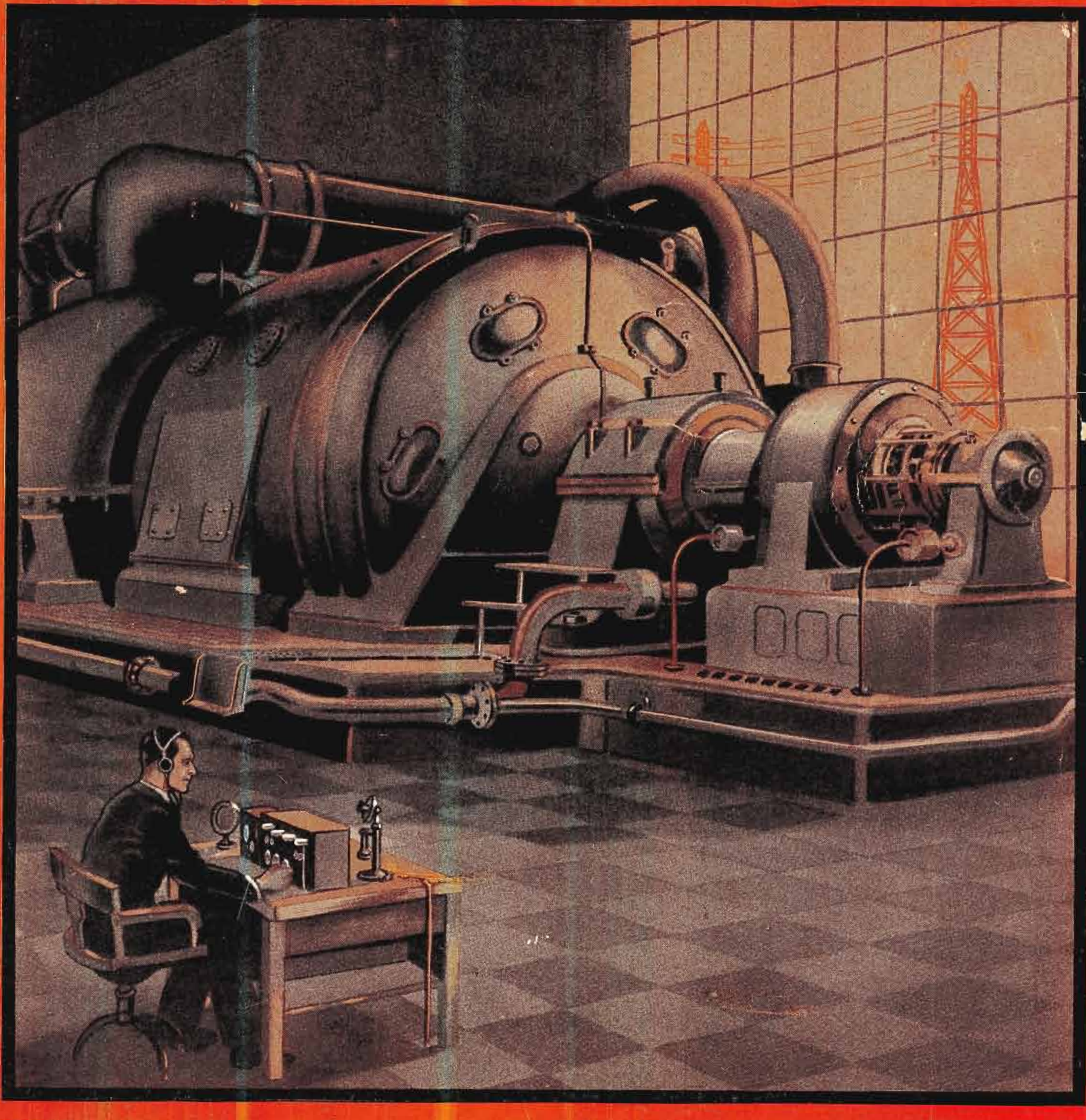
SPRING EDITION

CITIZENS

50¢

Radio Call Book N.S.E. Magazine and Technical Review



SERVICE - REPAIR - ENGINEERING
POWER AMPLIFICATION - TELEVISION

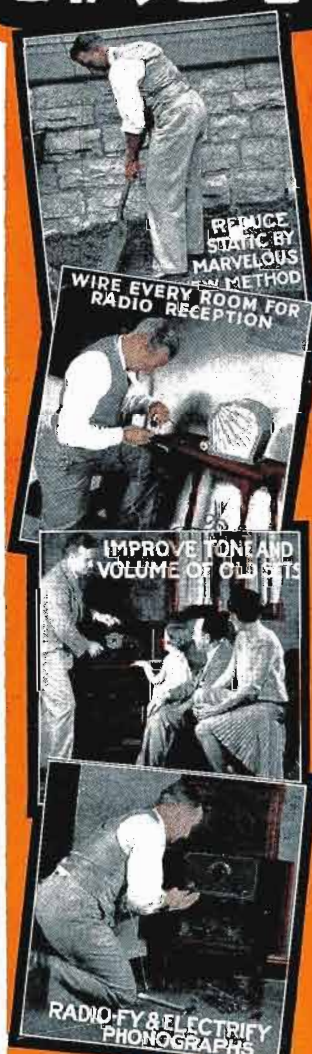
4 of the 40 Easy Ways to Make $3.00 an Hour In Your Spare Time in RADIO

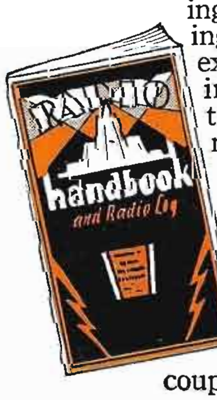
THE four plans shown are but a sample of the many ways in which our members are making $3.00 an hour upwards, spare time and full time, *from the day they join the Association.* If you want to get into Radio, have a business of your own, make $50 to $75 weekly in your spare time, investigate the opportunities offered the inexperienced, ambitious man by the Association.

Our Members Earning Thousands of Dollars Every Week

The Association assists men to cash in on Radio. It makes past experience unnecessary. As a member of the Association you are trained in a quick, easy, practical way to install, service, repair, build and rebuild sets—given sure-fire money-making plans developed by us—helped to secure a position by our Employment Department. You earn while you learn, while you prepare yourself for a big-pay Radio position.

The Association will enable you to buy parts at wholesale, start in business without capital, help you get your share of the $600,000,000 spent annually for Radio. As a result of the Association, men all over the country are opening stores, increasing their pay, passing licensed operator examinations, landing big-pay positions with Radio makers.





Mail Coupon Today for the FREE HANDBOOK

It is not only chock-full of absorbing information about Radio, but it shows you how easily you can increase your income in your spare time. Mailing the coupon can mean $50 to $75 a week more for you.

Radio Training Association of America

4513 Ravenswood Avenue Dept. RCB-1 **Chicago, Illinois**

Below are a few of the reports from those now cashing in on the "40 Easy Ways"

Clears $3,000.00 Frank J. Deutch, Pa.—"Since joining the Association I have cleared nearly $3,000.00. It is almost impossible for a young fellow to fail, no matter how little education he has, if he will follow your easy ways of making money."

$1,100.00 in 6 Weeks J. R. Allen, Calif. — "Have done over $1,100.00 worth of business in the last 6 weeks. Next month I am going to open up a store of my own. I never knew that money could come so fast and easy."

$25.00 a Week Spare Time N. J. Friedrich, N. Y.—"I have averaged $25.00 a week for the last 7 months even though I am not a graduate but just learning."

Training Lands Him Job R. C. Kirk, N. C.—"Your training has been very valuable to me. I landed a job with the big department store out here a few weeks ago because I had my membership card with me. There were a large bunch of applications ahead of me."

ACT NOW
If You Wish NO-COST Membership

For a limited time we will give to the ambitious man a No-Cost Membership which need not—should not—cost you a cent. For the sake of making more money now, and having a better position in the future, mail coupon below *now.* You'll always be glad you did.

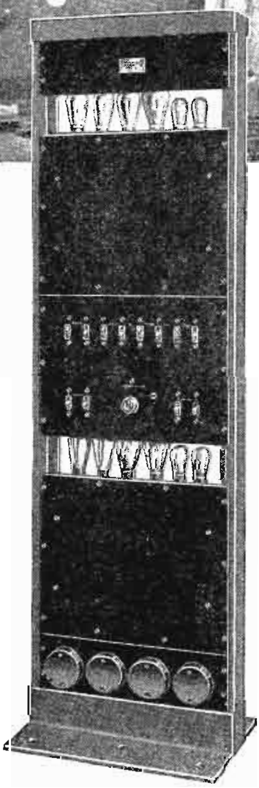
Radio Training Association of America
Dept. RCB-1, 4513 Ravenswood Ave., Chicago, Ill.

Gentlemen: Please send me by return mail full details of your Special No-Cost Membership Plan, and also a copy of your Radio Handbook.

Name ____________________

Address ____________________

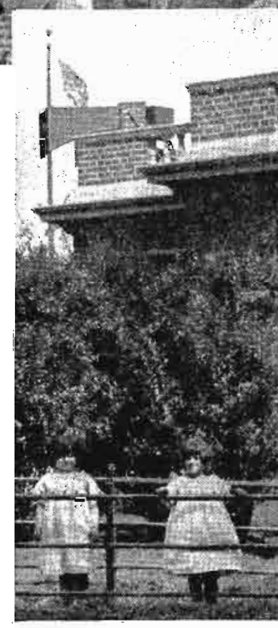
City ____________ *State* ____________



2-V PAM 19

New York Parks
are
PAM Equipped

In Central Park, New York, programmes such as Goldman's Band, speeches originating in the bandstand, etc., are picked up and amplified by a PAM amplifier similar to that illustrated at the left and fed over wires to twenty-five municipal parks in other sections of the city.



One of New York's Parks

In each of these other parks is installed a 2V PAM-19 shown above which supplies reproducers located at proper points, thus permitting simultaneous quality reproduction at widely separated points.

The parks in your city are logical prospects for a similar type of equipment. Have *you* seen *your* park authorities?

A new 16-page bulletin giving mechanical and electrical characteristics, representative installations, and many new PAM amplifiers will be sent upon receipt of 10 cents in stamps to cover postage. When writing ask for bulletin No. CRCB7.

Main Office:
Canton, Mass.

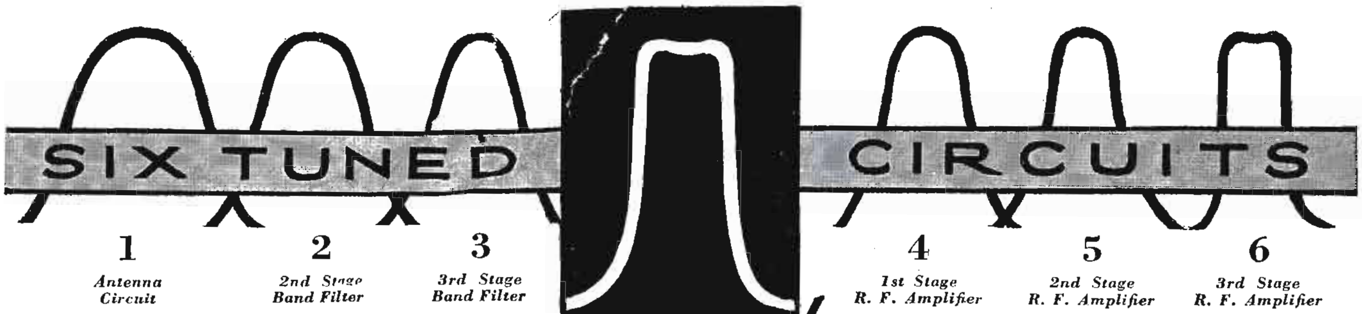
Samson Electric Co.

MEMBER R.M.A.

Manufacturers Since 1882

Factories at Canton and Watertown, Mass.

Citizens Radio Call Book Magazine and Technical Review, January, 1930. Published 4 times yearly, January 1, March 1, September 1, November 1. Volume XI, No. 1. Published at Chicago, Ill. Subscription price, $1.75 yearly. Entered as second-class matter March 17, 1927, at the Post Office at Chicago, Ill., under the Act of March 3, 1879. Citizens Radio Service Bureau, Inc., Publishers, 508 So. Dearborn St., Chicago.



Tuned BAND-FILTER

FLAT-TOP—STRAIGHT-SIDE

10-KILOCYCLE SELECTIVITY

HAMMARLUND once again has put over a screen-grid, band-filter radio with six tuned circuits, so amazingly efficient that professional radio men by the score are building it for their own use.

The "HiQ-29" was a startling revelation, but in the words of Al. Jolson, "You ain't heard nothin' yet" like the "HiQ-30" performance—or the "HiQ-30" tone.

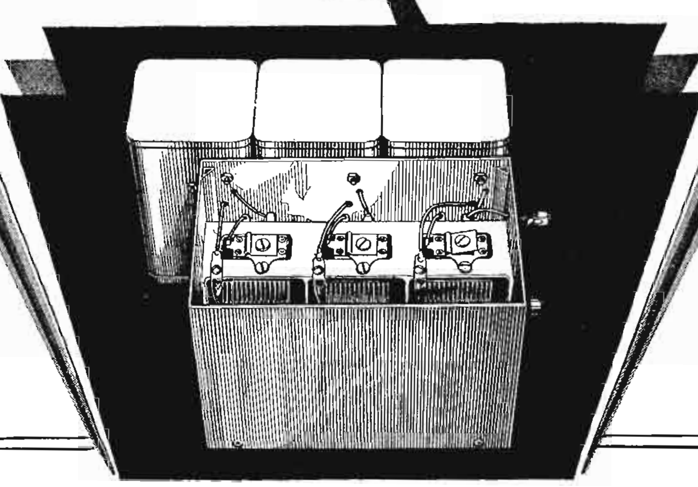
It is the only circuit that makes screen-grid tubes really do a day's work and the marvelous "HiQ-30" power amplifier with push-pull '45's takes all they can give it.

Pre-selected signals — ten-kilocycles apart — with no side-band cutting means *Selectivity* with a capital "S" and T-O-N-E that talks.

The easiest of all "H-Q's" to build, too, with complete, factory-wired and tested units. No adjustments —no troubles. It percolates from the start. A.C. or battery chassis fits standard cabinets, or your choice of nine special "HiQ-30" cabinets including phonograph combinations, $139.50 to $1175 complete, less tubes.

You should have a copy of the 48-page "HiQ-30" Manual. Price 25c. Use the coupon.

WORLD'S PREMIER **HiQ 30** **CUSTOM RADIO**



Complete Factory-Built Units—Wired and Tested, ready to install.

HAMMARLUND-ROBERTS, Inc.
Dept. CB1, 424-438 W. 33rd St., New York.
Enclosed 25c (stamps or coin) for "HiQ-30" Manual.

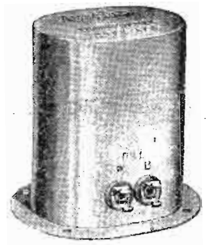
Name..

Address..

....

AMERTRAN

TRADE MARK REG. U.S. PAT. OFF.



Type AF-8 *Audio Transformer—Either 1st or 2nd stage audio. Turn ratio 3½ — List Price $6.00*

**AmerTran ABC Hi-Power Box—500 volts DC plate voltage, current up to 110 ma; AC filament current for all tubes for any set. Adjustable bias voltages for all tubes. Price, east of Rockies — less tubes — $130.00.*

**Complete 2 stage audio amplifier with first stage AmerTran De Luxe for UX 227 AC and second stage AmerTran Push-Pull for two 171 or 210 power tubes. Operates with 450 volt AmerTran Hi-Power Box. Price east of Rockies — less tubes—$80.00.*

AmerTran DeLuxe Audio Transformer—List Price $10.00. Type 151—Between one input and two output tubes—List Price $15.00

AmerTran Power Transformer Type PF-245A—*List Price $22.00*

*Licensed under patents of the Radio Corporation of America and associated companies for radio, amateur, experimental and broadcast reception.

Quality

RADIO PRODUCTS

AmerTran Audio and Power Transformers and Amplifiers are designed for those who truly appreciate fine quality in radio reception.

Weakness in the audio system in many receiving sets results in failure to deliver full richness of tone along the entire scale. AmerTran Radio Products perfect the audio system and reproduce music and the speaking voice in true tone (without distortion at any volume) just as broadcast in the studio.

For detailed information write for the following Bulletins:

Bulletin 1084 — AmerTran DeLuxe Audio Transformer
Bulletin 1087 — AmerTran Audio Transformer Type AF-8
Bulletin 1088 — AmerTran Power Transformer Type PF245A
Bulletin 1076-A — AmerTran Hi-Power Box Type 21-D
Bulletin 1075-A — AmerTran Push-Pull Amplifier Type 2-AP
Bulletin 1065 — The Complete AmerTran Line.

AmerTran Quality Radio Products are sold by all good dealers, or direct if they cannot supply you.

AMERICAN TRANSFORMER COMPANY
Transformer builders for over 29 years
172 Emmet Street, Newark, N. J.

C.B.-1-30

AMERICAN TRANSFORMER COMPANY
172 Emmet Street, Newark, N. J.

Please send me the following Bulletins (Check (✓) those you want).
Bulletin 1084 ( ); 1087 ( ); 1088 ( ); 1076-A ( ); 1075-A ( ); 1065 ( ).

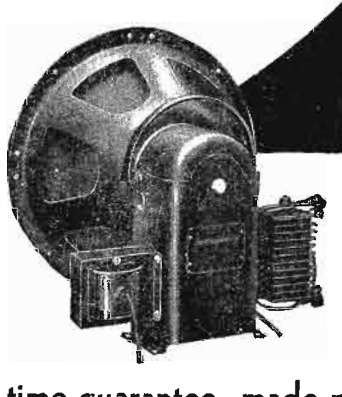
Name..

Street and No...

Town.............................. State..............

IF IT ISN'T A MAGNAVOX IT ISN'T A DYNAMIC

(With a bow to Kodak)



Models 401, 403 and 405
12¼" high, 12" wide,
8¼" deep, 10½" cone

Only Magnavox can build and sell a DYNAMIC Speaker; by authority of the United States Patent Office.

Only Magnavox customers and dealers can employ the selling force inherent in that word DYNAMIC.

Only Magnavox owners can enjoy true-to-life dynamic REALISM, and a life-time guarantee—made possible by the new Magnavox X-Core construction.

THE MAGNAVOX COMPANY

Originators of the dynamic loud speaker in 1911

Factory and Pacific Sales . . . . OAKLAND, CALIFORNIA
Factory and Sales East of the Rockies . . . . CHICAGO, ILLINOIS

2932

The NEW
Nelson AC Receiver
A Masterpiece in Radio

NELSON AC RECEIVER IN PALMER CONSOLE

This very attractive model appeals to those seeking for something different in a fine radio receiver. Slightly modernistic in design, it embodies good taste and graceful lines. Walnut construction throughout, with French doors of diamond matched Oriental walnut set off by carefully selected walnut panels. Equipped with large Jensen DC electro-dynamic speaker.

LIST PRICE $185, *without tubes*

This receiver fully described in this issue.

THE new Nelson AC Receiver fully utilizes every known advance in radio science. It offers the dealer the advantage of all modern essentials of performance, construction, reliability and dependability, which few receivers on the market today can match. Employing the Selectaphase system of complete tuning under the Technidyne circuit, it gives a new meaning to ***Selectivity.*** The Nelson AC Receiver actually "pre-selects" the signal and filters out interference and noise before amplification begins.

Uses nine tubes in all, five of them in the radio frequency circuit! ***Power Detection*** that eliminates the noisy intermediate stage! ***Push-Pull Audio,*** using the new 245 type tubes! Genuine Jensen Electro-Dynamic Speaker—the big 11″ size, to take the tremendous power of the highly efficient Technidyne circuit, and reproduce everything, bass or treble, music or voice, in the true, realistic tone re-created by the instrument itself. Here you have ***Power . . . Range . . . Tone!***

Note These Features:

AC OPERATION

Practical AC operation assures consistent performance. Oversize air-cooled power transformer, with unique voltage control device makes for more efficient operation and longer tube life.

HUMLESS

Use of the new AC heater type tubes insures freedom, from hum and all extraneous noises, which in combination with DC dynamic speaker and large capacity Mershon Filter Condenser means an unusually fine quality of reproduction.

SELECTIVITY

Completely shielded four-in-line tuning condenser and scientifically accurate coils, used in a highly efficient pre-selection circuit, permits a degree of selectivity which easily separates powerful locals and brings in distant stations with the punch of a local.

SUPER-SENSITIVITY

Power detector and improved radio frequency amplifying stages completely eliminates possibility of oscillation, yet maintains 100% sensitivity. Circuit is designed to provide equal amplification over the entire waveband.

APPEARANCE

Consoles are especially designed to incorporate beauty and good taste. Only the finest hardwoods and best craftsmanship enter into their construction. Lustrous hand-rubbed finish and authentic styles fit into any decorative scheme.

PRICE

Range of prices and styles sufficient to meet with the individual taste and ideas of each user. Large scale production allows price to be kept far below that of any other receiver of equal quality and performance.

POWER DETECTION

Tuned power detector circuit operating at high efficiency, is in keeping with latest engineering practice. Due to impossibility of overloading detector circuit, more volume and purer tone are a matter of course.

"245'S IN PUSH-PULL

Two 245 super power amplifying tubes in the output stage have an output far in excess of a 250 power tube, giving an unsurpassed quality of reproduction which represents the utmost in tonal refinement.

TONE

Large oversize transformers, well designed audio and radio frequency circuits, and a large Jensen dynamic speaker, each carefully matched, all contribute to the wonderful tone quality, characteristic of this fine receiver.

TREMENDOUS VOLUME

Perfection in the audio frequency amplifying stages coupled with the large [illegible] output of the detector circuit makes possible an ultimate power output of auditorium volume, and from concert volume to a whisper at will.

NELSON AC-30 RECEIVER IN MORTON CONSOLE

A moderately priced console receiver in a lowboy model of distinctly beautiful and graceful lines. Finest walnut and other hardwoods used throughout. Genuine walnut burl overlay with straight grained Oriental walnut instrument panel. Carefully matched diagonal grain sliding doors. Rich hand rubbed finish that fits in any decorative scheme whatever. Equipped with large Jensen electro-dynamic speaker.

LIST PRICE $170 *without tubes*

DEALERS WANTED

Responsible dealers everywhere will find it to their advantage to know more about the new Nelson AC Radio. Its furniture excellence and true-tone performance makes it a self seller that stays sold. Write today for complete details and dealer's proposition. Desirable territory is still open.

NELSON ELECTRIC COMPANY
508 South Dearborn Street Chicago, Ill.

"We Ship Faster"

NELSON ELECTRIC COMPANY
508 SOUTH DEARBORN STREET,
CHICAGO, ILLINOIS.

Please send me full information regarding the New Nelson AC Receiver, together with details on Dealer Franchise, etc.

Name ....

Address ....

....

☐ DEALER ☐ SERVICE MAN ☐ CUSTOM SET BUILDER

Citizens Radio Call Book Magazine

AND TECHNICAL REVIEW

Registered in U. S. Patent Office
Established 1921

C. O. STIMPSON, President
D. H. BELL, Secretary-Treasurer
H. ANHEISER, Assistant Treasurer

Executive Offices:
508 So. Dearborn St., Chicago, Ill.

Member Audit Bureau of Circulations

F. A. HILL, Editor
RICHARD K. PEW, Technical Editor
C. B. BENSON, Advertising Manager
M. R. HARRIS, Circulation Manager

JANUARY, 1930 — Published January, March, September, November — Vol. 11, No. 1

Contents This Issue

FEATURE ARTICLES

DIGEST OF SCIENCE

POWER AMPLIFICATION DEPARTMENT

SERVICE AND REPAIR DEPARTMENT

SERVICE AND REPAIR SCHEMATICS

RADIO ENGINEERING DEPARTMENT

MISCELLANEOUS INFORMATION

Citizens Radio Call Book Magazine is published four times a year and is on sale approximately the first of January, March, September and November. Subscription price $1.75 per year in U. S. A. Canada and Foreign $2.00 per year, payable in advance. Single copies 50 cents. Remit by check, draft, or P. O. order. No foreign stamps or coins accepted. Mail subscriptions to 508 So. Dearborn Street, Chicago. We will not be responsible for cash sent for subscriptions unless registered.

Advertising Representatives:
Chicago—A. B. Mills, 508 So. Dearborn St. Wabash 1901.
New York—(Branch Office)—154 W. 42nd St., Room 1125. Wisconsin 5681.
Entered as second class matter November 15, 1928, at the Postoffice at Chicago, Illinois, under the act of March 3, 1879.

Distribution of Broadcast Chains by Cities

	Chain	Kilocycles
Akron, Ohio		
WFJC	National	1450
Asheville, N. C.		
WWNC	Columbia	570
Atlanta, Ga.		
WSB	National	740
Baltimore, Md.		
WBAL	National	1060
WCAO	Columbia	600
Birmingham, Ala.		
WAPI	National	1140
WBRC	Columbia	930
Boston, Mass.		
WEEI	National	590
WBZA	National	990
WNAC	Columbia	1230
Bowmanville, Can.		
CKGW	Columbia	960
Buffalo, N. Y.		
WGR	National	550
WMAK	Columbia	900
WKBW	Columbia	1470
Charlotte, N. C.		
WBT	National	1080
Chattanooga, Tenn.		
WDOD	Columbia	1280
Chicago, Ill.		
WGN	National	720
WLIB	National	720
WENR	National	870
WLS	National	870
KYW	National	1020
KFKX	National	1020
WCFL	National	1280
WIBO	National	560
WMAQ	Columbia	670
WBBM	Columbia	770
WJJD	Columbia	1130
Cincinnati, Ohio		
WLW	National	700
WSAI	National	1330
WKRC	Columbia	550
Cleveland, Ohio		
WTAM	National	1070
WEAR	National	1070
WHK	Columbia	1390
Columbus, Ohio		
WAIU	Columbia	640
WCAH	Columbia	1430
Council Bluffs, Iowa		
KOIL	Columbia	1260
Covington, Ky.		
WCKY	National	1480
Dallas, Texas		
WFAA	National	800
KRLD	Columbia	1040
Davenport, Iowa		
WOC	National	1000
Denver, Colo.		
KOA	National	830
Des Moines, Iowa		
WHO	National	1000
Detroit, Mich.		
WWJ	National	920
WJR	National	750
WGHP	Columbia	1240
Dupont, Colo.		
KLZ	Columbia	560
Ft. Wayne, Ind.		
WOWO	Columbia	1160
Ft. Worth, Texas		
WBAP	National	800
Harrisburg, Pa.		
WHP	National	1430
Hartford, Conn.		
WTIC	National	1060
Hot Springs, Ark.		
KTHS	National	1040
Houston, Texas		
KPRC	National	920
Independence, Mo.		
KMBC	Columbia	950
Indianapolis, Ind.		
WFBM	Columbia	1230
Jackson, Miss.		
WJDX	National	1270
Jacksonville, Fla.		
WJAX	National	900
Kansas City, Mo.		
WDAF	National	610
Kingston, Can.		
CFRB	Columbia	960
Lawrence, Kan.		
WREN	National	1220
Lincoln, Neb.		
KFAB	National	770
Little Rock, Ark.		
KLRA	Columbia	1390
London, Can.		
CJGC	Columbia	910
Los Angeles, Calif.		
KECA	National	1430
KFI	National	640
KHJ	Columbia	900
Louisville, Ky.		
WHAS	National	820
Memphis, Tenn.		
WMC	National	780
Miami Beach, Fla.		
WIOD	National	1300
Milwaukee, Wis.		
WTMJ	National	620
WISN	Columbia	1120
Minneapolis, Minn.		
WCCO	Columbia	810
WRHM	Columbia	1250
Montreal, Can.		
CKAC	Columbia	730
Nashville, Tenn.		
WSM	National	650
WLAC	Columbia	1490
New Orleans, La.		
WSMB	National	1320
WDSU	Columbia	1270
New York, N. Y.		
WEAF	National	660
WJZ	National	760
WABC	Columbia	860
Norfolk, Va.		
WTAR	Columbia	780
Oakland, Calif.		
KGO	National	790
Oil City, Pa.		
WLBW	Columbia	1260
Oklahoma City, Okla.		
WKY	National	900
KFJF	Columbia	1470
Omaha, Neb.		
WOW	National	590
Philadelphia, Pa.		
WFI	National	560
WLIT	National	560
WCAU	Columbia	1170
WFAN	Columbia	610
Pittsburgh, Pa.		
WCAE	National	1220
KDKA	National	980
WJAS	Columbia	1290
Portland, Me.		
WCSH	National	940
Portland, Ore.		
KGW	National	620
KOIN	Columbia	940
Providence, R. I.		
WJAR	National	890
WEAN	Columbia	780
Raleigh, N. C.		
WPTF	National	680
Richmond, Va.		
WRVA	National	1110
Roanoke, Va.		
WDBJ	Columbia	930
Rochester, N. Y.		
WHAM	National	1150
WHEC	Columbia	1440
Salt Lake City, Utah		
KSL	National	1130
KDYL	Columbia	1290
San Antonio, Texas		
WOAI	National	1190
KTSA	Columbia	1490
San Francisco, Calif.		
KPO	National	680
KFRC	Columbia	610
Schenectady, N. Y.		
WGY	National	790
Seattle, Wash.		
KOMO	National	970
Sioux City, Iowa		
KSCJ	Columbia	1330
Spokane, Wash.		
KHQ	National	590
KFPY	Columbia	860
Springfield, Mass.		
WBZ	National	990
St. Louis, Mo.		
KSD	National	550
KWK	National	1350
KMOX	Columbia	1090
St. Paul, Minn.		
KSTP	National	1460
Superior, Wis.		
WEBC	National	1290
Syracuse, N. Y.		
WFBL	National	900
Tacoma, Wash.		
KVI	Columbia	760
Tallmadge, Ohio		
WADC	Columbia	1320
Toledo, Ohio		
WSPD	National	1340
Toronto, Can.		
CKGW	National	690
Topeka, Kan.		
WIBW	Columbia	1300
Tulsa, Okla.		
KVOO	National	1140
Washington, D. C.		
WRC	National	950
WMAL	Columbia	630
Whitehaven, Tenn.		
WREC	Columbia	600
Wichita, Kan.		
KFH	Columbia	1300
Worcester, Mass.		
WTAG	National	580
Youngstown, Ohio		
WKBN	Columbia	570

American Broadcasting Stations

Station assignments shown in the following pages were made by the Federal Radio Commission. This list is revised from issue to issue and is therefore up-to-the-minute. Initials such as E, C, M, and P denote Eastern, Central, Mountain and Pacific time.

KCRC
1370 kc, Enid, Okla., Champlin Refining Co., 100 w, C.

KDB
1500 kc, Santa Barbara, Calif., Santa Barbara Broadcasting Co., 100 w, P.

KDFN
1210 kc, Casper, Wyo. D. L. Hathaway, 100 w, P.

KDKA
980 kc, East Pittsburgh, Pa., Westinghouse E. & M. Co., 50,000 w. E.

KDLR
1210 kc, Devils Lake, N. D., Radio Electric Co., 100 w.

KDYL
1290 kc, Salt Lake City, Utah, Intermountain Broadcasting Corp., 1000 w, M, "On the Air, Goes Everywhere.

KECA
1430 kc, Los Angeles, Calif., Pacific Development Radio Co., 1000 w, P.

KEJK
710 kc, Beverly Hills, Calif., R. S. MacMillan, 500 w, P.

KELW
780 kc, Burbank, Calif., Earl L. White, 500 w, P, "The White Spot of the San Fernando Valley."

KEX
1180 kc, Portland, Ore., Western Broadcasting Co., 5000 w, P, "A Public Service Necessity."

KFBB
1360 kc, Great Falls, Mont., Buttrey Broadcast, Inc., 500 w, M.

KFBK
1310 kc, Sacramento, Calif., James McClatchy Co., 100 w, P.

KFBL
1370 kc, Everett, Wash., Leese Bros., 50 w, P, "The Voice of Puget Sound."

KFDM
560 kc, Beaumont, Tex., Magnolia Petroleum Co., 500 w, C, "Kall for Dependable Magnolene."

KFDY
550 kc, Brookings, S. D., State College, 500 w, C.

KFEL
920 kc, Denver, Colo., Eugene P. O'Fallon, Inc., 250 w, M, "The Argonaut Station."

KFEQ
680 kc, St. Joseph, Mo., Scroggin & Co., 2500 w. C.

KFGQ
1310 kc, Boone, Iowa, Boone Biblical College 100 w. C.

KFH
1300 kc, Wichita, Kan., Radio Station KFH Co., 500 w, C. "Kansas' Finest Hotel, in the Very Heart of God's Country."

KFHA
1200 kc, Gunnison, Colo., Western State College of Colorado, 50 w.

KFI
640 kc, Los Angeles, Calif., Earl C. Anthony, Inc., 5000 w, P, "National Institution."

KFIF
1420 kc, Portland, Ore., Benson Polytechnic School. 100 w, P.

KFIO
1230 kc, Spokane, Wash., Spokane Broadcasting Corp., 100 w day, P.

KFIZ
1420 kc, Fond du Lac, Wis., Reporter Printing Co., 100 w, C.

KFJB
1200 kc, Marshalltown, Iowa, Marshall Electric Co., 100 w, C, "Marshalltown, the Heart of Iowa."

KFJF
1470 kc, Oklahoma City, Okla., National Radio Mfg. Co., 5000 w, C, "Radio Headquarters of Oklahoma."

KFJI
1370 kc, Astoria, Ore., KFJI Broadcasters, Inc., 100 w, P.

KFJM
1370 kc, Grand Forks, N. D., University of North Dakota, 100 w, C.

KFJR
1300 kc, Portland, Ore., Ashley C. Dixon & Son. 500 w, P.

KFJY
1310 kc, Ft. Dodge, Iowa, C. S. Tunwal, 100 w, C.

KFJZ
1370 kc, Ft. Worth, Texas, Henry Clay Meacham, 100 w, C.

KFKA
880 kc, Greeley, Colo., Colorado State Teachers College, 500 w, M. Shared.

KFKB
1050 kc, Milford, Kan., KFKB Brdcstg. Assn., 5000 w, C, "The Sunshine Station in the Heart of the Nation."

KFKU
1220 kc, Lawrence, Kan., University of Kansas, 1000 w, C, "Up at Lawrence on the Kaw."

KFKX
See under KYW.

KFLV
1410 kc, Rockford, Ill., A. T. Frykman, 500 w, C.

KFLX
1370 kc, Galveston, Texas, Geo. Roy Clough, 100 w, C.

KFMX
1250 kc, Northfield, Minn., Carleton College, 1000 w, C.

KFNF
890 kc, Shenandoah, Iowa, Henry Field Seed Co., 500 w, C, "Known for Neighbor Folks."

KFOR
1210 kc, Lincoln, Neb., Howard A. Shuman, 100 w, C.

KFOX
1250 kc, Long Beach, Calif., Nichols & Warriner, Inc., 1000 w, P, "Where Your Ship Comes In."

KFPL
1310 kc, Dublin, Texas, C. C. Baxter, 15 w, C, "Baxter's Place."

KFPM
1310 kc, Greenville, Texas, The New Furniture Co., 15 w, C, "Biggest Little Ten Watts on the Air."

KFPW
1340 kc, Siloam Springs, Ark., Rev. Lannie W. Stewart, 50 w, C.

KFPY
860 kc, Spokane, Wash., Symons Investment Co., 500 w, P.

KFQA
See under KMOX.

KFQD
1230 kc, Anchorage, Alaska, Anchorage Radio Club, 100 w.

KFQU
1420 kc, Holy City, Calif., W. E. Riker, 100 w, P.

KFQW
1420 kc, Seattle, Wash., KFQW, Inc., 100 w, P. "Gateway to Alaska and the Orient."

KFQZ
860 kc, Los Angeles, Calif., Taft Radio & Broadcasting Co., Inc., 250 w, P.

KFRC
610 kc, San Francisco, Calif., Don Lee, Inc., 1000 w, P.

KFRU
630 kc, Columbia, Mo., Stephens College, 500 w, C, "Where Friendliness Is Broadcast Daily."

KFSD
600 kc, San Diego, Calif., Airfan Radio Corp., 500 w, P.

KFSG
1120 kc, Los Angeles, Calif., Echo Park Evan. Assn., 500 w, P, "The Church of the Air."

KFUL
1290 kc, Galveston, Texas, W. H. Ford, 500 w, C, "The City of Perpetual Sunshine."

KFUM
1270 kc, Colorado Springs, Colo., W. D. Corley, 1000 w, M, "Known for Unsurpassed Mountain Scenery."

KFUO
550 kc, St. Louis, Mo., Concordia Theological Seminary, 500 w, C, "The Gospel Voice."

KFUP
1310 kc, Denver, Colo., Fitzsimmons General Hospital, 100 w, M.

KFVD
1000 kc, Culver City, Calif., Los Angeles Broadcasting Co., 250 w. P.

KFVS
1210 kc, Cape Girardeau, Mo., Hirsch Battery & Radio Co., 100 w, C, "The City of Opportunity."

KFWB
950 kc, Hollywood, Calif., Warner Bros. Broadcasting Corp., 1000 w, P.

KFWF
1200 kc, St. Louis, Mo., St. Louis Truth Center, Inc., 100 w.

KFWI
930 kc, San Francisco, Calif., Radio Entertainments, Inc., 500 w, P.

KFWM
930 kc, Richmond, Calif., Oakland Educational Society, 500 w, P, "The Most Good to the Most People."

KFXD
1420 kc, Jerome, Idaho, Service Radio Co., 50 w, M.

KFXF
920 kc, Denver, Colo., Pikes Peak Broadcasting Co., 250 w, M, "The Voice of Denver."

KFXJ
1310 kc, Edgewater, Colo., R. G. Howell, 50 w, M, "America's Scenic Center."

KFXM
1210 kc, San Bernardino, Calif., Lee Bros. Broadcasting Co., 100 w, P, "The Voice of the Orange Empire."

KFXR
1310 kc, Oklahoma City, Okla., Exchange Avenue Baptist Church, 100 w, C.

KFXY
1420 kc, Flagstaff, Ariz., Mary M. Costigan, 100 w, M.

KFYO
1420 kc, Abilene, Texas, T. E. Kirksey, 100 w, C, "Breckenridge, the Dynamo of West Texas."

KFYR
550 kc, Bismarck, N. D., Hoskins-Meyer, 500 w, C.

KGA
1470 kc, Spokane, Wash., Northwest Radio Service Co., 5000 w, P.

KGAR
1370 kc, Tucson, Ariz., Tucson Motor Service Co., 100 w, M, "Way Out on the Desert."

KGB
1330 kc, San Diego, Calif., Pickwick Broadcasting Corp., 250 w, P, "Music for the Sick."

KGBU
900 kc, Ketchikan, Alaska, Alaska Radio & Service Co., 500 w.

KGBX
1370 kc, St. Joseph, Mo., Foster-Hall Tire Co., 100 w.

KGBZ
930 kc, York, Nebr., Geo. R. Miller, 500 w, C, "The Swine and Poultry Station."

KGCA
1270 kc, Decorah, Iowa, Chas. W. Greenley, 50 w, C.

KGCI
1370 kc, San Antonio, Texas, Liberto Radio Sales, 100 w, C, "Radio Sam at San Antonio."

KGCR
1210 kc, Watertown, S. D., Cutler's Radio Broadcasting Service, Inc., 100 w.

KGCU
1200 kc, Mandan, N. D., Mandan Radio Association, 100 w, M, "The Voice of the West."

KGCX
1310 kc, Wolf Point, Mont., First State Bank of Vida, 100 w, M.

KGDA
1370 kc, Dell Rapids, S. D., Home Auto Co., 50 w.

KGDE
1200 kc, Fergus Falls, Minn., Jaren Drug Co., 50 w, C.

KGDM
1100 kc, Stockton, Calif., E. F. Peffer, 50 w.

KGDY
1200 kc, Oldham, S. Dak., J. Albert Loesch, 15 w, C.

KGEF
1300 kc, Los Angeles, Calif., Trinity Methodist Church, 1000 w, P.

KGEK
1200 kc, Yuma, Colo., Beehler Elec. Equip. Co., 50 w, M. Shared.

KGER
1360 kc, Long Beach, Calif., C. Merwin Dobyns, 100 w, P, "The Service Club of the Air."

KGEW
1200 kc, Ft. Morgan, Colo., City of Ft. Morgan, 100 w, P.

KGEZ
1310 kc, Kalispell, Mont., Chamber of Commerce, 100 w, M, "Located in the Switzerland of America—The Beautiful Flathead Valley."

KGFF
1420 kc, Alva, Okla., D. R. Wallace, 100 w, C.

KGFG
1370 kc, Oklahoma City, Okla., Faith Tabernacle Assn., 100 w, C, "The Whole Gospel to the Whole World."

KGFI
1500 kc, Corpus Christi, Texas, Eagle Broadcasting Co., 100 w, C, "The Voice of West Texas."

KGFJ
1200 kc, Los Angeles, Calif., Ben S. McGlashan, 100 w, P, "Keeps Good Folks Joyful."

KGFK
1200 kc, Hallock, Minn., Lautzenheiser Mitchell, 50 w, C.

KGFL
1370 kc, Raton, N. Mex., Hubbard & Murphy, 50 w, M.

KGFW
1310 kc, Ravenna, Neb., Otto F. Sothman, R. H. McConnell, 50 w.

KGFX
580 kc, Pierre, S. D., Dana McNeil, 200 w, C.

KGGC
1420 kc, San Francisco, Calif., Golden Gate Broadcasting Co., 50 w, P.

KGGF
1010 kc, Picher, Okla., D. L. Connell, M.D., 500 w.

KGGM
1370 kc, Albuquerque, N. Mex., New Mexico Broadcasting Co., 250 w.

KGHF
1320 kc, Pueblo, Colo., Ritchie & Finch, 250 w, M.

KGHG
1310 kc, McGehee, Ark., Chas. W. McCollum, 50 w.

KGHI
1200 kc, Little Rock, Ark., Berean Bible Class, 100 w.

KGHL
950 kc, Billings, Mont., Northwestern Auto Supply Co., 500 w, M.

KGHX
1500 kc, Richmond, Tex., Houston Brdcstg. Co., 50 w, C.

KGIQ
1320 kc, Twin Falls, Idaho, Radio Broadcasting Corp., 250 w, M.

KGIR
1360 kc, Butte, Mont., KGIR, Inc., 250 w, M.

KGIW
1420 kc, Trinidad, Colo., Trinidad Creamery Co., 100 w, M.

KGIX
1420 kc, Las Vegas, Nev., J. M. Heaton, 100 w.

KGJF
890 kc, Little Rock, Ark., First Church of the Nazarene, 250 w.

KGKB
1500 kc, Brownwood, Tex., Eagle Publ. Co., 100 w, C.

KGKL
1370 kc, San Angelo, Tex., KGKL, Inc., 100 w, C.

KGKO
570 kc, Wichita Falls, Tex., Wichita Falls Broadcasting Co., 250 w, C.

KGKX
1420 kc, Sandpoint, Idaho, C. E. Twiss and F. H. McCann, 15 w, P.

KGO
790 kc, Oakland, Calif., General Electric Co., 7500 w, P.

KGRC
1370 kc, San Antonio, Texas, Eugene J. Roth, 100 w, C.

KGRS
1410 kc, Amarillo, Texas, Gish Radio Service, 1000 w, C. Shared.

KGU
940 kc, Honolulu, Hawaii, Marion Mulrony, Advertising Publ. Co., 500 w, "In the Land of Sunshine, the Future Playground of America."

KGW
620 kc, Portland, Ore., Oregonian Pub. Co., 1000 w, P, "Keep Growing Wiser."

KGY
1200 kc, Lacey, Wash., St. Martins College, 10 w, P, "Out Where the Cedars Meet the Sea."

KHJ
900 kc, Los Angeles, Calif., Don Lee, Inc., 1000 w, P, "Kindness, Happiness, Joy."

KHQ
590 kc, Spokane, Wash., Louis Wasmer, Inc., 1000 w, P, "In the Friendly City."

KICK
1420 kc, Red Oak, Iowa, Red Oak Radio Corp., 100 w.

KID
1320 kc, Idaho Falls, Ida., Jack W. Duckworth, Jr., 250 w, M.

KIDO
1250 kc, Boise, Idaho, Boise Broadcasting Station, 1000 w, P.

KIT
1370 kc, Yakima, Wash., C. E. Haymond, 50 w, P.

KJBS
1070 kc, San Francisco, Calif., Julius Brunton & Sons Co., 100 w, P, "The Voice of the Storage Battery."

KJR
970 kc, Seattle, Wash., Northwestern Broadcasting Co., 5000 w, P.

KLCN
1290 kc, Blytheville, Ark., C. L. Lintzenich, 50 w, C.

KLO
1370 kc, Ogden, Utah, Peery Building Co., 100 w, M.

KLPM
1420 kc, Minot, N. D., E. C. Reincke, 100 w, C.

KLRA
1390 kc, Little Rock, Ark., Arkansas Broadcasting Co., 1000 w.

KLS
1440 kc, Oakland, Calif., Warner Bros., 250 w, P, "The City of Golden Opportunity."

KLX
880 kc, Oakland, Calif., Tribune Pub. Co., 500 w, P, "Where Rail and Water Meet."

KLZ
560 kc, Dupont, Colo., Reynolds Radio Co., Inc., 1000 w, M, "The Pioneer Station of the West."

KMA
930 kc, Shenandoah, Iowa, May Seed & Nursery Co., 500 w, C, "Keeps Millions Advised."

KMBC
950 kc, Kansas City, Mo., Midland Broadcasting Co., 1000 w, C, "Kansas City's Most Powerful Public Service Broadcasting Station."

KMED
1310 kc, Medford, Ore., Mrs. W. J. Virgin, 50 w, P, 'See Crater Lake."

KMIC
1120 kc, Inglewood, Calif., Dalton's, Inc., 500 w, P.

KMJ
1210 kc, Fresno, Calif., J. McClatchy Co., 100 w, P.

KMMJ
740 kc, Clay Center, Neb., The M. M. Johnson Co., 1000 w, C, The Old Trusty Station."

KMO
860 kc, Tacoma, Wash., KMO, Inc., 500 w, P.

KMOX
1090 kc, St. Louis, Mo., Voice of St. Louis, Inc., 5000 w. C.

KMTR
570 kc, Hollywood, Calif., KMTR Radio Corp., 500 w, P, "Your Friend in Hollywood."

KNX
1050 kc, Hollywood, Calif., Western Broadcast Co., 50,000 w, P, "The Voice of Hollywood."

KOA
830 kc, Denver, Colo., General Electric Co., 12,500 w, M.

KOAC
550 kc, Corvallis, Ore., Oregon State Agricultural College, 1000 w, P, 'Science for Service."

KOB
1180 kc, State College, N. M., N. M. College of Agri. & Mech. Arts, 10,000 w, M, "The Sunshine State of America."

KOCW
1400 kc, Chickasha, Okla., Oklahoma College for Women, 250 w, C.

KOH
1370 kc, Reno, Nevada, Jay Peters, Inc., 100 w.

KOIL
1260 kc, Council Bluffs, Iowa, Mona Motor Oil Co., 1000 w, C, "The Hilltop Studio."

KOIN
940 kc, Portland, Ore., KOIN, Inc., 1000 w, P, "The Station of the Hour."

KOL
1270 kc, Seattle, Wash., Seattle Broadcasting Co., 1000 w, P.

KOMO
970 kc, Seattle, Wash., Fisher's Blend Station, Inc., 1000 w, P.

KOOS
1370 kc, Marshfield, Ore., H. H. Hanseth, 50 w, P.

KORE
1420 kc, Eugene, Ore., Eugene Broadcast Station, 100 w, P.

KOY
1390 kc, Phoenix, Ariz., Nielsen Radio Supply Co., 500 w, M, "Kind Friends Come Back."

KPCB
1210 kc, Seattle, Wash., Wescoast Broadcasting Co., 50 w, P. Shared.

KPJM
1500 kc, Prescott, Ariz., Miller & Klahn, 100 w, M.

KPO
680 kc, San Francisco, Calif., Hale Bros. & The Chronicle, 5000 w, P, "The City of the Golden Gate."

KPOF
880 kc, Denver, Colo., Pillar of Fire, Inc., 500 w. M.

KPPC
1210 kc, Pasadena, Calif., Pasadena Presbyterian Church. 50 w, P

KPQ
1210 kc, Seattle, Wash., Wescoast Broadcasting Co., 100 w, P.

KPRC
920 kc, Houston, Texas, Houston Printing Co., 1000 w, C, "Kotton Port Rail Center."

KPSN
1360 kc, Pasadena, Calif., Pasadena Star-News, 1000 w, P.

KPWF
1490 kc, Westminster, Calif., Pacific Western Broadcasting Federation, 5,000 w, P.

KQV
1380 kc, Pittsburgh, Pa., Doubleday-Hill Elec. Co., 500 w, E, "The Smoky City Station."

KQW
1010 kc, San Jose, Calif., First Baptist Church, 500 w, P, "For God and Country."

KRE
1370 kc, Berkeley, Calif., First Congregational Church, 100 w, P.

KREP
620 kc, Phoenix, Ariz.. KAR Broadcasting Co., 500 w, M, "Phoenix, Where Winter Never Comes."

KRGV
1260 kc, Harlingen, Texas, Valley Radio Electric Corp., 500 w.

KRLD
1040 kc, Dallas, Texas, KRLD, Inc., 10,000 w, C, "Down Where the Blue Bonnets Grow."

KRMD
1310 kc, Shreveport, La., Robert M. Dean, 50 w, C.

KRSC
1120 kc, Seattle, Wash., Radio Sales Corp., 50 w P.

KSAC
580 kc, Manhattan, Kan., Kansas State Agricultural College, 500 w, C.

KSAT
1240 kc, Ft. Worth, Texas, Texas Air Transport Broadcasting Co., 1000 w, C.

KSCJ
1330 kc, Sioux City, Iowa, Perkins Bros. Co., 1000 w, C.

KSD
550 kc, St. Louis, Mo., Pulitzer Pub. Co., 500 w, C.

KSEI
900 kc, Pocatello, Idaho, KSEI Broadcasting Assn., 250 w, M, "Kummunity Southeast Idaho."

KSL
1130 kc, Salt Lake City, Utah, Radio Service Corp., 5000 w, M, "The Voice of the Intermountain Empire."

KSMR
1200 kc, Santa Maria, Calif., Santa Maria Valley R. R. Co., 100 w, P, "The Valley of Gardens."

KSO
1380 kc, Clarinda, Iowa, Berry Seed Co., 500 w, C, "Keep Serving Others."

KSOO
1110 kc, Sioux Falls, S. D., Sioux Falls Broadcasting Assn., 1000 w, C.

KSTP
1460 kc, St. Paul, Minn., National Battery Broadcasting Co., 10,000 w, C.

KTAB
560 kc, Oakland, Calif., Associated Broadcasters, 1000 w, P, "Knowledge, Truth and Beauty."

KTAP
1420 kc, San Antonio, Texas, Alamo Broadcasting Co., 100 w, C, "The World's Biggest Little Station."

KTBI
1300 kc, Los Angeles, Calif., Bible Institute of Los Angeles, 750 w, P.

KTBR
1300 kc, Portland, Ore., M. E. Brown, 500 w, P.

KTBS
1450 kc, Shreveport, La., S. R. Elliott and A. C. Steere, 1000 w, E.

KTHS
1040 kc, Hot Springs, Ark., Chamber of Commerce, 10,000 w, C, "Kum to Hot Springs."

KTM
780 kc, Santa Monica, Calif., Pickwick Broadcasting Corp., 500 w, P, "The Station with a Smile."

KTNT
1170 kc, Muscatine, Iowa, Norman Baker, 5000 w C, "The Voice of the Iowa Farmers' Union."

KTSA
1290 kc, San Antonio, Texas, Lone Star Broadcast Co., 1000 w, C.

KTSL
1310 kc, Shreveport, La., Houseman Sheet Metal Works, Inc., 100 w, C.

KTSM
1310 kc, El Paso, Tex., W. S. Biedsoe and W. T. Blackwell, 100 w, C.

KTUE
1420 kc, Houston, Texas, Uhalt Electric, 5 w, C.

KTW
1270 kc, Seattle, Wash., First Presbyterian Church. 1000 w, P.

KUJ
1500 kc, Longview, Wash., Columbia Broadcasting Co., Inc., 10 w, P.

KUOA
1390 kc, Fayetteville, Ark., University of Arkansas, 1000 w, C.

KUSD
890 kc, Vermilion, S. Dak., University of South Dakota, 500 w, C.

KUT
1120 kc, Austin, Texas, Kut Broadcasting Co., 500 w, C, "Come to University of Texas."

KVEP
1500 kc, Portland, Ore., Schaeffer Radio Co., 15 w, P.

KVI
920 kc, Tacoma, Wash., Puget Sound Radio Broadcasting Co., 1000 w, P, "Puget Sound Station."

KVL
1370 kc, Seattle, Wash., Arthur C. Bailey, 100 w.

KVOA
1260 kc, Tuscon, Ariz., R. M. Riculfi, 500 w.

KVOO
1140 kc, Tulsa, Okla., Southwestern Sales Corp., 5000 w, C, "The Voice of Oklahoma."

KVOS
1200 kc, Bellingham, Wash., KVOS, Inc., 100 w, M.

KWCR
1310 kc, Cedar Rapids, Iowa, Harry F. Paar, 100 w.

KWEA
1210 kc, Shreveport, La., William E. Antony, 100 w, C.

KWG
1200 kc, Stockton, Calif., Portable Wireless Tel. Co., 100 w, P.

KWJJ
1060 kc, Portland, Ore., Wilbur Jerman, 500 w, P. "The Voice from Broadway."

KWK
1350 kc, St. Louis. Mo., Greater St. Louis Broadcasting Corp., 1000 w, C.

KWKC
1370 kc, Kansas City, Mo., Wilson Duncan Broadcasting Co., 100 w.

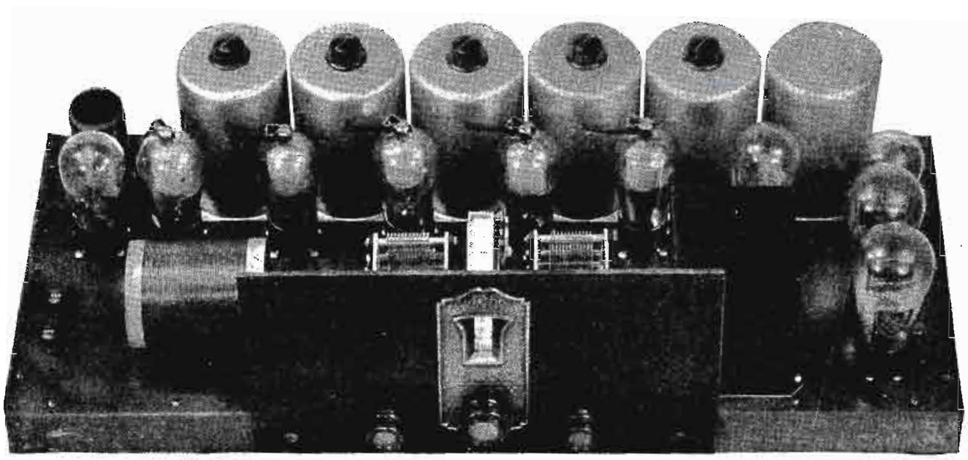
KWKH
850 kc, Kennonwood, La., W. K. Henderson. 10,000 w, C.

ANNOUNCING A GREAT SUPER RECEIVER

The Lincoln DeLuxe 10

Setting New Standards for Radio Performance

Five Tuned I. F. Screen Grid Stages



Seven Tuned Circuits

DAYLIGHT RANGE 700 MILES ~~ NIGHT UNLIMITED

Every Channel in Broadcast Band Registers Perfect 10 KC Separation from Local

ATMOSPHERIC NOISES PRACTICALLY ELIMINATED

Controlling five stages of extremely high gain screen grid stages with perfect stability has produced in the Lincoln DeLuxe 10 a receiver of phenomenal performance. Employing the highest type of solenoid transformers, individually tuned by a large capacity variable condenser, has produced a perfect filter system never before equaled.

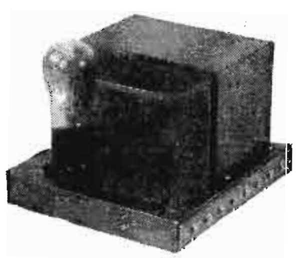
The high amplification resultant from five stages, brings the weakest signal up to local volume well below the noise level. It's simply uncanny to listen to a station 2,000 miles away coming in as powerful and quiet as your local station.

Statement by W. H. Hollister, Pres., Lincoln Radio Corporation

"In the last two years we have made some wonderful strides in the development of the super circuit, but none can compare with results accomplished in the new Lincoln DeLuxe 10. I wish every distance loving fan could be here in Chicago and see this new receiver in action. Demonstrating in our laboratory, in a steel and concrete building, it seemed impossible to miss one 10 KC band—WOR, WAEF and all stations 10 KC from our own local came in without interference. At my home in Oak Park, Illinois, distant stations can be played at noon with good volume. A feat supposed to be impossible on the most powerful receivers made. I hope you will have the pleasure of verifying this almost unbelievable performance."

Setbuilders and Distributors write at once for complete information. You can out-demonstrate any radio receiver known, with ease. Sold to authorized distributors only, direct from our offices.

CHASSIS SPECIFICATIONS:
10 Tubes; Heater Supply in Chassis; Bakelite Sub-base 10¾ x 22⅞ inches.



Lincoln DeLuxe 10-B supplies correct B voltages for Lincoln DeLuxe 10; also 60 mills, 150 volts for field of Dynamic Speaker.

LINCOLN RADIO CORPORATION

329 SOUTH WOOD ST. — CHICAGO - ILLINOIS.

LINCOLN RADIO CORP., Dept. C
329 S. Wood St., Chicago
Send full information on the Lincoln DeLuxe 10.

Name..

Address..

....

Western Representatives
LINCOLN RADIO SALES AGENCY
200 Davis Street
San Francisco, California

KWLC
1270 kc, Decorah, Iowa, Luther College, 100 w, C.

KWSC
1400 kc, Pullman, Wash., State College of Washington, 500 w, P, "The Voice of the Cougars."

KWWG
1260 kc, Brownsville, Texas, Chamber of Commerce, 500 w, C, "Good Night, World."

KXA
570 kc, Seattle, Wash., American Radio Tel. Co., 500 w, P.

KXL
1420 kc, Portland, Ore., KXL Broadcasters, Inc., 100 w, P, "The Voice of Portland."

KXO
1200 kc, El Centro, Calif., Irey & Bowles, 100 w, P.

KXRO
1310 kc, Aberdeen, Wash., KXRO, Inc., 75 w.

KYW
1020 kc, Chicago, Ill., Westinghouse E. & M. Co., 5000 w, C.

KYWA
1020 kc, Chicago, Ill., Westinghouse Elec. & Mfg. Co., 500 w, C.

KZM
1370 kc, Hayward, Calif., Leon P. Tenney, 100 w, P.

NAA
690 kc, 434.5 m, United States Navy Department, Washington, D. C., 1000 w, "Where the Time Signals Originate," E.

WAAF
920 kc, Chicago, Ill., Drovers Journal Pub. Co., 500 w daytime, C.

WAAM
1250 kc, Newark, N. J., WAAM, Inc., 1000 w, E, "Sunshine Station."

WAAT
1070 kc, Jersey City, N. J., Bremer Broadcasting Corp., 300 w, E.

WAAW
660 kc, Omaha, Neb., Omaha Grain Exchange, 500 w daytime, C, "Pioneer Market Station of the West."

WABC
860 kc, New York City, N. Y., Atlantic Broadcasting Corp., 5000 w. E.

WABI
1200 kc, Bangor, Maine, First Universalist Church, 100 w, E, "The Pine Tree Wave."

WABO
See under WHEC.

WABZ
1200 kc, New Orleans, La., Coliseum Place Baptist Church, 100 w, C.

WADC
1320 kc, Tallmadge, Ohio, Allen T. Simmons, 1000 w, E, "Watch Akron Develop Commercially."

WAGM
1310 kc, Royal Oak, Mich., Robert L. Miller, 50 w, E.

WAIU
640 kc, Columbus, Ohio, American Insurance Union, 500 w, E, "The Radio Voice of the American Insurance Union."

WAPI
1140 kc, Birmingham, Ala., Alabama Polytechnic Institute, 5000 w, C.

WASH
1270 kc, Grand Rapids, Mich., WASH Broadcasting Corp., 500 w, C.

WBAA
1400 kc, Lafayette, Ind., Purdue University, 500 w, C.

WBAK
1430 kc, Harrisburg, Pa., Pennsylvania State Police, 500 w, E, "The Voice of Pennsylvania."

WBAL
1060 kc, Baltimore, Md., Consolidated Gas, Elec. Co., 10,000 w, E, "The Station of Good Music."

WBAP
800 kc, Ft. Worth, Tex., Carter Publications, Inc., 50,000 w, C.

WBAW
1490 kc, Nashville, Tenn., Tennessee Publishing Co., 5000 w, C.

WBAX
1210 kc, Wilkes-Barre, Pa., John H. Stenger, Jr., 100 w, E, "In Wyoming Valley, Home of the Anthracite."

WBBC
1400 kc, Brooklyn, N. Y., Brooklyn Broadcasting Corp., 500 w.

WBBL
1370 kc, Richmond, Va., Grace Covenant Presbyterian Church, 100 w, E, "Richmond, the Gateway North and South."

WBBM
770 kc, Chicago, Ill., Atlas Investment Co., 25,000 w, C.

WBBR
1300 kc, Rossville, N. Y., People's Pulpit Association, 1000 w, E, "Watch Tower."

WBBY
1200 kc, Charleston, S. C., Washington Light Infantry, 75 w, E, "The Seaport of the Southeast."

WBBZ
1200 kc, Ponca City, Okla., C. L. Carrell, 100 w, C.

WBCM
1410 kc, Bay City, Mich., James E. Davidson, 500 w, E, "Where the Summer Trail Begins."

WBCN
See under WENR.

WBIS
See under WNAC.

WBMS
1450 kc, Fort Lee, N. J., WBMS Broadcasting Corp., 250 w.

WBNY
1350 kc, New York, N. Y., Baruchrome Corp., 250 w, E, "The Voice of the Heart of New York."

WBOQ
See under WABC.

WBOW
1310 kc, Terre Haute, Ind., Banks of Wabash Broadcasting Assn., 100 w, C, "On the Banks of the Wabash."

WBRC
930 kc, Birmingham, Ala., Birmingham Broadcasting Co., 500 w, C, "The Biggest Little Station in the World."

WBRE
1310 kc, Wilkes-Barre, Pa., Louis G. Baltimore, 100 w, E.

WBRL
1430 kc, Tilton, N. H., Booth Radio Laboratories, 500 w, E.

WBSO
920 kc, Wellesley Hills, Mass., Babson's Statistical Org., Inc., 250 w, E.

WBT
1080 kc, Charlotte, N. C., Station WBT, Inc., 5000 w, E, shared, "The Queen City of the South."

WBZ
990 kc, Springfield, Mass., Westinghouse E. & M. Co., 15,000 w, E, "The Broadcasting Station of New England."

WBZA
990 kc, Boston, Mass., Westinghouse E. & M. Co., 500 w, E.

WCAC
600 kc, Storrs, Conn., Connecticut Agricultural College, 250 w, E, "Voice from the Nutmeg State."

WCAD
1220 kc, Canton, N. Y., St. Lawrence University, 500 w, E, "The Voice of the North Country."

WCAE
1220 kc, Pittsburgh, Pa., Kaufman & Baer Co. 500 w, E, "Where Prosperity Begins."

WCAH
1430 kc, Columbus, Ohio, Commercial Radio Service Co., 500 w, E.

PILOT SCREEN-GRID NEW KIT Amazes Experts!

COVERS 200—600 METERS

KIT No. K-123. Complete kit of parts for Pilot Screen-Grid Receiver, including Walnut-finished metal cabinet, but without Power Pack. *Custom Set-Builders' Price in U. S. A.* **$29.75**

KIT No. K-122. Complete kit of parts for Pilot Screen-Grid Receiver, including drilled front panel. (Does *not* include cabinet or Power Pack.) *Custom Set-Builders' Price in U. S. A.* **$25.50**

KIT No. K-124. Complete kit of parts for Pilot Screen-Grid Receiver, including Walnut-finished cabinet and ABC Power Pack. *Custom Set-Builders' Price in U. S. A.* **$46.25**

FEATURES OF THE PILOT SCREEN-GRID KIT

Embodies Push-pull audio and all latest refinements of high-priced screen-grid receivers.

Two screen-grid amplifiers fully shielded (7 tubes including rectifier).

So sensitive it operates perfectly on a 10-foot indoor aerial—no outside antenna required.

Highly selective—razor-edge tuning.

Very simple to assemble and wire. Removable bottom on cabinet permits easy access.

Operated by practically all 171-A power packs.

SHORT WAVE

FOR A. C. OPERATION

KIT No. K-115. The A. C. Super-Wasp, designed by David Grimes, John Geloso and Robt. S. Kruse, is a 10,000 mile thriller utilizing Screen-grid and specially developed Pilotron 227.

Use your own ABC Power Pack or Pilot K-111 at $16.50, especially designed for the Super-Wasp. Power Pack Extra.

Custom Set-Builders' Price in U. S. A. **$34.50**

FOR BATTERY OPERATION

KIT No. K-110. The original Super-Wasp, used all over the world where A.C. is not available. Also preferred by many S.W. fans. *Custom Set-Builders' Price in U. S. A.* **$29.50**

USE PILOTRON RADIO TUBES, "endorsed by professionals," for these RECEIVERS—and wherever EXCEPTIONAL RESULTS are REQUIRED!

BECAUSE we make Pilotrons ourselves—and are SURE of their quality. BECAUSE Pilot's Screen-Grid and Short-wave Receivers were engineered to make FULL USE of the superior quality built into Pilotrons! When the A. C. Super-Wasp demanded the development of a tube to meet the exacting requirements of A.C. Short-wave work, Pilotron P-227 was the result—an outstandingly superior tube for broadcast receivers!

PILOT RADIO & TUBE CORP.

WORLD'S LARGEST RADIO PARTS PLANT ESTABLISHED 1908

323 BERRY STREET BROOKLYN, N. Y. U. S. A.

RETURN THIS COUPON

RADIO INTERNATIONAL GUILD
103 Broadway, Brooklyn, New York

Enroll me as member of Radio International Guild, sending membership pin, certificate, card, and current issue of "Radio Design," the Guild's official organ (also 3 additional quarterly issues). I enclose 50c, coin or stamps, to pay for everything for one entire year.

Name ....
[Please write or print plainly]

Address ....

City ....State..

WCAJ
590 kc, Lincoln, Neb., Nebraska Wesleyan University, 500 w, C.

WCAL
1250 kc, Northfield, Minn., St. Olaf College, 1000 w, C, "The College on the Hill."

WCAM
1280 kc, Camden, N. J., City of Camden, 500 w, E.

WCAO
600 kc, Baltimore, Md., Monumental Radio, Inc., 250 w, E, "The Gateway of the South."

WCAP
1280 kc, Asbury Park, N. J., Radio Industries Broadcast Co., 500 w, E.

WCAT
1200 kc, Rapid City, S. D., South Dakota State School of Mines, 100 w, M.

WCAU
1170 kc, Philadelphia, Pa., Universal Broadcasting Co., 10,000 w, E, "Where Cheer Awaits U."

WCAX
1200 kc, Burlington, Vt., University of Vermont, 100 w, E.

WCAZ
1070 kc, Carthage, Ill., Carthage College. 50 w.

WCBA
1440 kc, Allentown, Pa., B. B. Musselman, 250 w, E.

WCBD
1080 kc, Zion, Ill., Wilbur Glen Voliva, 5000 w, C.

WCBM
1370 kc. Baltimore, Md., Baltimore Broadcasting Corp., 100 w, E.

WCBS
1210 kc, Springfield, Ill., Dewing & Meester, 100 w, C.

WCCO
810 kc. Minneapolis, Minn., Northwestern Bdcstg., Inc., 7500 w, C, "Service to the Northwest."

WCDA
1350 kc, New York, N. Y., Italian Educational Broadcasting Co., 250 w, E.

WCFL
1280 kc, Chicago, Ill., Chicago Federation of Labor, 1000 w, C, "The Voice of Labor."

WCGU
1400 kc, Coney Island, N. Y., U. S. Broadcasting Corp, 500 w, E.

WCKY
1480 kc, Covington, Ky., L. B. Wilson, 5000 w, E.

WCLO
1200 kc, Kenosha, Wis., C. Whitmore, 100 w, C.

WCLS
1310 kc, Joliet, Ill., WCLS, Inc., 100 w, C.

WCMA
1400 kc. Culver, Ind.. Culver Military Academy. 500 w, C, "The Voice of Culver."

WCOA
1340 kc, Pensacola, Fla., City of Pensacola, 500 w, E, "Wonderful City of Advantages."

WCOC
880 kc, Meridian, Miss., Crystal Oil Co., 500 w, C.

WCOD
1200 kc, Harrisburg, Pa., N. R. Hoffman Co., 100 w, E.

WCOH
1210 kc, Yonkers, N. Y., Westchester Broadcasting Corp., 100 w, E.

WCRW
1210 kc, Chicago, Ill., Clinton R. White, 100 w, C.

WCSH
940 kc. Portland, Me., Congress Square Hotel Co., 500 w, E, "The Voice From Sunrise Land."

WCSO
1450 kc, Springfield, Ohio, Wittenberg College, 500 w, E.

WDAE
1240 kc, Tampa, Fla., Tampa Publishing Co., 1000 w, E, "WDAE, the Voice of the Times at Tampa."

WDAF
610 kc, Kansas City, Mo.. Kansas City Star Co., 1000 w, C, "Enemies of Sleep."

WDAG
1410 kc. Amarillo, Texas, National Radio & Broadcasting Corp., 250 w, C, "Where Dollars Always Grow."

WDAH
1310 kc, El Paso, Texas, Trinity Methodist Church, 100 w, M.

WDAY
940 kc, Fargo, N. D., WDAY, Inc., 1000 w, C.

WDBJ
930 kc. Roanoke, Va.. Richardson-Wayland Elec. Corp., 250 w, E, "The Magic City."

WDBO
1120 kc, Orlando, Fla., Rollins College, Inc., 1000 w, E, "Down Where the Oranges Grow."

WDEL
1120 kc, Wilmington, Del., WDEL, Inc., 250 w, E, "First City of the First State."

WDGY
1180 kc, Minneapolis, Minn., Dr. Geo. W. Young, 1000 w, C.

WDOD
1280 kc. Chattanooga. Tenn., Chattanooga Radio Co., Inc., 1000 w, C.

WDRC
1330 kc. New Haven, Conn., Doolittle Radio Corp., 500 w, E.

WDSU
1250 kc, New Orleans, La., Jos. H. Uhalt, 1000 w, C.

WDWF
1210 kc, Providence, R. I., Dutee W. Flint and The Lincoln Studios, 100 w, E.

WDZ
1070 kc, Tuscola, Ill., James L. Bush, 100 w.

WEAF
660 kc, New York, N. Y., National Broadcasting Co., Inc., 50,000, w, E.

WEAI
1270 kc, Ithaca, N. Y., Cornell Univ., 500 w, E.

WEAN
780 kc, Providence. R. I., The Shepard Stores Co., 250 w, E, "We Entertain a Nation."

WEAO
550 kc, Columbus, Ohio, Ohio State University, 750 w, E.

WEAR
1070 kc, Cleveland, Ohio, WTAM and WEAR, Inc., 1000 w, E.

WEBC
1290 kc, Superior, Wis., Head of The Lakes Broadcasting Co., 1000 w, C.

WEBE
1210 kc, Cambridge, Ohio, Roy W. Waller, 100 w, E.

WEBQ
1210 kc, Harrisburg, Ill., First Trust & Savings Bank, 100 w, C.

WEBR
1310 kc, Buffalo, N. Y., Howell Broadcasting Co., 100 w, E, "We Extend Buffalo's Regards."

WEBW
560 kc, Beloit, Wis., Beloit College, 500 w, C.

WEDC
1210 kc, Chicago, Ill., Emil Denemark, Inc., 100 w.

WEDH
1420 kc, Erie, Pa., Erie Dispatch-Herald, 30 w, E.

WEEI
590 kc. Boston. Mass., Edison Elec. Illum. Co., 1000 w, E, "The Friendly Voice."

WEHC
1370 kc, Emory, Va., Emory and Henry College, 100 w, E.

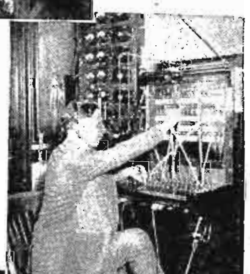
WEHS
1420 kc, Evanston, Ill., Victor C. Carlson, 100 w, C.

LET RCA INSTITUTES START YOU ON THE ROAD TO . . . .

SUCCESS IN RADIO

Radio needs you . . . That's why the entire Radio industry is calling for trained men . . . That's why thousands of men who answered these advertisements are now earning from $2,000 and up a year. Radio is thrilling work . . . easy hours, too, vacations with pay and a chance to see the world. Manufacturers and broadcasting stations are now eagerly seeking trained RCA men . . . Aviation and radio in the movies also provide innumerable opportunities . . . Millions of sets need servicing . . . thousands of ships require experienced operators . . . Never before was there an opportunity like this.

Radio Mechanic and Inspector $1800 to $4000 a Year.



Broadcast Station Mechanic $1800 to $3600 a Year.

Land Station Operator $1800 to $4000 a Year.

Broadcast Operators $1800 to $4800 a Year.

This is the Only Course Sponsored by Radio Corporation of America

RCA sets the standards for the entire Radio industry . . . The RCA Institutes' Home Laboratory Training Course enables you to quickly learn all the secrets of Radio . . . In your spare time, in only an hour or so a day, you can obtain a thorough, practical education in Radio . . . You get the inside information, too, because you study right at the source of all the latest, up-to-the-minute developments. RCA, the world's largest Radio organization sponsors every single detail in this course.

You learn Radio by actual experience with the remarkable outlay of apparatus given to every student. You learn the "How" as well as the "Why" of every Radio problem, such as repairing, installing and servicing fine sets. That's why every graduate of RCA Institutes has the experience, the ability and the confidence to hold a big-money Radio job.

For the added convenience of students who prefer a Resident Study Course, RCA Institutes, Inc., has established Resident Schools in the following cities:

New York	326 Broadway
Boston, Mass.	899 Boylston St.
Philadelphia, Pa. . .	1211 Chestnut St.
Baltimore, Md. . .	1215 North Charles St.
Newark, N. J.	560 Broad St.

Graduates of both the Home Laboratory Training Course and the Resident Schools receive exactly the same training and enjoy the same privileges so far as jobs and salaries are concerned. And every Home Study graduate may also attend any one of our resident schools for post-graduate instruction at no extra charge.

Graduates of RCA Institutes Find It Easier to Get Good Jobs

They are closest to the source of Radio's greatest achievements because the progress of Radio is measured by the accomplishments of the great engineers in the huge research laboratories of the Radio Corporation of America.

Students of RCA Institutes get first-hand knowledge, get it quickly and get it complete. Success in Radio depends upon training and that's the training you get with RCA Institutes. That's why every graduate who desired a position has been able to get one . . . That's why graduates are always in big demand.

Study Radio at the Oldest and Largest Commercial Training Organization in the World

Send for our Free Book . . . or step in at one of our resident schools and see how thousands of men are already on the road to success in Radio. Remember that you, too, can be successful . . . can speed up your earning capacity . . . can earn more money in Radio than you ever earned before. The man who trains today will hold down the big-money Radio job of the future. Come in and get our free book or send for it by mail. Everything you want to know about Radio. 40 fascinating pages, packed with pictures and descriptions of the brilliant opportunities in this gigantic, world-wide money-making profession.

See for yourself why graduates of RCA Institutes now occupy thousands of well-paid positions. These positions are usually available in from 3 to 10 days after graduation for men who can qualify. RCA Institutes will back you up to the limit. Our catalogue is yours free . . . SEND FOR IT TODAY!

Clip this Coupon *NOW!*

SPONSORED BY

RCA INSTITUTES, INC.

Formerly Radio Institute of America

RCA INSTITUTES Inc.
Dept. RCB-1, 326 Broadway, New York, N. Y.

Gentlemen: Please send me your FREE 40-page book which illustrates the brilliant opportunities in Radio and describes your laboratory-method of instruction at home!

Name..

Address..

WELK
1370 kc, Philadelphia, Pa., Howard R. Miller, 100, E.

WEMC
590 kc, Berrien Springs, Mich., Emmanuel Missionary College, 1000 w, C, "The Radio Lighthouse."

WENR
870 kc, Chicago, Ill., Great Lakes Radio Broadcasting Co., 50,000 w, C, "Voice of Service."

WEVD
1300 kc, New York, N. Y., Debs Memorial Radio Fund, 500 w, E.

WEW
760 kc, St. Louis, Mo., St. Louis University, 1000 w, C.

WFAA
800 kc, Dallas, Texas, Dallas News and Journal, 10,000 w, C, "Working for All Alike."

WFAN
610 kc, Philadelphia, Pa., Keystone Broadcasting Co., Inc., 500 w, E.

WFBC
1200 kc, Knoxville, Tenn., First Baptist Church, 50 w, E.

WFBG
1310 kc, Altoona, Pa., William F. Gable Co., 100 w, E, "The Original Gateway to the West and We Wish You All the Very Best."

WFBJ
1370 kc, Collegeville, Minn., St. Johns University, 100 w, C, "In the Heart of the Landscape Paradise."

WFBL
900 kc, Syracuse, N. Y., The Onondaga Co., Inc., 750 w, E, "When Feeling Blue, Listen."

WFBM
1230 kc, Indianapolis, Ind., Indianapolis Power & Light Co., 1000 w, C.

WFBR
1270 kc, Baltimore, Md., Baltimore Radio Show, Inc., 250 w, E, "Home of the Star Spangled Banner."

WFDF
1310 kc, Flint, Mich., Frank D. Fallain, 100 w, E.

WFI
560 kc, Philadelphia, Pa., Strawbridge & Clothier, 500 w, E.
"Key City of Industry."

WFIW
940 kc, Hopkinsville, Ky., The Acme Mills, Inc., 1000 w, C.

WFJC
1450 kc, Akron, Ohio, W. F. Jones Broadcasting, Inc., 500 w, E.

WFKD
1310 kc, Philadelphia, Pa., Foulkrod Radio Eng. Co., 50 w, E.

WFLA
620 kc, Clearwater, Fla., Clearwater Chamber of Commerce and St. Petersburg Chamber of Commerce, 1000 w, E, "Inviting the World to the Springtime City."

WGAL
1310 kc, Lancaster, Pa., Lancaster Elec. Sup. & Const. Co., 15 w, E, "World's Gardens at Lancaster."

WGBB
1210 kc, Freeport, N. Y., Harry H. Carman, 100 w, E, "The Voice of the Sunrise Trail."

WGBC
1430 kc, Memphis, Tenn., First Baptist Church, 500 w, C. Shared.

WGBF
630 kc, Evansville, Ind., Evansville on Air, 500 w, E, "Gateway to the South."

WGBI
880 kc, Scranton, Pa., Scranton Broadcasters, Inc., 250 w, E.

WGBS
1180 kc, New York, N. Y., General Broadcasting System, Inc., 500 w, E.

WGCM
1210 kc, Gulfport, Miss., Great Southern Land Co., Inc., 100 w, C.

WGCP
1250 kc, Newark, N. J., May Radio Broadcast Corp., 250 w.

WGES
1360 kc, Chicago, Ill., Oak Leaves Broadcasting Corp., 500 w, C, "World's Greatest Entertainment Service."

WGH
1310 kc, Newport News, Va., Virginia Broadcasting Co., Inc., 100 w, E.

WGHP
1240 kc, Detroit, Mich., American Broadcasting Corp., Inc., 750 w, E.

WGL
1370 kc, Ft. Wayne, Ind., Allen-Wayne Co., 100 w, C.

WGMS
See under WLB.

WGN
720 kc, Chicago, Ill., Tribune Co., 25,000 w, C.

WGR
550 kc, Buffalo, N. Y., WGR, Inc., 1000 w, E,

WGST
890 kc, Atlanta, Ga., Georgia School of Technology, 250 w, E, "The Southern School with the National Reputation."

WGY
790 kc, Schenectady, N. Y., General Electric Co., 50,000 w, E.

WHA
940 kc, Madison, Wis., University of Wisconsin, 750 w, C.

WHAD
1120 kc, Milwaukee, Wis., Marquette University 250 w, C.

WHAM
1150 kc, Rochester, N. Y., Stromberg-Carlson Tel. Mfg. Co., 5000 w, E.

WHAP
1300 kc, New York, N. Y., Defenders of Truth Society, Inc., 1000 w, E.

WHAS
820 kc, Louisville, Ky., The Courier Journal Co. & Louisville Times Co., 10,000 w, C.

WHAT
1310 kc, Philadelphia, Pa., A. A. Walker, 100 w, E.

WHAZ
1300 kc, Troy, N. Y., Rensselaer Polytechnic Institute, 500 w, E.

WHB
710 kc, Kansas City, Mo., Sweeney Auto School, 500 w, C.

WHBC
1200 kc, Canton, Ohio, St. John's Catholic Church, 10 w, E.

WHBD
1370 kc, Mt. Orab, Ohio, F. P. Moler, 100 w, E, "Ohio's Highest Point."

WHBF
1210 kc, Rock Island, Ill., Beardsley Specialty Co., 100 w, C.

WHBL
1410 kc, Sheboygan, Wis., Press Pub. Co., 500 w, C.

