequency channels whereas on the lower 10 divisions of the dial there is room for roughly 14 frequency channels. This shows very clearly that we would have to be able to separate 14 stations on the lower 10 divisions whereas we have only 2 to separate on the upper 10 divisions of the dial.

So it will be understood why turning the dials but a degree or two at the low setting causes a relatively large change in frequency, tuning in perhaps several stations within one degree of the dial, while at the higher settings, due to the small difference in frequency, as stated, on the higher waves, it may be necessary to turn the dials two or three degrees on either side of the peak of the broadcast wave before it is tuned out. (See *Dial.*)

LOGARITHM—abbreviation LOG—The power to which a number (defined as a base) must be raised in order to equal a given number. As an example, given the number 100, assume that it is desired to determine the *logarithm* of this number to the base 10. (When 10 is used as a base, the *logarithms* obtained are said to belong to the *common* or *Briggs system.*) Then the exponent or power which will raise 10 to the value of 100 is known as the *logarithm* of 100. Obviously, 10^2 equals 100, therefore 2 is the logarithm of 100. *Logarithms* are used in the processes of multiplication, division, raising to powers and taking roots. The whole number, or integer part of a logarithm is called its *characteristic* and the fractional part, is referred to as its *mantissa*. The characteristic of a number greater than unity is positive and is one less than the number of figures to the left of the decimal. The characteristic of a number less than unity is negative and is one greater than the number of ciphers between the decimal and the first significant figure. A *table of logarithms* gives the mantissas only, the characteristic being determined as indicated above.

Logarithms are also used which have as their base the number 2.718 +. These are called *natural* or *Naperian logs*. The base number is usually represented by the symbol ε (epsilon). The natural logarithm of any number may be found from a table of common logarithms by dividing the common log by the logarithm of 2.718 or simply by multiplying the common log by 2.30259. The symbol l_n is often used for the natural logarithm and the abbreviation *log* without a subscript is usually used for the logarithm to the base 10. (See *Naperian Log*, also *Mantissa*, and *Log Table.*)

LOGARITHMIC CURVE—A curve which has no definite minimum in a decreasing curve, or no definite maximum in an increasing curve. A *logarithmic curve* may be further defined as a curve whose ordinates increase arithmetically while its abscissas increase geometrically. A series of damped electrical oscillations diminish according to a logarithmic law and hence a curve drawn tangent to the successive maximum displacements will be a *logarithmic curve.*

LOGARITHMIC DAMPING—See *Damping.*

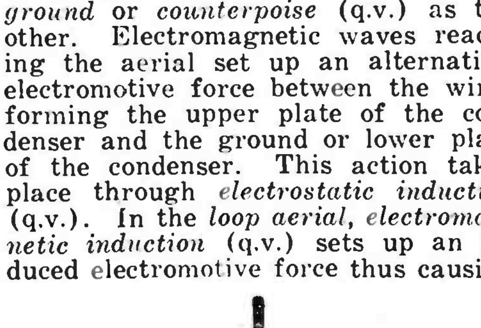
LOGARITHMIC DECREMENT—The *Naperian logarithm* (q.v.) of the ratio of any maximum to the next following maximum, with the current in the same direction in a decaying wave train. In other words the logarithm of the ratio of two maxima, one cycle apart. The rapidity with which the oscillations decay depends not only on the resistance of the circuit, but on the inductance as well. The greater the resistance and the smaller the inductance, the more rapid is the damping and the rate at which the oscillations increase. If the resistance, inductance and capacity of the circuit have fixed values, each successive maximum of current is the same fraction of the preceding maximum as the latter is of the maximum immediately preceding it. Thus, if the second maximum is 75 percent of the first maximum, the third will be 75 percent of the second, etc. The numerical value of the rate of decrease in this case is .75 and the natural logarithm of .75 is the *logarithmic decrement* or simply the *decrement.* (See *Decrement*, also *Damped Waves.*)

LOG TABLE—A tabulated arrangement of logarithms which gives the *mantissas* (q.v.) only. The numbers whose logarithms are to be looked up are arranged for convenience in consecutive order. (See *Logarithm.*)

LOMBARDI, DR. LUIGI—Italian radio authority. Dr. Lombardi was born at Dronero, August 21, 1876. He graduated from the Royal Engineering School at Turin, Italy. He was Professor of Electricity at the Zurich Polytechnical School, Zurich, Switzerland, and also at the Royal Polytechnic School, Naples, Italy. Dr. Lombardi published many scientific papers including a study of condensers for transmission and he also invented a special high-tension electrical condenser.

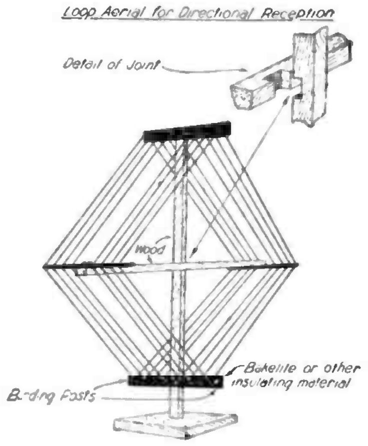
LONGITUDE—The distance east or west of a meridian passing through Greenwich, England, measured in degrees, minutes and seconds.

LOOP ANTENNA—*Loop Aerial*—Also called *Coil Aerial* or simply *Loop*—A receiving or transmitting *aerial* (q.v.) consisting essentially of one or more turns of wire connected to the radio set so as to form a closed circuit. The *loop* acts as a simple inductance coil. The ordinary radio aerial acts as a huge condenser with the aerial system as one plate of the condenser and the *ground* or *counterpoise* (q.v.) as the other. Electromagnetic waves reaching the aerial set up an alternating electromotive force between the wires forming the upper plate of the condenser and the ground or lower plate of the condenser. This action takes place through *electrostatic induction* (q.v.). In the *loop aerial, electromagnetic induction* (q.v.) sets up an induced electromotive force thus causing



A typical loop antenna.

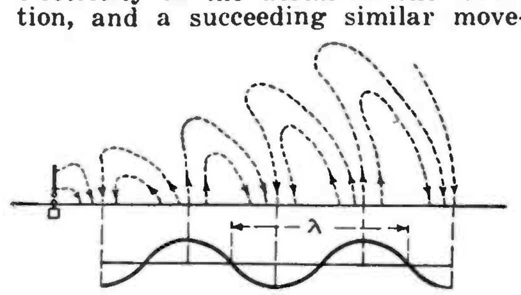
alternating current to flow to the detecting apparatus. While coil antennas may be used for transmitting, their use in this connection is rather limited. On the other hand, the use of the loop for radio receiving is widespread. The greater the area enclosed by a loop the greater the amount of energy it will receive. Loops more than two feet in diameter are usually constructed so as to be collapsible. A common type of loop shown in the illustration is 36 inches high and 28 inches wide. It consists of twelve turns of wire wound in the same vertical plane and held in place by polished hard rubber strips. It has a heavy cast base permitting rotation of the loop as desired. This loop folds up so as to fit into a four inch tube. In another type of loop, sometimes called the *box type*, the wires are wound so as to lie in the same horizontal plane instead of the vertical plane. The use of *Litzendraht*



A box-type loop.

(q.v.) for winding loops has been found to add to their efficiency. Loops are commonly used on *super-heterodyne* (q.v.) sets, *reflex* (q.v.) sets and in some *tuned radio frequency* (q.v.) sets. These latter generally require an extra stage of amplification, although tuned radio frequency sets having only five tubes (detector, two stages of radio frequency and two stages of audio frequency) will operate on a loop and give especially good results when used with the new power tube. As a general rule, it may be stated that any set which will give good results with a loop, will give better results, insofar as distance is concerned, with an outside aerial. For this reason loop operating sets are quite generally constructed with extra binding posts for connecting aerial and ground. The loop is connected directly into the grid circuit, while the aerial and ground are connected to the circuit through an inductance such as an *oscillo-coupler* or antenna coupler. Loops may be used with satisfactory results inside of buildings. Where a compact, portable and selective aerial is desired, the loop is especially useful. The use of the loop, results in a marked directional effect and also has a tendency to reduce *static* (q.v.) and other forms of *interference* (q.v.). Loops are employed in wireless direction finders or *radio compasses* (q.v.) and are also used as aerials in submarine and aeroplane work. Where the loop is used as an aeroplane antenna it may be wound on the wings of the plane or it may be wound on a small frame and placed in the rear of the plane. (See *Coil Antenna*, also *Frame Aerial.*)

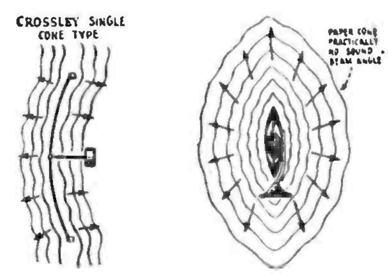
LOOPS—The points of greatest amplitude in a wave train. Sometimes called *antinodes*. The term *loop* is also used in describing the electrostatic field spreading out from a charged aerial. Each time an aerial is charged (for example by an induction coil) and discharged across a spark gap a group of gradually decaying oscillations is produced in the aerial called a *train* of oscillations. The interval of time which elapses between a flow of the electricity in the aerial in one direction, and a succeeding similar movement is called the *periodic time* and the reciprocal of this is called the frequency. For example, if the periodic time is one-millionth of a second, the frequency is one million. The diagram shows the manner in which *semi-loops* of electric force represented by the dotted lines move away from the aerial which is represented by the short black line.



Semi-loops of electric force represented by the dotted lines moving away from the aerial represented by the short black line.

LORENZ COIL—A form of low loss inductance coil, having an air core and of cylindrical shape, being wound in a single layer, with turns slightly kinked to make the coil self-supporting. (See *Coil, Inductance Coils,* also *Low Loss Coils.*)

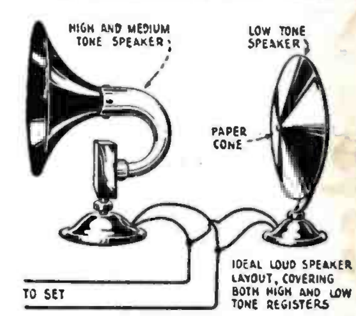
LOUD SPEAKER—A sound producing device for converting audio frequency currents into sounds loud enough to be heard by an assemblage of people. Nearly all *loud speakers* utilize an electromagnet in order to directly or indirectly cause a diaphragm to vibrate.