WHBQ
1370 kc, Memphis, Tenn., Broadcasting Station WHBQ, Inc., 100 w, C.

WHBU
1210 kc, Anderson, Ind., Citizens Bank, 100 w, C, "First Hoosier Bank on the Air."

WHBY
1200 kc, Green Bay, Wis., St. Norbert's College, 100 w, C.

WHDF
1370 kc, Calumet, Mich., Upper Michigan Brdcstg. Co., 100 w, C.

WHDL
1420 kc, Tupper Lake, N. Y., G. F. Bissell, 10 w, E.

WHDH
830 kc, Gloucester, Mass., Matheson Radio Co., Inc., 1000 w, E.

WHDI
1180 kc, Minneapolis, Minn., Wm. Hood Dunwoody Ind. Inst., 500 w, C.

WHEC
1440 kc, Rochester, N. Y., Hickson Electric Co., Inc., 500 w, E.

WHFC
1420 kc, Cicero, Ill., Triangle Broadcasters, 100 w, C.

WHIS
1420 kc, Bluefield, W. Va., Daily Telegraph Printing Co., 100 w, E.

WHK
1390 kc, Cleveland, Ohio, Radio Air Service Corp., 1000 w, E, "Cleveland's Pioneer Station."

WHN
1010 kc, New York, N. Y., Marcus Loew Booking Review, 250 w, E, "Voice of the Great White Way."

WHO
1000 kc, Des Moines, Iowa, Bankers Life Co., 5000 w, C, "W-H-O, Who? Banker's Life, Des Moines."

WHP
1430 kc, Harrisburg, Pa., Pennsylvania Broadcasting Co., 500 w, E.

WIAS
1420 kc, Ottumwa, Iowa, Poling Electric Co., 100 w, C.

WIBA
1210 kc, Madison, Wis., Capital Times Co., 100 w, C.

WIBG
930 kc, Elkins Park, Pa., St. Paul's M. E. Church, 50 w, E.

WIBM
1370 kc, Jackson, Mich., C. L. Carrell, 100 w.

WIBO
560 kc, Chicago, Ill., Nelson Bros. Bond & Mortgage Co., 1000 w, C.

WIBR
1420 kc, Steubenville, Ohio, G. W. Robinson, 50 w, E, "Where Investments Bring Results."

WIBS
1450 kc, Elizabeth, N. J., New Jersey Broadcasting Co., 250 w, E.

WIBU
1310 kc, Poynette, Wis., W. C. Forrest, 100 w, C.

WIBW
580 kc, Topeka, Kan., Topeka Broadcasting Assn., Inc., 1000 w, C, "Topeka—Where Investment Brings Wealth."

WIBX
1200 kc, Utica, N. Y., WIBX, Inc., 100 w, E.

WICC
1190 kc, Bridgeport, Conn., Bridgeport Broadcasting Station, Inc., 500 w, E, "The Industrial Capital of Connecticut."

WIL
1200 kc, St. Louis, Mo., Missouri Broadcasting Co., 100 w, C, "A Wave Length Ahead."

WILL
890 kc, Urbana, Ill., University of Illinois, 250 w, C.

WILM
1420 kc, Wilmington, Del., Delaware Broadcasting Co., Inc., 100 w, E.

WIOD
1300 kc, Miami Beach, Fla., Isle of Dreams Broadcasting Co., 1000 w, E, "Wonderful Isle of Dreams."

WIP
610 kc, Philadelphia, Pa., Gimbel Bros., Inc., 500 w, E, "Watch Its Progress."

WISN
1120 kc, Milwaukee, Wis., Evening Wisconsin Co., 250 w, C.

WJAC
1310 kc, Johnstown, Pa., Johnstown Automobile Co., 100 w, E, "The Voice of the Friendly City."

WJAD
1240 kc, Waco, Texas, Frank P. Jackson, 1000 w, C, shared, "Waco, Texas, All Around It."

WJAG
1060 kc, Norfolk, Neb., Norfolk Daily News, 1000 w, C, "Home of the Printer's Devil."

WJAK
1310 kc, Marion, Ind., Marion Brdcst. Co., 50 w.

WJAR
890 kc, Providence, R. I., The Outlet Co., 250 w, E, "The Southern Gateway of New England."

WJAS
1290 kc, Pittsburgh, Pa., Pittsburgh Radio Supply House, 1000 w, E.

WJAX
900 kc, Jacksonville, Fla., City of Jacksonville. 1000 w, E, "WJAX—W for Wonderful, JAX for Jacksonville."

WJAY
620 kc, Cleveland, Ohio, Cleveland Radio Broadcasting Corp., 500 w, E.

WJAZ
1480 kc, Chicago, Ill., Zenith Radio Corp., 5000 w, C.

WJBC
1200 kc, LaSalle, Ill., Hummer Furniture Co., 100 w, C.

WJBI
1210 kc, Red Bank, N. J., Robt. S. Johnson, 100 w, E.

WJBK
1370 kc, Ypsilanti, Mich., J. F. Hopkins, 50 w, C.

WJBL
1200 kc, Decatur, Ill., Wm. Gushard Dry Goods Co., 100 w, C.

WJBO
1370 kc, New Orleans, La., Valdemar Jensen, 100 w, C.

WJBT
See under WBBM.

WJBU
1210 kc, Lewisburg, Pa., Bucknell University, 100 w, E, "In the Heart of the Keystone State."

WJBW
1200 kc, New Orleans, La., C. Carlsen, Jr., 30 w, C, "The Serve You Broadcasting Sttaion at New Orleans.

WJBY
1210 kc, Gadsden, Ala., C. J. Black, 50 w, C.

WJDX
1270 kc, Jackson, Miss., Lamar Life Ins. Co., 500 w, C.

WJJD
1130 kc, Mooseheart, Ill., Loyal Order of Moose, 20,000 w, C, "Every Child Is Entitled to a High School Education and a Trade."

WJKS
1360 kc, Gary, Ind., Johnson-Kennedy Radio Corp., 500 w, C.

WJR
750 kc, Detroit, Mich., The Goodwill Station, Inc. 5000 w, E.

WJSV
1460 kc, Mt. Vernon Hills, Va., Independent Pub. Co., 10,000 w.

WJW
1210 kc, Mansfield, Ohio, Mansfield Broadcasting Association, 100 w, E.

WJZ
760 kc, New York City, N. Y., Radio Corporation of America, 30,000 w, E.

WKAQ
890 kc, San Juan, Porto Rico, Radio Corp. of Porto Rico, 500 w, E, "Porto Rico, The Island of Enchantment in the Caribbean Sea."

WKAR
1040 kc, East Lansing, Mich., Michigan State College, 1000 w, E.

WKAV
1310 kc, Laconia, N. H., Laconia Radio Club, 100 w, E, "The Voice of the Winnepesaukee Lake Region."

WKBB
1310 kc, Joliet, Ill., Sanders Bros., 100 k, C.

WKBC
1310 kc, Birmingham, Ala., R. B. Broyles Furniture Co., 100 w, C.

WKBF
1400 kc, Indianapolis, Ind., Noble Butler Watson, 500 w, C, "We Keep Building Friendships."

WKBH
1380 kc, LaCrosse, Wis., Callaway Music Co., 1000 w, C.

WKBI
1420 kc, Chicago, Ill., Fred L. Schoenwolf, 50 w, C.

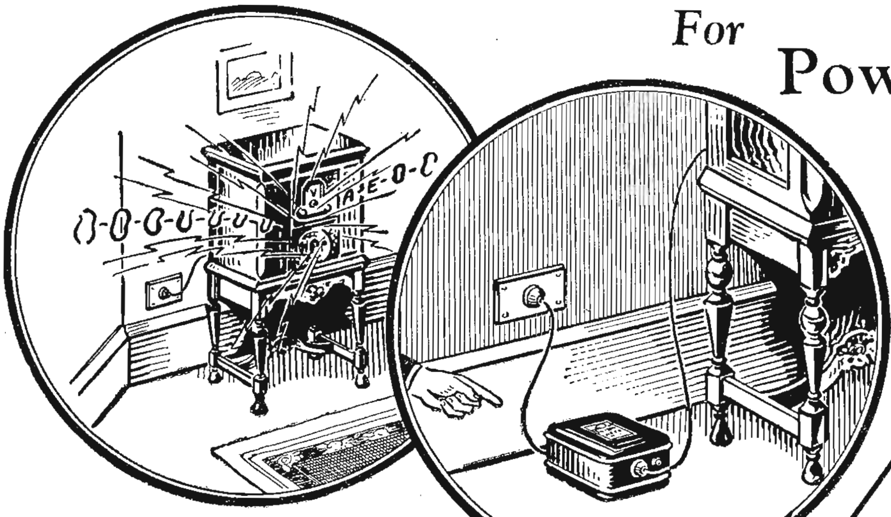
WKBN
570 kc, Youngstown, Ohio, W. P. Williamson, Jr., 500 w, E.

WKBO
1450 kc, Jersey City, N. J., Camith Corp., 250 w, E.

Breaking All Sales Records!

New TOBE Filterette

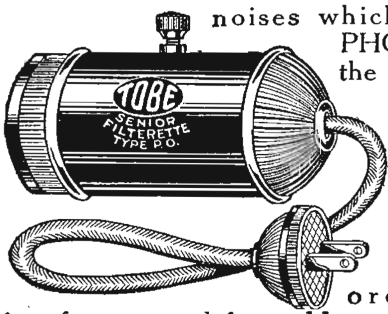
For Power-Line Noises



AT LAST

A SIMPLE INTERFERENCE HANDBOOK

Are the electrical disturbances in your neighborhood being carried by "DIRECT WIRE" right to your set? Tobe Filterettes Senior and 110 P. O. instantly cut down the noises which are being TELEPHONED to your set over the electric light wiring in your home. Put one on your set. Notice the difference! The little senior* will eliminate most ordinary interference, and for stubborn cases there is the 110 P. O.† more than twice as powerful. Or stop the trouble at the source with one of the 64 TOBE Filterette Models. Backed by a name that for years has stood for the ultimate in SERVICE.

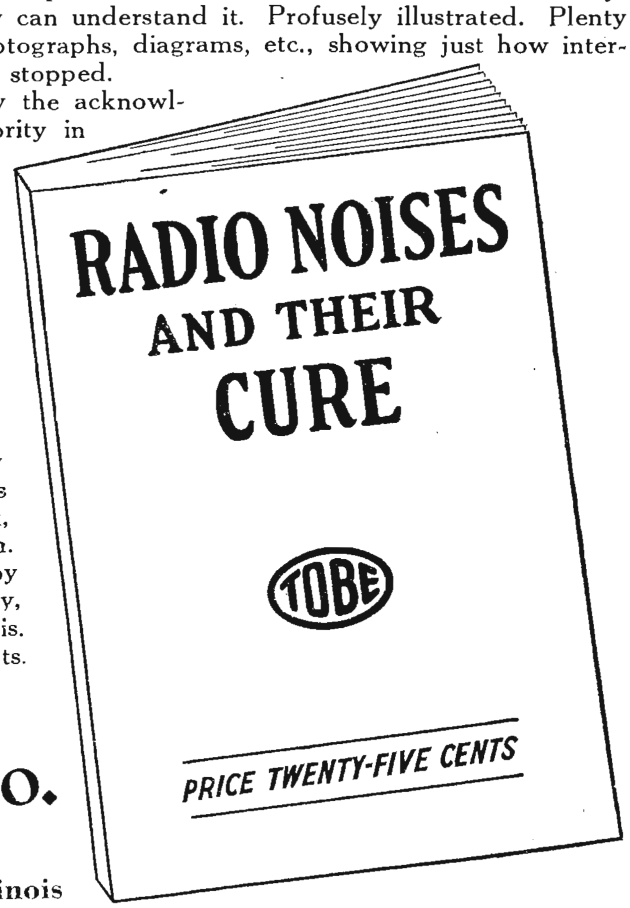


***Tobe Filterette Senior**
Price $7.50
†Tobe Filterette 110 P. O.
Price $12.50

The Newark Electric Company takes pleasure in offering to its friends the latest and most authoritative work on Radio Interference, The Tobe Filterette Manual.

A complete instruction book for all—written so anybody can understand it. Profusely illustrated. Plenty of photographs, diagrams, etc., showing just how interference is stopped.

Put out by the acknowledged authority in this field, the Tobe Deutschmann Corporation. To this company is due largely the credit for the nation-wide publicity given the problem. For years past they have been waging the fight against interference—creating electrical apparatus. Now they offer you the benefit of those years of research in a sixty-four page book, covering every phase of the problem. Copies of this book may be obtained by writing to the Newark Electric Company, 226 West Madison Street, Chicago, Illinois. The price of the book is twenty-five cents. Postpaid.



Newark Electric Co.

"Nothing But Radio"

226 West Madison Street **Chicago, Illinois**

WKBP
1420 kc, Battle Creek, Mich., Enquirer-News Co., 50 w, E.

WKBQ
1350 kc, New York, N. Y., Standard Cahill Co., Inc., 250 w, E.

WKBS
1310 kc, Galesburg, Ill., Permil N. Nelson, 100 w, C.

WKBV
1500 kc, Brookville, Ind., Knox Battery & Electric Co., 100 w, C.

WKBW
1470 kc, Buffalo, N. Y., Churchill Evan. Assn., Inc., 5000 w, E.

WKBZ
1500 kc, Ludington, Mich., K. L. Ashbacker, 50 w.

WKEN
1040 kc, Buffalo, N. Y., WKEN, Inc., 1000 w, E.

WKJC
1200 kc, Lancaster, Pa., Kirk Johnson & Co., 100 w, E.

WKRC
550 kc, Cincinnati, Ohio, J. S. Boyd, 500 w, E, "WKRC, K—Kodel, R—Radio, C—Corporation."

WKY
900 kc, Oklahoma City, Okla., WKY Radiophone Co., 1000 w, C.

WLAC
1490 kc, Nashville, Tenn., Life & Casualty Ins. Co., 5000 w, C, "The Thrift Station."

WLAP
1200 kc, Louisville, Ky., American Broadcasting Corp. of Kentucky, 30 w, C.

WLB
1250 kc, Minneapolis, Minn., University of Minnesota, 500 w, C.

WLBC
1310 kc, Muncie, Ind., Donald A. Burton, 50 w.

WLBF
1420 kc, Kansas City, Kan., Everett L. Dillard, 100 w, C, "Where Listeners Become Friends."

WLBG
1200 kc, Petersburg, Va., Robert Allen Gamble. 100 w, E.

WLBL
900 kc, Stevens Point, Wis., Wisconsin Department of Markets, 2000 w, daytime, C, "Wisconsin, Land of Beautiful Lakes."

WLBW
1260 kc, Oil City, Pa., Radio-Wired Program Corp., 500 w, E.

WLBX
1500 kc, Long Island City, N. Y., John N. Brahy, 100 w.

WLBZ
620 kc, Bangor, Me., Maine Broadcasting Co., 500 w, E.

WLCI
1210 kc, Ithaca, N. Y., Lutheran Assn. of Ithaca, 50 w, E.

WLEX
1360 kc, Lexington, Mass., Lexington Air Station, 500 w, E.

WLEY
1420 kc, Lexington, Mass., Lexington Air Station, 100 w, E.

WLIB
See under WGN.

WLIT
560 kc, Philadelphia, Pa., Lit Brothers, 500 w, E, "The Quaker City Siren."

WLOE
1500 kc, Boston, Mass., Boston Broadcasting Co., 100 w.

WLS
870 kc, Chicago, Ill., Agricultural Broadcasting Co., 5000 w, C.

WLSI
See under WDWF.

WLTH
1400 kc, Brooklyn, N. Y., Voice of Brooklyn, Inc., 500 w, E.

WLW
700 kc, Cincinnati, Ohio, Crosley Radio Corp., 50,000 w, E.

WLWL
1100 kc, New York, N. Y., Missionary Society of St. Paul, 5000 w, E.

WMAC
570 kc, Casenovia, N. Y., Clive B. Meredith, 250 w, E, "Voice of Central New York."

WMAF
1360 kc, So. Dartmouth, Mass., Round Hills Radio Corp., 500 w, E.

WMAK
900 kc, Buffalo, N. Y., WMAK Broadcasting System, Inc., 750 w, E.

WMAL
630 kc, Washington, D. C., M. A. Leese Co., 250 w, E.

WMAN
1210 kc, Columbus, Ohio, W. E. Heskitt, 50 w, E.

WMAQ
670 kc, Chicago, Ill., Chicago Daily News, Inc., 5000 w, C.

WMAY
1200 kc, St. Louis, Mo., Kingshighway Presbyterian Church, 100 w, C.

WMAZ
890 kc, Macon, Ga., Macon Junior Chamber of Commerce, 250 w, E, shared, "Watch Mercer Attain Zenith."

WMBA
1500 kc, Newport, R. I., LeRoy Joseph Beebe, 100 w, E.

WMBC
1420 kc, Detroit, Mich., Michigan Broadcasting Co., Inc., 100 w, E.

WMBD
1440 kc, Peoria Heights, Ill., Peoria Heights Radio Laboratory, 500 w.

WMBF
See under WIOD.

WMBG
1210 kc, Richmond, Va., Havens & Martin, Inc., 100 w, E, "The Daytime Station."

WMBH
1420 kc, Joplin, Mo., Edwin Dudley Aber, 100 w, C, "Where Memories Bring Happiness."

WMBI
1080 kc, Chicago, Ill., Moody Bible Institute Radio Station, 5000 w, C, shared, "The West Point of Christian Service."

WMBO
1370 kc, Auburn, N. Y., Radio Service Laboratories, 100 w, E.

WMBQ
1500 kc, Brooklyn, N. Y., Paul J. Gollhofer, 100 w.

WMBR
1370 kc, Tampa, Fla., F. J. Reynolds, 100 w, E, "WMBR, Everything for Radio at Tampa, Fla."

WMC
780 kc, Memphis, Tenn., Memphis Commercial Appeal, Inc., 500 w, C, "WMC, Memphis, Down in Dixie."

WMCA
570 kc, New York, N. Y., Knickerbocker Broadcasting Co., Inc., 500 w, E, "Where the White Way Begins."

WMES
1500 kc, Boston, Mass., Massachusetts Educational Society, 50 w.

WMMN
890 kc, Fairmont, W. Va., Holt Rome Novelty Co., 250 w, E.

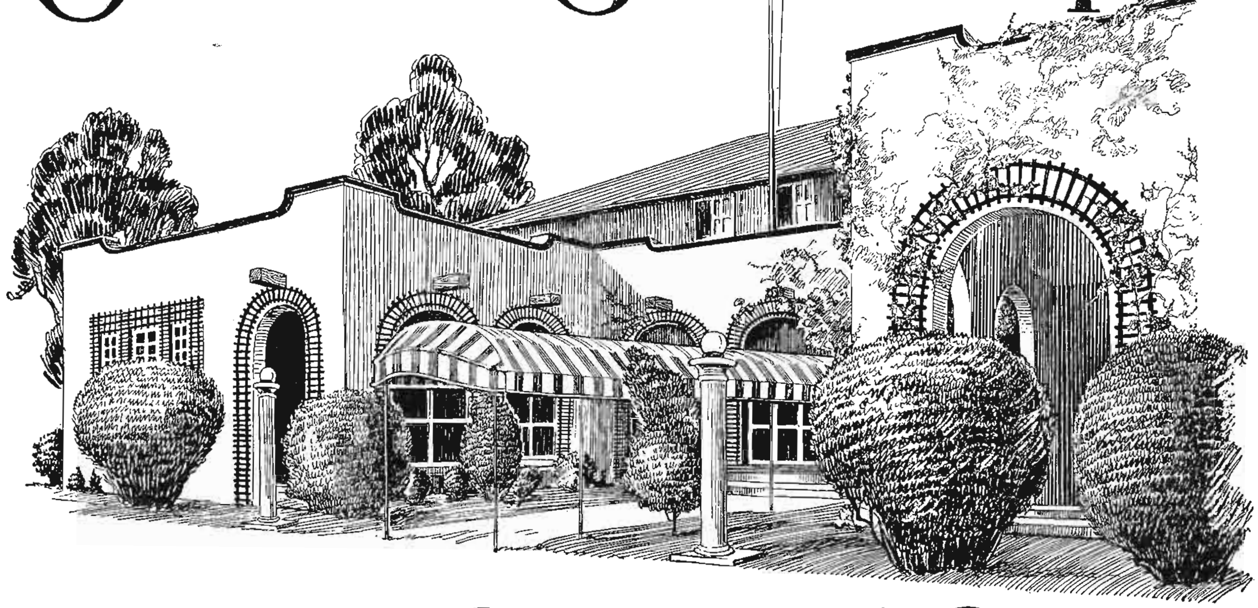
WMPC
1500 kc, Lapeer, Mich., First Methodist Protestant Church, 100 w, E, "Where Many Preach Christ."

WMRJ
1420 kc, Jamaica, N. Y., Peter J. Prinz, 10 w, E, "The Gateway of the Sunrise Trail."

WMSG
1350 kc, New York, N. Y., Madison Square Garden Broadcast Co., 250 w, E.

WMT
600 kc, Waterloo, Iowa, Waterloo Broadcasting Co., 250 w, C.

OSCEOLA GRAMATAN INN



DAYTONA BEACH
FLORIDA

ON the outskirts of Daytona Beach in Northern Florida, lies the Osceola Gramatan Inn with its cottages nestled here and there, among the trees of one of Florida's finest orange groves.

The outstanding characteristics of the Inn are its simplicity and good taste, both in architecture and its furnishings. The property is now owned and operated by the Estate of the late Mr. William V. Lawrence, who made a national reputation in the development of the Lawrence Park Properties in Bronxville, New York, and who made the construction and beautification of the Osceola Gramatan both an occupation and recreation.

The Inn is particularly fortunate in its location, lying directly on the Dixie Highway, and adjoining the Daytona Country Club with its eighteen hole golf course, tennis courts and splendid club house, all of which are reached by a few minutes' walk through a forest of Palmetto and Live Oak.

Daytona Beach lies about sixty miles south of St. Augustine within the great orange belt, which is considered the most perfect climate in Florida, having cool winter nights and brilliant sunshiny days. It is a center, also, for motoring over Florida's fine state highways, which radiate north, south and west from Daytona Beach. Immediately at hand is the old famous Daytona-Ormond Beach, with its twenty miles of perfect surface beside the surf.

Osceola Gramatan Inn provides accommodations for 200 guests, and one of the best chefs in the North is in charge of the cuisine. There are about twenty cottages in the Osceola Grove, each with living room, open fireplace, porch, and complete hotel service. White servants are employed exclusively.

For Golfers the Daytona Country Club offers one of the finest eighteen hole courses in the south, and only a short distance away are the Sea Breeze Golf Course, the Ormond Course, and the College Arms Club at De Land; privileges of all these courses being extended to our guests.

The Halifax Yacht Club is but a short distance, and all the amusements of the city of Daytona Beach are available. There is sea and surf bathing all Winter.

The American Plan prevails with rates that are surprisingly moderate for the type of accommodations. The season is from January 1st to April 1st and the management will welcome your inquiry for a copy of our illustrated folder.

OSCEOLA GRAMATAN INN
DAYTONA BEACH, FLORIDA
Chester A. Wescott, Manager

WNAC
1230 kc, Boston, Mass., The Shepard Norwell Co., 1000 w. E.

WNAD
1010 kc, Norman, Okla., University of Oklahoma 500 w, C, "The Voice of Soonerland."

WNAX
570 kc, Yankton, S. Dak., Gurney Seed & Nursery Co., Dakota Radio Apparatus Co., 1000 w, C.

WNBF
1500 kc, Binghamton, N. Y., Howitt-Wood Radio Co., 50 w, E, "The Voice of the Triple Cities."

WNBH
1310 kc, New Bedford, Mass., New Bedford Broadcasting Co., 100 w, E, shared, "The Gateway to Cape Cod."

WNBJ
1310 kc, Knoxville, Tenn., Lonsdale Baptist Church, 50 w, C.

WNBO
1200 kc, Washington, Pa., J. B. Spriggs, 100 w, E.

WNBR
1430 kc, Memphis, Tenn., John Ulrich, 500 w, C.

WNBW
1200 kc, Carbondale, Pa., Home Cut Glass & China Co., 10 w, E.

WNBX
1200 kc. Springfield, Vt., First Congregational Church Corp., 10 w, E.

WNBZ
1290 kc, Saranac Lake, N. Y., Smith & Mace, 50 w, E.

WNJ
1450 kc, Newark, N. J., Radio Investment Co., 250 w, E, "The Voice of Newark."

WNOX
560 kc, Knoxville, Tenn., Stercki Bros., 1000 w, C. "Smoky Mountain Station."

WNRC
1440 kc, Greensboro, N. C., Wayne M. Nelson, 250 w, E.

WNYC
570 kc, New York, N. Y., Department of Plant & Structures, 500 w, E, "Municipal Broadcasting Station of the City of New York."

WOAI
1190 kc, San Antonio, Texas, Southern Equipment Co., 5000 w, C, "The Winter Playground of America."

WOAN
600 kc, Lawrenceburg, Tenn., J. D. Vaughan, 500 w, C, "Watch Our Annual Normal."

WOAX
1280 kc, Trenton, N. J., Franklyn J. Wolff, 500 w, E, "Trenton Makes, the World Takes."

WOBT
1310 kc. Union City, Tenn., Titsworth's Radio & Music Shop, 100 w, C.

WOBU
580 kc, Charleston, W. Va., Charleston Radio Broadcasting Co., 250 w, E.

WOC
1000 kc, Davenport, Iowa, Palmer School of Chiropractic, 5000 w, C.

WOCL
1210 kc, Jamestown, N.Y., A. E. Newton, 25 w, E.

WODA
1250 kc, Paterson, N. J., Richard E. O'Dea, 1000 w, E, "The Voice of the Silk City."

WODX
1410 kc, Mobile, Ala., Mobile Brdcstg. Corp., 500 w, C.

WOI
640 kc, Ames, Iowa, Iowa State College, 5000 w, C.

WOKO
1440 kc, Poughkeepsie, N. Y., H. E. Smith and R. M. Curtis, 500 w, E.

WOL
1310 kc, Washington, D. C., American Broadcasting Co., 100 w, E.

WOMT
1210 kc, Manitowoc, Wis., Francis M. Kadow, 100 w.

WOOD
1270 kc, Grand Rapids, Mich., Walter B. Stiles, Inc., 500 w, C, "The Voice of the Whispering Pines."

WOPI
1500 kc, Bristol, Tenn., Wilson Radiophone Service Co., 100 w, E.

WOQ
1300 kc, Kansas City, Mo., Unity School of Christianity, 1000 w, C.

WOR
710 kc, Newark, N. J., L. Bamberger & Co., 5000 w, E.

WORC
1200 kc, Worcester, Mass., A. F. Kleindienst, 100 w, E.

WORD
1480 kc, Chicago, Ill., People's Pulpit Association, 5000 w, C, "The Watch Tower—Radio WORD."

WOS
630 kc, Jefferson City, Mo., State Marketing Bureau, 500 w, C, "Watch Our State."

WOV
1130 kc, New York, N. Y., International Broadcasting Corp., 1000 w, E.

WOW
590 kc, Omaha, Neb., Woodmen of the World, 1000 w, C, "The Omaha Station."

WOWO
1160 kc, Ft. Wayne, Ind., Main Auto Supply Co., 10,000 w, C.

WPAP
See under WQAO.

WPAW
1210 kc, Pawtucket, R. I., Shartenberg & Robinson, 100 w, E, "The City of Diversified Industries."

WPCC
560 kc, Chicago, Ill., North Shore Congregational Church, 500 w, C.

WPCH
810 kc, New York, N. Y., Eastern Broadcasters, Inc., 500 w, E.

WPEN
1500 kc, Philadelphia, Pa., Wm. Penn Broadcasting Co., 100 w, E, "First Wireless School in America."

WPG
1100 kc, Atlantic City, N. J., Municipality of Atlantic City, 5000 w, E.

WPOE
1370 kc, Patchogue, N. Y., Nassau Broadcasting Corp., 30 w, E.

WPOR
See under WTAR.

WPSC
1230 kc, State College, Pa., Pennsylvania State College, 500 w, day, E, "The Voice of the Nittany Lion."

WPTF
680 kc, Raleigh, N. C., Durham Life Insurance Co., 1,000 w, E.

WQAM
560 kc, Miami, Fla., Miami Broadcasting Co., 100 w, E.

WQAN
880 kc, Scranton, Pa., Scranton Times, 250 w, E.

WQAO
1010 kc, New York, N. Y., Calvary Baptist Church, 250 w, E.

WQBC
1360 kc, Utica, Miss., Utica Chamber of Commerce, 300 w, C.

WQBZ
1420 kc, Weirton, W. Va., J. H. Thompson, 60 w, E.

WRAF
1200 kc, La Porte, Ind., The Radio Club, Inc.. 100 w.

WRAK
1370 kc, Erie, Pa., C. R. Cummins, 50 w, E.

WRAW
1310 kc, Reading, Pa., Avenue Radio & Electric Shop, 100 w, E, "The Schuylkill Valley Echo."

WRAX
1020 kc, Philadelphia, Pa., Berachah Church, Inc., 250 w, E.

FREE!

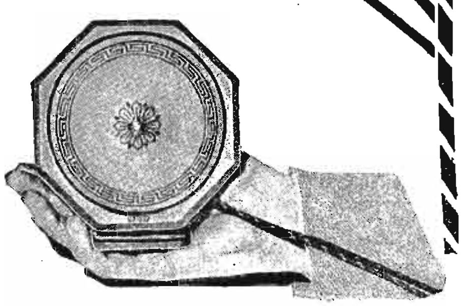
YOU can enjoy the perfect reproduction and the unusual convenience of this Midget Cone Speaker ***absolutely free.*** Manufactured by one of the largest manufacturers in the country, this speaker has innumerable advantages in portability and perfect tone. Ideal for apartment use, or in different rooms of the house, the Midget Speaker is delighting thousands who are now using it.

One of these speakers may be yours for the cost of the "Call Book" alone, by just filling in the coupon below for one year's subscription to the Citizens Radio Call Book Magazine. Because the supply is ***limited***, do not delay in sending in the coupon.

Mail Coupon Today!

From Elizabeth, N. J.:
"I received the Midget speaker today. It's great and I am well pleased."
Richard Ogden.

From Ocean Breeze, Cal., W. P. McGuide writes: "I received your Midget Speaker and sure was surprised by its performance. I play all distant stations just as good as any speaker I've had, and it performs dandy." . . .



CITIZENS RADIO SERVICE BUREAU
508 S. Dearborn St., Chicago, Ill.

Here's my $2.00, for which please send me Citizens Radio Call Book Magazine for one year, beginning ☐ January ☐ March ☐ September ☐ November. This subscription entitles me to a FREE MIDGET LOUDSPEAKER.

NAME (Print Plainly)....................

STREET & NO....................

CITY.................... STATE....................

Please Place Your Signature Here....................

My vocation is: ☐ Service and Repair ☐ Radio Engineer ☐ Radio Dealer ☐ Radio Experimenter.

WRBI
1310 kc, Tifton, Ga., Kent's Furniture & Music Store, 20 w, E.

WRBJ
1500 kc, Hattiesburg, Miss., Woodruff Furniture Co., 10 w, C.

WRBL
1200 kc, Columbus, Ga., David Parmer, 50 w, E.

WRBQ
1210 kc, Greenville, Miss., J. Pat Scully, 100 w, C.

WRBT
1370 kc, Wilmington, N. C., Wilmington Radio Association, 100 w, E.

WRBU
1210 kc, Gastonia, N. C., A. J. Kirby Music Co., 100 w, E.

WRC
950 kc, Washington, D. C., Radio Corporation of America, 500 w, E, "The Voice of the Capital."

WREC
600 kc, Whitehaven, Tenn., WREC, Inc., 500 w.

WREN
1220 kc, Lawrence, Kan., Jenny Wren Co., 1000 w, C.

WRHM
1250 kc, Minneapolis, Minn., Minnesota Broadcasting Corp., 1000 w, C. "Welcome Rosedale Hospital, Minneapolis."

WRJN
1370 kc, Racine, Wis., Racine Broadcasting Corp., 100 w, C.

WRK
1310 kc, Hamilton, Ohio, S. W. Doron & John C. Slade, 100 w, E. "The Voice of Hamilton."

WRNY
1010 kc, New York, N. Y., Aviation Radio Station, 250 w, E.

WRR
1280 kc, Dallas. Texas, City of Dallas, 500 w, C.

WRUF
830 kc, Gainesville, Fla., University of Florida, 5000 w, E.

WRVA
1110 kc, Richmond, Va., Larus Bros. & Co., Inc., 5000 w, E, "Carry Me Back to Old Virginny."

WSAI
1330 kc, Cincinnati, Ohio, Crosley Radio Corp., 500 w, E, "The Gateway to Dixie."

WSAJ
1310 kc, Grove City, Pa., Grove City College, 100 w, E.

WSAN
1440 kc, Allentown, Pa., Allentown Call Pub. Co., 250 w, E, "We Serve Allentown Nationality." ity."

WSAR
1450 kc, Fall River, Mass., Doughty & Welch Electrical Co., Inc., 250 w, E.

WSAZ
580 kc, Huntington, W. Va., WSAZ, Inc., 250 w,E.

WSB
740 kc, Atlanta, Ga., Atlanta Journal Co., 1000 w, E, "The Voice of the South."

WSBC
1210 kc, Chicago, Ill., World Battery Co., 100 w, C.

WSBT
1230 kc, South Bend, Ind., South Bend Tribune. 500 w, C.

WSDA
See under WSGH.

WSFA
1410 kc, Montgomery, Ala., Montgomery Brdcstg. Co., 500 w, C.

WSGH
1400 kc, Brooklyn, N. Y., Amateur Radio Specialty Co., 500 w.

WSIX
1210 kc, Springfield, Tenn., 638 Tire & Vulcanizing Co., 100 w, C.

WSJS
1310 kc, Winston-Salem, N. C., The Journal Co., 100 w, E.

WSM
650 kc, Nashville, Tenn., National Life & Accident Ins. Co., 5000 w, C, "We Shield Millions."

WSMB
1320 kc, New Orleans, La., Saenger Theaters, Inc., & Maison Blanche Co., 500 w, C, "America's Most Interesting City."

WSMK
1380 kc, Dayton, Ohio, Stanley M. Krohn, Jr., 200 w, C, "The Home of Aviation."

WSOA
1480 kc, Forest Park, Ill., Radiophone Broadcasting Corp., 5000 w, C.

WSPD
1340 kc, Toledo, Ohio, Toledo Broadcasting Co., 500 w, E.

WSSH
1360 kc, Boston, Mass., Tremont Temple Baptist Church, 100 w, E, "Stranger's Sunday Home."

WSUI
600 kc, Iowa City, Iowa, State Univ. of Iowa, 500 w, C, "The Old Gold Studio."

WSUN
See under WFLA.

WSVS
1370 kc, Buffalo, N. Y., Seneca Cocational High School, 50 w, E, "Watch Seneca Vocational School."

WSYR
570 kc, Syracuse, N. Y., Clive B. Meredith, 250 w, E.

WTAD
1440 kc, Quincy, Ill., Illinois Stock Medicine Broadcasting Corp., 500 w.

WTAG
580 kc, Worcester, Mass., Worcester Telegram Pub. Co., Inc., 250 w, E. "The Voice From the Heart of the Commonwealth."

WTAM
1070 kc, Cleveland, Ohio, WTAM & WEAR, Inc., 50,000 w, E, "The Voice From the Storage Battery."

WTAQ
1330 kc, Eau Claire, Wis., Gillette Rubber Co., 1000 w, C.

WTAR
780 kc, Norfolk, Va., WTAR Radio Corp., 500 w, E.

WTAW
1120 kc, College Station, Texas, Agri. & Mech. College of Texas, 500 w, C.

WTAX
1210 kc, Streator, Ill., Williams Hardware Co., 50 w.

WTBO
1420 kc, Cumberland, Md., Associated Brdcstg. Corp., 50 w, E.

WTFI
1450 kc, Toccoa, Ga., Toccoa Falls Institute, 250 w, E.

WTIC
1060 kc, Hartford, Conn., Travels Broadcasting Service Corp., 50,000 w, E, "The Insurance City."

WTMJ
620 kc, Milwaukee, Wis., Milwaukee Journal, 1000 w, C.

WTNT
1490 kc, Nashville, Tenn., Tenn. Pub. Co., 5000 w, C.

WTOC
1260 kc, Savannah, Ga., Savannah Broadcasting Corp., 500 w, E.

WWAE
1200 kc, Hammond, Ind., Hammond - Calumet Broadcasting Corp., 100 w.

WWJ
920 kc, Detroit, Mich., Evening News Assn., 1000 w, E.

WWL
850 kc, New Orleans, La., Loyola University, 5000 w, C.

WWNC
570 kc, Asheville, N. C., Citizens Broadcasting Co., 1000 w, E.

WWRL
1500 kc, Woodside, N. Y., Long Island Broadcasting Corp., 100 W.

WWVA
1160 kc, Wheeling, W. Va., West Virginia Broadcasting Corp., 5000 w, E.

Consolidated Broadcast List

Call Town

KCRC—Enid, Okla.
KDB—Santa Barbara, Calif.
KDFN—Casper, Wyo.
KDKA—East Pittsburgh, Pa.
KDLR—Devils Lake, N. D.
KDYL—Salt Lake City, Utah
KECA—Los Angeles, Calif.
KEJK—Beverly Hills, Calif.
KELW—Burbank, Calif.
KEX—Portland, Ore.
KFAB—Lincoln, Neb.
KFBB—Great Falls, Mont.
KFBK—Sacramento, Calif.
KFBL—Everett, Wash.
KFDM—Beaumont, Tex.
KFDY—Brookings, S. D.
KFEL—Denver, Colo.
KFEQ—St. Joseph, Mo.
KFGQ—Boone, Iowa
KFH—Wichita, Kans.
KFHA—Gunnison, Colo.
KFI—Los Angeles, Calif.
KFIF—Portland, Ore.
KFIO—Spokane, Wash.
KFIZ—Fond du Lac, Wis.
KFJB—Marshalltown, Iowa
KFJF—Oklahoma City, Okla.
KFJI—Astoria, Ore.
KFJM—Grand Forks, N. D.
KFJR—Portland, Ore.
KFJY—Fort Dodge, Ia.
KFJZ—Fort Worth, Tex.
KFKA—Greeley, Colo.
KFKB—Milford, Kans.
KFKU—Lawrence, Kans.
KFKX—Chicago, Ill.
KFLV—Rockford, Ill.
KFLX—Galveston, Tex.
KFMX—Northfield, Minn.
KFNF—Shenandoah, Ia.
KFOR—Lincoln, Neb.
KFOX—Long Beach, Calif.
KFPL—Dublin, Tex.
KFPM—Greenville, Tex.
KFPW—Siloam Springs, Ark.
KFPY—Spokane, Wash.
KFQA—St. Louis, Mo.
KFQD—Anchorage, Alaska
KFQU—Holy City, Calif.
KFQW—Seattle, Wash.
KFQZ—Los Angeles, Calif.
KFRC—San Francisco, Calif.
KFRU—Columbia, Mo.
KFSD—San Diego, Calif.
KFSG—Los Angeles, Calif.
KFUL—Galveston, Tex.
KFUM—Colorado Spgs., Colo.
KFUO—St. Louis, Mo.
KFUP—Denver, Colo.
KFVD—Culver City, Calif.
KFVS—Cape Girardeau, Mo.
KFWB—Hollywood, Calif.
KFWF—St. Louis, Mo.
KFWI—San Francisco, Calif.
KFWM—Richmond, Calif.
KFXD—Jerome, Idaho
KFXF—Denver, Colo.
KFXJ—Edgewater, Colo.
KFXM—San Bernardino, Calif.
KFXR—Oklahoma City, Okla.
KFXY—Flagstaff, Ariz.
KFYO—Abilene, Tex.
KFYR—Bismarck, N. D.
KGA—Spokane, Wash.
KGAR—Tucson, Ariz.
KGB—San Diego, Calif.
KGBU—Ketchikan, Alaska
KGBX—St. Joseph, Mo.
KGBZ—York, Neb.
KGCA—Decorah, Ia.
KGCI—San Antonio, Tex.
KGCR—Watertown, S. D.
KGCU—Mandan, N. D.
KGCX—Wolf Point, Mont.
KGDA—Dell Rapids, S. D.
KGDE—Fergus Falls, Minn.
KGDM—Stockton, Calif.
KGDY—Oldham, S. D.
KGEF—Los Angeles, Calif.
KGEK—Yuma, Colo.
KGER—Long Beach, Calif.
KGEW—Fort Morgan, Colo.
KGEZ—Kalispell, Mont.
KGFF—Alva, Okla.
KGFG—Oklahoma City, Okla.
KGFI—Corpus Christi, Tex.
KGFJ—Los Angeles, Calif.
KGFK—Hallock, Minn.
KGFL—Raton, N. M.
KGFW—Ravenna, Neb.
KGFX—Pierre, S. D.
KGGC—San Francisco, Cal.
KGGF—Picher, Okla.
KGGM—Albuquerque, N. M.
KGHF—Pueblo, Colo.
KGHG—McGehee, Ark.
KGHI—Little Rock, Ark.
KGHL—Billings, Mont.
KGHX—Richmond, Tex.
KGIQ—Twin Falls, Idaho
KGIR—Butte, Mont.
KGIW—Trinidad, Colo.
KGIX—Las Vegas, Nev.
KGJF—Little Rock, Ark.
KGKB—Brownwood, Tex.
KGKL—San Angelo, Tex.
KGKO—Wichita Falls, Tex.
KGKX—Sandpoint, Idaho
KGO—Oakland, Calif.
KGRC—San Antonio, Tex.
KGRS—Amarillo, Tex.
KGU—Honolulu, T. H.
KGW—Portland, Ore.

Call Town

KGY—Lacey, Wash.
KHJ—Los Angeles, Calif.
KHQ—Spokane, Wash.
KICK—Red Oak, Ia.
KID—Idaho Falls, Idaho
KIDO—Boise, Idaho
KIT—Yakima, Wash.
KJBS—San Francisco, Calif.
KJR—Seattle, Wash.
KLCN—Blytheville, Ark.
KLO—Ogden, Utah
KLPM—Minot, N. D.
KLRA—Little Rock, Ark.
KLS—Oakland, Calif.
KLX—Oakland, Calif.
KLZ—Dupont, Colo.
KMA—Shenandoah, Ia.
KMBC—Kansas City, Mo.
KMED—Medford, Ore.
KMIC—Inglewood, Calif.
KMJ—Fresno, Calif.
KMMJ—Clay Center, Neb.
KMO—Tacoma, Wash.
KMOX—St. Louis, Mo.
KMTR—Hollywood, Calif.
KNX—Hollywood, Calif.
KOA—Denver, Colo.
KOAC—Corvallis, Ore.
KOB—State College, N. M.
KOCW—Chickasha, Okla.
KOH—Reno, Nev.
KOIL—Council Bluffs, Ia.
KOIN—Portland, Ore.
KOL—Seattle, Wash.
KOMO—Seattle, Wash.
KOOS—Marshfield, Ore.
KORE—Eugene, Ore.
KOY—Phoenix, Ariz.
KPCB—Seattle, Wash.
KPJM—Prescott, Ariz.
KPO—San Francisco, Calif.
KPOF—Denver, Colo.
KPPC—Pasadena, Calif.
KPQ—Seattle, Wash.
KPRC—Houston, Tex.
KPSN—Pasadena, Calif.
KPWF—Westminster, Calif.
KQV—Pittsburgh, Pa.
KQW—San Jose, Calif.
KRE—Berkeley, Calif.
KREP—Phoenix, Ariz.
KRGV—Harlingen, Tex.
KRLD—Dallas, Tex.
KRMD—Shreveport, La.
KRSC—Seattle, Wash.
KSAC—Manhattan, Kans.
KSAT—Ft. Worth, Tex.
KSCJ—Sioux City, Ia.
KSD—St. Louis, Mo.
KSEI—Pocatello, Idaho
KSL—Salt Lake City, Utah
KSMR—Santa Maria, Calif.
KSO—Clarinda, Ia.
KSOO—Sioux Falls, S. D.
KSTP—St. Paul, Minn.
KTAB—Oakland, Calif.
KTAP—San Antonio, Tex.
KTBI—Los Angeles, Calif.
KTBR—Portland, Ore.
KTBS—Shreveport, La.
KTHS—Hot Springs, Ark.
KTM—Santa Monica, Calif
KTNT—Muscatine, Ia.
KTSA—San Antonio, Tex.
KTSL—Shreveport, La.
KTSM—El Paso, Tex.
KTUE—Houston, Tex.
KTW—Seattle, Wash.
KUJ—Longview, Wash.
KUOA—Fayetteville, Ark.
KUSD—Vermillion, S. D.
KUT—Austin, Tex.
KVEP—Portland, Ore.
KVI—Tacoma, Wash.
KVL—Seattle, Wash.
KVOA—Tucson, Ariz.
KVOO—Tulsa, Okla.
KVOS—Bellingham, Wash.
KWCR—Cedar Rapids, Ia.
KWEA—Shreveport, La.
KWG—Stockton, Cal.
KWJJ—Portland, Ore.
KWK—St. Louis, Mo.
KWKC—Kansas City, Mo.
KWKH—Kennonwood, La.
KWLC—Decorah, Ia.
KWSC—Pullman, Wash.
KWWG—Brownsville, Tex
KXA—Seattle, Wash.
KXL—Portland, Ore.
KXO—El Centro, Calif.
KXRO—Aberdeen, Wash.
KYW—Chicago, Ill.
KYWA—Chicago, Ill.
KZM—Hayward, Calif.
WAAF—Chicago, Ill.
WAAM—Newark, N. J.
WAAT—Jersey City, N. J.
WAAW—Omaha, Neb.
WABC—New York City, N. Y.
WABI—Bangor, Me.
WABO—Rochester, N. Y.
WABZ—New Orleans, La.
WADC—Tallmadge, Ohio
WAGM—Royal Oak, Mich.
WAIU—Columbus, Ohio
WAPI—Birmingham, Ala.
WASH—Grand Rapids, Mich.
WBAA—Lafayette, Ind.
WBAK—Harrisburg, Pa.
WBAL—Baltimore, Md.
WBAP—Fort Worth, Tex.
WBAW—Nashville, Tenn.

Call Town

WBAX—Wilkes-Barre, Pa.
WBBC—Brooklyn, N. Y.
WBBL—Richmond, Va.
WBBM—Chicago, Ill.
WBBR—Rossville, N. Y.
WBBY—Charleston, S. C.
WBBZ—Ponca City, Okla.
WBCM—Bay City, Mich.
WBCN—Chicago, Ill.
WBIS—Boston, Mass.
WBMS—Fort Lee, N. J.
WBNY—New York, N. Y.
WBOQ—New York, N. Y.
WBOW—Terre Haute, Ind.
WBRC—Birmingham, Ala.
WBRE—Wilkes-Barre, Pa.
WBRL—Tilton, N. H.
WBSO—Wellesley Hills, Mass.
WBT—Charlotte, N. C.
WBZ—Springfield, Mass.
WBZA—Boston, Mass.
WCAC—Storrs, Conn.
WCAD—Canton, N. Y.
WCAE—Pittsburgh, Pa.
WCAH—Columbus, Ohio
WCAJ—Lincoln, Neb.
WCAL—Northfield, Minn.
WCAM—Camden, N. J.
WCAO—Baltimore, Md.
WCAP—Asbury Park, N. J.
WCAT—Rapid City, S. D.
WCAU—Philadelphia, Pa.
WCAX—Burlington, Vt.
WCAZ—Carthage, Ill.
WCBA—Allentown, Pa.
WCBD—Zion, Ill.
WCBM—Baltimore, Md.
WCBS—Springfield, Ill.
WCCO—Minneapolis, Minn.
WCDA—New York, N. Y.
WCFL—Chicago, Ill.
WCGU—Coney Island, N. Y.
WCKY—Covington, Ky.
WCLO—Kenosha, Wis.
WCLS—Joliet, Ill.
WCMA—Culver, Ind.
WCOA—Pensacola, Fla.
WCOC—Meridian, Miss.
WCOD—Harrisburg, Pa.
WCOH—Yonkers, N. Y.
WCRW—Chicago, Ill.
WCSH—Portland, Me.
WCSO—Springfield, Ohio
WDAE—Tampa, Fla.
WDAF—Kansas City, Mo
WDAG—Amarillo, Tex.
WDAH—El Paso, Tex.
WDAY—Fargo, N. D.
WDBJ—Roanoke, Va.
WDBO—Orlando, Fla.
WDEL—Wilmington, Del.
WDGY—Minneapolis, Minn.
WDOD—Chattanooga, Tenn.
WDRC—New Haven, Conn.
WDSU—New Orleans, La.
WDWF—Providence, R. I.
WDZ—Tuscola, Ill.
WEAF—New York, N. Y.
WEAI—Ithaca, N. Y.
WEAN—Providence, R. I.
WEAO—Columbus, Ohio
WEAR—Cleveland, Ohio
WEBC—Superior, Wis.
WEBE—Cambridge, Ohio
WEBQ—Harrisburg, Ill.
WEBR—Buffalo, N. Y.
WEBW—Beloit, Wis.
WEDC—Chicago, Ill.
WEDH—Erie, Pa.
WEEI—Boston, Mass.
WEHC—Emory, Va.
WEHS—Evanston, Ill.
WELK—Philadelphia, Pa.
WEMC—Berrien Springs, Mich.
WENR—Chicago, Ill.
WEVD—New York, N. Y.
WEW—St. Louis, Mo.
WFAA—Dallas, Tex.
WFAN—Philadelphia, Pa.
WFBC—Knoxville, Tenn.
WFBG—Altoona, Pa.
WFBJ—Collegeville, Minn.
WFBL—Syracuse, N. Y.
WFBM—Indianapolis, Ind.
WFBR—Baltimore, Md.
WFDF—Flint, Mich.
WFI—Philadelphia, Pa.
WFIW—Hopkinsville, Ky.
WFJC—Akron, Ohio
WFKD—Philadelphia, Pa.
WFLA—Clearwater, Fla.
WGAL—Lancaster, Pa.
WGBB—Freeport, N. Y.
WGBC—Memphis, Tenn.
WGBF—Evansville, Ind.
WGBI—Scranton, Pa.
WGBS—New York, N. Y.
WGCM—Gulfport, Miss.
WGCP—Newark, N. J.
WGES—Chicago, Ill.
WGH—Newport News, Va.
WGHP—Detroit, Mich.
WGL—Fort Wayne, Ind.
WGMS—Minneapolis, Minn.
WGN—Chicago, Ill.
WGR—Buffalo, N. Y.
WGST—Atlanta, Ga.
WGY—Schenectady, N. Y.
WHA—Madison, Wis.
WHAD—Milwaukee, Wis.
WHAM—Rochester, N. Y.
WHAP—New York, N. Y.

Call Town

WHAS—Louisville, Ky.
WHAT—Philadelphia, Pa.
WHAZ—Troy, N. Y.
WHB—Kansas City, Mo.
WHBC—Canton, Ohio
WHBD—Mt. Orab, Ohio
WHBF—Rock Island, Ill.
WHBL—Sheboygan, Wis.
WHBQ—Memphis, Tenn.
WHBU—Anderson, Ind.
WHBY—Green Bay, Wis.
WHDF—Calumet, Mich.
WHDH—Gloucester, Mass.
WHDI—Minneapolis, Minn.
WHDL—Tupper Lake, N.
WHEC—Rochester, N. Y.
WHFC—Cicero, Ill.
WHIS—Bluefield, W. Va.
WHK—Cleveland, Ohio
WHN—New York, N. Y.
WHO—Des Moines, Iowa
WHP—Harrisburg, Pa.
WIAS—Ottumwa, Ia.
WIBA—Madison, Wis.
WIBG—Elkins Park, Pa.
WIBM—Jackson, Mich.
WIBO—Chicago, Ill.
WIBR—Steubenville, Ohio
WIBS—Elizabeth, N. J.
WIBU—Poynette, Wis.
WIBW—Topeka, Kans.
WIBX—Utica, N. Y.
WICC—Bridgeport, Conn.
WIL—St. Louis, Mo.
WILL—Urbana, Ill.
WILM—Wilmington, Del.
WIOD—Miami Beach, Fla.
WIP—Philadelphia, Pa.
WISN—Milwaukee, Wis.
WJAC—Johnstown, Pa.
WJAD—Waco, Tex.
WJAG—Norfolk, Neb.
WJAK—Marion, Ind.
WJAR—Providence, R. I.
WJAS—Pittsburgh, Pa.
WJAX—Jacksonville, Fla.
WJAY—Cleveland, Ohio
WJAZ—Chicago, Ill.
WJBC—LaSalle, Ill.
WJBI—Red Bank, N. J.
WJBK—Ypsilanti, Mich.
WJBL—Decatur, Ill.
WJBO—New Orleans, La.
WJBT—Chicago, Ill.
WJBU—Lewisburg, Pa.
WJBW—New Orleans, La.
WJBY—Gadsden, Ala.
WJDX—Jackson, Miss.
WJJD—Mooseheart, Ill.
WJKS—Gary, Ind.
WJR—Detroit, Mich.
WJSV—Mt. Vernon Hills, Va.
WJW—Mansfield, Ohio
WJZ—New York, N. Y.
WKAQ—San Juan, P. R.
WKAR—E. Lansing, Mich.
WKAV—Laconia, N. H.
WKBB—Joliet, Ill.
WKBC—Birmingham, Ala.
WKBF—Indianapolis, Ind.
WKBH—La Crosse, Wis.
WKBI—Chicago, Ill.
WKBN—Youngstown, Ohio
WKBO—Jersey City, N. J.
WKBP—Battle Creek, Mich.
WKBQ—New York, N. Y.
WKBS—Galesburg, Ill.
WKBV—Brookville, Ind.
WKBW—Buffalo, N. Y.
WKBZ—Ludington, Mich.
WKEN—Buffalo, N. Y.
WKJC—Lancaster, Pa.
WKRC—Cincinnati, Ohio
WKY—Oklahoma City, Okla.
WLAC—Nashville, Tenn.
WLAP—Louisville, Ky.
WLB—Minneapolis, Minn.
WLBC—Muncie, Ind.
WLBF—Kansas City, Kans.
WLBG—Petersburg, Va.
WLBL—Stevens Point, Wis.
WLBW—Oil City, Pa.
WLBX—Long Island City, N. Y.
WLBZ—Bangor, Me.
WLCI—Ithaca, N. Y.
WLEX—Lexington, Mass.
WLEY—Lexington, Mass.
WLIB—Chicago, Ill.
WLIT—Philadelphia, Pa.
WLOE—Boston, Mass.
WLS—Chicago, Ill.
WLSI—Providence, R. I.
WLTH—Brooklyn, N. Y.
WLW—Cincinnati, Ohio
WLWL—New York, N. Y.
WMAC—Cazenovia, N. Y.
WMAF—S. Dartmouth, Mass.
WMAK—Buffalo, N. Y.
WMAL—Washington, D. C.
WMAN—Columbus, Ohio
WMAQ—Chicago, Ill.
WMAY—St. Louis, Mo.
WMAZ—Macon, Ga.
WMBA—Newport, R. I.
WMBC—Detroit, Mich.
WMBD—Peoria Heights, Ill.
WMBF—Miami Beach, Fla.
WMBG—Richmond, Va.
WMBH—Joplin, Mo.
WMBI—Chicago, Ill.
WMBO—Auburn, N. Y.
WMBQ—Brooklyn, N. Y.
WMBR—Tampa, Fla.
WMC—Memphis, Tenn.

Call Town

WMCA—New York, N. Y.
WMES—Boston, Mass.
WMMN—Fairmont, W. Va.
WMPC—Lapeer, Mich.
WMRJ—Jamaica, N. Y.
WMSG—New York, N. Y.
WMT—Waterloo, Ia.
WNAC—Boston, Mass.
WNAD—Norman, Okla.
WNAT—Philadelphia, Pa.
WNAX—Yankton, S. D.
WNBF—Binghamton, N. Y.
WNBH—New Bedford, Mass.
WNBJ—Knoxville, Tenn.
WNBO—Washington, Pa.
WNBR—Memphis, Tenn.
WNBW—Carbondale, Pa.
WNBX—Springfield, Vt.
WNBZ—Saranac Lake, N. Y.
WNJ—Newark, N. J.
WNOX—Knoxville, Tenn.
WNRC—Greensboro, N. C.
WNYC—New York, N. Y.
WOAI—San Antonio, Tex.
WOAN—Lawrenceburg, Tenn.
WOAX—Trenton, N. J.
WOBT—Union City, Tenn.
WOBU—Charleston, W. Va.
WOC—Davenport, Ia.
WOCL—Jamestown, N. Y.
WODA—Paterson, N. J.
WODX—Mobile, Ala.
WOI—Ames, Ia.
WOKO—Poughkeepsie, N. Y.
WOL—Washington, D. C.
WOMT—Manitowoc, Wis.
WOPI—Bristol, Tenn.
WOOD—Grand Rapids, Mich.
WOQ—Kansas City, Mo.
WOR—Newark, N. J.
WORC—Worcester, Mass.
WORD—Chicago, Ill.
WOS—Jefferson City, Mo.
WOV—New York, N. Y.
WOW—Omaha, Neb.
WOWO—Ft. Wayne, Ind.
WPAP—New York, N. Y.
WPAW—Pawtucket, R. I.
WPCC—Chicago, Ill.
WPCH—New York, N. Y.
WPEN—Philadelphia, Pa.
WPG—Atlantic City, N. J.
WPOE—Patchogue, N. Y.
WPOR—Norfolk, Va.
WPSC—State College, Pa.
WPTF—Raleigh, N. C.
WQAM—Miami, Fla.
WQAN—Scranton, Pa.
WQAO—New York, N. Y.
WQBC—Utica, Miss.
WQBZ—Weirton, W. Va.
WRAF—La Porte, Ind.
WRAK—Erie, Pa.
WRAW—Reading, Pa.
WRAX—Philadelphia, Pa.
WRBI—Tifton, Ga.
WRBJ—Hattiesburg, Miss.
WRBL—Columbus, Ga.
WRBQ—Greenville, Miss.
WRBT—Wilmington, N. C.
WRBU—Gastonia, N. C.
WRC—Washington, D. C.
WREC—Whitehaven, Tenn.
WREN—Lawrence, Kans.
WRHM—Minneapolis, Minn.
WRJN—Racine, Wis.
WRK—Hamilton, Ohio
WRNY—New York, N. Y.
WRR—Dallas, Tex.
WRUF—Gainesville, Fla.
WRVA—Richmond, Va.
WSAI—Cincinnati, Ohio
WSAJ—Grove City, Pa.
WSAN—Allentown, Pa.
WSAR—Fall River, Mass.
WSAZ—Huntington, W. Va.
WSB—Atlanta, Ga.
WSBC—Chicago, Ill.
WSBT—South Bend, Ind.
WSDA—Brooklyn, N. Y.
WSFA—Montgomery, Ala.
WSGH—Brooklyn, N. Y.
WSIX—Springfield, Tenn.
WSJS—Winston-Salem, N. C.
WSM—Nashville, Tenn.
WSMB—New Orleans, La.
WSMK—Dayton, Ohio
WSOA—Forest Park, Ill.
WSPD—Toledo, Ohio
WSSH—Boston, Mass.
WSUI—Iowa City, Ia.
WSUN—Clearwater, Fla.
WSVS—Buffalo, N. Y.
WSYR—Syracuse, N. Y.
WTAD—Quincy, Ill.
WTAG—Worcester, Mass.
WTAM—Cleveland, Ohio
WTAQ—Eau Claire, Wis.
WTAR—Norfolk, Va.
WTAW—College Station, Tex.
WTAX—Streator, Ill.
WTBO—Cumberland, Md.
WTFI—Toccoa, Ga.
WTIC—Hartford, Conn.
WTMJ—Milwaukee, Wis.
WTNT—Nashville, Tenn.
WTOC—Savannah, Ga.
WWAE—Hammond, Ind.
WWJ—Detroit, Mich.
WWL—New Orleans, La.
WWNC—Asheville, N. C.
WWRL—Woodside, N. Y.
WWVA—Wheeling, W. Va.

U. S. Broadcasting Stations by Frequencies

550 Kilocycles, 545.1 Meters:
KOAC, WGR, WEAO, WKRC, KFUO, KSD, KFDY, KFYR.

560 Kilocycles, 535.4 Meters.
WLIT, WFI, KFDM, WNOX KTAB, KLZ, WIBO, WEBW, WPCC, WQAM.

570 Kilocycles, 526.0 Meters:
WYNC, WMCA, WSYR, WMAC, WKBN, WWNC, KGKO, WNAX, KXA, KMTR

580 Kilocycles, 516.9 Meters—Canadian Shared:
WTAG, WOBU, WSAZ, KGFX, KSAC, WIBW

590 Kilocycles, 508.2 Meters:
WEEI, WEMC, WCAJ, WOW, KHQ

600 Kilocycles, 499.7 Meters—Canadian Shared:
WTIC, WCAO, WREC, WOAN, KFSD, WCAC, WMT, WSUI

610 Kilocycles, 491.5 Meters:
WFAN, WIP, WDAF, KFRC

620 Kilocycles, 483.6 Meters:
WLBZ, WTMJ, KGW, WJAY, KREP, WFLA, WSUN

630 Kilocycles, 475.9 Meters—Canadian Shared:
WMAL, WOS, KFRU, WGBF

640 Kilocycles, 468.5 Meters:
WAIU, KFI, WOI

650 Kilocycles, 461.3 Meters:
WSM

660 Kilocycles, 454.3 Meters:
WEAF, WAAW

670 Kilocycles, 447.5 Meters:
WMAQ

680 Kilocycles, 440.9 Meters:
WPTF, KPO, KFEQ

690 Kilocycles, 434.5 Meters—Canadian Wave:

700 Kilocycles, 428.3 Meters:
WLW

710 Kilocycles, 422.3 Meters:
WOR, KEJK, WHB

720 Kilocycles, 416.4 Meters:
WGN, WLIB

730 Kilocycles, 410.7 Meters—Canadian Wave:

740 Kilocycles, 405.2 Meters:
WSB, KMMJ

750 Kilocycles, 399.8 Meters:
WJR

760 Kilocycles, 394.5 Meters:
WJZ, WEW

770 Kilocycles, 389.4 Meters:
KFAB, WBBM, WJBT

780 Kilocycles, 384.4 Meters—Canadian Shared:
WTAR, WPOR, KELW, KTM, WMC, WEAN

790 Kilocycles, 379.5 Meters:
WGY, KGO

800 Kilocycles, 374.8 Meters:
WBAP, WFAA

810 Kilocycles, 370.2 Meters:
WPCH, WCCO

820 Kilocycles, 365.6 Meters:
WHAS

830 Kilocycles, 361.2 Meters:
KOA, WHDH, WRUF

840 Kilocycles, 356.9 Meters—Canadian Wave:

850 Kilocycles, 352.7 Meters:
KWKH, WWL

860 Kilocycles, 348.6 Meters:
WBOQ, WABC, KFQZ, KMO, KFPY

870 Kilocycles, 344.6 Meters:
WLS, WENR, WBCN

880 Kilocycles, 340.7 Meters—Canadian Shared:
WQAN, WGBI, WCOC, KLX, KPOF, KFKA

890 Kilocycles, 336.9 Meters—Canadian Shared:
WJAR, WMMN, WMAZ, WGST, KGJF, WILL, KUSD, KFNF, WKAQ

900 Kilocycles, 331.1 Meters:
WFBL, WMAK, WKY, WLBL, KHJ, KSEI, KGBU, WJAX

910 Kilocycles, 329.5 Meters—Canadian Wave:

920 Kilocycles, 325.9 Meters:
WWJ, KPRC, WAAF, WBSO, KVI, KFXF, KFEL

930 Kilocycles, 322.4 Meters—Canadian Shared:
WIBG, WDBJ, WBRC, KGBZ, KMA, KFWM, KFWI

940 Kilocycles, 319 Meters:
WCSH, WFIW, KOIN, KGU, WHA, WDAY

950 Kilocycles, 315.6 Meters:
WRC, KMBC, KFWB, KGHL

960 Kilocycles, 312.3 Meters—Canadian Wave:

970 Kilocycles, 309.1 Meters:
KOMO, KJR

980 Kilocycles, 305.9 Meters:
KDKA

990 Kilocycles, 302.8 Meters:
WBZ, WBZA

1000 Kilocycles, 299.8 Meters:
WHO, WOC, KFVD

1010 Kilocycles, 296.9 Meters—Canadian Shared:
WQAO, WPAP, WHN, WRNY, KGGF, WNAD, KQW

1020 Kilocycles, 293.9 Meters:
KYW, KFKX, KYWA, WRAX

1030 Kilocycles, 291.1 Meters—Canadian Wave:

1040 Kilocycles, 288.3 Meters:
WKEN, WKAR, KTHS, KRLD

1050 Kilocycles, 285.5 Meters:
KNX, KFKB

1060 Kilocycles, 282.8 Meters:
WBAL, WJAG, KWJJ, WTIC

1070 Kilocycles, 280.2 Meters:
WAAT, WTAM, WEAR, WCAZ, WDZ, KJBS

1080 Kilocycles, 277.6 Meters:
WBT, WCBD, WMBI

1090 Kilocycles, 275.1 Meters:
KMOX, KFQA

1100 Kilocycles, 272.6 Meters:
WPG, WLWL, KGDM

1110 Kilocycles, 270.1 Meters:
WRVA, KSOO

1120 Kilocycles, 267.7 Meters—Canadian Shared:
WTAW, KUT, WISN, WHAD, KFSG, KMIC, KRSC, WDEL, WDBO

1130 Kilocycles, 265.3 Meters:
WOV, KSL, WJJD

1140 Kilocycles, 263.0 Meters:
WAPI, KVOO

1150 Kilocycles, 260.7 Meters:
WHAM

1160 Kilocycles, 258.5 Meters:
WWVA, WOWO

1170 Kilocycles, 256.3 Meters:
WCAU, KTNT

1180 Kilocycles, 254.1 Meters:
WGBS, KEX, KOB, WGDY, WHDI

1190 Kilocycles, 252.0 Meters:
WICC, WOAI

1200 Kilocycles, 249.9 Meters: Canadian Shared:
WABI, WNBX, WORC, WIBX, WHBC, WLAP, WLBG, WNBO, WKJC, WNBW, WABZ, WJBW, WBBY, WBBZ, WFBC, WRBL, KGCU, WJBC, WJBL, WWAE, WRAF, WMT, KFJB, WCAT, KGDY, KFWF, KGDE, KGFK, WCLO, WHBY, KXO, KSMR, WIL, KFHA, KVOS, KGY, WMAY, KWG, KGEK, KGEW, KGHI, WCAX, WCOD

1210 Kilocycles, 247.8 Meters—Canadian Shared:
WJBI, WGBB, WCOH, WOCL, WLCI, WPAW, WDWF, WLSI, WMAN, WJW, WEBE, WBAX, WJBU, WMBG, WSIX, WRBU, WJBY, WRBO, WGCM, KWEA, KDLR, KGCR, KFOR, WHBU, KFVS, WEBO, WCRW, WEDC, WCBS, WTAX, WHBF, WIBA, WOMT, KPQ, KPCB, WSBC, KFDN, KMJ, KFXM, KPPC, KGFJ

1220 Kilocycles, 245.6 Meters:
WCAD, WCAE, WREN, KFKU

1230 Kilocycles, 243.8 Meters:
WNAC, WBIS, WPSC, WSBT, WFBM, KFIO, KFQD

1240 Kilocycles, 241.8 Meters:
WGHP, WJAD, KSAT, WDAE

1250 Kilocycles, 239.9 Meters:
WGCP, WODA, WAAM, WLB, WGMS, WRHM, KFMX, WCAL, KIDO, WFOX, WDSU

1260 Kilocycles, 238.0 Meters:
WLBW, KWWG, KRGV, KOIL, KVOA, WTOC

1270 Kilocycles, 236.1 Meters:
WEAI, WASH, WOOD, KWLC, KGCA, KTW, KOL, KFUM, WFBR, WJDX

1280 Kilocycles, 234.2 Meters:
WCAM, WCAP, WOAX, WDOD, WRR, WCFL

1290 Kilocycles, 232.4 Meters:
WNBZ, WJAS, KTSA, KFUL, KLCN, KDYL, WEBC

1300 Kilocycles, 230.6 Meters:
WBBR, WHAP, WEVD, WHAZ, KFH, KGEF, KTBI, KFJR, KTBR, WIOD, WMBF, WOQ

1310 Kilocycles, 228.9 Meters:
WKAV, WEBR, WNBH, WOL, WGH, WRK, WAGM, WFDF, WHAT, WFKD, WFBG, WRAW, WGAL, WSAJ, WBRE, WKBC, KGHG, WOBT, WNBJ, KRMD, KFPM, WDAH, KFPL, KFXR, WKBS, WRBI, WCLS, WKBB, KWCR, KFJY, KFGO, WBOW, WJAK, WLBC, WIBU, KFBK, KTSL, KGEZ, KFUP, KFXJ, KFBK, KGEZ, KMED, KTSM, KGCX, WJAC, WSJS, KXRO, KGFW

1320 Kilocycles, 227.1 Meters:
WADC, WSMB, KID, KGIQ, KGHF

1330 Kilocycles, 225.4 Meters:
WDRC, WTAQ, KSCJ, WSAI, KGB

1340 Kilocycles, 223.7 Meters:
WSPD, KFPW, WCOA

1350 Kilocycles, 222.1 Meters:
WBNY, WMSG, WCDA, WKBQ, KWK

1360 Kilocycles, 220.4 Meters:
WLEX, WQBC, WJKS, WGES, KFBB, KGIR, KGER, KPSN, WMAF, WSSH

1370 Kilocycles, 218.8 Meters:
WMBO, WSVS, WCBM, WBBL, WHBD, WJBK, WIBM, WRAK, WELK, WJBO, WHBQ, WRBT, KGFG, KIT, KGCI, KGRC, KFJZ, KGKL, KFLX, WFBJ, KGDA, KZM, KRE, WPOE, KFBL, KWKC, KGBX, WRJN, KGAR, KLO, KOH, KVL, KFJI, KGFL, KGGM, WHDF, KOOS, WGL, KFJM, KCRC, WEHC, WMBR

1380 Kilocycles, 217.3 Meters:
KQV, KSO, WKBH, WSMK

1390 Kilocycles, 215.7 Meters:
WHK, KLRA, KUOA, KOW, KOY

1400 Kilocycles, 214.2 Meters:
WCGU, WSGH, WSDA, WLTH, WBBC, WCMA, WKBF, KOCW, WBAA, KWSC

1410 Kilocycles, 212.6 Meters:
KGRS, WDAG, KFLV, WHBL, WBCM, WODX, WSFA

1420 Kilocycles, 211.1 Meters:
WMRJ, WTBO, WKBI, WIBR, WEDH, WMBC, WKBP, WQBZ, KGFF, WHIS, KTAP, KTUE, KFYO, KICK, WIAS, KGGC, WLBF, WMBH, KFIZ, KORE, WILM, KGIW, KGKX, WLEY, KFQW, KLPM, KXL, WHDL, WHFC, WEHS, KFQU, KFXD, KGIX, KFIF

1430 Kilocycles, 209.7 Meters:
WBRL, WHP, WCAH, WGBC, WNBR, WBAK, KECA

1440 Kilocycles, 208.2 Meters:
WHEC, WABO, WOKO, WCBA, WNKC, WTAD, WMBD, KLS, WSAN

1450 Kilocycles, 206.8 Meters:
WBMS, WNJ, WIBS, WKBO, WSAR, WFJC, WTFI, KTBS, WCSO

1460 Kilocycles, 205.4 Meters:
WJSV, KSTP

1470 Kilocycles, 204.0 Meters:
WKBW, KFJF, KGA

1480 Kilocycles, 202.6 Meters:
WJAZ, WORD, WCKY, WSOA

1490 Kilocycles, 201.6 Meters:
WBAW, WLAC, KPWF, WTNT

1500 Kilocycles, 199.9 Meters:
WMBA, WLOE, WMES, WNBF, WMBO, WLBX, WWRL, WKBZ, WMPC, WOPI, WPEN, WRBJ, KGKB, KGHX, WKBV, KPJM, KVEP, KDB, KUJ, KGFI

U. S. Broadcasting Stations Listed by States

ALABAMA

Birmingham, WBRC, WKBC, WAPI
Gadsden, WJBY
Mobile, WODX
Montgomery, WSFA

ALASKA

Anchorage, KFQD
Ketchikan, KGBU

ARIZONA

Flagstaff, KFXY
Phoenix, KREP, KOY
Prescott, KPJM
Tuscon, KGAR, KVOA

ARKANSAS

Blytheville, KLCN
Fayetteville, KUOA
Hot Springs, KTHS
Little Rock, KLRA, KGHI, KGJF
McGehee, KGHG
Siloam Springs, KFPW

CALIFORNIA

Berkeley, KRE
Beverley Hills, KEJK
Burkank, KELW
Culver City, KFVD
El Centro, KXO
Fresno, KMJ
Hayward, KZM
Hollywood, KMTR, KNX, KFWB
Holy City, KFQU
Inglewood, KMIC
Long Beach, KFOX, KGER
Los Angeles, KFI, KFSG, KGEF, KGFJ, KHJ, KTBI, KECA, KFQZ
Oakland, KGO, KLS, KLX, KTAB
Pasadena, KPPC, KPSN
Richmond, KFWM
Sacramento, KFBK
San Bernardino, KFXM
San Diego, KFSD, KGB
San Francisco, KFRC, KFWI, KJBS, KPO, KGGC
San Jose, KQW
Santa Barbara, KDB
Santa Maria, KSMR
Santa Monica, KTM
Stockton, KGDM, KWG
Westminster, KPWF

COLORADO

Colorado Springs, KFUM
Denver, KFEL, KFUP, KFXF, KOA, KPOF
Dupont, KLZ
Edgewater, KFXJ
Fort Morgan, KGEW
Greeley, KFKA
Gunnison, KFHA
Pueblo, KGHF
Trinidad, KGIW
Yuma, KGEK

CONNECTICUT

Bridgeport, WICC
Hartford, WTIC
New Haven, WDRC
Storrs, WCAC

DELAWARE

Wilmington, WDEL, WILM

DISTRICT OF COLUMBIA

Washington, NAA, WMAL, WRC, WOL

FLORIDA

Clearwater, WFLA, WSUN
Gainesville, WRUF
Jacksonville, WJAX
Miami Beach, WIOD, WMBF, WQAM
Orlando, WDBO
Pensacola, WCOA
Tampa, WDAE, WMBR

GEORGIA

Atlanta, WGST, WSB
Columbus, WRBL
Macon, WMAZ
Savannah, WTOC
Tifton, WRBI
Toccoa, WTFI

HAWAII

Honolulu, KGU

IDAHO

Boise, KIDO
Idaho Falls, KID
Jerome, KFXD
Pocatello, KSEI
Sandpoint, KGKX
Twin Falls, KGIQ

ILLINOIS

Carthage, WCAZ
Chicago, KYW, WAAF, WCFL, WCRW, WEDC, WENR, WGES, WKBI, WPCC, WGN, WMAQ, WMBI, WBBM, KYWA, WSBC, WBCN, WIBO, WJAZ, WJBT, WLIB, WLS, WORD, KFKX
Cicero, WHFC
Decatur, WJBL
Evanston, WEHS
Forest Park, WSOA
Galesburg, WKBS
Harrisburg, WEBQ
Joliet, WCLS, WKBB
La Salle, WJBC
Mooseheart, WJJD
Peoria Heights, WMBD
Quincy, WTAD
Rockford, KFLV
Rock Island, WHBF
Springfield, WCBS
Streator, WTAX
Tuscola, WDZ
Urbana, WILL
Zion, WCBD

INDIANA

Anderson, WHBU
Brookville, WKBV
Culver, WCMA
Evansville, WGBF
Fort Wayne, WGL, WOWO
Gary, WJKS
Hammond, WWAE
Indianapolis, WFBM, WKBF
Lafayette, WBAA
La Porte, WRAF
Marion, WJAK
Muncie, WLBC
South Bend, WSBT
Terre Haute, WBOW

IOWA

Ames, WOI
Boone, KFGQ
Cedar Rapids, KWCR
Clarinda, KSO
Council Bluffs, KOIL
Davenport, WOC
Decorah, KGCA, KWLC
Des Moines, WHO
Ft. Dodge, KFJY
Iowa City, WSUI
Marshalltown, KFJB
Muscatine, KTNT
Ottumwa, WIAS
Red Oak, KICK
Shenandoah, KFNF, KMA
Sioux City, KSCJ
Waterloo, WMT

KANSAS

Kansas City, WLBF
Lawrence, KFKU, WREN
Manhattan, KSAC
Milford, KFKB
Topeka, WIBW
Wichita, KFH

KENTUCKY

Covington, WCKY
Hopkinsville, WFIW
Louisville, WHAS, WLAP

LOUISIANA

Cedar Grove, KGGH
Kennonwood, KWKH
New Orleans, WABZ, WCBE, WJBO, WJBW, WSMB, WWL, WDSU
Shreveport, KTSL, KWEA, KRMD, KTBS

MAINE

Bangor, WABI, WLBZ
Portland, WCSH

MARYLAND

Baltimore, WCAO, WCBM, WBAL, WFBR
Cumberland, WTBO

MASSACHUSETTS

Boston, WBZA, WEEI, WNAC, WSSH, WMES, WBIS
Fall River, WSAR
Gloucester, WHDH
Lexington, WLEX, WLEY
New Bedford, WNBH
Springfield, WBZ
Wellesley Hills, WBSO
Worcester, WTAG, WORC

MICHIGAN

Battle Creek, WKBP
Bay City, WBCM
Berrien Springs, WEMC
Calumet, WHDF
Detroit, WMBC, WWJ, WJR, WGHP
East Lansing, WKAR
Flint, WFDF
Grand Rapids, WASH, WOOD
Jackson, WIBM
Lapeer, WMPC
Ludington, WKBZ
Royal Oak, WAGM
Ypsilanti, WJBK

MINNESOTA

Anoka, WCCO
Collegeville, WFBJ
Fergus Falls, KGDE
Hallock, KGFK
Minneapolis, WDGY, WHDI, WLB, WRHM, WCCO, WGMS
Northfield, KFMX, WCAL
St. Paul, KSTP

MISSISSIPPI

Greenville, WRBQ
Gulfport, WGCM
Hattiesburg, WRBJ
Jackson, WJDX
Meridian, WCOC
Utica, WQBC

MISSOURI

Cape Girardeau, KFVS
Columbia, KFRU
Jefferson City, WOS
Joplin, WMBH
Kansas City, KWKC, WDAF, WOQ, WHB, KMBC
St. Joseph, KGBX, KFEQ
St. Louis, KFWF, KSD, KWK, WEW, WIL, KMOX, KFUO, WMAY, KFQA

MONTANA

Billings, KGHL
Butte, KGIR
Great Falls, KFBB
Kalispell, KGEZ
Wolf Point, KGCX

NEBRASKA

Clay Center, KMMJ
Lincoln, KFAB, KFOR, WCAJ
Norfolk, WJAG
Omaha, WAAW, WOW
Ravenna, KGFW
York, KGBZ

NEVADA

Las Vegas, KGIX
Reno, KOH

NEW HAMPSHIRE

Laconia, WKAV
Tilton, WBRL

NEW JERSEY

Asbury Park, WCAP
Atlantic City, WPG
Camden, WCAM
Elizabeth, WIBS
Fort Lee, WBMS
Jersey City, WAAT, WKBO
Newark, WAAM, WGCP, WNJ, WOR
Paterson, WODA
Red Bank, WJBI
Trenton, WOAX

NEW MEXICO

Albuquerque, KGGM
Raton, KGFL
State College, KOB

NEW YORK

Auburn, WMBO
Binghamton, WNBF
Brooklyn, WBBC, WLTH, WMBQ, WSGH, WSDA
Buffalo, WEBR, WGR, WKBW, WKEN, WSVS, WMAK
Canton, WCAD
Cazenovia, WMAC
Coney Island, WCGU
Freeport, WGBB
Ithaca, WLCI, WEAI
Jamaica, WMRJ
Jamestown, WOCL
Long Island City, WLBX
New York, WBNY, WHN, WJZ, WKBQ, WMCA, WMSG, WNYC, WPCH, WRNY, WABC, WOV, WQAO, WLWL, WBOQ, WCDA, WEAF, WEVD, WGBS, WHAP, WPAP
Patchogue, WPOE
Poughkeepsie, WOKO
Rochester, WHAM, WHEC
Rossville, WBBR
Saranac Lake, WNBZ
Schenectady, WGY
Syracuse, WFBL, WSYR
Tupper Lake, WHDL
Troy, WHAZ
Utica, WIBX
Woodhaven, WEVD
Woodside, WWRL
Yonkers, WCOH

NORTH CAROLINA

Asheville, WWNC
Charlotte, WBT
Gastonia, WRBU
Greensboro, WNRC
Raleigh, WPTF
Wilmington, WRBT
Winston-Salem, WSJS

NORTH DAKOTA

Bismarck, KFYR
Devils Lake, KDLR
Fargo, WDAY
Grand Forks, KFJM
Mandan, KGCU
Minot, KLPM

OHIO

Akron, WFJC
Canton, WHBC
Cambridge, WEBE
Cincinnati, WKRC, WSAI, WLW
Cleveland, WEAR, WHK, WJAY, WTAM
Columbus, WAIU, WCAH, WEAO, WMAN
Dayton, WSMK
Hamilton, WRK
Mansfield, WJW
Middleton, WSRO
Mt. Orab, WHBD
Springfield, WCSO
Steubenville, WIBR
Tallmadge, WADC
Youngstown, WKBN

OKLAHOMA

Alva, KGFF
Chickasha, KOCW
Enid, KCRC
Norman, WNAD
Oklahoma City, KFJF, KFXR, KGCB, KGFG, WKY
Picher, KGGF
Ponca City, WBBZ
Tulsa, KVOO

OREGON

Astoria, KFJI
Corvallis, KOAC
Eugene, KORE
Marshfield, KOOS
Medford, KMED
Portland, KEX, KOIN, KFIF, KFJR, KGW, KTBR, KVEP, KWJJ, KXL

PENNSYLVANIA

Allentown, WCBA, WSAN
Altoona, WFBG
Carbondale, WNBW
East Pittsburgh, KDKA
Elkins Park, WIBG
Erie, WEDH, WRAK
Frankford, WFKD
Grove City, WSAJ
Harrisburg, WRAK, WCOD
Johnstown, WJAC
Lancaster, WGAL, WKJC
Le Moyne, WHP
Lewisburg, WJBU
Oil City, WLBW
Philadelphia, WCAU, WFI, WIP, WLIT, WRAX, WPEN, WFAN, WELK, WHAT
Pittsburgh, KQV, WCAE, WJAS
Reading, WRAW
Scranton, WGBI, WQAN
State College, WPSC
Wilkes-Barre, WBAX, WBRE
Washington, WNBO

PORTO RICO

San Juan, WKAQ

RHODE ISLAND

Cranston, WDWF
Newport, WMBA
Pawtucket, WPAW
Providence, WEAN, WJAR

SOUTH CAROLINA

Charleston, WBBY

SOUTH DAKOTA

Brookings, KFDY, KGOR
Dell Rapids, KGDA
Oldham, KGDY
Pierre, KGFX
Rapid City, WCAT
Sioux Falls, KSOO
Vermillion, KUSD
Watertown, KGCR
Yankton, WNAX

TENNESSEE

Bristol, WOPI
Chattanooga, WDOD
Knoxville, WFBC, WNBJ, WNOX
Lawrenceburg, WOAN
Memphis, WGBC, WHBQ, WMC, WNBR
Nashville, WBAW, WLAC, WSM, WTNT
Springfield, WSIX
Union City, WOBT
Whitehaven, WREC

TEXAS

Abilene, KFYO
Amarillo, KGRS, WDAG
Austin, KUT
Beaumont, KFDM
Brownsville, KWWG
Brownwood, KGKB
College Station, WTAW
Corpus Christi, KGFI
Dallas, KRLD, WFAA, WRR
Dublin, KFPL
El Paso, WDAH, KTSM
Forth Worth, KFJZ, WBAP, KSAT
Galveston, KFLX, KFUL
Greenville, KFPM
Harlingen, KRGV
Houston, KPRC, KTUE
Richmond, KGHX
San Angelo, KGFI, KGKL
San Antonio, KGRC, KTAP, KTSA, WOAI
Waco, WJAD
Wichita Falls, KGKO

UTAH

Ogden, KLO
Salt Lake City, KDYL, KSL

VERMONT

Burlington, WCAX
Springfield, WNBX

VIRGINIA

Arlington, NAA
Emory, WEHC
Mt. Vernon Hills, WJSV
Newport News, WGH
Norfolk, WTAR, WPOR
Petersburg, WLBG
Richmond, WBBL, WMBG, WRVA
Roanoke, WDBJ

WASHINGTON

Aberdeen, KXRO
Bellingham, KVOS
Everett, KFBL
Lacey, KGY
Longview, KUJ
Pullman, KWSC
Seattle, KOL, KFQW, KPQ, KJR, KOMO, KPCB, KRSC, KTW, KVL, KXA
Spokane, KFIO, KFPY, KGA, KHQ
Tacoma, KMO, KVI
Yakima, KIT

WEST VIRGINIA

Bluefield, WHIS
Charleston, WOBU
Fairmont, WMMN
Huntington, WSAZ
Wheeling, WWVA
Wierton, WQBZ

WISCONSIN

Beloit, WEBW
Eau Claire, WTAQ
Fond Du Lac, KFIZ
Green Bay, WHBY
Kenosha, WCLO
La Crosse, WKBH
Madison, WHA, WIBA
Manitowac, WOMT
Milwaukee, WHAD, WISN, WTMJ
Poynette, WIBU
Racine, WRJN
Sheboygan, WHBL
Stevens Point, WLBL
Superior, WEBC

WYOMING

Casper, KDFN

SHORT WAVE RELAY BROADCASTING STATIONS

United States

Call	Owner	Kilocycles	Meters
W2XAC	General Electric, Schenectady, N. Y.	8,690	34.5
W2XAD	General Electric, Schenectady, N. Y.	15,340	19.56
W2XAF	General Electric, Schenectady, N. Y.	9,530	31.48
W2XAL	Aviation Radio, Coytesville, N. J.	6,040	49.67
W2XAL	Aviation Radio, Coytesville, N. J.	11,800	25.42
W2XAL	Aviation Radio, Coytesville, N. J.	15,250	19.67
W2XAL	Aviation Radio, Coytesville, N. J.	21,460	13.97
W2XBR	Baruchrome Corporation, New York, N. Y.	6,020	49.83
W2XCX	L. Bamberger, Newark, N. J.	6,080	49.34
W2XE	Atlantic Broadcasting Co., Jamaica, N. Y.	11,840	25.34
W2XE	Atlantic Broadcasting Co., Jamaica, N. J.	15,280	19.63
W3XAL	Radio Corporation, New York, N. Y.	6,100	49.18
W3XAL	Radio Corporation, New York, N. Y.	9,570	31.35
W3XAL	Radio Corporation, New York, N. Y.	11,720	25.6
W3XAL	Radio Corporation, New York, N. Y.	15,130	19.83
W3XAL	Radio Corporation, New York, N. Y.	17,780	16.87
W3XAL	Radio Corporation, New York, N. Y.	21,500	13.95
W3XL	Radio Corporation, New York, N. Y.	6,020	49.83
W3XAU	Universal Broadcasting Co., Philadelphia, Pa.	6,060	49.5
W3XAU	Universal Broadcasting Co., Philadelphia, Pa.	9,590	31.3
W6XAL	Pacific-Western Broadcasting Fed., Westminster, Calif.	6,080	49.34
W6XAL	Pacific-Western Broadcasting Fed., Westminster, Calif.	15,250	19.67
W6XAL	Pacific-Western Broadcasting Fed., Westminster, Calif.	21,500	13.95
W6XN	General Electric, Oakland, Calif.	12,850	23.35
W8XAL	Crosley Radio Corporation, Cincinnati, Ohio	6,060	49.5
W8XK	Westinghouse, East Pittsburgh, Pa.	6,140	48.86
W8XK	Westinghouse, East Pittsburgh, Pa.	9,570	31.35
W8XK	Westinghouse, East Pittsburgh, Pa.	11,880	25.25
W8XK	Westinghouse, East Pittsburgh, Pa.	15,210	19.72
W8XK	Westinghouse, East Pittsburgh, Pa.	17,780	16.87
W8XK	Westinghouse, East Pittsburgh, Pa.	21,540	13.93
W9XA	General Electric, Denver, Colo.	9,530	31.48
W9XAQ	Chicago Daily News, Chicago, Ill.	6,040	49.67
W9XU	Mona Motor Oil Co., Council Bluffs, Iowa	6,060	49.5
W9XF	Great Lakes Broadcasting Co., Chicago, Ill.	6,020	49.83
W9XF	Great Lakes Broadcasting Co., Chicago, Ill.	11,800	25.42
W9XF	Great Lakes Broadcasting Co., Chicago, Ill.	21,500	13.95

Foreign

Call	Owner	Kilocycles	Meters
G5SW	Chelmsford, England	12,500	24
PJZ	Curacao, Curacao	11,718.9	25.60
TJW	Hamilton, Bermuda	9,500	31.6
PCJ	Hilversum, Holland	15,220	19.71
PCJ	Hilversum, Holland	9,560	31.38
PHI	Huizen, Holland	17,773	16.88
OXQ	Kopenhavn, Denmark	9,520	31.51
OXQ	Kopenhavn, Denmark	6,090	49.26
	Koenigswusterhausen, Germany	9,560	31.38
	Koenigswusterhausen, Germany	15,200	19.74
	Koenigswusterhausen, Germany	21,500	13.95
VK3ME	Melbourne, Australia	9,510	31.55
	Paris, France	6,122	49.02
VK6WF	Perth, Australia	3,000	100
	Rome, Italy	11,810	25.40
GBX	Rugby, England	10,770	27.86
VK2ME	Sidney, Australia	9,590	31.28
UOR2	Vienna, Austria	6,072	49.4
CJRX	Winnipeg, Canada	11,720	25.60
ZTD	Durban	7,400	40.5

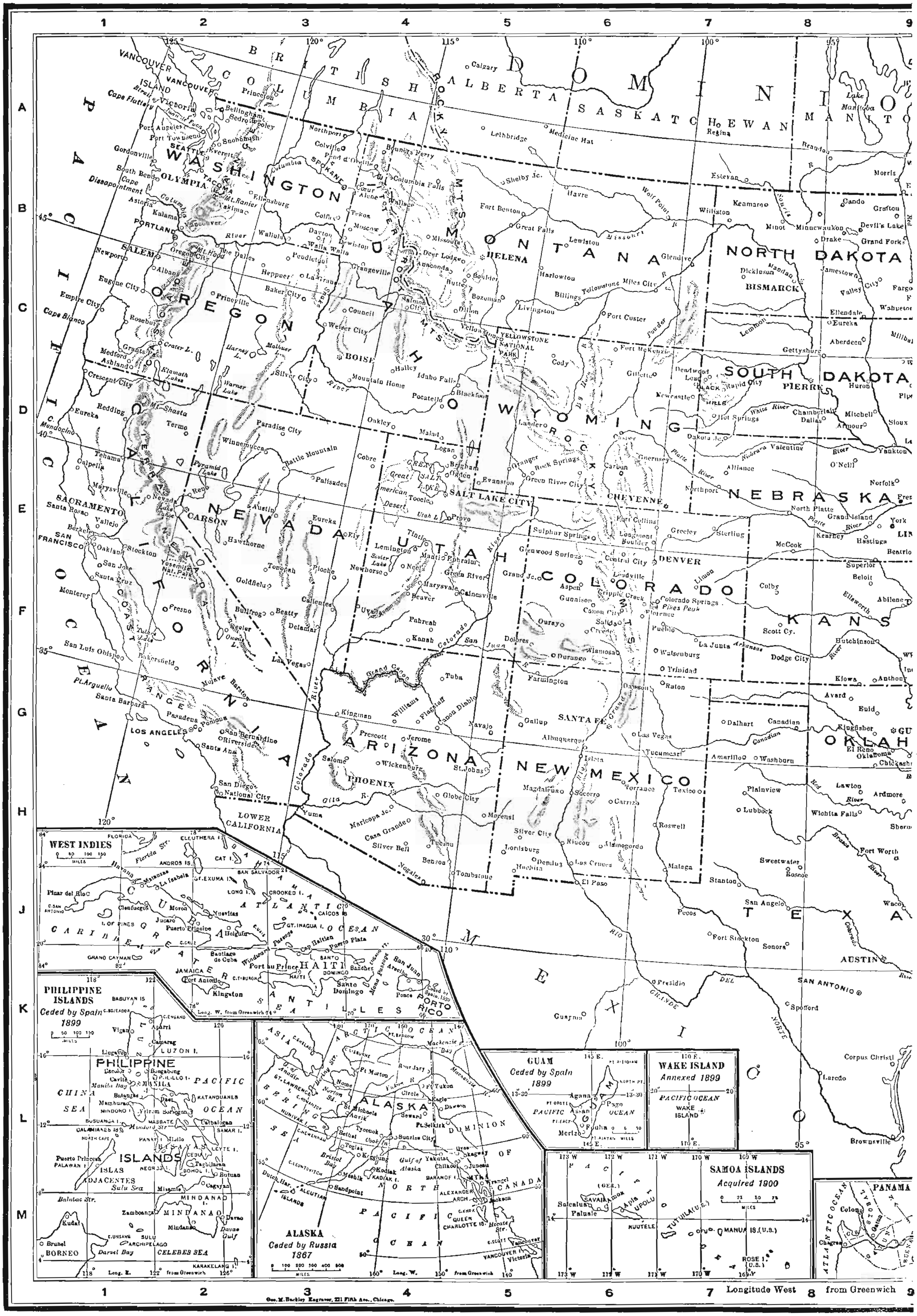
VISUAL BROADCASTING STATIONS

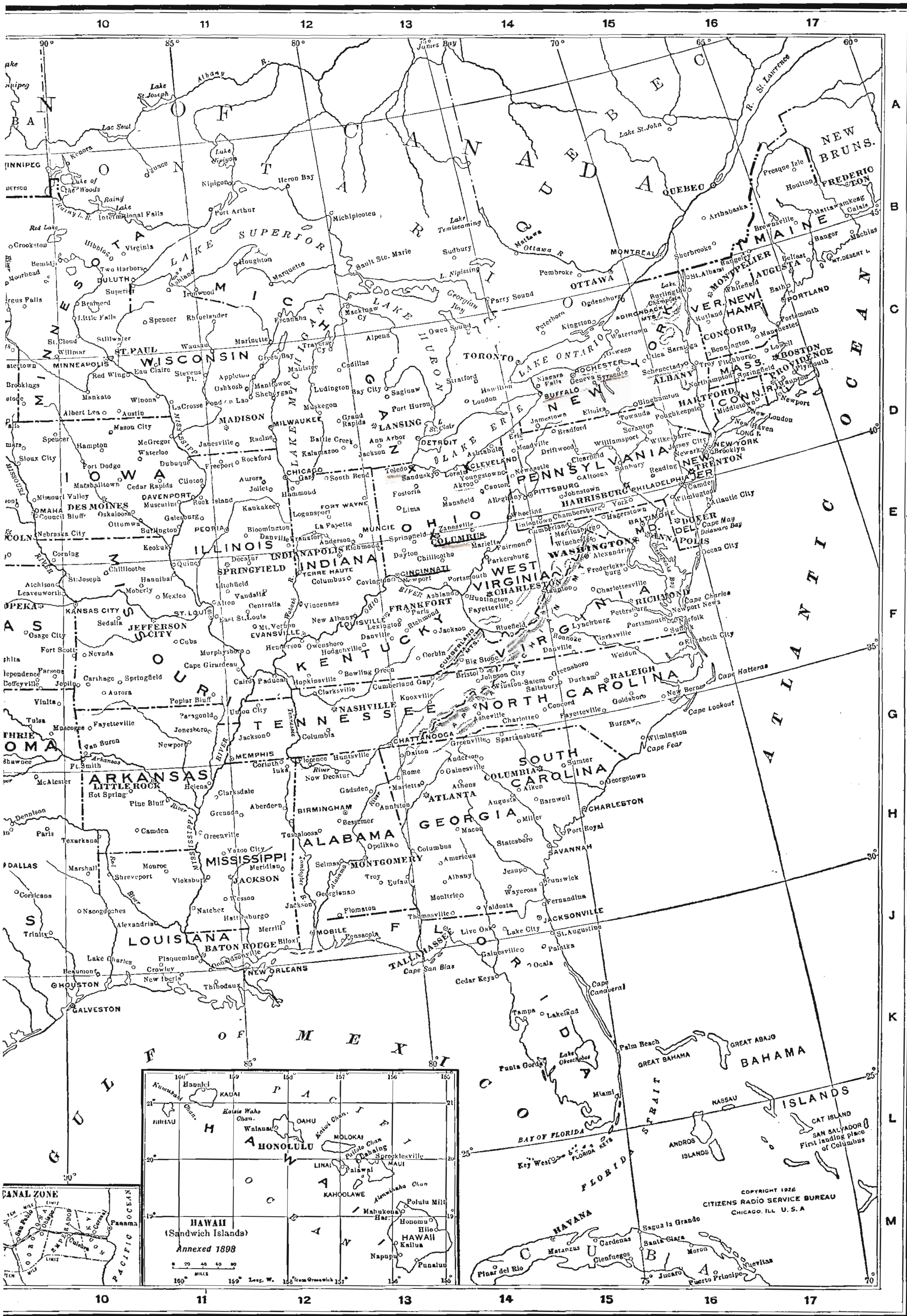
Call	Kilocycles	Meters	Owner
W1XAE	2000-2100	150-143	Westinghouse, Springfield, Mass.
W1XAY	2000-2100	150-143	Air Station, Lexington, Mass.
W1XB	2100-2200	143-136	General Industries, Somerville, Mass.
W1XB	2750-2850	109-105	General Industries, Somerville, Mass.
W2XBA	2750-2850	109-105	WAAM, Inc., Newark, N. J.
W2XBS	2000-2100	150-143	R. C. A., New York, N. Y.
W2XBU	2000-2100	150-143	H. E. Smith, Beacon, N. Y.
W2XBW	2000-2100	150-143	R. C. A., New York, N. Y.
W2XCL	2000-2100	150-143	Pilot Electric, Brooklyn, N. Y.
W2XCO	2100-2200	143-136	R. C. A., New York, N. Y.
W2XCP	2000-2100	150-143	Freed-Eisemann, New York, N. Y.
W2XCP	2850-2950	105-102	Freed-Eisemann, New York, N. Y.
W2XCR	2750-2850	109-105	Jenkins, Jersey City, N. J.
W2XCW	2100-2200	143-136	General Electric, Schenectady, N. Y.
W2XR	2850-2950	105-102	Radio Pictures, Inc., New York, N. Y.
W2XR	2100-2200	143-136	Radio Pictures, Inc., New York, N. Y.
W2XX	2000-2100	150-143	R. F. Gowen, Ossining, N. Y.
W3XAK	2000-2100	150-143	R. C. A., Bound Brook, N. J.
W3XK	2000-2100	150-143	Jenkins, Washington, D. C.
W3XK	2850-2950	105-102	Jenkins, Washington, D. C.
W4XE	2000-2100	150-143	W. J. Lee, Winter Park, Fla.
W6XAM	2000-2100	150-143	B. S. McGlashan, Los Angeles, Calif.
W6XC	4500-4600	66.7-65.2	R. B. Parrish, Los Angeles, Calif.
W7XAO	2750-2850	109-105	W. Jerman, Portland, Ore.
W8XAV	2000-2100	150-143	Westinghouse, Pittsburgh, Pa.
W8XAV	2100-2200	143-136	Westinghouse, Pittsburgh, Pa.
W8XAV	2750-2850	109-105	Westinghouse, Pittsburgh, Pa.
W9XAA	6080-	49.34	Federation of Labor, Chicago, Ill.
W9XAA	11,840-	25.34	Federation of Labor, Chicago, Ill.
W9XAA	17,780-	16.87	Federation of Labor, Chicago, Ill.
W9XAG	2000-2100	150-143	Aero Products, Chicago, Ill.
W9XAO	2000-2100	150-143	Nelson Bros. Co., Chicago, Ill.
W9XAP	2750-2850	109.1-105.3	Chicago Daily News, Chicago, Ill.
W9XAZ	2000-2100	150-143	University of Iowa, Iowa City, Ia.
W9XR	2850-2950	105-102	Great Lakes Broadcasting Co., Chicago, Ill.
WRNY	1010-	297-	Aviation Radio, Coytesville, N. J.

FOREIGN BROADCAST STATIONS

Call		Meters
	AFGHANISTAN	
	ALBANIA	
	ARGENTINA	
LOZ	Buenos Aires	330
LOS	Buenos Aires	291.2
LON	Buenos Aires	210
LOR	Buenos Aires	344.8
LOV	Buenos Aires	361.5
LOY	Buenos Aires	315.2
LOX	Buenos Aires	380
LOQ	Buenos Aires	261.8
LOO	Buenos Aires	252
LOJ	Buenos Aires	270
LOW	Buenos Aires	303
LOT	Buenos Aires	400
LOL	Buenos Aires	236
D3	Buenos Aires	253.3
B2	Buenos Aires	275
H5	Cordova	275
H6	Cordova	250
LOP	La Plata	425
LOU	Mendoza	380
M6	Mendoza	348
F2	Rosaria	270
F1	Santa Fe	279
	AUSTRALIA	
5CL	Adelaide	409
5DN	Adelaide	313
5KA	Adelaide	250
2MK	Bathurst	260
4QG	Brisbane	385
7ZL	Hobart	516
3AR	Melbourne	484
3LO	Melbourne	371
3UZ	Melbourne	319
3DB	Melbourne	255
2HD	Newcastle	288
2KY	Sydney	280
2FC	Sydney	442
2BL	Sydney	353
2BE	Sydney	316
2GB	Sydney	316
2UE	Sydney	293
2UW	Sydney	267
4GR	Toowoomba	294
	AUSTRIA	
	Graz	352
	Innsbruck	283
	Insbruck	218
	Klagenfurt	453
	Linz	246
	Vienna	516.3
	BELGIAN COLONIES	
	BELGIUM	
EB4ED	Anvers	250
EB4GT	Bruxells	260
EB4RB	Bruxells	508.5
EB4RC	Bruxells	215
EB4FO	Bruxells	230
EB4CE	Chatelineau	220
EB4FG	Dampremy	210
EB4RG	Gand	275
EB4RW	Liege	280
EB4BQ	Marchienne-Docherle	290
EB4EX	Ottomont	225
EB4CF	Verviers	215
	BOLIVIA	
	La Paz	175
	La Paz	300
	BRAZIL	
PRAM	Amparo	230
PRAH	Bahia	350
PRAN	Curytiba	340
PRAZ	Franca	270
PRAJ	Juiz de Fora	350
PRAY	Mogy das Cruzes	300
PRAD	Pelotas	326
PRAG	Porto Alegre	275
PRAP	Recife	400
PRAI	Ribeirao Preto	260
PRAA	Rio de Janeiro	400
PRAB	Rio de Janeiro	320
PRAC	Rio de Janeiro	360
PRAK	Rio de Janeiro	260
PRAS	Santos	300
PRAE	Sao Paulo	350
PRAL	Sao Paulo	400
PRAO	Sao Paulo	320
PRAR	Sao Paulo	295
	BRITISH COLONIES	
TJW	Hamilton, Bermuda	545
ZBW	Victoria Peak, Hong Kong	350
7LO	Narobi	90
1SE	Singapore	330
	BRITISH INDIA	
VUB	Bombay	357.1
VUC	Calcutta	370.4
VPB	Colombo	480
VUR	Rangoon	398
	BULGARIA	
	CANADA	
CKCR	Brantford	296.9
CFAC	Calgary	434.5
CKCN	Calgary	434.5
CHCA	Calgary	434.5
CJCJ	Calgary	434.5
CNRC	Calgary	434.5
CFCY	Charlottetown	312.3
CHCK	Charlottetown	312.3
CHWK	Chilliwack	247.8
CKMC	Cobault	247.8
CJRW	Fleming	296.9
CFNB	Fredericton	247.8
CHMA	Edmonton	516.9
CJCA	Edmonton	516.9
CKUA	Edmonton	516.9
CNRE	Edmonton	516.9
CHNS	Halifax	322.4
CHNS	Halifax	322.4
CKOC	Hamilton	340.9
CHCS	Hamilton	340.9
CFCH	Iroquois Falls	499.7
CFJC	Kamloops	267.7
CFMC	Kingston	267.7
CFRB	King	312.3
CFRC	Kingston	267.7
CJOC	Lethbridge	267.7
CJGC	London	329.5
CKPR	Midland	267.7
CFCF	Montreal	410.7
CHYC	Montreal	410.7
CKAC	Montreal	410.7
CNRM	Montreal	410.7
CJRM	Moose Jaw	296.9
CNRA	Moncton	475.9
CHML	Mt. Hamilton	340.9
CKCO	Ottawa	434.5
CNRO	Ottawa	434.5
CFLC	Prescott	296.9
CKPC	Preston	247.8
CKCI	Quebec	340.9
CKCV	Quebec	340.7
CNRQ	Quebec	340.9
CHRC	Quebec	340.9
CHWC	Regina	312.3
CJBR	Regina	312.3
CNRR	Regina	312.3
CKCK	Regina	312.3
CHCT	Red Deer	356.9
CKLC	Red Deer	356.9
CJHS	Saskatoon	329.5
CFQC	Saskatoon	329.5
CNRS	Saskatoon	329.5
CJOR	Sea Island	291.1
CKSH	St. Hyacinthe	296.9
CFBO	St. John	336.9
CHGS	Summerside	267.7
CJCB	Sydney, N. S.	340.9
CHNC	Toronto	516.9
CKNC	Toronto	516.9
CKGW	Toronto	434.8
CJBC	Toronto	517.2
CNRT	Toronto	356.9
CJSC	Toronto	516.9
CKCL	Toronto	516.9
CKOW	Toronto	356.9
CFCA	Toronto	356.9
CHLS	Vancouver	410.7
CKCD	Vancouver	410.7
CKFC	Vancouver	410.7
CKMO	Vancouver	410.7
CKWX	Vancouver	410.7
CNRV	Vancouver	291.1
CFCT	Victoria	475.9
CKY	Winnipeg	384.4
CNRW	Winnipeg	384.4
CJGX	Yorktown	475.9
	CHILE	
CMAO	Antofagasta	
	Asuncion	
CMAI	Concepcion	345
CMAD	Santiago	320
CMAE	Santiago	280
CMAT	Tacna	550
CMAK	Temuco	245
	Valparaiso	400
	CHINA	
COHB	Harbin	445
COMK	Mukden	425
	Shanghai	342
XOL	Tientsin	480
GEC	Tientsin	280
	COLOMBIA	
	COSTA RICA	
	CUBA	
CM6EV	Caibarien	250
CM6LO	Caibarien	325
CM7AZ	Camaguey	225
CM7LO	Camaguey	230
CM6YR	Camajuani	200
CM7BY	Ciego de Avila	235
CM7FU	Ciego de Avila	200
CM7HS	Ciego de Avila	192
CM6BY	Cienfuegos	260
CM5EV	Colon	360
CM1PK	Guanajay	190
CMI	Habana	376
CMC	Habana	357
CM2AB	Habana	250
CM2AR	Habana	248
CM2AZ	Habana	334
CM2CP	Habana	280
CM2HP	Habana	205
CM2JP	Habana	270
CM2OH	Habana	300
CM2OK	Habana	360
CM2RK	Habana	326
CM2SE	Habana	208
CM2TW	Habana	255
CM2UF	Habana	228
CM2WX	Habana	341
CM2XA	Habana	230
CM2XX	Habana	225
CM2BX	Habana	312.5
CM2JK	Habana	342.5
CM2LC	Habana	315
CM2LP	Habana	359
CM2LR	Habana	215
CM2MC	Habana	243
CM2MG	Habana	292
CM2PC	Habana	212
CM2RC	Habana	258
CM2FG	Hershey	226
CM2WD	Marianao	274
CM2XX	Marianao	225
CM2JF	Marianao	252
CM2JL	Marianao	294
CM2MA	Marianao	278
CM2SW	Marianao	274
CM1AZ	Mariel	275
CM7NM	Nuevitas	264

Call	Station	Meters
CM6HS	Sagua la Grande	200
CM6KP	Sancti Spiritus	280
CM6MN	Santa Clara	210
CM8HS	Santa Clara	200
CM6WT	Santiago	200
CM8BY	Santiago	150
CM8KW	Santiago	250
CM6KW	Tuinucu	368
	CURACAO	
	CZECHOSLOVAKIA	
OKR	Bratislava	279
	Bratislava	300
OKB	Brno	342
	Kosice	293
	Moravska-Ostrava	263
OKP	Praha	487
	Prague	250
	DANZIG	
	Danzig	453
	DENMARK	
	Kalundborg	1153.8
	Kalundborg	1680
	Kobenhavn	281
	Soro	1153.8
	Soro	1680
	DOMINICAN REPUBLIC	
	DUTCH EAST INDIES	
PFC	Batavia	220.7
PLE	Bandoeng	31.86
PLE	Bandoeng	15.93
	Bandoeng	310
PLF	Malabar	17
	Surabaya	140
	ECUADOR	
	EGYPT	
SRE	Cairo	255
	ETHIOPIA	
	ESTONIA	
	Tallinn	295
	FINLAND	
	Helsingin	221
	Lahden	1800
	Pietarsaaren	246
SCG	Porin	218
	Tampereen	400
	Turun	256
	Tammerfors	453
	Turku	246
	Viipurin	291
	FRANCE	
PTT	Bordeaux	304
	Corsica	237
	Grenoble	329
	Limoges	293
	Lille	265
	Lyon	466
	Marseilles	316
	Montpelier	286
	Nice	237
	Paris	1725
FL	Paris	1444
	Paris	447
	Rennes	272
	Strasbourg	346
	Toulousse	381
	Toulousse	255
	FRENCH COLONIES	
8DR	Algiers	310
8KR	Constantine	42.8
	Haiphong	320
TUA	Tunis	1450
	GERMANY	
	Aachen	453
	Augsburg	560
	Berlin I	418
	Berlin II	283
	Bremen	339
	Breslau	325
	Dresden	319
	Flensburg	218
	Frankfurt	390
	Freiburg	569
	Gleiwitz	253
	Hamburg	372
	Hanover	560
	Kaiserslautern	270
	Kassel	246
	Kiel	246
	Koln	227
	Konigsberg	276
	Konigswusterhausen	1635
	Langenberg	473
	Leipzig	259
	Magdeburg	283
	Munchen	533
	Munster	234
	Nurnberg	239
	Stettin	283
	Stuttgart	360
	Zeesen	1635
	GREAT BRITAIN	
2BD	Aberdeen	301
2BE	Belfast	242
6BM	Bournemouth	288.5
2LS	Bradford	288.5
5WA	Cardiff	310
5GB	Daventry	479
5XX	Daventry	1553
2DE	Dundee	288.5
2EH	Edinburgh	288.5
5SC	Glasgow	399
6KH	Hull	288.5
2LS	Leeds-Bradford	200
6LV	Liverpool	288.5
2LO	London	356
2ZY	Manchester	377
5NO	Newcastle	261
5PY	Plymouth	288.5
6FL	Sheffield	288.5
6ST	Stoke-on-Trent	288.5
5SX	Swansea	288.5
	GREECE	
	GUATEMALA	
	HAITI	
HHK	Port au Prince	361.2
	HEDJAZ	
	HOLLAND	
	Bloemendaal	200
	Hilversum	1875
HDO	Hilversum	1071
	Hilversum	298
	Huizen	298
	Huizen	1875
	Scheveningen	1870
	HONDURAS	
	HUNGARY	
	Lakihegy	550
	ICELAND	
	Akureyri	192
	Reykjavik	
	IRAQ	
	IRISH FREE STATE	
6CK	Cork	225
2RN	Dublin	413
	ITALY	
1BO	Bolzano	445.9
1GE	Genoa	385.1
1MI	Milan	500.8
1NA	Naples	331.4
	Palermo	209.8
1RO	Rome	441.1
1TO	Torino	275.2
	Trieste	256.4
	ITALIAN COLONIES	
	JAPAN	
JQAK	Dairen	395
JOFK	Hiroshima	353
JODK	Keijo	366
JOGK	Kumamoto	380
JOCK	Nagoya	370
JOBK	Osaka	400
JOIK	Sapporo	361
JOHK	Sendai	390
JOAK	Tokyo	345
	JUGOSLAVIA	
	Belgrade	429
	Ljubljano	566
	Zagreb	308
	LATVIA	
YLZ	Riga	525
	LIBERIA	
	LITHUANIA	
RYK	Kaunas	1935
	LUXEMBURG	
	MEXICO	
XFF	Chihuahua	325
XEA	Guadalajara	250
XFC	Jalapa	475
XES	Lerdo	250
XEY	Merida	548.6
XEX	Mexico City	325
XFX	Mexico City	357
XEN	Mexico City	410
XEB	Mexico City	450
XFG	Mexico City	470
XFI	Mexico City	507
XFA	Mexico City	600-500
XEH	Monterey	311
XEI	Morelia	300
XEF	Oaxaca	265
XEE	Puebla	312
	MONACO	
	Monaco	237
	MOROCCO	
CNO	Casablanca	250
AIN	Casablanca	51
	Rabat	416
	Rabat	724.6
	NEWFOUNDLAND	
	NEW HEBRIDES	
	NEW ZEALAND	
1ZB	Auckland	275.2
1ZQ	Auckland	252.1
1YA	Auckland	333.3
3ZC	Christchurch	250
3YA	Christchurch	306.1
4ZB	Dunedin	277.8
4ZO	Dunedin	277.8
4ZL	Dunedin	245.9
4ZM	Dunedin	277.8
4YA	Dunedin	461.5
2ZM	Gisborne	260.9
2ZF	Palmerston	285.7
2ZK	Wanganui	500
2YA	Wellington	416.7
	NICARAGUA	
	NORWAY	
LKA	Alesund	453
LKB	Bergen	364
LKF	Fredriksstad	394
LKH	Hamar	570
LKN	Notodden	283
LKO	Oslo	493
LKP	Porsgrund	453
LKR	Rjuken	447
LKM	Tromso	453
	Trondjhen	1072
	PANAMA	
	PARAGUAY	
	PERSIA	
	PERU	
OAX	Lima	380
	PHILIPPINE ISLANDS	
KZIB	Manila	260
KZKZ	Manila	270.3
KZRM	Manila	413
	POLAND	
	Krakow	313
	Krakow	244
	Kattowitz	408
	Lodz	234
	Poznan	335
	Warszawa	214
	Warszawa	1411
	Wilno	385.1
	PORTUGAL	
PIAA	Lisbon	305
	PORTUGUESE COLONIES	
	ROUMANIA	
	Bucharest	394
	Bucharest	226
	Jassy	211
	SAAR TERRITORY	
	SALVADOR	
AQM	Salvador	482
	SIAM	
	SPAIN	
EAJ18	Almeria	251
EAJ13	Barcelona	462
EAJ1	Barcelona	344.8
EAJ12	Barcelona	268
EAJ9	Bilbao	434.8
EAJ3	Cadiz	400
EAJ16	Cartagena	246
EAR5	Las Palmas	250
EAR5	Las Palmas	350
EAJ7	Madrid	375
EAJ2	Madrid	424
EAJ25	Malaga	100
EAJ19	Oviedo	268
EAJ27	Salamanca	453
EAJ8	San Sebastian	349
EAJ17	Seville	368
	SURINAM	
	SWEDEN	
SBE	Boden	1200
SCA	Boras	231
SCB	Eskilstuna	246
SCC	Falum	322
SCD	Gavle	204.1
SBB	Goteborg	322
SCE	Halmstad	216
SCG	Halsingborg	231
SBH	Horby	257
SCF	Hudiksvall	270
SCH	Jonkoping	202
SCI	Kalmar	246
SCJ	Karlskrona	196
SCK	Karlstadt	218
SCL	Kiruna	246
SCM	Kristinehamn	203
SCN	Malmberget	436
SBC	Malmo	231
SBG	Motala	1348
SCO	Norrkoping	270
SCV	Orebro	237
SCW	Ornskoldsvik	218
SBF	Ostersund	770
SCP		
SCP	Saffle	246
SBA	Stockholm	436
SBD	Sundsvall	542
SCQ	Trollhattan	270
SCR	Uddevalla	283
SCS	Umea	231
SCT	Uppsla	453
SCU	Varborg	283
	SWITZERLAND	
HB3	Bale	1010
	Berne	403
	Geneva	760
	Lausanne	680
HBZ	Zurich	459
	TURKEY	
	Angora	1806
TAL	Istanbul	1200
	Osmanieh	1200
	UNION OF SOVIET SOCIALIST REPUBLICS	
	Archangel	511
RA47	Armavir	720
RA56	Artemovsk	379
RA26	Astrakhan	700
RA45	Baku	750
RA8	Bogorodsk	750
RA30	Dneipropetrovsk	383
RA49	Erivan	1050
RA39	Gomel	483
RA57	Irkutsk	1100
RA7	Ivanovo-Vosnesensk	337
RA43	Kharkov	1304
RA45	Kiev	800
RA34	Koursk	401
RA38	Krasnodar	513
	Kharhor	427
RA59	Leningrad	351
RA42	Leningrad	1000
RA18	Minsk	700
	Moscow	938
	Moscow	825
	Moscow	497
RA2	Moscow	450
RA4	Moscow	450
RA1	Moscow	1581
RA67	Nalchik	1075
RA13	Nizhni-Novgorod	840
RA32	Novorossisk	1117
	Nikolaerev	366
RA40	Odessa	411
RA25	Orenburg	640
RA64	Petropavlovsk	778
RA46	Petrozavodsk	765
RA14	Rostov-on-Don	820
RA22	Samara	900
RA32	Saratov	420
RA9	Sevastopol	900
	Simferopol	476
RA68	Smolensk	330
RA72	Smolensk	150
	Smolensk	565
RA77	Stalino	730
RA20	Stavropol	550
RA15	Sverdlovsk	1050
RA27	Tashkent	715
RA11	Tiflis	870
RA21	Tomsk	300
RA44	Tver	370
RA51	Ulyanovsk	500
RA16	Vel Ustjuk	650
RA17	Vladivostok	480
RA41	Vologda	875
RA12	Vorenezh	950
	URUGUAY	
CWOA	Montevideo	428.4
CWOH	Montevideo	300
CWOO	Montevideo	294.1
CWOR	Montevideo	394.6
CWOS	Montevideo	380
CWSK	Montevideo	250
CWSC	Montevideo	277.8
CWOB	Montevideo	290
CWOW	Montevideo	450
CWSI	Paysandu	268
CWOI	Salto	246
CWOJ	Salto	250
	UNION OF SOUTH AFRICA	
ZTC	Capetown	375
ZTD	Durban	406.5
ZTJ	Johannesburg	450
ZTJ	Johannesburg	32
	Pretoria	323
	VENEZUELA	
AYRE	Caracas	375


BRITISH COLUMBIA
ALBERTA
SASKATCHEWAN
MANITOBA
DOMINION
PACIFIC OCEAN
WASHINGTON
OREGON
CALIFORNIA
NEVADA
IDAHO
MONTANA
WYOMING
UTAH
ARIZONA
COLORADO
NEW MEXICO
NORTH DAKOTA
SOUTH DAKOTA
NEBRASKA
KANSAS
OKLAHOMA
TEXAS
MEXICO
LOWER CALIFORNIA
ROCKY MTS.
WEST INDIES
ATLANTIC OCEAN
CARIBBEAN SEA
ANTILLES
HAITI
PORTO RICO
PHILIPPINE ISLANDS
Ceded by Spain 1899
PACIFIC OCEAN
CHINA SEA
ALASKA
Ceded by Russia 1867
BERING SEA
ARCTIC OCEAN
GUAM
Ceded by Spain 1899
WAKE ISLAND
Annexed 1899
SAMOA ISLANDS
Acquired 1900
PANAMA
Longitude West from Greenwich
Geo. M. Buchley Engraver, 321 Fifth Ave., Chicago.



ONTARIO
QUEBEC
CANADA
LAKE SUPERIOR
LAKE HURON
LAKE ONTARIO
LAKE ERIE
LAKE MICHIGAN
MINNESOTA
WISCONSIN
MICHIGAN
IOWA
ILLINOIS
INDIANA
OHIO
PENNSYLVANIA
NEW YORK
MAINE
VER.
NEW HAMP
MASS.
CONN.
R.I.
NEW JERSEY
DEL.
MD.
WEST VIRGINIA
VIRGINIA
KENTUCKY
TENNESSEE
NORTH CAROLINA
SOUTH CAROLINA
GEORGIA
ALABAMA
MISSISSIPPI
LOUISIANA
ARKANSAS
MISSOURI
FLORIDA
NEW BRUNS.
ATLANTIC OCEAN
GULF OF MEXICO
BAHAMA ISLANDS
CUBA
HAVANA
FLORIDA STRAIT
BAY OF FLORIDA
HAWAII
(Sandwich Islands)
Annexed 1898
PACIFIC OCEAN
CANAL ZONE
OTTAWA
MONTREAL
QUEBEC
TORONTO
ALBANY
BOSTON
PROVIDENCE
HARTFORD
CONCORD
MONTPELIER
AUGUSTA
PORTLAND
TRENTON
HARRISBURG
PHILADELPHIA
PITTSBURG
DOVER
ANNAPOLIS
WASHINGTON
RICHMOND
CHARLESTON
COLUMBUS
CLEVELAND
DETROIT
LANSING
CHICAGO
MILWAUKEE
MADISON
ST. PAUL
MINNEAPOLIS
DULUTH
DES MOINES
DAVENPORT
SPRINGFIELD
INDIANAPOLIS
CINCINNATI
FRANKFORT
LOUISVILLE
EVANSVILLE
NASHVILLE
MEMPHIS
CHATTANOOGA
ATLANTA
RALEIGH
COLUMBIA
SAVANNAH
CHARLESTON
JACKSONVILLE
TALLAHASSEE
MONTGOMERY
BIRMINGHAM
MOBILE
JACKSON
BATON ROUGE
NEW ORLEANS
LITTLE ROCK
ST. LOUIS
JEFFERSON CITY
KANSAS CITY
HOUSTON
GALVESTON
DALLAS
HONOLULU
COPYRIGHT 1926
CITIZENS RADIO SERVICE BUREAU
CHICAGO, ILL. U. S. A.

AIR-LINE DISTANCES IN STATUTE MILES

FROM/TO	Albuquerque, N. Mex.	Atlanta, Ga.	Baltimore, Md.	Boise, Idaho	Boston, Mass.	Brownsville, Tex.	Buffalo, N. Y.	Chicago, Ill.	Cincinnati, Ohio	Cleveland, Ohio	Denver, Colo.	Des Moines, Iowa	Detroit, Mich.	El Paso, Tex.	Fargo, N. Dak.	Fort Worth, Tex.	Galveston, Tex.	Hastings, Nebr.	Hot Springs, Ark.	Houghton, Mich.	Jacksonville, Fla.	Kansas City, Mo.	Los Angeles Calif.	Louisville, Ky.	Memphis, Tenn.
Albuquerque, N. Mex.	......	1273	1670	774	1967	838	1577	1126	1248	1417	332	833	1360	228	968	561	803	588	773	1252	1492	717	663	1174	938
Atlanta, Ga.	1273	......	575	1830	933	960	695	583	368	550	1208	738	595	1293	1112	750	688	901	498	947	286	675	1935	317	335
Baltimore, Md.	1670	575	......	2055	358	1525	273	603	423	305	1505	913	398	1750	1143	1239	1245	1154	964	808	682	962	2313	498	792
Boise, Idaho	774	1830	2055	......	2266	1610	1872	1453	1663	1754	637	1155	1671	969	975	1263	1538	934	1384	1367	2098	1158	663	1623	1506
Boston, Mass.	1967	933	358	2266	......	1881	398	849	737	550	1766	1159	613	2067	1304	1574	1598	1415	1302	922	1015	1250	2590	823	1133
Brownsville, Tex.	838	960	1525	1610	1881	......	1575	1234	1184	1402	1047	1102	1398	682	1445	471	287	1013	650	1543	1025	923	1370	1093	777
Buffalo, N. Y.	1577	695	273	1872	398	1575	......	454	392	175	1368	762	218	1690	923	1221	1289	1019	956	560	880	862	2195	483	802
Chicago, Ill.	1126	583	603	1453	849	1234	454	......	249	307	918	310	236	1249	571	820	954	566	585	367	861	413	1741	268	481
Cincinnati, Ohio	1248	368	423	1663	737	1184	392	249	......	218	1090	509	234	1333	818	839	897	742	569	589	628	541	1892	92	410
Cleveland, Ohio	1417	550	305	1754	550	1402	175	307	218	......	1223	617	94	1521	838	1046	1116	871	787	518	768	700	2044	309	627
Denver, Colo.	332	1208	1505	637	1766	1047	1368	918	1090	1223	......	607	1153	554	642	643	925	353	749	970	1468	555	828	1035	878
Des Moines, Iowa	833	738	913	1155	1159	1102	762	310	509	617	607	......	545	980	397	640	851	256	488	458	1024	180	1433	477	485
Detroit, Mich.	1360	595	398	1671	613	1398	218	236	234	94	1153	545	......	1475	745	1018	1111	800	761	427	832	643	1976	315	621
El Paso, Tex.	228	1293	1750	969	2067	682	1690	1249	1333	1521	554	980	1475	......	1161	543	723	757	802	1422	1481	836	702	1253	978
Fargo, N. Dak.	968	1112	1143	975	1304	1445	923	571	818	838	642	397	745	1161	......	973	1218	440	875	393	1400	548	1426	818	882
Fort Worth, Tex.	561	750	1239	1263	1574	471	1221	820	839	1046	643	640	1018	543	973	......	283	544	273	1093	943	460	1212	751	448
Galveston, Tex.	803	688	1245	1538	1598	287	1289	954	897	1116	925	851	1111	723	1218	283	......	808	375	1277	799	677	1423	807	492
Hastings, Nebr.	588	901	1154	934	1415	1013	1019	566	742	871	353	256	800	757	440	544	808	......	513	666	1178	226	1177	693	591
Hot Springs, Ark.	773	498	964	1384	1302	650	956	585	569	787	749	488	761	802	875	273	375	513	......	901	728	326	1437	480	176
Houghton, Mich.	1252	947	808	1367	922	1543	560	367	589	518	970	458	427	1422	393	1093	1277	666	901	......	1216	633	1787	636	830
Jacksonville, Fla.	1492	286	682	2098	1015	1025	880	861	628	768	1468	1024	832	1481	1400	943	799	1178	728	1216	......	952	2153	595	591
Kansas City, Mo.	717	675	962	1158	1250	923	862	413	541	700	555	180	643	836	548	460	677	226	326	633	952	......	1352	480	370
Los Angeles, Calif.	663	1935	2313	663	2590	1370	2195	1741	1892	2044	828	1433	1976	702	1426	1212	1423	1177	1437	1787	2153	1352	......	1825	1602
Louisville, Ky.	1174	317	498	1623	823	1093	483	268	92	309	1035	477	315	1253	818	751	807	693	480	636	595	480	1825	......	319
Memphis, Tenn.	938	335	792	1506	1133	777	802	481	410	627	878	485	621	978	882	448	492	591	176	830	591	370	1602	319	......
Miami, Fla.	1710	610	958	2368	1258	1100	1184	1190	957	1088	1732	1338	1156	1662	1721	1150	941	1468	983	1545	328	1247	2355	923	878
Minneapolis, Minn.	980	905	948	1140	1125	1335	733	356	603	632	699	235	542	1156	219	870	1087	399	722	272	1192	413	1522	605	700
Missoula, Mont.	895	1790	1947	252	2124	1706	1740	1348	1578	1640	670	1074	1552	1115	819	1312	1595	891	1385	1208	2070	1117	910	1550	1483
Nashville, Tenn.	1117	218	597	1631	941	952	626	394	239	456	1018	523	468	1169	900	643	666	697	370	760	502	472	1777	153	195
New Orleans, La.	1030	427	1001	1713	1359	536	1087	831	708	922	1079	825	938	986	1221	470	288	870	358	1187	511	678	1675	623	358
New York, N. Y.	1810	747	170	2153	188	1695	291	711	568	404	1628	1023	483	1902	1213	1398	1415	1275	1125	849	838	1097	2446	650	953
Norfolk, Va.	1696	507	167	2137	467	1465	435	696	474	429	1562	983	522	1755	1258	1226	1195	1216	955	946	548	1009	2352	528	778
Oklahoma, Okla.	518	753	1173	1138	1490	659	1117	689	755	946	503	469	905	578	786	188	456	357	260	926	988	293	1182	675	422
Omaha, Nebr.	718	815	1026	1044	1280	1061	883	432	620	738	485	122	666	875	390	590	828	135	490	547	1098	165	1312	579	529
Philadelphia, Pa.	1748	663	90	2113	268	1614	278	664	501	343	1575	972	444	1834	1186	1324	1335	1222	1051	827	758	1037	2388	580	878
Phoenix, Ariz.	330	1592	2002	733	2295	1023	1904	1451	1578	1745	585	1154	1685	347	1225	858	1065	901	1094	1550	1800	1045	357	1512	1264
Pittsburgh, Pa.	1498	520	194	1863	478	1424	178	411	258	115	1320	718	208	1592	952	1097	1140	967	825	630	703	784	2135	345	660
Portland, Me.	2015	1022	446	2282	100	1961	438	892	802	603	1803	1197	657	2126	1313	1642	1678	1454	1371	924	1113	1300	2631	892	1205
Portland, Oreg.	1107	2172	2367	349	2553	1944	2167	1765	1987	2063	985	1479	1975	1286	1248	1612	1885	1271	1733	1638	2442	1397	825	1953	1852
Richmond, Va.	1628	470	128	2060	471	1428	375	618	399	353	1488	905	445	1695	1180	1170	1154	1142	897	870	953	937	2283	457	722
St. Louis, Mo.	938	467	731	1389	1036	975	662	259	308	490	793	270	452	1033	658	568	697	455	325	591	755	238	1585	242	242
Salt Lake City, Utah	483	1580	1858	292	2099	1317	1701	1260	1450	1567	372	952	1490	689	865	977	1249	708	1116	1242	1840	922	577	1400	1250
San Francisco, Calif.	893	2133	2451	516	2696	1675	2298	1855	2037	2163	946	1547	2087	993	1447	1454	1693	1297	1648	1833	2375	1500	345	1983	1800
Schenectady, N. Y.	1823	840	278	2120	150	1770	249	702	605	408	1618	1012	467	1930	1157	1445	1487	1267	1175	776	960	1107	2445	695	1010
Seattle, Wash.	1178	2180	2341	405	2508	2015	2130	1743	1974	2035	1020	1470	1945	1373	1206	1658	1938	1288	1759	1588	2450	1505	956	1945	1867
Shreveport, La.	764	548	1064	1433	1410	510	1080	725	688	904	799	624	891	752	1002	209	233	615	142	1043	733	326	1420	598	279
Spokane, Wash.	1028	1960	2110	290	2279	1852	1900	1514	1746	1804	827	1243	1715	1238	976	1470	1753	1061	1552	1360	2239	1286	939	1720	1652
Springfield, Mass.	1889	863	282	2196	79	1805	325	774	659	473	1692	1085	540	1990	1240	1495	1524	1340	1224	860	957	1173	2515	745	1055
Vermillion, S. Dak.	742	917	1083	973	1314	1161	916	479	694	785	468	187	705	920	284	689	938	167	605	510	1203	280	1291	663	642
Washington, D. C.	1648	542	33	2045	392	1493	290	594	403	303	1490	985	397	1726	1141	1210	1214	1139	936	813	647	943	2295	473	763

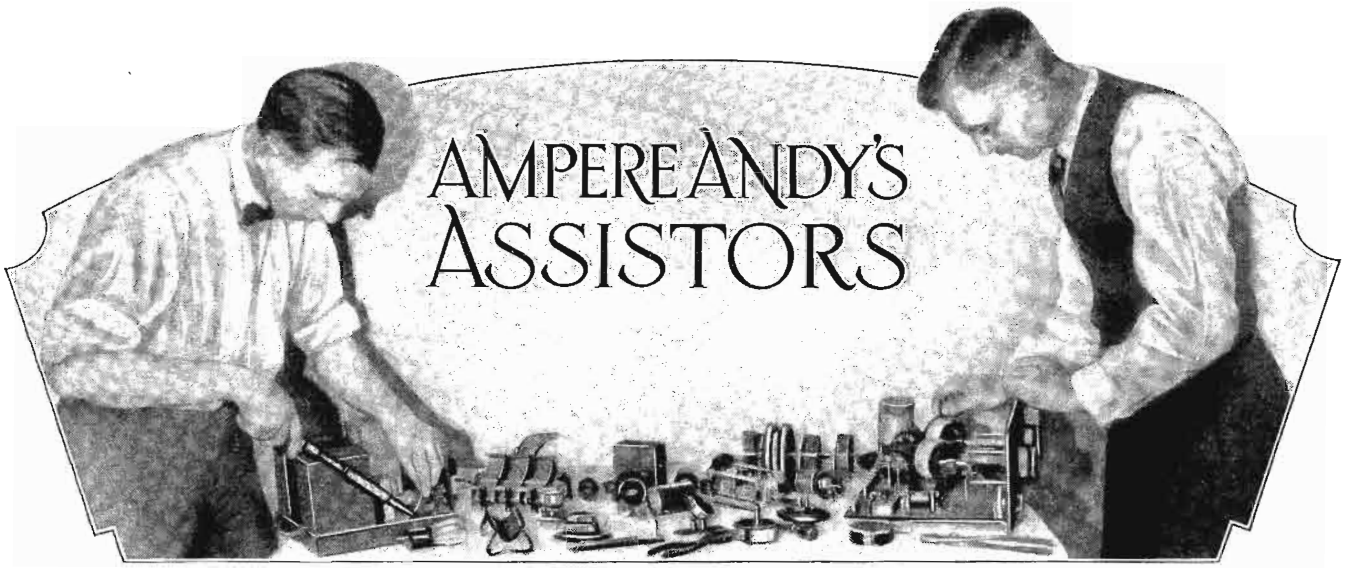
AIR-LINE DISTANCES IN STATUTE MILES

FROM/TO	Miami, Fla.	Minneapolis, Minn.	Missoula, Mont.	Nashville, Tenn.	New Orleans, La.	New York, N. Y.	Norfolk, Va.	Oklahoma, Okla.	Omaha, Nebr.	Philadelphia, Pa.	Phoenix, Ariz.	Pittsburgh, Pa.	Portland, Me.	Portland, Ore.	Richmond, Va.	St. Louis, Mo.	Salt Lake City, Utah	San Francisco, Calif.	Schenectady, N. Y.	Seattle, Wash.	Shreveport, La.	Spokane, Wash.	Springfield, Mass.	Vermillion, S. Dak.	Washington, D. C.
Albuquerque, N. Mex.	1710	980	895	1117	1030	1810	1696	518	718	1748	330	1498	2015	1107	1628	938	483	893	1823	1178	764	1028	1889	742	1648
Atlanta, Ga.	610	905	1790	218	427	747	507	753	815	663	1592	520	1022	2172	470	467	1580	2133	840	2180	548	1960	863	917	542
Baltimore, Md.	958	948	1947	597	1001	170	167	1173	1026	90	2202	194	446	2367	128	731	1858	2451	278	2341	1064	2110	282	1083	33
Boise, Idaho	2368	1140	252	1631	1713	2153	2137	1138	1044	2113	733	1863	2282	349	2060	1389	292	516	2120	405	1433	290	2196	973	2045
Boston, Mass.	1258	1125	2124	941	1359	188	467	1490	1280	268	2295	478	100	2553	471	1036	2099	2696	150	2508	1410	2279	79	1314	392
Brownsville, Tex.	1100	1335	1706	952	536	1695	1465	659	1061	1614	1023	1424	1961	1944	1428	975	1317	1675	1770	2015	510	1852	1805	1161	1493
Buffalo, N. Y.	1184	733	1740	626	1087	291	435	1117	883	278	1904	178	438	2167	375	662	1701	2298	249	2130	1080	1900	325	916	290
Chicago, Ill.	1190	356	1348	394	831	711	696	689	432	664	1451	411	892	1765	618	250	1260	1855	702	1743	725	1514	774	479	594
Cincinnati, Ohio	957	603	1578	239	708	568	474	755	620	501	1578	258	802	1987	399	308	1450	2037	605	1974	688	1746	659	694	403
Cleveland, Ohio	1088	632	1640	456	922	404	429	946	738	343	1745	115	603	2063	353	490	1567	2163	408	2035	904	1804	473	785	303
Denver, Colo.	1732	699	670	1018	1079	1628	1562	503	485	1575	585	1320	1803	985	1488	793	372	946	1618	1020	799	827	1692	468	1490
Des Moines, Iowa	1338	235	1074	523	825	1023	983	469	122	972	1154	718	1197	1479	905	270	952	1547	1012	1470	624	1243	1085	187	895
Detroit, Mich.	1156	542	1552	468	938	483	522	905	666	444	1685	208	657	1975	445	452	1490	2087	467	1945	891	1715	540	705	397
El Paso, Tex.	1662	1156	1115	1169	986	1902	1755	578	875	1834	347	1592	2126	1286	1695	1033	689	993	1930	1373	752	1238	1990	920	1726
Fargo, N. Dak.	1721	219	819	900	1221	1213	1258	786	390	1186	1225	952	1313	1248	1180	658	865	1447	1157	1206	1002	976	1240	284	1141
Fort Worth, Tex.	1150	870	1312	643	470	1398	1226	188	590	1324	858	1097	1642	1612	1170	568	977	1454	1445	1658	209	1470	1495	689	1210
Galveston, Tex.	941	1087	1595	666	288	1415	1195	456	828	1335	1065	1140	1678	1885	1154	697	1249	1693	1487	1938	233	1753	1524	938	1214
Hastings, Nebr.	1468	399	891	697	870	1275	1216	357	135	1222	901	967	1454	1271	1142	455	708	1297	1267	1288	615	1061	1340	167	1139
Hot Springs, Ark.	983	722	1385	370	358	1125	955	260	490	1051	1094	825	1371	1733	897	325	1116	1648	1175	1759	142	1552	1224	605	936
Houghton, Mich.	1545	272	1208	760	1187	849	946	926	547	827	1550	630	924	1638	870	591	1242	1833	776	1588	1043	1360	860	510	813
Jacksonville, Fla.	328	1192	2070	502	511	838	548	988	1098	758	1800	703	1113	2442	953	755	1840	2375	960	2450	733	2239	957	1203	647
Kansas City, Mo.	1247	413	1117	472	678	1097	1009	293	165	1037	1045	784	1300	1397	937	238	922	1500	1107	1505	326	1286	1173	280	943
Los Angeles, Calif.	2355	1522	910	1777	1675	2446	2352	1182	1312	2388	357	2135	2631	825	2283	1585	577	345	2445	956	1420	939	2515	1291	2295
Louisville, Ky.	923	605	1550	153	623	650	528	675	579	580	1512	345	892	1953	457	242	1400	1983	695	1945	598	1720	745	663	473
Memphis, Tenn.	878	700	1483	195	358	953	778	422	529	878	1264	660	1205	1852	722	242	1250	1800	1010	1867	279	1652	1055	642	763
Miami, Fla.	......	1516	2359	821	681	1095	802	1233	1402	1023	1998	1014	1357	2716	831	1067	2098	2603	1229	2740	950	2528	1210	1510	927
Minneapolis, Minn.	1516	......	1010	695	1050	1019	1047	692	291	985	1279	745	1145	1435	968	464	988	1585	975	1403	859	1173	1056	238	936
Missoula, Mont.	2359	1010	......	1582	1733	2030	2045	1162	978	1997	932	1754	2133	430	1967	1331	435	762	1978	395	1457	170	2060	887	1940
Nashville, Tenn.	821	695	1582	......	470	758	586	602	604	683	1445	472	1015	1970	526	253	1390	1958	820	1973	470	1752	863	704	567
New Orleans, La.	681	1050	1733	470	......	1173	932	575	845	1090	1318	923	1445	2063	899	599	1433	1923	1259	2098	280	1898	1287	960	968
New York, N. Y.	1095	1019	2030	758	1173	......	293	1324	1144	83	2142	313	277	2455	287	873	1972	2568	142	2419	1230	2190	120	1189	204
Norfolk, Va.	802	1047	2045	586	932	293	......	1186	1095	220	2027	316	565	2458	79	771	1925	2510	426	2440	1037	2211	411	1166	145
Oklahoma, Okla.	1233	692	1162	602	575	1324	1186	......	405	1256	843	1013	1550	1488	1122	456	862	1386	1354	1523	297	1324	1412	502	1150
Omaha, Nebr.	1402	291	978	604	845	1144	1095	405	......	1094	1032	837	1318	1373	1020	352	833	1425	1133	1372	617	1149	1205	115	1012
Philadelphia, Pa.	1023	985	1997	683	1090	83	220	1256	1094	......	2079	254	360	2419	205	808	1923	2518	205	2388	1153	2159	201	1143	122
Phoenix, Ariz.	1998	1279	932	1445	1318	2142	2027	843	1032	2079	......	1829	2345	1007	1960	1270	504	652	2152	1112	1067	1020	2220	1043	1980
Pittsburgh, Pa.	1014	745	1754	472	923	313	316	1013	837	254	1829	......	545	2174	242	561	1670	2264	350	2145	939	1918	400	891	188
Portland, Me.	1357	1145	2133	1015	1445	277	565	1550	1318	360	2345	545	......	2563	565	1094	2127	2725	197	2513	1484	2285	159	1345	480
Portland, Oreg.	2716	1435	430	1970	2063	2455	2458	1488	1373	2419	1007	2174	2563	......	2381	1723	636	536	2405	143	1783	295	2488	1293	2360
Richmond, Va.	831	968	1967	526	899	287	79	1122	1020	205	1960	242	565	2381	......	699	1850	2436	406	2362	985	2133	407	1089	96
St. Louis, Mo.	1067	464	1331	253	599	873	771	456	352	808	1270	561	1094	1723	699	......	1158	1738	898	1722	466	1500	958	450	710
Salt Lake City, Utah	2098	988	435	1390	1433	1972	1925	862	833	1923	504	1670	2127	636	1850	1158	......	592	1950	697	1155	548	2027	785	1845
San Francisco, Calif.	2603	1585	762	1958	1923	2568	2510	1386	1425	2518	652	2264	2725	536	2436	1738	582	......	2548	680	1655	730	2625	1383	2437
Schenectady, N. Y.	1229	975	1978	820	1259	142	426	1354	1133	205	2152	350	197	2405	406	989	1950	2548	......	2363	1290	2139	86	1165	313
Seattle, Wash.	2740	1403	395	1973	2098	2419	2440	1523	1372	2388	1112	2145	2513	143	2362	1722	697	680	2363	......	1820	229	2445	1282	2335
Shreveport, La.	950	859	1457	470	280	1230	1037	297	617	1153	1067	939	1484	1783	985	466	1155	1655	1290	1820	......	1621	1333	726	1035
Spokane, Wash.	2528	1173	170	1752	1898	2190	2211	1324	1149	2159	1020	1918	2285	295	2133	1500	548	730	2139	229	1621	......	2216	1055	2105
Springfield, Mass.	1210	1056	2060	863	1287	120	411	1412	1205	201	2220	400	159	2488	407	958	2027	2625	86	2445	1333	2216	......	1242	321
Vermillion, S. Dak.	1510	238	887	704	960	1189	1166	502	115	1143	1043	891	1345	1293	1089	450	785	1383	1165	1282	725	1055	1242	......	1073
Washington, D. C.	927	936	1940	567	968	204	145	1150	1012	122	1980	188	480	2360	96	710	1845	2437	313	2335	1035	2105	321	1073	......

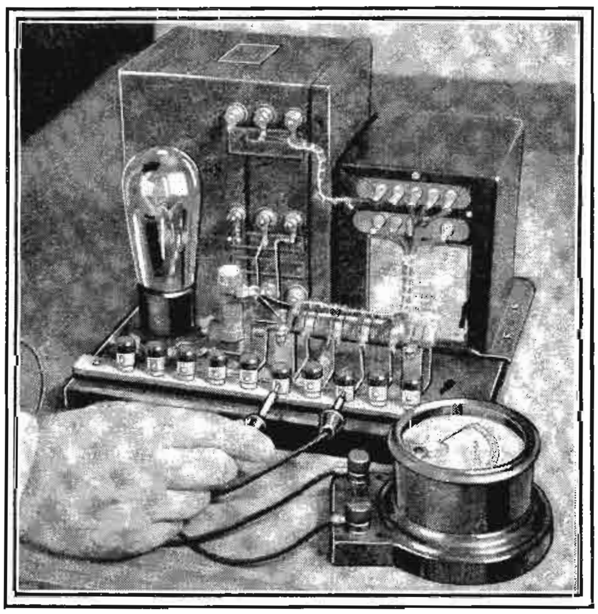
—Compiled by Department of Commerce.

KC	Meters	STATIONS	DIALS 1	DIALS 2
1500	199.9			
1490	201.2			
1480	202.6			
1470	204.0			
1460	205.4			
1450	206.8			
1440	208.2			
1430	209.7			
1420	211.1			
1410	212.6			
1400	214.2			
1390	215.7			
1380	217.3			
1370	218.8			
1360	220.4			
1350	222.1			
1340	223.7			
1330	225.4			
1320	227.1			
1310	228.9			
1300	230.6			
1290	232.4			
1280	234.2			
1270	236.1			
1260	238.0			
1250	239.9			
1240	241.8			
1230	243.8			
1220	245.8			
1210	247.8			
1200	249.9			
1190	252.0			
1180	254.1			
1170	256.3			
1160	258.5			
1150	260.7			
1140	263.0			
1130	265.3			
1120	267.7			
1110	270.1			
1100	272.6			
1090	275.1			
1080	277.6			
1070	280.2			
1060	282.8			
1050	285.5			
1040	288.3			
1030	291.1			

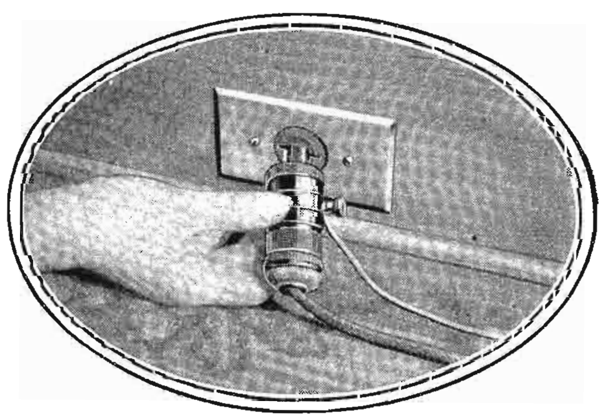
KC	Meters	STATIONS	DIALS 1	DIALS 2
1020	293.9			
1010	296.9			
1000	299.8			
990	302.8			
980	305.9			
970	309.1			
960	312.3			
950	315.6			
940	319.0			
930	322.4			
920	325.9			
910	329.5			
900	333.1			
890	336.9			
880	340.7			
870	344.6			
860	348.6			
850	352.7			
840	356.9			
830	361.2			
820	365.6			
810	370.2			
800	374.8			
790	379.5			
780	384.4			
770	389.4			
760	394.5			
750	399.8			
740	405.2			
730	410.7			
720	416.4			
710	422.3			
700	428.3			
690	434.5			
680	440.9			
670	447.5			
660	454.3			
650	461.3			
640	468.5			
630	475.9			
620	483.6			
610	491.5			
600	499.7			
590	508.2			
580	516.9			
570	526.0			
560	535.4			
550	545.1			



Measuring High Voltage with Small Scale Meter



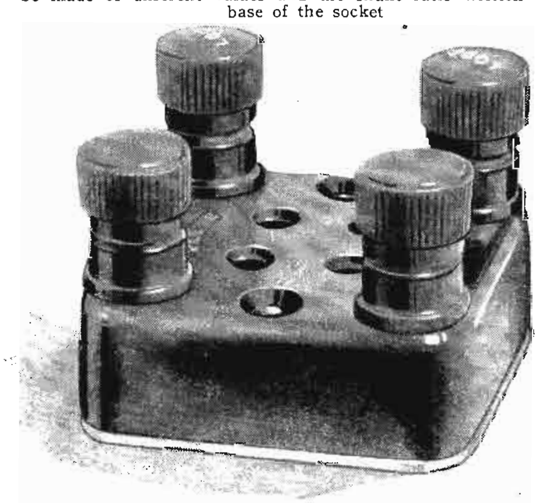
Readings of d. c. voltages several times the scale of the meter may be read on a power supply using a bleeder system. In the picture a half wave 281 rectifier is shown whose maximum voltage output would be around 425 volts. To read this with a 0-150 voltmeter, add values of negative to 90 volts, 90 to 180 volts and 180 to maximum voltages. The sum will be the overall voltage of the power supply which, however, should be measured under load in order to get accurate voltages

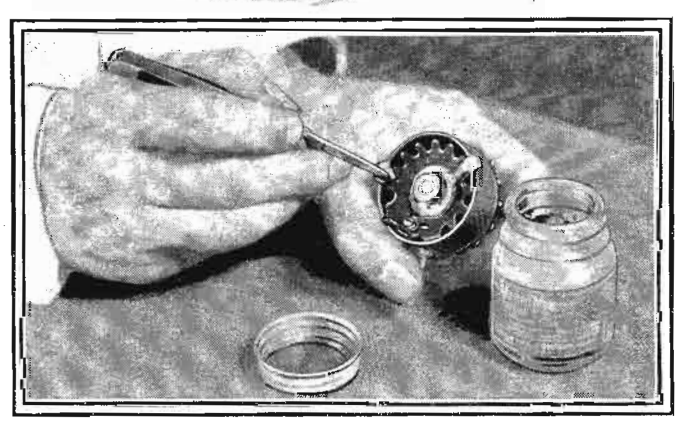


A. C. line noises, clicking of household switches and other line interference may sometimes be eliminated from the alternating current sets by plugging the set's supply plug into a filter and then plugging the filter into the wall socket. The binding post at the side of the filter should be grounded

Novel Multiplier Permits Reading of Amperes with Milliammeter

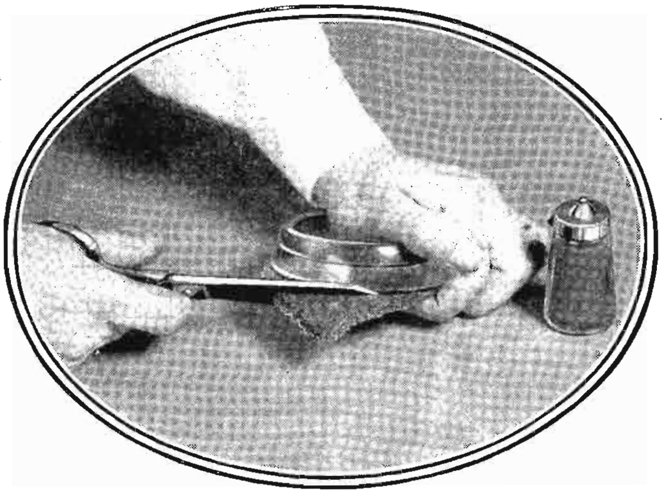
A discarded tube socket can be made into a multiplier for reading amperes by means of a milliammeter. Between the binding post marked "loop" is placed a loop of enameled wire approximately No. 20 and about 5 inches long at the start, the length of the shunt being found by comparison of an ampere meter against a milliammeter. The ampere meter is in series with the shunt while the milliammeter is across the shunt. Then when the ammeter reads 5 amperes the shunt may be lengthened until the milliammeter reads 5 mils. The milliammeter is placed across the two binding posts in the front of the photograph, each of these posts being connected to a loop post by means of a solder lug. The shunt is placed between the two loop posts. In the beginning of calibration the shunt wire should not be more than about 5 inches in length to prevent burning out the milliammeter. The socket is equipped with an aluminum base. More than one shunt may be made of different values and the shunt ratio written on the base of the socket



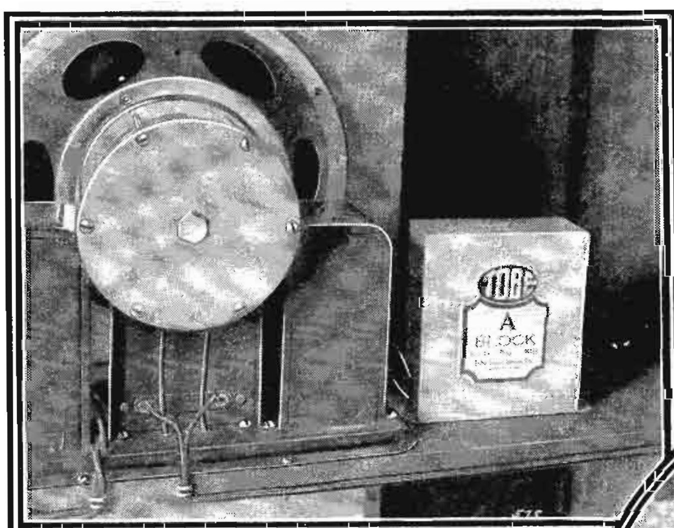


Many times the operation of a volume control will result in set noises due to an imperfect contact. This trouble may be eliminated by wiping the wire surface clean with a dry rag and then putting on the wire surface a small film of white unmedicated vaseline or Nujol. This oily film will prevent corrosion. Be sure the movable arm is making good contact at the beginning

Console Legs Transmit Set Vibrations to Floors and Walls

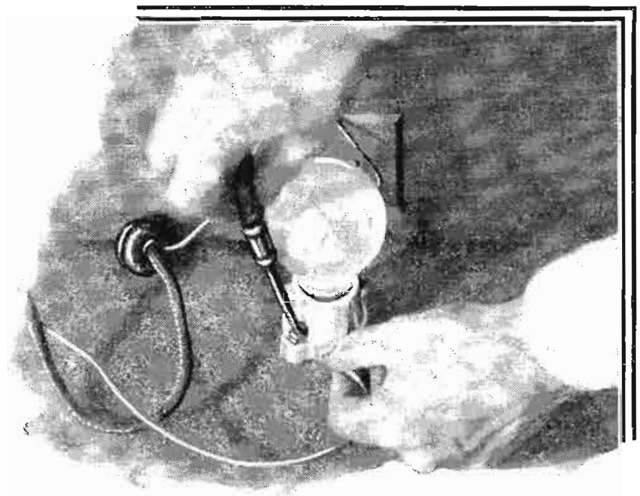


If the "boom boom" of an orchestra coming through a radio set in the apartment above you is extremely noticeable, you may be assured the console legs of the installation up-stairs are probably resting directly on the wooden floor and are transmitting sound vibrations through the floor and walls. This is particularly noticeable on the lower frequencies. A simple cure is to place the radio set on a rug or carpet. If that is not feasible take four glass cups of the kind shown in the photograph, glue a piece of ozite to the bottom of each cup and then set the cups under the four legs of the console. The ozite on the bottom of the cup will prevent the passage of mechanical vibrations from the radio set. You might do this yourself and tell your neighbor about it, too



Above is shown a method of placing a filter condenser across the rectifier output on a dynamic speaker utilizing 6 volt contact rectifiers. Part of the hum found in the older type dynamic speakers was produced by imperfect filtration of the rectifier. A filter block such as the one shown may be placed inside of the speaker cabinet and the two wires from the condenser placed across the extremities of the rectifier. There is no polarity to the condensers so it does not matter which connections go to the rectifier ends. A small condenser may not always suffice and for that reason one with 2000 or more microfarads will have to be used in obstinate cases

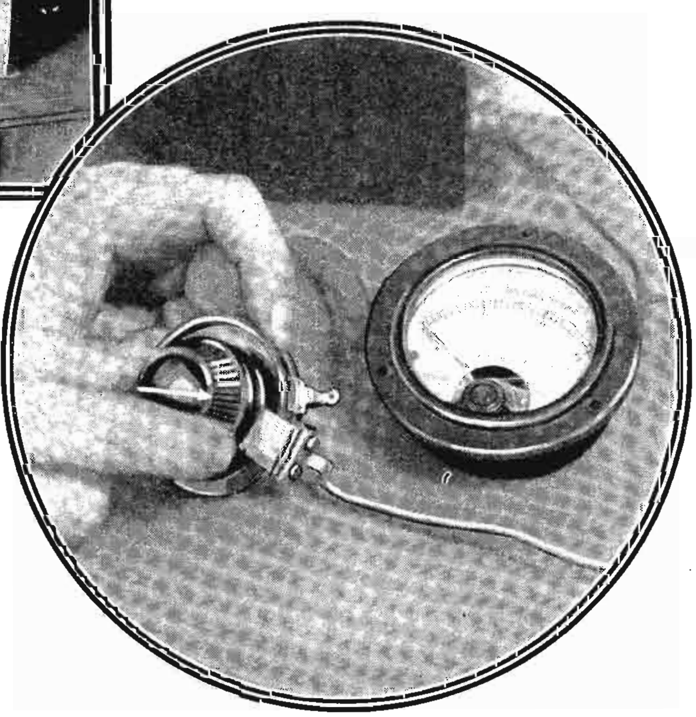
Lamp Used to Establish Ground in the Radio Set



A simple means of grounding your 110 volt supply at your radio set instead of the pole transformers out in the alley is shown in the photograph above, where a small electric light bulb, 15 watts, is connected to one side of your set supply plug, the other side going to a water pipe ground. When the plug is put into the wall receptacle in one direction the light will glow. The plug should then be turned around so that the light does not glow. Under these conditions the neutral wire is grounded directly to your water pipe and this may eliminate some of the hum that is found in radio sets where an extremely long neutral wire is employed. The lamp consumes no current. It is only used as a protective measure to show the user which is the live side of the line and which is the neutral

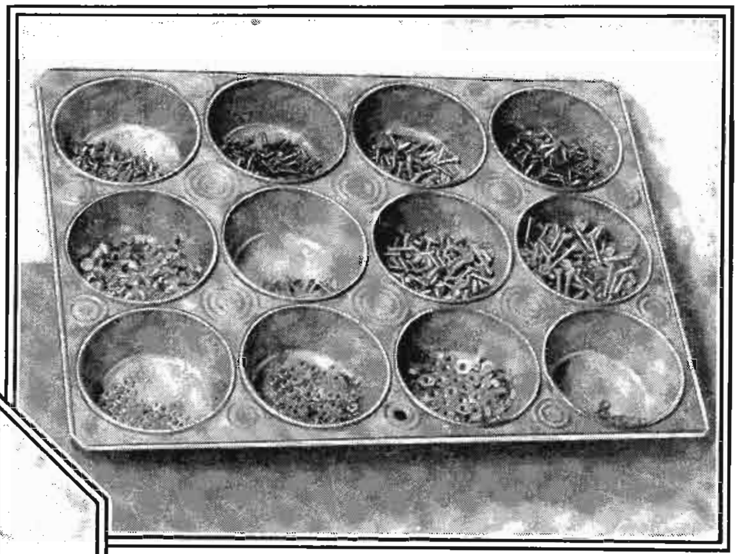
Rheostat Serves as a Variable Shunt for Milliammeter

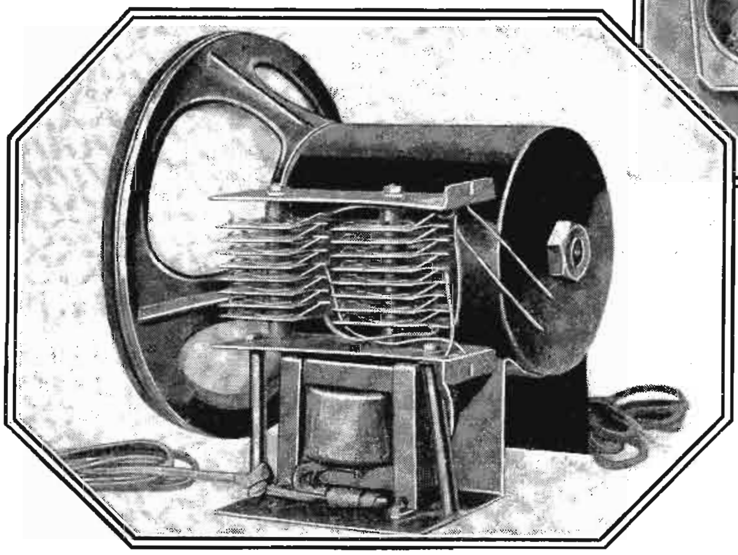
In the picture below is shown an 0-15 milliammeter with a variable resistance in shunt. Many times the service man will want to read total current in a circuit but having only a small meter may not be able to do so. The way to accomplish this is to take about a 25 ohm rheostat, place it in shunt to the milliammeter and turn the rheostat until the meter reads ½ or ¼ of the smallest load. Then when the milliammeter is placed in series with the maximum load the reading may be multiplied either by two or by four depending on which ratio the service man desires



Now Your Wife Knows Where Her Muffin Tin Went

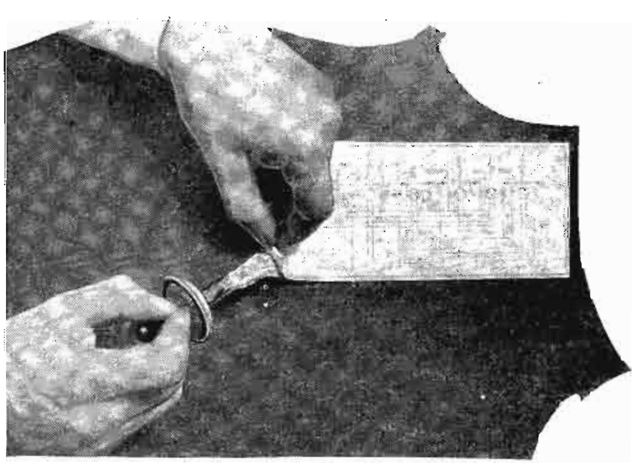
It is seldom that the radio hound can find any domestic utensils that will be of any service. However, there is one exception and that is the muffin tin shown at the right as a depository for assorted sizes of nuts, bolts and screws. By soldering a wire loop at the top left and right edges of the muffin tin it may be hung up against the wall. If you like muffins better than you like orderliness, you'd better drop in at the dime store and get a cheap muffin tin





At the left is shown a chassis of a dynamic speaker. At the bottom of the rectifier is located the step-down transformer used on a. c. jobs. Frequently the laminations in the transformer will be loose and their physical vibration is communicated to the cabinet of the speaker. In the event that there is no way of tightening up the laminations by means of a screw or clamp, the legs of the transformer may be raised from the bottom of the chassis and felt or blotter washers placed under these legs so as to absorb as much physical vibration as possible

Paste the Schematic of Your Set on Inside of Cabinet Cover



Here's a wail from the service man! "Please tell the public that when getting their set they should paste the schematic circuit on the inside of the cover or somewhere inside the cabinet so that when the service man comes along he can determine the electrical constants of the set without the owner having to rummage through the attic and three drawers in the writing desk to find this most important data." In the long run it is cheaper for the owner to have such information pasted inside the set because otherwise a service man takes two or three times as long to check for trouble. Since service man's time is by the hour the schematic of the set will enable him to get to work at once

Have a Spare Tube for Each Kind in Set

When buying a radio set it is always advisable to have one spare tube of each kind used in the receiver. These spares should be labeled and kept for test purpose only. Then when the owner has a suspicion one of the tubes is bad, he can plug in the spare to prove whether or not that tube is defective. The spares should only be kept for emergency purposes and a new tube should be bought as soon as a defective one is located. As a rule the spares would be a 227, a 226, and a 171 or 245. With the number of screen grid sets, however, it is possible that a 224 should also be listed among the spares

Radio Fundamentals Applied to Wires in Carrier Current Work

Methods Employed Are Technically Important and Interesting; Review of the Art Given

By J. E. SMITH*

THE carrier method of multiplexing power lines, telephone and telegraph lines is technically one of the most interesting and important of the developments which have been perfected in the art of electrical communications during the past few years. In this article is given a brief sketch of the development of this art, an explanation of the principles on which it is based, and a description of a few of the applications.