At the left is shown a cone-type speaker having a single diaphragm; at the right one with a double diaphragm.

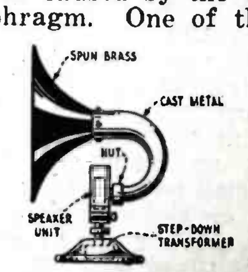
The audio frequency currents flow through the windings of the electromagnet and the vibrations of the diaphragm correspond to the minute changes and fluctuations of the current thus accurately reproducing sounds. In loud speakers which utilize a metallic diaphragm, the electromagnet directly actuates the diaphragm. In other types, the diaphragm may be of mica, as in the Baldwin unit type, or of parchment or wood as in the cone type speakers. In these speakers, the electromagnet actuates an armature which in turn actuates the diaphragm through a lever action. In certain loud speakers, the electromagnet is of very powerful type and has a very small coil of fine wire attached to a diaphragm but not touching the poles of the magnet. The small coil is connected to the radio set or amplifier and the fluctuating audio frequency currents pass through it. These currents force the coil out of the strong magnetic field in the air gap. In moving, it moves the diaphragm to which it is attached. Speakers of this nature are sometimes called electrodynamic speakers. They are also referred to as power speakers. Such speakers give plenty of volume and in certain makes are reasonably good in tonal quality but they have the disadvantage that the electromagnet must be energized from a source of current such as the storage battery. A loud speaker has been developed in England called the Crystavox for use with crystal sets. This consists essentially of an electromagnetically operated speaker connected with a microphonic relay. The relay is actuated by a storage battery. Its function is to magnify the incoming signals from the crystal set, passing them along with increased strength to the electromagnet of the loud speaker. Still another type of speaker which has been used to a limited extent abroad, dispenses entirely with the electromagnet as the actuating source of diaphragm vibration. In this type, electrostatic principles are involved. An agate cylindrical drum, over which a band of copper or similar metal is wound, is revolved at a uniform rate by a small motor or by clockwork. To one end of the band a diaphragm is fastened mechanically. The other end of the band is secured by a fairly stiff spring. Current from the receiving set is led to the cylinder by means of a brush contact and as the current fluctuates the attraction of the band to the cylinder fluctuates with it and the drag on the diaphragm due to the rotation is increased and decreased. The use of the motor constitutes the most serious disadvantage in this type of loud speaker.

Having discussed the various *types*



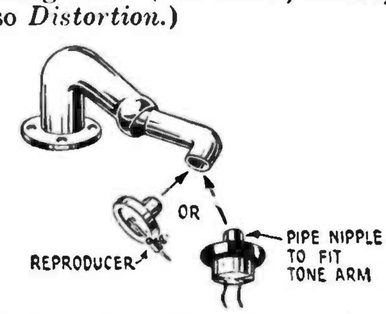
A high and a low pitched speaker connected in parallel for simultaneous operation.

of loud speakers, from the standpoint of principles of operation, the more important of these will now be considered from the constructional standpoint. The early forms of directly actuated metallic diaphragm, electromagnetic loud speakers consisted essentially of a watch-case telephone receiver, or a pair of receivers attached to a horn. The purpose of the horn was to concentrate and redistribute the sounds caused by the vibration of the diaphragm. One of the first im-



A loud speaker of the horn type having curved cast metal neck and spun brass bell.

provements was to modify the shape of the horn so as to make it conform more nearly with correct acoustical principles. Another improvement was to introduce an adjustment by means of which the air gap could be varied. In some cases this was accomplished by moving the magnet closer to the diaphragm and in others by moving the diaphragm itself. This adjustment provided a means of getting greater sensitivity on distant stations (by drawing diaphragm closer to the magnet) and of preventing sticking of diaphragm or rattling, on local stations. The ordinary metallic diaphragm has *one* frequency to which it will respond most strongly. This is called its *resonant* frequency. Special speakers called *tuned receivers* have been designed in England which permit the resonant frequency to be varied. In one type, the variations of the magnetic field operate a vibrating reed attached to a non-magnetic diaphragm. The resonant frequency can be varied by adjusting the position of the vibrating reed with a set screw. Another method of getting rid of resonant points in diaphragms has been to use corrugated instead of flat diaphragms. In some of these diaphragms the center is left flat, the remainder of the diaphragm being corrugated with concentric circles either evenly spaced or spaced in section at radii bearing a ratio to each other corresponding to prime numbers. In some cases conical diaphragms with corrugated edges are used. The material as well as the shape of the horn have been found to materially affect the sound reproduction. Horns are constructed of metal, fibre, composition, hard rubber, wood, etc. In general the horn should be of a material which will not give out metallic sounds. The tone arm which carries the speaker unit at one end and the horn at the other is usually constructed of cast metal such as a lead alloy or aluminum. The requirement here is that it must be of an acoustically "dead" material. In some cases the speaker unit and sound chamber are concealed in an artistically designed cabinet thus forming a *cabinet speaker.* Loud speaker units are also made especially for use in conjunction with the sound chamber of a phonograph. These are referred to as *phonograph attachments.* They are ordinarily attached to the phonograph tone arm being put in place of the phonograph reproducer. Some phonographs are now made with provision for attachment of the speaker unit without removal of the reproducer. There is also an attachment on the market for use in connection with a phonograph which has provision for conveniently changing over from the reproducer to the speaker unit or vice versa. Cone speakers may be of the single cone variety or of the double cone style. In these speakers a metal rod extends from the magnet armature and is rigidly fastened to the center of the cone. The most common type of cone speaker has a parchment diaphragm. This seems to give excellent reproduction especially for tones in the lower register. Its points of disadvantage are that it is affected to some extent by moisture and temperature change and furthermore seems to bring out static interference more clearly than some other types. Another type of cone speaker uses a teak wood diaphragm. Some of these speakers have a small fastening screw at the point of attachment between the rod and the diaphragm. This is provided so that tension can be removed from the diaphragm during shipment and also if the speaker is to remain in a room where change in temperature may take place. A cylindrical parchment speaker which utilizes the same principle as the cone speaker, has recently been placed on the market. Its chief point of difference is that the parchment is not under tension as in the case of the cone speaker. Large volume loud speakers are provided with power amplifiers which are often an integral part of the speaker itself. One of the most recent loud speakers is contained in a large cabinet and contains apparatus for utilizing ordinary lighting circuits for operating the set and speaker. The power amplifier unit is also contained within the speaker cabinet and the design of the speaker is such that it can handle any volume without distortion. The rectifier is arranged to supply not only the necessary voltages for the power amplifier but also plate voltage for practically any type of receiving set. (See *Horn, Loudspeaker,* also *Distortion.*)



A loud speaker unit used as a phonograph attachment.

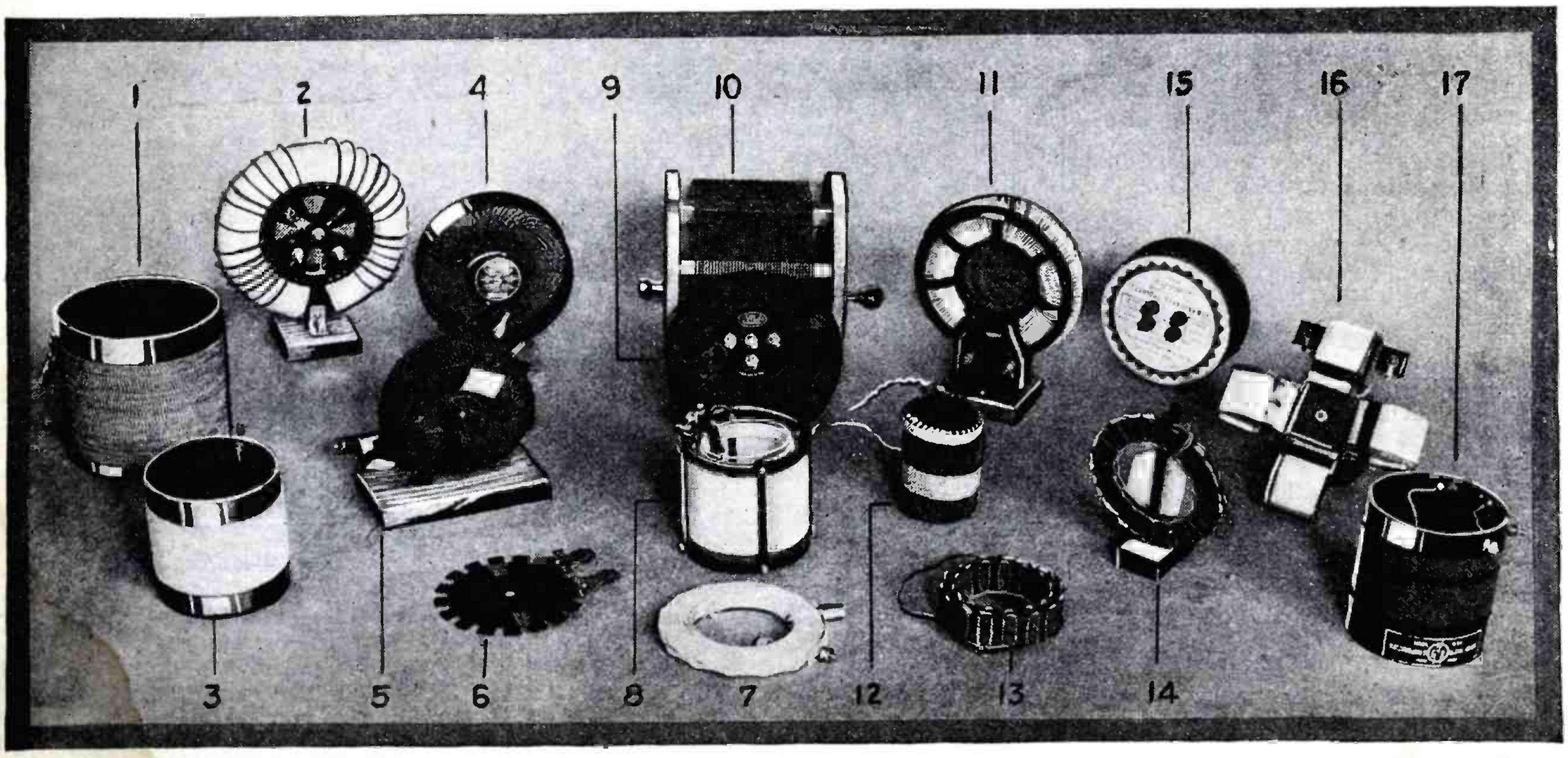
LOUDSPEAKER UNIT—The sound reproducing unit attached to the tone arm of the horn type speaker or to the diaphragm of the cone type speaker. Various types of units are described under the heading *Loudspeakers.*