How It Is Done

In a carrier multiplex system, a number of separate telephone, telegraph or signalling messages are superimposed simultaneously on a single electrical circuit by employing a separate alternating current, usually called a "carrier current," for each of the separate messages. This carrier current is made to vary in accordance with the variations of current representing the telephone, telegraph or signalling message. The different carrier frequencies which are superimposed on a circuit must differ sufficiently in frequency so that they may be separated from each other at the terminals by the use of proper electrical circuits. Each carrier may be of either audible or ultra-audible frequency, but its frequency must be higher than the highest frequency represented in the message to which it corresponds. These currents are known as carriers, since in a sense, they may be said to "carry" the telephone, telegraph or signalling currents by which they are controlled.

*President, National Radio Institute, Washington, D. C.

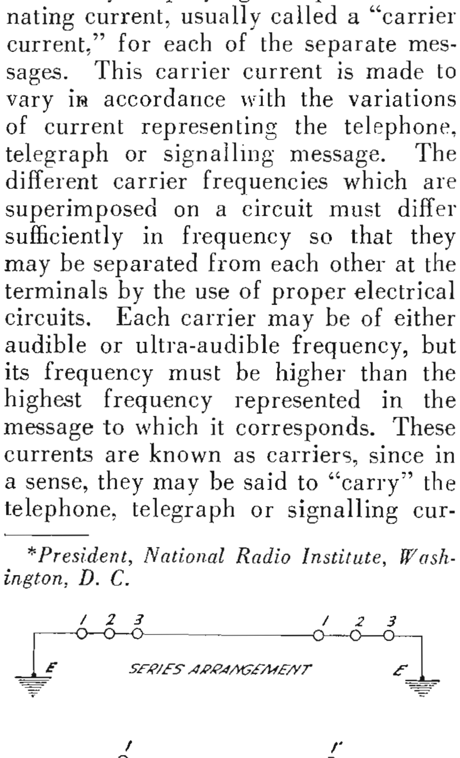


Fig. 1. The multiplex system illustrated here is a reproduction of Elisha Gray's system published in 1886

The underlying principles are old in the communication art and indeed go back to the date of the invention of the telephone itself, for it will be recalled that it was Bell's experiments with the vibrating reed type of multiplex telegraph system which led to his discovery of the telephone. A short history of the art during the years that have elapsed between the conception of its possibilities by the early communication pioneers and the present realization of their hopes is given below under the heading "Historical."

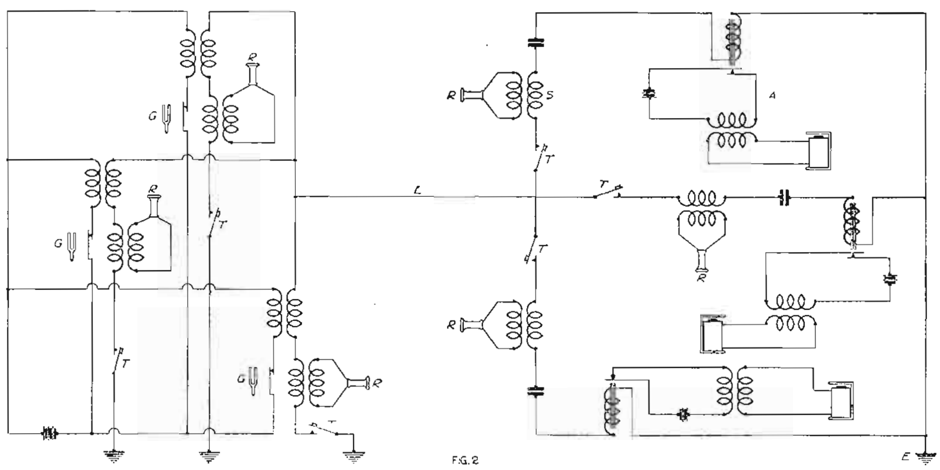


Fig. 2. Michael Pupin was another of the early inventors whose system is illustrated in simplified form

In looking back over the early history of the carrier art it is now clear that the development of successful multiplex carrier systems had necessarily to await not only the evolution of the fundamental ideas for carrier operation, but also the development of radically new types of apparatus and the developments in electrical wave transmission over wires which have characterized the recent progress of long-distance telephony.

Circuits Used Daily

Some of the telephone and telegraph systems which are described are in daily use over long toll circuits in the Bell telephone system. The telephone installations in service furnish simultaneously as many as four two-way telephone conversations over each circuit in addition to the telephone and telegraph facilities normally afforded by the circuit. The telegraph systems in service are arranged to furnish as many as ten duplex carrier telegraph circuits over each circuit in addition to the telephone and telegraph facilities normally afforded by the circuit. These figures do not indicate the maximum numbers of facilities which it will be found economical to employ ultimately, but cover the facilities furnished by the systems which are now commercially employed.

The increased circuit facilities obtained in this way are, in general, up to the high standards set for the best grade of long-distance circuits. They are relatively stable and are maintained by the regular telephone plant personnel. The carrier circuits, both telephone and telegraph, are so designed that as circuits they fit in completely with the more usual circuit facilities of the telephone system. They may be connected

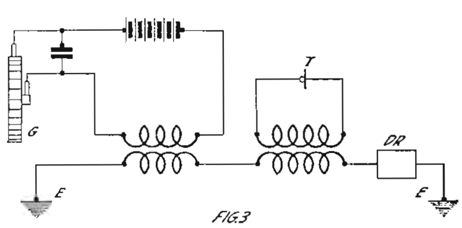


Fig. 3. Hutin and Leblanc illustrated the use of relatively high frequency alternating current for telephony in the above diagram

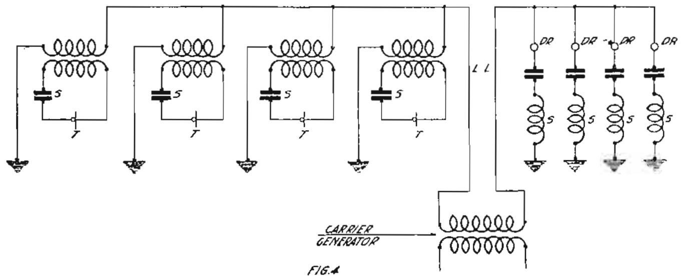


Fig. 4. Another diagram representative of early 1892 contributions to carrier telephony is reproduced at the left

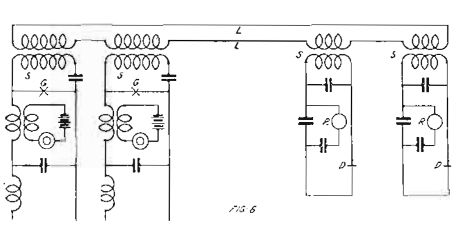
with each other and with ordinary circuits, and, in general, present much the same degree of practicability and flexibility of operation as do the more usual forms of circuits.

While the development has thus succeeded in making available to the communication art new types of circuit facilities, these facilities can only be made to meet the high standards required in a public service plant by the use of correspondingly high-grade equipment which, unfortunately, is correspondingly expensive. Indeed, the cost of these systems, at least at present, is such as to make their use economical only over relatively long toll circuits. For short-distance toll service, and for local exchange service, the equivalent facilities can be provided more cheaply by the older methods.

Historical

As indicated above, the multiplex carrier art had its origin in the harmonic telegraph systems dating back to the time of the invention of the telephone itself. With such alternating-current telegraph systems are associated the names of Gray, Bell, Van Rysselberghe, Edison and Mercadier. The multiplex feature of these systems is well illustrated by Fig. 1, which is a reproduction of a diagram of Elisha Gray's system published in 1886.

In this figure, the circles numbered 1, 2 and 3 represent vibrating reed transmitting instruments, while those numbered 1′, 2′ and 3′, represent the corresponding receiving electromagnetic reeds. When one of the transmitting reeds is vibrated, the electrical waves sent out set into oscillation the correspondingly tuned receiving reed which thus gives out an audible note. The systems invented by these pioneers are all characterized by the use of the mechanical resonance of tuned reed instruments for generating and selecting the carrier frequencies involved. This type of system has been more fully developed by Mercadier.



Figfl 6. The Ruhmer system in vogue in Europe around 1910 is illustrated in the above diagram

The Art of the 1890's

Shortly after 1890 there occurred the next outstanding development in this art, namely, the use of electrical resonance instead of mechanical resonance for selecting the carrier frequencies. An interesting piece of technical history is disclosed in the manner in which several investigators, Professor Pupin, Hutin and Leblanc, and John Stone independently invented about the same time the electrical method of selection of a plurality of carrier frequencies. Pupin was adjudged the earliest inventor in the United States. His original system is illustrated in simplified form in Fig. 2.

In order to permit the successive figures in this historical discussion to be readily followed, a uniform system of lettering their important parts has been employed. These conventions are as follows:

G—Generator of carrier current.
T—Telegraph key, telephone transmitter or other carrier modulating device.
L—Line.
S—Selecting or tuned circuit.
D—Detector.
A—Amplifier.
R—Receiver.
DR—Detecting receiver.
E—Earth.

By following this lettering Fig. 2 will be readily understood. It will be noted that at each end the line branches into three parts, and that each circuit is tuned by capacity and inductance to a particular frequency. It will be seen, furthermore, that each of the channels derived in this manner is arranged for sending in both directions, although not simultaneously. Each generator consists of a self-excited tuning fork driving a contact or a microphone transmitter. Receiving is accomplished either hy a telephone receiver or by a vibrating reed device which is operated by a microphone amplifier.

Pupin also invented an electrolytic detector for use in such alternating-current telegraph systems.

The function of this detector was to rectify the alternating current and thus enable a d-c. telegraph relay to be operated from the rectified current. This marked the beginning of the use of separate devices for performing the two primary functions of carrier receiving; (1) that of reproducing from the carrier the current variations which represent the original signals, and (2) that of indicating the signals, as by relay or telephone receiver. The separation of these two functions is important in the carrier art because it permits the place at which detection is effected to be separated from that at which the indication or interpretation occurs.

While the contributions up to this time were concerned primarily with telegraphy, they were very soon carried over into the field of telephony (still in the early 90's) by such pioneers as Gibboney, Hutin and Leblanc, and Stone. Their predecessors were concerned with the use of carrier frequencies of the order of a few hundred cycles, whereas, these inventors appreciated the necessity of employing for telephony carrier currents sufficiently high in frequency to preserve the characteristics of the voice currents. Thus we find suggested at this early date the use of carrier currents in the tens of thousands of cycles, which values have since proved to be in the

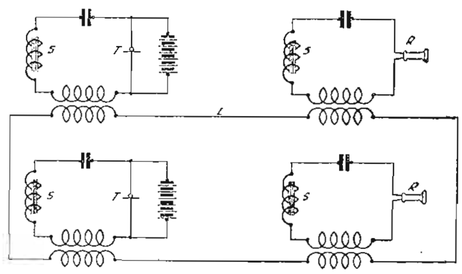


Fig. 5. The system developed by John Stone during 1894 is here illustrated

preferred frequency range. Hutin and Leblanc so simply illustrated the use of relatively high-frequency alternating currents for telephony that it is useful to reproduce their early diagram as shown in Figure 3, for the purpose of obtaining in our discussion an appreciation of the principles involved.

Simple Carrier System

This is a carrier telephone circuit of the simplest type, arranged for a single one-way transmission. Connected in the line are three elements, the generator of the high-frequency currents *G*, the voice-actuated modulator *T*, and the detector-receiver *DR*. The generator is a high-frequency commutator; the modulator is a microphone transmitter; and the receiver which is of the dynamometer type serves the double function of detection and of translation into sound waves.

Multiplex operation of this type of carrier telephone channel as devised by these French inventors at the same time (about 1892) is also representative of

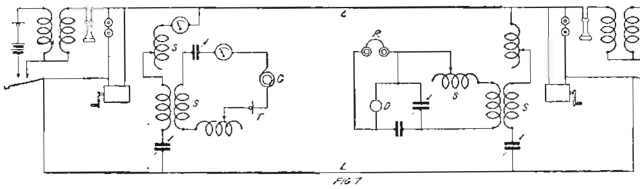


Fig. 7. At the left is shown the original circuit used by Squier in 1910 and 1911

these early contributions to carrier telephony and is reproduced in Fig. 4. Here we have the carrier telephone channel of Fig. 3, arranged for multiplex operation by the use of electrical selection, each of the carrier circuits being tuned by capacity and inductance to its own carrier frequency.

As indicated the carrier currents of all the channels are introduced into the line at a common point through a transformer. At each terminal the line divides into four branches. Each sending branch contains a microphone transmitter *T* connected into circuit through a transformer. Each receiving branch contains a dynamometer receiver *DR*. The condenser in each transmitting circuit and the inductance in each receiving circuit were employed in tuning the channels.

The multiplex system invented by John Stone was very similar to those illustrated above by Pupin, and Hutin and Leblanc, and is therefore not illustrated. It did, however, contain an important improvement over those of his contemporaries in that he tuned the local branch circuit individually instead of tuning the system from end to end for each carrier channel, as did Pupin, and Hutin and Leblanc. This improvement is evident also in a system which he developed shortly afterwards, especially for high-frequency transmission. This is illustrated in Fig. 5.

Stone devised and tested this system in 1894. The high-frequency currents were generated by means of small arcs which were fed from a d-c. source through a suitable choke coil. One of the electrodes of each are in Fig. 5, was made light in weight and was attached to a diaphragm which served, when acted upon by voice air waves, to modulate the high-frequency currents generated by the arc. The particular arrangement illustrated is also of interest in showing the tuned circuits at both the sending and receiving ends as associated with the line in a series manner, an arrangement which is an alternative of the parallel connections previously illustrated.

It is also of interest to note in connection with these older multiplex telegraph systems that Van Rysselberghe recognized as early as 1886 the advantage of superimposing the alternating-current circuits on an ordinary d-c. telegraph circuit, thereby enabling the ordinary telegraph wires to be employed for the transmission of the multiplex system. While the idea of extending the range of frequencies employed in the multiplex system down to zero frequency and thereby including the d-c. signaling circuit would naturally be obvious in a more advanced stage of the art, its invention at this early date illustrates the clear engineering appreciation these earlier inventors possessed.

It will be seen, therefore, that the foundation of the carrier art was laid back in the 1890's, at which time there had been contributed these cardinal features:

1. Electrical selection or tuning.
2. The use of continuously generated high-frequency carrier currents.
3. Modulation of the carrier, as by a microphone transmitter.
4. Detection and indication of the high-frequency currents by means responsive continuously and proportionally to the received current.

Relations of Radio Developments

With the entrance of wireless telegraphy into the communication field, the attention of those scientists and engineers who might otherwise have developed the art of wire multiplex, so well begun, as indicated above, seems to have been diverted to the newly found art. The wireless art started with the use of very high frequencies, generated discontinuously by the spark method, and gradually came to use waves of lower and lower frequency, and of increasing persistency. Finally, with the use of continuously generated waves, the radio-frequency range came to overlap the frequency range earlier employed in high-frequency wire transmission. The wire carrier art started with the use of audible frequencies and extended into the ultra-audible range, where it was later met by the radio frequencies. The similarity of the history of the two developments is illustrated by the fact that the major steps, which are noted above for the early carrier art, also mark the major steps of advancement of the radio art. By reading over the four points above, keeping radio in mind, the parallel will be seen to be quite complete.

These ideas of continuous wave telephone transmission were quite thoroughly appreciated in the radio art by about 1905, although they have not been fully attained in practice until quite recently. It was natural that radio engineers should carry these ideas over to wires, using radio instrumentalities which, while different in form, operated on the same principles as did the means employed by the earlier wire pioneers.

Simultaneously with this evolution of the radio art, attention continued to be given to the older wire carrier transmission by such other investigators as Vreeland in America and Bela Gati and Maior in Europe. About 1906 Vreeland, using his well-known mercury-vapor oscillator as a generator of sinusoidal carrier currents, devised a multiplex carrier telegraph system which embodied improvements in the use of loosely coupled tuned circuits in proper relation to the impedance of the line. An engineering and commercial development of this period, as distinguished from more purely laboratory or theoretical investigations, was the so-called "Phantoplex" system devised by engineers of the Postal Telegraph Company and quite extensively employed by that company. In this system a relatively low-frequency carrier telegraph channel was superposed on the ordinary direct-current circuit. In addition to the above, attention may be called to the disclosures by Ehret and Kitsee. Ehret shows a multiplex carrier telephone system including amplifiers, and Kitsee shows a carrier telegraph channel operating over an ordinary telephone circuit.

Previous to 1910, Dr. Ruhmer in Europe had undertaken experiments on high-frequency wire transmission, employing apparatus taken from the then current radio art. Ruhmer's system is illustrated in Fig. 6.

He employed oscillating arcs as high-frequency generators, microphone transmitters as modulators, tuning at both

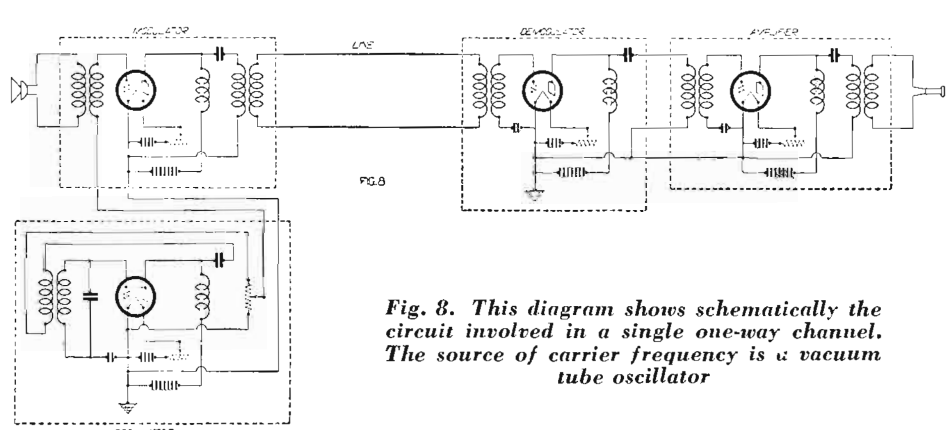


Fig. 8. This diagram shows schematically the circuit involved in a single one-way channel. The source of carrier frequency is a vacuum tube oscillator

the transmitting and receiving ends, and a radio detector in the receiving circuit.

In 1910 and 1911 Major, now Major-General, Squier carried out a set of experiments employing a carrier channel operating over a short telephone cable circuit. The announcement of his work popularized the interest in this art, and brought out considerable discussion.

The system which he used in his experiments is illustrated by Fig. 7. This figure shows a carrier telephone channel operating over the wires of an ordinary telephone circuit. A high-frequency alternator is employed to generate the carrier current, a microphone transmitter is used as a modulator, tuning is employed at the sending and receiving ends, and a radio detector is employed in the receiving circuit.

As a part of the evolution of the radio art, there was developed in its early and somewhat crude form a device which was destined to play an extremely important part, not only in radio, but in wire communication as well, that is, the thermionic tube. Originally invented by Edison, this device was first applied as a radio detector by Fleming about 1904. DeForest in 1906 made a vital contribution by adding the grid, and thereby laid the foundation for its use as an amplifier. The history of this very remarkable device is so well known that we will discuss it here only in connection with its specific application to the carrier art.

The preceding history brings us up to about 1912. About this time an important step was taken toward the adaption of the vacuum tube as a non-distorting amplifier by the addition of a negative grid battery by Lowenstein.

Since the above date, in addition to the active developments which were carried out in the Bell System and are described below, certain other investigators have been working in this field, among whom may be mentioned the General Electric Company, U. S. Signal Corp Engineers, Lee DeForest and certain European investigators, especially in Germany and France.

Bell System Developments

The most important developments, which have occurred since 1912 and are principally the work of the research and development departments of the Bell System, may be stated as follows:

1. Development of the thermionic vacuum tube into a reliable and stable instrument for amplification, modulation and demodulation.

2. Development of the electrical filter and an improved technique of separating electrical currents of different frequencies.

3. Development of the technique of transmission over wires, particularly in connection with repeater operation and of methods for overcoming interference between circuits.

4. Development and operation of commercial carrier systems.

In considering the above developments which have led to commercial operation, it should be appreciated that in order for a carrier system to be commercially successful, it must compete on equal terms with the ordinary types of wire circuits, that is, it must have the same degree of reliability and stability, and must give the same degree of privacy and the same freedom from interference. Moreover, the system must be arranged so that it may be used interchangeably in the ordinary manner with any of the facilities furnished by the plant. All of these conditions must be met at a cost less than that of the ordinary types of circuits for similar service.

Vacuum Tube Developments

The development of the thermionic vacuum tube as an amplifying element in a telephone repeater has already been described as has also its application to radio telephony.

The success which attended these two lines of development indicated that in this one device was embodied the solutions of many of the controlling difficulties that had previously stood in the way of the commercial development of carrier systems. In connection with a resonant circuit, the vacuum tube provides a compact and reliable source of continuous oscillations of readily adjustable frequency. As an amplifier of both low and high-frequency currents, it removes the necessity for excessive line currents. As a modulator and demodulator, it provides an ideal means of impressing the voice waves on the carrier current, and of restoring them to their original form at the receiving end. These tubes have, moreover, been developed into devices which are very stable and reliable in operation, and may be maintained with only routine periodic supervision.

Electrical Filters

Another development which has been of vital importance in the success of carrier telephone systems is that of the "band-filter" invented by G. A. Campbell. Without such electrical filters, it would be impossible to utilize economically the relatively low-frequency range employed in the present carrier telephone systems, or to separate various channels in this range from each other or from the ordinary telephone and telegraph channels. The simple tuned circuits of the prior art would either introduce prohibitive distortion or, if made sufficiently non-selective to avoid distortion, would require placing the carrier channels widely apart in frequency. The Campbell filter, therefore, enabled the carrier channels to be squeezed closely together at comparatively low frequencies where the difficulties of transmission over lines are at a minimum.

Wire Transmission Circuits

Since the attenuation over wire circuits is much greater at carrier frequencies than at the ordinary telephone frequencies the successful operation of carrier systems is particularly dependent on the use of repeaters at comparatively frequent intervals in the line. This has required the development of high-frequency repeaters. As in the case of telephone repeaters at voice frequencies, the amount of amplification which can be given by each repeater depends entirely on line conditions, such as the degree of line balance which can be maintained at the repeater point and the degree to which mutual interference between line circuits can be prevented.

This prevention of interference between line circuits required the development of more elaborate methods of transposing and adjusting them. In order to overcome the large transmission losses and irregularities introduced in open-wire lines by unavoidable sections of cable, new types of loading for cable circuits were developed for these carrier frequencies and put into practical use.

Commercial Carrier Systems

In 1914, simple forms of carrier circuits, embodying the fundamentals of our present system, were successfully set up in the laboratory, and experiments carried out with them. In view of the favorable conditions which had resulted from the various developments noted above, it was decided to begin active work toward commercial carrier systems. Field measuring apparatus was developed with which the characteristics of existing telephone lines were carefully studied in the carrier-frequency range. At the same time in the laboratory the physical possibilities and limitations of the various types of apparatus and circuits were being studied. Based on these fundamental data there was developed in the laboratory a complete multiplex telephone system providing two-way telephone conversations, and operating over an artificial line. This laboratory apparatus was then taken into the field and tried out on a line between South Bend, Indiana, and Toledo, Ohio. The practical difficulties always encountered were overcome, and satisfactory results were obtained on a simple type of carrier telegraph system between Chicago and Toledo.

The entry of this country into the war brought the work to a standstill for a time. However, the same cause

(*Continued on page* 97)

S-M 722 D. C. Now Designed for Use on Batteries With High Gain

When Using Standard Tube Combinations of Three 222's and Three 112-A's, Total Current Only 20 Mils.

FOR some time past there has been considerable of a demand on the part of individuals living in sections not served by alternating current lines for a receiver that will be economical as far as battery current is concerned and at the same time which will give performance on a par with the regular alternating current sets in other localities.

In considering the matter from the standpoint of economy it very early became apparent that it would be necessary to employ the screen grid battery tubes in order to cut down on the filament current and at the same time give the receiver the utmost in amplification possibilities that these screen grid tubes afford. Added to that there was the desirability of having a single tuning control for simplicity of operation.

Battery Supply

Inasmuch as the 722 a. c. receiver merchandised by the Silver-Marshall organization had been working quite satisfactorily it was thought that this particular design could readily be adapted to battery operation with a few minor changes in the chassis wiring to permit the use of storage batteries on the filament and "B" batteries for a plate supply.

By glancing at the schematic diagram shown in Figure 3 the reader will be able to get an idea of the type of circuit employed quite effectively in the 722 a. c. and now equally effective for battery operation. Looking at the input stage where a number 124 r. f. transformer is employed it will be seen that the primary of that transformer has two taps, one for use with a long antenna and the other for employment with a short one. Binding post No. 2 is for a short antenna, since it connects to the entire primary winding of the r. f. transformer. Binding post No. 1 is for a long antenna, since it taps in on the primary a number of turns down from the maximum inductance.

Uses Selector Coupler

The secondary of this inductance is led through a selector coupler No. 30X and then into the center tap of a 15-ohm center tap resistance in the negative side of the 222 filament. The secondary of this selector coupler is in series with the grid inductance r. f. coil No. 122 which also returns to the center tap of the 15-ohm resistor in the filament line. The r. f. transformer No. 124 is in a shielded can and the same applies to r. f. coil No. 122. One section of a .00035 mfd variable condenser goes between the cap of the first 222 tube and the ground.

From the plate of the first 222 tube the circuit is conventional through the r. f. transformer 123 primary and then to the plus 135-volt tap. The secondary is also of the conventional type, going from the cap of the second 222 to the center tap of a 15-ohm center tap resistance in series with the negative filament of the tube. The rotor on this condenser, of course, is common with ground. The second r. f. transformer, No. 123, is connected in the same fashion as the first one, although the secondary is connected to the grid circuit of the 222 detector through a .00015 mfd grid condenser spanned by a two megohm gridleak. The tuning capacity here is likewise between the G terminal of the inductance and ground.

Resistance Coupled

The plate circuit of the detector has a r. f. choke No. 275 which is bypassed by means of a .0005 mfd fixed condenser for the elimination of r. f. strays. Between one end of the r. f. choke and the plus 135-volt terminal there is a 60,000 ohm fixed resistance in series which serves to cut the voltage to the proper value for the operation of the 222 detector tube. The coupling from this stage to the input of the first audio tube where a 112-A is employed is by means of the .006 mfd fixed condenser leading into one terminal of a 2-A closed circuit jack. The other terminal of the jack leads to the grid of the 112-A and to one side of a 2 megohm resistance going to the minus C 4½-volt terminal. The frame of the jack is grounded and if desired a pick-up unit may be plugged into this particular portion of the circuit.

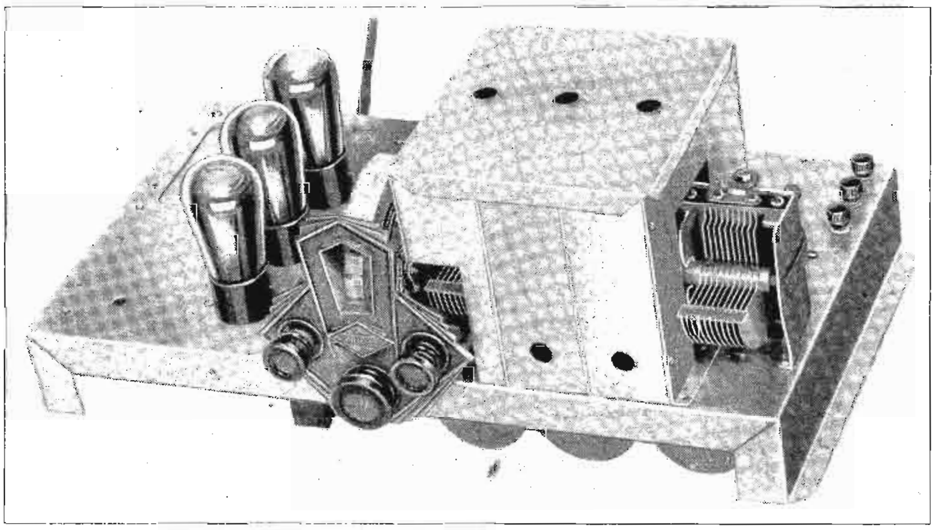


Fig. 1. Shown in this photograph is the S-M 722 battery operated receiver designed especially for individuals living in sections where alternating current is not available and who desire a receiver with high gain and current economy

The push-pull input transformer type 270-U is conventional and needs no particular explanation. The secondary feeds into each grid of the 112-A used in push-pull as a power output tube. The push-pull output is a choke, No. 258-S, the speaker being placed across the extremities of the choke and the center tap being supplied with 135 volts of B potential.

There is a 3-ohm sub-base rheostat used in the positive side of the A voltage supply as a means of securing proper voltage on the filaments of all tubes. The switch used on this receiver is an H-H 191 switch which breaks two lines, one being the minus A, B and plus C terminals and the other being that line carrying the 10,000 ohm potentiometer and the 20,000-ohm fixed resistance. Under these conditions when the switch is open no current is being dissipated through the resistance across the battery from plus 135 to negative B.

When using the standard tube combination of 3, 222's and 3, 112-A tubes the total B battery drain is only 20 milliamperes. The A battery current is 1.15 amperes, so that an 80 ampere hour, 6 volt storage battery, need be recharged only after 70 hours of use. This permits two weeks' operation between charges when the set is used five hours a day. Less use gives correspondingly longer battery life.

Four Tuned Circuits

As will be seen from an examination of the schematic the set has four tuned circuits including a Siamese or band selector-circuit used as an antenna coupler. This double tuned circuit is followed by two of the S-M 123 high gain interstage tuned transformers used in the 722. The unusually uniform minimum to maximum gain ratio of 1 to 1.5 has been maintained.

Because of the use of four tuned circuits with a band selector combination and because of the higher selectivity of the interstage transformers when using 222 tubes with an exceptionally high plate resistance, this receiver provides extraordinary selectivity.

Screen Volume Control

The volume control is operated by changing the potential on the screen grid which gives a very small uniform control from zero to maximum volume. A 222 tube screen grid detector is used which contributes to the high gain of the receiver and is resistance coupled to the 112-A first audio stage. The 270 transformer is used to couple the first audio tubes with the two power tubes which are connected in push-pull. The use of resistance coupling in the first stage together with a low ratio push-pull transformer and the low plate im-

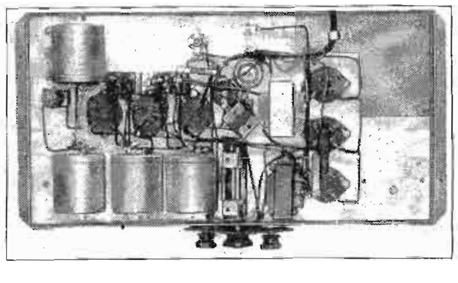


Fig. 2. This photograph shows the bottom view of the chassis used on the S-M 722 described in the accompanying article

pedance of the 112-A tube in the first stage gives such a flat frequency characteristic that the quality of reproduction is virtually limited only by the speaker itself. Realizing that magnetic speakers will be used in the majority of cases because of the field excitation required for dynamic speaker, a 258 output choke is used which prevents damage to the dynamic speaker through the plate current of the power tubes even when 171-A tubes are used.

A separate "C" battery lead is used to supply the biasing voltage for the power stage so that either 112-A or 171-A power tubes may be used. The former are usually recommended because of their lower plate current since their undistorted output is adequate for the average room. When moderate power is wanted the 171-A tube in push-pull with 135 volts for plate supply may be used. Maximum output may be obtained by raising the B battery voltage to 180 volts, although in this case the B battery life is comparatively short.

Selectivity

The selectivity of the receiver may be demonstrated by the fact that in Chicago within the short distance from WMAQ and WGN, WLW can be received with no background from the locals. This is a feat which could not be accomplished by the 720 of last year and is one of the tests for exceptional selectivity used by the designers in this particular area. This performance was duplicated in the day time and indicates that under satisfactory conditions the daylight range of the receiver on high powered stations will exceed 300 miles.

An adjustable filament rheostat is mounted on the chassis to drop the storage battery voltage to the 5 volts required for the 112-A or 171-A tube. With the suggested tube combination this rheostat may be set at about 1/3 of the resistance in the circuit. If the storage battery is used until it is almost completely discharged this may be set to the minimum resistance position to secure the full A battery voltage.

Tubes to Use

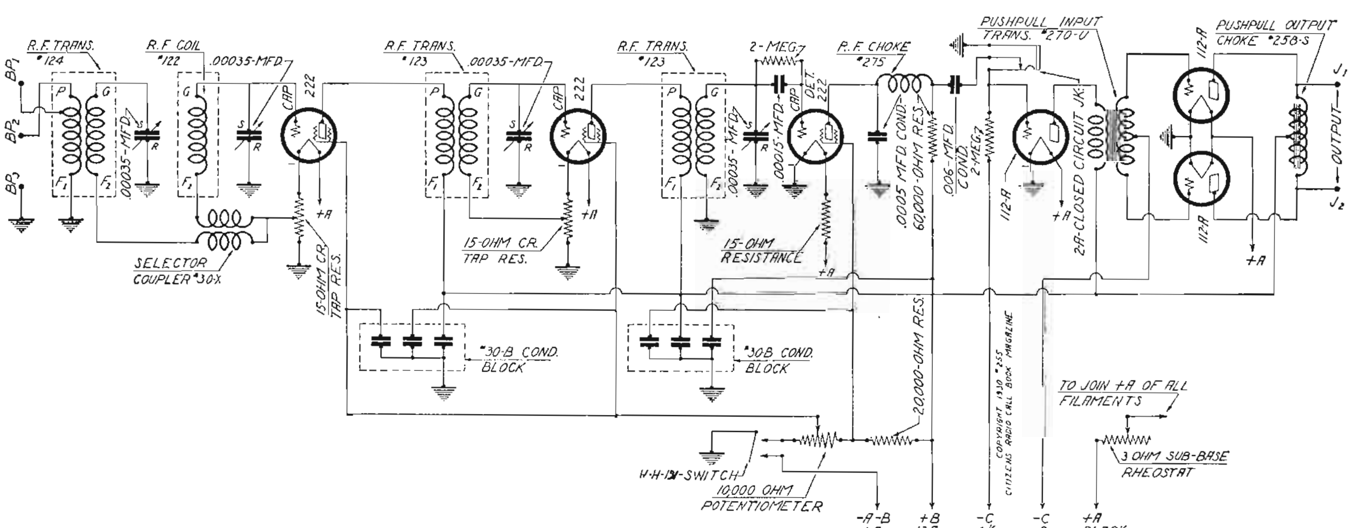
The use of Radiotron or Cunningham tubes is recommended by the designer both because of their performance and the fact that 112-A and 171-A tubes draw 1/4 ampere filament current. Some of the other tubes having corresponding type numbers require 1/2 ampere A battery current and this not only overloads the rheostat but shortens the storage battery discharge rate.

Parts Needed

Parts used in the construction of the S-M 722 d. c. are shown in the list below:

- 1 Silver-Marshall 722 pierced metal chassis
- 1 Silver-Marshall 812 control escutcheon
- 1 Silver-Marshall 810R illuminated drum dial
- 1 Silver-Marshall 322 .00035 mfd 4-gang condenser
- 1 Silver-Marshall 723 3-compartment shield with hardware
- 1 Silver-Marshall 124 shielded r. f. coil

(Continued on page 130)



F'g. 3. The schematic diagram of the S-M 722 described on this page is shown in the above illustration. As will be seen from an inspection of the photograph in Fig. 2, very little wiring is required. Two screen grid tubes are used in the radio frequency stages and one in the detector, while the output stage is a couple of 112-A tubes in push pull

Lincoln DeLuxe Ten Now Using Five Tuned Intermediate Stages

Screen Grid Tubes With Tunable Plate Inductances Employed to Get Maximum Amplification

ROUNDING out a year and a half of its experience in connection with the design of intermediate amplifiers the Lincoln Radio Corporation has now put out its DeLuxe Ten model which is described in the article to follow.

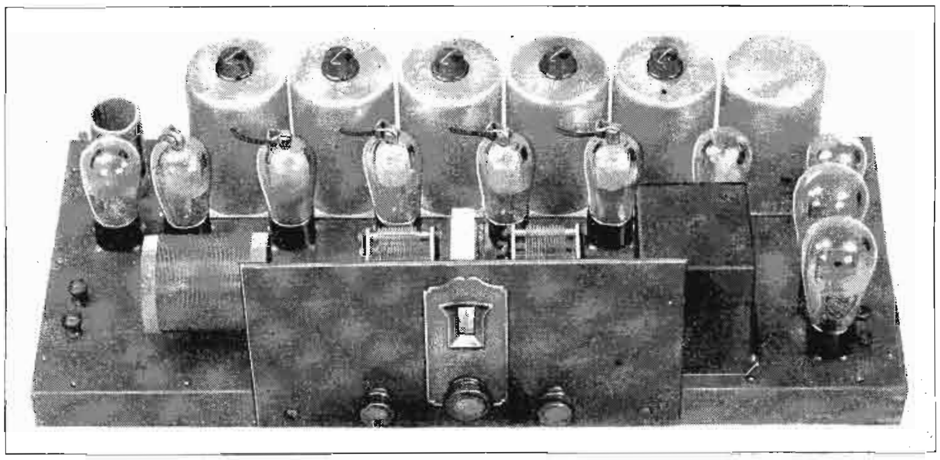


Fig. 1. ***In this photograph may be seen the front and top view of the Lincoln DeLuxe Ten with all tubes in place***

Photographically the chassis of the receiver may be seen in Figure 1 where a front and top view is given, while the schematic diagram of the receiver itself may be traced from the drawing in Figure 2. Figture 3 is a photograph of the power supply used for the operation of this receiver while the electrical circuit of that power supply is illustrated in Figure 4. A table of typical voltages as made with Weston 547 set tester is included in Figure 5.

Solenoid Inductances

Utilizing the highest type of solenoid coils the intermediate amplifier transformer, correctly designed, has produced a very high gain per stage. It was the natural supposition that with the tremendously high gain obtained it would not be practical to use many stages of this type. Contrary to this belief, however, in the Lincoln Ten five tuned intermediate stages were successfully used building up a total intermediate amplification exceeding anything previously known to the designer.

Combined in this system each stage is accurately tuned by a high grade low loss stator and rotor type condenser, tuning the plate circuit of the screen grid tube. The overall of the five operative tuning units produces a high degree of rejectivity from the undesired frequency.

The wave length range is from below 220 meters and up to 550 meters. A space wound oscillator coil is also used and both the input and the oscillator are tuned by a .0005 mfd special variable condenser. The antenna coil in the Lincoln DeLuxe Ten is a large sized one, space wound, using No. 16 enamel wire for the inductance.

227 Oscillator

The oscillator in this model is the type 227 while the first detector is a 224. Then follow four 224's as intermediate stages with a 227 as second detector and a 227 as the first audio. Two of the 245 tubes are used in push pull for the power stage. The chassis of the receiver combines a filament and heater supply transformer with a large safety factor. A bakelite sub-panel is used which is supported by a rigid hardwood frame extending from four sides.

According to the designer the stability of the new type of intermediate transformers was proven by laboratory experiments in which ten intermediate stages were successfully operated with perfect control without oscillating or distortion.

The DeLuxe Ten has an auxiliary plate supply furnishing adequate voltages for the receiver as well as 150 volts at 60 mils for excitation of the dynamic speaker field.

Preliminary Tests

The performance of the DeLuxe Ten has exceeded the expectations of the designer according to the statement recently made after a preliminary test of the first model finished. This test was made at Oak Park, Illinois, eight miles from the center of Chicago and in the center of the ring of Chicago's broadcasting stations. At that time

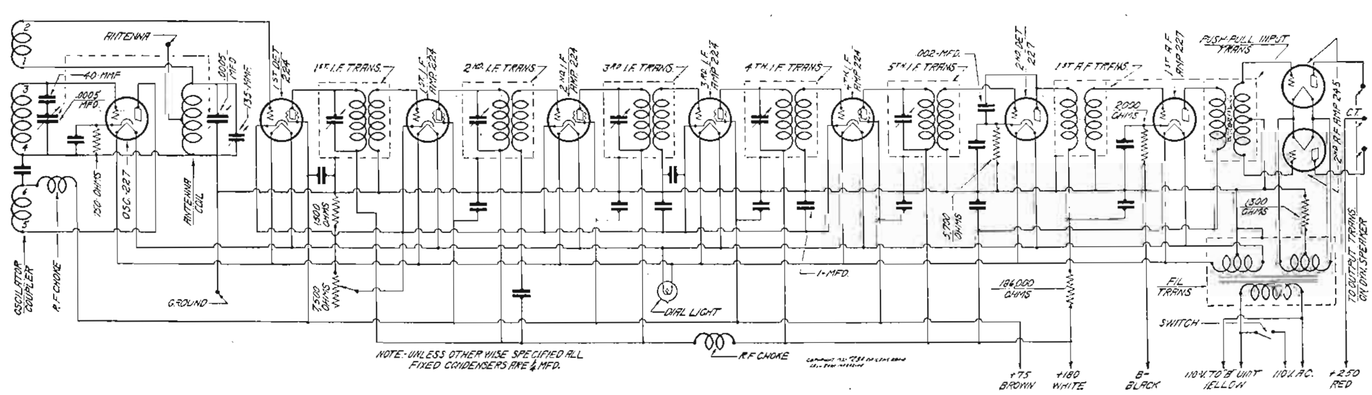


Fig. 2. ***The schematic diagram of the receiver is set forth in the above illustration***

twenty-five outside stations were played at 12:30 noon. The number of stations received ranged from Hot Springs, Arkansas, down to Birmingham, Alabama; Schenectady, New York; Ft. Worth, Texas and Denver, Colorado. Others were played with considerable volume although the noise level was perceptible on many of them. On repeated tests made at the same location starting at 550 k. c. every channel was played down to 1500 k. c.'s.

For the benefit of those interested in the factors which determined the choice of intermediate coupling in this receiver we are reproducing some of the ideas of the designer as set forth in the following paragraphs:

Which Coupling Desirable?

As is known the transformer has proved to be the most practical and efficient means of coupling vacuum tubes for making a cascade amplifier. There are four variations of transformer coupling; namely, untuned, tuned primary, tuned secondary, and tuned primary and secondary.

The untuned transformer is very successful in low frequency amplifiers, but at high frequencies, very little gain can be obtained because of the short circuiting effect of the input impedance of the 3 element vacuum tube.

At a frequency of 500 kilocycles it is possible to get an impedance of several hundred thousand ohms from a tuned circuit. This impedance increases with both the efficiency as well as the inductance of the coil. In the three-electrode tube with a plate to filament resistance with less than 20,000 ohms it does not take a very large impedance in the primary of the transformer in order to get a considerable portion of the voltage generated across the primary. This means that it does not take very close coupling between the primary and secondary of a tuned secondary transformer to get sufficient reflected impedance into the primary.

Instability Appears

It is not possible to get all of the gain out of a transformer when used between three-electrode tubes for a condition of instability and tendency for oscillation appears when the gain reaches a certain value per stage. The maximum gain, of course, would be reached with good shielding, by-passing of each stage to eliminate coupling by common impedance, and neutralizing. There would be no object in using a tuned primary and tuned secondary transformer for coupling three-electrode tubes because all of the gain obtained by tuning only the secondary cannot be used even with perfect shielding and neutralization.

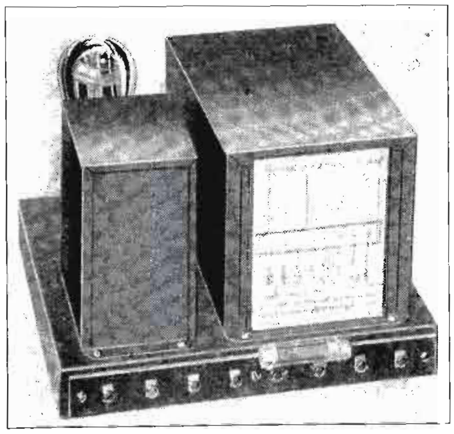


Fig. 3. This photograph is that of the power supply used in connection with the Lincoln DeLuxe Ten

Lincoln Tube Analysis

No.	Type	Position	Fil. "V"	"B"	C	M.A.	Grid	Cont. Grd.	K. "V"
1	227	Osc.	2.3	120	—6	6.5	7.5	....	+6
2	224	1st Det.	2.3	140	+30	.25	4.5	Off scale	+11.5
3	224	I.F.	2.3	140	+30	.25	4.5	Off scale	+11.5
4	224	I.F.	2.3	140	+30	.25	4.5	Off scale	+11.5
5	224	I.F.	2.3	140	+30	.25	4.5	Off scale	+11.5
6	224	I.F.	2.3	140	+30	.25	4.5	Off scale	+11.5
7	227	2nd Det.	2.3	60	—20	.75	1.0	....	+20
8	227	1st A.F.	2.3	180	—12	5.0	6.0	....	+11.5
9	245	P.P.	2.4	220	—48	18.5	23.0	....	....
10	245	P.P.	2.4	220	—48	18.5	23.0	....	....

Fig. 5. Using a Weston 547 tube tester, the typical voltage analysis of the receiver described here may be seen in the above table

From these considerations, it is very evident why it has been standard practice in designing transformers for coupling three-electrode tubes to use the tuned secondary method.

The four electrode shield grid tube, however, has radically different properties from the three-electrode tube. The presence of a shield between the grid and the plate reduces the capacity between the grid and plate. The shield does not materially change the input capacity which is the grid to filament capacity, but the plate to filament capacity is considerably increased.

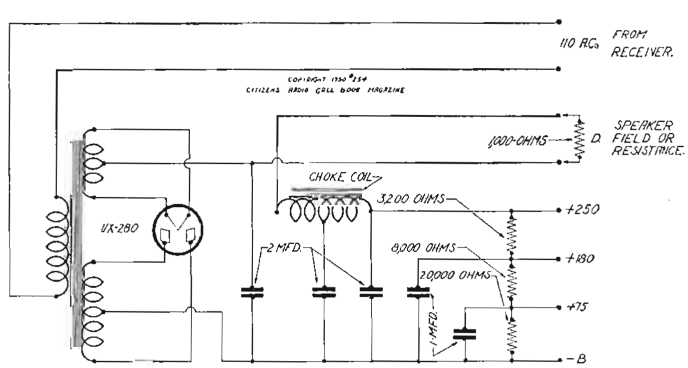
This means that the short circuiting effect of the output capacity of a shield grid tube is several times the short circuiting effect of its input capacity. Since tuning either the primary or the secondary of a transformer has the effect of removing either the output capacity or the input capacity respectively, the idea is immediately suggested to tune the primary.

The effect of the shield is to greatly increase the plate to filament resistance from a value of less than 20,000 ohms to a value on the order of 500,000 ohms. With the three-electrode tube it was not very difficult to get a primary impedance at least equal to the plate to filament resistance of the tube.

A tuned secondary transformer which was satisfactory for the three-electrode tube having a primary impedance of possible 50,000 ohms would give very little gain when used with shield grid tubes because of the very small proportion of the total plate circuit impedance which the primary of the transformer would represent. A tuned primary would, however, have a very high impedance and would make it possible to get a much larger proportion of the voltage generated in the tube across it. It is evident that, if the primary impedance of the transformer was equal to the plate to filament resistance of the tube, that only one-half of the voltage would appear across the primary. From these considerations, it is easily seen that the primary of a transformer used with shield grid tubes must be tuned. In the case of the shield grid tube, the plate to filament resistance is so high that its effect upon the tuned primary in producing an equivalent series resistance is negligible. This means that there would be no loss in selectivity in tuning the primary, but a considerable increase in voltage amplification would be effected.

(*Continued on page* 130)

Fig. 4. The electrical circuit of the power supply which is illustrated in the photograph at the top of this page may be seen in the schematic diagram printed here



Excello R-154 Phono-Radio Console

EXCELLO Products Corporation, an old line manufacturer of quality radio furniture has now made arrangements to merchandise his products complete with a radio and phonograph combination. The photographic view of the combined radio and phonograph model is shown in the illustration Figure 1, while the electrical details of the radio frequency and power end of the model R-154 is illustrated in the schematic diagram Figure 2.

The circuit of the chassis comprises three stages of tuned radio frequency amplification with four tuned circuits using the 224 screen grid tube. The detector is a 227 type and operated as a grid bias or plate circuit rectification tube. The first audio frequency stage uses the 227 type tube in resistance coupled amplification. Following this are two type 245 tubes in push-pull.

A local distance switch is provided in the circuit as shown in Figure 1. It will be seen that this switch operates to tap the primary coil of the first r. f. transformer. By so doing it varies the degree of amplification.

The volume control consists of a 6,000-ohm wire wound potentiometer arranged to vary the screen voltage on the screen grid tube and in that manner the amplification of these tubes. In combination with this volume control is a single pole double throw toggle switch which operates to change the receiver from phonograph to radio. When the control is turned all the way to the left the circuit of the input to the resistance coupled audio stage is switched from the output of the detector circuit to the phonograph jack on the chassis rear.

Fig. 1. This photograph shows a view of the Excello R-154 phonograph-radio console

The following figures are the approximate voltages on the various tubes in the Excello R-154 receiver. Variation in tubes and normal variations of resistors allow for these values to be practically correct in the average chassis. These voltages should be read in the no-signal condition of the receiver and with the volume control all the way on. A standard set tester should be employed for making these readings.

The 224 tubes have a filament voltage from 2.35 to 2.4 volts. The screen grid to cathode voltage will run from 75 to 80 volts. From plate to cathode the voltage will be from 160 to 170. From ground to cathode the voltage will be from 1.5 to 2 volts.

In the detector circuit where a 227 is used the filament voltage will be 2.35 to 2.4. The plate to cathode voltage will be from 60 to 75 volts, while the ground to cathode voltage will be from 6 to 7.5.

In the audio stage the 227 filament voltage will run from 2.35 to 2.4 volts. The plate to cathode voltage will be from 90 to 100, while the ground to cathode voltage will be 4.5 volts.

In the case of the 245 tubes used in push-pull the filament circuit readings will be 2.4 to 2.5 volts. The plate to cathode voltage will be from 240 to 250 volts, while the grid to filament voltage will be from 45 to 50 volts d. c.

With the rectifier the filament voltage will be 4.8 to 5 volts a. c. and the plate to cathode voltage will run from 340 to 360 volts d. c.

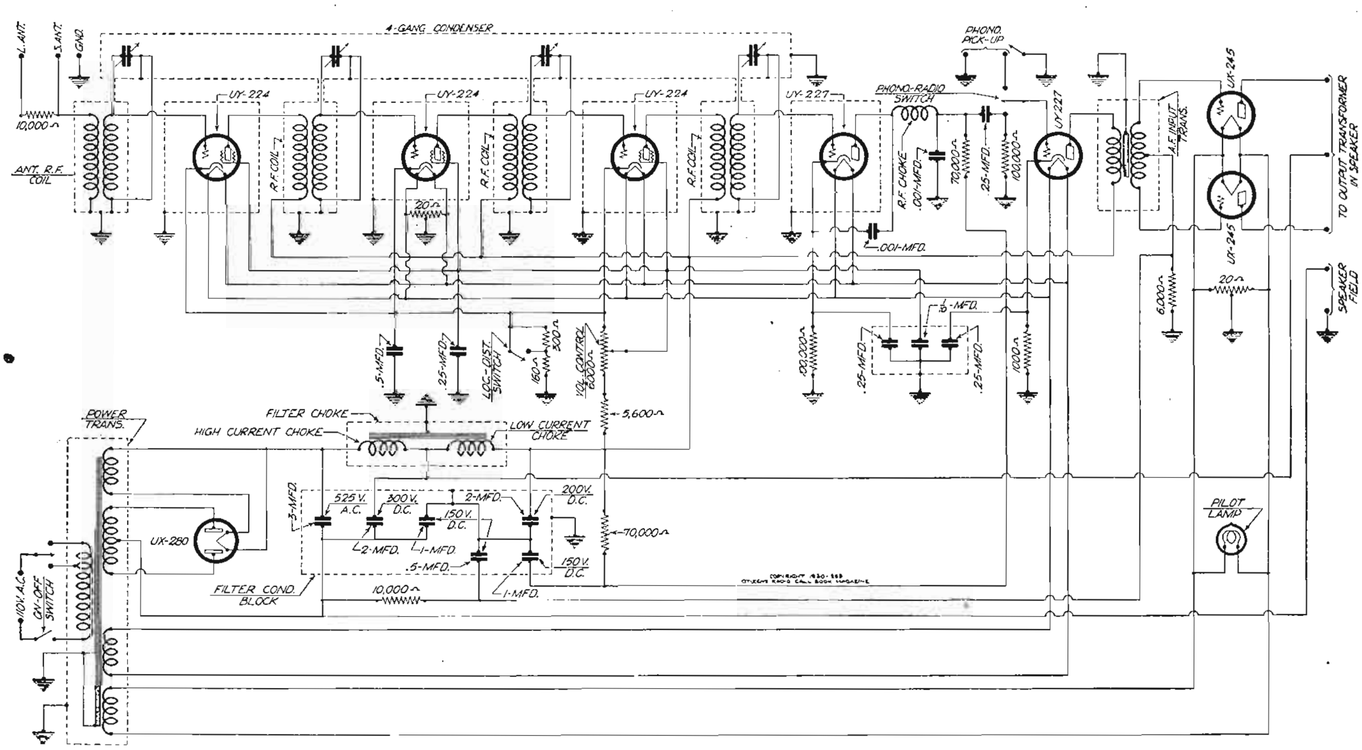


Fig. 2. The schematic diagram of the receiver and the power supply of the Excello R-154 is shown above

New Design Is Seen in Pilot P-E-6 S. G. Broadcast Receiver

Two Radio Frequency Stages Employ 224's, While the Detector Uses a 227; 171 Push-Pull in Audio

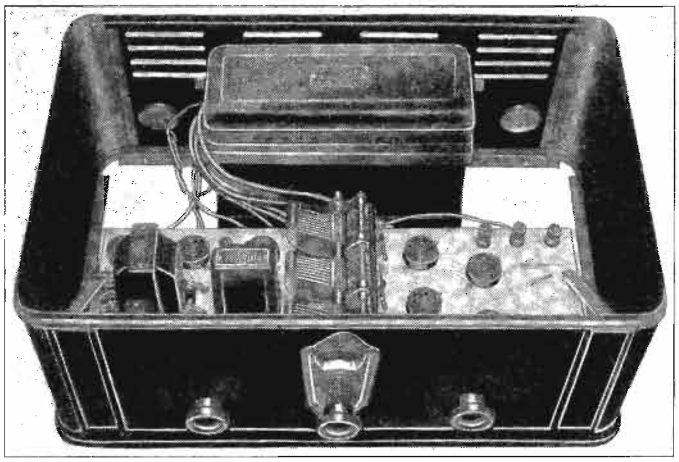


Fig. 1. Photograph of the completed receiver is here shown

MANY radio experimenters, custom set builders and professional service men have the idea that a screen-grid receiver, in order to be selective, must incorporate complicated band-pass tuner circuits and other tricks. This is true only if the designer or builder of the set intends it for use with an aerial of the dimensions many have become accustomed to; that is, an outside exposed wire totaling between fifty and two hundred feet in length. With a pick-up system of this size, and with the enormous amplification afforded by even the early stages of a screen-grid receiver, the intermediate stages overload very quickly, act as detectors, and cause the mysterious "cross talk" effects so common to many present-day factory outfits.

In talking about the admittedly high amplification of the screen-grid tube, radio writers and even many otherwise qualified radio engineers lose sight of its poor power-handling capacity. Its maximum allowable grid swing for good amplification, along the straight section of the grid voltage-plate current curve, is only 1½ or 2 volts, as compared to 14 volts for a 227 type tube. Even a single screen-grid r. f. stage, preceded by a long aerial, will affect the following tube to this extent. Very strong local signals will frequently be rectified by the very first tube, and will "ride" in on the loud speaker regardless of what wave the set is actually tuned to. If the first r. f. stage is of the so-called "untuned" type this effect will be particularly aggravating.

Loose Coupling

In bringing out a new kit of parts for a screen-grid broadcast receiver, the engineers of the Pilot Radio & Tube Corporation took these factors into consideration, and have developed a successful receiver that uses two stages of screen-grid r. f. with regular r. f. transformers and that is more than selective enough for present conditions. They made the coupling between the antenna and the first r. f. tube very loose, providing two values to suit urban and suburban conditions, and they shielded both tubes and coils to prevent signal pick-up by these instruments themselves. The receiver thus works with satisfaction on an indoor aerial eight or ten feet long; with a very long aerial it is naturally more productive of signals, but then the selectivity starts dropping. The point to emphasize is that it is a wholly effective set with an indoor aerial, and on this basis it is offered to set builders

(*Continued on page* 115)

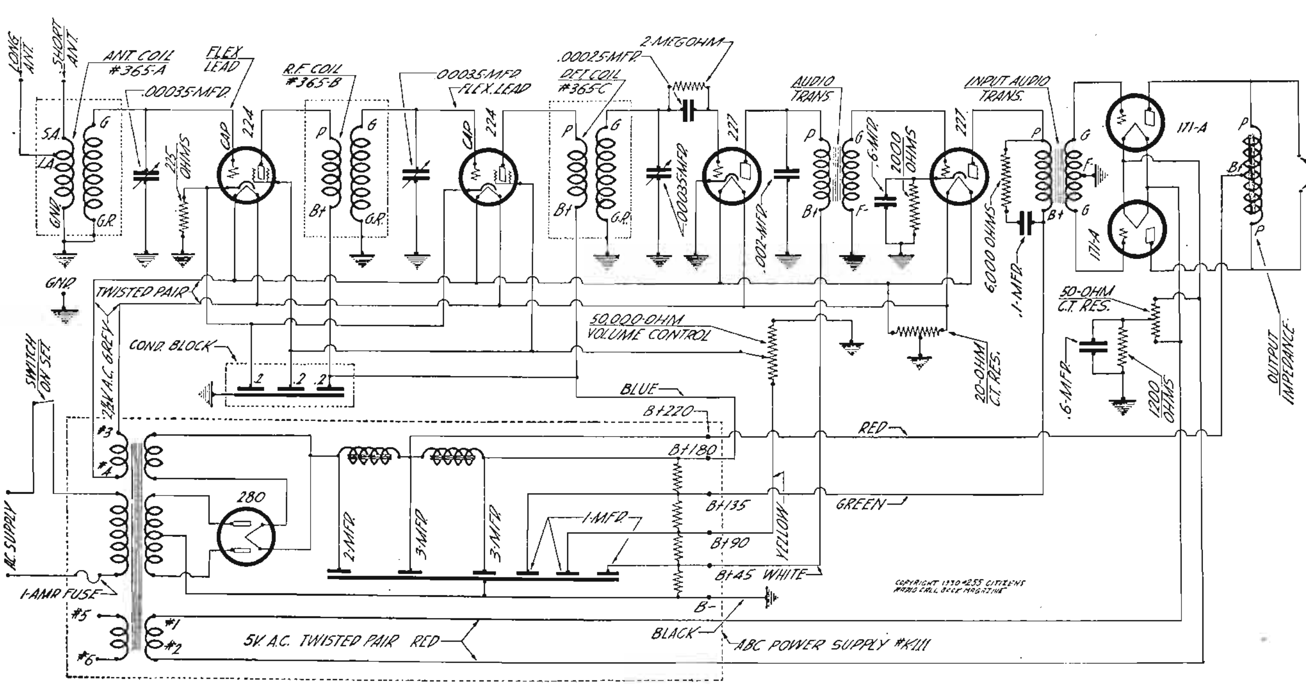


Fig. 2. Electrical details of the Pilot P-E-6 broadcast receiver are shown in this schematic

Theremin Produces Musical Tones By Beat Frequencies

Variation of Proximity of Operator's Hand to Control Electrode Changes the Tonal Notes

SINCE the announcement during the Radio Show this year of the Theremin, a musical instrument using radio fundamentals; merchandised by the Radio Corporation of America through musical outlets, there has been considerable interest on the part of readers in this particular device.

Many Applications

Accordingly we are showing photographically and schematically some of the features of this particular system of musical production invented by L. S. Theremin. Dr. Theremin's original application was filed on December 5, 1925, and patent was issued on February 28, 1928, under the number 1,661,058. In Germany his patent application was filed December 8, 1924. The patent applications and the granting of the patent brings to a close a number of years of arduous work on the part of the inventor to perfect the system of utilizing beat frequencies to produce musical sounds. How well he has succeeded in his endeavor may be seen by those who have listened to the Theremin played at the various radio shows and in other demonstrations.

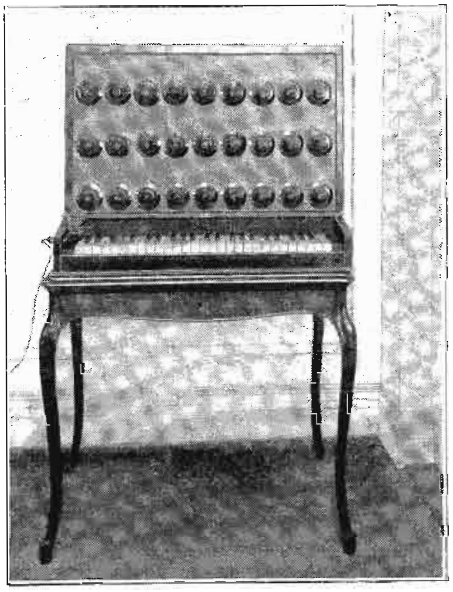


Fig. 1. The instrument shown in the photograph above is an electrical piano, one of the several variants of the Theremin. It plays chords, the tonal characteristics of which may be varied to as fine a degree as 1/100 of the tone

With the method and apparatus for the generation of sound established by Dr. Theremin, those interested in the technical end can readily see the vast number of applications that may be made beyond the construction of a single apparatus.

Electrical Piano

For example in the photograph shown in Figure 1 may be seen one of the Theremin devices which is an electrical piano on which chords can be played. Each tone can be tuned to 1/100 of a tone by means of variations in the oscillating circuit. In the photograph the keyboard may be seen at the lower front while the controls permitting the tuning of individual notes may be seen above.

In the schematic diagram shown in Figure 2 is given the basic circuit from which all the modifications may be made. This diagram is that of a complete instrument for two tones. While the patent papers contain a number of other schematics it was thought that this one gives a general idea of the system and in the interest of space conservation we are only printing this particular drawing.

Another interesting application may (*Continued on page* 127)

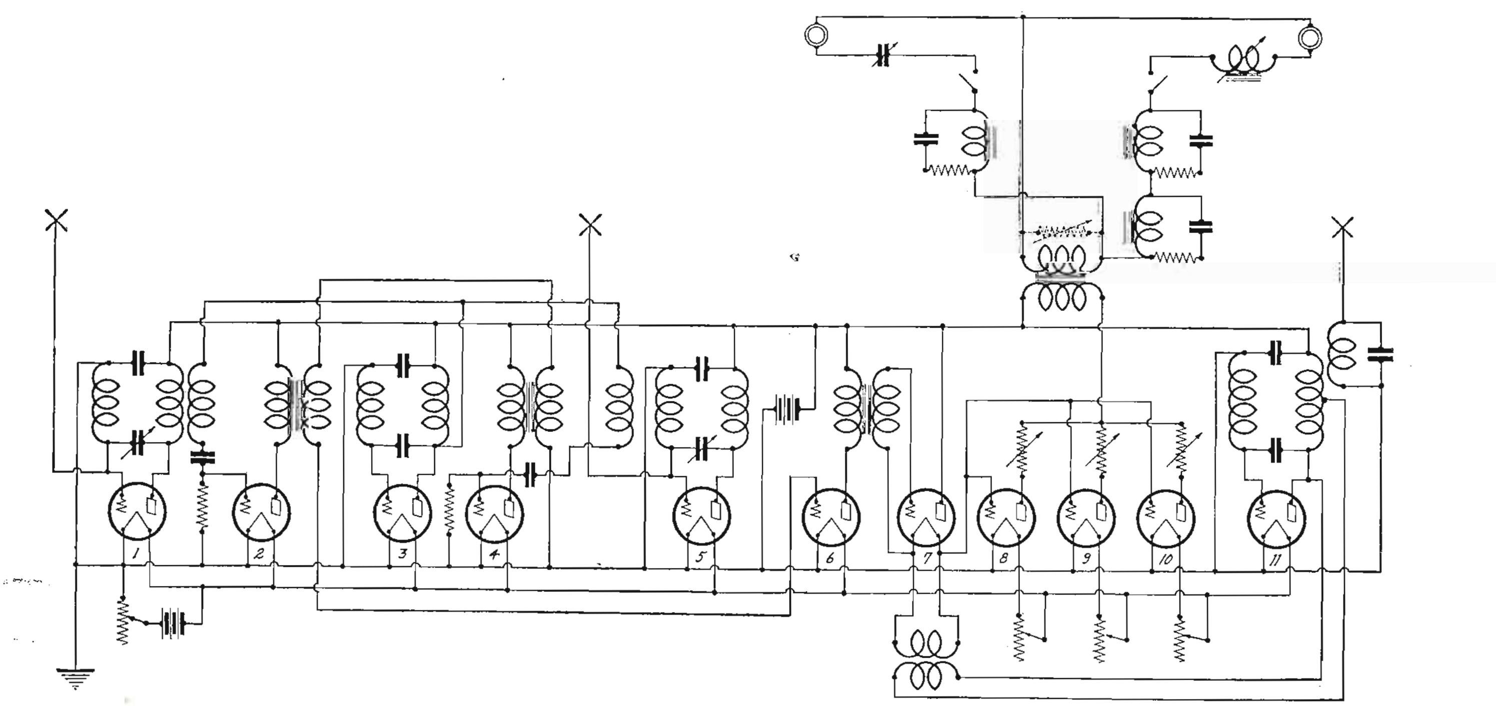


Fig. 2. The schematic diagram of the basic idea embodied in Dr. Theremin's invention is shown in this illustration. In the patent application, however, there are many schematic drawings but lack of space permits the use of only one of a characteristic type

Chemical Action and Capacity in Storage Battery Described

Proper Care Must Be Given Cells If Maximum Satisfaction and Service Are to Be Secured

(Part II)

CORRECTION

[The formulas in paragraph 2, column 2, page 114, Volume 10, No. 4 should read Pb04 and Pb0.]

IN Part 1 of this article there was discussed the various parts that go to make up the lead-acid storage cell, and the methods of the manufacture from the raw material to the completed cell. The purpose of Part 2 of this article is to familiarize the user of such a battery with the chemical operations of the lead acid cell, its usual troubles and rectifications of same in order that the greatest amount of service may be obtained from the storage batteries. At its best, the storage battery is a very inefficient electrical device and when given the average care which they usually receive such as overcharging, under-charging, not having the proper amount of water, etc., the storage battery usually does not last for any length of time, whereas if the storage battery has the proper care it will last for a great length of time and give an abundance of satisfactory service.

Capacity of Battery

The capacity of a storage battery is a product of the current drawn from the battery multiplied by the number of hours this current flows. Theoretically a battery has a capacity of 40 ampere hours when it furnishes 10 amperes for four hours and if it is unable at the end of that time to furnish any more current. If we drew only one ampere from this battery it should be able to furnish one ampere for 40 hours. The capacity of the battery should be the same no matter what current is taken from it. However, a storage battery should not be discharged to a lower voltage than 1.7 volts per cell. The factors upon which the capacity of storage batteries depend are grouped in two named classifications: First, the design and construction of the battery. Second, the conditions of operation. Each of these classifications may be sub-divided into a great number of divisions, each one materially affecting the capacity of the battery. However, the most important of these sub-divisions is the area of plate surface. It is evident that the chemical and electrical activity of the storage battery are greatest at the surface of the plate, since the acid and active material are in intimate contact here and a supply of acid is more readily available as the battery is discharged. Therefore, it may be said that the capacity of a storage battery will be greater if the surface area of its plate

Fig. 2. A positive plate ready for use

is increased with larger plates or a greater number of plates. There is, of course, a greater amount of plate area and acid available which results in an increase in capacity.

As an analogy of capacity ratings we will consider the two water tanks in Fig. 14. The water in tank "B" is placed under a pressure by means of the weight *T* which floats on top of the water. We will assume that this weight is six pounds per square inch, as indicated on the gauge *D*. In the larger tank *J* the weight is of a size sufficient to place the water under the same pressure of six pounds per square inch. When the valve *E* is opened the water in tank *B* will flow through this pipe *F* at a rate which we will say at ten gallons per minute. As this tank holds sixty gallons it will be readily seen that it will be empty in six minutes. If the valve is opened in tank *G* and the water drained is at the same rate as from the smaller tank which was ten gallons per minute it will be seen that it will take ten hours to empty it as the last tank holds 100 gallons. This will show that it will take longer to empty the larger tank than the smaller tank at the same rate of water flow. From this the capacity of the larger tank is greater than the capacity of the smaller tank in what we may term in gallon hours.

Using an Analogy

Referring to Fig. 13 this analogy can be applied to the storage battery. In Fig. 13 we have two storage cells. Each of these cells has a voltage of approximately two volts when there is no current drain. Both of these cells have the same electrical pressure, which is two volts. If the switch *B* is closed cell *A* when fully charged will deliver current to the light *F* which we will assume to draw current at the rate of five amperes. Assuming that these lights will burn at their rated brilliancy for ten hours, cell *A* would then discharge at the rate of five amperes for twelve hours, giving an ampere hour capacity of sixty ampere hours. If the switch *E* is then closed cell *B* will then discharge through the light *F*. These lights also draw five ampere hours with the length of time that this current is connected to the light due to the larger plate in cell *B* is increased to twenty hours. Then the capacity of cell *B* is 100 ampere hours.

From this it will be seen that the capacity of a cell is dependent upon the plate area. This means that smaller

Fig. 1. Overheated group of plates caused by excessive sulphation

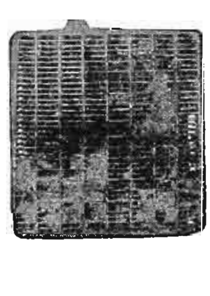


Fig. 3. A positive plate from a battery which has been frozen due to lack of charge

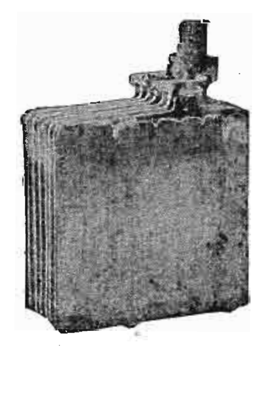


Fig. 4. Group showing excessive sulphation on plate due to lack of water

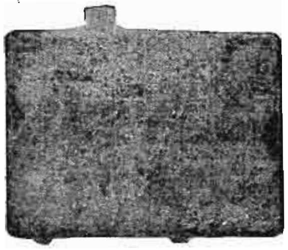


Fig. 5. Appearance of an under-charged plate

plates but a greater number of plates may be used, just as well as a larger single plate to obtain the same capacity hours rating. The voltage of the storage cell is independent of the number of plates in the cell, but the voltage will drop with the time discharge at a certain rate due to the chemical changes which take place, so it is necessary to set a voltage cut-off so as to determine the time of discharge. The higher the ampere drain the faster the battery will discharge. This cut-off voltage is usually set according to the lowest voltage at which the apparatus being used with the storage cell or battery will operate at the current which it draws.

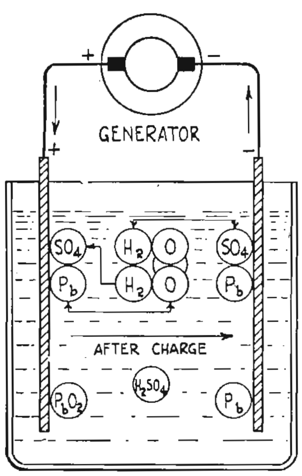


Fig. 6. Illustrates the chemical change after the storage cell has been charged

Capacity Varies

Referring to Fig. 16, from a careful study of this graph it will be seen that the ampere hour capacity of the storage battery varies with the rate of discharge. It will be seen that the higher the discharge rate the less ampere hour capacity delivered from the battery. For this reason the user of a storage battery should use a battery which is adaptable for the use which it is being put. A battery which would be satisfactory for lighting purposes would not be satisfactory for automobile purposes and vice-versa. Commercially storage batteries

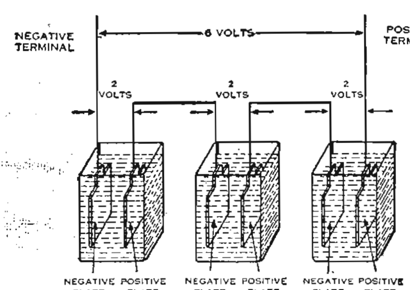


Fig. 7. Illustrates how three storage cells are connected in series

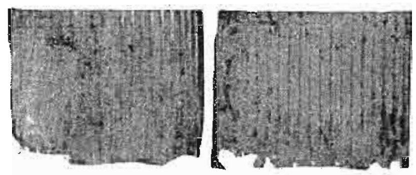


Fig. 8. Shows typical worn out separators

are rated according to which service the battery is to be put and the conditions under which it has to operate. There is the five ampere capacity rate, meaning the capacity obtained by discharging the batteries at five amperes. All capacity rates are based at 80 deg. F. There is then the twenty hour rate which is the capacity by discharging at a rate which will discharge the battery in twenty hours. Then there is a capacity upon the twenty minute rate. This is a capacity which is obtained by discharging the battery at a rate which will discharge it to its cut-off voltage in twenty minutes. The farm lighting batteries or stationary batteries are rated at the eight hour rate or intermittance rate which is the 72 hour rate at normal temperature. Radio batteries are rated at the 100 hour rate. The 100 hour battery based on the radio rate would mean a battery which would deliver 1 ampere for 100 hours at a cut-off of 1.75 volts per cell. While a 100 ampere hour battery rated at the five ampere rate would deliver five amperes for twenty hours under the same condition. If the first battery was rated at the five ampere rate it would only deliver five amperes for 13.4 hours. Each battery would have the capacity to do the work for which it was designed for but the capacity would be based on different rates. For this reason it is essential that the purchaser or user of the storage battery should be careful in the type of storage battery he is using to get the most service out of it. As will be noticed all capacity ratings have been based at 80 deg. F. temperature. This is due to the fact that the capacity of the storage cell will vary with the temperature and 80 deg. has been selected as the standard operating temperature.

Referring to Fig. 15 will show the difference in capacity for a change in temperature.

In order to further understand the capacity and operation of the lead-acid storage cell it will be necessary to un-

Fig. 9. Shows a group of badly buckled plates due to overheating

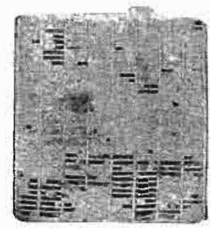


Fig. 10. Another plate from a frozen battery

derstand a little of the electral chemical action within the cell. If we should examine a storage battery which has been completely discharged and test the electrolyte and the materials on the plate we would find that the electrolyte was pure water and both sets of plates composed of white sulphate. And if we should make a like test on the plates and electrolyte of a storage cell which has been fully charged we would find that the electrolyte is now composed of water and sulphuric acid, the water being about 70 per cent and the acid about 30 per cent of the electrolyte. The negative plate would now be composed of pure lead in extensive form and the

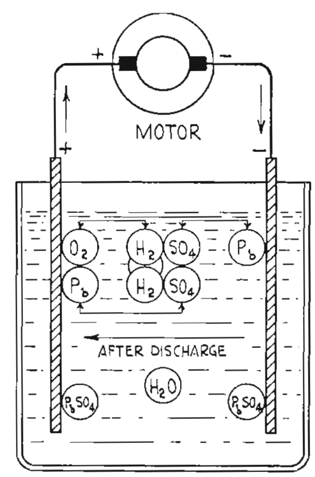


Fig. 11. Illustrates the chemical change after the storage cell has been discharged

positive plate would consist of peroxide of lead. The substances considered in the chemical action are sulphuric acid, water, pure lead, lead peroxide and lead sulphite. With the exception of the pure lead each of the substances is chemical compound composed of several elements such as sulphuric acid which is made up of two parts of hydrogen, which is a gas, one part of sulphur, which is a solid, and four parts of oxygen, which is a gas. These combine to

Fig. 12. Shows a temperature thermometer for a storage cell with the maximum heat at 110 degree, safe operating temperature

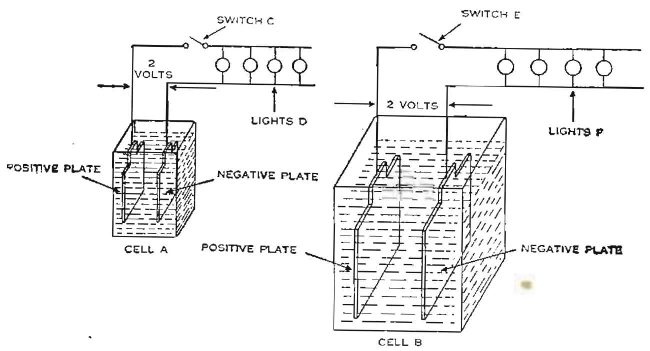


Fig. 13. This illustrates the difference in capacity ratings of a storage cell

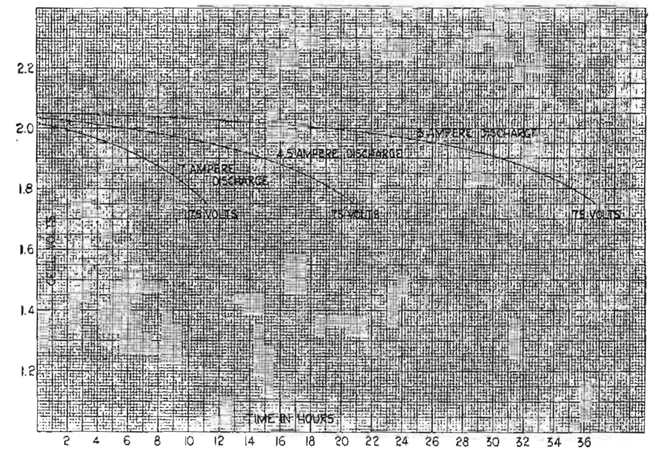


Fig. 16. Curves showing capacity at different discharge ratings

form the acid which is in a liquid form and which is written chemically H_2SO_4. H_2 represents the two parts of hydrogen, S the one part of sulphur and O_4 the four parts of oxygen. Likewise the water is made up of two parts of hydrogen and one part of oxygen which would be written chemically as H_2O. The pure lead which is an element and not a compound has a chemically sym-

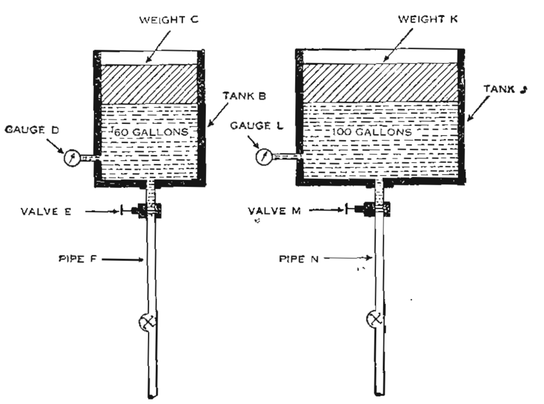


Fig. 14. A water analogy of capacity ratings

bol Pb. Lead sulphate which is a compound solid consists of one part of lead, one part of sulphur and four parts of oxygen. This would be written chemically as $PbSO_4$. Lead peroxide is also a solid and a compound and is made up of one part of lead and two parts of oxygen. In the changes that take place each compound split up into the substances of which they are composed, such as lead, hydrogen, oxygen and sulphur, making four elementary substances, two of which are gasses and two solids.

Sulphur, however, does not separate itself entirely from the compound, but split into H_2SO_4 and $PbSO_4$ respectively. This shows that the sulphur always remains combined with four parts of oxygen.

Now let us suppose that we have a single storage cell made up of one positive plate, one negative plate and electrolyte. When this cell is fully charged the positive plate is made up of peroxide of lead PbO_2, and the electrolyte of dilute sulphuric acid H_2SO_4.

When Cell Discharges

Referring to Fig. 11 we will illustrate what takes place when the cell is discharging and the result of the changes are that the positive plate, lead peroxide and sulphuric acid, produce lead sulphate, water and oxygen. Chemically written this would appear to be $PbO_2 + H_2SO_4 = PbSO_4 + H_2O + O$, and at the negative plate lead and sulphuric acid produce lead sulphate and hydrogen which would be written chemically as $Pb + H_2SO_4 = PbSO_4 + H_2$. The oxygen in the first equation and the hydrogen of the second equation combine to form water, as will be readily seen by adding the two equations, giving one equation with the entire storage action, which would be written $PbO_2 + Pb + 2H_2SO_4 = 2PbSO_4 + 2H_2O$. In this last equation we started with the active materials and electrolyte in their original condition and finished with the lead sulphate and water which are the products of the discharged condition. Upon examination we see that the acid of the electrolyte is used in forming lead sulphate on both positive and negative plates and is therefore removed from the electrolyte which may be said that during a discharging condition the acid goes into the plate. These chemical changes are not instantaneous upon the discharging of a battery, but are a slow process, the speed of which is determined by the rates at which the battery is discharged. The slower the discharge the slower the change and likewise the faster the discharge the faster the change. Referring to Fig. 6, supposing that we are now going to charge a cell which is completely discharged. When the battery's charging with lead sulphate and water will gradually be changed back into lead, lead peroxide and sulphuric acid. The lead sulphate

(*Continued on page* 115)

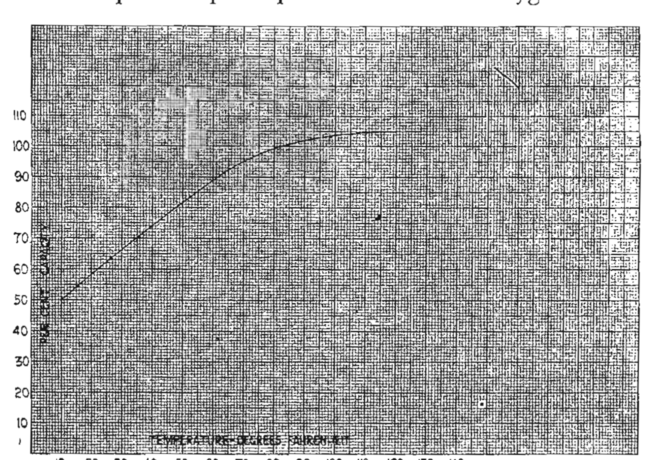


Fig. 15. Curve showing change of capacity with change of temperature

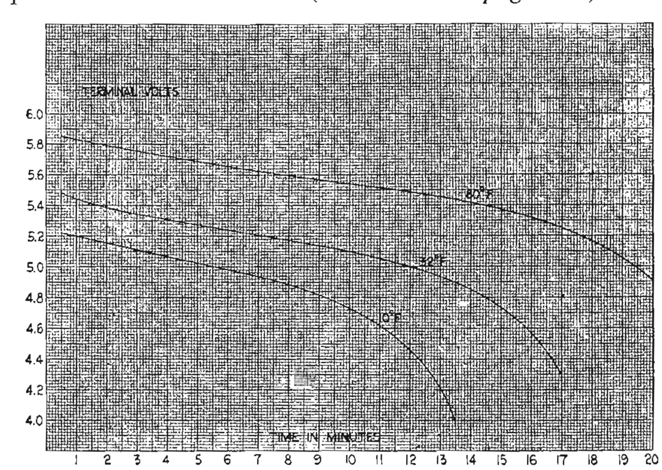
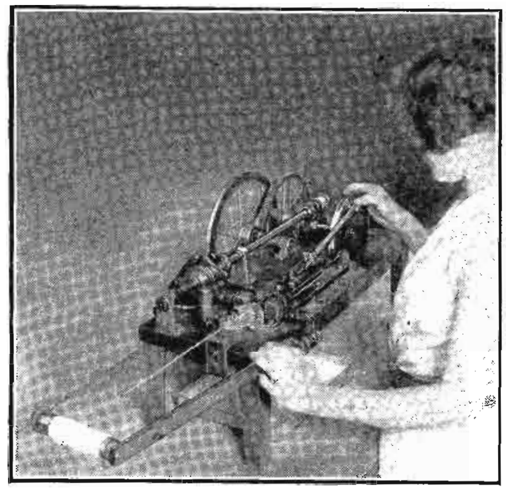
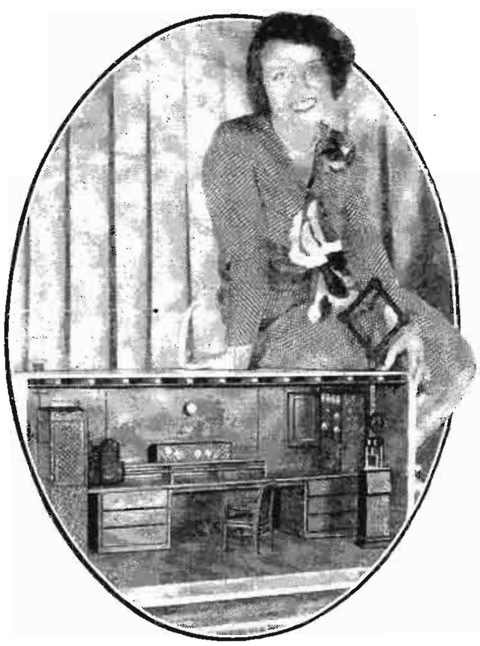


Fig. 17. Curves showing voltage decrease at different temperatures at constant current drain

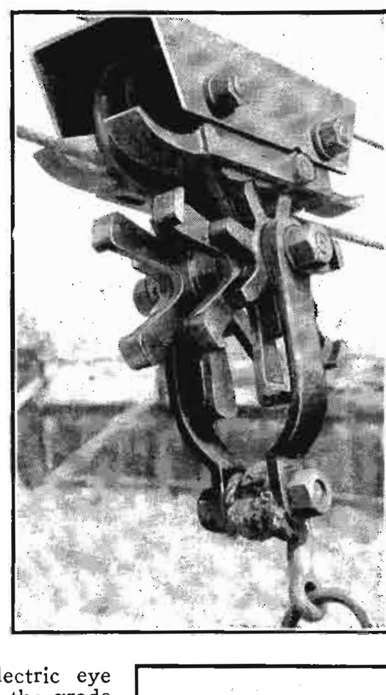


Right. Nucrometer filament cutter in the Duovac tube plant, one of two such machines in existence, automatically and precisely measures, cuts and scrapes ends of the delicately coated filament wire heretofore cut, scraped and measured by hand



Wide World Photo

Left. Photo shows a model of a steamship installation which is valued at about $10,000. It is shown with Miss Florence Levy, who is cashier for the radio operators, taking care of their finances while they are at sea. It was exhibited in the display of the Radio Corporation of America at the World's Radio Fair in Madison Square Gardens recently

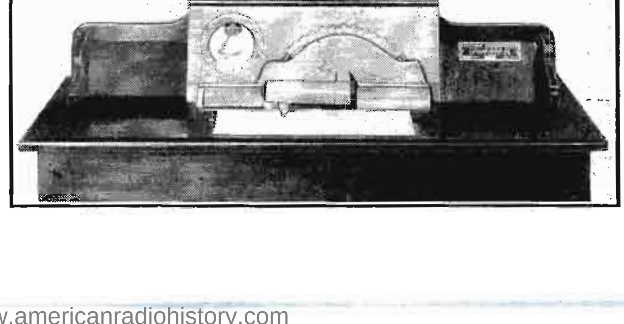


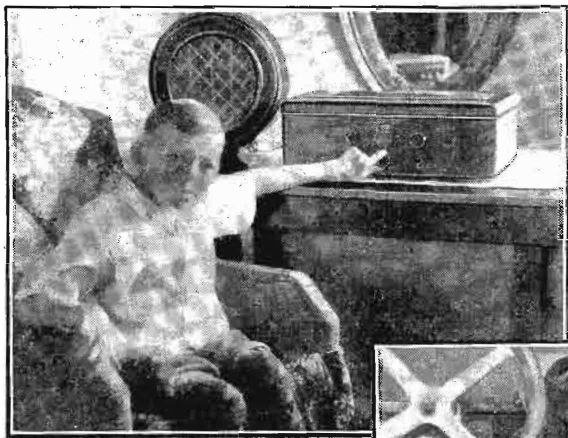
P. & A. Photo

Left. Photo shows the new "Stepping Trolley" as it is called by its inventor. Its name is due to the fact that it steps over cable supports as though they were not there. The steppers or fingers are built in a circle, and when they hit a cable support they revolve, in that way stepping over the support. While they are revolving three of the fingers or steppers are always holding the load

P. & A. Photo

Lower right. A machine that exercises artistic judgment was recently displayed at the annual convention of the Master Photo Finishers of America, in Washington, D. C. It looks through a photographic negative with an electric eye and then stamps on edges of the film the grade of photographic paper the picture should be printed on and the degree of light that should be used, in printing it. The Printometer is the invention of Roland Wilkinson, of Jackson, Michigan



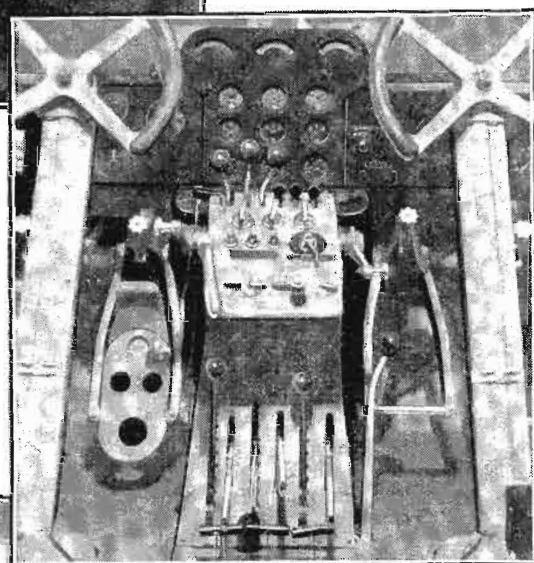


P. & A. Photo

Left. Bobbie Farr, 12 years old, of Iowa City, Ia., with radio sent him by President Hoover, after he wrote the chief executive telling him how much he enjoyed his speech for the Golden Jubilee of Light through hook-up with a neighbor's radio set. Bobbie first became acquainted with the President when the latter stopped at Iowa City en route to home coming celebration at West Branch last August. The President spied Bobbie in the crowd and shook hands with him

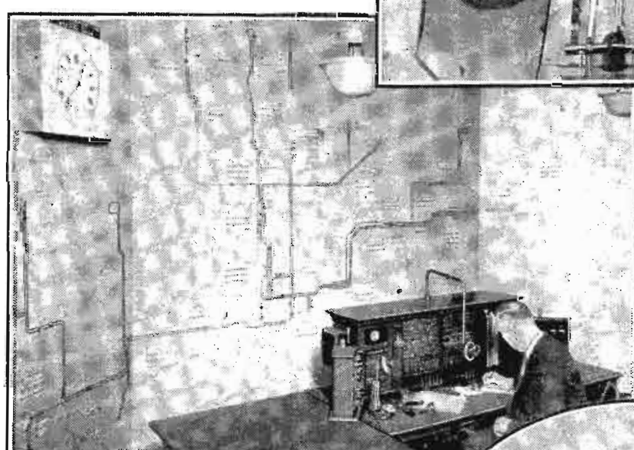
P. & A. Photo

Below at right. This bottle-like object is a cathode ray tube which forms the receiver of the new type of television invented by Dr. Vladimir Zworykin, Westinghouse research engineer, who is seen holding it. The broadcast pictures appear on the round end of the tube and from there are projected on a mirror in view of the spectators



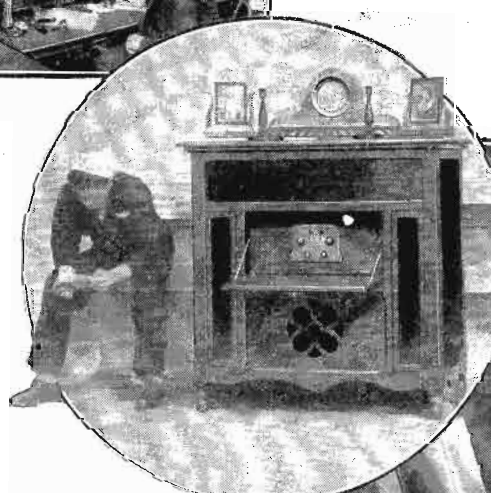
Wide World Photo

Right. One reason why giant tri-motored transport planes have two pilots is shown by this instrument board of the Boeing-San Francisco - Chicago transport. These planes have ninety controls and instruments to aid the pilots while in flight



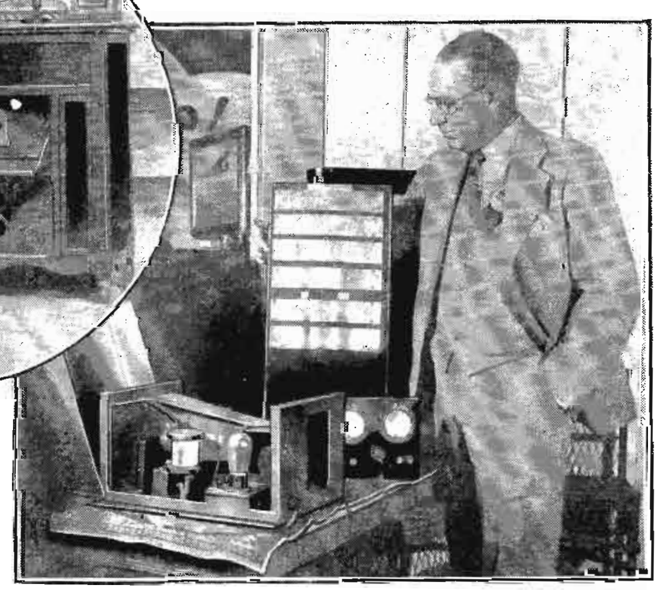
P. & A. Photo

Left. In the heart of Chicago's loop district and 15 miles distant from remote points of the electrified railroad it governs, is located this huge diagram, which furnishes a manual and visual key to all "juice" used on Rapid Transit lines highways, transporting hundreds of millions of people annually. A glance at the diagram, with its miniature red and green lamps, colored strips denoting power lines and blocks representing 35 power sources, tells in a moment the condition of the sources, idle or operating, and the sets of tracks energized by them. A figurative flick of the power supervisor's thumb would halt any one train or tie up the entire system



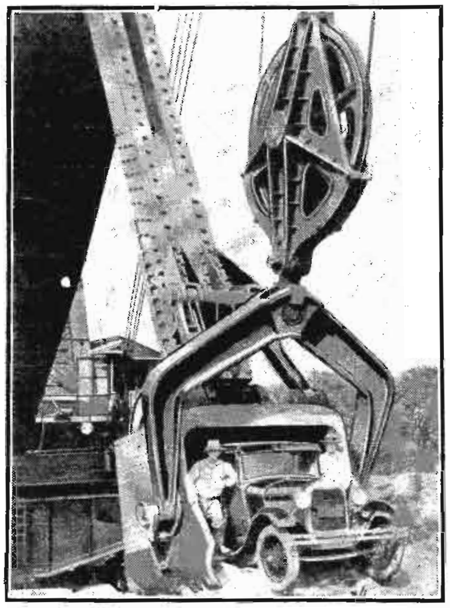
P. & A. Photo

Right in oval. One of the many exhibits displayed on the deck of the U. S. S. California, on Navy Day. All items were made right on board ship. Shown are a radio cabinet, clock, candlesticks and picture frames



P. & A. Photo

At extreme right. A new device to guide airplanes to a landing field in a fog has recently been invented by Byrdette A. Palmer. The device consists of a captive balloon which contains several electrically controlled or automatic instruments which perform the following functions: 1. A fog indicator, to determine when the balloon is in and out of fog. 2. A large facsimile of an altimeter to indicate to pilot the height of the balloon above the airport. 3. A ceiling height indicator, to show pilot in air the extent of visibility below the fog. 4. Wind velocity indicator. 5. Wind direction indicator. 6. A sound detecting device to automatically throw on the airport siren and flood lights if pilot desires to land. 7. An instrument to show the pilot the number of the nearest airport where there is a ceiling of sufficient height for landing in case there is no visibility over the airport where the balloon is anchored. This balloon above the fog gives the pilot the necessary information for landing and a camera recording device in the balloon records in the station below, conditions in the air

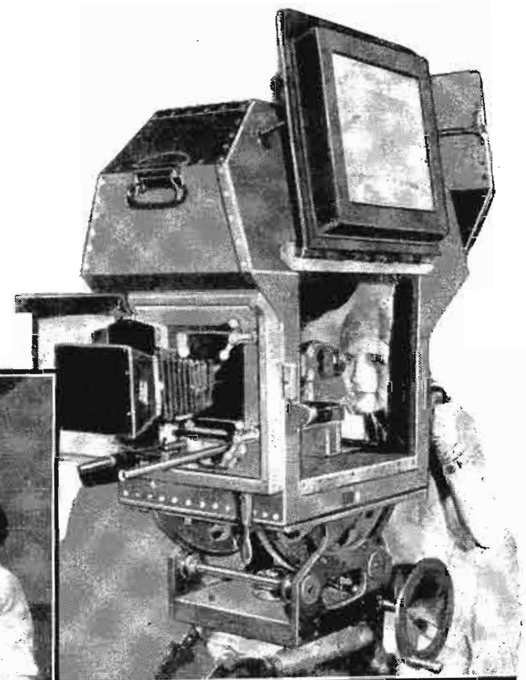


Wide World Photo

Above. The dipper or scoop of this huge new electric shovel, the largest in the world, will hold approximately 20 cubic yards. It was built for use in the Fidelity Mine of the United Electric Coal Company at Du Quoin, Illinois. One scoop would fill the average coal bin with its winter supply, and, as example of its tremendous power, could lift the load shown here and dump it on the roof of a seven-story building in less than a minute

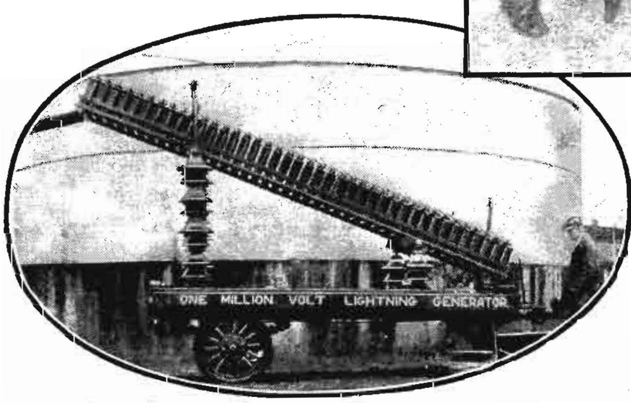
P. & A. Photo

Below. Dr. Vladimir Zworykin, Westinghouse Electric research engineer, is seen demonstrating his new cathode ray television set which can entertain large groups instead of one or two spectators. The broadcast images are projected on a mirror on the top of the cabinet making it possible for many to watch



Wide World Photo

Above. Norma Shearer, Metro-Goldwyn-Mayer star, inspects the newest development in talkie photographic inventions, the sound-proof camera "bungalow" which eliminates the use of the unwieldy booths and permits the same sweep of camera action as in silent pictures



P. & A. Photo

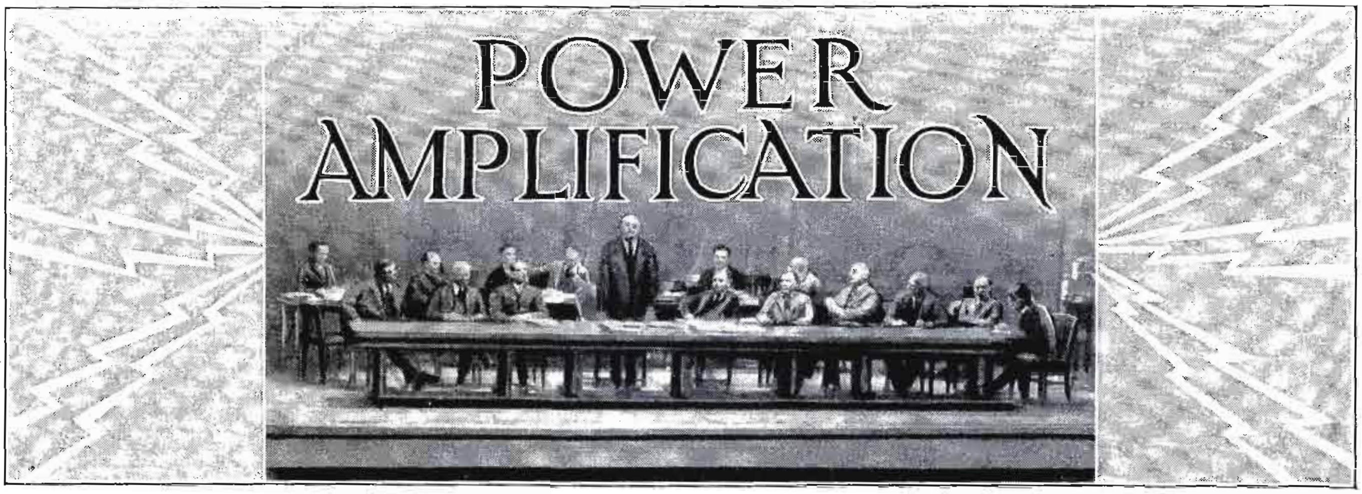
Above. This photo shows the recently completed million volt lightning generator, the only one of its kind in the world, built at the laboratory of the General Electric Company, at Pittsfield, Mass., where it was recently demonstrated

Wide World Photo

Above. The many attractions of Sing Sing prison have been added to by the inclusion of a radio phone "Point" in each of the 800 cells in the new block. A prison official chooses the program and it is then relayed to the cells, this precaution being necessary to obviate the possibility of prisoners' friends talking to them via a nightclub microphone. Photo shows one of the inmates about to don a set of the head phones and listen in on a current program. Each cell is equipped with a set of head phones and there are over 2300 of them throughout the prison and also 21 loudspeakers

Wide World Photo

Right. An automatic testing machine has been devised which checks the performance of the completed radio chassis. This apparatus, which is being used in the engineering department of the Bremer-Tully company does the work of nine inspectors with accuracy and automatically registers any defects in the receiver. Photo shows an operator testing a radio chassis with the new apparatus which resembles a telephone switchboard



New York Power Amplifier System May Serve as Model for Others

Nearly 1,000 Miles of Lines Used in Covering Vast Area; 25 Days Allowed to Complete Work

TO Albert Goldman, commissioner of the Department of Plant and Structures, City of New York, belongs the credit for the successful development of the plan to bring the music of the famous Central Park Mall concerts, as well as those given in Prospect Park, Brooklyn, to twenty-five other parks in the five boroughs of New York.

The idea of the above system originated with the present mayor of New York City, James J. Walker, early in the spring of this year, which idea he presented to Mr. Goldman to carry through to completion. Mr. Goldman placed the active charge of the work in the hands of the chief engineer of Plant and Structures, Edward A. Byrne, who detailed the city's chief radio engineer, Isaac Brimberg, to the task of actual supervision of the installation work to be done by the contractor.

Serve as Model

The specifications covering this installation, prepared by Chief Engineer Byrne and Chief Radio Engineer Brimberg, under the direction of Commissioner Goldman are especially outstanding in that they not only represent a pioneer effort but are so all inclusive that they should advantageously serve other communities whether smaller or even larger systems of like character are contemplated.

After two successful demonstrations and after a most thorough investigation into the history, the stability and experience of the Natural Sound Amplifying System, Inc., by the engineers appointed by Mr. Goldman, the contract was awarded to that company.

Chart Shows Area

The accompanying chart (Figure 3—Park Music Distributing System) will give the reader a fairly comprehensive idea of the vast area covered by the system in the twenty-five parks, Central Park Mall and the Municipal Building. Nearly 1,000 miles of fire department telegraph cable were utilized to connect the amplifying system to and between the various parks in the five boroughs of New York City; eight parks in Manhattan, six parks in the Bronx, six parks in Brooklyn, three parks in Queens and two parks in Richmond (Staten Island).

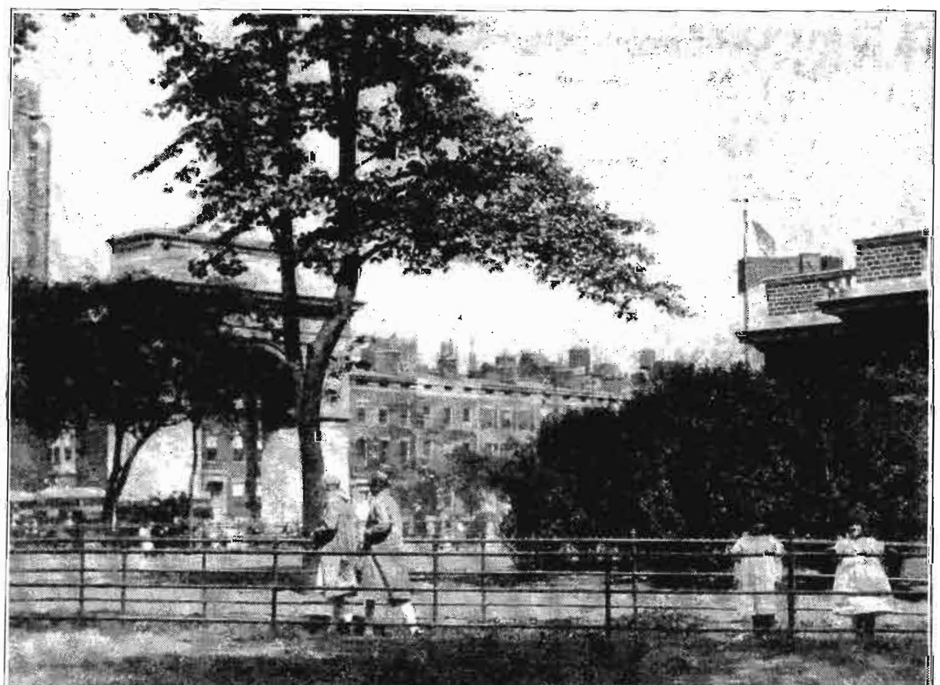


Fig. 1. On top of the building at the right in this photograph may be seen one of the large Wright-DeCoster horns used in supplying voice and music entertainment to visitors at one of the New York parks

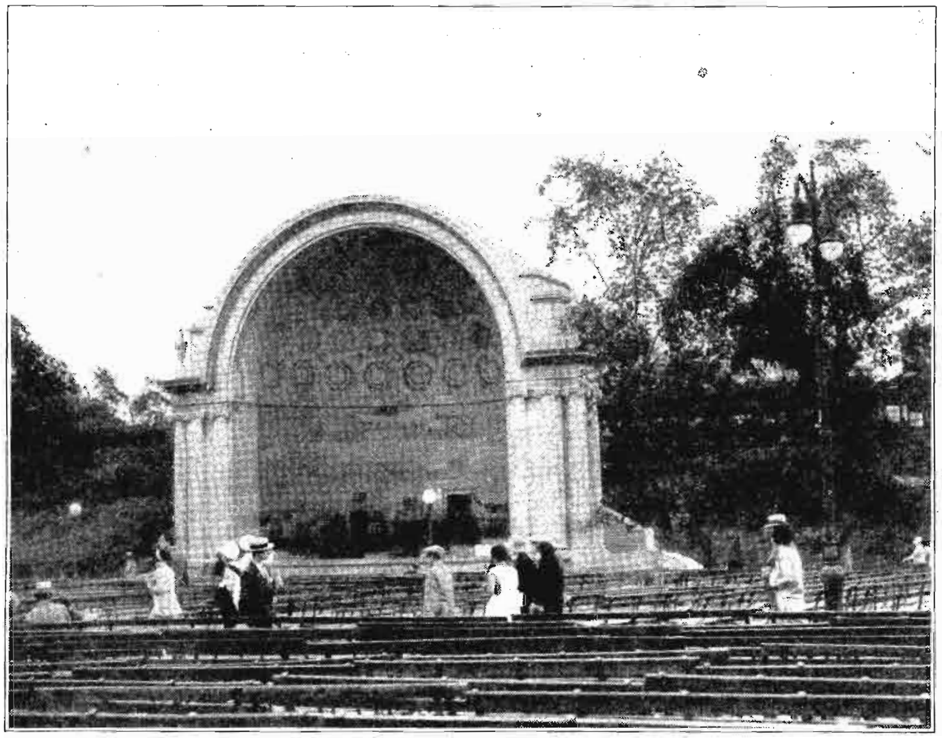


Fig. 2. This photograph shows the band stand in the Mall of Central Park. The band music is picked up by microphone from this position and relayed to all the various distributing stations in the New York park system

The contract allowed twenty-five days for the completion of the work. The entire job had to be organized and its work planned in the minutest detail, between the dates of notification of the award of contract and of beginning of work—a period of two weeks. During this time equipment was specified, ordered and manufactured. Shipments were arranged so as to dovetail with the installation schedule. Any duplication of work had to be avoided because of the shortness of time allowed for the completion of the installation, particularly in view of the fact that a penalty was attached to the lack of such completion within twenty-five days. Each park had to be completely installed without necessity for return trips. Distribution of material and equipment was arranged for in advance of the appearance of the installation crew at each park. The completion of work in all parks in each borough had to synchronize with the completion of the panel installation in the fire department telegraph headquarters in each of the boroughs. All of this planning, to provide against all manner of disappointments and upsets, required experience and ability on the part of the engineering staff of the Natural Sound Amplifying System and the full co-operation of the engineering division of the Department of Plant and Structures of the City of New York which was assigned to this work.

Checking Wire Characteristics

One of the chief difficulties encountered by the engineering staff was the determining of the characteristics of the wires running between the various fire department telegraph headquarters and the parks, as well as the characteristics of the wires running from the main headquarters in the borough of Manhattan (the central distributing point) and the associated headquarters in the remaining boroughs. Another major difficulty was the determining of the frequency characteristics of the allotted conductors. The system was designed to work with pair conductors and the allotted conductors were not of uniform lengths nor of the same kind of insulation, and some of the wires doubled back on themselves in order to reach their destination.

As an example of the above: between the Central Park pickup, at 72nd Street, and Battery Park at the lower end of Manhattan, a distance of about twelve miles, one conductor of the pair ran from Central Park Mall, where the concerts were given, to the 79th Street fire department telegraph headquarters, then to the Municipal Building, approximately eight miles, then back to 79th Street, then to Battery Park, while the other conductor of this pair ran direct from Central Park Mall to Battery Park.

Disconnect Speedily

It was necessary to supply a speedy means of disconnecting these fire department telegraph loops during the day so as to enable the fire department to use

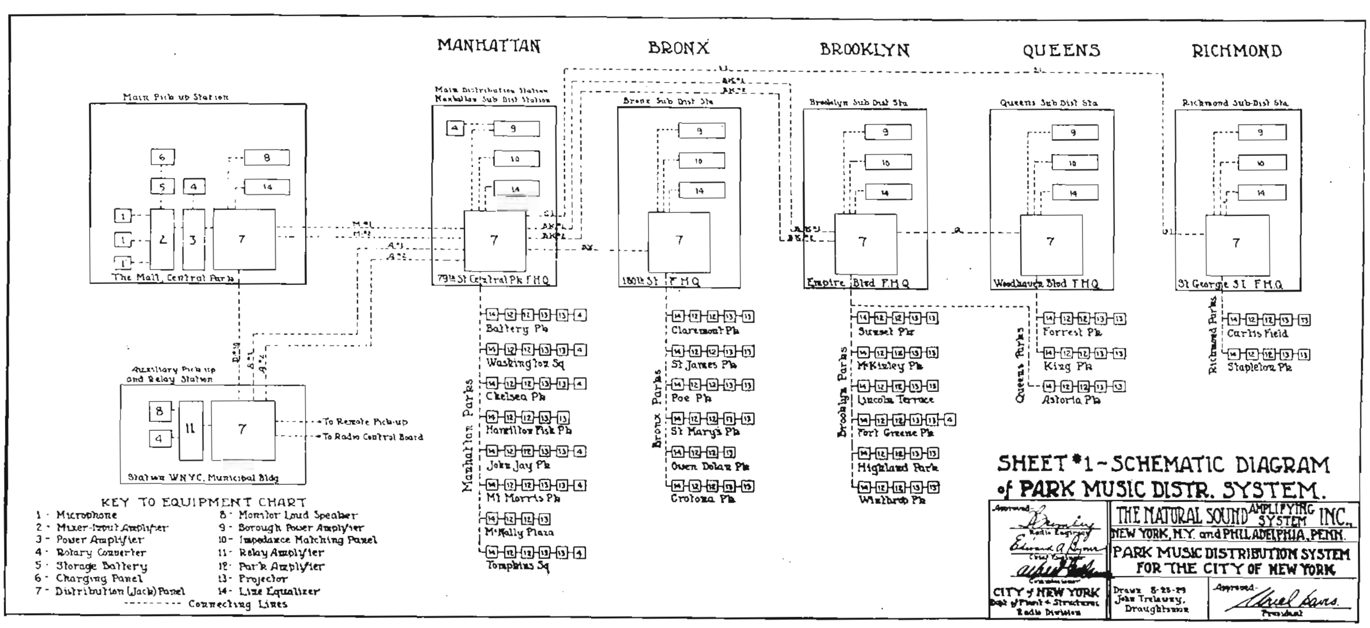


Fig. 3. This drawing shows a schematic diagram of the park music distribution system described in this article

them when necessary in its fire alarm telegraph system without disturbing the "balance" of the music distributing system.

The fire department telegraph system operates with a 67-volt common storage battery and the signals are transmitted by a mechanical means which causes this voltage to peak at as high as 300 volts on some of the parallel conductors associated with the pairs allotted for the use of the music distributing system.

Used One Crew

Because each of the twenty-seven installations offered a distinctly separate problem it was impossible to use more than one installation crew. This force was placed in charge of two engineers. The engineering staff and their co-workers were housed at the same address in order that nightly meetings might be held to discuss the problems of each day's work and to plan the work for the following day.

Dual amplifying equipment was provided in each park to allow for instant change-over in case of difficulty or disturbance of any sort, particularly as an insurance against disappointment on the part of the listeners.

Monitoring System

A highly important feature of the system is a method introduced by the engineers to automatically insure the satisfactory working of the system in the event of the non-working of any individual park or parks or wire section, for any cause whatsoever. Without such an arrangement the operation of the system would require a staff of operators whose sole duty it would be to keep

Fig. 5. At the Chicago municipal airport a speech amplifier is used for broadcasting arrival time and messages to the pilot while the planes are on the ground in front of the passenger station. The three Wright DeCoster speakers are shown above the railing in this photograph

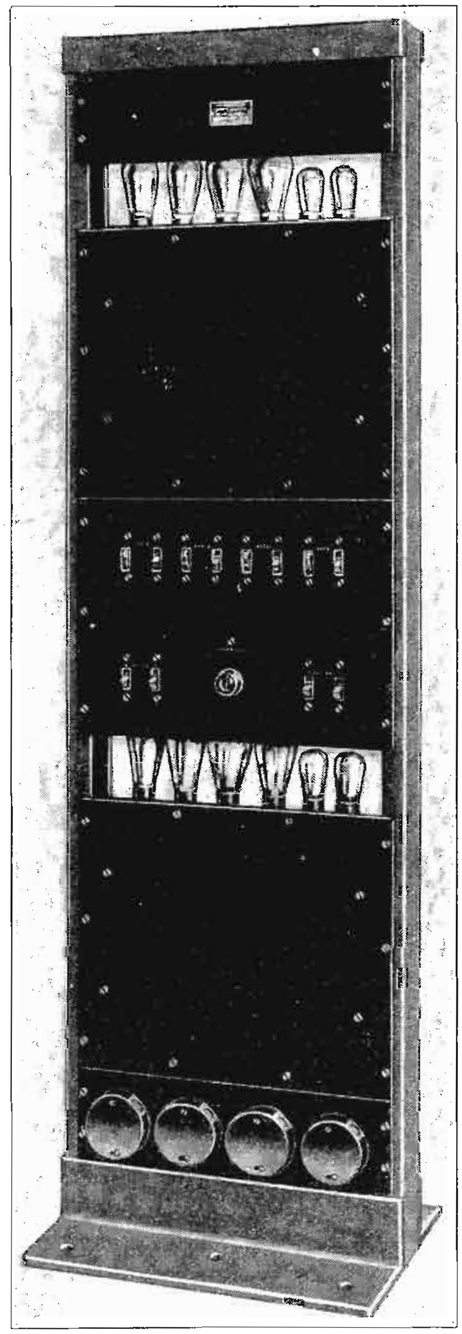


Fig. 4. One of the Samson amplifier panels used on this installation is illustrated in this photograph

in touch with each park to constantly ascertain whether the system was operating successfully during the period of each concert.

The operating personnel consisted of an attendant at each of the five fire department telegraph headquarters; an operator and an announcer at Central Park Mall (or at Prospect Park, Brooklyn, from which park band concerts were sent through the system over a connecting telephone line to the 79th Street fire department telegraph headquarters on evenings when no concerts were scheduled at Central Park Mall); an additional attendant for each borough to visit the parks in that borough each day to turn the systems on and report their condition to the chief radio engineer. After the concert each evening, the superintendent or caretaker in each park turned the system off. The chief radio engineer could listen in at his office in the Municipal Building to ascertain just how the music was passing through the system to the various associated parks.

A telephone system between the various fire department telegraph headquarters was sufficient to keep the entire music distributing system under the control of the chief operator stationed at Central Park Mall or the chief radio engineer at the Municipal Building.

Prior to the completion of the installation Mayor Walker expressed a desire to dedicate the music distributing system. Within forty-eight hours after receipt of this message fifteen parks were hooked up and tested and on the evening of the dedicatory exercises, August 14, 1929, thousands of people in fifteen sections of New York City for the first time were able to hear Mayor Walker speak and the famous Edwin Franko Goldman Band play, at the same time enjoying the cool summer breezes in the public parks of the city.

The engineering staff of the Natural Sound Amplifying System was in charge of its chief engineer, Maurice A. Lichten, who was capably assisted by Messrs. E. M. Winecoff and Charles Stevens, associate engineers.

The horn shown atop the building in Figure 1 was a Wright-DeCoster with flare, while Samson amplifiers were used in the various distributing stations.

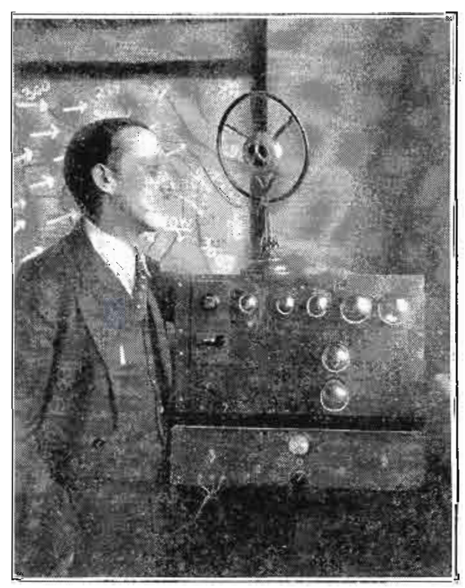


Fig. 6. One of the Silver-Marshall 690 amplifiers is illustrated in this photograph. At the right (not shown) is a modified 722 A. C. long wave receiver with which is picked up the data for plotting the isobars shown on the blackboard in the background. The microphone is located at the top and is used by the announcer for giving arrival and departure time of the planes from the Universal Air Line passenger station at the municipal airport, Chicago

Service Man Should Study All Types of Power Amplifier Systems

Tubes Generally Cause Seventy-Five Per Cent of Amplifier Troubles; Watch for Double Grounds

By JOHN ERWOOD
[*Chief Engineer, The Webster Co.*]

DISCUSSION of power amplifier problems could be conducted along humorous lines except for the very sad fact that the subject is funny to neither the manufacturer nor the user. Only a very versatile comedian could extract any merriment from a talkie installation with a silent amplifier, and by the same token there is nothing involved in an inoperative coin-in-the-slot machine which would tend to gladden the heart of its owner.

Difference of Degree

Analyzing the public address amplifier and the type of amplifier used in radio work, we readily see the only difference between them is one of degree. The service troubles are likely to be the same in either case. Both are power handling devices. Greater power is expected from the public address or theater amplifier than from one used for radio. Many of the current models of radio sets may claim the right of classification in the power amplification group on account of the type of tubes employed in their output systems. However, many radio service men look askance and shrug their shoulders when

Arcturus Tube Characteristics

Type Number	Filament Terminal Voltage	Filament Current (Amperes)	Detector Bias (Megohms)	Detector "B" Voltage	Detector Plate Current (M. A.)	Amplifier "B" Voltage	Amplifier "C" Voltage	Amplifier "C" Bias Resistor (Ohms)	Screen Grid "B" Voltage	Screen Grid Current (M. A.)	Plate Resistor (Ohms)	Amplifier Plate Current (M. A.)	A. C. Plate Resistance (Ohms)	Mutual Conductance (Micromhos)	Voltage Amplification Factor	Maximum Undistorted Output (Milliwatts)	Purpose
22	15.0	0.35	....	....	....	135	—1.0	....	30	....	....	1.0	700,000	570	400	....	Det. & Amp.
26	15.0	0.35	....	22.5	1.0	....	+4.5	....	....	....	....	....	....	....	....	....	Amplifier
			....	45.0	2.5	....	+9.0	....	....	....	....	....	....	....	....	....	Detector
30	15.0	0.35	....	....	....	180	—27.0	1,227	....	....	....	22.0	3,500	1,085	3.8	....	Power
28	15.0	0.35	....	....	....	90	—1.5	200	....	....	....	7.5	9,000	1,165	10.5	....	Amplifier
32	15.0	0.35	....	....	....	135	—3.0	2,000	....	....	....	1.5	32,000	940	30.0	....	Amplifier
40	15.0	0.40	....	....	....	180	—40.5	1,928	....	....	....	21.0	2,000	1,500	3.0	....	Power
48	15.0	0.35	....	....	....	90	—4.5	1,000	....	....	....	4.5	9,200	1,185	10.0	....	Amplifier
126	1.5	1.05	....	....	....	135	—9.0	1,451	....	....	....	6.2	7,800	1,050	8.2	....	Amplifier
127	2.5	1.75	....	45	....	....	....	....	....	....	....	....	....	....	....	....	Detector
	....	....	....	....	....	135	—9.0	1,800	....	....	....	5.0	9,000	1,000	9.0	....	Amplifier
071	5.0	.50	....	....	....	180	—40.5	2,025	....	....	....	20.0	1,500	2,000	3.0	....	Power
180	5.0	2.00	....	....	....	300	....	....	....	....	....	125	....	....	....	....	Rectifier
124	2.5	1.75	....	....	....	180	—1.5		75.0	....	....	3.8	400,000	1.050	420	....	Det. & Amp.
145	2.5	1.50	....	....	....	250	—50	1,230	....	....	....	32.5	1,850	1,895	3.5	....	Power

RCA Tube Characteristics

Type Number	Filament Terminal Voltage	Filament Current (Amperes)	Detector Bias (Megohms)	Detector "B" Voltage	Detector Plate Current (M. A.)	Amplifier "B" Voltage	Amplifier "C" Voltage	Amplifier "C" Bias Resistor (Ohms)	Screen Grid "B" Voltage	Screen Grid Current (M. A.)	Plate Resistor (Ohms)	Amplifier Plate Current (M. A.)	A. C. Plate Resistance (Ohms)	Mutual Conductance (Micromhos)	Voltage Amplification Factor	Maximum Undistorted Output (Milliwatts)	Purpose
UV&UX199	3.0	.06	2-9	45	1	9	4.5	1,800	....	...	...	2.5	15,500	425	6.6	7	Det. & Amp.
UX-200A	5.0	.25	2-3	45	1.5	....	....	....	....	...	...	....	30,000	666	20.0	....	Detector
UX-201A	5.0	.25	2-9	45	1.5	90	4.5	1,800	....	....	...	2.5	11,000	725	8.0	15	Det. & Amp.
						135	9.0	3,000	....	....	....	3.0	10,000	800	8.0	55	Det. & Amp.
UX-240	5.0	.25	2-5	135	.3	135	1.5	....	....	...	250,000	0.2	150,000	200	30	....	Det. & Amp.
				180	.4	180	3	....	....	.	250,000	0.2	150,000	200	30	....	Det. & Amp.
UX-222	3.3	.132	....	....	....	135	1.5	910	45	.15	....	1.5	850,000	350	300	....	R. F. Amp.
UX-222	3.3	.132	....	....	....	180	1.5	238	22.5	6.0	....	0.3	150,000	400	60	....	A. F. Amp.
UX-226	1.5	1.05	....	....	....	90	6.0	1,620	...	....	..	3.7	9,400	875	8.2	20	Amplifier
						135	9.0	1,500	....	....	....	6.0	7,400	1,100	8.2	70	Amplifier
						180	13.5	1,800	....	....	....	7.5	7,000	1,170	8.2	160	Amplifier
UY-227	2.5	1.75	2-9	45	2	90	6.0	2,000	....	....	....	3.0	10,000	900	9.0	30	Det. & Amp.
						135	9.0	1,800	....	....	....	5.0	9,000	1,000	9.0	78	Det. & Amp.
						180	13.5	2,250	....	....	....	6.0	9,000	1,000	9.0	164	Det. & Amp.
UY-224	2.5	1.75	....	....	....	180	1.5	....	75	....	....	4.0	400,000	1,050	420	....	Det. & Amp.
UX-120	3.0	.125	....	....	....	135	22.5	3,470	....	....	....	6.5	6,600	500	3.3	110	Power
UX-112-A	5.0	.25	....	....	....	135	9.0	1,285	....	....	....	7.0	5,000	1,600	8.0	120	Power
						157.5	10.5	1,105	....	....	....	0.5	4,700	1,700	8.0	195	Power
						180	13.5	1,420	....	....	....	9.5	4,700	1,700	8.0	275	Power
UX-171-A	5.0	.25	....	....	....	90	16.5	1,650	....	....	....	10.0	2,500	1,200	3.0	130	Power
						135	27.0	1,690	....	....	....	16.0	2,200	1,360	3.0	330	Power
						180	40.5	2,025	....	....	....	20.0	2,000	1,500	3.0	700	Power
UX-245	2.5	1.5	....	....	....	180	33.0	1,270	....	....	....	26.0	1,950	1,800	3.5	780	Power
						250	50.0	1,565	....	....	....	32.0	1,900	1,850	3.5	1,600	Power
UX-210	7.5	1.25	....	....	....	250	18.0	1,800	....	....	....	10.0	6,000	1,330	8.0	340	Power
						300	22.5	1,730	....	....	....	13.0	5,600	1,450	8.0	600	Power
						350	27.0	1,690	....	....	....	16.0	5,150	1,550	8.0	925	Power
						400	31.5	1,750	....	....	....	18.0	5,000	1,600	8.0	1,325	Power
						425	35.0	1,945	....	....	....	18.0	5,000	1,600	8.0	1,540	Power
UX-250	7.5	1.25	....	....	....	250	45.0	1,605	....	....	....	28.0	2,100	1,800	3.8	900	Power
						300	54.0	1,545	....	....	....	35.0	2,000	1,900	3.8	1,500	Power
						350	63.0	1,400	....	....	....	45.0	1,900	2,000	3.8	2,350	Power
						400	70.0	1,275	....	....	....	55.0	1,800	2,100	3.8	3,250	Power
						450	84.0	1,525	....	....	...	55.0	1,800	2,100	3.8	4,650	Power

the subject of power amplification, a very remunerative field, is discussed. It is believed that their indifference to this field has resulted from one or two sad experiences with early products in this line. With the advance that has been made in this particular art, it is believed that most of the troubles have been removed.

Study Yields Results

Common sense is still just as requisite to the installation, operation and maintenance of power amplification systems as it is in any other calling. In addition to this it would seem that the more data secured and time spent on a study of the particular apparatus to be used in an installation would yield a greater dividend in satisfaction that any one other factor.

Continuous Service

From the standpoint of the user continuity of service is of major importance. The talkie installation with an inoperative power amplifier is embarrassing as well as a financial loss. The owner of a coin operated phonograph system faces loss of revenue and abuse on the part of the customer to the machine if the installation is not working. The public address system is in an equally disconcerting position when inoperative and faces the disappointment of the audience. In order to maintain "on with the show" as a slogan perfect operation must be the goal.

When to Return it

The question of when an amplifier should be returned to the manufacturer for repairs can easily be answered. The only time that such an amplifier should be returned is when the service man knows absolutely that the trouble is in the amplifier and not with the associated equipment. If he is able to make repairs in the equipment there is no need for returning the amplifier to its source.

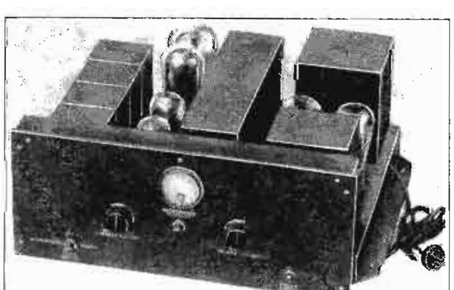


Fig. 1. This photograph shows a Webster DH 250 amplifier where microphone current is supplied in the amplifier

Tube Troubles

Tubes themselves are probably responsible for 75 per cent of all amplifier troubles today, ranging from burned out units to excessive hum and distortion. There are several interesting sidelights on the question of tubes and their efficiency. Quite frequently a service man will say that the amplifier must be at fault because he took a set of tubes out of another amplifier and still the unit did not perform properly. This is a rather fallacious statement to make. The very fact that tubes in another amplifier have been operating properly does not necessarily indicate they will work best in a second amplifier unless both amplifiers are identically the same. Also it is quite possible that the tubes removed from one amplifier position may have been inserted in another position in the second amplifier. The only way to prove that the tubes are not

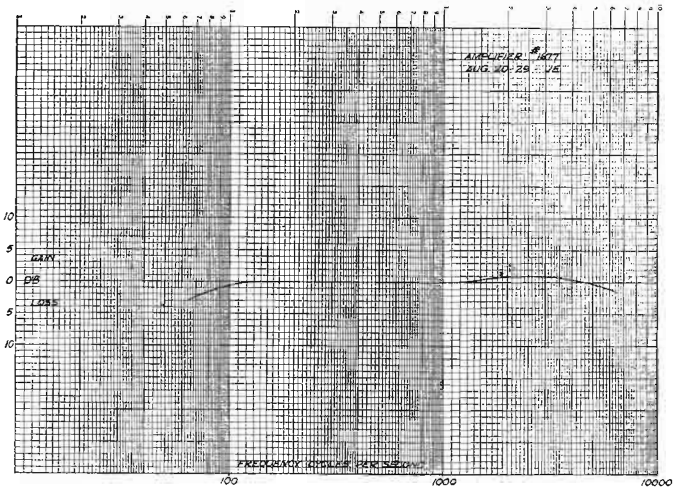


Fig. 2. The response curve on the DH 250 amplifier made by Webster is shown in the accompanying graph

at fault is to check each one of them completely before it is placed in the amplifier desired. Just because a tube is new or has operated perfectly in another amplifier is no indication that it will do so in a second one. Therefore, be sure to check the tubes before placing in the amplifier and recheck at regular intervals, as this will reduce interrupted programs.

Turn Off Set First

However, one must remember that in checking tubes they should not be pulled out of the amplifier while it is operating because to do so is likely to cause a voltage surge on the remaining tubes that is sure to break down either the audio transformers or the condensers.

Where Hum Originates

Hum can often be traced to defective or shorted tubes, either in the stages preceding the last stage or in the last stage itself. Unbalanced rectifier tubes also may cause excessive hum. Worn out tubes (low emission) frequently cause squealing and howling.

A peculiar and somewhat common type of distortion which occurs at high volume levels (a cracking or popping noise) can often be located in the mash or base of the power tube, especially the 250 type of tube. The magnitude of the output transient causes breakdown of insulation and sparking. It, of course, goes without further mention that shorted or grounded elements in the tubes, will if left in the amplifier, burn out audio transformers, voltage divider or drop resistors, chokes and finally the power transformer itself. Again the first point to remember is to check the tubes and take nothing for granted.

The question of hum is one of importance. A hum level which is sometimes passable in one location will probably cause a great amount of discomfort in a place that is acoustically bad. For example, sounding waves are often set up. Again excessive hum causes a masking effect covering the lower frequencies.

Excessive Hum

Excessive hum can be caused by

Gold Seal Tube Characteristics

Type Number	Filament Terminal Voltage	Filament Current (Amperes)	Detector Bias (Megohms)	Detector "B" Voltage	Detector Plate Current (M. A.)	Amplifier "B" Voltage	Amplifier "C" Voltage	Amplifier "C" Bias Resistor (Ohms)	Screen Grid "B" Voltage	Screen Grid Current (M. A.)	Plate Resistor (Ohms)	Amplifier Plate Current (M. A.)	A. C. Plate Resistance (Ohms)	Mutual Conductance (Micromhos)	Voltage Amplification Factor	Maximum Undistorted Output (Milliwatts)	Purpose
GS199	3.0	.06	2-9	45	1	90	4.5	1,800	....	....	....	2.5	15,500	425	6.6	7	Det. & Amp.
GSX199	3.0	.06	2-9	45	1	90	4.5	1,800	....	....	....	2.5	15,500	425	6.6	7	Det. & Amp.
GSX200A	5.0	.25	2-3	45	1.5	....	....	....	....	....	....	....	30,000	666	20.0	....	Detector
GSX201A	5.0	.25	2-9	45	1.5	90	4.5	1,800	....	....	....	2.5	11,000	725	8.0	15	Det. & Amp.
						135	9.0	3,000	....	....	....	3.0	10,000	800	8.0	55	Det. & Amp.
GSX222	3.3	.132	....	....	....	135	1.5	....	....	....	....	1.5	850,000	350	300	....	Det. & Amp.
GSX240	5.0	.25	....	....	....	135	1.5	....	....	....	....	.2	150,000	200	30	....	Resis. Amp.
GSX226	1.5	1.05	....	....	....	90	6.0	1,710	....	....	....	3.5	9,400	875	8.2	20	Amplifier
						135	9.0	1,500	....	....	....	6.0	7,400	1,100	8.2	70	Amplifier
						180	13.5	1,800	....	....	....	7.5	7,000	1,170	8.2	160	Amplifier
GSY227	2.5	1.75	2-5	45	2	90	6.0	2,000	....	....	....	3.0	10,000	800	8	....	Det. & Amp.
			¼-1	90	7	180	13.5	1,225	....	....	....	7.0	8,000	1,000	8	....	Det. & Amp.
GSY224	2.5	1.75	....	....	....	180	1.5	....	75	....	....	4.0	400,000	1,000	420	....	Det. & Amp.
GSX120	3.0	.125	....	....	....	135	22.5	3,620	....	....	....	6.5	6,300	525	3.3	110	Power
GSX112A	5.0	.25	....	....	....	135	9.0	1,285	....	....	....	7.0	5,000	1,600	8	120	Power
						157.5	10.5	1,110	....	....	....	9.5	4,700	1,700	8	195	Power
GSX171A	5.0	.25	....	....	....	90	16.5	1,000	....	....	....	10.0	2,500	1,200	3.0	130	Power
						135	27.0	1,695	....	....	....	16.0	2,200	1,360	3.0	330	Power
						180	40.5	2,025	....	....	....	20.0	2,000	1,500	3.0	700	Power
GSX245	2.5	1.5	....	....	....	250	50	1,560	....	....	....	32.0	1,900	1,850	3.5	750	Power
						180	33	1,270	....	....	....	26.0	1,950	1,800	3.5	1,600	Power
GSX210	7.5	1.25	....	....	....	250	18	1,060	....	....	....	17.0	6,000	1,330	8.0	340	Power
						300	22.5	1,250	....	....	....	18.0	5,600	1,450	8.0	600	Power
						350	27	1,350	....	....	....	20.0	5,150	1,550	8.0	925	Power
						400	31.5	1,370	....	....	....	23.0	5,000	1,600	8.0	1,325	Power
						425	35	1,510	....	....	....	23.0	5,000	1,600	8.0	1,540	Power
GSX250	7.5	1.25	....	....	....	250	45	1,610	....	....	....	28.0	2,100	1,800	3.8	900	Power
						300	54	1,540	....	....	....	35.0	2,000	1,900	3.8	1,500	Power
						350	63	1,400	....	....	....	45.0	1,900	2,000	3.8	2,350	Power
						400	70	1,270	....	....	....	55.0	1,800	2,100	3.8	3,250	Power
						450	84	1,530	....	....	....	55.0	1,800	2,100	3.8	4,650	Power

Triad Tube Characteristics

Type Number	Filament Terminal Voltage	Filament Current (Amperes)	Detector Bias (Megohms)	Detector "B" Voltage	Detector Plate Current (M. A.)	Amplifier "B" Voltage	Amplifier "C" Voltage	Amplifier "C" Bias Resistor (Ohms)	Screen Grid "B" Voltage	Screen Grid Current (M. A.)	Plate Resistor (Ohms)	Amplifier Plate Current (M. A.)	A. C. Plate Resistance (Ohms)	Mutual Conductance (Micromhos)	Voltage Amplification Factor	Maximum Undistorted Output (Milliwatts)	Purpose
T-01-A	5.0	.25	2-5	45	1.5	45	1.5	....	....	....	....	.9	18,500	430	8.0	....	Det. & Amp.
						67.5	3.0	1,765	....	....	....	1.7	14,000	570	8.0	....	Det. & Amp.
						90.0	4.5	1,800	....	....	....	2.5	11,000	725	8.0	15.0	Det. & Amp.
						135	9.0	3,000	....	....	....	4.5	8,600	1,000	8.0	55.0	Det. & Amp.
T-22	3.3	.132	....	....	....	135	1.5	9,100	45	.15	....	1.5	850.000	350	290	....	Amplifier
						180	1.5	2,380	22.5	6.0	250,000	3.0	750,000	400	290	....	Amplifier
T-26	1.5	1.05	....	....	....	90	6.0	1,700	....	....	....	3.7	9,400	875	8.2	20	Amplifier
						135	9.0	1,500	....	....	....	6.0	7,400	1,100	8.2	70	Amplifier
						180	13.5	1,800	....	....	....	7.5	7,000	1,170	8.2	160	Amplifier
T-27	2.5	1.75	2-5	45	2.0	90	6.0	2,000	....	....	....	3.0	10,000	900	9.0	....	Det. & Amp.
						135	9.0	1,800	....	....	....	5.0	9,000	1,000	9.0	....	Det. & Amp.
						180	13.5	2,250	....	....	....	6.0	9,000	1,000	9.0	....	Det. & Amp.
T-24	2.5	1.75	....	....	....	180	1.5	....	75	....	....	4.0	400,000	1,050	420	....	Det. & Amp.
T-12-A	5.0	.25	....	....	....	90	4.5	850	....	....	....	5.5	5,300	1,500	8.0	....	Power
						135	9.0	1,300	....	....	....	7.0	5,000	1,600	8.0	120	Power
						157	10.5	1,050	....	....	....	9.5	4,700	1,700	8.0	185	Power
						180	13.5	1,350	....	....	....	11	4,000	2,000	8.0	275	Power
T-171-A	5	.25	....	....	....	135	27	1,687	....	....	....	16	2,500	1,360	3	....	Power
						157	33	1,833	....	....	....	18	2,200	1,400	3	....	Power
						180	40.5	2,025	....	....	....	20	2,150	1,500	3	700	Power
T-45	2.5	1.5	....	....	....	180	33	1,350	....	....	....	26	1,950	1,800	3.5	780	Power
						250	50	1,550	....	....	....	32	1,900	1,850	3.5	1,600	Power
T-210	7.5	1.25	....	....	....	180	12	1,715	....	....	....	7	7,000	1,100	8.0	....	Power
						250	22	1,800	....	....	....	10	6,000	1,330	8.0	340	Power
						350	31	1,950	....	....	....	16	5,150	1.550	8.0	925	Power
						425	39	1,950	....	....	....	18	5,000	1.600	8.0	1,540	Power
T-250	7.5	1.25	....	....	....	300	54	1,500	....	....	....	35	2,000	1,900	3.8	1,500	Power
						350	63	1,400	....	....	....	45	1.900	2.000	3.8	2.350	Power
						400	70	1,300	....	....	....	55	1.800	2.100	3.8	3.250	Power
						450	84	1,550	....	....	....	55	1.800	2.100	3.8	4.650	Power

shorted bypass condensers, open audio transformers and bias resistors, shorted filter chokes and filter condensers, although the latter condition will manifest itself in over-heating of the rectifier tubes and power transformer. Occasional bad hum can also be traced to the fields from adjacent electrical equipment, such as mercurcy arc rectifiers, rotary converters, and small motors. Do not take for granted that audio units even if placed in a can will not pick up stray fields. Great care must be exercised that the input wiring to the amplifiers is well shielded from all a. c. wiring. A. c. pick-up is frequently a cause of trouble. In the event that a. c. excited dynamic speakers are used occasional hum will originate from the rectifier unit. This can be checked by disconnecting the amplifier output, leaving the a. c. field excitation on, and shorting the voice coil transformer. Base of amplifier should also be grounded to prevent hum.

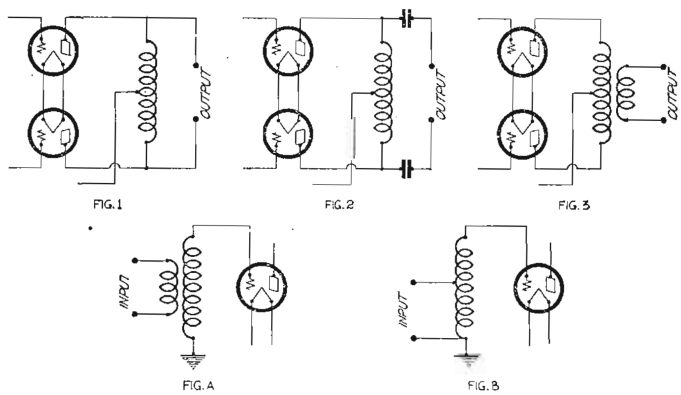


Fig. 3. Common forms of input and output coupling mentioned by Mr. Erwood in his article are shown in the above sketches

Cause of Feedback

Another of the common causes of distortion and whistling in amplifier output is due to feed-back, regeneration, having the input and output wiring too closely associated, run in the same conduit. This cannot be done without disastrous results.

Care must be exercised to properly insulate the speaker wiring against the surges imposed upon it. Break-down in junction boxes and fittings is not uncommon and causes a rattle in the speaker. The noise made under these conditions is similar to the one occurring in a break-down inside the mash or base of the tube.

Coupling Methods

Three methods are in general use today as shown in diagrams 1, 2 and 3. In the event that the scheme in Fig. 1 is in use it is absolutely necessary to keep the system clear of grounds. A ground in the speaker wiring or voice coil transformer will in all probability ruin the rectifier tubes and burn out the amplifier.

System No. 2 is the same as system No. 1 in that the load into which the amplifier looks must be the same. The advantage of this is that the d. c. is isolated from the speaker wiring.

Scheme No. 3 has the most points in its favor and gives the greatest flexibility. Scheme A is transformer input, while B is auto-transformer.

Watch Double Grounds

Some amplifier manufacturers ground one side of the pickup transformer winding inside the amplifier. Some installers ground one side of the pickup winding externally. This is particularly true where a common fader is used for two amplifiers. In this case it is very important that the pickup be poled properly. Otherwise with the winding inside grounded in the amplifier, and again grounded externally (but wrongly poled) the pickup would be shorted out.

Fast Versus Slow Heater Cathodes

By C. F. Stromeyer
(*Chief Engineer, Cable Radio Tube Corp.*)

ANYTHING new or somewhat radical in design always goes through a very trying stage of rebuff issued from those who are prone to dogma. Certainly fast heating cathodes used in -27 and -24's are having their share. To ascertain the validity of this criticism, compare in detail both slow and fast heaters.

Slow heaters can be defined as those having a heater surrounded by a full sleeve insulator which heats conductively the thermionic emiting base. It is immaterial whether coil or hairpin heaters are employed. The indirect heating method produces a large time lag—thus slow heaters. The insulators and heaters both in manufacturing process and operating conditions reach dangerous fusing temperatures. Fusing troubles are attributed to many last year's -27 burn-out complaints, for the two constitutents have different expansion coefficients. Something must give! The tungsten splits, opens, and finally renders the tube useless. Also, at the fusing points, the insulators become fair electrical conductors where a. c. leakage is impressed on the coated sleeve, considerably raising the hum and noise level. Hot insulators extended from the ends of the cathodes will further increase the noise level by discharging stray static charges, which they periodically assume.

Although slow heaters have been improved to some extent by using better insulating material and full length sleeves which totally shield the insulators, they are not without question better than fast heaters.

Cathodes whose emiting bases are directly heated by heater radiation can be classed as fast heaters. Some employ centering plug insulators at each end, but this in no way defeats radiation. If designed properly, the plugs operate comparatively cool—consequently no fusing or static discharges are possible. Coil heaters, even at their low operating frequency, can inductively introduce a. c. on the coated sleeve; but if the coil diameter is kept small compared to the metal sleeve, this effect becomes negligible.

On the other hand, the hairpin type is free from this effect; but because of their geometric proximity, the heater must be coated with an insulating material to prevent heater to cathode shorts. This material is in the neighborhood of a few thousandths of an inch. No burnout difficulties, as previously mentioned, are encountered, but hum conditions remain. If a heater does lay up against a metal sleeve, there is grave danger of an insulation breakdown, especially when the heater becomes excessively hot or a high potential difference exists between the two. In producing coated heaters, a production short test does not reveal the story. Tubes may go to the consumer with heaters completely out of alignment. Even with these difficulties, one manufacturer is successfully making a hairpin type, but he uses a special low temperature heater.

All metals under certain conditions emit electrons. The current flow from heater to sleeve is objectionable. Common practice balances this out by biasing the metal sleeve. Fast heaters in this respect are on a par with their opponents. By what reasoning should anyone conclude that a fast heater's life span is less when the same type of emission coating can be used on both types? The sensitivity of the coating is not effected—so no increase in temperature is necessary. The nickel base may remain the same. They can without question stand more heater voltage overload. The mechanical constructions are not necessarily weaker because the insulators are removed, for the sleeve may be supported in some other way. It may be well to mention that fast heaters do not heat instantaneously as stated in some advertisements. It is ambiguous to state their heating time without setting some standardization of measuring the lag. However, they average about twelve seconds for optimum volume under normal conditions.

After all these principles were proved by extensive tests, our laboratories conclude that properly designed fast heaters of the coil type were an achievement and so placed them on the market last January. The only positive way we could prove the validity of these statements was through our consumer acceptance. It is gratifying to state that they are satisfied and returns have dropped to a minimum figure.

Where is the catch? The increased cost of manufacturing fast heater is almost half again as great, yet the selling price remains the same. No wonder some manufacturers will not change!

What Address, Mr. Bates?

MANY of our readers have requested resistance, capacity, transformer and other values covering the Universal ABC Power Supply with Master Power Amplifier which appeared on page 71 of the September, 1929, edition. The information is now available and we shall be glad to pass it on to those desiring it.

We have a letter in our files from Henry W. Bates wherein he asks for additional data on this particular unit. However, failing to give us his address, we were unable to assist him. Perhaps the above note will come to his attention.

Short Life of Tubes in Brunswick and Bremer-Tully Receivers

Complaints have reached Sylvania Products Company regarding short life of 227 and 224 tubes in Brunswick and Bremer-Tully receivers, according to a recent bulletin from W. R. Jones, sales engineer of that company.

Extensive investigation has proven that in most cases where this has occurred a voltage regulator Type 105 or Type 110 has been employed and the heater voltage has usually been higher than 2.6 volts, and thus shortened tube life. The Brunswick Company are now recommending a Type 98 voltage regulator. The same applies to the Bremer-Tully receiver.

Replace the present voltage regulators with Type 98 and tube difficulties should end.

What City, Mr. Daugherty

We recently received an inquiry from R. Daugherty, 2113 N. Charles Street. Mr. Daugherty neglected to give us the name of the city where he resides, so we are unable to reply until such information is received. If Mr. Daugherty sees this, we would appreciate learning from him the city of his residence.

Radio Noises and Cures

A booklet "Radio Noises and Their Cure" has just been announced by the Tobe Deutschmann Corp. at Canton, Mass. It is replete with suggestions and ideas for noise elimination. The manual sells for 25 cents and may be secured from the address given above. Please mention this magazine when writing.

Unbalanced Rectifiers

Several service men have called attention to the fact that some hum in the present-day receivers has been found to have been caused by a difference in the emission of one of the rectifier plates in a 280. For example: the maximum current output from the 280 is 125 mils which would make approximately 62½ mils per anode. If there is a deviation of much more than 20 per cent of the anode current in one, hum possibilities exist. In the absence of a means of checking the individual anode current reading, the best test is a spare 280 carried in the kit.

Slagle Model 9 Receiver and Supply

THE Slagle model 9 receiver and power supply illustrated on this page is made by the Continental Radio Corporation at Fort Wayne, Indiana. It uses nine tubes, seven of the 227 type, two 171-A, and one rectifier type 280. The set comprises six r. f. stages, and one a. f. push pull stage. The detector is of the untuned grid bias type. The set has an antenna compensating condenser adjustable for short, medium and long antenna. Total watts consumed 109. Plate voltage on the audio stage is 180 volts.

Analysis of Voltages

Using a Weston No. 537, type 2 radio set-tester, the following is a typical analysis of the voltages on the Slagle model 9.

First r. f. 227, tube out A voltage 2.45, B voltage 94, tube in tester A voltage 2.15, B voltage 80, C voltage 3, cathode volts positive 3, normal plate m. a. 4.5, plate m. a. grid test 7.

Second r. f. 227, tube out A voltage 2.45, B voltage 98, tube in tester A voltage, 2.15, B voltage 88, C voltage 3, cathode volts positive 3, normal plate m. a. 5.8, plate m. a. grid test 8.8.

Third r. f. 227, tube out A voltage 2.45, B voltage 94, tube in tester A voltage 2.15, B voltage 80, C voltage 3, cathode volts positive 3, normal plate m. a. 3.8, plate m. a. grid test 6.1.

Fourth r. f. 227, tube out A voltage 2.45, B voltage 98, tube in tester A voltage 2.15, B voltage 88, C voltage 3, cathode volts positive 3, normal plate m. a. 5, plate m. a. grid test 8.

Fifth r. f. 227, tube out A voltage 2.45, B voltage 98, tube in tester A voltage 2.15, B voltage 80, C voltage 3, cathode volts positive 3, normal plate m. a. 4.6, plate m. a. grid test 7.2.

Sixth r. f. 227, tube out A voltage 2.45, B voltage 98, tube in tester A voltage 2.15, B voltage 90, C voltage 3, cathode volts positive 3, normal plate m. a. 4.5, plate m. a. grid test 7.2.

Detector 227, tube out A voltage 2.45, B voltage 192, tube in tester A voltage 2.15, B voltage 177, C voltage 20, cathode volts positive 20, normal plate m. a. 1, plate m. a. grid test 5.5.

Push Pull Readings Same

Readings of the push pull 171-A tubes are identical. With tube out A voltage 5, B voltage 192, tube in tester A voltage 4.9, B voltage 172, C voltage 37, normal plate m. a. 16.5, plate m. a. grid test 53.

Rectifier 280, tube out, A voltage 5.2, tube in tester A voltage 4.5, normal plate m. a. 45.

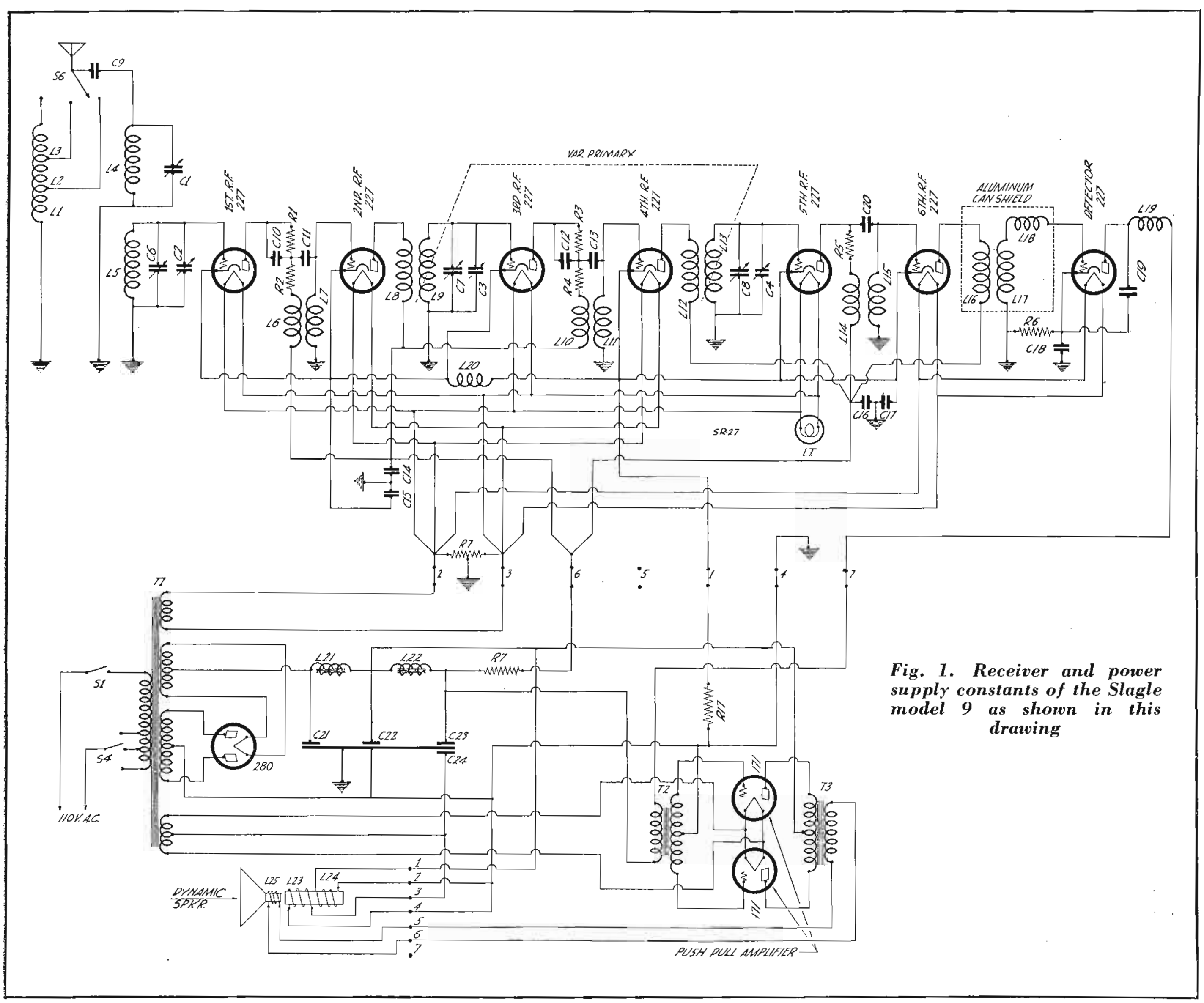


Fig. 1. Receiver and power supply constants of the Slagle model 9 as shown in this drawing

Atwater Kent Receiver Model No. 38

ONE of the many receivers made by the Atwater Kent Manufacturing Company of Philadelphia, Pennsylvania, is model 38 illustrated on this page. It is a seven-tube, single dial, a. c. receiver, with a power unit incorporated in a metal cabinet that houses the set.

Four R. F. Stages

As disclosed in the schematic diagram Figure 3, the circuit has four stages of radio frequency amplification, with double coil type r. f. transformers, a tuned detector and two stages of audio frequency amplification. The first radio frequency tube is not tuned and acts as an antenna coupling tube. The second audio stage is of the power type with condenser-choke coupling to the speaker.

Local-DX Switch

Since the volume provided by this set is ordinarily more than required for local reception, a special switch (the local-long distance toggle switch) is provided on the front of the cabinet to open the plate circuit of the second radio frequency amplifying tube, thereby reducing the volume materially.

The volume control consists of an adjustable resistance connected from antenna to ground. It is shown at the extreme left in the schematic circuit, Figure 3. As will be seen, the antenna lead enters the set through a shielded cable.

The schematic diagram of the power unit used with this receiver is shown in Figure 2. The unit is encased in a metal cover which has an opening in the left-hand end of the top for insertion of the rectifier tube. There are two metal containers, one for the power transformer and one for the condensers and choke.

Typical Set Voltages

Using a Jewel No. 199 a. c.-d. c. set analyzer, typical voltage readings on the Model 38 with a line voltage of 115 are shown below:

First r. f. 226, tube out, A voltage 1.3, B voltage 173, tube in tester A voltage 1.25, B voltage 165, C voltage 10, normal plate m. a. 4.8, plate m. a. grid test 8.4, plate m. a. change 3.6.

Second r. f. 226, tube out, A voltage 1.3, B voltage 173, tube in tester A voltage 1.25, B voltage 165, C voltage 10, normal plate m. a. 4.8, plate m. a. grid test 8.4, plate m. a. change 3.6

Third r. f. 226, tube out, A voltage 1.3, B voltage 173, tube in tester A voltage 1.25, B voltage 165, C voltage 10, normal plate m. a. 4.8, plate m. a. grid test 8.4, plate m. a. change 3.6.

Detector 227, tube out A voltage 2.25, B voltage 80, tube in tester A voltage 2.0, B voltage 22.5, normal plate m. a. 2.2, plate m. a. grid test 2.2, plate m. a. change 0.0

First audio 226, tube out A voltage 1.3, B voltage 173, tube in tester A voltage 1.25, B voltage 165, C voltage 10, normal plate m. a. 4.8, plate m. a. grid test 8.4, plate m. a. change 3.6.

Second audio 171, tube out A voltage 4.6, B voltage 192, tube in tester A voltage. 4.3, B voltage 180, C voltage 36, normal plate m. a. 18.0, plate m. a. grid test 19.5, plate m. a. change 1.5

Rectifier 280, tube in tester, A voltage 4.3, normal plate m. a. 20.

Replacements

It is observed in the Atwater-Kent instruction manual that if one variable condenser is found defective on test, it is necessary to replace the entire group of four variable condensers. If one of the double radio frequency transformers is defective it will be necessary to replace the entire group of four double r. f. transformers. In replacing the volume control the chassis must be removed from the cabinet.

Color Coding

The schematic diagram in Fig. 3 shows all of the colors used in the cable leads. It will also be seen that the input of the first coupling tube is a choke input, the volume control placed across it. Each of the 226 r. f. stages have a resistor in the grid circuit. None is used in the first tube and none in the detector.

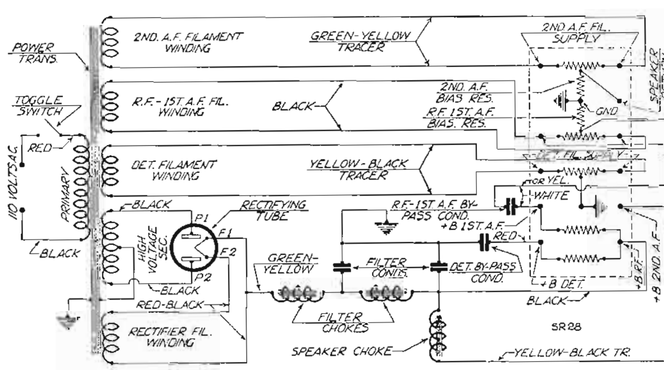


Fig. 2. At the left is shown the diagram of the power unit used on Atwater Kent Models 37 and 38

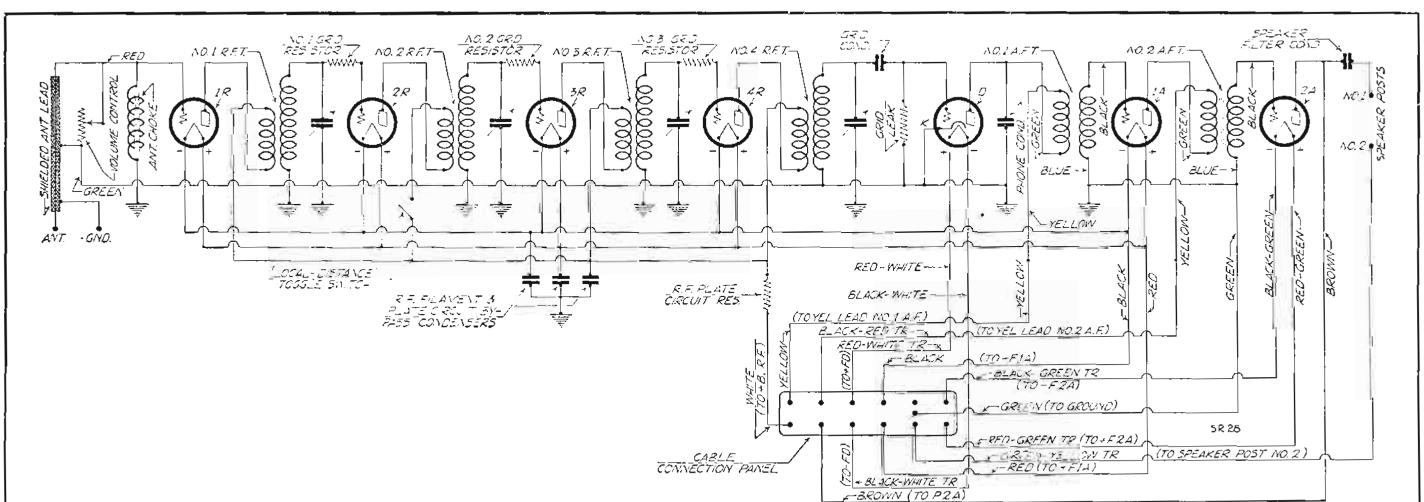


Fig. 3. In this illustration is the schematic wiring diagram of the Model 38 Atwater Kent receiver

Colonial Model 31 A. C. and Supply

SHOWN schematically on this page is the Colonial Model 31 a. c. receiver and its power supply, manufactured by the Colonial Radio Corporation, Long Island City, N. Y.

The set consists of a receiver unit employing two 226 tubes in a tuned and inductively balanced r. f. circuit, a 227 detector stage and a first audio stage also using a 227 tube. The second or power unit employs a push-pull stage using two 171 tubes and the 280 rectifier with the associated power supply apparatus. The two units are connected by cable and plug.

The schematic diagram of the power supply is shown in Figure 4, while the drawing of the receiver circuit itself is illustrated in Figure 5.