LOW FREQUENCY—See *Low Frequency Current.*

LOW FREQUENCY CURRENT—An alternating current of less than 10,000 cycles. In radio work the alternating currents used are often classified as *low* frequency currents and *high* frequency currents. While there is no fixed value separating high and low frequencies, 10,000 cycles is generally taken as the dividing line. Thus audio frequency currents are considered as low frequencies and radio frequency currents are high frequencies. The term *low frequency* current as applied to power and lighting circuits refers to circuits having frequencies of 25, 60, etc., cycles per second. (See *Current, High Frequency.*)

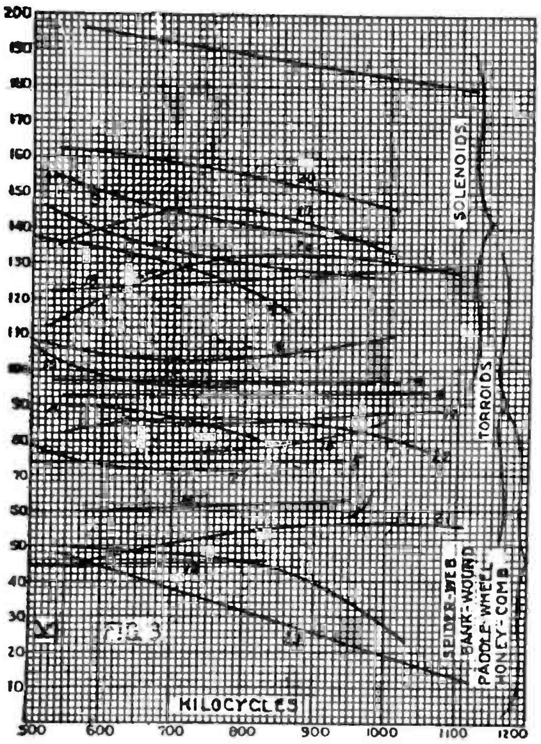
LOW FREQUENCY IRON CORE INDUCTANCE—A variable inductance having an open-ended iron wire core. This inductance is used with spark transmitters to place the primary transformer circuit in resonance with the alternating current frequency.

LOW LOSS COILS—*Inductance coils* (q.v.) having low resistance and specially wound so as to reduce to a minimum condenser effect and hence dielectric losses. The term low loss has been used rather loosely but for practical purposes coil losses should be taken as referring to self-capacity, often called *distributed capacity* (q.v.) ohmic resistance, *skin effect* (q.v.) in the wire due to the effects of frequency and leakage and absorption in or through the insulating materials upon which the coil is built or with which the wire is covered. While it is impossible to obtain a coil having pure inductance only, it is feasable to design the coil so that the various losses will be reduced to a minimum. Often, it has been found that a design which will greatly reduce one type of loss will result in an increase of another. The illustrations show various types of low loss coils together with curves showing comparative efficiency tests. Figure 1 shows the results of an investigation regarding the distributed



Various types of low loss coils including: 1, Bell wire coil; 2, Naxon; 3, Marco; 4, All-American; 5, Orbit; 6, Turney; 7, Sickles; 8, Aerocoil; 9, Erla; 10, Wavemeter coil; 11, Thorola; 12, Pathe; 13, Freshman; 14, Coast Coil: 15. Summitt; 16, Quadroformer; 17, Bruno.

capacity of various coils. This was obtained by making measurements of



The efficiency of a coil is indicated by the height of its curves on this graph.

the inductance of the coils. If the self-capacity of the coil is very small, the self-inductance will not change perceptibly as the frequency changes. On the other hand, if the self-capacity amounts to anything, the curve showing the relation between inductance

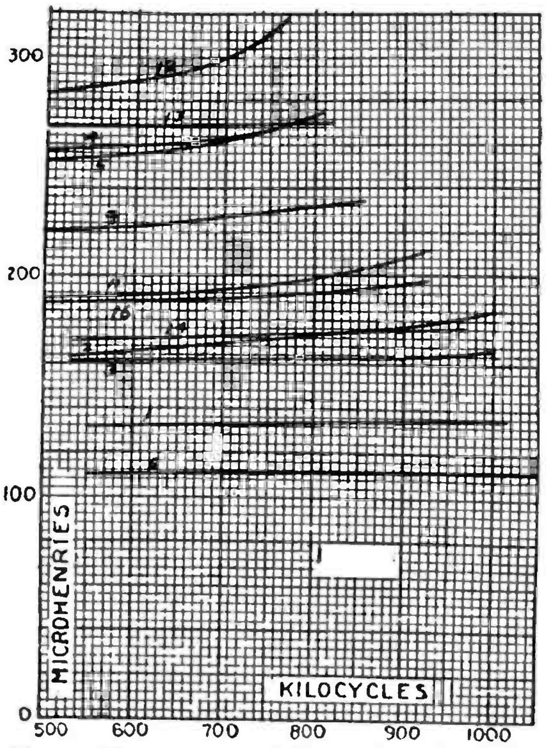
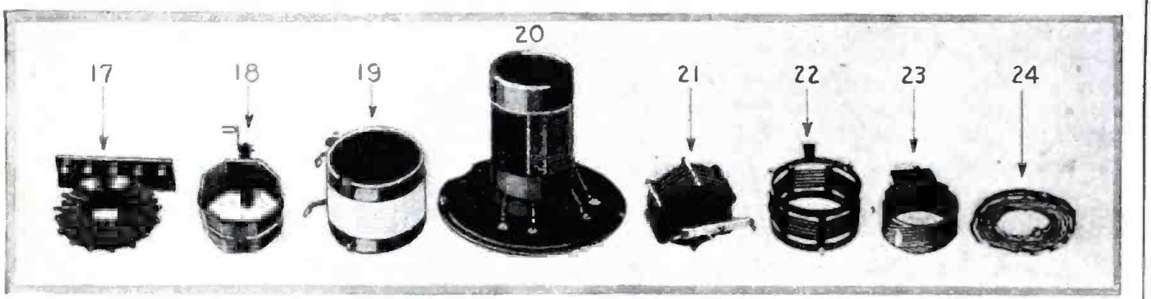


Fig. 1.—The curvature of the graphs indicate the presence of distributed capacity in the coils.

and frequency will bend upward as the frequency increases, and the greater the capacity of the coil, the more sharply will the curve bend. The curves shown in Figure 1 do not give any idea of what value the self-capacity may have, but simply show whether the inductance varies or not, which is one method of determining how harmful is the effect of the distributed capacity. The more sharply the curve bends upward the less desirable is the coil. In general, the smaller the size of the wire (for sizes smaller than about No. 16 B & S) the higher the resistance. The larger the wire and the thinner the insulation, the greater is the skin effect. The greatest inductance is obtained for a given amount of wire when the coil has a true cylindrical shape. The skin-effect in multi-layer coils is much greater than in single-layer coils. The effect of coil capacity and absorption or leakage in insulation is small compared with the skin-effect except in multi-layer coils, where the distributed capacity may become very great. To keep the physical size of toroidal coils within practical limits the diameter of the turns must be relatively small, so that many more turns are required to obtain a given inductance.



Additional examples of low loss coils: 17, Marwol; 18, Eastern Coil; 19, Workrite; 20, Walbert; 21, Andrews; 22, Bremer Tully; 23, Cotocoil; 24, Kresge Lorenz coil.

LOW TENSION—abbreviation L. T.—A comparatively low voltage. A circuit supplied by a low voltage battery such as the filament circuit of a vacuum tube is called a low tension circuit. In electrical engineering work, any circuit of 600 volts or under is considered to be a low tension circuit.

LUGS—Metal projections used for permanently connecting conductors with electrical apparatus. In one type of lug, the metal is bent over at one end to form a tube into which the conductor can be soldered, while the other

Typical lugs.

end is flat and has a hole drilled to receive any desired terminal.

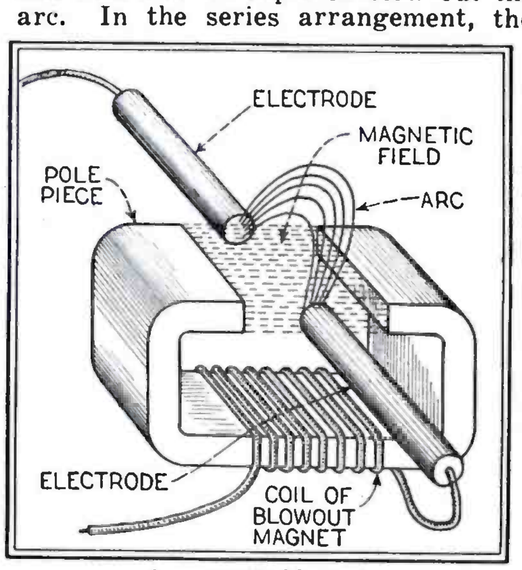
M

MAGNET—A piece of iron or steel having the power to attract other pieces of iron and to attract or repel other magnets. Natural magnets are known as *Loadstones* (q.v.). (See *Electromagnet*, also *Permanent Magnet* and *Temporary Magnets*.)

MAGNET WIRE—Insulated wire for the construction of magnet coils. In radio extremely fine wire is used to wind the coils of the electromagnets used in headsets and loud speaker units. The most common insulation used in radio work for magnet wire is enamel. Other types of magnet wire utilize a single cotton covering, a double cotton covering or a silk covering. (See *Enameled Wire*.)

MAGNETIC ATTRACTION AND REPULSION—The mechanical force tending to draw together two magnetic poles of unlike polarity, or to force apart two magnetic poles of like polarity.