Using a Weston Model 547 radio set tester the following are typical voltage characteristics of this receiver.

The first stage r. f. 226 tube should measure A voltage of 1.35, B voltage 95, C voltage 4.5, and normal plate m. a. 6. This value and the succeeding ones are those used when the tubes are in the set tester.

The reading of the second r. f. 226 stage is identical with that of the first.

In the case of the 227 detector the A voltage is 2.15, B voltage 30, and the normal m. a. is 2.

The 227 used in the first audio stage has an A voltage of 2.15, B voltage of 80 and C voltage of 4.5. Its normal m. a. is 3.

Both of the 171-A's used in the push-pull stage read alike and the A voltage will be 4.5, B voltage 160, C voltage 38 and the normal m. a. should be 15.

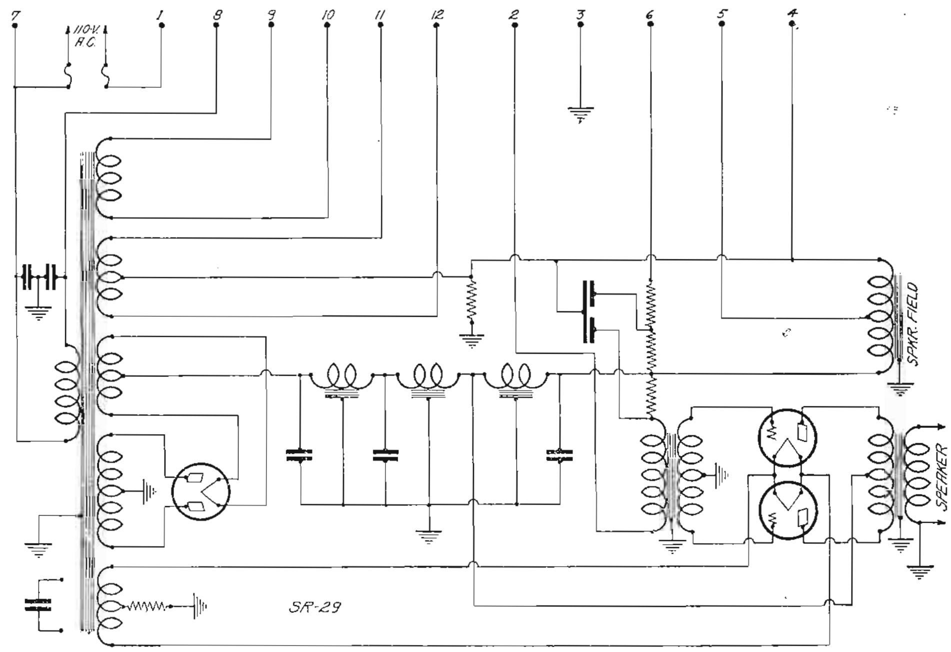


Fig. 4, shown above, is the schematic diagram of the power supply for the Colonial 31 a. c.

With respect to the 280 rectifier A voltage should be 4.5, while the normal m. a. should be 42 per anode.

Possible defects and their accompanying symptoms which may occur:

Distorted output. Low plate voltage on first a. f. generally due to by-pass condenser (1475 p) or voltage divider (1478 p) both located in power units, right-hand side, under shelf near Mershon condenser. No plate voltage on detector. Possible ground in phono jack or open voltage divider. Sometimes this is also due to a ground occurring in the system shunting the first a. f. transformer primary. No plate voltage in this stage is seldom due to a by-pass condenser (1475 p) or the a. f. transformer itself.

Modulated hum is often caused by a defect in the r. f. by-pass condenser (1476 p). In this case grid voltage on the r. f. tubes will be only about two or three volts, which should normally be five or six. It is seldom caused by the line buffers excepting some of the early models 31 which have no buffers.

In case the volume control works on one side only it generally indicates an open input primary or a broken connection in the same circuit.

Very loud hum and no grid voltage on the first and second r. f. and first a. f. may sometimes be caused by the cathode lead from the detector socket grounding on the sharp edge of right-hand bulwark in the chassis.

Ordinary hum is most often caused by an old or defective Mershon condenser, or one from which the liquid has leaked out. Poor external ground or incorrect detector plate voltage may also be a cause.

Radio frequency oscillation may be due to incorrect adjustment of the balancing system. The balancing adjusters 9L-10L are situated inside the second and third r. f. primary coils and are held fast by a round head brass screw which moves in a slot, permitting the adjustment of the adjusters. If an accidental ground occurs in the r. f. grid returns oscillation will result.

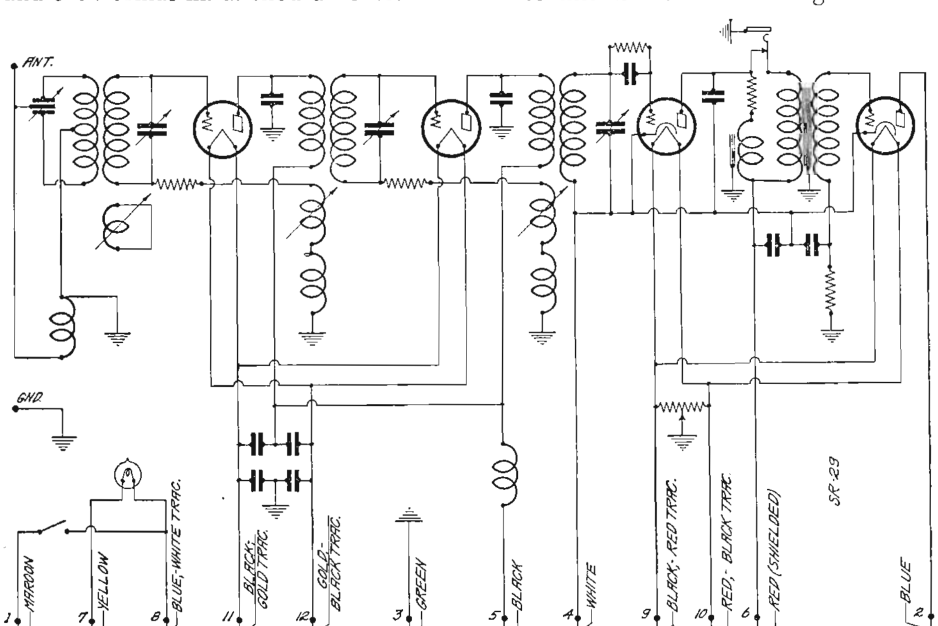


Fig. 5. This drawing is the schematic of the Model 31 Colonial receiver described on this page

Radiola Model 60 Superheterodyne

USING nine tubes including the rectifier the Radiola Model 60 superheterodyne is presented schematically in this article. The set is made by the Radio Corporation of America and the model 60 is considered the basic superheterodyne circuit for the Radiola line. Therefore, the circuit shown on this page is substantially the same as the one used in the R. C. A. model 62 and 64. However, in the case of the 64 a slightly different hook-up is used because an extra 227 tube is added which is used on the automatic volume control. This tends to keep the volume constant at all stages regardless of the input signals. In the case of the 64 a 250 power tube is employed.

In the case of the model 60 here described the output stage is a 171.

Mostly 227 Tubes

All of the tubes in the receiver are 227 type with the exception of the power stage which is the 171A and the rectifier which is the 280. The oscillator tube is the third from the left in schematic Figure 6 and has a balanced grid input. A regeneration control is included in the plate circuit of the second 227 from the left.

An analysis of voltage readings on the model 60 as taken with a Jewell 199 set analyzer is given below:

Typical Voltage Readings

These readings are taken from the line voltage of 117 volts. The volume control should be set centrally with the line vertical in order to get these readings. The C voltage on tubes 1, 2, 4, and 5 will vary from nine to twenty-seven volts, depending upon the position of this volume control, hence these readings are taken at the middle point.

Coupling Tube

With the tube out the antenna coupling 227 shows A voltage of 2.35 and B voltage of 148. With the tube in the tester the A voltage is 2.2, B voltage 144, C voltage 18, cathode voltage 25, normal plate m. a. 1, plate m. a. grid test 3 and plate m. a. change 2.

The first radio frequency 227 tube with the tube out shows a reading of 2.35 for filament voltage and B voltage of 148. With the tube in the tester the A voltage is 2.2, B voltage 144, C voltage 18, cathode voltage 25, normal plate m. a. 1, plate m. a. grid test 3, and plate m. a. change 2.

In the case of the first detector 227 with the tube out the filament voltage is 2.35 while the B voltage is 84. When the tube is in the tester filament voltage is 2.2, B voltage 70, C voltage 9, cathode voltage 10, normal plate m. a. 1, plate m. a. grid test 3, plate m. a. change 2.

I. F. Stages

The first and second intermediate frequency 227 tubes show the same readings. When the tube is out the filament voltage is 2.35 and plate voltage 148. With the tube in the tester filament voltage is 2.2, B voltage 144, C voltage 18, cathode voltage 25, normal plate m. a. 1, plate m. a. grid test 4, and plate m. a. change 3.

Oscillator Voltage

With the oscillator 227 tube out the filament voltage is 2.35 and B voltage 118. With the tube in the tester the A voltage is 2.2, B voltage 70, no C voltage, no cathode voltage, normal plate m. a. 7, plate m. a. grid test 7, and no plate m. a. change.

The second detector is also a 227 tube and when this tube is out the A voltage is 2.35 and the B voltage 162. When the tube is in the tester the A voltage on this stage is 2.2, B voltage 157, C voltage 18, no cathode volt, normal plate m. a. 1, plate m. a. grid test 3 and plate m. a. change 2.

Audio Voltage

The first audio stage is a 171-A and with the tube out the filament voltage is 5, B voltage 178. With the tube in, A voltage is 4.8, B voltage 157, C voltage 31.5, no cathode volts, normal plate m. a. 15, plate m. a. grid test 17, and plate m. a. change 2.

The 280 rectifier has a filament voltage of 5 when the tube is out, and 4.8 when the tube is in with a normal plate m. a. of 19.

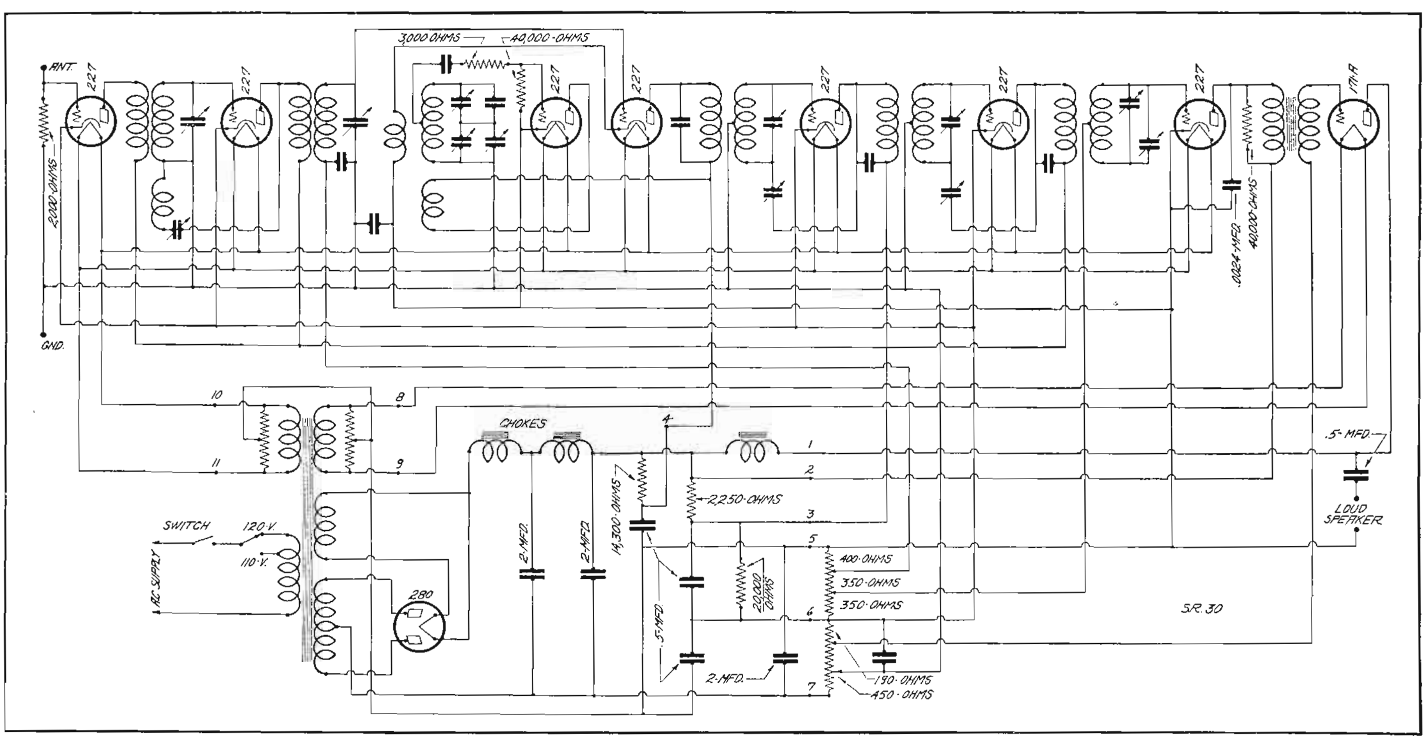


Fig. 6. The complete schematic diagram of the Radiola 60 superheterodyne and its power pack is shown in the illustration here

King Model J Set and Power Supply

FOUR 226 tubes, one 227, two 171-A's in push pull and a 280 rectifier comprise the tubes used in the King Model "J" and power supply, made by the King Manufacturing Corporation of Buffalo, New York.

According to the instructions provided by King for service men, each of the rotors in the gang condenser is adjusted on the gang at the factory. Under no circumstances should an attempt be made to re-set these rotors. Minimum adjusters are provided to make up for any minor difference in capacity due to wiring. The minimum adjusters are located on the front of the condenser gang and should be adjusted with a strip of flat bakelite slotted on the end to take the hexagonal head of the screw. When connected to an oscillator and output meter a peak should be obtained on each condenser with settings of 280 meters, 400 meters and 480 meters, by turning minimum adjustment screw. Of course, the peak will be much sharper on the lower setting. Failure to obtain a peak may either mean condenser rotors out of gang or coil butterflies out of adjustment.

The neutralizing condensers are located at the rear of the condenser bearing. If it is found necessary to reneutralize this set this may be accomplished in the regular way by using a tube with one filament prong cut off. In case the rotors are in need of reganging or the plates are out of line, the entire gang should be sent to the factory for adjustment. Another gang may be installed.

The inductance of the r. f. coil is adjusted at the factory by means of the brass inductance adjuster or butterfly, in the end of the soil. These are set on an oscillograph so that every soil has exactly the same value of inductance. The butterfly is locked in the exact position with an especially strong cement. In case this cement is loosened, return the coil and shield assemblies to the factory for adjustment. Another assembly may be installed temporarily.

In connection with neutralizing of the set there are some troubles peculiar to the a. c. tubes. If the set is neutralized at a voltage of 100 and the set is then moved to a locality where the voltage is as high as 120 the set may be thrown into oscillation. This would show up as a loud hum which would blanket all reception. Therefore, be sure when neutralizing the set that the voltage tap on the power transformer is set at the correct line voltage being used. For neutralizing the tap switch should be set one point ahead of the actual line voltage. For instance, if the line shows 110 volt neutralization should be done with a tap switch set on 100 volts.

Voltages for the filament, plate and grid should read within limits as noted below. Any deviation from this may mean that the transformer is wrong or that the drain of the set is wrong.

With a line voltage of 115 to 120 volt, 120 tap on pack, the 226 filament should read from 1.3 to 1.5; the 227 should read from 2.3 to 2.5, the 171 filament should read 4.8 to 5.2 and the 280 filament reads from 4.9 to 5.3.

Plate voltage on the r. f. stages should be between 115 and 135, while the plate voltage on the detector runs between 30 to 45 volt. Plate voltage on the first audio frequency will measure from 125 to 150. Plate voltages on the 171, measured plate to filament will be 160 to 185, while measured from plate to ground will be 185-210. R. f. grid bias should be from 6 to 7.5 and the 171 grid bias 30 to 40 volts.

The factory has noted in a number of cases where after the set has been in operation for a few hours trouble developed showing up as a distinct loss of volume. This apparently is due to a change in capacity of the detector circuit minimum adjusters due probably to a change in the tension of the spring brass used in this adjuster. As the tuning of this one circuit is especially sharp a small change of capacity affects the operation materially. All that it is necessary to do to correct this is to readjust this one minimum adjuster with a small open end wrench.

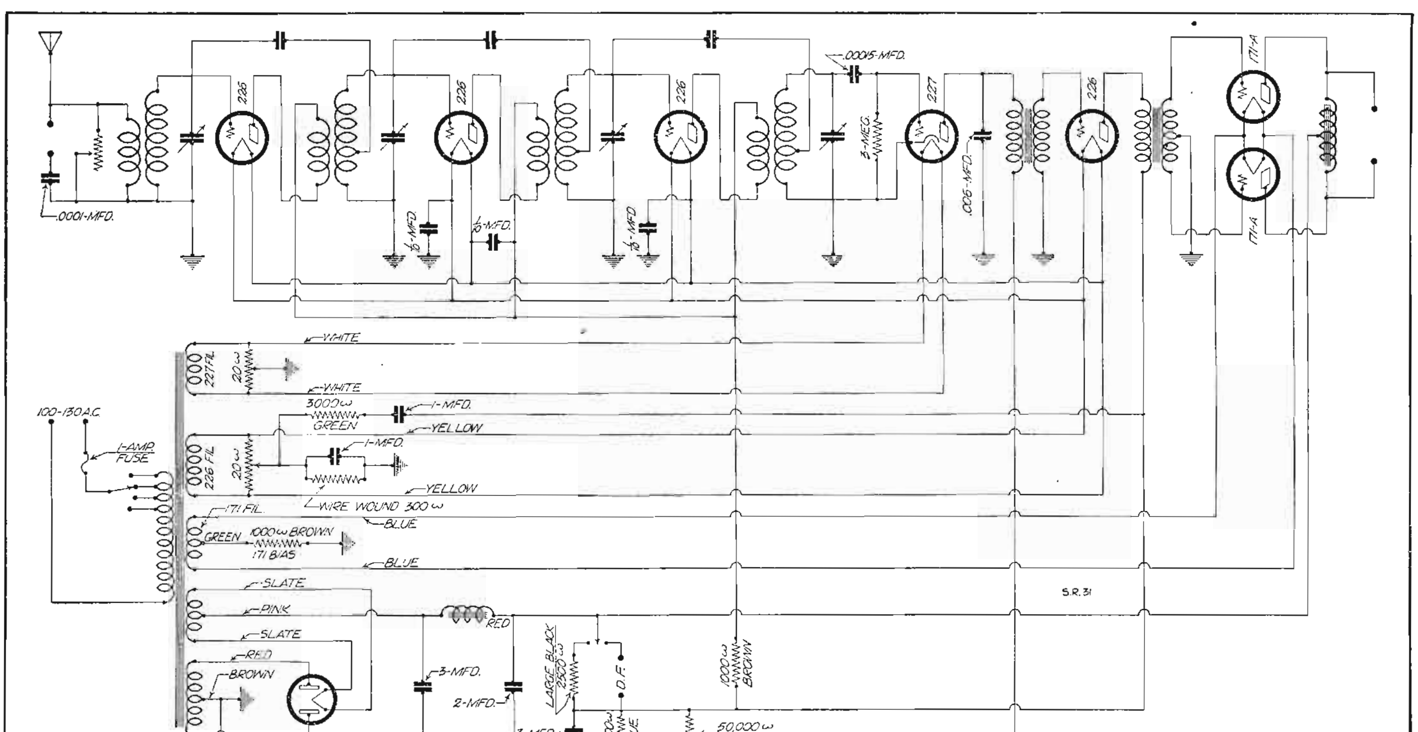


Fig. 7. The general layout of the circuit used in the King Model "J" receiver and power supply is set forth in the above schematic diagram

Gilfillan Bros. Model 100 Receiver

USING six 227 type tubes in the r. f. and first audio the schematic circuit of the Gilfillan Bros. model 100 receiver and its power supply is shown on this page. The output tube is a 245 while all of the r. f. stages, the detector and the first audio employ the 227. The diagram of the receiver is shown in the schematic Figure 9 while the power supply is illustrated in Figure 8. A 280 rectifier is used for the high voltage.

Looking at the schematic of the receiver shown in Figure 9 it is observed that the four radio frequency stages use the stabilizing resistances in the grids of the 227 tubes. These values are shown as 800 ohms. The first 227 used as an antenna stage has a trimmer across the tuning condenser to compensate for various antenna loads. It will also be noticed that from the primary of the first r. f. transformer to the plate of the first 227 is placed a midget capacity. Between the plate of the first and second 227 is another midget capacity while between the plate of the second and third is another capacity and the same applies to the coupling between the plate of the third and the fourth tubes. The condensers previously mentioned are used for phase balancing, one of the several methods of neutralization.

All the r. f. transformers have twelve turns of No. 36 double silk primaries and a secondary of 114 turns. The antenna input r. f. transformer has 15 turns in the primary of No. 36 d. s. and 96 turns on the secondary.

It will be seen by referring to the schematic that two taps are provided for antenna control. The long tap throws into the circuit the entire primary so that energy comes directly from the antenna to the primary and thence to ground, inducing a voltage in the secondary. When the antenna switches on the short side, it throws the aerial in on a tap 30 turns down from the top of the secondary inductance. As previously stated the trimmer across the first section of the tuning condenser serves to balance up the antenna stage so that it will be in line with succeeding radio frequency stages.

Volume control used on the set is a 10,000 ohm variable in series with a 450 ohm fixed resistance between the common cathode line and the ground.

The plate circuit of the 227 dectector has the usual r. f. choke in series with it and is bypassed by a .002 mfd condenser. The coupling to the first audio is a combined resistance and capacity method. The resistor in the plate circuit of the 227 is a .1 megohm while the coupling capacity is a .1 mfd condenser. Bias on the 227 in the first audio stage is secured by the drop across the 1500 ohm resistance between cathode and ground, while a .5 megohm is used for grid to ground. The detector circuit uses the high bias for detection, the cathode-ground resistor being .025 megohm.

The second stage audio transformer is also a resistive load arrangement, the d. c. going through the resistor in the 227 plate circuit, the a. c. going through the coupling condenser and primary, the secondary being hooked up in an auto-transformer style, the bottom of the secondary winding being made common with the top of the primary winding so that the return is from the grid of the 245 through the secondary, through the plate and thence to ground.

Plate voltage for the first, second, third, fourth radio frequency stages and the detector as well as the first audio should be 140 volts from the power supply. The output tube secures 250 or 300 volts. All of the tubes secure their filament current from the 2.5 volt winding.

In the schematic diagram Figure 8 which covers the power supply a 280 is used as the rectifier. A hum control resistance of 10 ohms is placed across the two and a half volt filament secondary. A 1500 ohm resistance between B minus and the center of the hum control resistor serves to provide the bias for the 245 tube. A 30 ohm resistance is placed across the low voltage secondary for the filament of the 280 and its center point becomes the high voltage terminal. The speaker field used with this job is one of 2250 ohms and is placed between the maximum voltage tap and the 140 volt terminal. The resistor between 140 volts and B minus is one having a value of 4000 ohms.

The primary of the power supply is for 105 to 120 volts a. c., the switch being located on the set. Two taps are provided, one for 105 volts and the other for 120.

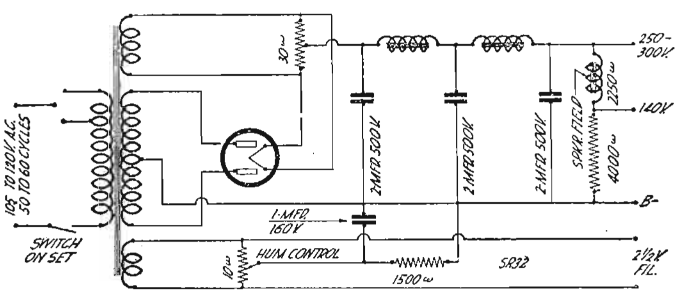


Fig. 8. The schematic of the power pack used with the model 100 Gilfillan receiver is shown in this diagram

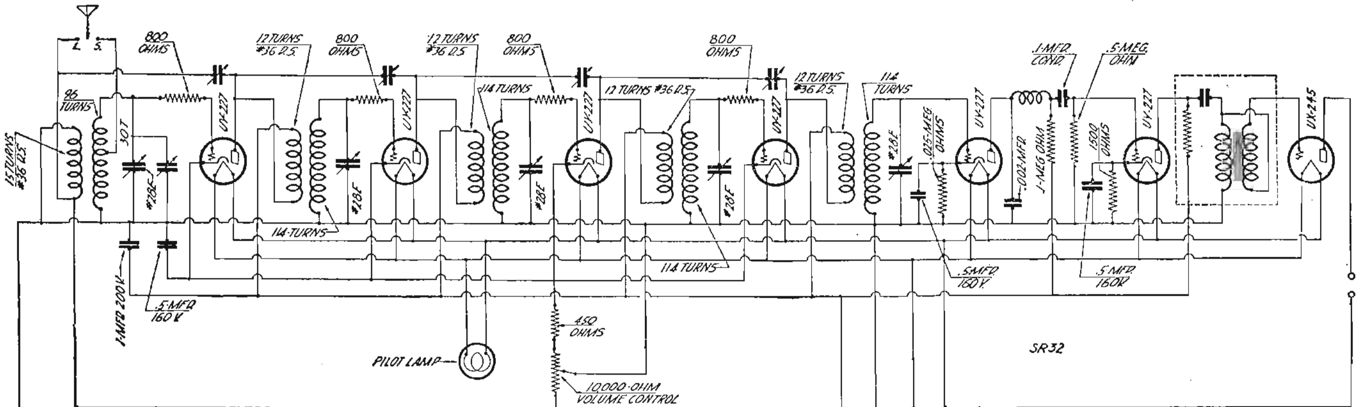


Fig. 9. In this drawing are shown the constants of the model 100 Gilfillan receiver described on this page

Erla Duo-Concerto Model Receiver

MANUFACTURED by the Electrical Research Laboratories of Chicago, Illinois, the Erla Duo-Concerto model receiver is shown schematically on this page. The receiver portion which is known as model R2 is illustrated in Figure 10, while the audio amplifier and power supply units known as model A2 is set forth in drawing, Figure 11.

As will be seen in the schematic of the receiver there are three radio frequency stages using 226 tubes and a detector using a 227 heater type. The radio frequency condensers are all on a gang and the three r. f. stages are neutralized. Input to the antenna stage is across a 10,000 ohm potentiometer in parallel with the primary winding of the first r. f. transformer.

The second stage audio and the two 171-A tubes in push pull are located within the power unit as shown in the drawing Figure 11. A 280 rectifier is employed for the high voltage, while filament current for all tubes is supplied from the necessary low voltage windings on the power transformer.

The complete outfit consists of a chassis R2 carrying the radio frequency, an audio amplifier A2 and its power supply, and a dynamic speaker type D. The job is made up in two forms, one for use in connection with a loop antenna, the other with the regular outside or inside antenna.

Looking at the radio frequency chassis from the front it will be seen that there are three balancing hex nuts and three neutralizing hex nuts. Beginning at the right the first nut is neutralizer 1, then balancing, then neutralizing two, then balancing, then neutralizing three, and finally the balancing for the third r. f. The order of tubes reading from the right towards the left is first r. f., second r. f., third r. f., and then detector at the extreme left. To balance the receiver tune in sharply a distant station with low volume between 240 and 280 meters. Then with a balancing wrench obtainable from the maker of the receiver turn the balancing nut B previously mentioned for maximum volume.

For neutralizing the receiver in the event this is necessary, a neutralizing tube is required. This tube is a good 226 with one filament prong sawed off. Tune in sharply a local station between 240 and 280 meters, then remove the third r. f. tube and insert the neutralizing tube, retuning the receiver for maximum volume. Then with a special balancing wrench turn the nut N3 (located in line with the tube sockets) left or right until a null or minimum volume position is found. Replace regular tube in its socket. This stage is neutralized. Proceed in the same manner on the second stage, adjusting nut N2 and first stage adjusting nut N1.

According to instructions from the factory the outside or indoor antenna used in connection with this receiver should never exceed 50 feet in length.

In the rear of the radio unit are two tip jacks for connecting an electrical pick-up unit. It is merely necessary to place the two phone tips in those jacks. As will be seen in the schematic diagram Figure 10 at the lower right hand corner, arrangement has been made for a switch whereby the listener may turn the receiver from a radio to a phonograph combination.

In the absence of any actual measurement of tube voltages on this model we are not able to supply this information.

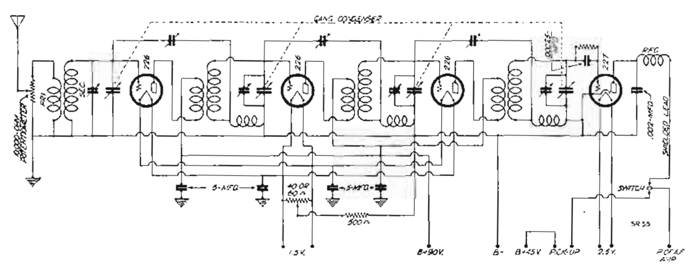


Fig. 10. The receiver portion of the Erla Model described on this page is shown in the above schematic diagram. The audio and power supply end of the receiver is contained in another unit and is illustrated schematically in Fig. 11

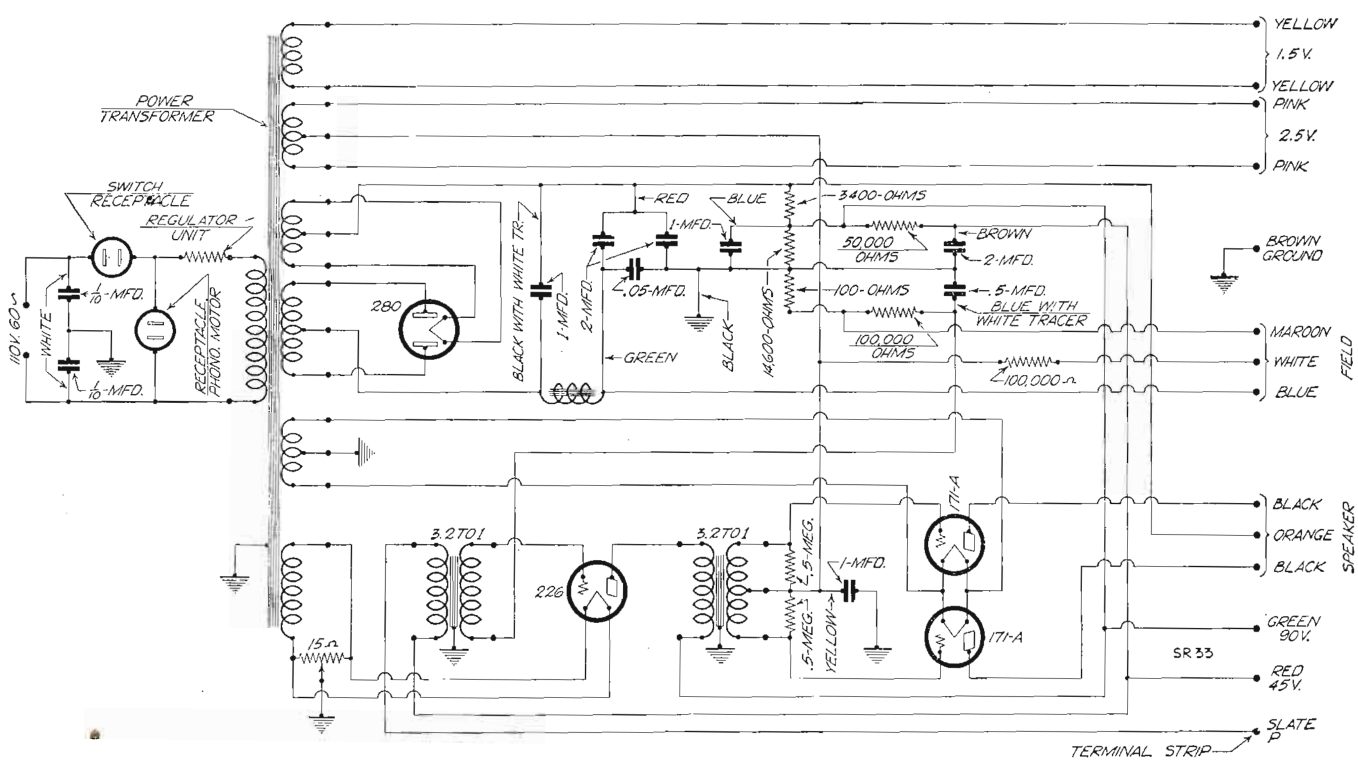


Fig. 11. Electrical constants of the power supply and audio amplifier used on the Erla model are shown above

Stewart Warner Series 900 Receiver

THE balanced bridge type of circuit is used in the 900 series a. c. radio receiver made by Stewart Warner and shown schematically on this page. This circuit differs from the usual circuit of its kind in that it makes use of shunt capacity through separate choke coils and bypass condensers, thus separating all radio frequency from the power circuit which makes for greater stability, allowing amplification to be carried to a further point without oscillation. The complete circuit diagram is shown in Figure 12.

Voltage Analysis

An analysis of voltages on the series 900 receiver made with a Weston 547 test set shows the following:

First r. f. 227 A volts 2.2, B volts 145, C volts minus 10, cathode heater volts plus 10, normal plate m. a. 3.7, plate m. a. grid test 6.7.

The second r. f. 227 shows A volts 2 2, B volts 145, C volts minus 10, cathode volts plus 10, normal plate m. a. 4.7 and plate m. a. grid test 8.

The third r. f. 227 shows A volts 2.2, B volts 147, C volts minus 10, cathode volts plus 10, normal plate m. a. 3.9 and plate m. a. grid test 7.1.

The detector 227 reads 2.2 A volts, B volts 30, C volts 0, cathode heater volts 0, normal plate m. a. 1.8 and plate m. a. grid test 2.

The first a. f. 227 has A volts 2.2, B volts 140, C volts minus 8, cathode heater volts plus 8, normal plate m. a. 4.5, plate m. a. grid test 5.7.

One of the 245's used in push pull reads 2.2 for A volts, B volts 235, C volts minus 43, normal plate m. a. 27.5 and plate m. a. grid test 30. The other 245 has A volts of 2.2, B volts 235, C volts minus 44, normal plate m. a. 32 and plate m. a. grid test 35.

The 280 rectifier reads A volts 4.6, normal plate m. a. 47.5. These readings are taken with the volume control full on and a line voltage of 109.

Tube Variation

It is to be noted that a certain amount of variation is to be expected in tube readings. Experience coupled with a knowledge of the circuit of the set should tell whether the variation found with any particular receiver is normal or not.

The standard test with a suitable radio set tester will indicate more or less closely in what circuit the defect may be found. It then becomes necessary to make a series of continuity tests to locate exactly the source of the trouble.

Causes of Noise

Noisy operation is usually due to outside disturbances picked up by the aerial system. To determine its source disconnect both aerial and ground. If the noise continues it is evidently in the set. It may be necessary to turn back the volume control of the receiver and set the dial for a fairly high wave length station to prevent oscillation without the ground.

A loose connection anywhere in the entire receiving system will cause a noise. It is necessary to check all possible points. Jarring or shaking the items under suspicion will frequently indicate the cause of the noise.

Detector Noisy

A defective tube particularly when used in the detector socket may cause noisy reception. An interrupted buzzing that continues with the aerial and ground disconnected is almost certain to be caused by the detector tube.

Excessive hum may be caused by a defect in the receiver, the tubes or the power circuit. Most likely source of hum in the set itself is an open or short circuited resistor, particularly of the center tap kind. Check all resistors and fixed condensers particularly those used for bypassing r. f. current.

Poor Tone Quality

Poor tone quality may often be caused by a defective tube, this being more noticeable when the volume is increased. Low voltage, either low filament or plate voltage will cause scratchy reception. Incorrect C bias may also be the cause of poor tone quality. Check all grid bias resistors, make certain their resistances are correct and that they are not short-circuiting anywhere. Check grid voltage.

Mechanical Vibration

Occasionally mechanical vibration of the power transformer cover will result in a decided hum. This can be checked easily by pulling out the speaker plug while the set is in operation. If the hum continues it is almost certainly vibration of the transformer cover. To eliminate it remove the cover, pry off its lid and pull outward on all four sides to give the cover a noticeable barrel shape. Force the lid on again and replace the cover.

Another frequent cause of hum will be a rectifier tube in which the emission on one side will be considerably less than the other. This apparently unbalances the transformer to such an extent that hum is secured.

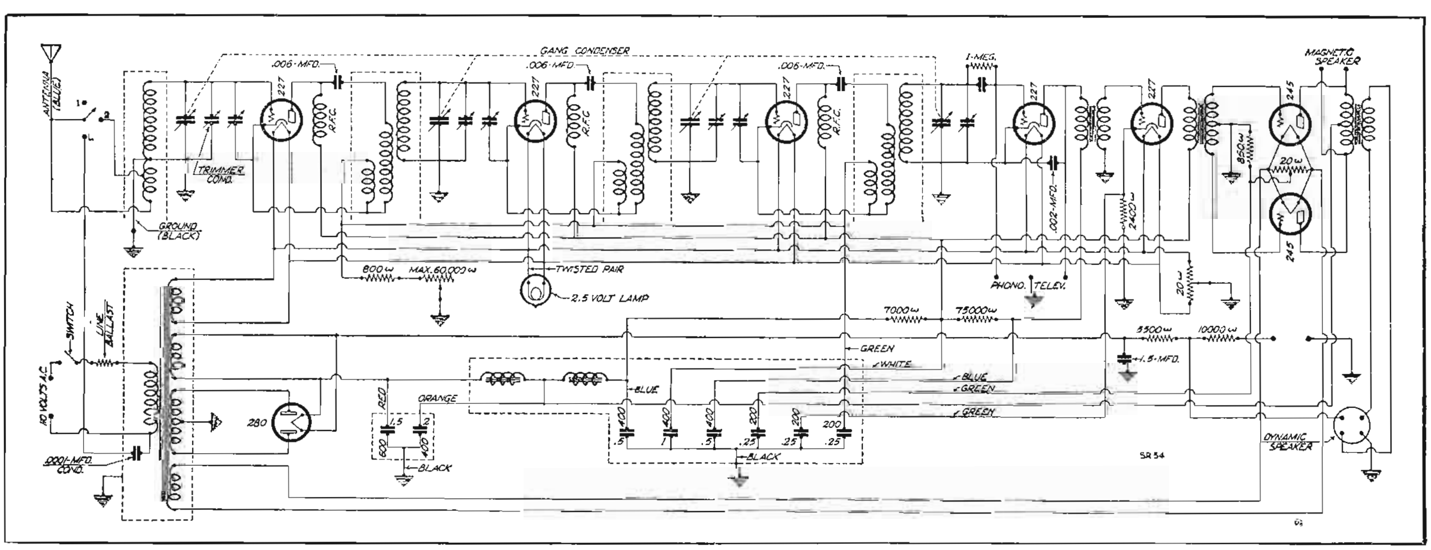


Fig. 12. The electrical circuit of the Stewart Warner series 900 receiver described here is shown in the above schematic

Silver Model 30 Receiver and Pack

FOUR screen grid 224 tubes, one 227, two 245's and a 280 rectifier are used in the Silver Model 30 reveiver described on this page. The schematic diagram of the receiver and its power supply is shown in Figure 13.

Measurements made on two stock Silver chassis with a Jewell 199 Analyzer are given below and indicate normal variations which may be encountered due to the varying tubes and line voltages. Variations within the limits shown or even slightly beyond are no indication of trouble unless some other operating fault is seen.

On one set with a line voltage at 117 and the volume control at maximum the first r. f. 224 showed a shield voltage of 64, A voltage of 2.45, B voltage 152, C voltage 1.5, cathode voltage 1.7 and normal plate m. a. of 4.5.

The second r. f. 224 showed a shield voltage of 64, A voltage of 2.47, B voltage 145, C voltage 2, cathode voltage 2, and normal plate m. a. 3.6.

Third r. f. 224 shield voltage 64, A voltage 2.48, B voltage 148, C voltage 2, cathode voltage 2, and normal plate m. a. 3.3.

Detector 224 showed shield voltage 72, A voltage 2.51, B voltage 68, C voltage 6, cathode voltage 5, and normal plate m. a. .1.

The first a. f. 227 showed an A voltage of 2.51, B voltage 184, C voltage 1, cathode voltage 13 and normal plate m. a. 7.

In the case of the push pull 245 there was a difference of 9 mils between one tube and another. For example, the first tube showed A voltage of 2.49, B voltage 223, C voltage 44 and normal plate m. a. 21. The second 245 showed A voltage of 2.49, B voltage 220, C voltage 43.5 and normal plate m. a. 32. This unbalance in the 245 while not desirable did not seriously affect the operation of these two sets.

The second set was tested with a line voltage of 117, volume control at maximum and showed:

First r. f. 224, shield voltage 71, A voltage 2.45, B voltage 170, C voltage 1, cathode voltage 1, and normal plate m. a. 2.8.

Second r. f. 224, shield voltage 71, A voltage 2.48, B voltage 161, C voltage 2, cathode voltage 1.7, and normal plate m. a. 3.1.

Third r. f. 224 showed shield voltage of 70, A voltage 2.48, B voltage 164, C voltage 2, cathode voltage 2, and normal plate m. a. 3.

Detector 224 showed shield voltage of 69, A voltage 2.5, B voltage 76, C voltage 7, cathode voltage 7, and normal plate m. a. .1.

The first a. f. showed a voltage 2.49, B voltage 196, C voltage 1, cathode voltage 14, and normal plate m. a. 7.8.

One of the 245's in the push-pull stage showed A voltage 2.45, V voltage 222, C voltage 44 and normal plate m. a. 32. The other showed A voltage of 2.45, B voltage 224, C voltage 44, and normal plate m. a. 22.

The above readings do not apply to receivers equipped with the external type 30 filter units or to receivers bearing serial numbers above 12,907. In the case of such receivers an additional 10 volt drop in B voltage must be allowed for across the type 339 U choke coil known as L12.

In general, if no voltage is obtained in any measurement with the analyzer, the receiver should be removed from its cabinet and the particular circuit at which no voltage is apparent checked through, using the set analyzer with its test leads. For example, if the first r. f. tube showed no plate voltage, its circuit should be checked through winding of coil L-2, through one winding of the coupling coil L-3, through the choke coil L-7, and through the red-white connecting wire, to the common join of resistors R-9, R-10, and R-11 (mounted on a panel behind the On-Off switch). If no screen potential was observed upon the third r. f. tube, for example, it would be necessary to check the screen circuit through the resistor R-6 and through the slate cabled lead to the arm of the potentiometer P-1 and then through to the joint between the green resistor R-9 and P-1 (and so on).

Again, should no grid bias be observed (read as "cathode volts" on the set analyzer) on the first audio tube, S-5, the circuit should be checked through by disconnecting the lead from the condenser bank (to check for a possible short-circuited condensed) and again determining if voltage appeared across the white resistor R-8. Should it fail to appear, the cathode might be directly grounded (possibly by contact between *both* ends of the resistor and the shielding), or no plate current might be being drawn, which would indicate an open plate circuit, which in turn, would be checked obviously.

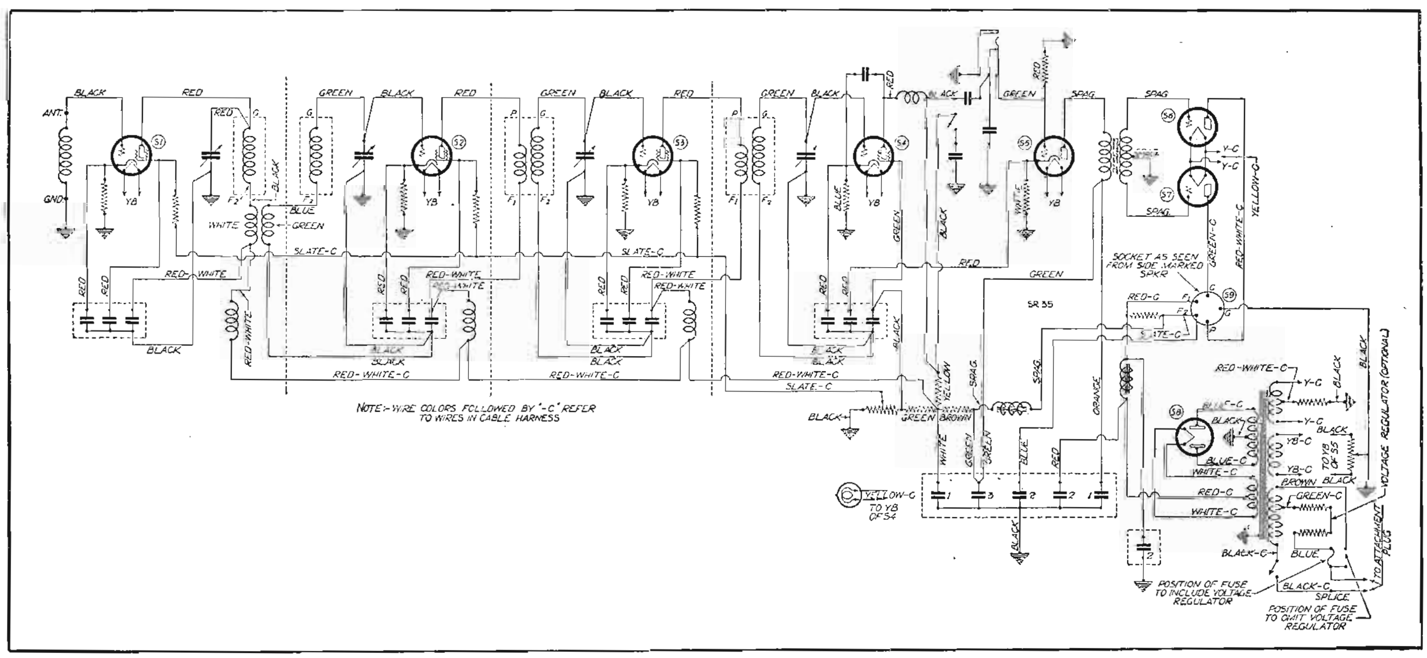


Fig. 13. Schematic diagram of the radio receiver and its power supply is shown in the above illustration. This is the model 30 Silver

The Splidorf E175 Receiver and Pack

MADE by the Splitdorf Radio Corporation of Newark, New Jersey, the type E175 receiver and power supply is illustrated below. Schematically the receiver and the high voltage supply are shown in Figure 14.

Examination of the schematic circuit will indicate that the antenna stage has three taps on the primary for different antenna lengths. The second radio frequency and third radio frequency stages have a grid suppressor resistance in series between the coil and the grid. No grid resistor is used on the first r. f. stage. Detection in the case of the receiver here described is by means of the grid condenser and grid leak. The secondary of the first audio transformer has a resistor placed across its extremities which is used to flatten out the response curve of that particular transformer.

The detector used in this receiver is a 227, while all of the remaining tubes in the r. f. and first a. f. stages are of the 226 type. The resistance R-6 in Figure 14 is placed across the 226 filament line and is by-passed both ways from the center with condensers C-8 and C-9. Resistor R-8 supplies the required bias for the 226 grids. In the case of the 227 detector a resistance R-7 is placed across the filament line and the center tap of this resistor is made common with the cathode. The cathode is also at ground potential as are all of the grid returns on the radio frequency stages as well as the first and second audio.

Primary Fused

A switch is provided in the primary circuit of the power transformer together with a fuse and a fixed resistance R-10. The high voltage secondary S-4 goes to the plates of the 280 rectifier, while the filament current for the rectifier is supplied by the secondary S-3. The center tap of S-3 becomes the high voltage terminal of the system in conjunction with the choke coils X-1 and X-2 and the voltage divider resistance R-11. S-2 furnishes the filament current for the 226 tubes while S-1 furnishes the current for the 227 detector. S-5 furnishes current for the output tube. Condensers C-10 and C-11 are arranged around the input and output of the choke X-1. The voltage divider resistor is made up into four sections, A from the maximum voltage to the voltage for the plates of the 226's, B for the voltage applied to the detector, and C the resistor between the detector voltage and negative. Resistance D is the bias resistor for the power output stage.

The speaker is cut in through a condenser C-14 between the plate of the output stage and the center tap of the filament winding for that particular filament circuit.

It will be observed that the resistance R-4 is placed across the extremities of the primary in the fourth radio frequency transformer. The arm of this variable resistance is common with one side of switch SW-1 and the bottom side of by-pass capacity C-7, this variable resistor serving to give a resistance and capacity coupling between the plate of the third 226 and the plate of the 227 detector.

The hum control for the first audio 226 is resistance R-9 across the secondary S-2 of the power pack. Its center tap is common with the center tap of resistance R-6.

In the absence of any analysis of voltages for this particular model this information cannot be given.

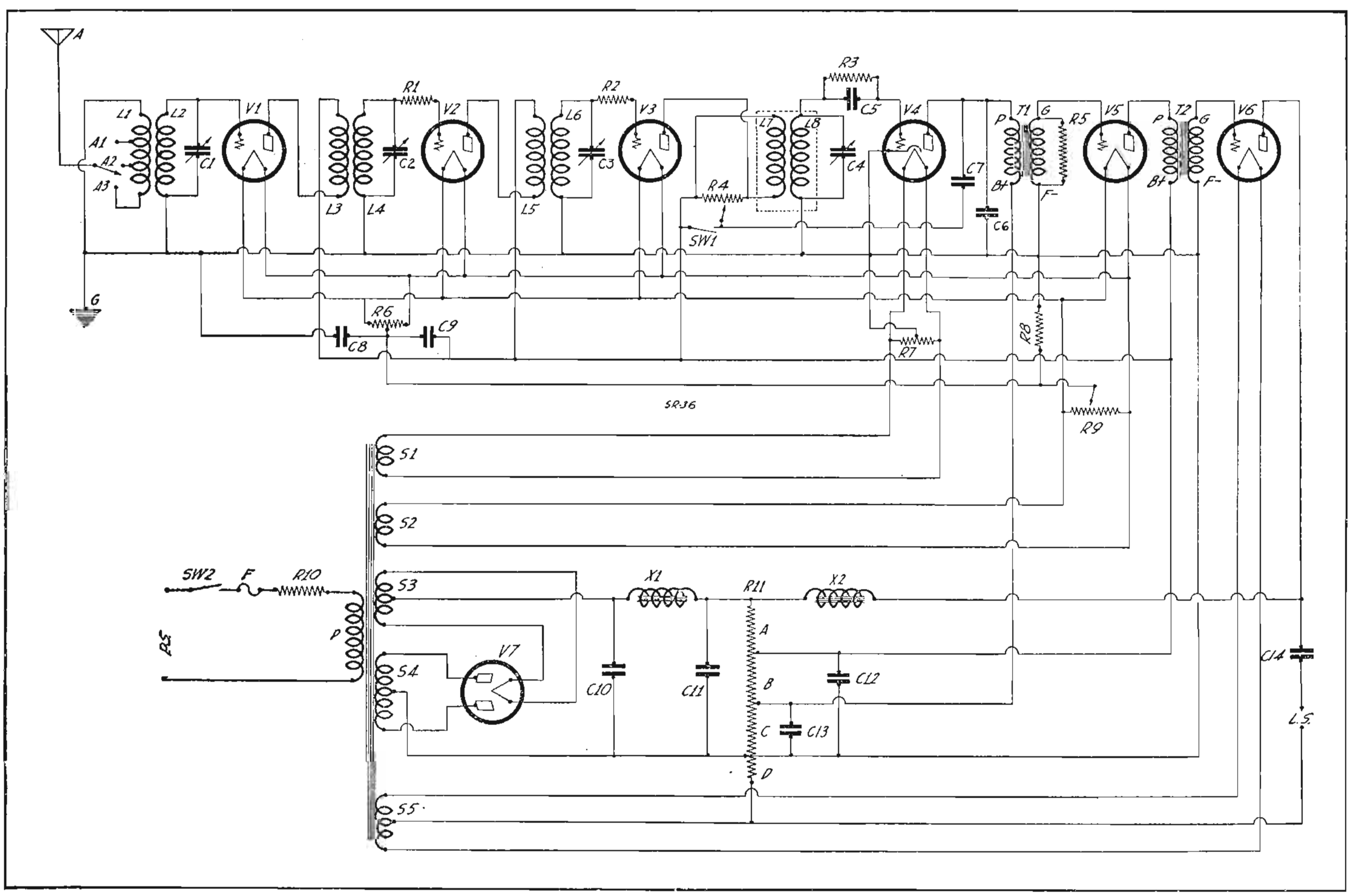
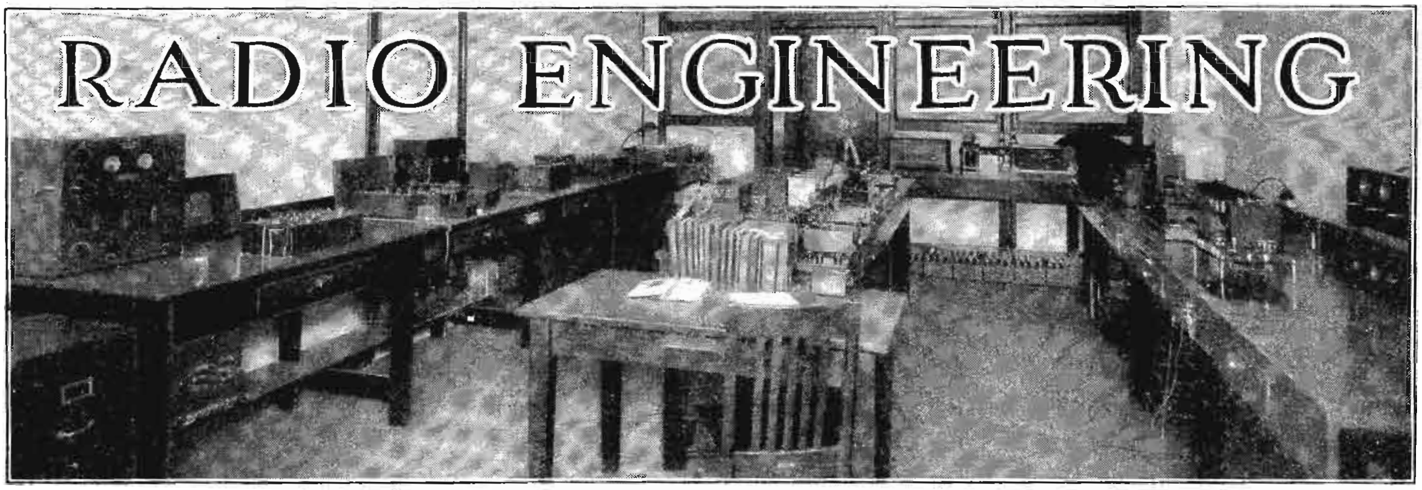


Fig. 14. All details of the receiver and power supply for the Splitdorf E175 shown on this page is contained in the schematic drawing above



Engineering Show Might Take Place of Annual Consumer Show

Many Engineers and Executives Queried as to Opinions Concerning Advisability of a Change

BELIEVING there is room in the industry for the holding of an engineering show dedicated exclusively to the exhibition of component parts and accessories making up the factory built sets, instead of having a public show which apparently is not proving as valuable as might be desired to the manufacturers, this magazine addressed a questionnaire to a large number of engineers and executives in the industry to ascertain their reactions toward the idea of holding such an engineering show.

Response Gratifying

The response was very gratifying from the number of replies received, the varied comments made by the engineers and the apparent interest with which this suggestion was received. As soon as a complete tabulation has been made of all replies and comments, the material will be turned over to the Radio Manufacturers Association by this magazine with a request that they give consideration to the statements appearing in these questionnaires and determine whether such an engineering meeting would fit in with the policy of the Radio Manufacturers Association.

The Letter

The letter which was addressed to chief engineers and executives read:—

"We believe only two radio shows are needed by the industry. These are:

An Engineering show where all parts suppliers may exhibit products for the exclusive benefit of engineers. A Trade show where dealers and jobbers may see working models of sets and arrange their buying schedule.

By holding the Engineering show sufficiently in advance of the Trade Show, engineers and parts supplies will have ample time to produce satisfactory models for the Trade show.

An orderly arrangement of an Engineering show followed by a Trade exhibition in June will serve to unkink the industry's annual sales curve, reduce overproduction, curb price cutting, eliminate double expense in the consumer shows, and put design, production and sale of radio apparatus on an intelligent, systematic and profitable basis.

We wish an expression from engineers on three points:

When is the most logical time for an Engineering show? ....

Where should it be held? ....

Under whose auspices? ....

We will be glad to have your view on this matter. A return envelope is enclosed for your convenience."

Engineers' Comments

In addition to the routine answers indicating personal preference on the part of the engineers, several engineers and executives have added comments, which we are printing because they indicate interesting angles on this subject.

Caxton Brown, vice president and secretary, Weston Electrical Instrument Corp., Newark, N. J.: "We are in favor of limiting to two radio shows; one to be an engineering and the other a trade show. In our opinion, however, it is difficult to believe that the engineering fraternity will have their developments ready to present much before June of any one year and of course it would be desirable to have the trade show some time before the early fall. We presume that the ideal arrangement would be, if possible, to have the engineering show in March and the trade show in June."

John H. Miller, electrical engineer, Jewell Electrical Instrument Co., Chicago, Ill.: "As we do not make radio sets we are not very much concerned. The trade show seems to serve our purpose best, as we are able to keep in touch with the parts suppliers fairly well from these shows. The writer does not believe that an engineering show would be of any great service, at least, as far as we are concerned, as we are fairly self-contained and use only basic products made outside."

E. N. Rauland, president, The Rauland Corp., Chicago, Ill.: "I do not believe that an Engineering Show or any other show would be successful unless it was held under the auspices of the Radio Manufacturers Association. As you probably know, the RMA have conducted three trade shows which have been highly successful, and with a great deal of benefit to the exhibitors and the industry in general. I do not believe that an engineering show as such is feasible, inasmuch as development

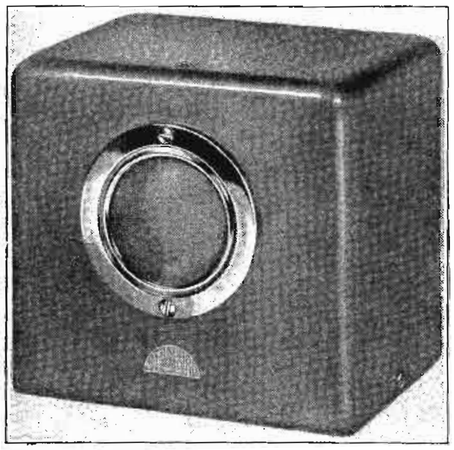


Fig. 1. This is a photograph of one of the condenser microphones made by the Standard Radio Co. of Chicago

among the manufacturers now is practically continuous throughout the year. It is not logical to believe that the manufacturers would withhold development of engineered models until they had the opportunity of seeing component parts or supplies exhibited at an engineering show. I strongly favor parts manufacturers and other suppliers of radio manufacturers to exhibit at the annual trade show of the RMA and at that time show their wares to the radio industry in general."

A. Hauser, chief engineer, Brown & Caine, Chicago, Ill.: "We do not seem to believe that an engineering show is actually possible with the exclusion of a trade show. A trade show is merely an exhibition of engineering developments. Should it be possible that engineers display an exhibit, their developments to one another, it should be held at the engineering societies like A. I. E. E. or I. R. E. similar to the standard meetings held by such societies. The question referring to the auspices under which such a show should be held is rather hard to decide and the writer at this time cannot give you information, as the first paragraph of this letter explains this. He would be very glad to hear from you as to what you are planning to do and upon receipt of more detailed information he will be able to form a better opinion."

E. E. Horine, chief engineer, National Carbon Co., New York City: "We are constantly being informed by parts makers of the merits of their products and of new developments just around the corner. It is doubtful if a show of the kind here proposed would add to this information, or in any way be of benefit to us in engineering new receiver developments."

R. W. Cotton, Samson Electric Co., Canton, Mass.: "I see very little purpose to be served by an engineer's show."

In addition to filling in the regular questionnaire indicating their choices in the matter, the following engineers gave added suggestions which may be of interest:

E. K. Oxner, chief engineer, High Frequency Laboratories, Chicago: "I believe that an engineering show should be held in January on the assumption that trade shows will continue to be held in June or possibly May. The location of such a show will, of course, have to be a subject based on the choice of the majority and quite naturally we feel that Chicago would be most beneficial to the majority of set manufacturers. It is very difficult, indeed, to form an opinion as to what branch of the industry should hold such a show, although it would appear to devolve on the parts manufacturers themselves. This subject is a somewhat difficult one and I am not so sure that the idea of

(*Continued on page* 130)

Rochester I. R. E. Convention

ONE of the most interesting of the engineer meetings held this year was the Eastern Great Lakes District Convention of the Institute of Radio Engineers at the Sagamore Hotel in Rochester, New York, November 18-19. Attendance at the meeting exceeded the expectations of those in charge and it is understood there were in excess of 200 at this convention.

Credit to Graham

A great deal of the credit for such a successful convention is due to the activity of Virgil M. Graham, executive chairman at Rochester, who was assisted by L. Grant Hector, vice-chairman, from Buffalo; and A. R. Barfield, secretary and H. J. Klumb, treasurer, both from Rochester.

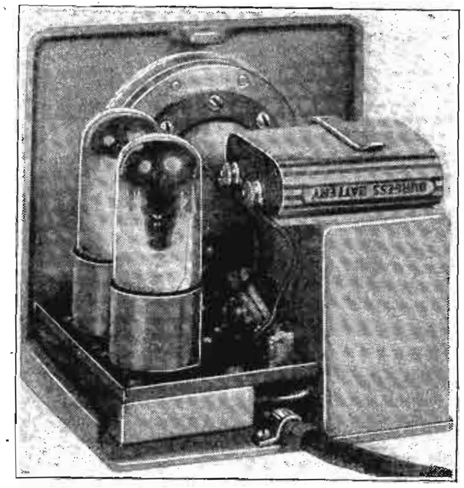


Fig. 2. This is a view of the inside of the condenser microphone illustrated in Figure 1 and is of the direct coupled type, the A and B supply being self contained

The publicity committee was headed by R. A. Hackbusch, chairman from Toronto, with K. L. Henderson, vice-chairman of Buffalo, and E. C. Karker, and I. G. Maloff of Rochester, and D. Schregardus from Cleveland.

Other committees operating in conjunction with the executive chairman were:

Finance

H. J. Klumb, Chairman, H. A. Brown, H. E. Gordon, E. A. Hanover, A. T. Haugh, and I. G. Maloff.

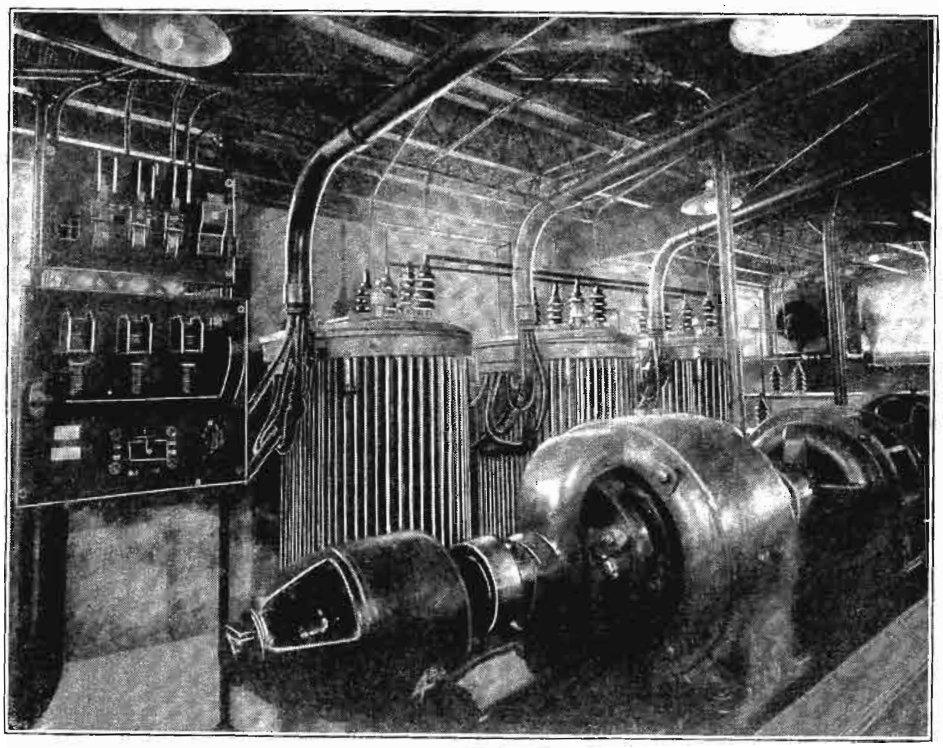


Fig. 3. Transmission engineers may be interested in this photograph of the power plant of Station WOWO at Ft. Wayne, Indiana, which has recently been completed by the owners under the supervision of a Chicago transmission engineer

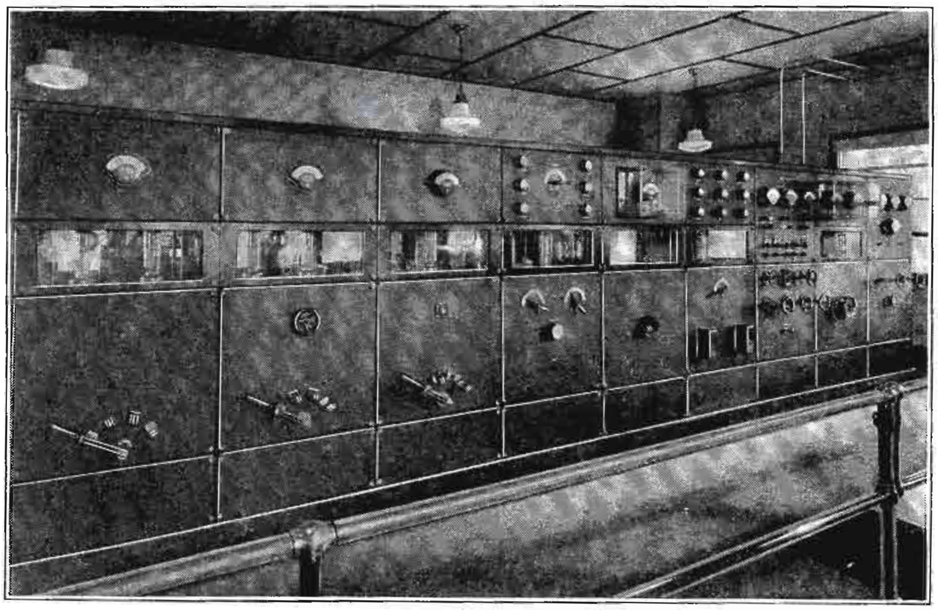


Fig. 4. In this photograph may be seen the complete control panel of Station WOWO at Ft. Wayne, a brief description of which appears elsewhere in this section

Technical Papers

Virgil M. Graham, Rochester.

Transportation and Accommodation

J. Eichman, Chairman, Buffalo; J. M. Leslie, Toronto; J. R. Martin, Cleveland; and A. E. Soderholm, Rochester.

Fellowship

H. E. Gordon, Chairman, Rochester; F. A. Lidbury, Buffalo; and C. L. Richardson, Toronto.

Trips

A. L. Schoen, Chairman, Rochester and A. E. Soderholm, Rochester.

Entertainment and Reception

E. C. Karker, Chairman, Rochester and Howard Brown, Rochester.

Ladies' Entertainment

Mrs. O. L. Angevine, Chairman, Mrs. C. S. Barrows, Mrs. H. A. Brown, Mrs. H. E. Gordon, Mrs. V. M. Graham, Mrs. E. A. Hanover, Mrs. E. C. Karker, Mrs. H. J. Klumb, Miss Marie Maeder, Mrs. R. H. Manson, Mrs. V. M. Palmer, Mrs. A. L. Schoen and Mrs. A. E. Soderholm.

Exhibits

I. G. Maloff, Chairman, Rochester.

Registration

A. E. Soderholm, Chairman, Rochester; O. L. Angevine, Registration Secretary (Executive Secretary of Rochester Engineering Society), E. C. Karker, Rochester; Bruce W. David, Cleveland; L. Grant Hector, Buffalo; V. G. Smith, Toronto; Miss Marie Maeder, Rochester and Miss Viola Hanley, Rochester.

Program

The program for the meeting follows:

MONDAY, November 18

8:00 a.m. Registration at Convention Headquarters, Sagamore Hotel.

10:00 a.m. Opening Technical Session.
"Welcome," by Earl C. Karker, Chairman of Rochester Section.
"What Executives Expect of Engineers," by I. G. Maloff, Valley Appliances, Inc.
"Consideration in Screen-Grid Receiver Design," by W. A. MacDonald, Hazeltine Corporation, read by D. E. Hartnett.

12:30 p.m. Adjournment for luncheon.

2:00 p.m. Inspection trip to Kodak Park and Valley Appliances, Inc.

8:00 p.m. Technical Session.
"Ultra High-Frequency Transmission and Reception," by A. Hoyt Taylor, Naval Research Laboratory.
"Television With Cathode Ray Tube for Receiver," by Dr. V. Zworykin, Westinghouse Electric and Manufacturing Co.

TUESDAY, November 19

9:30 a.m. Technical Session.
"A Broadcast Receiver for Use in Automobiles," by Paul O. Farnham, Radio Frequency Laboratories.
"Standardization in the Radio Vacuum-Tube Field," by W. C. White, General Electric Research Laboratory.
"New Developments in Direct Coupled Amplifiers," by E. H. Loftin and S. Y. White, read by S. Y. White.

12:30 p.m. Joint Luncheon with Rochester Engineering Society.
Speaker—W. Roy McCanne, President of Stromberg-Carlson Telephone Manufacturing Company.

2:00 p.m. Inspection Trip to Stromberg-Carlson Plant.

6:30 p.m. Banquet—A. T. Haugh, Toastmaster.
Speaker—H. B. Richmond, President of Radio Manufacturers' Association.
Subject—"The Engineer in the Radio Industry."

WOWO Transmitter

TRANSMISSION engineers may be interested in the photographs and a brief description of the 50,000 watt broadcast transmitter built for WOWO at Ft. Wayne which is now operating on 10,000 watts, in accord-

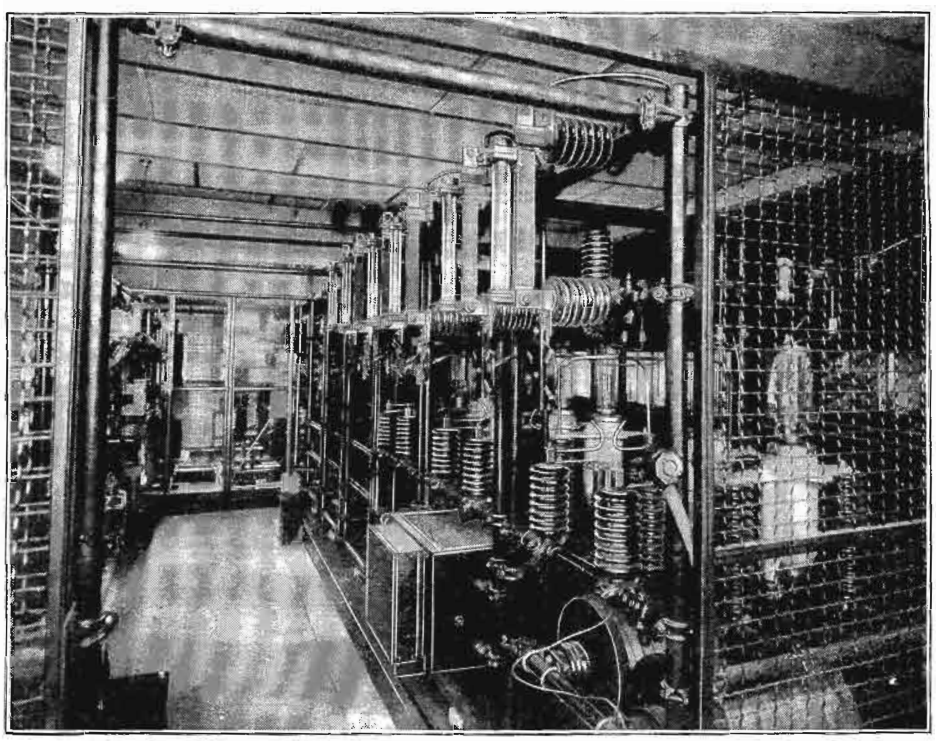


Fig. 5. This photograph shows the rear of the control panel illustrated in Figure 4. A description of the parts is given elsewhere in this article

ance with authorization by the Federal Radio Company.

The transmitter was designed, constructed, installed and supervised by a firm of Chicago radio transmission engineers, E. A. Beane Engineers.

A photograph of the control panel is shown in Figure 4, while Figure 5 shows rear of this set of panels. Figure 3 is an illustration of the power plant for this particular transmitter.

Control Apparatus

In Figure 4 may be seen the nine individual panels which are placed together forming the entire control apparatus. Beginning at the left and reading towards the right, the first, second and third panels are for the first, second and third phases of the rectifier. The fourth control panel is the crystal control, the fifth the modulator, the sixth a 500-watt amplifier, the seventh all primary power control panels, eighth, power amplifier tube rack, and the ninth contains the tank circuit and antenna tuning remote control devices.

In the photograph Figure 5 is illustrated the back of the nine control panels and in this picture reading from right to left are the three rectifier panels, then the crystal control, modulator, 500-watt amplifier, all primary power control, power amplifier tube rack and at the extreme left the tank circuit and antenna tuning remote control system.

Entirely Automatic

The installation is entirely automatic and is controlled by a push button. Every type of relay is employed in this installation for guarding against either overload or unload, excessive water temperature, and all other conditions arising from a change in electrical constants of the transmitter.

In the photograph shown in Figure 3 may be seen the primary power supply for the 200 k. w. rectifiers. At the left are the contactors to start the rectifiers, then the 3 transformers, each weighing about 3 tons apiece and standing 7 feet high. At the left of the generators may be seen the excitor, then one of the high voltage generators, next the motor in the middle and another generator at the right end. At the top and in the extreme right may be seen the fan used for the water cooling system.

Condenser Microphone

Another one of the devices designed by the E. A. Beane Engineers for the Standard Radio Company may be seen in Figure 1 which is a condenser microphone, the interior of which is illustrated in Figure 2. These are designed to take the place of the ordinary carbon microphone without any changes in the circuit. The output level of the condenser microphone is the same as that of the carbon. It cannot overload and there is no rustle. These microphones are particularly adapted for picking up organ selections and in use at WJJD, WLS, KMA, WFBM, WSBT. It is small, light and compact, has very few electrical parts and its frequency loss is practically negligible.

Preliminary Analysis of the Loftin-White Circuit

Article on Page 86 Serves as Basis for Laboratory Study; Some Possibilities Revealed

By R. K. Pew
(Technical Editor)

MESSRS. Loftin and White gave a paper on their Cascaded Direct Coupled Tube Systems as operated from alternating current at the Rochester convention of the Institute of Radio Engineers on November 18 and 19, 1929. Incorporated in this paper were detailed the various steps in the development of this amplifier, the theoretical operation of the various types of amplifiers and a statement as to the operation of same as a broadcast receiver and a few voltage amplification versus frequency curves. They failed to state, however, the majority of circuit constants and under what conditions their measurements were made. (Their article starts on page 86.—Editor.)

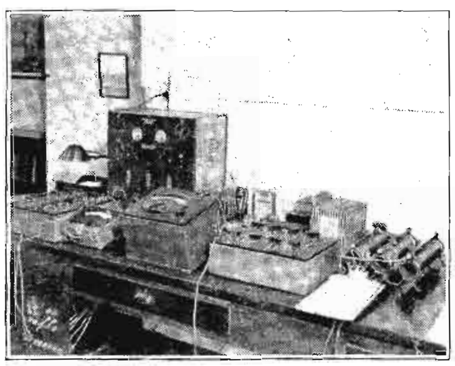


Fig. 3. The amplifier and associated measuring equipment is shown here

The purpose of this preliminary analysis of this type of amplifier was to determine the constants of the circuit and from these fixed values determine the characteristics under different operating conditions, that is, varying input voltages.

Simplest Adaptation

The most simple of the various circuits were selected. This consisted of a single 224 tube and a 250 output tube. A half wave rectifier with a twenty henry choke and three microfarads of condenser for the filter circuit were used. The filter output was 540 volts at .070 amperes.

The schematic circuit of the amplifier is illustrated in Fig. 1, with all circuit constants as used during the measurements.

In Fig. 2 is the schematic circuit of the amplifier as existed during the measurements. In Fig. 3 is illustrated the amplifier and the associated measuring equipment.

Apparatus Calibrated

The apparatus was set up as illustrated in Fig. 2 and calibrated as follows: the input circuit consisting of a

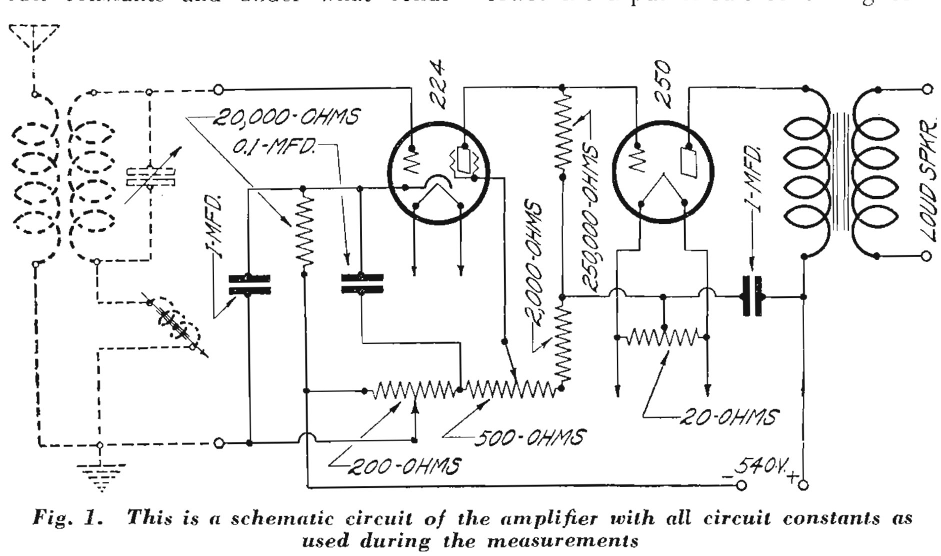


Fig. 1. This is a schematic circuit of the amplifier with all circuit constants as used during the measurements

.002 ampere thermo-couple and a 200 micro-ampere micro-ammeter were calibrated at .001 amperes. The variable shunt resistance of 10,000 ohms was placed across the input circuit of amplifier. $E = R \times I$ giving the input voltage to the amplifier. The output circuit consisted of two series decade boxes and a 4 mfd coupling condenser. The two series decade boxes had a total resistance of 3,200 ohms. The vacuum tube voltmeter had a maximum value of three volts a. c. and was shunted across a known portion of the circuit. The remainder of meters in the circuit were for the purposes as indicated by their position. The alternating current input was generated by a General Radio Type 377 low frequency oscillator.

Measurements were made at 90, 120, 240, 500, 1000, 1400, 2000, 3000, 4000, 6000, 8000 and 10,000 cycles. Input voltages were selected as .5, .1, .5 and 1.0 volts. Curves were made at all frequencies listed at these input voltages and voltage amplification derived by Eo/Ei.

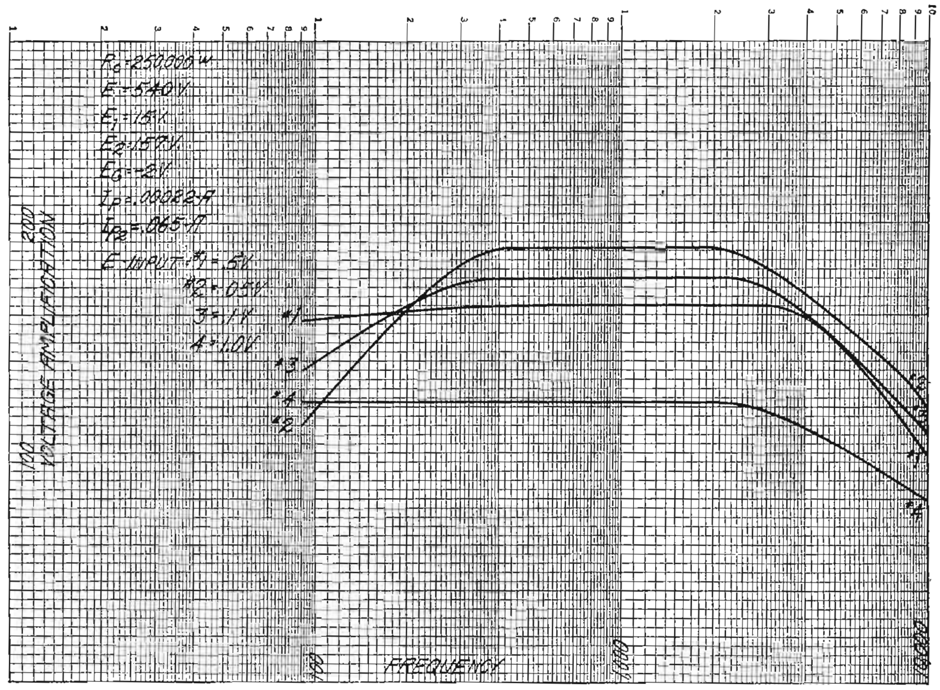


Fig. 4. *Voltage amplification curves for the different input voltages*

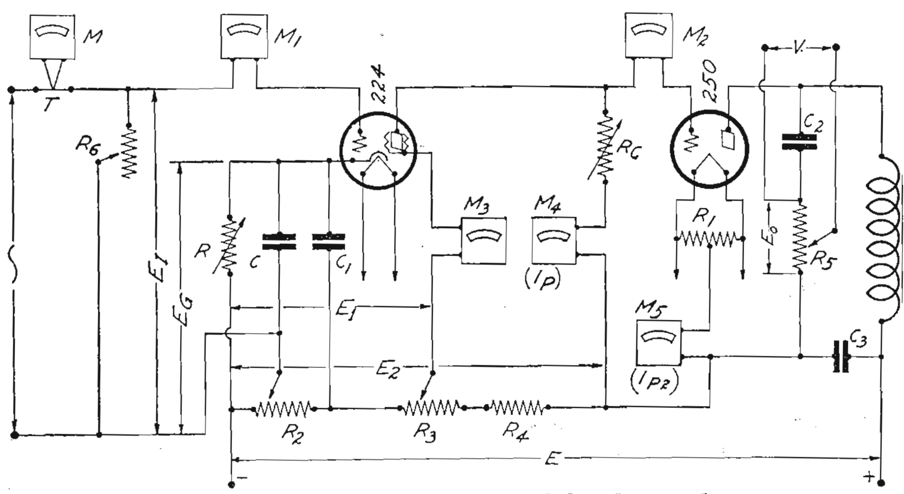


Fig. 2. *The above is a schematic of the amplifier during the measurements*

With the system at rest the effective grid bias of the 224 tube was two volts negative, as measured by a static voltmeter. 540 volts was the output of the filter circuit at 70 milliamperes. This voltage was divided into 387 volts on the plate of the 250 tube and 157 volts applied to the resistor in the plate circuit of the 224. This would give an applied voltage on the 224 of 102 volts. The screen voltage was selected at 15 volts. The plate resistance of the 224 in these measurements was set at 250,000 ohms.