MAGNETIC BLOWOUT—An electromagnet with its pole pieces placed so that the direction of the magnetic field will be at right angles to the movement of the ions in an electric arc. The coil of this magnet is energized in some cases in series with the line and acts to expel or blow out the arc. In the series arrangement, the



A magnetic blowout.

blow-out action is stronger, the larger the current to be interrupted. For small shunted arcs, permanent magnets are often used. The operating principle of the blowout coil depends upon the fact that in a magnetic field, an electric current tends to move across the lines of force or in other words to cut them. In the illustration, the pole pieces are shown so placed that the general direction of the lines of force is at a right angle to the flow of the ions in the arc. The electromagnetic action causes the arc to move outside the field. This increases the length of the arc, thus rapidly breaking it. Magnetic arcs are used in connection with *keys* (q.v.) used for interrupting a large current, in certain types of *lightning arresters* (q.v.) and also in motor controllers..

MAGNETIC CIRCUIT—The path traversed by magnetic lines of force. A magnetic circuit may be entirely through iron, as in the case of a closed core transformer or partly through iron and partly through air as in the case of a motor or generator. (See *Line of Force*.)

MAGNETIC COUPLING—See *Coupling*.

MAGNETIC COUPLING TRANSFORMERS—See *Coupling Transformer*, also *Jigger*.

MAGNETIC FIELD—The whole space over which a magnet exerts influence. The space traversed by the magnetic flux. Wherever magnetism is present the space in the immediate vicinity is called a magnetic field. (See *Electromagnetic Induction.*)

MAGNETIC FLOW—The passage of magnetic lines through a magnetic circuit. This term is sometimes used in the place of magnetic flux. (See *Flux Magnetism.*)

MAGNETIC FLUX—Symbol ϕ—The total magnetism present at any cross-section perpendicular to the lines of force. Magnetic flux is analagous to current flow. That is to say, it is convenient to consider a flow of magnetism in the same way as electricity is considered to flow. The unit of magnetic flux in the c.g.s. (centimeter gram second system) electromagnetic system is the *maxwell* (q.v.) or simply the *line*. The unit of magnetic flux in the practical system is also the *maxwell*. (See *Line* of *Force, Alternator,* also *Flux, Magnetism.*)

MAGNETIC FLUX DENSITY—The number of lines of force per unit cross-sectional area of a magnetic path. The *gauss* (q.v.) is the unit of magnetic flux density. It is equal to one *line* (q.v.) per square centimeter.

MAGNETIC FORCE—The force with which a magnet attracts or repels any piece of iron or steel. The intensity of a magnetic field at any point as measured by the force which it would exert upon a unit magnetic pole if placed at that point.

MAGNETIC FORCE DUE TO CURRENT—A magnetizing force due to current flow which can be determined mathematically for any point in the surrounding medium. Consider any closed stream line of electric current surrounded by a medium having uni-

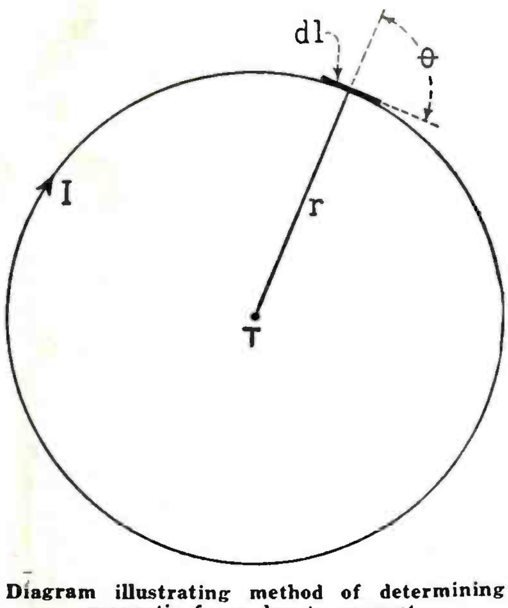


Diagram illustrating method of determining magnetic force due to current.

form magnetic properties. It can be demonstrated that each elementary length of the current stream line, dl, contributes to the magnetizing force H, at any point T an amount dH =

$$\frac{(I \sin \theta)\, dl}{r^2}$$

where I is the current flowing along this stream line, r is the distance from T to dl, and θ (theta) is the angle between r and dl. The direction of dH is perpendicular to the plane of r and dl. The total magnetizing force at T is the vector sum of dH for all the elementary lengths into which the current stream line is divided.

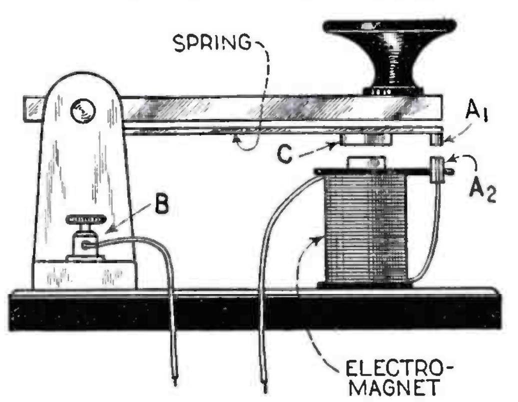
MAGNETIC HYSTERESIS—The opposition which minute particles of a magnetic material offer to being magnetized or to having their magnetization changed. It is sometimes referred to as molecular friction or as *magnetic lag*. (See *Hysteresis.*)

MAGNETIC INDUCTION—See *Induction,* also *Diamagnetic Material.*

MAGNETIC INDUCTIVE CAPACITY—symbol μ (mu)—Also termed Magnetic Inductivity—Names sometimes used instead of *Permeability* (q.v.). The ratio between the number of lines of force per unit area passing through a magnetizable substance and the magnetizing force which produces them. Stated another way, it is the ratio of flux density to magnetizing force. It can be considered as a measure of the ease with which magnetism passes through any substance. The magnetic inductive capacity of air is taken as unity. The term magnetic inductive capacity is analogous to *specific inductive capacity* (q.v.) which is the ratio of the dielectric constant of a material to that of a vacuum.

MAGNETIC INTERRUPTER—A device energized by an electromagnet for interrupting a circuit. (See *Interrupter.*)

MAGNETIC KEY—An electromagnetic adjunct to a wireless transmitting key for reducing or eliminating sparking due to the self-induction of the heavy



A magnetic key.

currents which are interrupted. A form of magnetic key is shown in the illustration. Underneath the lever arm of the key is placed a spring to which an iron armature C and a platinum contact A_1 are attached. If the key and hence the spring are pressed down contact A_1 touches contact A_2 and the path of the current is completed. The current passes not only through the key, but also through the winding of the electromagnet. If the key is released so as to move upward, the contact A_1 still remains touching A_2, as the magnetic action due to the current continues to hold down the armature C and hence the spring with the contact A_1. Not until the alternating current reaches a zero value is the armature released. This releases A_1 from A_2, at an instant of zero current and hence there is no spark.

MAGNETIC LEAKAGE—Magnetic flux which serves no useful purpose. There are no substances which will prevent the passage of magnetic flux. This fact introduces a certain amount of difficulty into practical magnetic circuit calculations, since it is impossible to confine all the flux into a predetermined magnetic path. Since there is no magnetic insulator there will always be a certain amount of *leakage flux*. However this can be reduced to a minimum by proper design of the magnetic circuit. Magnetic Leakage is also referred to as *Stray Flux.*

MAGNETIC LINES OF FORCE—See *Line* of *Force,* also *Electromagnet.*

MAGNETIC MOMENT—The product of the strength of pole of a magnet and its virtual length. The torque exerted by a magnetic field upon a magnet depends upon the magnetic moment.

MAGNETIC NEEDLE—A light, thin steel magnet mounted on a pivot or suspended so as to be free to move. It takes a position pointing to the magnetic north.

MAGNETIC POLES—Points on a magnet where the lines of force leaving or entering the iron are concentrated. In a magnetic needle, that end which tends to point north is called a north or positive pole; that end which tends to point south is called a south or negative pole. A unit magnetic pole is defined as one which, when placed at a distance of one centimeter from a like pole of equal strength, will repel it with the force of one dyne. The north magnetic pole of the earth is situated in latitude 70 North and longitude 97 West. The south pole is located at latitude 70 South and longitude 102 East. It should be noted that the magnetic poles do not coincide with the geographical poles. (See *Induction, Magnetic.*)

MAGNETIC PROPERTIES—Materials are classified according to whether or not they offer a good path for the magnetic lines of force. Substances of comparatively low *reluctance* (q.v.) are termed *magnetic.* They are also often referred to as *ferro-magnetic.* They include iron, steel, nickel, cobalt, manganese, chromium, magnetite, certain alloys of copper, manganese and aluminum (called Heusler Alloys), and certain other oxides. The magnetic laws governing these substances can best be set forth by means of magnetization curves. Substances having high reluctance are termed *non-magnetic.* For commercial purposes, air is the most important non-magnetic substance. However, practically all substances, with the exception of the ferro-magnetic ones, follow the same magnetic laws as air. While the reluctance of a non-magnetic substance is constant, the reluctance of magnetic substances varies, as the amount of *flux* (q.v.) in the substance changes. Although air and all other substances, with the exception of the ferro-magnetic ones are classed as non-magnetic substances, and are poor conductors of magnetic flux, when compared to iron, etc., nevertheless they are by no means magnetic insulators. There are no substances which will absolutely prevent the passage of magnetic flux. (See *Ferro-Magnetic Substances.*)

MAGNETIC PYRITES—See *Pyrites.*

MAGNETIC STORM—Sudden and irregular variations of the earths magnetic field. Magnetic storms are sometimes coincident with the appearance of sun spots. These storms often disrupt telegraph service and also cause much interference with radio communication.

MAGNETISM—A phenomena exhibited by certain materials which is characterized by the attraction or repulsion of soft iron or of conductors carrying electricity. Magnetism is one of the manifestations of electricity, since a current flow is always associated or linked with a *magnetic field* (q.v.). (See *Free Magnetism, Magnet,* also *Magnetic Properties.*)

MAGNETISM, LAWS OF—Like magnetic poles repel one another; unlike magnetic poles attract one another. The force exerted between two magnetic poles is proportional to the product of their strengths and is inversely proportional to the square of the distance between them. (See *Like Poles.*)

MAGNETITE — symbol Fe_3O_4 — A mineral composed mainly of magnetic oxide of iron. When found in magnetized condition it is known as a *loadstone* (q.v.) or a natural magnet. It is a black brittle substance having a specific gravity of 5.2.

MAGNETIZATION—(also spelled *Magnetisation*)—The process of communicating magnetism. The act of rendering iron, steel, etc., magnetic. According to Ewing's theory, a substance which is magnetized has its molecules rearranged so that they assume symmetrical positions, each molecule lying in line with or parallel with its neighbor. In this rearranged position each molecule adds its separate magnetic force to every other one and the cumulative effect of this is that the substance exhibits the property of a magnet. (See *Demagnetization.*)

MAGNETO GENERATOR—A small generator consisting essentially of an armature rotating between permanent magnets, usually of the horse-shoe type. Magnetos are mainly used for motor ignition, medical coils, bell ringing and for firing high explosives. (See *Intermittent Current.*)

MAGNETOMOTIVE FORCE OR DIFFERENCE OF MAGNETIC POTENTIAL—abbreviation m.m.f.—The force causing magnetic flow. *Magnetomotive force* is the magnetic cause, while *flux* (q.v.) is the magnetic effect, just as in electrical terms, *electromotive force* (q.v.) is the cause and current is the effect. The c.g.s. (centimeter gram second) unit of magnetomotive force is the gilbert (q.v.). The unit ordinarily employed in practical calculations of the magnetic circuit is the *ampere-turn* (q.v.). (One ampere-turn is equal to 1.2566 gilberts.) An ampere-turn consists of a current of one ampere flowing through one complete turn of a conductor. The expression "turn" means that the conductor is wound in a solenoid. That is to say, it is wrapped around a core which may consist of air or of any other substance. The same magnetic field will result from ten ampere-turns consisting of ten amperes flowing through one turn, as from ten ampere-turns consisting of one ampere flowing through ten turns. (See *Force, Magnetomotive.*)

MAGNIFIER, OR RELAY—An apparatus for intensifying the variations of a current. The term *magnifier* has been incorrectly used for *amplifier* (q.v.). One type of *magnifier* used in radio is the microphonic relay (see loud speaker) by means of which the minute currents in a crystal set can be magnified so as to actuate a loud speaker. In the ordinary telephone repeater, a microphone is acted upon by the receiver of the first line circuit so as to introduce a local circuit which acts inductiveley on the second line wire. Relays are also used in wire telegraphy to boost weak line currents by means of strong local batteries. (See *Relay.*)

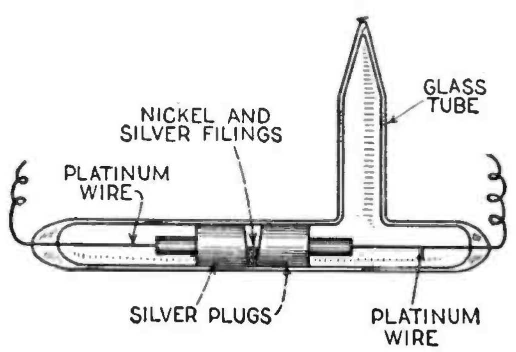
MANTISSA — The decimal part of a *logarithm* as differentiated from the integral part or characteristic. For example in the logarithm 1.23578, 1 is the characteristic and the decimal .23578 is the mantissa. (See *Logarithms.*)

MARBLE—The name given to any limestone sufficiently compact to permit being polished. Pure marble is white, the presence of oxides giving the different colors. Marble is used extensively for switchboard work and when so used must be free from metallic veins. Where circuits carrying 1000 volts or more are used, the switchboard should be saturated with an insulating varnish and baked. Inasmuch as the marble shows oil spots, it is sometimes stained black and given a finish called a *marine finish*.

MARCHANT, EDGAR WALFORD. British radio expert. Born in 1876, he was educated at University School, Hastings, and Central Technical College and London University. In 1897 he was appointed superintendent of the laboratory and workshops of Lord Blythswood at Renfrew, where he carried out many experiments in wireless telegraphy. He became chief assistant at Finsbury Technical College, 1900, under Professor Silvanus P. Thompson, and the following year was appointed lecturer in electro-technic at University College, Liverpool. In 1903 he was appointed the first professor of electrical engineering at the university.

Marchant was for some time closely associated with W. Duddell in developing the oscillograph, and the two read a joint paper on the study of the electric arc by the aid of oscillographs to the Institution of Electrical Engineers, of which institution Marchant became vice-president. He is also a vice-president of the Radio Society of Great Britain. He has written many papers on radio, and contributed an article to the proceedings of the Royal Society on the magnetic behaviour of iron under oscillatory discharge of a condenser.

MARCONI FILINGS COHERER—Also called Marconi Coherer—A detector of electric waves consisting of fine nickel and silver filings contained in a suitable glass tube between two electrodes consisting of two silver plugs. These two plugs are connected to platinum wires brought out through the sealed ends of the tube, which is carefully exhausted of its air. The metallic filings in a loose condition have feeble conductivity for the current from a single dry cell. If a very weak electric oscillation is passed through the coherer, the filings cling together or cohere and hence conduct electricity better and they will then pass sufficient current from a single dry cell to operate a telegraphic relay. To bring



The Marconi filings coherer.

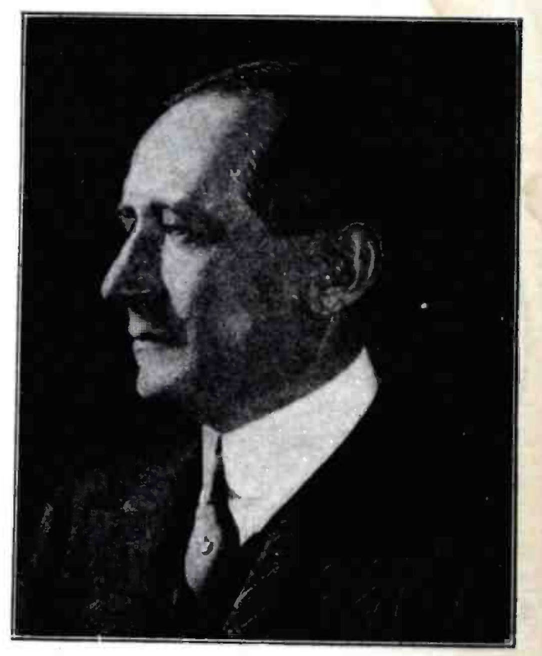
these filings back to a non-conductive condition, the tube is tapped by an electromagnetic tapper, similar to an electric bell with the gong removed. The Marconi coherer is now obsolete. (See *Coherer.*)

MARCONI, GUGLIELMO—Italian-Irish radio pioneer. Guglielmo Marconi was born at Bologna, Italy, April 25, 1874, and was educated at the Leghorn Technical School, under Professor Rosa. From his earliest years he was keenly interested in communication by means of Hertzian waves, and began his brilliantly successful series of experiments in June, 1895. These first experiments were carried out on his father's estate near Bologna. Marconi soon found that the Hertzian form of resonator gave only feeble signals at a distance, and he substituted a vertical wire, with the result that in 1895 he was able to transmit signals to a distance of one and a half miles. About the same time he improved the Branly coherer, which he was using as a detector, and invented an electric tapping device to decohere the filings.

This early apparatus of Marconi, from which has sprung the far-flung wireless chain of to-day, consisted of a coherer, a relay, a decoherer, and a Morse printing instrument, all working from storage batteries. Between the coherer and the relay Marconi interposed choke coils, and this had a very marked effect on the receptivity of his set. By close attention to the details of his system he was able to carry on his signals at greater ranges than had up to this time been accomplished by other experimenters.

The transmitting apparatus used by Marconi in these early efforts consisted of a large spark gap to which the aerial and earth wires were connected. The high-tension current for the spark was provided through an induction coil from batteries. The spark gap consisted of a ball discharger comprising four brass balls. The two middle balls were separated by a small space filled with vaseline oil, the actual spark jumping from the two end balls to the middle ones and through the vaseline, producing a high-frequency spark.

Marconi came to England in 1876, where he took out the first patent ever granted for a practical system of wire-



Guglielmo Marconi.

less telegraphy. He made a number of experiments at Westbourne Park, and demonstrated his system before Sir William Preece and other high officials at the Post Office. In the following year he increased the range of his set to nine miles using a 29 in. spark coil and kites to raise the vertical aerials. In July, 1897, in demonstrating before the Italian Government, he covered 12 miles between warships, and he began to instal a number of his sets for lighthouses, and the success of his experiments led to stations being erected for the corporation of Trinity House.

In 1899, the first proof of the advantages of wireless over other forms of communications came with the saving of the lives on board the ship R. F. Matthews, which ran into the East

Goodwin lightship. The latter was equipped with one of Marconi's transmitting sets and was able to communicate with the South Foreland lighthouse and summon assistance.

The genius of Marconi lies not so much in his inventions, as in his farsightedness in being the first man to realize the immense commercial possibilities of radio, and to make the best use of all the scientific effort of his time to further the object he had in view.

Marconi has received innumerable honors from all countries. He holds the honorary degrees of universities all over the world, and the freedom of a large number of cities. In 1909 with Professor Braun, he was awarded the Nobel Prize for Physics, and in 1914 he was given the Honorary Knighthood of the Grand Cross of the Victorian Order. He has been awarded the Albert Medal of the Royal Society of Arts, the Gold Medal of the Institute of Radio Engineers of New York, the John Fritz Gold Medal for the invention of wireless telegraphy, and the Franklin Gold Medal of the Franklin Institute. He was the Italian delegate to the Peace Conference, and signed on behalf of Italy. He is chairman of the board of directors of the Marconi Company.