In Fig. 4 are plotted the voltage amplification curves for the different input voltages as indicated.

Curves Plotted

In Fig. 5 has been plotted the curves for the effective grid bias of the 224 against a change in input voltage. It will be noted that with an increase in input voltage the variation of grid bias between two widely separated frequencies increases materially. As an example, at .1 volts input the bias at ninety and ten thousand cycles is practically the same, whereas at 1 volt input the bias at ninety cycles is .15 volts higher than at ten thousand cycles. Considering that this amount of change in grid bias will have a considerably greater change in the plate circuit of the 224 and consequently a change in bias of the 250 output tube, the effect should be shown in the voltage amplification at the different voltage input values. A study of the curves in Figs. 4 and 5 will show the resulting action on the voltage amplification with a variation of frequency and input voltage values.

Conclusion

In order to use the foregoing outlined

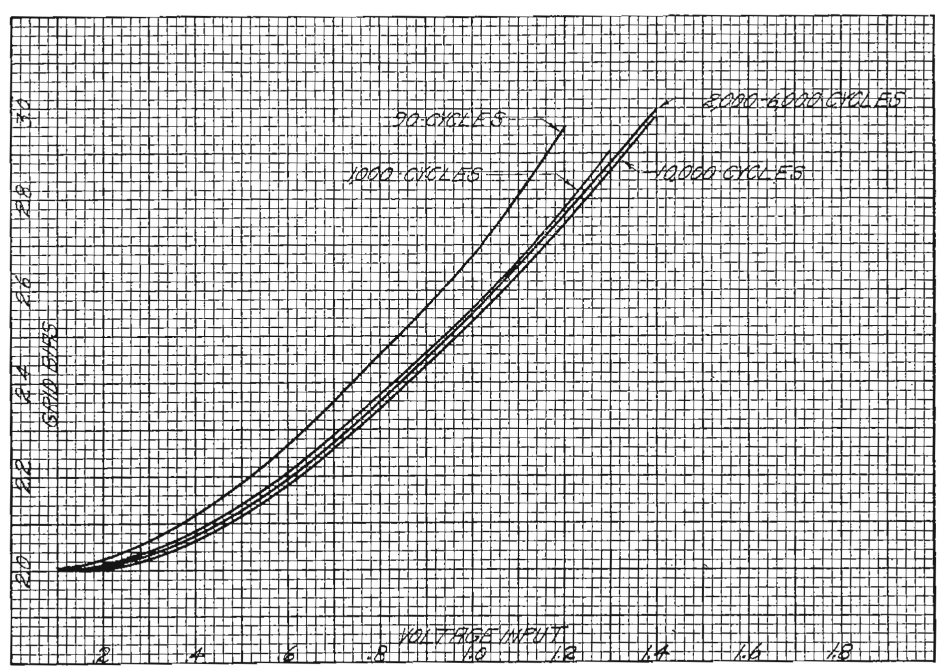


Fig. 5. *The curves for the effective grid bias of the 224 agains ta change in input voltage are plotted here*

amplifier with the specified values of resistance and voltages, it will be necessary to know the exact conditions of operation and input values in order to properly regulate the frequency response and overall gain.

The antenna and phonograph connections with the associated transformer and condenser as shown by dotted lines in Fig. 1 are indicated for the purpose of showing the method of properly connecting these items and not to indicate that the amplifier will operate satisfactorily as a phonograph amplifier or radio receiver.

[We will be glad to hear from engineers who do any measurements on this circuit. If our laboratory can be of any assistance, we will be glad to help. —Editor.]

Direct Coupled Tube Systems A. C. Operated

By Edward H. Loftin and S. Young White

[Editor's Note. This paper was delivered by Messrs. Loftin and White at the Rochester convention of the Institute of Radio Engineers November 18th and 19th, 1929. It is quite likely that it will appear in one of the forthcoming Proceedings of the I. R. E.—Editor.]

Statement of Problem

In any audio amplifier or detector-amplifier the following characteristics are desirably essential:

1. Minimum frequency discrimination; 2, minimum wave form distortion; 3, minimum hum if a. c. operated; 4, reasonable high gain from the tubes used; 5, low cost; and 6, permissive large tolerance in manufactured parts.

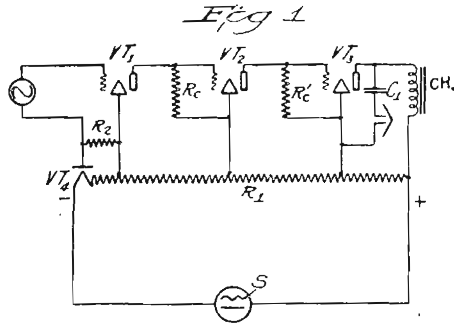
In a. c. operated direct coupled cascaded tube systems the characteristics depend upon or are influenced by the following features:

1. Maintaining the operation of all tubes at the midpoint of their operating or output current curves, or what may be termed stabilizing against "drift" tending to arise from—(A) changing tubes (they are not all alike), (B) change of constants or conditions due to—(a) aging of resistors, (b) temperature coefficient effects in resistors, (c) line voltage modifications, (d) grid emission from tubes, (e) gas current in output tubes, and (f) manufacturing tolerances. 2. Feed back phenomena at audio frequencies; 3, the hum problem; 4, motor-boating; 5, trigger action; 6, maximum gain of tube; 7, providing current for auxiliaries, such as speaker field; and 8, increase to very high gain, such as that required by photo-electric cell operation.

Since the direct coupled cascaded system is usable as a most effective detector-audio amplifier it is well to keep in mind the following desirable essentials of which the system is capable in addition to those listed above:

1. Low grid bias for weak carrier currents and high grid bias for strong carrier currents, automatically self-adjusting; 2, supply of potentials for the radio frequency tubes sufficiently filtered to prevent modulation hum.

Fig. 1



Some Procedures in A. C. Operation

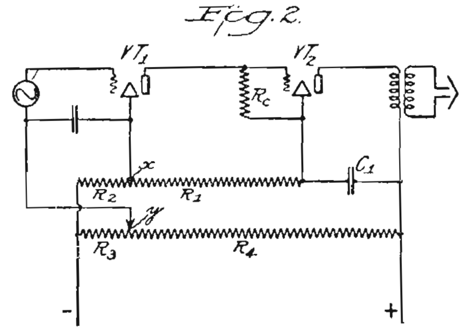
Some of the inherent difficulties we had to overcome in making the direct coupled cascaded system stable and practical are discussed in a prior paper ("Direct Coupled Detector and Amplifiers with Automatic Grid Bias," Proceedings Institute of Radio Engineers, March, 1928), by us, but because of lack at that time of commercial a. c. tubes having sufficiently high amplification constants for satisfactory direct coupled operation we confined our discussion to battery operated systems. Our a. c. work had to be commenced and carried on in large part with commercially non-available a. c. high mu tubes such as we could get constructed on special order, and we secured them in both the heater type and filament type cathodes having mus ranging from 16 to 80. In the case of the filament type for raw a. c. heating it was found practically desirable to go as low as ¼ volt on a heavy filament, since the excellent amplifying ability of the system at 120 cycles makes even very slight filament hum troublesome.

It is thought that the technical and practical features that have been encountered in our research and experiences which have led to arrival at an extremely simple, efficient, and remarkably hum-free a. c. operated system will be more certainly understood and appreciated if we follow through some of the developments that have resulted in success in one way and another.

An early workable a. c. operated system employing our specially constructed a. c. high mu tubes is shown in Fig. 1. A current large compared to that required for the plate circuit of tube VT_3 flows through resistance R_1 from source S to develop the grid and plate potentials required by the tubes. In our early experience we found a large current in R_1 necessary to avoid what might be termed a "trigger action," an effect not wanted in amplifiers and amplifying detectors, but which may be otherwise turned to good account. (Article by Nicholas Minorsky, E. E., Journal of The Franklin Institute, February, 1927, pages 181-209, Vol. 203, No. 2.)

This trigger action is peculiar to direct coupled systems and, unless harnessed, may operate to prevent operating the last tube at the midpoint of its plate current curve, so essential to good amplification. It is apparent that in the arrangement of Fig. 1 if the plate current of VT_3 is a substantial fraction of the total current through R_1, there is possibility of changes in this plate current so effectively modifying the bias of preceding tubes as to result in snapping the plate current of VT_3 to one or the other ends of the curve and holding it there in an effective blocked or saturated condition of the last tube, and therefore render the system further in-

Fig. 2.



effective until something is done to re-establish original conditions.

Continuing with Fig. 1, the output of the last tube comprises a choke coil and condenser combination which tends to localize audio signal current flow (except in the case of lowest frequencies), thus limiting audio signal current in arm R_1 where, if present, it can cause regenerative phenomena due to being able to act on the grids and plates of preceding tubes.

The system of Fig. 1 is prevented from drifting (is stabilized) by the inclusion of the filament of tube VT_4, the 199 type for example, in the arm R_1. The emission from this filament flows through the resistance R_2, and with the filament operated at a critical point for emission, a slight change in current through the filament changes the plate current and therefore the potential across resistance R_2. This potential across R_2 is the biasing potential for tube VT_1, and with a proper choice of constants a relatively small change in plate current of VT_3 produces a large change in the grid bias of VT_1.

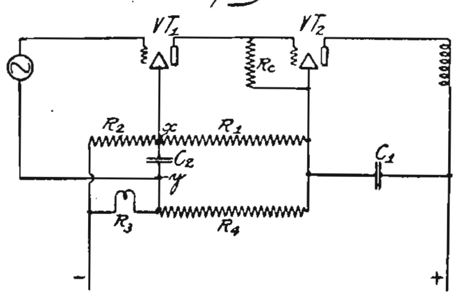
Obviously the degree of plate current of tube VT_3 is dependent upon its grid bias, but since its grid bias is obtained from the flow of plate current of tube VT_2 through resistance R'_c, and so on through the system to tube VT_1, a change in the grid bias of VT_1 will carry through the system; that is, the grid bias of VT_1 is the controlling factor in determining the degree of plate current of VT_3.

Thus, the tying together of the plate current of VT_3 and the grid bias of VT_1 by a means generating an effect opposing any change in VT_3's plate current, the system is corrected against drift and the plate current of VT_3 can be set at a desired point and be substantially maintained there.

In using the 199 type of tube as the stabilizer VT_4, we prefer to operate at a temperature at which the filament is just on the threshold of emission (32 milliamperes), so that the thermal inertia is great and requires an appreciable length of time for noticeable change of temperature. With this selection of conditions any audio frequency component flowing in R_1 is much too fast to noticeably affect the emission, but any effect enduring more than a second or so will give the filament of VT_4 time enough to change temperature and emission sufficiently to correct the result of the effect. Thus the arrangement is in effect a low pass filter for everything beyond the order of several cycles per second, and consequently relieves the grid of VT_1 from any audio signal current effect flowing in the arm R_1.

The practical undesirability of high current in the arm R_1 and use of a rather costly tube as a stabilizer in the

Fig. 3.



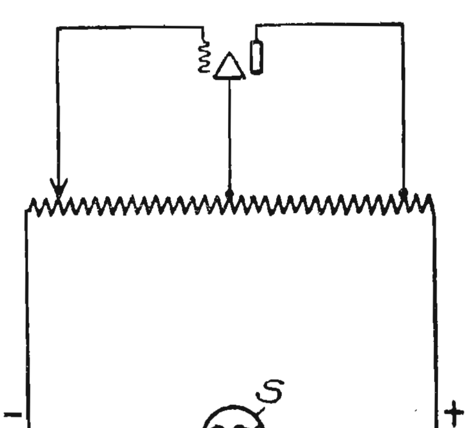
arrangement of Fig. 1 is overcome in the arrangement of Fig. 2.

In this Fig. 2 arrangement a proper choice of constants permits the elimination of a part of the arm R_1 across the supply filter, and a regular transformer output can be used with the last tube, the audio circuit being completed by a condenser C_1.

The stabilizing effect is accomplished in a bridge formed by resistances R_1, R_2, R_3, and R_4. Since the object of drift prevention is to avoid any permanent displacement of the point of operation in the plate current curve of the last tube, the plate current of the last tube is passed through resistances R_1 and R_2 to give opportunity for control thereby. The resistances R_3 and R_4, forming the other two arms of the bridge, are connected across the relatively unvarying potential of the filter supply, and the resistance values of the bridge are so chosen that with normal plate current in the output tube the potential between the balance points x and y of the bridge is of correct polarity and magnitude for a desired grid bias of VT_1.

With such an arrangement when anything happens to vary the plate current of the output tube the potential across R_2 likewise varies, while the potential across R_3 remains substantially constant. The result is the development of a counter grid bias potential for VT_1 opposing a change in either direction in the plate current of the output

Fig. 4.



tube. As a practical matter, the arrangement is designable to be capable of maintaining the system of Fig. 2 against drift within very close approximation to a predetermined desired operating adjustment against a rather wide variety of conditions tending to cause drift.

One drawback of the arrangement of Fig. 2 is that hum currents, if the system is a. c. operated, and audio signal currents are in assisting phase in the arms R_2 and R_3 with respect to the grid bias of VT_1, thus making it difficult to handle hum producing features and signal current feed-back features. Since only small resistance is needed in arms R_2 and R_3, success through by-passing of the hum and signal currents can be had only in the use of several hundred microfarads of by-pass condenser inserted, for example, between the points x and y. Since the difference of potential between these points is very small, it is not outside of the realm of practical possibilities that a decidedly small and cheap electrolytic condenser of sufficient capacity to be effective can be produced, but for the time being no such condenser with satisfactory life characteristics is known to be commercially available.

The hum and feed-back problems of Fig. 2 can be met by substituting for the by-pass condenser idea a thermal effect along with a re-arrangement of the bridge system, these features being included in the arrangement of Fig. 3.

Here the two major legs of the bridge are connected in parallel with respect to the plate current of the output tube, thus making the hum and audio current components in them of like direction and phase. Under these conditions if the arms R_2 and R_3 are substantially balanced for direct current components in establishing the grid bias potential for VT_1, likewise the hum and audio current components are substantially balanced.

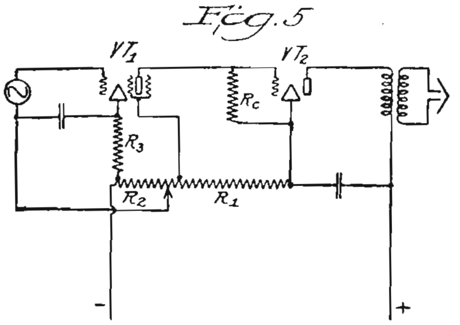
In order to make attempted changes in the predetermined plate current of the output tube effective to produce a correcting change in bias potential of VT_1, a thermal effect is employed. For example, the resistance R_3 may be the filament of an ordinary 10 watt, 115 volt incandescent lamp caused to operate at a dull red heat by selecting the right amount of current for this operation in choosing the value of resistance R_4. At such a temperature the filament of the usual incandescent lamp changes its resistance pronouncedly with slight temperature changes either side of the selected point of operation. Since R_2 is an unvarying resistance, any change in the plate current of the output tube divided between the arms R_2 and R_3 will result in an unbalance to develop a correcting change in the bias potential of VT_1.

Due to the high thermal inertia of the filament of the incandescent lamp, the bridge only unbalances for effects lasting an appreciable fraction of a second, thus eliminating audio frequency signal current effects. For this reason no feed-back difficulty is had with the arrangement of Fig. 3. The condenser C_2 shown is merely a radio frequency by-pass condenser which need be included only when the arrangement is intended to function as a carrier current detector.

The hum resulting with a. c. energizing of the arrangement of Fig. 3 may be made indeed low in the presence of extremely poor filtration, and the reason why such result is obtainable may be more readily explained by reference to the simple diagram of Fig. 4.

Here we have an arrangement similar to what is commonly termed the "Miller bridge," it being noted that in the figure we supply the direct current energizing components from the bridge arm. If attempt be made to balance out the hum of the fluctuating source S, it is found that when the grid potentiometer is moved far enough to the left to have the grid fluctuating component neutralize the plate fluctuating component, the tube is in a practically blocked condition. However, in our mode of operating the direct coupled system we resort to such high impedance conditions that we closely approach the blocked condition, and therefore our form of operation is automatically adapted to hum neutralization on the Miller bridge principle, so that the hum in the system of Fig. 3 is in practice remarkably low in spite of an extraordinarily cheap filter.

Fig. 5



The system of Fig. 3 has a limitation in that the amount of change of grid bias potential of VT_1 in practical construction is not sufficient to adequately compensate the system against the effects of strong carrier currents when using the system as a detector. The amount of compensation obtainable is however amply sufficient when the system is used as an audio amplifier where only limited cause for drift exists, such as changing from one tube to another and change in potential of energizing supply.

A system having an arrangement capable of any encounterable required degree of stabilization is shown in Fig. 5, in this instance a screen grid tube being used in the input position.

In the arrangement of Fig. 2, in trying to solve the signal feed-back and hum current difficulties previously mentioned, attempt was made to filter the currents of these effects from the grid of the input tube by inserting therein a fraction of a megohm of resistance by-passed to the filament by a fraction of a microfarad of condenser. All these attempts were frustrated by motor-boating production at the period of the filter employed. When the screen grid tube became available, it was immediately realized that the screening grid introduces hum and audio signal feed-back, and like attempts to isolate this element by filtering also led to motor-boating.

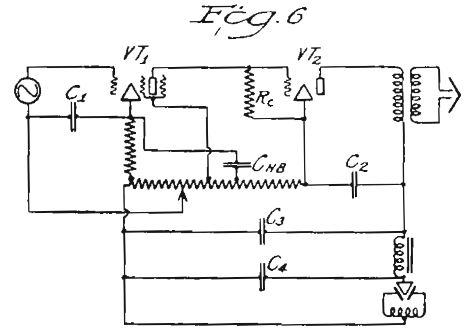
Further investigation disclosed the fact that effective filtration without motor-boating could be obtained by inserting a filter impedance R_3 in a position common to the circuits of all three elements of the screen grid tube, as shown in Fig. 5, the location bringing about a cancellation of the effects tending to motor-boating production.

A resistance R_3, combining as it does both the plate current and the screen grid current, develops rather a large potential across its terminals when of a value to be effective for low frequency current filtration. In order to obviate this fact being a disadvantage and rendering the system inoperative, advantage was taken of it to form a bridge composed of resistances R_1, R_2, R_3, and the impedance of the tube combined with resistance R_c. For example, R_3 may have 20 volts developed across its terminals when the system is balanced. Then, merely for analysis, we may assume that it is desired to have the grid bias of VT_1, initially set at zero. In order to overcome the 20 volts of R_3, the grid return is made to a point on R_2 substantially 20 volts positive, thus cancelling the 20 volt potential across R_3 to leave an initial zero bias for VT_1, and with everything in balance. It is of course understood that any initial bias can be given to VT_1 by selecting the point of return of the grid circuit to a position on resistance R_2.

Now with the balance established, or any selected initial grid bias setup, a strong carrier current will cause pronounced rectification and consequent increase of plate current in VT_1, say of the order of 10 per cent. The potential across R_3 will consequently rise to say some 22 volts, thus contributing 2 volts towards a negative bias on the grid in lieu of the previous zero bias. However, this is not yet the full action as there also takes place a decrease of plate current of the output tube, and since the potential across R_2 is a function of the plate current of the output tube, the differential potential developed in R_2 will be reduced. That is, where we originally had 20 volts of R_2 opposing 20 volts of R_3 to give zero bias with no incoming signal, we now have 18 volts in R_2 opposing say 22 volts in R_3 to give an effective bias of 4 volts. It is thus seen that the stabilizing arrangement of Fig. 5, including as it does a differential effect, permits of the development of most powerful stabilizing reaction to attempted drifting arising from very strong carrier currents.

While the problem of stabilizing is more than adequately solved by the stabilizing arrangement of Fig. 5 for all encounterable requirements in practical uses, it isolates the grid of VT_1 from the hum source R_1, R_2, and consequently completely eliminates the use of the Miller bridge arrangement for hum neutralization. However, because of the freedom of the direct coupled system from phasing and harmonic effects, it is admirably adapted to hum elimination by hum bucking. The arrangement of Fig. 6 shows one practice, and a very simple one, we employ most effectively for hum bucking in the presence of an extremely poor filter. It comprises merely a connection of the filament to a point of preferably variable selection on the resistance R_1 through a condenser Chb of 1/10 microfarad for example. If it were not for the variability in the commercial screen grid tubes the connection to R_1 might well be once determined and left fixed.

Fig. 6



Operational Characteristics

Almost an endless series of different characteristics and performances may be obtained from direct coupled cascaded systems, so that through choice of elements in number and character, circuit constants and potentials, the uses to which such systems may be put are manifold. In carrying out our work we have been repeatedly surprised and gratified with new and seemingly impossible results.

For example, Fig. 7 is a simple 2-tube system comprising a 224 screen grid tube as input and a 250 power amplifier as output, supplied from a single half wave 281 rectifier. The general constants are shown or later stated.

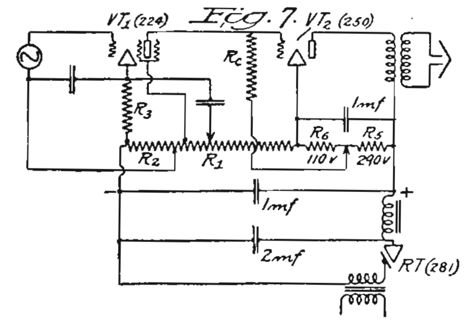
With this simple system we obtain over-all voltage amplifications ranging from 50 to a seemingly impossible 1000 through selection of constants and energizing potentials. By adding a second 224 tube to make a 3-tube system we have increased the over-all amplification to 50,000 even with a 245 power amplifier output, and know no reason why the 3-tube system cannot be worked up to a calculated over-all amplification of 250,000 with careful selection of optimum values in the case of each 224 tube, though this is a matter we have not as yet had time to practically determine.

To give a practical idea of the effectiveness of these systems, the 2-tube one gives good dynamic speaker volume on most of the New York broadcast stations at a point in the heart of the city using only antenna input, while the 3-tube one accomplishes the same result on a 3-inch coil for a number of stations. The 3-tube system, preceded by a band-pass filter, makes an extremely good broadcast receiver. In general, the 2-tube system is about 10 times as sensitive as the power detector, 1-stage audio system.

It is well to here point out that the damping of a tuned input circuit is extremely low in the direct coupled system, and more so when the screen grid type of tube is used because of elimination of the effect on the input circuit of the capacitive reactance of the output circuit. In other words, when using the system as a detector-amplifier real selectivity and resonant rise is had in the input circuit compared to other forms of detection, thus lessening the amount of tuning needed in the preceding radio frequency system. In fact, the selectivity had in the single circuit when coupled directly to an antenna is unusual.

In the case of three electrode tubes the over-all gain depends upon the mu of the tubes and the value of coupling resistance R_c, with the exception that with low values of R_c wide changes of mu do not make much difference. In going to screen grid tubes the over-all gain further depends upon plate, screen grid and grid potentials.

The two graphs of Fig. 8 show with the aid of logarithmic abscissae and linear ordinates the measured and plotted voltage gain throughout the entire audio range of the 2-tube system of Fig. 7, the system being the same for the taking of both graphs except for change in the value of coupling resistor R_c and suitable change of screen grid potential, 1/10 megohm being used in one case and ¼ megohm in the other, as indicated on the graphs. The skeleton diagram accompanying the graphs shows and states the details of the output of the system employed in measuring for these graphs. In Fig. 7

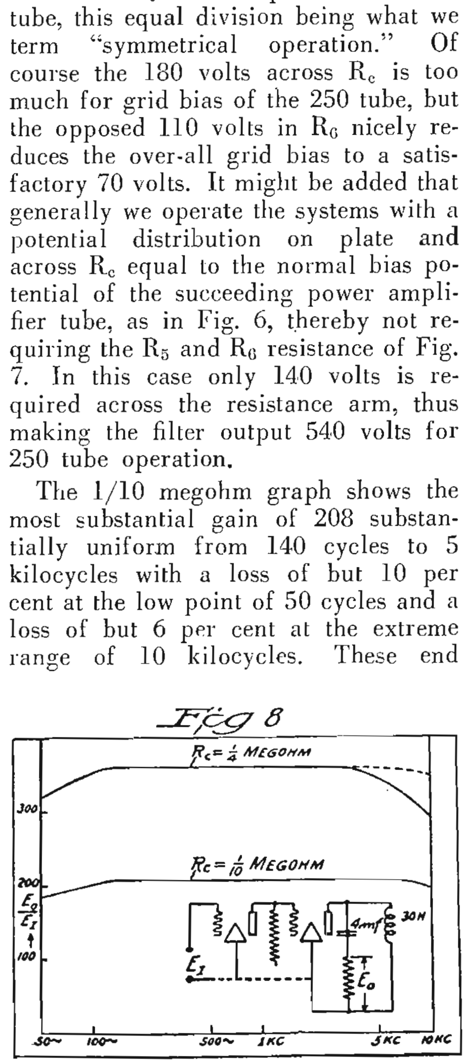


the potential developed by the filter was 650 volts at 50 milliamperes, 400 volts of this being across the 250 output tube and 250 volts across the arm R_2. Grid potential with the system at rest was about 2 volts, and screen grid potentials were 45 and 30 volts respectively. A 400 mu 224 tube was used.

In order to operate on this occasion with the high potential of 180 volts on the plate of the 224 tube, the 400 volts across the 250 tube was divided into the 110 volt and 290 volt portions by high resistances R_6 and R_5 respectively as shown, the high resistances avoiding noticeably increasing the current drain on the filter. R_c was connected at this division, thereby adding 110 volts to the 250 volts in R_2, a total of 360 volts to divide into 180 volts across coupling resistance R_c and the plate of the 224 tube, this equal division being what we term "symmetrical operation." Of course the 180 volts across R_c is too much for grid bias of the 250 tube, but the opposed 110 volts in R_6 nicely reduces the over-all grid bias to a satisfactory 70 volts. It might be added that generally we operate the systems with a potential distribution on plate and across R_c equal to the normal bias potential of the succeeding power amplifier tube, as in Fig. 6, thereby not requiring the R_5 and R_6 resistance of Fig. 7. In this case only 140 volts is required across the resistance arm, thus making the filter output 540 volts for 250 tube operation.

The 1/10 megohm graph shows the most substantial gain of 208 substantially uniform from 140 cycles to 5 kilocycles with a loss of but 10 per cent at the low point of 50 cycles and a loss of but 6 per cent at the extreme range of 10 kilocycles. These end

Fig 8



droops can in large part be accounted for in the frequency-reactance relations of the output circuit, substantiating the theroretical constancy of the direct coupled amplifier per se.

The ¼ megohm graph shows the much greater gain of 360 (80 per cent increase) substantially uniform from 140 cycles to 3 kilocycles. Like the 1/10 megohm graph, it shows a 10 per cent loss at 50 cycles, indicating that the increase of R_c has no effect on the low frequency side. However, the 10 kilocycle point shows an increase of loss to 16 per cent. This fact requires a little consideration, for it is obvious that if R_c be increased to the megohms region we frequently use the high frequency fall off may become of serious proportions.

The fall off is due to a feed-back effect. In the direct coupled system the increasing of the resistance of R_c makes the feed-back through the internal capacity of the non-screen grid output tube increasingly effective and, being a capacitively reacting plate circuit feed-back at the high frequency end for most output systems, the feed-back decreases amplification increasingly with increase of R_c. Of course, if we succeed in getting a screen grid power amplifier we need give the matter no further attention, there being none of this action in the screen grid input tube, but for the time being properly chosen but simple feed-back neutralizing easily overcomes this effect in large degree. By way of example, the dotted portion of the ¼ megohm graph shows the improvement had with a hastily adjusted neutralizer arrangement.

While we have cited some explanatory examples around a zero grid bias of the input tube, in practice we generally set an initial bias of about 2 volts to allow for the fact that the emission pressure in some tubes may be such as to start a grid current at 1 volt. In general we have the screen grid potential low, as we usually operate with but a few microamperes in the plate circuit and a too high screen grid potential will materially reduce amplification. It is also necessary to adjust the screen grid potential to operate near the mid point of its current curve, as in the case of all plate electrodes, as otherwise this additional member in the system may cause some severe unwanted rectification on its own account.

From what we have explained in connection with arrangements for drift correction in direct coupled systems it may be seen that these effects, and that of the arrangement in Figs. 5, 6, and 7 in particular, may be used to advantage in the usual detection systems, and further are capable of automatically producing large voltage differences for automatic volume control effects without the addition of an auxiliary tube. If there should be need for it, we can carry the drift correction responsiveness to such low frequency that the system can be made capable of high amplification for frequencies as low as 1 cycle. Usual audio work allows plenty of room in which to obtain drift compensation without interfering with the very lowest audio tones.

One very interesting characteristic is the ability to receive unmodulated C W signals without heterodyne for printer, tape or other relay operated recording, it being apparent that the high frequency rectifying action that carries through the system is of the square wave type and ideal for the necessary result.

The mildness of the hum difficulties is apparent from examination of the rectifier and filter system constants of Fig. 7. Here we use a single wave (281) rectifier followed by a single stage filter of 2 and 1 microfarads respectively separated by a 20 henry choke. The 2 microfarad condenser is really not used because needed for filtering, but to develop the required high potential from the 281 tube. Another high voltage 1 microfarad condenser is used in the signal circuit of the output tube. Even with this cheap and insignificant filter and half wave rectifier our hum is well within commercial estimate of what is tolerated. When it is appreciated from Fig. 8 that the gain at 60 and 120 cycles is practically the same as elsewhere, the result is really astounding.

Of course we have little or no difficulty with hum from induction, there being no effective magnetic pickup in the system, and wiring loops are easily taken care of. Even in the extremely high gain systems mentioned electrostatic shielding is all that is necessary, and we all appreciate how simple and cheap electrostatic shielding is compared to electromagnetic. Close location of parts is not at all a troublesome feature.

Reference to Fig. 7 also makes clear that there is plenty of high potential and current for energizing the tubes of a preceding frequency amplifier without increased drain on the filter, and also for energizing the field coils of dynamic speakers, the current in the arm R_1 being adequate for this. The system also lends itself to push-pull operation as two complete systems in push-pull relation, or the equivalent of simple push-pull output tubes, but in view of the extremely fine characteristics we really see no need for push-pull for the reasons it is now so generally employed. Photo-electric cell operation becomes a simple and satisfactory matter through the medium of the very high gain amplifier.

While other features of interest could be touched upon, and many of those taken up considerably amplified, the present writing is necessarily limited by space and like considerations. In general we feel that direct coupled systems offer unusual possibilities in space and cost savings, our estimate being that the present radio receivers, amplifiers and like apparatus can be reproduced with improved quality at costs well below those now existing.

Cathode Ray Tube Television

By V. Zworykin

(Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa.)

[Editor's Note. — Mr. Zworykin's paper on "Television with Cathode Ray Tube for Receiver" was presented at the Eastern Great Lakes District convention of the I. R. E. at Rochester, New York, November 18-19, 1929. The paper in full is to appear in a forthcoming issue of the Proceedings of the Institute of Radio Engineers.—Editor.]

THE problem of television has interested humanity since early times. One of the first pioneers in this field, P. Nipkow, disclosed a patent application in 1884 (P. Nipkow, English patent No. 30105, January 6, 1884), describing a mechanical scheme for television. It involved a scanning of the object and picture, for which purpose the familiar perforated disk was employed. The scanning disk is used even now, almost without alteration, in all practically developed schemes of television apparatus. However, Nipkow's ingenious invention could not materialize in his day because of the lack of powerful modern aids—the photo-cell and radio amplification. At present the rotating disk is giving excellent results within the mechanical possibilities of our time.

Proposed By Rosing

Out of a number of other methods which have been proposed for the solution of television by various inventors, the author (U. S. Patent application, March 17, 1924) has been attracted by the application of the cathode ray for scanning purposes. This method was proposed for the first time by Boris Rosing, professor of physics in Petrograd, in 1907 (English Patent No. 27270, December 13, 1907). The same reasons which handicapped Nipkow prevented Posing from achieving practical results. Later Belin and Holweck (Belin et Holweck, Bull. No. 243 de la Societe Francaise de Physique, p. 35. S, March, 1927), Douvillier (A. Douvillier, Revue General de L'Electricite p. 5. January 7, 1928) and Takayanagi (K. Takayanagi, Jour, I. E. E., Japan No. 482, pp. 932, Sept., 1928) were working in the same direction with various degrees of success, striving to develop television reception by means of cathode-ray tubes.

Has Advantages

The cathode-ray tube presents a number of distinct advantages over all other receiving devices. There is, for

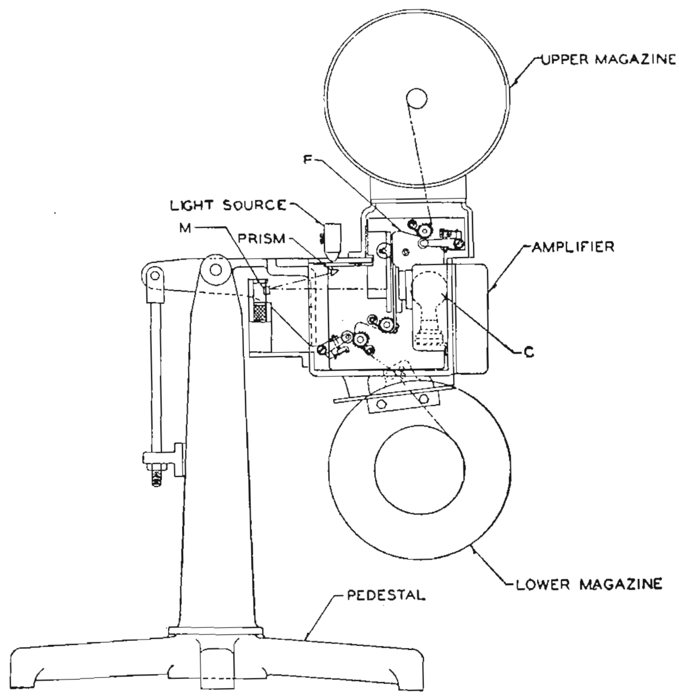


FIG. 1

Fig. 1. The construction of the transmitter is shown in Fig. 1. A light source is provided by an ordinary 6-volt automobile lamp. The light is focussed by a condensing lens L upon a diaphragm D with a small orifice. From there the beam of light emerging through the orifice is reflected upon a vibrating mirror M and focussed into a sharply defined spot on the moving film F. (See Fig. 2.)

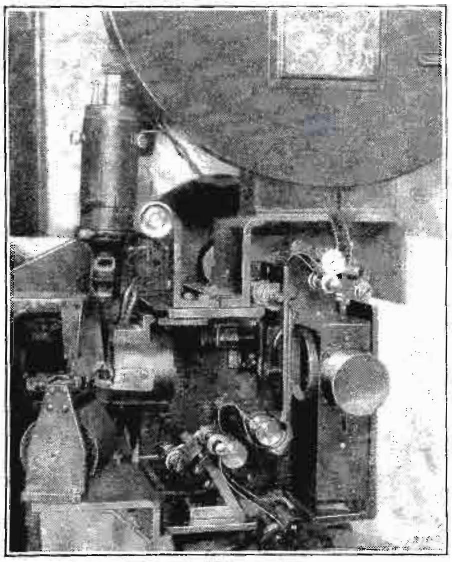


Fig. 3. The vibrating mirror is shown in the above photograph. It consists of a small steel rod with a vane placed between the poles of an electromagnet

example, an absence of moving mechanical parts with consequent noiseless operation, a simplification of synchronization permitting operation even over a single carrier channel, an ample amount of light for plain visibility of the image, and indeed quite a number of other advantages of lesser importance. One very valuable feature of the cathode-ray tube in its application to television is the persistence of fluorescence of the screen, which acts together with persistence of vision to the eye and permits reduction of the number of pictures per second without noticeable flickering. This optical phenomenon allows a greater number of lines and consequently better details of the picture without increasing the width of the frequency band.

This paper will be limited to a description of an apparatus developed in Westinghouse research laboratories for transmission by radio of moving pictures using the cathode-ray tube for reception.

In the author's opinion, if a receiver is to be developed for practical use in private homes, it should be designed without any mechanically moving parts. The operation of such a receiver should not require great mechanical skill. This does not apply to the transmitter, since there is no commercial difficulty in providing a highly trained operator for handling the transmitter at a broadcasting station.

Transmitter

The transmitter consists of a modified standard moving picture projector. The intermittent motion device, the optical system, and the light source are dismantled. The film is caused to move with a constant speed downward, this

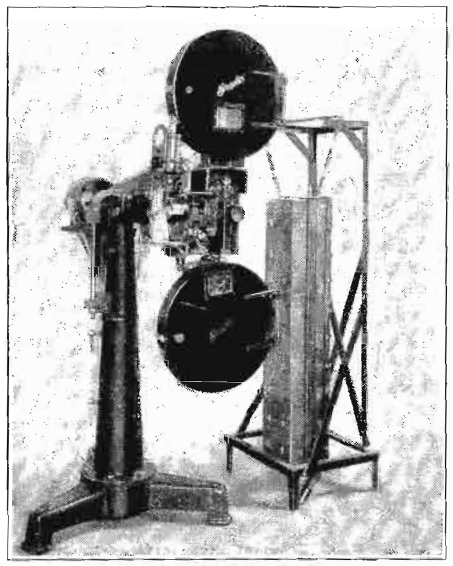


Fig. 4. A general view of the transmitter is shown in the above photograph

motion providing the vertical component of scanning.

Construction

The construction of the transmitter is shown in Fig. 1. A light source is provided by an ordinary 6-volt automobile lamp. The light is focussed by a

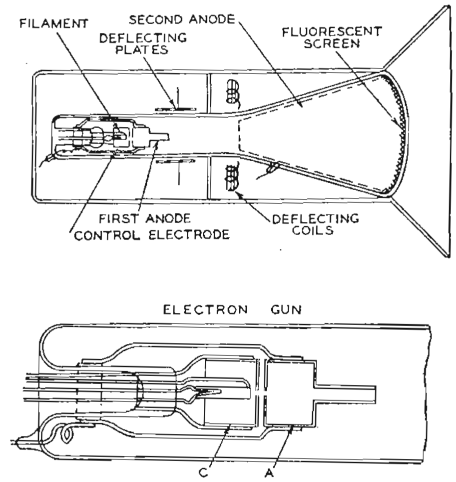


FIG. 5

Fig. 5. This diagram shows the general inside construction and function of the electron gun which is illustrated photographically in Fig. 6

condensing lens L upon a diaphragm D with a small orifice. From there the beam of light emerging through the orifice is reflected from a vibrating mirror M and focussed into a sharply defined spot on the moving film F. With the mirror vibrating at a frequency of 480 cycles about a vertical axis, the light spot sweeps the film horizontally. This vibration of the mirror combined with the downward movement of the film causes the light spot to explore the whole surface of the pictures as shown in Fig. 2. After passing the film, the light enters a photoelectric cell C which

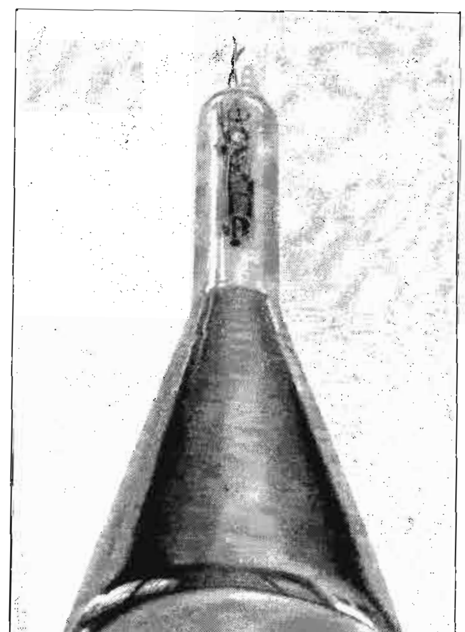


Fig. 6. The type of tube used by Mr. Zworykin in his demonstration is illustrated in this photograph

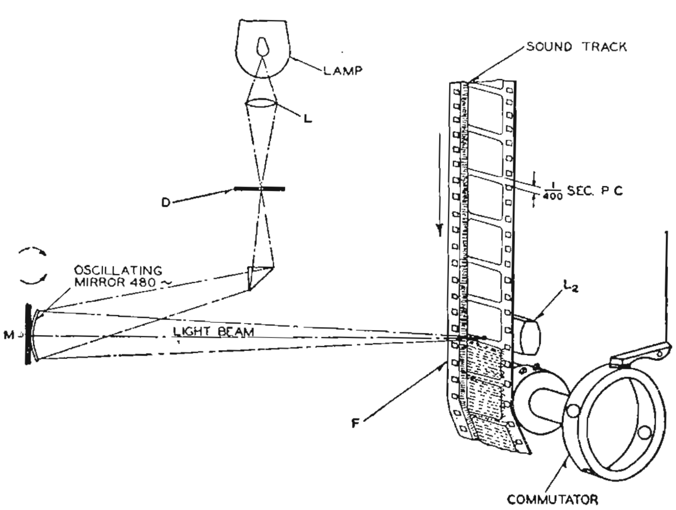


FIG. 2

Fig. 2. With the mirror M vibrating at a frequency of 480 cycles about a vertical axis the light spot sweeps the film horizontally. This vibration of the mirror combined with the downward movement of the film causes the light spot to explore the whole surface of the pictures

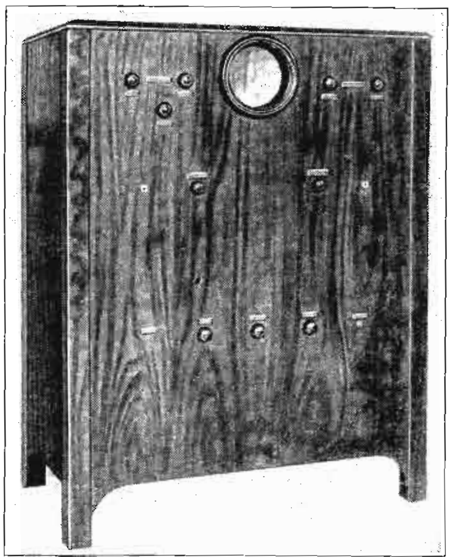


Fig. 7. This photograph shows one type of the receiver used in the test

transforms the variations of optical density in the film into a variable electric current.

The vibrating mirror is shown in Fig. 3. It consists of a small steel rod with a vane placed between the poles of an electromagnet. The poles are U-shaped and each leg is provided with a coil. An oscillating current of the same frequency as the natural frequency of the rod is supplied to the coils, thus causing the rod and the mirror to oscillate about the axis of the rod. In order not to depend upon the uniformity of sensitivity over the cathode area of the photo-cell, an additional lens L_2 is provided between the film and photo-cell. This lens is so situated that the mirror and sensitive surface are at conjugate foci. Thus the scanning beam is always focussed upon a stationary spot in the cell.

From the facts that the horizontal scanning is produced by a sinusoidal current, it follows that the velocity of the beam across the picture is not uniform. The velocity in the center is about 57 per cent higher than that of a spot scanning at uniform rate a picture the same width. Before work was started on the machine, it was anticipated that this feature would be found objectionable and correction by optical filter was planned. Practical tests, however, indicate that the non-uniform distribution of light across the picture is not readily apparent to the eye, and therefore no precautions are now used. A general view of the transmitter is shown in Fig. 4.

Receiver

The receiver consists of a cathode-ray tube especially designed for this purpose. The principles of the cathode-ray tube are well-known from their application for oscillographs. In their ordinary form, however, they cannot be used for picture reception, because although they have scanning arrangement in two dimensions they do not have means for varying the intensity of the picture. Moreover, neither of the main types of oscillograph is suited for television purposes. The high potential type, which would give a sufficiently brilliant spot, is always operated in connection with a vacuum pump. Such a pump is impractical for a home television receiver. The low potential type of cathode-ray oscillograph is of the sealed-off type but the amount of light available from the screen is far too small. In order to give sufficient briliancy for the picture of 5 in. size, the tube should operate at least at 3000 volts. For larger pictures still higher voltage is required, since the brightness increases with the accelerating voltage. According to these requirements, a new type of cathode-ray tube was developed. This is shown in Figs. 5 and 6. An oxide-coated filament is mounted within a controlling electrode C. The cathode beam passes through a small hole in the front part of the controlling element and then again through a hole in the first anode A. The first anode accelerates the electrons to a velocity of 300 to 400 volts. There is also a second anode consisting of a metallic coating on the inside of the glass bulb. This second anode gives to the electrons a further acceleration up to 3000 or 4000 volts. The velocity of the electrons at this voltage is about one-tenth that of

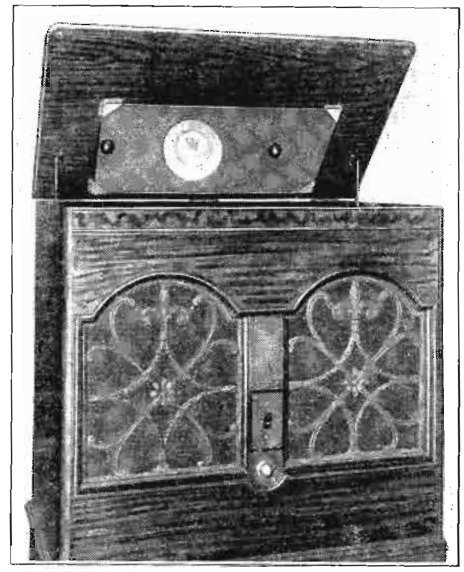


Fig. 8. Another type of receiver more suitable for the home is shown in this photograph

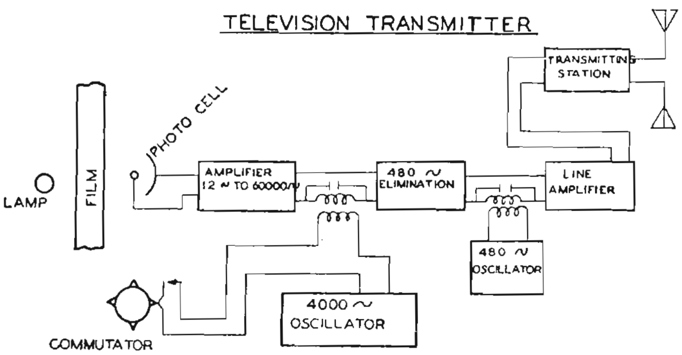


FIG. 9

Fig. 9. This drawing illustrates in a simple manner the general idea back of the television transmitter described in this article

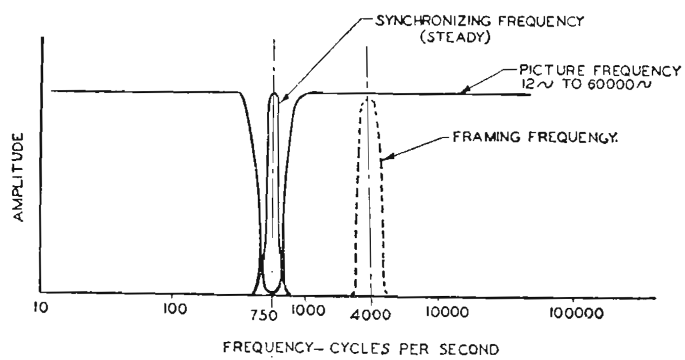


FIG. 10

Fig. 10. The picture frequency together with a framing frequency is passed through a band eliminating filter which removes the picture component of the same frequency as that of the horizontal scanning

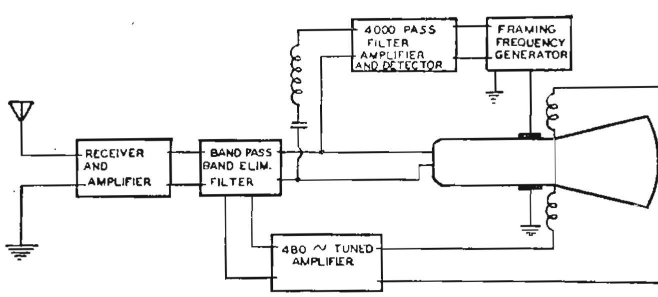


FIG. 11

Fig. 11. At the receiving station the output of a local radio receiver is amplified and divided by a band pass band elimination filter into two parts, one the synchronizing frequency, and the other the picture frequency plus the framing frequency.

light. An important function of this second anode is also to focus electrostatically the beam into a sharp spot on the screen. The target wall of the bulb is about 7 in. in diameter and is covered with a fluorescent material such as willemite prepared by a special process so as to make it slightly conductive. Conductivity is required to remove the electrical charges from the screen supplied by the electron beam. This tube will be referred to hereafter in this paper as the kinescope.

Moving the Beam

The beam of electrons can easily be moved across the screen either by an electrostatic or an electromagnetic field, leaving a bright fluorescent line as it passes. For this purpose a set of deflecting plates and a set of deflecting coils are mounted on the neck of the kinescope, outside the tube. The plates and coils are adjusted in the same plane, so as to give vertical and horizontal deflection at right angles to each other. As a result of the location of the deflecting elements between first and second anode, the deflecting field is acting on comparatively slowly moving electrons. Hence the field strength required is much less than that which would ordinarily be used to deflect the beam under the full acceleration of the second anode voltage.

The brightness of the line can be controlled to any desired extent by a negative bias on the controlling element. The bias controls the mean intensity of the picture whose lights and shadows are super-imposed upon this mean intensity. It is evident that if we apply to this controlling electrode the amplified impulses from the transmitter and at the same time deflect the beam in synchronism with the motion of the light beam across the picture on the film, the picture will be reproduced on the fluorescent screen. Figs. 7 and 8 show a general view of two types of receivers.

Synchronization

If separate channels are available for each of the synchronizing signals, the problem of synchronization of the receiver with the transmitter is very simple. For horizontal scanning, it is necessary only to transmit the scanning frequency operating the mirror as a sinusoidal voltage and to impress it on the deflecting coils of the kinescope. The cathode beam will follow exactly the movement of the light beam across the film.

For the framing or picture frequency, a voltage is generated at the receiving end and merely controlled by signals from the transmitter. A condenser is charged at constant current through a current limiting device, such as a two-electrode tube, so that the voltage at the condenser rises linearly. The deflecting plates of the kinescope are connected in parallel to this condenser, and therefore, when the condenser is charging, this cathode beam is deflected gradually from the bottom to the top of the fluorescent screen at a constant speed. This speed is regulated by the temperature of the filament of the charging tube to duplicate the downward movement of the film. An impulse is sent from the transmitter between pictures, which discharges the condenser, quickly returning the beam to the bottom position, ready to start upward and reproduce the next picture.

For transmission of the complete picture, three sets of signals are therefore required: picture signals, horizontal scanning frequency, and impulses for framing. It was found that it is possible to combine all of these sets of signals into one channel. In this case the photo-cell voltage of the transmitter is first amplified to a level sufficiently high for transmission. There is then superimposed upon this a series of high audio-frequency impulses lasting a few cycles only and occurring when the light beam passes the interval between the pictures. (Fig. 9.)

Transmitted Signal

The picture frequencies together with the framing frequencies are then passed through a band eliminating filter, which removes the picture component of the same frequency as that of horizontal scanning. Following this, a portion of the voltage which drives the transmitter vibrator is impressed upon the signals, passed through the filter, and the entire spectrum is used to modulate the radio-frequency carrier. (Fig. 10.)

At the receiving station the output of the local radio receiver is amplified and divided by a band-pass band-elimination filter into two parts; one the synchronizing frequency, and the second the picture frequency plus the framing frequency. The synchronizing frequency is amplified by a tuned amplifier which supplies current to the deflecting coils of the kinescope. (Fig. 11.)

The picture and framing frequencies are applied directly to the control electrode of the kinescope.

The same voltage which modulates the light is impressed upon a band-pass filter, which is tuned to the frequency of the a. c. voltage used for the framing impulses. The output of this filter is amplified, rectified, and used to unbias a discharging triode which is normally biased to zero plate current, and which takes its plate voltage from the condenser which provides the vertical scanning voltage.

Thus, the picture signals and both synchronizing and framing frequencies are transmitted on one channel, and fully automatic synchronization is obtained.

The amplification problem in this case does not differ from that of the amplifier for mechanical television of the same picture frequency. The frequency band for which the amplifier should be constructed is much lower for the same number of lines due to the smaller number of pictures per second.

Conclusion

Those who are accustomed to the conventional scanning disk type of television notice a number of differences in the appearance of the picture as viewed on the end of the cathode-ray tube. The picture is green, rather than red (as when a neon glow tube is used). It is visible to a large number of people at once, for an enlargement by means of lenses is unneccssary. There are no moving parts, consequently no noise. The framing of the picture is automatic; and it is brilliant enough to be seen in a moderately lighted room.

Technically, the kinescope type of receiver presents added advantages. The high-frequency motor for synchronization, together with its power amplifier, is not required. The power required to operate the grid of a kinescope is no more than that for an ordinary vacuum tube.

Instruments for Production Testing Work

By P. MacGahn

Meter Engineering Department, Westinghouse Electric and Mfg. Co.

THE manufacture of electrical apparatus and in fact manufacturing processes in general carried out on a production basis often involved the necessity for accurate measurements of the electrical quantities.

An example of this is the manufacture of radio vacuum tubes of different kinds.

The accuracy required for such measurements is in general much higher than that obtainable with ordinary panel or switchboard type instruments. For example it is well known that a slight error in the setting of the grid voltage in the testing of radio tubes

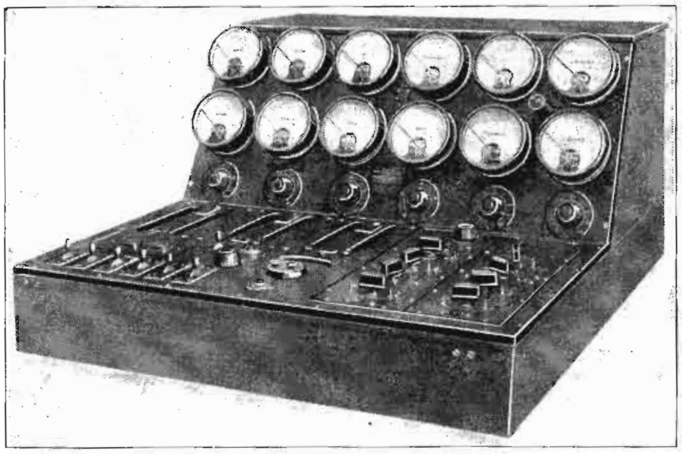


Fig. 1. Radio tube test bench showing instruments mounted on vertical panel at the rear of the bench

will result in a very large difference in the plate current. Therefore if sufficiently close test limits are set on plate currents to assure in this respect a satisfactory tube characteristic many good tubes will be rejected in testing and many defective tubes will be accepted due to lack of sufficient instrument accuracy. Similarly a higher order of accuracy is needed for many of the other production measurements in many manufacturing processes aside from radio tubes.

Switchboard instruments are not primarily intended for close measurement work. Their principal field of application is for operating or control. The pointers are furnished with large index ends to facilitate reading at a distance and for the same reasons the division lines are made very heavy. The calibration accuracy of switchboard instruments is generally of the order of 1 to 3 per cent allowable error. Many of the smaller types of switchboard instruments are furnished with etched printed dials resulting in variable accuracy at different scale points.

The accuracy considered essential and acceptable for switchboard instruments can be obtained without exceptional care in balancing the movement. The design of the bearings, pointers, and other parts are intended to withstand the overloads and rough usage of operating or control work rather than carrying the delicacy required for high accuracy work.

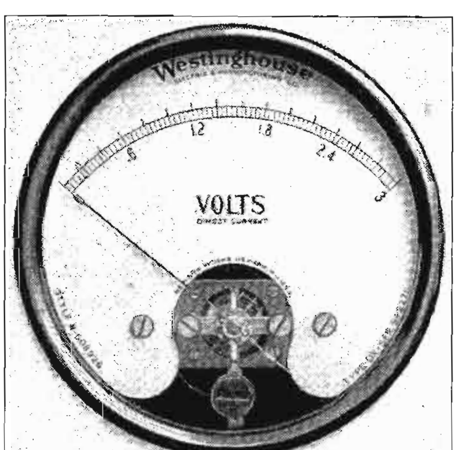


Fig. 3. New Westinghouse panel standard d-c. voltmeter

Designed for Accuracy

Portable instruments, however, are designed for use where greater accuracy is required. The preferable position for the use of portable instruments is horizontal and this involves practical difficulties in their application to permanent testing benches designed for speedy production testing such as in radio tubes or similar modern manufacture. It is generally the practice to mount the test sockets on the top surface of the test bench together with the switches and other controls and mount the test instruments on vertical panels at the rear of the bench in a position easily read by the operator making a self-contained outfit. This enables quick readings to be taken.

Figure 1 shows a bench of this character. Typical circuit connections are shown in Fig. 2 as intended for testing 1½ volt amplifier tubes.

With large production it is desirable to specialize the test positions or benches for testing of each piece of apparatus only, therefore simplifying the connections and controls and avoiding multi-range scales on the instruments. This means that in any manufacturing plant there will be many different test outfits as there are different varieties of apparatus to be tested.

Unfortunately in the past there has been as indicated above, a conflict between such test requirements and the use of switchboard type instruments which do not have sufficient accuracy for test purposes.

In order to provide a line of instruments especially intended for this class of service instrument engineers have carefully studied the problems of testing measurements in production for large quantity production work as regards measuring instruments and this has resulted in the design of the so-called "panel standard instruments." These were originally intended for mass production work on vacuum tubes but are of course equally applicable to all kinds of manufacture where quick high accuracy inspection readings or tests are necessary.

Briefly the "panel standard instruments" consist of the combination of a panel or switchboard type case and mounting into which are placed high-accuracy portable instrument mechanisms. The dial markings are hand calibrated of the fine line type enabling close readings to be taken and the calibration is performed with the same painstaking care and by the same experts that perform the calibration on the high grade portable instruments.

Therefore these instruments possess so far as possible the accuracy and qualifications of the corresponding portable types. The reservation "as far as possible" in the above statement is introduced because due to the horizontal position of the pivot in the bearings of panel mounted instruments there must of necessity be somewhat more pivot friction than in the bearings of portable instruments which are normally vertical in position. This is due to the fact that with a vertical shaft arrangement the contact between the pivot and the jewel is at the center line of the pivot, and therefore the friction works at a much shorter radius than in the case of the horizontal shaft. In horizontal shafts the end play requirement is such that the contact point between the pivot and the jewel is at the side of the pivot and therefore at a point where the effective radius is greater. Consequently, there is more friction effect.

Figures 3 and 4 clearly show the scales and pointers in two of these panel standard instruments. The scales are almost 4 in. long and very clearly divided. The cases however are only 4⅜ in. in diameter and therefore the instruments are very compact indeed taking up the least possible space on the panel. The cases are made of heavy, soft-drawn steel, which shields the movement from external magnetic fields. A large amount of experience particularly in actual production of radio tubes has shown that this size of instrument is the

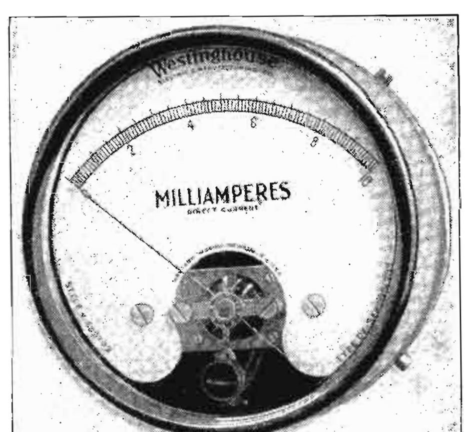


Fig. 4. New Westinghouse panel standard milliameter, three quarters view

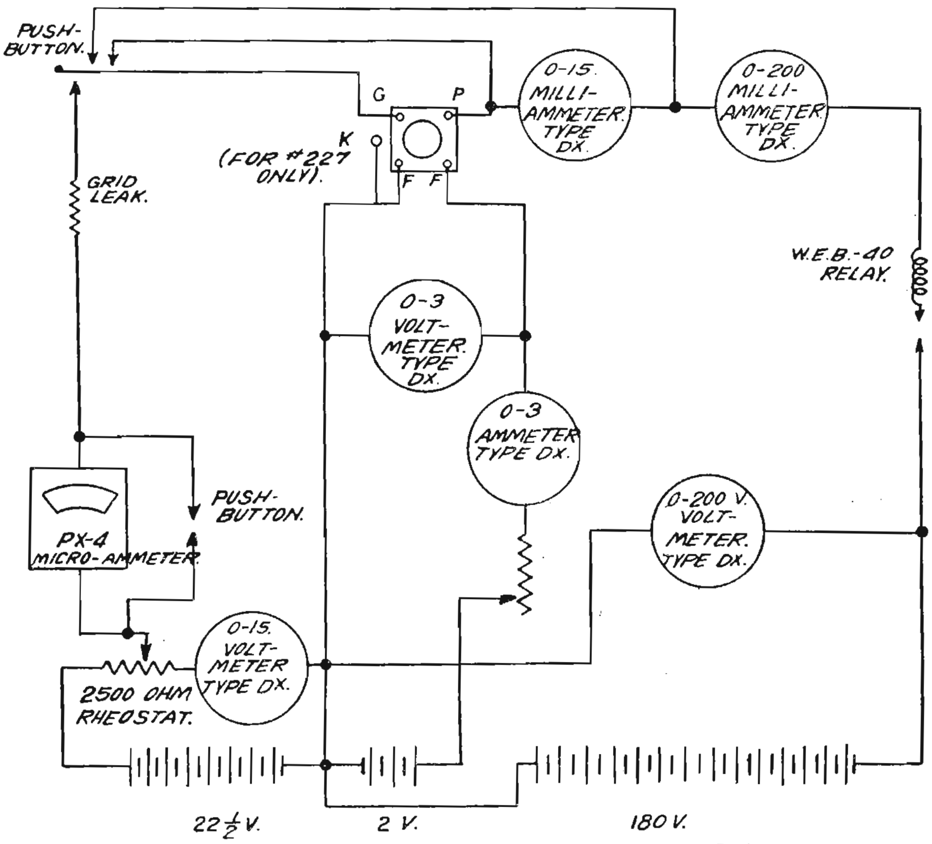


Fig. 2. Typical test bench circuit connections for testing 1½ volt. a-c. amplifier tubes

best suited for general production testing purposes.

The scales are long enough to make accurate readings on the lower parts which is often necessary and yet the pointers are not too long which would cause instability or variations in balancing due to moisture or other causes.

The happy combination of portable instrument movements and scales with switchboard cases and mountings is thought to be entirely novel and should find a large application in all kinds of testing work where the otherwise preferable horizontal position of portable instruments cannot be employed.

The general designation of "panel standard instruments" has been chosen as being both descriptive of this new type distinguishing it from "portable standard instruments" and also from the usual switchboard or panel instruments.

MANY requests have come into this department for information on specifications of the various dynamic speakers. In the notes following are given as many specifications as could be secured from the various manufacturers represented. The material given herewith may therefore answer a number of the questions from our readers.

Best

Best Mfg. Company, 1200 Grove St., Irvington, N. J., advises it is their practice to furnish their standard models equipped with an impedance coupling transformer of either 500 or 4000 ohms output and requests that the transformer be specified. We are also advised that the impedance of the moving coil is .07 ohms and the power delivered to the field coil is at the rate of 27 watts.

Magnavox

Information from the Magnavox Company, Oakland, Calif., states the primary impedance of the stock model input transformer used by Magnavox is close to 6000 ohms at 400 cycles. They have but one standard transformer which is applicable to either 171, 245 or 250 tubes, either singly or in push-pull. Specifications of the transformer referred to are: primary 3000 turns No. 34 enamel copper wire, center tapped. Secondary 85 turns No. 22 enamel copper wire. Core ⅞ by ⅞ center section 3 per cent silicon steel. All models carry the same movable coil, namely 92 turns of No. 32 enamel copper wire with a d. c. resistance of 5.3 ohms. The output ratio of the transformer referred to is 35 to 1.

On Models 100, 101, 106, 107, the resistance of the field coil is 2000 ohms, on models 104, 105, 108, 109, it is 7500 ohms. On models 200 and 201 the ohmic resistance is 8.5 ohms while on models 400 and 401 the resistance is 5.4 ohms.

Utah

According to information received from the Utah Radio Products Co., Michigan Ave. at 18th St., Chicago, Ill., the speakers which they supply to the jobbing trade are equipped with transformers having an impedance of approximately 5500 ohms at 60 cycles. The push-pull transformer which they supply on order is made especially for two 245 tubes in push-pull. It operates about equally well on 210 or 250 tubes.

Jensen

From the Jensen Radio Mfg. Co., 5601 S. Laramie Ave., Chicago, Ill., we learn the primary impedance of their standard input transformer is 6000 ohms. This transformer has a primary of 2640 turns of No. 36, secondary coil 120 turns of No. 22. The d. c. resistance of the voice coil is 10½ ohms. The a. c. impedance of the voice coil is 15 ohms at 1000 cycles. The voice coil is wound with 100 turns of No. 32 aluminum wire.

Miles

Data received from the Miles Mfg. Corp., 31 W. 21st St., New York, manufacturers of dynamic units and theatrical horns, states that on the M-100 d. c. model the primary impedance is 3800-4000 ohms. The secondary impedance is 12 ohms at 60 cycles. Secondary d. c. resistance is 7 ohms for the voice coil. Field current is 1.2 amps. at 7 volts and 1.4 amps. at 8 volts.

Transformer Corp.

No stock models are made by the Transformer Corp. of America, 2301 S. Keeler Ave., Chicago, Ill. This company advises us that all of their products are made directly to manufacturers specifications.

Wright-DeCoster

Specifications on the model 107 Wright-DeCoster reproducer made by the Wright-DeCoster, Inc., manufacturers, at St. Paul, Minn., are as follow: field wire size No. 24, field current .17 amps., field resistance 340 ohms, voltage field and choke 75, voltage field 55, ampere current 2900, flux density 125, music and voice cone impedance 9 ohms, voice only cone impedance 12 ohms, input transformer primary impedance 4000 ohms, input transformer turns ratio 17-1, bucking coil impedance 1.5 ohms, filter choke 5 Hys., filter condenser 2 mfd.

Operadio

Information covering the dynamics made by the Operadio Mfg. Co., St. Charles, Ill., is given here: Model 106 works direct to the voice coil which has an effective impedance of 5 to 7 ohms. Model 1106 works out of a 171-A, 245 or 250 tube in push-pull and can be used as the output transformer if desired. Model 2106 operates on a high impedance output type 171-A, 245 or 250 tubes singly or in push-pull. Model

3106 works out of a type 210 tube in push-pull arrangement, and can be used as the output transformer of such tube. Model 13106 works out of a high impedance output from a type 210 tube either singly or in push-pull. Model 5106 works out of an amplifier or radio set which has a low impedance output designed to work in to a standard 15 ohm dynamic speaker voice coil. The speakers referred to in the preceding paragraph all have 2500 ohm fields and are of d. c. type.

For operation 110 volt 50 to 60 cycle a. c. model 306 works direct to the voice coil which has an effective impedance of 5 to 7 ohms. Model 2306 operates on a high impedance output from 171-A, 245 or 250 tubes used singly or in push-pull.

Valley

Practically all of the business of Valley Appliances, Inc., electrical equipment, Rochester, N. Y., is done with manufacturers of sets. Therefore, they adapt the Valley speaker according to the output characteristics of the receiver for which the speaker is specified.

Farrand

From the Farrand Mfg. Co., Inc., Long Island City, N. Y., we learn the impedance of their push-pull transformer in the dynamic speakers is 8000 ohms, single tube input in transformers 4000 ohms. The bobbin inductance of their Green Inductor dynamic speaker is 7550 ohms, while the Red is 17,500 ohms at 1000 cycles.

Interesting Developments

[Engineers and others desiring full information on the items presented in this column may secure it by writing to Radio Engineering Section, care of this magazine.—Editor.]

Colonial Radio hangs its dynamic face downward under the chassis, economizing on console or cabinet space.

Pacent announces a combination switch and volume control for pick-up operation, enabling the user to turn instantly from radio to record without disturbing any connections. When the arrow points to position marked "radio" the phonograph is disconnected and ready to play. The first movement, clockwise, connects the phonograph and volume is increased as the knob is further turned.

Sabinite, named after Dr. Paul Sabine of the Riverbank Laboratories, may be used to plaster the walls of a radio studio. This material absorbs sound, preventing reverberation and insuring the program will go on the air exactly as performed. Its use also permits a more beautiful type of studio decoration.

Unusual precautions against over-emphasized notes of the cabinet resonant frequency have been observed by Fada in their console model where a slotted receiver shelf, open back, vented floors, solid braced cabinet construction, celotex baffle, large speaker grille and shock mounting of the speaker is observed.

An old principle in snap fasteners is now being employed in the construction of a new and better radio socket made by a mid-western manufacturer. It is known as the Cinch socket.

Departing from the usual custom of having a permanently lighted dial on the radio set, the Edison model is using the scheme of having the dial light flash only when the receiver is tuned to a station. The user logs his set in the beginning and then as each position is reached the light will flash. In between the logged positions the dial will not be illuminated.

The bother of having to set the tone arm at a prescribed position for automatically stopping the turntable motor when the end of a record has been reached, has been eliminated in the Oro-tone pick-up supporting arm equipped with a new automatic non-set stop for all standard phonograph records. The stop referred to is so designed as to be built into the base of the arm and in line with the needle to cut off the motor when the needle reaches the central area of the record. By incorporating the stop in the arm it eliminates the former type of stop and switch from the top of the motor-board, increasing neatness of appearance of assembly. The construction of the stop is such that when the needle moves on the central circle it cuts off the current from the motor and stops the revolving of the turntable. When the arm is lifted back to the starting position and clear of the record, the current is automatically switched on and the machine is again in full operation.

Radio, phonograph, dynamic speaker and console, all in one and at a low price is observed as one of the Sentinel offerings this season. This probably indicates a trend on the part of manufacturers to take advantage of the public desire for a combination radio phonograph arrangement at a moderate price.

A firm of Chicago broadcast station consulting engineers has been having exceptional success with the employment of condenser microphones. This type is quite superior to the carbon.

Radio has now reached the stage where it may be coin operated satisfactorily, judging from the recent entry of the Mills Novelty Co. in the radio field. A coin operated receiver and radio-phono combination is being manufactured for commercial use in hotels, clubs, etc.

Fabric diaphragms for dynamic speakers seem to be gaining in popularity. According to a recent report from Stevens, 650,000 of these Burtex diaphragms have been delivered so far to manufacturers of the Victor radio and talking machine products.

Utah is using a full wave high voltage contact rectifier instead of the tube rectifier in their model 66-A dynamic. The contact rectifier is directly across the 110 volt a. c. and eliminates the stepdown transformer usually employed.

Janette is now marketing a 32 volt rotary converter enabling the radio dealer to take advantage of farm sections where 32 volt d. c. lighting plants are operated. A filter is provided for cutting out d. c. hum and the unit is equipped with starter and voltage regulator. This should open up additional sales on farms where modern a. c. sets can now be employed with such a converter.

Shakeproof washers have made quite a headway in the radio industry if we are to consider statements made by service men working on factory sets. In the early days quite frequent cause of trouble was a connection working loose under a screw head. With the present type of washers this cause of dissatisfaction has been removed. It is interesting to note that the washers themselves are furnished in two styles, one with internal teeth and the other with external teeth. In addition the soldering terminal is also equipped with teeth.

Stevens announces a new portable electric phonograph driven by motor with step-down transformer and rectifier, operating directly from the a. c. line. A feature is a small battery compartment. When the portable is used where no a. c. is available, a small switch disconnects the a. c. rectifier and substitutes the battery.

Radio Fundamentals Applied to Wires in Carrier Current Work

(*Continued from page* 49)

created a demand for more telephone circuits between Washington and Pittsburgh. It was decided to meet this demand by a trial installation of carrier telephone system between Pittsburgh and Baltimore, from which point cable circuits to Washington were available. In view of the urgency of the situation, the apparatus used in the earlier field experiments was adapated to equip the Pittsburgh terminal, while new apparatus was built for the Baltimore terminal. This carrier system went into service and has since been operating satisfactorily.

Principles of Operation

General. An adequate understanding of carrier systems requires a consideration in some detail of the fundamental principles underlying their operation. Some of these principles, which are also important in connection with radio telephony, have already been discussed in previous articles. Emphasis will therefore be placed on those features which pertain more strictly to carrier operation.

The underlying principles of carrier will be described in their application to carrier telephony. Their application to the somewhat different conditions of carrier telegraphy will be treated separately in a later section.

We will first discuss the features which are involved in a single one-way carrier telephone transmission channel, including generation of carrier current, modulation and demodulation or detection. Next will be considered multiplex operation in a single direction, involving separation of channels by selective circuits, followed by a consideration of two-way operation of single and multiplex channels. Next will be presented an explanation of another type of system in which no modulated carrier current is transmitted over the line and of a special mode of carrier current generation particularly adapted to this system. Finally the repeaters used for amplifying the currents of carrier frequency at intermediate points, and certain other matters such as ringing and the assignment of carrier frequencies will be discussed.

Fig. 8 shows schematically the circuits involved in a single one-way channel. The source of carrier frequency shown in a vacuum-tube "oscillator."

Modulation. The process by which the carrier current produced by the oscillator is so combined with the voice currents from the telephone transmitter, that the variations of the latter are impressed upon the former, is known as "modulation," and the tube circuit in which this is accomplished is known as the "modulator."

It will be noted in the circuit shown that the potentials of carrier and voice frequencies are applied in series in the grid circuit of the modulating tube together with a steady voltage from a battery. Owing to the non-linear relation, which exists between the plate current and grid voltage, the output current of the tube is not simply a reproduction of the alternating voltages applied to the grid. In fact, the modulating properties of the tubes result from the interactions between applied voltages which this non-linear relation introduces. The subject of modulation and the action of a modulating vacuum tube has already been thoroughly covered in previous articles and will not be dealt with further at this time.

It has been determined that speech of satisfactory commercial quality in telephony may be secured if the circuit is capable of transmitting all sustained alternating currents whose frequencies lie, let us say, between 200 and 2,000 cycles per second. These limits having been determined, the apparatus may then be designed on the basis of its meeting these requirements as to the transmission of sustained single frequencies.

The information accumulated at voice frequencies can be applied directly to the solution of the carrier current problem and incidentally to radio telephony, provided we know what component frequencies are present in the modulated carrier wave and what relations exist between these components and the component frequencies of the modulating or voice wave.

Demodulation. By the term "demodulation" is meant the process of reproducing the original low-frequency modulating wave from the carrier wave upon which it has been impressed. Various methods of accomplishing this result have been known for many years, such as the use of the electrolytic detector of Pupin or of a crystal detectors of various form. All of these operate by virtue of their non-linear current-voltage characteristics. The instrument which has, however, come to be employed almost exclusively for this purpose is the three-element vacuum tube, and the following discussion presupposes its use.

For a concrete example of the use of the vacuum tube as a demodulator, reference may be made to Fig. 8, above, where at the receiving station a modulated wave is shown applied to the input circuit of a vacuum tube. This figure also shows a low-frequency amplifier in the output circuit of the demodulating tube. Because of the bearing of demodulation on the transmission requirements of the system as a whole, we will discuss this matter at some length.

The operation of the demodulating tube is exactly similar to that of the modulating tube, in that if voltages of two different frequencies are applied to its input circuit, there appears in its output circuit, a complex current wave. When the output current wave is resolved into its components, we find currents identical with the two frequencies which had been applied to the input, one component whose frequency is the sum of the applied frequencies, one component whose frequency is the difference frequencies. The amplitudes of the two currents whose frequencies are the sum and difference of the applied frequencies are proportional to the product of the amplitudes of the applied voltages. When, therefore, the received modulated wave is applied to the demodulating tube, we may determine the frequencies and relative amplitudes of the components of voice frequency in the output circuit of the demodulator by considering the interaction of the various pair of frequencies in the modulated wave.

Obviously frequencies in the voice range can occur in the demodulator output circuit only as the difference of two components of the modulated wave. If we subtract the carrier frequency from any component of the upper side band, the result is the original speech frequency which produced that component. The interaction of the carrier and the entire upper side band therefore reproduces all the components of the voice wave with their relative amplitudes, since the amplitudes of the side band components are proportional to those of the original voice components, and that of the carrier is the same for all of them. The reproduction of the original voice wave also results from the interaction of the carrier with the lower side band.

It is evident that since speech can be reproduced from either side band alone, there is no necessity for transmitting both. Accordingly, the selective circuits to be described later can be so designed as to transmit only one side band. At this effectively halves the range of frequencies assigned to each channel, its great importance is at once obvious.

It is necessary to consider the interactions between the frequency components of the side band itself, for if, in the case of telephony, the voice wave includes components of more than one frequency, each will be represented by a corresponding component in the side band. The interaction of two of these component frequencies, simultaneously present in the side band, gives rise to a component in the output circuit of the demodulator, the frequency of which is the difference between those of the corresponding two components of the original voice wave. Such currents will have a serious effect on the quality of the reproduced speech, if their amplitude is comparable with that of the reproduced voice currents. The amplitude of this distorting component is proportional to the product of the amplitudes of the two side band components, whereas the amplitude of each of the two components of the desired voice current is proportional to the product of the amplitudes of its corresponding side band component and the carrier. The reproduced voice current can be made large compared with the distorting current only by insuring that the carrier is large compared with the component of the side band. As a result of this, it follows that in order to secure good quality it is necessary that the greater portion of the energy applied to the demodulator consist of unmodulated carrier frequency.

The behavior of the receiving apparatus—that is, the demodulating tube—to interfering currents, such as may be produced by induction from external sources of electrical energy, so-called static interference, etc., can be directly deduced from the above consideration. With properly designed selective circuits only those line currents whose frequencies lie in the range of the side band being transmitted can reach the demodulator. These can produce noise of voice frequency either by interaction with the currents normally associated with that channel or by interaction with each other. Unless the interfering currents are of greater amplitude than the carrier current, in which case commercial operation is impossible, the noise components of the greatest amplitude result from the interaction of the interfering currents with the carrier current. The noise current in the output circuit therefore bears the same ratio to the reproduced voice current as the interfering line current does to the side band current. It follows, therefore, that in designing a system it is the side band current, in which are preserved the characteristics of the speech, which must at all points along the line be kept large compared with the extraneous disturbing currents lying within its range of frequency. This consideration has a very important bearing on the electrical design of apparatus operating on the carrier principle, whether dealing with wire or radio transmission.

While our discussion of modulation and demodulation has been made as concise as possible, it is evident from the foregoing that these two are complementary processes. Modulation may be thought of as elevating the band of essential speech frequencies to a position adjacent to the carrier frequency, and demodulation may be regarded as the process of restoring this band to its normal position in the frequency scale.

Selection—Electrical Filters

When a number of one-way channels, of the type schematically shown in Fig. 8, each employing a different carrier frequency, are operated by superposition on a common line, each channel must be connected with the line through selective circuits which transmit only the range of frequency assigned to that particular channel. Not only must the demodulator assigned to a given channel be prevented from receiving the line currents of other channels, but the sending modulator must be prevented from putting onto the line currents of frequencies outside of its assigned band. The general position of the selective circuits in such a one-way multiplex system is indicated in Fig. 9.

As will be brought out later in the discussion of the behavior of lines with respect to their transmission efficiency at carrier frequencies and with respect to cross-talk between adjacent circuits on a pole line, the most desirable frequency range is rather limited. For this reason, where it is proposed to secure a maximum number of channels simultaneously operating on a given circuit it is necessary to make the frequency interval between the adjacent carrier channels as small as pos-

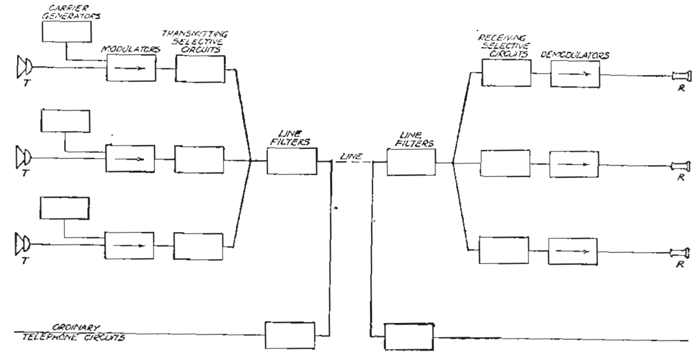


FIG 9

sible. The first limitation to the frequency separation between carrier frequencies is determined by the fact that, as has already been pointed out, the width of the side band must correspond to the voice frequency range; that is, even with idea apparatus the carrier frequencies must have at least a separation of approximately 2,000 cycles per second. The ideal selective circuit which would permit this close spacing of frequencies is one which would transmit efficiently this side band, having a frequency range of 2,000 cycles and would absolutely block off frequencies outside of this band. Because it is not physically possible to secure such ideal circuits, we are obliged to make a greater separation in carrier frequencies than that made necessary by the width of the side band.