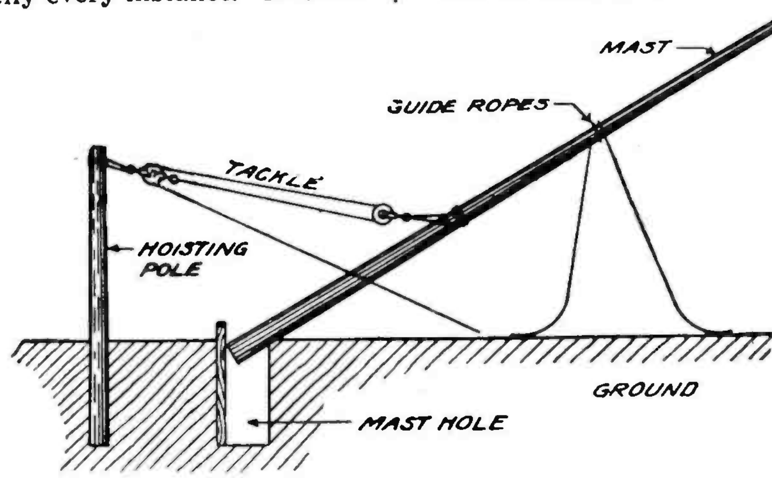
MARINE TYPE CHARGING PANEL—A switchboard equipped with resistance coils, carbon filament pilot lights, voltmeter and necessary switches. Manipulation of the switches allows the battery to be placed on charge or on the line. By throwing a switch on this board, it is also possible to work the wireless transmitter either from the ship's generator or from the storage battery.

MASS—The quantity of matter which a body contains. Physical quantities such as force, velocity, etc., are expressed in terms of length, *mass*, and time. The unit of length is the centimeter; of mass, the gram; and of time, the second. Hence this system of measurement is known as the C.G.S. (centimeter gram second) system. The gram is equal to 15.432 grains and represents the mass or quantity of a cubic centimeter of water at 4 degrees centigrade.

MASTER-OSCILLATOR SYSTEM—A radio telephone transmitting circuit in which a small extra *audion* (q.v.) is used to supply the power to excite the grid circuit. This extra oscillator or exciter is referred to as the master-oscillator. The master-oscillator system has several advantages over the self-excited system. Changes in antenna constants, such as might be caused by a swaying aerial or *lead-in* (q.v.) do not affect the transmission where the former system is used. In addition the master-oscillator system is more convenient to work with and the adjustment for maximum output for different wave lengths and antenna resistances is more easily made.

MASTER-OSCILLATOR SYSTEM AMPLIFIER—In the master-oscillator system, the power tube acts as an amplifier of the power supplied by the small extra exciting, or master-oscillator. The exciter must develop sufficient power to supply the losses in its own oscillating circuit and those of the grid circuit of the power tube.

MASTS, ERECTION OF—High powered stations generally use latticed steel masts. In some cases tubular metal masts in telescoping sections are used. Wooden masts have been used to quite an extent. For portable outfits, these are made in sections which can be fitted together like a fishing rod. Guy ropes or wires are necessary in practically every instance. In erecting a mast, it is usual not to make the installation too rigid, but rather to allow some freedom of movement so that the mast may sway slightly in the wind. Where a one-wire aerial is being erected this may be fastened to any support available. In marine construction, the ship's masts are used to support the aerial, the wires being stretched between the two booms or spreaders from which halyards run to the masts. (See *Aerial*.)



A method of erecting a tall mast using tackle and hoisting pole.

MATCHED IMPEDANCES—Circuits balanced or matched so that the total impedance of one circuit will equal the impedance of another circuit with which it is coupled. (See *Impedances, Matched*.)

MAXWELL—symbol φ—The unit of *magnetic flux* (q.v.). It is also known as the *line* (q.v.). One maxwell is equal to one line of force. (See *Flux Density*, also *Kiloline*.)

MAXWELL'S CORKSCREW RULE—If the direction of travel of a right-handed corkscrew represents the direction of current in a straight conductor, the direction of rotation of the corkscrew will represent the direction of the magnetic lines of force.

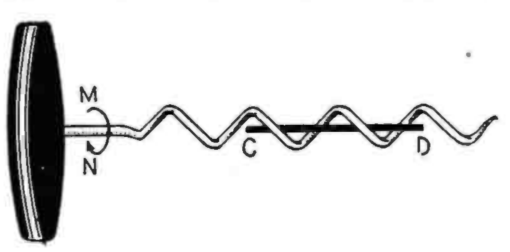


Illustration of Maxwell's corkscrew rule. When current flows from C to D, magnetic lines encircle the wire in the direction of the curved arrow MN.

MAXWELL'S LAWS—The magnetic fields surrounding parallel currents in the same direction will react upon each other in such a way that the conductors will tend to move together. In the case of parallel currents in opposite directions, the fields between the two conductors will be in the same direction and will merge together, thus tending to push the conductors apart. The magnetic fields around two conductors at an angle will react upon each other in such a way as to tend to bring the conductors parallel, and with the currents flowing in the same direction.

MAXWELL'S LAW OF MOTOR ACTION—A conductor carrying a current whose direction of flow is at right angles to a magnetic field, will tend to move out of this field.

MAXWELL'S RULE—Every portion of a circuit is acted upon by a force urging it in such a direction as to make it enclose the greatest possible number of lines of force.

MAXWELL TURNS—The deflection value in a ballistic galvanometer or *fluxmeter* (q.v.). This depends upon the number of turns in the exploring coil and the instantaneous value of the flux in maxwells linked with this coil. (See *Grassot Fluxmeter*.)

McLACHLAN, NORMAN W.—British radio authority. Born at Longtown, Cumberland in 1888, and educated at Carlisle Grammar School and the George Watson and the Heriot Watt Colleges, Edinburgh, and Liverpool University. He was appointed lecturer in Engineering and Mathematics at Newcastle-on-Tyne in 1909. In 1913 McLachlan was appointed supervisor of classes in engineering subjects in the Liverpool Technical Institutes, and after the Great War, during which he was engaged in aeronautical research and the study of anti-submarine devices, he made a special study of magnetos at the National Physical Laboratory, Teddington. Appointed research engineer to the Marconi Company, he is the author of many papers on wireless and electrical subjects in the journal of the Institution of Electrical Engineers and other scientific journals, including those on Characteristic Curves of a Poulsen Arc., the Magnetic Behaviour of Iron at very High Frequencies; and Theory of Iron-cored High Frequency Transformers. He has taken out a number of radio patents.

MEASUREMENT OF INDUCTANCE—Some methods of measuring inductance (also applicable to the measurement of *capacity*) are various bridge methods; by measuring the voltage, current, power, and frequency; and by the wave meter method. Connections in one bridge method for measuring inductance are similar to those in the ordinary *Wheatstone Bridge* (q.v.). A coil having a known inductance is balanced against the inductance to be measured. A device called a *Secohmmeter* is in use to increase the sensibility of bridge measurement of inductance. The Secohmmeter serves the purpose of making an alternating current to use in measurements of self-induction and of commutating such portion of this current as flows in the galvanometer circuit to a direct current. When a source of alternating current of known frequency is available the following method is convenient. Place the inductance across the alternating current mains, measure the power absorbed, the current flowing, the voltage across the unknown inductance and the frequency of the circuit. Then the inductance L is equal to the reactance, x, divided by

2 π times the frequency. Expressed as a formula

$$L = \frac{x}{2\pi f} = \frac{\sqrt{\left(\frac{E}{I}\right)^2 - \left(\frac{\text{Power}}{I}\right)^2}}{2\pi f}$$

The inductance L should be expressed in henries. This method gives results of fair accuracy but is not adapted to measurements of low values of inductance. Small inductances are more usually measured by bridge methods. In the wave meter method, a condenser is discharged through a spark gap in a circuit containing a known capacity and by means of a wave meter measuring the wave length. The expression for the number of oscillations in a closed circuit containing both inductance and capacity is given by the formula

$$n = \frac{1}{2\pi\sqrt{CL}}$$

and the wave length is equal to the velocity of propogation divided by the number of waves and calling λ the wave length we have

$$\lambda = V \text{ times } 2\pi\sqrt{CL}$$

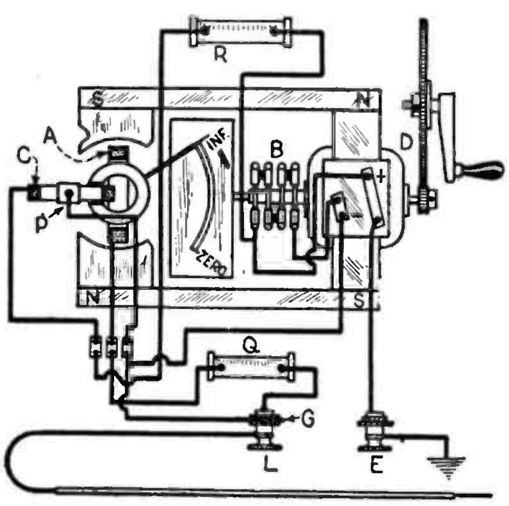
In this last equation everything is known but the inductance which can be calculated. (See *Inductance*, Measurement of.)

MEASUREMENT OF WAVE LENGTH—The usual method of measuring an unknown wave length is by means of a wavemeter. Other apparatus required in this connection is a hot wire ammeter indicator in a coupled circuit, or crystal detector and telephones. Also an antenna excited oscillating circuit supplied by electron tube. A wavemeter placed in inductive coupling with a coil or antenna carrying radio current will show decided increase of current in its own coil and condenser when it is tuned to resonance with the source. The wave length is read directly from the wavemeter setting for resonance or from a calibration curve. A receiving set can be used to measure the wave lengths of received waves if it is first standardized in terms of wave lengths. The operator listens in through the head set attached to the receiving set. As the wavemeter condenser knob is turned the loudest sound is heard when the wavemeter circuit is tuned to the same wave length as that for which the receiving set is adjusted. The wave length is then read from the wavemeter scale or calibration curve. Continuing in this manner, the receiving circuit can be calibrated as a wavemeter by setting it at many different adjustments and reading the wave lengths at resonance each time. The wave length of the waves emitted by an antenna, when no added inductance or capacity is inserted in the antenna circuit, is known as its fundamental wave length. For a single vertical wire grounded antenna the fundamental wave length is slightly greater than four times the length of the wire. The approximate constant often used is 4.2 and this applies also to "L" or "T" type aerials with vertical lead in wire, the total length being measured from the transmitting apparatus up the lead-in wire and over to the end of the flat top. It is of course, more accurate to measure the wave length radiated from an antenna directly by use of a wavemeter. The wavemeter coil needs merely to be brought near the antenna or lead-in wire and the condenser of the wavemeter adjusted to give maximum current in the wavemeter indicator. The wave length corresponding to the wavemeter setting is then the length of the waves radiated by the antenna. The fundamental wave length of the antenna may be determined by gradually decreasing the number of turns in the *loading inductance* (q.v.), measuring the wave length for each setting of the loading coil and plotting a curve showing the wave length corresponding to the various numbers of turns of the loading coil. The fundamental, then, is the wave length corresponding to zero turns and is found at the point where the extension of the curve cuts the wave length axis. (See *Measurement of Inductance*, also *Formula.*)

MECHANICAL MIXTURE— A mixture of two or more elements which leaves them essentially the same. This is sometimes incorrectly called a mechanical compound. Sugar and sand mixed together give an example of a mechanical mixture. A *chemical compound* is formed when two or more substances combine chemically to form another substance having different characteristics. Thus iron filings and sulphur can be combined to form a third substance unlike either of the original two.

MEG OR MEGA—symbol M—The prefix placed before the name of a unit to denote one million times (10^6) that unit, as for example *megohm* (q.v.) *mega-volt, megerg*, etc.

MEGGER—An instrument for measuring insulation resistance or in general any resistance by the direct deflection of a pointer on a scale. The "Evershed" type is made in two forms (1) the *megger* insulation testing set and (2) the bridge-megger testing set which combines the functions of type (1) with those of a *Wheatstone Bridge* (q.v.). Both types consist of an ohmmeter of the moving coil type combined in one box with a hand driven generator for providing the necessary



A diagrammatic illustration of a megger.

testing voltage and current. When the handle of the generator is not being turned, the pointer is entirely free and will rest anywhere on the scale. The general principles underlying the construction and operation of the megger are shown in the illustration. As can be seen, the megger is a combination of a *magneto generator* (q.v.) shown at the right, with an ohmmeter shown at the left, in a magnetic circuit common to both and consisting of two pairs of field poles braced by strong bar magnets, NS, NS, and forming two bi-polar field magnets in series. In the right hand one, and rotated by a folding handle and spur gearing D, is the armature of the generator, with its brush gear B, and terminal bars marked + and —. In the left hand field is the current coil A, pressure coil P, and compensating coil C of the ohmmeter, connected to resistances Q and R, a *guard plate* G, and the only two external terminals L and E (marked Line and Earth on the actual instrument). The bridge-megger testing set is available for use both as an insulation testing set and as a specialized Wheatstone Bridge. It differs from the ordinary megger in outward appearance only by the addition of two pairs of terminals and of two switches, one of which is the *ratio* switch of the Wheatstone Bridge and the other one is a two-way change over-switch. This latter when set to "Megger" prepares the instrument for measuring insulation resistance or high metallic resistance by coupling the two windings of the constant voltage generator in series and making the two front terminals, marked Line and Earth, the only two available for connection. When the change-over switch is set to "Bridge" the instrument is ready for Wheatstone Bridge work, the two windings of the generator now being connected in parallel in order to increase the current obtainable from it. In this case the ohmmeter part is changed into a galvanometer for the bridge and the arms of the bridge are switched into their appropriate places in the circuit and connected to the terminals marked R and X at the end.

MEGOHM—One million ohms. This unit is usually employed in the measurement of insulation resistance. It is also used in measuring *grid leaks* (q.v.), etc. See *Ohm*, also *Begohm.*)

MEGOHMITE, also spelled Megohmit—An insulating material similar to micanite, obtainable in several forms, one of which is known as *hard megohmite* and is made of thin sheets of mica built up of shellac. *Flexible megohmite* consists of sheets of mica stuck together by vegetable adhesives. Flexible megohmite covered with Japanese paper is called mica paper while flexible megohmite covered with linen, is called *mica linen.*

MEISSNER, ALEXANDER.— Austrian radio expert. Born at Vienna, 1883, he was educated at the Technical High School and University of Vienna. He joined the Telefunken Company in Berlin, 1907, and is one of the leading authorities in Germany on radio. To him is due a large number of wireless inventions, including the Telefunken compass, musical quenched sparks, interference preventers, the direct current cathode valve relay for the reception of Morse Code, etc. In 1913 he invented the generation of oscillations by means of the three-electrode valve. He holds many patents, including spark gap for impulse excitation, quenched-spark signalling in conjunction with G. Von Arco, etc., and he is the author of many papers for scientific journals and societies on the subject.

MERCURY ARC RECTIFIER (MERCURY VAPOR CONVERTER)—A device for changing alternating current to direct current, which depends for its action upon the unidirectional conductivity of the mercury arc in an exhausted vessel. An idea of the principle of operation of the mercury arc rectifier may be obtained from the illustration. Assume an instant when the terminal H of the supply transformer is positive, the anode A is then positive and the arc is free to flow between A and B, B being the mercury cathode. Following the direction of the arrows still further, the current passes through the lead J, through the reactance coil E and back to the negative terminal G on the transformer. A little later when the impressed electromotive force falls below a value sufficient to maintain the arc against the counter electromotive force of the arc and the lead, the reactance E which heretofore has been charging, now discharges, the discharge current being in the same direction as formerly. This serves to maintain the arc in the rectifier until the electromotive force of the supply has passed through zero, reverses and builds up to such a value as to cause A' to have a sufficiently positive value to start

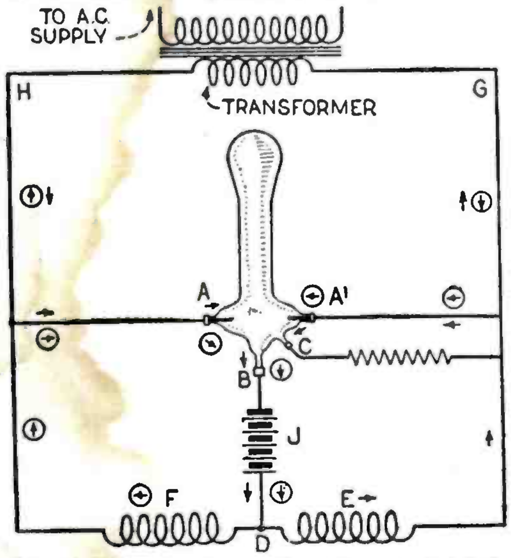
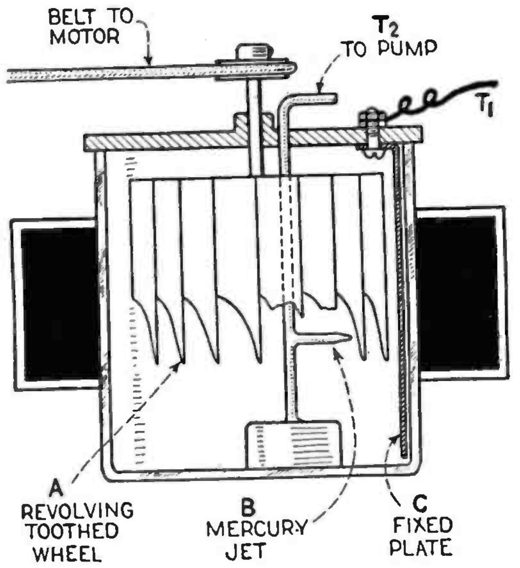


Illustration showing action of mercury arc rectifier.

an arc between it and the mercury cathode B. The discharge circuit of the reactance coil E is now through the arc A'B, instead of through its former circuit. Consequently the arc A'B is now supplied with current, partly from the transformer and partly from the reactance coil E. The new circuit from the transformer is indicated by the arrows enclosed in circles. The amount of reactance inserted in the circuit reduces the pulsations of the direct current sufficiently for all ordinary commercial purposes. The mercury rectifier is used in small sizes for charging storage batteries from alternating current circuits and in the larger sizes for operating direct current arc lamps from alternating circuits and also in electric traction work in the place of rotary converters in the substations or even on the train itself.

MERCURY INTERRUPTER (MERCURY JET INTERRUPTER)—A contact breaker in which contact is made between moving metallic contacts and a jet of mercury provided by a small centrifugal pump driven by the same motor as the contacts. When the primary winding of an induction coil is supplied with a continuous current it is necessary to interrupt the current in order that a secondary voltage shall be induced in the secondary winding. The mercury interrupter offers a satisfactory method of accomplishing this. In one type of mercury interrupter a stream of mercury is forced from a jet against a metal plate. The stream of mercury is interrupted by a toothed wheel of insulating material so that the electrical circuit is periodically made and broken between the mercury and the metal plate. In some forms of mercury interrupters, the jet itself revolves, the mercury impinging against a fixed metal plate. The mercury interrupter is used in operating X-ray bulbs from an induction coil where the source is direct current. A form of mercury interrupter is shown in the illustration. A is a tooth-shaped wheel made of insulating material. This wheel is driven by a small motor and the number of revolutions can be



A type of mercury interrupter.

varied within wide limits. A small centrifugal pump forces the mercury upon the jet B, while the revolving wheel A interrupts the contact of the mercury with the plate C. The wheel A can be raised or lowered, thereby enabling the duration of contact of the mercury with the plate to be varied without altering the number of interruptions in a given time.

MESH GROUPING—A method of connecting coils in a polyphase circuit whereby they form a closed circuit and have the line wires attached to the points of junction between the coils. The term mesh is used interchangeably with delta. (See *Delta Connection.*)

METER—An instrument used to make measurements. (See *ammeter* or *amperemeter, double range meters, integrating wattmeter, voltmeter, wavemeter, wattmeter.*)

METER (*Measure*)—A unit of length in the *metric system* (q.v.). One meter is equal to 100 centimeters or 39.37 inches. It is equal to the length of a standard platinum bar, kept in Paris, and representing approximately a ten-millionth part of a quadrant of the earth's meridian measured from the equator to the pole through Paris. Wireless waves are measured in meters. The length of a wave is the distance, usually measured in meters between two points in the successive waves where the disturbance is at a maximum or at a minimum or between any two points of equal disturbance. There is a fixed relationship between the length of a single wave, the frequency of oscillation and the velocity of the wave. Thus if 3,000,000 waves pass a given point in one second, each wave must be 100 meters long, since the velocity of radio waves is equal to 300,000,000 meters per second.

METER-AMPERES—The product of the antenna current in amperes at the point of maximum current and the antenna effective height in meters, for any radio transmitting station. It constitutes a factor for indicating the radiating strength of radio transmitting stations.

METRIC SYSTEM—A system of measurement in which the meter is the fundamental unit of length and in which all the units both fundamental and derived are divided decimally and higher units are formed in multiples of ten. (See *Centimeter Gram Second.*)

M F D—Abbreviation for *Microfarad* (q.v.)

MICA—An anhydrous silicate of aluminum and potash or sodium. Mica has very high insulating qualities and can withstand high temperatures. Mica obtained in the natural state is separated into laminations which are sorted and graded. These are then cemented together to form plate or flexible mica of any desired thickness or purity. Mica is used in radio work as the dielectric of small fixed condensers. It is also used as the sound producing diaphragm in certain types of head sets and *loud speakers* (q.v.).

MICABOND CLOTH—India sheet mica faced on one side with muslin and on the other side with Japanese insulating paper bonded together with a special binder. It is used for insulating field coils and transformer coils.

MICABOND PAPER—India sheet mica faced on one side with Japanese insulating paper of one grade and on the other side with paper of a different grade.

MICABOND PLATE—Mica sheets bonded together with orange shellac. Various grades of plate are made some of which are used for magnet spools, others for insulating of commutator segments, while still others are used in electric irons.

MICANITE—A form of reconstructed mica. Canadian amber mica and white India mica are used.

MICRO—A prefix placed before the name of a unit to denote one-millionth part of that unit, as for example *microfarad* (q.v.).

MICRO-AMPERE—One-millionth of an ampere. A unit used in measuring extremely small currents. (See *Ampere.*)

MICROFARAD—abbreviation Mfd.—A unit of electrical capacity equal to one-millionth of a farad. Since the farad is too large for most practical measurements, the microfarad is generally used. (See *Farad*, also *Jar.*)

MICROHM—A unit of resistance equal to one-millionth of an *ohm* (q.v.).

MICROMETER—An instrument for making minute measurements. Usually controlled by an accurate screw of fine pitch.

MICROMETER SPARK GAP—A minute adjustable spark gap of about four-hundredths of an inch placed in the aerial circuit of a multiple tuner to allow heavy charges to pass readily to earth by sparking across its points.

Courtesy of Western Electric Co.
An example of the microphone used in modern broadcasting.

MICROPHONE—A sound magnifier. The ordinary form of microphone consists essentially of a diaphragm set in vibration by the sound waves and causing by its motion variation in the resistance of a mass of loosely packed carbon granules. This variation in resistance causes corresponding variations in the current through the instrument so that at every instant the form of the current corresponds to the variations in sound. This type of microphone is often referred to as a *Carbon Microphone.* The telephone transmitter is a form of microphone, and the microphone (nicknamed *Mike*) used in radio broadcasting is merely a larger and more sensitive variation of the same instrument. (See *Electromagnetic Microphone.*)

MICROPHONE, CARBON — See *Microphone*, also *Granular Carbon.*

MICROPHONE TRANSMITTER — See *Microphone.*

MICROPHONIC JOINT — A loose contact between two solid conductors, so mobile that feeble vibrations vary its resistance.

MICROPHONIC RELAY — An instrument for magnifying the variations of a given current by passing it through an electromagnet that acts on the diaphragm or reed of a microphone. The resistance variations are repeated in the current produced by a constant voltage in a circuit in series with the *microphone* (q.v.). In general a microphonic relay can be described as a microphone combined with a telephone so that a message transmitted over the telephone is repeated by the microphone over another line.

MIL — A unit of length equal to one-thousandth part of an inch.

MIL-FOOT—A wire one foot long having a diameter of one mil. Unit resistance may be measured in *ohms* (q.v.) per mil-foot. This refers to a conductor having a cross-sectional area of a *circular mil* (q.v.) and a length of one foot.

MILLI — The prefix placed before the name of a unit to indicate one-thousandth part of that unit, as for example *milli-ampere* (q.v.).

MILLI-AMPERE—One-thousandth of an *ampere* (q.v.). Sometimes abbreviated to *milli-amp.*

MILLI-MICRO—A prefix denoting one thousand millions. (10^{-9}). The term *Billi* is an alternate prefix.

MILLI-VOLT—One-thousandth of a volt.

MILS, CIRCULAR—See *Circular Mils.*

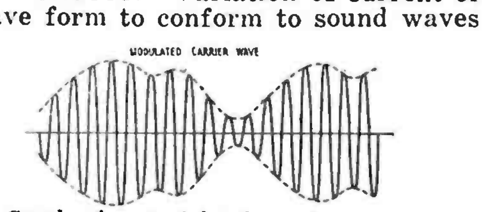
MIRROR GALVANOMETER—A galvanometer for measuring very small currents which utilizes a reflected beam of light for a pointer. In one type of mirror galvanometer a fixed nearly circular magnet is used and a coil of wire is suspended in its field. When the current flows through the coil it tends to turn the coil so as to set its axis in the direction of the magnetic force. This movement can be observed by means of a beam of light reflected from a mirror fixed to the coil. (See *Galvanometer.*)

MINERALLAC—An insulating compound made in several different grades all of which are impervious to water and show no alkali or acid reactions.

M.M.F. — Abbreviation for *Magnetomotive force* (q.v.).

MODULATED CURRENTS — Currents which have their amplitude periodically varied as in the case of the carrier current used in radio telephony which is varied or modulated in accordance with the vibrations of a microphone. If a sound wave actuates a microphone, its inward and outward displacement, varving the resistance in the aerial circuit, results in a high frequency current in the aerial of variable amplitude, called a modulated high frequency current. The illustration shows an extremely simplified diagram of the apparatus in a broadcasting station. The initial impulse that starts a radio signal towards the receiving set is furnished by the voice of the speaker or singer or by some other sound originating in the studio. This sound strikes the microphone, the operating element of which is a thin metal disk or diaphragm. The sound waves cause this diaphragm to vibrate. In doing so, the disk causes changes to take place in the electrical circuit. Pulsations of current are set up, the pulsations corresponding in strength to the variations of the spoken word, music or other sound as the case may be. These fluctuations are quite weak when they first come from the microphone and therefore they must be strengthened. They go through what is known as a voice amplifier which utilizes vacuum tubes to make the current stronger. The next piece of apparatus to consider is the *oscillator* (q.v.). This consists of one or more vacuum tubes, connected in a circuit of such a type that the tubes, when lighted and properly furnished with a high voltage direct current, will generate another current, alternating in character, which is said to be oscillating at radio frequency. Upon this current so generated, the voice current is impressed or super-imposed. This process is called *modulation* (q.v.). The current from the oscillator is known as the *carrier wave* (q.v.) current and when voice currents are impressed upon it, it is known as modulated radio frequency current. This current flows in the aerial and there sets up radio waves.

MODULATION—Variation of current or wave form to conform to sound waves



Graph of a modulated carrier wave.

or to other predetermined forms. Various forms of modulation are dot and dash modulation, chopper modulation, buzzer modulation and *speech modulation* (q.v.). (See *Distortion, Double Modulation,* also *Modulation Frequency Ratio.*)

MODULATION, DOUBLE — See *Double Modulation.*

MODULATION FREQUENCY RATIO —The ratio of modulation frequency to wave frequency. An alternating current is said to be *modulated* when the amplitude of its oscillations is varied periodically. The frequency at which the variations occur, that is to say the *modulation frequency* is necessarily less than the frequency of the alternating current which is being modulated. The nature of the variations may assume practically any form. As examples, there are dot and dash modulation, chopper modulation, buzzer modulation and *speech modulation* (q.v.).

MOLECULE—The smallest group of *atoms* of an element or compound which can exist by themselves. A familiar analogy states that if a drop of water could be magnified to the size of the earth, its component molecules would be the size of base-balls.

MOLYBDENITE—symbol MoS_2—A lead gray sulphide of Molybdenum. It is used as a rectifier detector in contact with copper.

MOLYBDENUM—Symbol Mo—A silver white metal found in nature as *molybdenite* (q.v.), a sulphide of molybdenum. When pure this metal is ductile and can be forged. It is used chiefly as an alloy to produce extremely hard steel. Molybdenite is used as a *crystal* (q.v.) in the detection of radio waves.

MORSE LIGHT—A search light used to signal code messages by means of intermittent flashes. (See *Code.*)

MORSE INKER—An instrument for recording Morse code signals in the form of dots and dashes on a moving paper band. In one form of Morse recorder, the attraction of the armature raises an inked wheel against the paper ribbon and thereby prints upon it the dots and dashes of the message.

MOSCICKI CONDENSER—A condenser in which the dielectric thickens out at the edges. It is essentially a form of *Leyden Jar* (q.v.) composed of a glass tube, especially thickened at the neck where the dielectric stress is greatest, coated inside and out with metal foil. The design of this condenser is such as to minimize *brush discharge* (q.v.) or *corona* (q.v.) effect at its edges.

MOTOR — A device for transforming electrical energy into mechanical energy. Motors may be designed for operation on direct current, on alternating current or on either direct or alternating current. These latter are known as *universal* motors. Direct current motors are classified as shunt, series and compound. This classification is arrived at according to the manner in which the field windings are connected. In the shunt motor the field winding is connected in parallel with the brushes (that is with the armature winding). In the series motor the field winding is connected in series with the armature and the line. Compound motors have a shunt winding in parallel with the brushes and a series winding in series with the armature and the line. Compound motors may be further classified as differentially compounded and cumulatively compounded. A differentially compounded motor is one in which the series field winding is so connected as to oppose the shunt field. A cumulatively compounded motor is one in which the series field aids the shunt field. The speed of the shunt motor is nearly constant, falling slightly as the load increases. The speed of the series motor decreases as the load increases. The differential motor may be constructed so that an absolutely constant speed will be maintained at all loads. The speed of the cumulative motor decreases rapidly as the load is increased. Alternating current motors are of the series type, the induction type, commutator type, synchronous type and repulsion type. There are a number of special classifications of alternating current motors such as single phase induction, polyphase induction, repulsion induction, etc. An ordinary direct current series motor used on alternating current will operate but at a low power factor, with a large eddy current loss and with violent sparking at the commutator. In order to adapt the series motor for universal use, it must be specially designed, the field structure being *laminated* (q.v.) in order to avoid *eddy currents* (q.v.) and the field coils having only a few turns to avoid too great *self-inductance* (q.v.) and consequently low *power factor* (q.v.). Sparking at the brushes can be avoided to a certain extent by designing the motor for a small field flux and with but a few turns in series in each armature coil.