The nearest approach to this ideal selective circuit particularly for carrier operation at moderate frequencies, is secured by the use of what has come to be known as an "electrical filter." This arrangement was invented and thoroughly studied by Dr. G. A. Campbell even before practical carrier operation was made possible by the perfecting of vacuum tubes and the development of their use as oscillators, modulators and demodulators. Campbell's electrical filter is a network composed of inductances and capacities which transmits with a minimum of attenuation currents whose frequencies lie in a predetermined range and attenuates very greatly currents whose frequencies lie outside that range. While these filters may take a variety of forms to meet special needs, they are all alike in that the currents traverse a succession of meshes or "sections," the attenuation effects of which are cumulative. The discrimination against the frequencies which it is desired to exclude may be increased to any physical practical value by increasing the number of sections.

Fig. 10 shows a type of filter which has been used to great advantage in carrier telephony. As this filter transmits a band of frequencies, it has, for convenience, been termed a "band-pass" filter. The transmission characteristics of this filter are also shown in Fig. 10, where the attenuation introduced into a circuit by the insertion of this filter is plotted against the frequency of the applied current. The attenuation is expressed in miles of standard cable. For the convenience also of those not familiar with this usage there is shown at the right

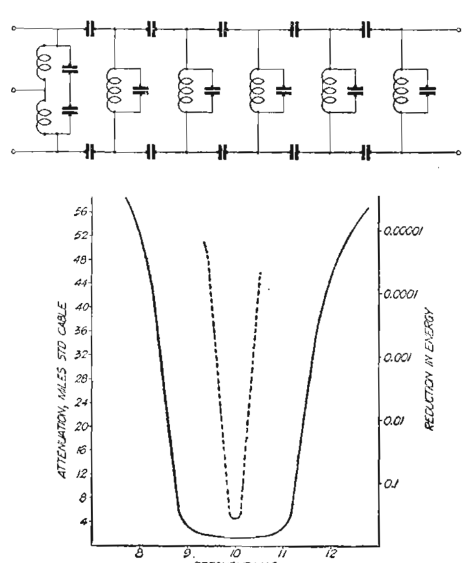


FIG.10

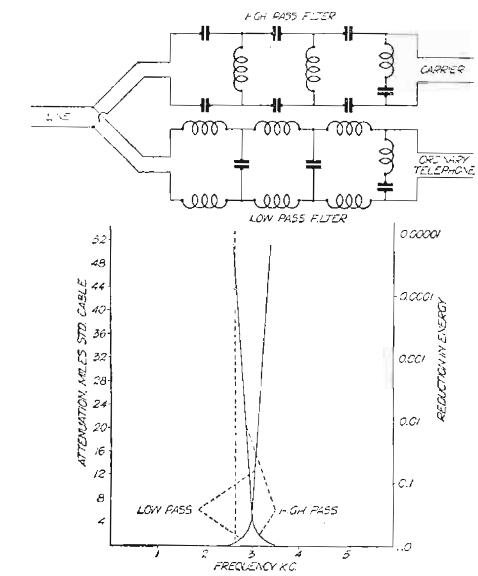


FIG. 11

a scale from which may be read for any frequency the fractional reduction of the energy due to transmission through the filter. This particular filter is designed to transmit the upper side band of a carrier of 9,000 cycles or the lower side band of a carrier of 11,000 cycles.

At this point it may be instructive to compare the performance of the filter just described with that of a pair of loosely coupled circuits resonant to a frequency in the transmission band of the filter. The attenuation characteristics of such a tuned circuit are shown by the dotted curve in Fig. 10. It is obvious from the attenuations of this circuit in the frequency range of the side band that such a circuit is very poorly adapted to the purposes of carrier telephony.

Referring again to the band-pass filter above described, it is of interest to consider the relation between its attenuation characteristic and the operation of the system. The form of the attenuation curve within its transmission range is important from the standpoint of the quality of the transmission of the carrier channel in which the filter is used. If the attenuation is uniform throughout the frequency range which the filter is designed to pass, the effect is merely the same as that of increasing the length of line by corresponding amount, and the loss can be compensated for by amplification inserted somewhere in the system. If the attenuation is not the same for all frequencies within the band, as, for example, if it is greater at the edges than at the center of the band, then the difference in transmission equivalent for different components of the side band will introduce a similar distortion into the over-all transmission frequency curve for various voice frequencies, as measured from the modulator input to the demodulator output. Such a distortion would manifest itself by more or less impairment in the quality of the telephone transmission.

Both the magnitude of the attenuation within the frequency band transmitter and the variation with frequency are dependent upon the dissipation of energy in the coils and condensers, as well as upon the choice of their electrical constants, so that the problem of securing filters of desired transmission characteristics has been largely one of obtaining reactance elements of high time-constants and of high accuracy and stability. For the capacities mica condensers are largely used. For the inductances, special core material of finely divided iron has been developed which has made possible toroidal iron-core coils which are superior in time-constant to air-core coils for frequencies up to the highest value used. At the same time they are more compact and have less stray field. Transformers having similar iron cores are also used throughout the carrier system.

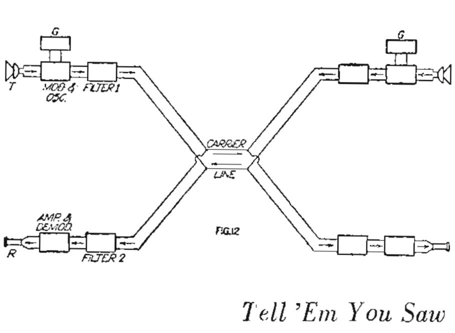
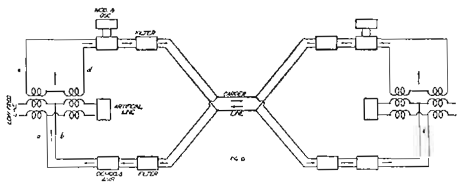


FIG. 12

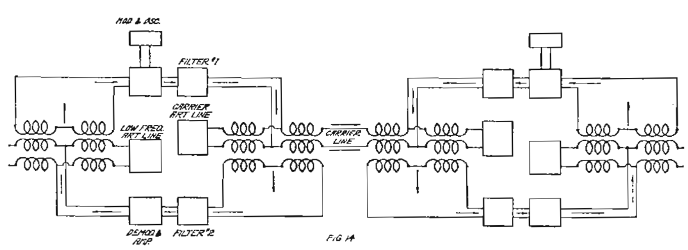
As has been indicated above, the attenuation of the filter outside of its efficient transmission band, deter-



mines the necessary frequency separation between the side bands of adjacent channels and therefore to a large degree also the number of channels which may be operated in a given frequency range. For example, if channel *A* is operating through the filter shown in Fig. 10, then the frequency band of channel *B* must be so chosen in the frequency range that the attenuation of the filter in channel *A* for currents of the frequencies of channel *B* is at least as great as some value fixed by the cross-talk requirements imposed on the system.

The attenuation outside of the transmission band is practically independent of the resistance of the coils and the dissipation in the condensers, but is determined almost wholly by the arrangement and values of the reactances employed in a section and by the number of sections. Numerous special arrangements have been devised for controlling the form of the attenuation curve and for giving to the filter an impedance best suited to the circuit with which it is connected. It has been found practicable to design filters which permit of operating with an interval of about 1000 cycles between adjacent telephone channels; that is, 3000 cycles between adjacent carrier frequencies.

In addition to separating the various carrier channels from each other it is found convenient from an operating standpoint to separate within the toll offices the carrier frequencies as a group from the frequencies used for ordinary telephony and telegraphy. For this purpose the portion of the line which is used in common is connected with the carrier apparatus through a "high-pass" filter, which transmits all frequencies above a predetermined value (in this case above about 3000 cycles) and suppresses all frequencies below this value (in this case below 3000 cycles). Similarly connection is made with the ordinary telephone and telegraph circuits through a "low-pass" filter, which in this instance passes frequencies below 3000 cycles and suppresses those above. This combina-



tion of carrier line filters, sometimes called a "high-frequency composite set," is shown in Fig. 11, together with the attenuation curves of the two filters. Referring to this figure, it will be seen that currents in the multiplex line divide between the low-pass and high-pass filters shown at the top of the figure. The division is determined at any particular frequency by the relative input impedances of these two branches. Accordingly, the high-pass filter is designed to offer a high input impedance to currents of ordinary telephone frequency, and to have an impedance equal to that of the line for currents within the carrier frequency range. Correspondingly, the low-pass filter is designed to offer a high input equal to that of the line for currents of ordinary voice frequencies. The attenuation of the high-pass filter is small for carrier frequencies and large for voice frequencies, while the reverse is true for the low-pass filter. Referring to the attenuation curves, which show, as indicated, the attenuation for both the high-pass and the low-pass filters, it is interesting to note how sharp a discrimination is

(*Continued on page* 110)

Grid Dip Oscillator Now Converted for Operation on A. C. Line

Plate Current Supplied by 226 Tube Used as Rectifier with Grid and Plate Paralleled

DESCRIBED originally on page 94 of the November, 1928, issue of this magazine the laboratory design grid dip oscillator has been built by many technicians and service men. It has always been felt, however, that the design appearing in the November issue was not suited for many who wished to employ alternating current and therefore did not care to be bothered with batteries for the plate and filament supply of the grid dip oscillator.

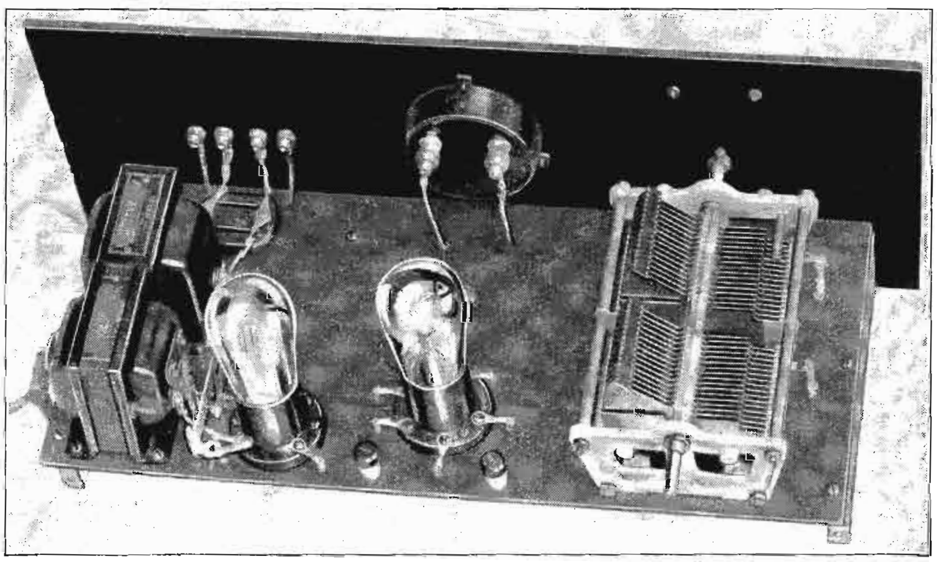


Fig. 1. The completed grid oscillator is shown in the above photograph. The model illustrated in our November, 1928, issue has been revamped so that it is operated from the alternating current line

Revamped for A. C.

Accordingly the design has now been revamped so that the grid dip oscillator is operated from the electric light line. As will be seen in the schematic diagram Fig. 2 a 226 tube with its grid and plate tied together serves as a rectifier, the 110 volt a. c. being applied directly to the plate of the 226. The transformer used for this purpose as well as lighting the filament of the 227 is a Thordarson type 3081 filament transformer. A 30 henry choke type R-196 made by the same concern is used in the positive side of the high voltage rectified output. It is bypassed at input and output by means of the one mfd fixed condensers shown in the drawing. Sufficient filtration is secured by means of this choke and condenser to give practically the equivalent of d. c. on the plate of the 227 oscillator.

Using a 227 as an oscillator the grid circuit consists of one section of the General Radio plug-in coil, the outside extremity of the coil being connected to the grid while the inside extremity is connected to the top of the 5000 ohm modulation resistor. The other section of the coil is connected with its outside turn to the plate of the 227 and the inside turn to one terminal of the 30 henry choke. In the drawing the outside turns are indicated by the letter "O" and the inside turns by the letter "I." The type of coil employed is shown in the photograph Fig. 3 at the extreme right. The regeneration or oscillation control is a fixed one and is represented by the .006 mfd fixed condenser between terminals "I" of the grid coil and "I" of the plate coil. The rotor of the condenser is common for both sections and connects to the cathode of the 227, and one side of the 110 volt a. c. line.

Do Not Ground Unit

Because one side of the 110 volt a. c. line is common with a portion of the circuit it is obvious that under no condition should any attempt be made to ground this grid dip oscillator. There are several parts of the circuit where trouble would result if the unit were grounded. For example, the positive terminal of the 0-1 milliammeter, the arm of the 30 ohm rheostat, and the rotor of the variable condenser. Of course, if the plug in the 110 volt light socket happened to be in the correct direction nothing would happen. But, on the other hand, if the plug were turned the opposite way the chances are the fuse in the house meter would be blown. It is also necessary that extreme caution be used when employing the grid dip oscillator for measurement purposes that no grounded lead of any kind come in contact with portions of the circuit.

A better idea of the connections and the parts employed in the grid dip oscillator can be obtained by referring to the diagram shown in Fig. 4 which is a graphic one. The four terminals for the plug-in coils are shown at the lower right hand portion of this drawing. The .006 mfd oscillation condenser is located between the two inside terminals, and as shown in the photograph Fig. 1, the Sangamo condenser may rest on the top of the subpanel. As previously explained one of the outside terminals goes to the grid of the 227 and the other to the plate.

Coil Ranges

The range of coil 384A is from 15 to 30 meters when tuned with a .0005 mfd variable condenser. The range of the 384B is from 30 to 80 meters, that of 384C from 70 to 200 meters and 384D, from 190 to 575. Thus the last coil covers the entire broadcast band, while the three preceding types cover the range from 15 to 200 meters, which is ample for any experimental or professional set building work.

While all of the previous ranges given are for ordinary purposes, nevertheless it is possible to obtain sets of coils all the way up to 30,000. For example: 384-E runs from 565 to 1700 meters; the next coil, which is 384-F, runs from 1700 to 4400 meters; after that comes 384-G which tunes from 4400 to 12,000 meters; the last coil in the series is 384-H, which tunes from 12,000 to 30,000 meters.

The schematic circuit shown in Fig.

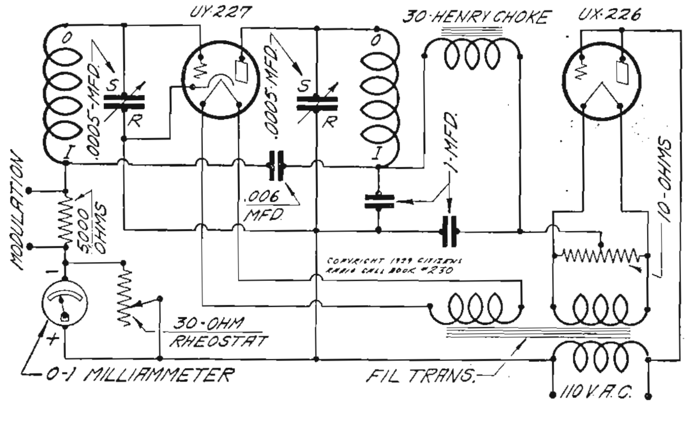


Fig. 2. Above is shown the schematic diagram of the a. c. operated grid dip oscillator

2 relates the electrical details of this grid dip meter, whose chief function is to indicate resonance between its own associated circuits and a circuit under measurement or comparison. This indication of resonance is accomplished by the drop in grid current at the position of resonance between the grid dip meter coil and another coil under measurement. For example, if when the meter is turned on the milliammeter in the grid circuit were to read one milliampere and then an inductance were placed in fairly close proximity to the plug-in coil on the grid dip meter and the tandem condenser rotated at the point of resonance, the meter needle would show a pronounced dip towards zero, the depth of this dip depending upon the inductive relation between the coil under measurement and the coil of the grid dip meter. If the two coils are too close together, the dip will be so pronounced that the tube will stop oscillating and the needle will drop to zero. On the other hand, if the coil is too far away, there will not be enough transfer from one circuit to another to cause the meter needle to dip at all. Consequently in testing for a dip the coil under measurement should be tried at various distances until it is possible to let the needle drop into the crevice or the lowest portion of the dip without jumping jerkily upwards.

When the bottom of the dip has been ascertained, if the device has been calibrated, the operator will know the frequency at which resonance has been established by referring to the chart which he makes up when calibrating his own meter. In the event that the meter is not calibrated but is placed adjacent to a calibrated wave meter, the frequency of resonance may be determined when the wave meter condenser is rotated across its scale and causes the needle of the grid dip meter to drop.

Some distinction should be made between the dip of the meter, itself, at a fundamental of a coil being measured and the dip of a meter at one of the harmonics of the particular coil being measured.

For example, if the meter reads one mil before the coil is placed near it, and the dip drops down to a half mil when the resonant position is found for the fundamental, then when a harmonic of this coil is encountered the dip will be slight and may only be a small fraction of the depth secured on the fundamental. This fact alone will frequently show the operator whether he has the fundamental of a coil or one of its harmonics.

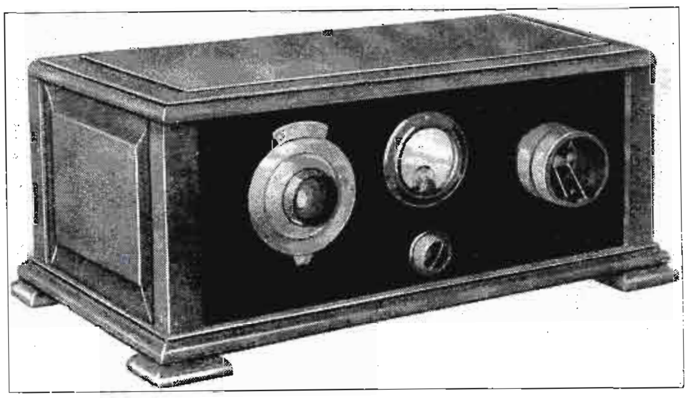


Fig. 3. The complete instrument is mounted in a small wooden cabinet. The front of this unit is the same as the one described in an earlier issue

Parts Needed

Parts for the model built in our laboratory are shown below:—

1—DS-25 Amsco .0005 mfd variable condenser
1—Sangamo .006 mfd fixed condenser
1—530 Yaxley 30 ohm junior rheostat
1—Electrad grid leak mounting
1—Durham 5000 ohm cartridge resistance
1—Formica 7 x 18 x 3/16 in. panel
1—Formica 7 x 16 x 3/16 in. sub-panel
2—XL Binding posts
1—VND National 100-0 laboratory dial
4—274J General Radio jacks
1—8629 Benjamin brackets
1—301 Weston 0-1 milliammeter
1—384-A General Radio coil
1—384-B General Radio coil
1—384-C General Radio coil
1—384-D General Radio coil
1—3081 Thordarson filament transformer
1—R-196 Thordarson 30 henry choke
1—511 Silver-Marshall socket
1—512 Silver-Marshall socket
2—10 ohm Yaxley center tapped resistance
2—Potter 1 mfd condensers
1—Package Corwico Braidite hookup wire

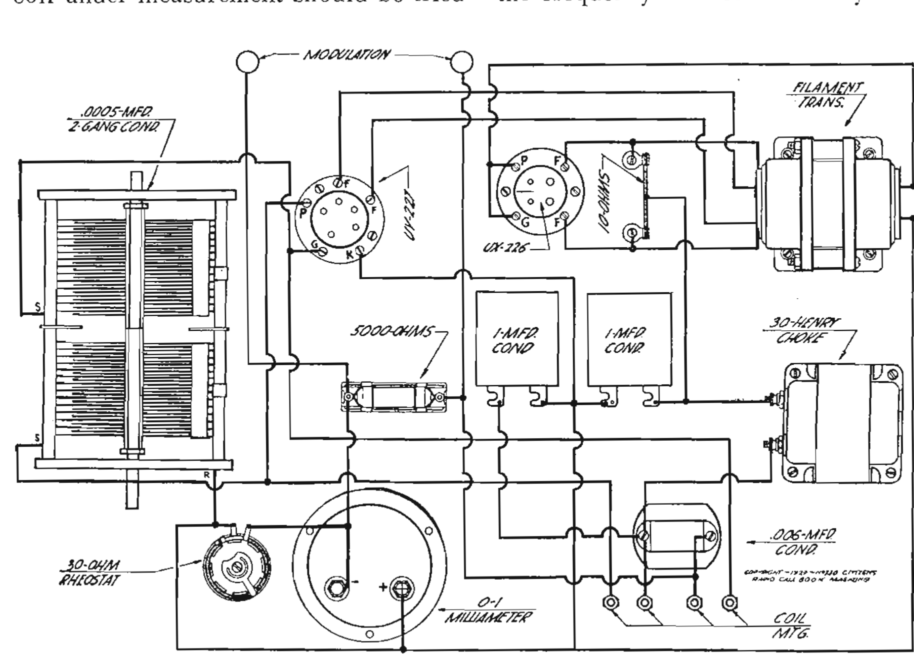
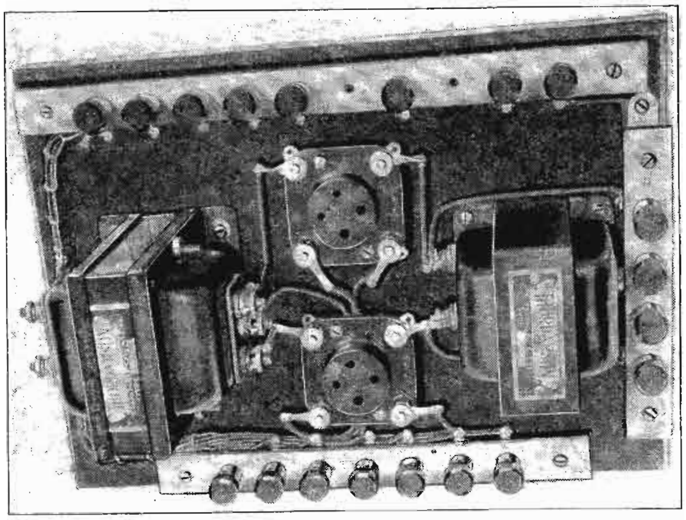


Fig. 4. Wiring of the grid dip oscillator may be done by following the graphic diagram shown in this illustration

Citizens Unit Audio Amplifier



Push pull stage and power supply are first two sections of system which may be extended to serve many purposes

AN interesting audio amplifier and power supply has recently been designed by technicians in our laboratory for the benefit of those who wish to follow out the unit plan of construction. The first unit of the amplifier consists of a push pull stage illustrated photographically at the top of this page, schematically in Fig. 1 and graphically in Fig. 2.

The power supply for the push pull stage is illustrated pictorially in Fig. 3, schematically in Fig. 4, and a graphic wiring diagram of this section is illustrated in Fig. 5.

May Add Units

Binding posts are arranged on both of these units so that the binding post strip of the power supply will line up with the input binding post strip of the push pull stage. Then as it is desired to add more units to this design it is possible to couple in the added units through connecting up the various binding post strips.

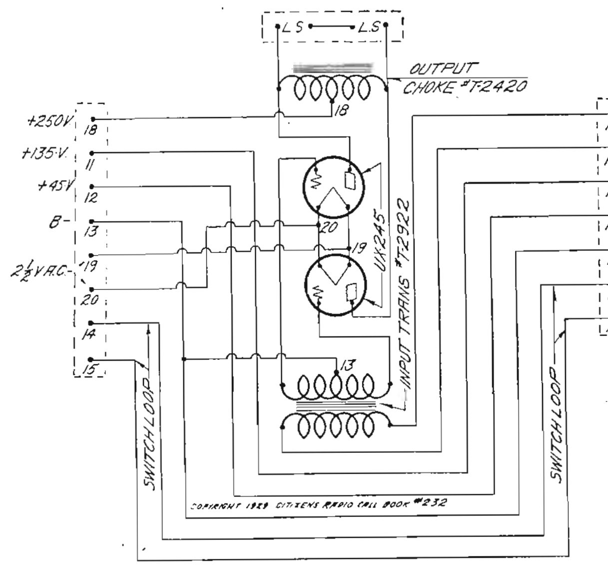


***Fig. 1.** This illustration is a schematic diagram of the push pull stage made in unit form. A photograph of the completed unit is shown at the top of this page*

Push Pull 245's

By referring to the schematic diagram shown in Fig. 1 it will be seen that two 245 tubes are used in push pull, with a standard input transformer T-2922, the output circuit being the standard P-2420 output choke. The speaker is placed across the extremities of this output choke.

Terminal Strips Match

At the left of the schematic diagram of Fig. 1 are the necessary terminals each numbered so as to correspond with a like set of binding posts on the output of the power supply illustrated in Fig. 4. The idea in the design of this particular amplifier was that the push pull stage and the power supply should represent the first two sections of a simple public address system if desired, or as a push pull stage for an existing audio amplifier in a radio set, or as a portion of a speech input system ahead of the push pull stage.

The graphic diagram shown in Fig. 2 represents the manner in which parts may be laid out in the first unit.

In looking at the photograph at the

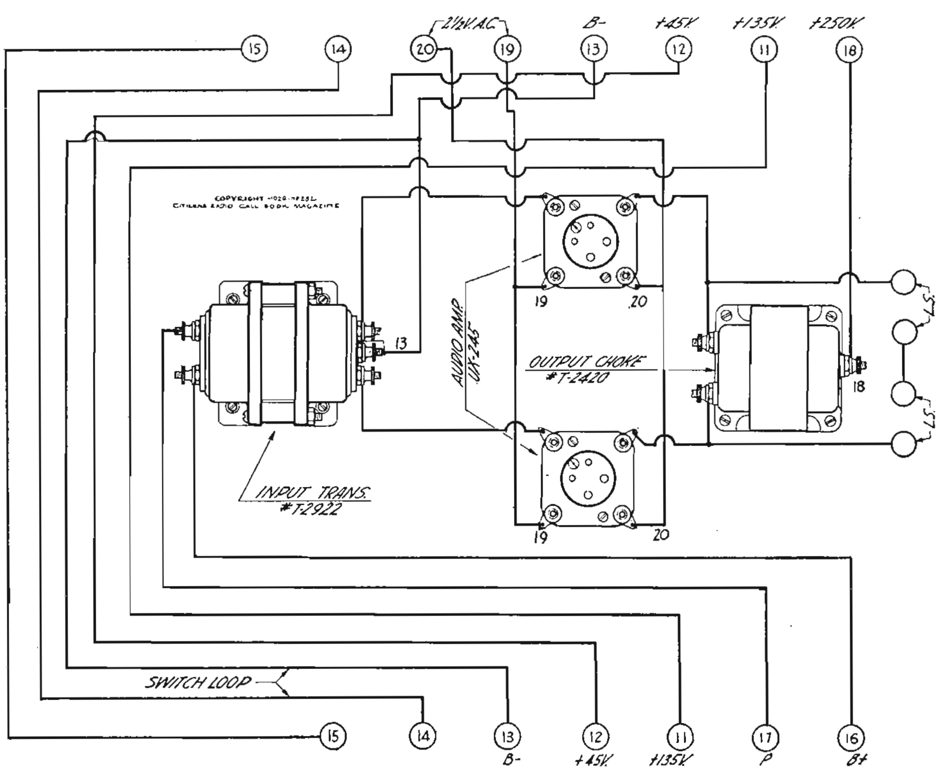


***Fig. 2.** A graphic diagram of the push pull stage is shown above*

head of this page it will be seen that the four binding posts at the right of the picture correspond to the four binding posts at the right of the graphic diagram in Fig. 2. These binding posts are represented in the schematic diagram as the four terminals marked LS at the top of Fig. 1.

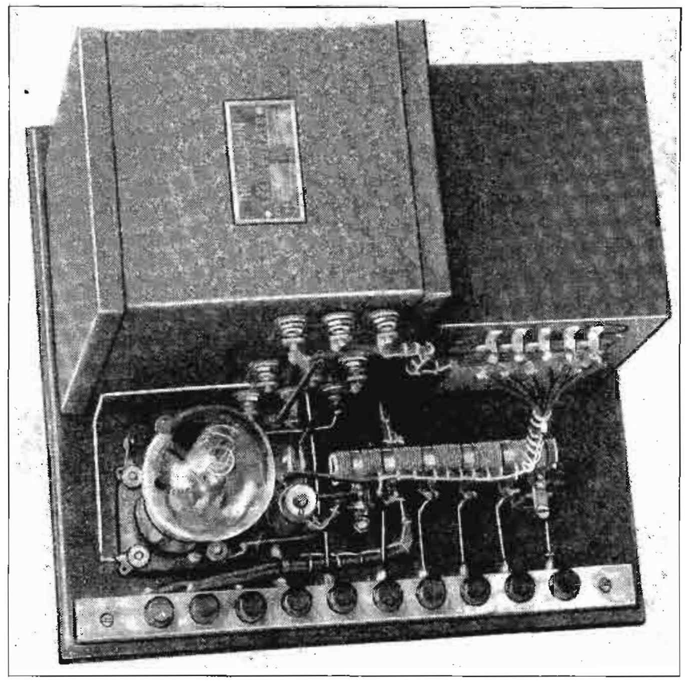
Easily Built

The push pull stage is easily built. It requires a minimum number of parts and connections. The wires leading from one set of binding posts on the input side to another set on the output side may be cabled after the connections have been soldered.

All Needed Voltages

In the power supply a standard R-245 compact is employed with a 280 rectifier. The compact is illustrated at the top left in the photograph Fig. 3 while the filter block is shown at the right and contains all of the necessary high and low voltage capacities. The resistor network may be seen in the photograph and consists of five sections, or taps, on a single tube. The 8500 ohm resistor used for biasing the grid of the 245 tube is noted in a vertical position at the right of the rectifier tube in the photograph. Voltages of 250, 135, 90, 45 and 22 are available together with the 2½ volt a. c. for the filament of the 245 tubes.

Fig. 3. The completed power supply is shown in the photograph at the right. A graphic diagram showing how all parts should be laid out and wired is shown elsewhere on this page



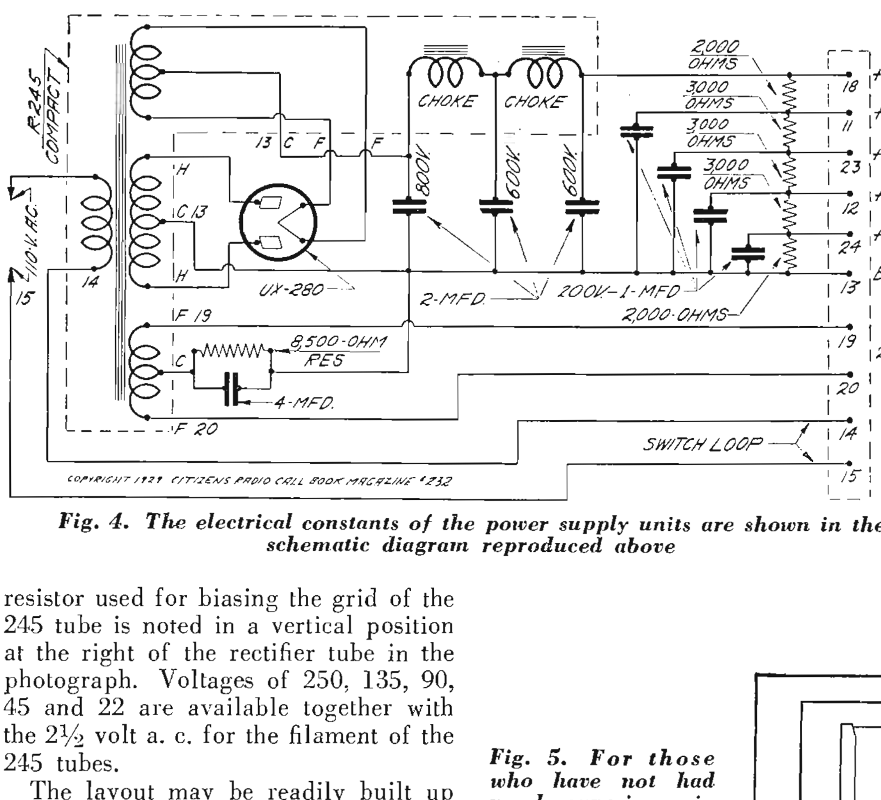


Fig. 4. The electrical constants of the power supply units are shown in the schematic diagram reproduced above

The layout may be readily built up from the diagram shown in Fig. 5 or if the builder is experienced he may follow the connections shown in schematic illustration, Fig. 4.

Parts Used

Parts from which the laboratory model of the push pull stage and the power supply units were built are shown in the list below:

Push Pull Stage

1—Thordarson T-2922 input transformer
1—Thordarson T-2420 output choke
2—Benjamin 9040 sockets
19—XL-Bakelite binding posts
1—¾ x 10 x 3/16 in. Bakelite strip
1—¾ x 4¾ x 3/16 in. Bakelite strip
1—¾ x 7¾ x 3/16 in. Bakelite strip
1—10½ x 7½ x ⅝ in. wood baseboard
1—Package Corwico Braidite hookup wire

Power Supply

1—Thordarson R-245 compact
1—Potter RR-245 condenser block
1—Benjamin 9040 socket
1—85 Electrad 8500 ohm fixed resistance
1—Electrad resistance unit having taps at 2000 ohms, 5000 ohms, 8000 ohms, 11,000 ohms and 13,000 ohms
10—XL-Bakelite binding posts
1—9½ x 10½ x ⅝ in. wood baseboard
1—¾ x 10½ x 3/16 in. Bakelite strip
1—Package Corwico Braidite hookup wire

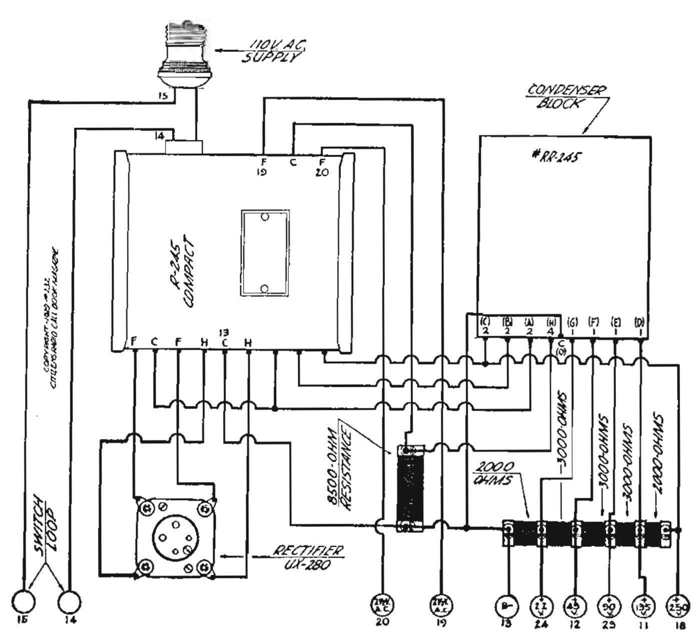


Fig. 5. For those who have not had much experience in construction of radio units the graphic diagram illustrated at the right is presented. The photograph shown in figure 3 will give the builder an idea as to the appearance of the completed units.

A. C. Self-Modulated Oscillator May Be Help in Servicing Sets

Most Designs Involve Use of Batteries Whereas Service Men Need Unit to Plug in Socket

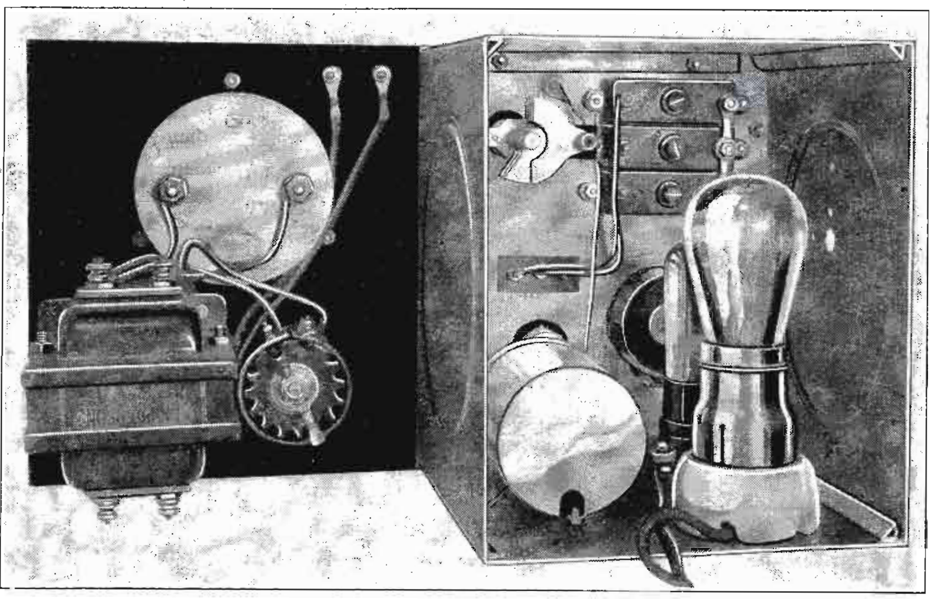


Fig. 1. This illustration shows the back of the tester with the shielding covers removed showing the arrangement and placement of all parts

ALONG with all the former ills of the radio sets the service man is now confronted by new complications in the servicing of modern receivers arising from the single dial control system and by virtue of the fact that the modern receivers are considerably sharper in tuning than the receivers have been heretofore. With this condition predominating in the modern receiver it is almost sure that at some time or other one or more of the various stages of tuned radio frequency will be found out of line with the remainder of the stages.

The slang term for this expression is "out of phase" and when this condition exists the receiver will be broad in tuning and a part of its sensitivity will be lost. This condition arises from a change of tube, aging of radio frequency coils and condensers, and where trimmers of the spring tension type are used the springs will lose their tension and change the capacity slightly. And since it is practically impossible to align a multiple gang receiver by ear and by using a broadcast station as a signal source due to the inherent broadness of a local station and the discrepancy in volume level of the ear it is necessary to have some sort of a signal generating device and an accurate resonance reading device to align the set properly.

Compact Unit

A great many articles have been published and various designs submitted to the service man for units of this type. However, the majority of these designs have incorporated batteries as a power source and also the majority of them having a variable condenser in conjunction with the coil for the purpose of covering the wave band of the receiver. These two conditions existing in such a design would automatically cause such a test arrangement to be more or less bulky and quite frequently heavy, and when such was carried around by the service man it became quite cumbersome and after a while was usually left behind. With these thoughts in mind the laboratory designed and constructed this tester with the following viewpoints in mind:

Features Desired

Compactness in so far as reasonable.

Elimination of as much weight as possible.

Coverage of the broadcast wave band without the use of a variable condenser which would increase the size of the tester materially.

Shielding sufficient to be able to create a fairly sharp signal on an unshielded receiver.

A signal which may be audible in the loud speaker for audible measurements as well as measurable on an output indicating device.

A signal generator that would have an output control to control the signal input to the receiver so that in case a very sensitive receiver is being used the signal may be cut down sufficiently so that it will remain sharp.

An output indicating device that would be universal to all types of receivers and output circuits, and inasmuch as this type of testing is not dependent upon the fidelity of the receiver this is a comparatively simple matter to take care of.

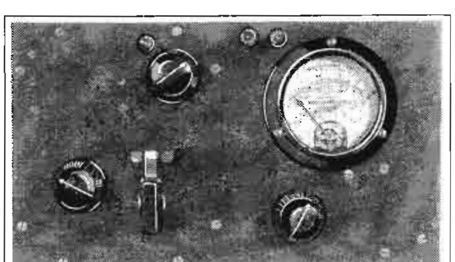


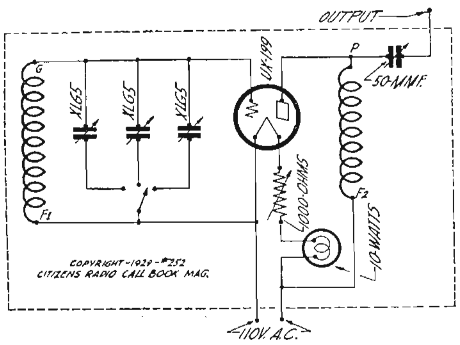
Fig. 2. An illustration of the appearance of the front of the tester

Standard Parts

All of the parts used in this test arrangement were of a standard nature and may be easily procured from any of the radio jobbers or manufacturers.

Referring to Figure 1, the aluminum can is made by Hammarlund and comes in sections, permitting it to be drilled and assembled in portions and is wired with practically no difficulty at all. It is suggested that all wiring be done with flexible wire so that the jarring and vibration during transportation will not have a tendency to break the connection which would be the condition if solid bus bar were used.

In Figure 1 will be noticed on the front panel within the shield the three X. L. variable condensers. Immediately to the left is the Hammarlund 50 m. m. f. midget condenser which is the output coupling condenser. Immediately below this coupling condenser are the three taps on the selector switch. To the right of this selector switch is the 1000 ohm rheostat which is in the filament circuit of the oscillating tube which controls the filament voltage of



NOTE - BOTH WINDING ARE CONTAINED IN A SM-121 SHIELDED COIL UNIT

Fig. 3 is a schematic diagram of the oscillator portion of the circuit

the 199 tube and also may be used for an output signal control. Immediately in back of the 199 tube is the 10 watt lamp which serves as a voltage drop device to cut the 110 volt line voltage to the necessary 3 volts for the filament of the 199. To the left of the tube is the shielded coil. The shielding of the coil plus the shielding of the large can will give sufficient shielding so that when used with an unshielded receiver the signal will be quite sharp, making all adjustments very simple and rapid.

On the left end of the panel will be noticed the Jewell thermo coupled galvanometer. This meter has a top range of 115 milliamperes. The Thordarson 2902 transformer to which the meter is connected serves quite readily for the purpose of a current transformer, the primary of which has sufficient rating to carry the current of a 250 output tube. It is suggested not to deviate from the specifications of using this particular transformer. Immediately to the right of the transformer is the 30-ohm rheostat which is connected across the meter and the secondary of the transformer. The purpose of this rheostat is so that when a very strong signal is in the output circuit of the receiver the meter's deflection may be cut at will from the maximum reading of the meter, by adjusting the resistance of this rheostat so that a portion of the current passes through the rheostat and a portion through the meter. It also acts as a protection against the burn-out of the thermo couple in the meter.

Layout Diagram

Referring to Figure 2 will be seen the layout as it will be seen from the front of the panel. The lower right-hand knob is on the rheostat in the output circuit control. The lower left-hand rheostat is the control of the filament of the tube. The two upper right-hand binding posts are those which are connected to the output of loud speaker terminals and the receiver. The remaining binding post is connected to the aerial binding post of the receiver.

Referring to the schematic diagram, as is illustrated in Figure 3, the two coils are contained in the Silver-Marshall No. 121 shielded coil. The secondary of this coil is used across the grid and filament of the oscillating circuit and is wound on a bakelite tube with enameled wire. The primary which is used from plate to filament of the oscillator tube is wound over the secondary with sufficient coupling to cause stable oscillation with just about the correct amount of coupling for a sharp signal. The three X-L type G-5 condensers are placed from the grid to the filament circuit with a switch, giving a selection of any one of the three condensers. These three condensers may be adjusted so that the circuit will oscillate on almost any frequency and as the circuit of this oscillator is inherently full of harmonics, these condensers may be adjusted quite readily so that the signal may be received at about every ten points on the dial and the 50 m. m. f. coupling condenser may be varied which will change the frequency output to almost any frequency between the fundamental and harmonic frequencies of the oscillator circuits. It may be readily seen that a signal may be obtained almost anywhere on the wave band.

How to Balance Receiver

The procedure of balancing a receiver with this instrument would be as follows: Disconnect the regular aerial from the receiver and connect the aerial binding post to the output binding post of the oscillator. Connect the oscillator into the light line. Under no condition should the 50 m. m. f. coupling condenser be taken out or shorted out of

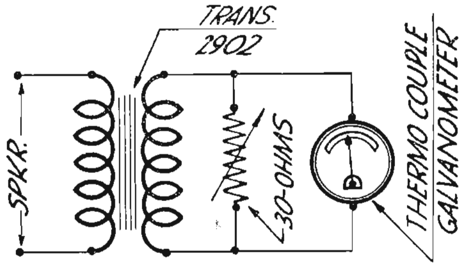
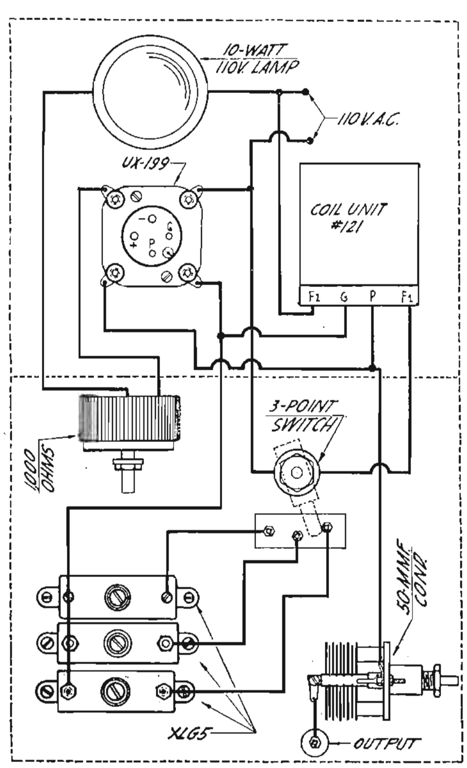


Fig. 4 is a schematic diagram of the indicator portion of the circuit

the circuit, as this might cause disastrous results, inasmuch as the aerial binding post is connected to ground through the primary winding of this coil. It will be noticed that the plate side of the coupling condenser is connected to one side of the 110-volt a. c. line, and inasmuch as one side of the a. c. line is grounded it will be readily seen that if this coupling condenser is shorted and if it happens that this side of the a. c. line is not grounded and the coupling condenser were shorted there might be fireworks. After the oscillator is plugged into the light line, tune the receiver until the signal is heard. In the loud speaker the signal will be heard as a 60-cycle hum. Tune the receiver until the hum is the loudest and by gradually decreasing the 1000-ohm rheostat which decreases the output of the oscillator the receiver may be tuned to a very sharp point. The loud speaker should then be disconnected and the output indicating device connected to the loud speaker terminal. The meter will then read and the readings may be adjusted by varying the 30-ohm rheostat. The tuning control of the receiver should then be varied to obtain maximum reading of the meter. When this is done the control should be left in this position and the trimmers may then be adjusted with some sort of an insulated screw-driver or adjusting

(*Continued on page* 130)



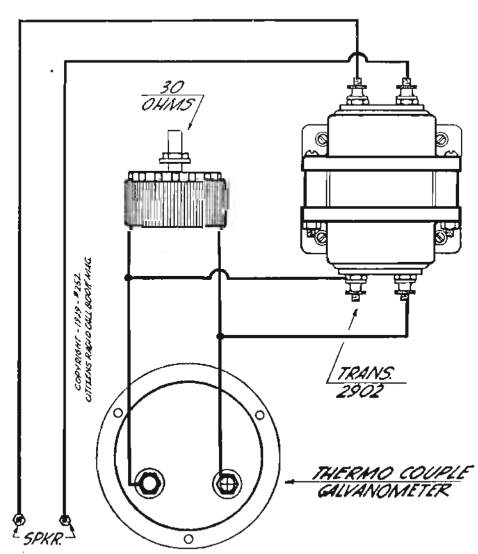
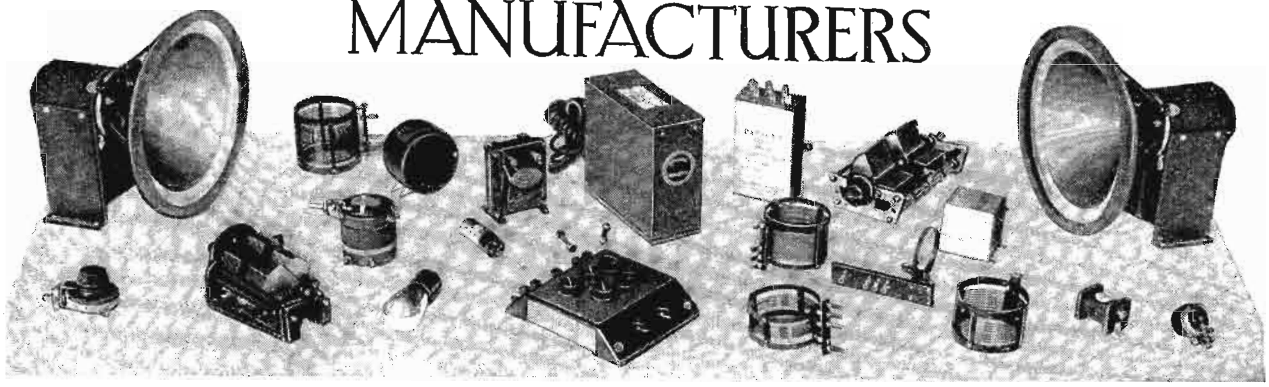


Fig. 5 is a graphic illustration of the entire tester showing the point to point connections

WITH THE ACCESSORY & PARTS MANUFACTURERS



New Resistance Units Designed by Compo Mfg. Co.

REALIZING there is a demand for fixed resistances meeting at least seven specific trade requirements, the Compo Mfg. Co. of Chicago have designed a line of fixed resistance units which they call "Candohms," taken from the fact that the ohms are in cans. An illustration of one of the units is shown in this column.

According to a statement made by J. L. McWeeny, the organization has gone ahead on the general premise that fixed resistors must meet the following specific trade requirements: 1. they must be accurate within 3 per cent of ohm specification; 2. the temperature coefficient must be as low as possible; 3. they must not be easily damaged; 4. they must occupy minimum space; 5. they must lend themselves readily to modern production requirements; 6. they must be capable of heavy overloads for indefinite periods; 7. they must stand up and give perfect service throughout the normal life of the apparatus of which they are a part.

Made in Two Sizes

At the present Candohm resistors are manufactured in two sizes. Type R, the larger size, is delivered in all ohm values from .2 ohms to 12,500 ohms. Type J, the smaller size, ranges from .2 ohms to 6,250 ohms.

One of the interesting features in connection with their winding set-ups is the fact that they wind ohms, not feet. This is believed to be directly opposite to present practice but it does make it a relatively simple matter to comply with a 3 per cent standard of accuracy.

The temperature coefficient of these resistors is considerably less than the normal reaction of the resistance wire suspended in free air. It is widely taken for granted that commercially pure asbestos is an excellent heat insulator.

The technical department of this magazine was supplied with two temperature tables. No. 1 records the test room temperatures, resistance unit metal covered temperature and inner core resistor temperature at all loads from 1 to 15 watts. No. 2 shows test room temperature and wound core temperature of the same resistor under the same loads but lacking the radiation advantages of the outer asbestos wrapper and protective metal cover. These tables indicate rather conclusively that the winding enclosed in the finished unit operates at a lower temperature than that of the exposed unit. In each case the temperature coefficient is simply that which is characteristic of the wire used. The winding was made of "Advance" wire.

The samples may be hammered and dented without breaking the fine wire winding and without causing turn to turn internal shorts. The cores end in wire terminals and are fabricated from cold rolled dead soft steel tumbled and hot tinned. Because of their unique construction they cannot be pulled out of the assembly. The terminals will withstand more than 25 complete continuous 180 degree bends.

In looking at one of the resistance units that has been cut open, the end view discloses that the resistance winding is on the inside, being wound around a milled edge bakelite base strip. Then follows the terminal wrap, then a dehydrated fibre with an insulation test of 500 volts d. c. and on the outside is a C. R. D. S. steel cover, Duco dipped and furnished in black, white, blue, green, red or orange.

Fit Production Needs

These units lend themselves admirably to modern production requirements. We are advised that the company is in position to supply a wide variety of mounting brackets, furnishing the unit with solder terminals at both ends, solder terminal at one end and a variable length wire pigtail at another end, or wire pigtails on both ends.

The largest permissible wire gauge is used in winding each resistance value. The wire is brought out and given at least four turns around the tinned terminal and then is further clamped with a U-shaped tinned steel collar. The result is extremely low contact resistance between the wire and the terminal inside the unit. Both terminal and collar being hot tinned, the wire is practically imbedded in the softer metal. Where space does not permit the use of large size units and resultant operating temperatures are higher than the oxidizing point of tin plate, Compo supplies parkerized iron covers. This material being already oxidized shows no reaction to high temperature and the internal unit, of course, is capable of standing temperatures of 1200 F.

Another type of resistor which is contemplated is a small Candohm applicable as a grid suppressor or other r. f. uses.

(*Continued on page* 133)

(*Continued from page* 102)

obtained even for frequencies very close to the cut-off points of these filters. For instance, if we select a frequency of 2700 which happens to fall near the upper limit of the normal voice range, it is seen from an inspection of these curves that currents of this frequency are attenuated by about one mile of standard cable when passing through the low-pass filter, but are attenuated by about forty-five miles of standard cable when passing through the high-pass filter. Likewise, a frequency of 3200 near the lower limit of the carrier range is attenuated by less than one mile when passing through the high-pass filter, but is attenuated by about forty-five miles when passing through the low-pass filter. These differences in attenuation correspond roughly to a ratio of energies greater than ten thousand to one.

The location of these line filters in a carrier system is indicated in Fig. 9. A low-pass filter is also used in the output circuit of the demodulator to prevent currents of frequencies higher than the essential voice range from being transmitted to the subscriber.

Two-Way Transmission

Thus far the discussion has been limited to transmission in one direction. Provision must be made, however, for associating these one-way channels with the connecting telephone of power lines so as to permit two-way conversation. In many aspects the problem resembles that encountered in adapting a one-way amplifying element to a two-way talking circuit by means of a telephone repeater. The similarity of the two problems consists not only in the fact that the carrier channel and the repeater element are both unilateral or one-way arrangements, but also that both involve amplification, and therefore the same possibilities of "singing" are present in the case of the carrier as in the case of the repeater. The experience, which was gained in the development and engineering of telephone repeaters, has proved of very great value in connection with the development of carrier current systems.

In Fig. 12 there is shown schematically an elementary form of two-way carrier telephone circuit. Filters are included in the transmitting and receiving branches, as they are necessary in those branches for multiplex operation. This circuit is entirely operative between two fixed telephone stations. If the same frequency is used for transmitting in both directions, there will obviously be an excess of sidetone in the receiver circuits. It is plain that such a type of circuit has very limited commercial application, and it is shown here merely as a starting point for building up the more generally applicable types.

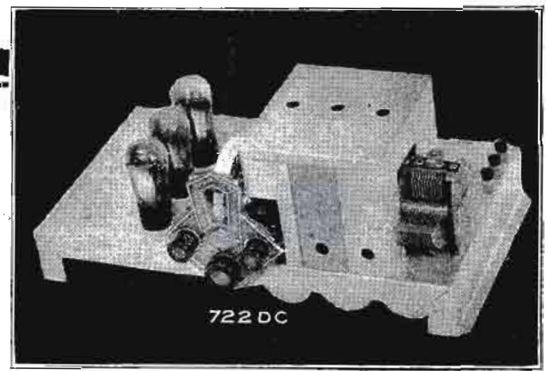
As in general it is desirable to be able to connect any desired power telephone trunk or toll line to the section of line equipped for operation by the carrier current method, it is necessary to adopt for connecting these lines together a circuit of the type which has been studied for many years by telephone engineers, first in connection with subscriber sets, and second in connection with repeater circuits.

Fig. 13 shows schematically one such arrangement. At either terminal of the carrier frequency line, the sending and receiving branches, instead of terminating in a transmitter and receiver, terminate in what are, in effect, conjugate branches of an alternating-current bridge. If the impedance of the artificial line exactly simulates the impedance of the voice frequency line looking outward from the carrier terminal, and an electromotive force applied between the points, a and b, does not cause any current to flow in the branch, d-d, of the carrier current circuit, this represents a condition of zero coupling between the input and output circuits of the carrier system; hence persistent oscillations, i. e., singing cannot be set up. If, however, the balancing network does not accurately

(*Continued on page* 112)

SM

"S-M 722 a Knockout" —Setbuilders Demand D.C. Design—It's Here!

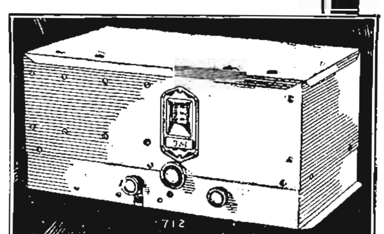


"722" Results for Battery Users

Experienced setbuilders have learned to expect big results from any screen-grid custom design that S-M offers—but the 722 Band-Selector Seven has broken all records. And no wonder—a custom receiver that is sold, completely wired, at $74.75 net, topping the performance of widely advertised factory sets selling at twice the price. Yet there is nothing mysterious about it—just the long experience of S-M engineers applied to the job of producing those essential receiver parts whose quality spells the difference between the performance that "gets by" and the performance that an S-M fan demands. Everything that is the "last word" is in the S-M 722—the '24 power detector, the band filter—the uniform gain all over the dial—single dial tuning—all-electric with built-in power supply. Tubes required: 3—'24, 1—'27, 2—'45, 1—'80. Wired, less tubes, $74.75 net; parts total $52.90.

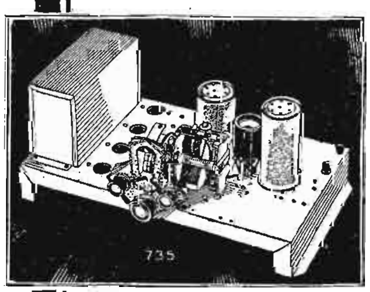
The new 722DC for battery use (illustrated) gives every advantage of the a. c. design—big volume, DX ability, and uniform amplification at all frequencies, just like the a. c. set—truly the ideal battery receiver. Tubes required: 3—'22, 3—'12A. Wired, less tubes, $57.50. Parts total $38.50.

Do You Want Absolutely the Best There Is?



It doesn't cost an awful lot more than the 722, but this S-M 712 tuner, in its neat innocent-looking all-metal shielding cabinet, is absolutely guaranteed to out-distance and out-perform all competition regardless of circuit or price—just as its famous predecessor, the Sargent-Rayment 710, did last year. Read, in last month's issue of this magazine, how one listener living only a mile from the powerful WSM tunes in regularly a station 400 miles away with only 20 kc. separation! That's performance—and with one-dial tuning—*no verniers*. Tubes required: 3—'24, 1—'27. Wired as shown, less tubes, $64.90 net. Parts total $40.90.

Any good audio amplifier can be used with the 712; ideal tone quality and perfect convenience are secured by using the S-M 677. Uses 1—'27, 2—'45, 1—'80 tubes. Wired complete, less tubes, $58.50. Parts total $43.40. For 25-40-cycle current, $72.50 wired.



And a "Bearcat" for the Short Waves

"The little 735 is a "bearcat". The way it will pick up stations is nobody's business. You want to see the hams come in and play with it. First one I wired I got 5SW Chelmsford, England, also a Dutch station and a lot of others . . . this was around 2 P. M."

That's the verdict of R. G. Sceli of Hartford, Conn.—one of the most expert setbuilders in New England, and remember he is speaking of the first completely-a.c.-operated short-wave sets ever brought out! The new S-M 735 Round-the-world seven is carrying all before it this year. On same chassis as the 722; tubes required: 1—'24, 2—'27, 2—'45, 1—'80; wired $64.90, parts total $44.90. 735DC for battery use, using 1—'22, 4—'12A, wired $44.80. Parts total $26.80.

Beautiful Cabinets

A full line of cabinets is available for all these S-M receivers—the beautiful 707 table cabinet, in rich crystalline brown and gold, is only $7.75 net. Other cabinets of remarkable charm are listed in the S-M catalog—see coupon.

"THE RADIOBUILDER" for December contained details of the 722DC; every issue gives advance technical information of great interest and profit to setbuilders. Use the coupon!

Over 3000 Authorized S-M Service Stations cover the United States and Canada. Many are profiting handsomely! Write us for the address of the nearest one if you wish a custom-built set. Setbuilders write us regarding a franchise in your territory.

SILVER-MARSHALL, Inc.

6413 West 65th Street Chicago, U. S. A.

Silver-Marshall, Inc.
6413 West 65th Street, Chicago, U. S. A.

........Please send me, free, the new fall S-M Catalog; also sample copy of the Radiobuilder.

For enclosed..............in stamps, send me the following:
......50c Next 12 issues of The Radiobuilder
......$1.00 Next 25 issues of The Radiobuilder

S-M DATA SHEETS as follows, at 2c each:

......No. 3. 730, 731, 732 Short-Wave Sets
......No. 4. 255, 256, etc., Audio Transformers
......No. 5. 720 Screen Grid Six Receiver
......No. 6. 740 "Coast-to-Coast" Screen Grid Four
......No. 7. 675ABC High-Voltage Power Supply
......No. 8. 710 Sargent-Rayment Seven
......No. 9. 678PD Phonograph-Radio Amplifier
......No. 12. 669 Power Unit
......No. 14. 722 Band-Selector Seven
......No. 15. 735 Round-the-World Six
......No. 16. 712 Tuner (Development from the Sargent-Rayment)
......No. 17. 677 Power Amplifier for use with 712
......No. 18. 722DC Band-Selector Six

Name..

Address..

(*Continued from page* 110)

simulate the low-frequency line, either of two types of singing may occur. In the circuit arrangement in Fig. 13, if the same frequency is used for transmission in both directions, the type of singing most likely to occur would be local singing at either terminal. This occurs for the reason that in general the amount of energy applied to the two terminals, c and d, is largely amplified in the course of passing through the circuit—modulator, filter 1, filter 2, demodulator and amplifier. If the unbalance in the bridge circuit is such that the fraction of this energy which is fed back to the points, c and d, is as large as that originally supplied, singing occurs. To avoid this type of singing different carrier frequencies may be chosen for transmission in the two directions. If this is done, local singing cannot be set up, for the reason that filter 2 acts as a block to the return of the output current on itself. End to end singing as distinguished from local singing may, however, occur provided the over-all transmission loss of the line and the terminal apparatus is made less than zero, and provided that there is sufficient unbalance between the artificial lines and the low-frequency lines at both ends. By "transmission loss of less than zero" is meant that the attenuation of the carrier line is more than compensated for by amplification introduced either at the terminal stations or at intermediate repeater stations. However, the accuracy of line balance necessary to prevent end to end singing with carrier circuits such as we have shown is very much less than would be required to prevent local singing if the same frequency were used for transmission in both directions. It is interesting to note that in both of these types of singing the sustained oscillations in different portions of the circuit are of different frequencies. Those in the portions used for transmission at voice frequency have some value lying in the voice frequency range. Those in the portions used for transmission at carrier frequency differ from the carrier frequency associated with that particular channel by the frequency of the oscillations in the low-frequency circuit.

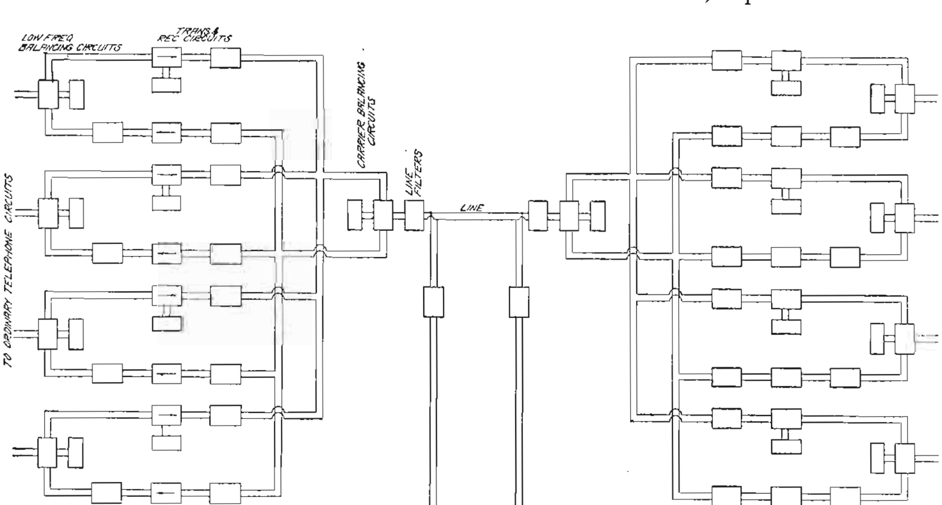


FIG.15

Whereas, with the circuit shown in Fig. 13, local singing is prevented by the use of different carrier frequencies in the two directions, it is possible to prevent this type of singing without resorting to different frequencies, with the attendant reduction in number of channels, by the use of the arrangement shown in Fig. 14. In this arrangement the energy from the output of the modulator is prevented from reaching the input of its associated demodulator by placing the two in conjugate relation in an alternating-current bridge circuit, of which the carrier frequency line forms one arm, and a balancing network, designed to simulate the line impedance, the other arm.

Both the arrangements shown in Fig. 13 and that shown in Fig. 14 have been successfully employed for two-way carrier current transmission.

We have already discussed quite fully the selective characteristics of filters and their relation to one-way multiplex operation, and have, in the preceding paragraphs of the present section pointed out the fundamental principles of two-way operation. In Fig. 15 is shown schematically an arrangement for two-way multiplex operation capable of giving four two-way carrier conversations in addition to the normal telephone facilities. It will be noted that, in this multiplex system, the basic two-way transmission system of Fig. 14 is employed. A similar two-way multiplex system could be built up employing the basic two-way transmission system shown in Fig. 13.

Carrier Suppression

One of the systems which has been developed, particularly for use in long high-grade circuits, involves certain fundamental principles in addition to those already discussed. It will be recalled that, as stated, the proper operation of the demodulator requires that the side-band currents, by which are transmitted the characteristics of the speech, be accompanied by a relatively large amount of unmodulated current of carrier frequency. When this carrier current is transmitted from the modulator, it is evident that only a relatively small part of the line current is actually used in conveying the characteristic variations of the voice current. If, therefore, this carrier current is supplied to the demodulator from a local source instead of over the line from the sending station, the amount of line current which it is necessary to transmit per channel is very materially reduced, for then only the relatively small side bands are transmitted. In the application of this method, means must be provided for eliminating the carrier current at the sending end and for supplying it to the demodulator from a local source at the receiving end.

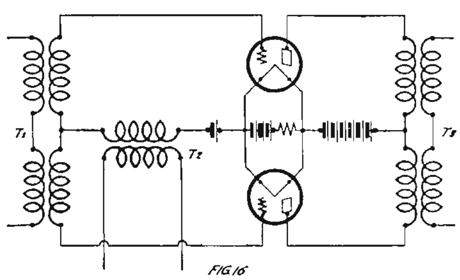


FIG 16

Elimination of the carrier frequency at the sending end can be accomplished by what is known as a "balanced modulator," a schematic circuit of which is shown in Fig. 16. In this arrangement two tubes are connected in a manner somewhat similar to the "push-pull" repeater circuit which is described later. The voice frequency potential is applied through the transformer T_1. The carrier potential is applied through the transformer T_2, to the common portion of the input circuit in such a manner that the carrier frequency potentials of the two grids with respect to the filament are at any instant the same. The resultant carrier frequency currents in the plate circuits of the two tubes are then equal, and the fluxes which they set up in the core of the differential transformer T_3, are equal and opposite; hence no voltage of the frequency of the unmodulated carrier is induced in the output circuit. By a more detailed analysis it can be shown that the side-band currents resulting from the interaction of the carrier and speech-frequency currents are not balanced out but are reproduced in the output circuit. It should be noted that under these conditions, high-frequency current appears in the output circuit only when low-frequency telephone currents are being applied to the input circuit of the modulator.

Harmonic Generator

In order to insure that the carrier current applied to the demodulator in the above system, employing suppressed carrier, is of exactly the same frequency as that used for modulation at the sending end, an arrangement has been devised whereby both of these frequencies are derived from the same source. For this purpose at one terminal of the system a vacuum-tube oscillator generates a frequency somewhat above the voice range—say 5000 cycles. Current of this frequency is applied to the input of another vaccum tube in such a way as to overload it. This "harmonic generator," as it has been termed, is so arranged that the current in its output circuit has a distorted wave-form containing prominent components whose frequencies are exact multiples of the applied frequency. The various harmonics of the base frequency (in this case 10,000, 15,000, 20,000 cycles, etc.) are separated by suitably designed selective circuits and led into individual circuits where they are amplified and made available for use as carrier currents, each in connection with a different channel. At the same time, current of the base frequency from the controlling oscillator, in this case 5000 cycles, is amplified and transmitted over the line to the other terminal. Here it is separated out by a filter, amplified and applied to a second harmonic generator, which produces the same series of carrier frequencies as does the harmonic generator at the controlling station already referred to. These regenerated harmonics may not only be used for demodulating the transmissions received from the controlling terminal, but may also be used in connection with balanced modulators which send in the reverse direction. The demodulators at the controlling station are supplied with carrier current from the harmonic generator at that terminal.

The suppressed carrier system, besides employing smaller line currents, has two other important advantages. One is the absence of audible beat notes resulting from interaction in the demodulating circuits between the carrier frequency normally present and others which may be present through cross-talk or lack of perfect balance. Where all the carrier frequencies are generated separately, these combination frequencies may in certain cases give rise to disturbing tones within the voice range. With the harmonic arrangement, on the other hand, the only possible frequencies are differences of the base frequency itself and its harmonics, all of which are above the normal voice range, and accordingly are suppressed by the low-pass filter in the output circuit of the demodulator. As a matter of fact, this harmonic arrangement is practically essential where the same frequency is used for both directions.

The second advantage arises from the fact that variations in the attenuation of the line, due to weather changes or other causes, have less effect on the transmission equivalent of the system where the carrier frequency itself is not transmitted. This will be clear when it is recalled that the magnitude of the voice current in the output of the demodulator is proportional to the product of the amplitudes of the carrier and side band currents. If, therefore, the change in line attenuation is such as to increase or decrease the side band current by a given ratio, the carrier current when transmitted will in general also be changed in the same ratio, and the resulting voice current will be changed by the square of this ratio. In the suppressed carrier system on the other hand, while the side band is changed as before, the carrier is increased or decreased—not by the change in attenuation which occurs at the carrier frequency—but by the changes, in general much smaller, which occur at the base frequency, so that the voice current is less affected in this case.

Chemical Action and Capacity in Storage Battery Described

(*Continued from page* 59)

on the negative plate is changed to pure lead and the lead sulphate on the positive plate is changed to lead peroxide and the sulphuric acid will be added to the water. The chemical changes will be as follows:

The lead sulphate and water will produce sulphuric acid. hydrogen and lead peroxide which may be written chemically as $PbSO_4 + 2H_2O = PbO_2 + H_2SO_4 + H$. The changes at the negative plate will be lead sulphate and water produce sulphuric acid, oxygen and lead, which may be expressed $PbSO_4 + H_2O = Pb + H_2SO_4 + O$. The hydrogen H_2 which is produced at the positive plate and the oxygen is O which is produced at the negative plate unite and form water, which will be shown as follows: $2PbSO_4 + 2H_2O = PbO_2 + Pb + 2H_2SO_4$. This last equation starts with lead sulphate and water which are produced when the battery was discharged. It will be noted that we started with lead sulphate and water. Therefore, plates may be charged in water. Badly discharged negatives may even be charged better in water than in an acid electrolyte. In the last equation the sulphate on the plate combined with the water to form sulphuric acid we may then say, with reservation, that during the charge acid is driven out of the plate. When all the lead sulphate has been used by the chemical changes caused by charging current, no further charging will take place. If a current is continued to be sent through the cell after it is fully charged the water will continue to be split up into hydrogen and oxygen, but since there is no lead sulphate left with which the hydrogen and oxygen can combine to form lead peroxide and sulphuric acid, the hydrogen and oxygen rise to the surface of the electrolyte and is released from the cell. This is known as gassing and is an indication that the cell is fully charged.

[Further data on this subject will appear in a later issue.—Editor.]

New Design is Seen in Pilot P-E-6 S. G. Broadcast Receiver

(*Continued from page* 55)

who want for themselves or can sell to others a low-priced screen-grid receiver of good characteristics.

The set is known as the P-E-6, and is put out by the Pilot

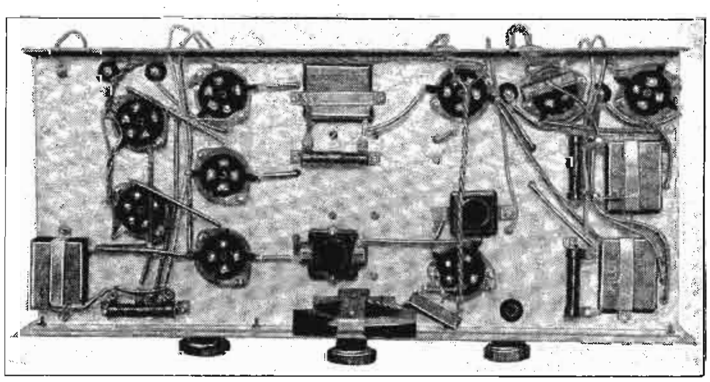


Fig. 3. This shows a bottom view of the chassis and indicates the compact wiring

company in the form of three different kits. The sub-panel and all the electrical components are the same in all cases, but in kit number K-122 a metal front panel, without cabinet

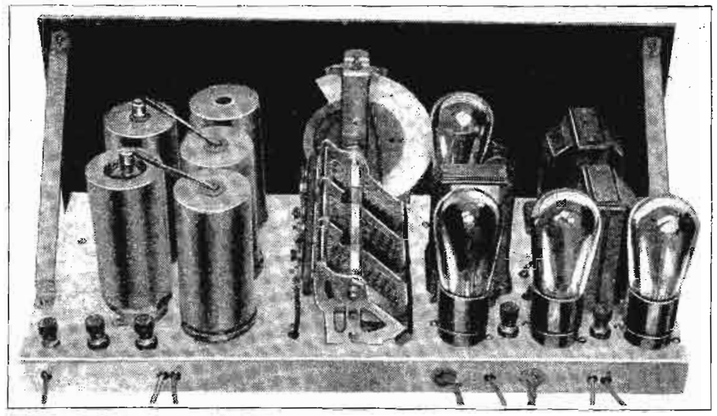


Fig. 4. A rear view of the set is shown photographically with tube shields in place

or power pack, is supplied. This panel is of steel neatly finished to resemble light walnut. A set assembled from this kit may be mounted in any standard 7 by 18 cabinet or console, and may be used with any 171A power pack. Both panels are accurately drilled, and all parts and hardware are supplied.

This second kit, No. K-123, includes a very attractive walnut-finished metal cabinet, the front of which is drilled to form the front panel, to support the tuning dial, a switch and a volume control. The third kit, K-124, is exactly like the second, except that a Pilot K-111 power pack is supplied. The cabinet is 19 inches long, 12 inches deep and 9 inches high. The Pilot power pack fits neatly inside, in back of the sub-panel, and the whole outfit presents a very pleasing and professional appearance.

Push-Pull Audio

Electrically, the P-E-6 comprises two stages of tuned r. f. amplification, with screen-grid tubes, a 227 detector, a 227 first audio stage, and a 171A push-pull stage. The screen-grid tubes and the r. f. coils are enclosed within individual shield cans. Tuning is done by means of a three-gang condenser, mounted in the center of the sub-panel. A formed aluminum sub-panel, completely drilled and all ready for assembling of the parts, is furnished. The purchaser does not have to drill a single hole.

The entire receiver may be wired without the front panel in place. This makes the work very easy, as all the parts are then easily accessible. With the wiring completed, the sub-panel is simply slipped against the back of the front panel, or the inside of the cabinet, and the dial bushing screwed to the condenser shaft. The two wires to the power switch and two more to the volume control (both of which are on the front panel) complete the job. The long flexible wires for the filament and plate "juice" are connected to the power pack, after being enclosed in a short length of large-diameter fabric tubing. This protective sleeve removes the sloppy appearance usual to a group of tangled wires.

The bottom of the cabinet supplied with the K-123 and K-124 kits is removable. When removed, the bottom of the sub-panel, on which all the wiring appears, is readily accessible for inspection, trouble-shooting, etc.

Screen Volume Control

The volume control is a potentiometer which regulates the screen voltage on the two screen-grid tubes. This is a very smooth and effective control, as it gets right at the heart of the set: the amplifying power of the screen-grid tubes.

The primary of the first r. f. transformer has a total of six turns, center-tapped. With an indoor aerial between ten and thirty feet in length, the full six turns are usually used. With an outside aerial, the three-turn section allows 2-degree selectivity if the wire is not more than fifty or sixty feet long. Of course, local conditions determine the actual aerial construction. In large cities, with a number of powerful stations in the near vicinity, the indoor aerial is recommended. In the country, a progressively larger outside wire is permissible.

The P-E-6 is intended for use with 171A output tubes, although 245's may be used if only the biasing resistor is changed. The 171A tubes are used because they have more than enough power handling capacity for most homes, and because a 171A power pack and 171A tubes are considerably cheaper than a 245 pack and 245 tubes.

The accompanying illustrations give a good idea of the overall appearance and construction of the P-E-6. No detailed assembly instructions are given here because the manufacturer supplies such data with the kits.

Unusual Lighting Effects

A MAGIC illuminating system which changes the shape of a room at will has been found in the most intensely lighted room in the world, atop a New York skyscraper dedicated to the science of sound.

The discovery was made when illuminating engineers, who sometimes move their meetings bodily aboard the Ile de France or other places known to have unusual lighting systems, staged their latest session in the Cathedral Studio of the National Broadcasting Company high up in the tower of 711 Fifth Avenue.

Dr. M. Luckiesh, wizard of Nela Park, Cleveland, personally explained the system he designed, and called into play the entire battery of lights within the studio for the first time. More than 200 lighting engineers were held spellbound by the shifting color effects from concealed batteries which seemed to make the walls of the room advance and recede, and by means of cunningly-designed shadows entirely change the architectural pattern of the studio.

The expert disclosed that the room they were in was the most intensely lighted in the world, being equipped for 23 watts per square foot as compared with 15 watts per square foot in the Cleveland Auditorium, where lighting engineers had specially planned for brilliant illumination as an aid to mass enthusiasm.

He explained that formerly designers were forced to imitate the lighting effects of nature, such as sunset, twilight, afterglow and moonlight. These were duplicated within the walls of the NBC studio, and then Dr. Luckiesh demonstrated the possibilities for creative imagination by the use of secondary colors. With the aid of these, reinforced by sunning shadows, he completely altered the architectural design of the studio from a cathedral to a severe Roman forum, and to a modernistic futurist design typical of the present day.

Dr. Luckiesh paid tribute to Raymond Hood, the architect of the National Broadcasting Company Building, who had evolved a design which adapted itself to the novel lighting system, and intensified the various effects desired. Further novelties were an effect of swift motion by "fountains of light" from giant chandeliers, and an impressionistic extravaganza he termed an "Eva Tanguay" effect.

The wizard of Nela Park also complimented M. H. Aylesworth, president of the NBC, on his vision in resorting to light effects for stimulating broadcast artists. Walter Demrosch and a symphony orchestra, with famous stars such as Galli-Curci and Maria Jeritza, have performed in the Cathedral Studio before a critical audience during nationwide broadcasts over the NBC System.

Dr. Luckiesh demonstrated that the NBC installation was a revolutionary departure from accepted methods, and predicted that it would pave the way to similar installations in giant theaters where lighting effects are under the supervision of artistic men.

At the switchboard for the demonstration was O. B. Hanson, manager of plant operations and engineering of the NBC, with George McElrath, NBC operating engineer, and a staff of electricians.

Prof. S. K. Barrett, professor of illuminating engineering at New York University and chairman of the New York section of the Engineers' Society, presided at the meeting and introduced the speaker.

Remote Control System

REMOTE control is the next step in the advancement of radio receiving. Many of the engineers in the industry have been working on this problem for some years, but so far the ideal "remote control" has not been uncovered.

According to Joseph Attardo, of 77 E. 107th Street, New York, New York, the present affairs on the market will not answer the purpose, since they are not real remote control. According to this contributor a real remote contol should have the radio set in some remote place like the cellar or a closet. He believes that his device, illustrated schematically and photographically on these pages, will be in demand.

Selector in Cabinet

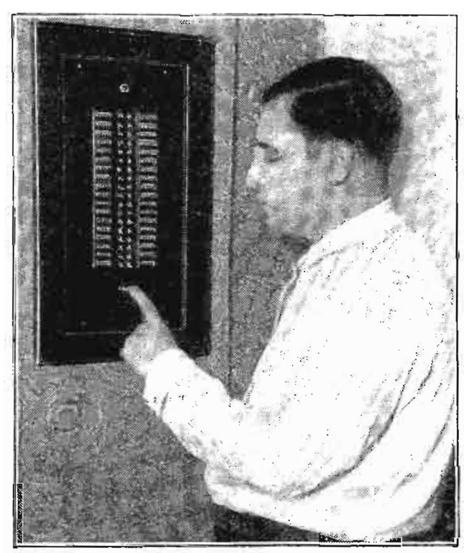
As shown in the photograph on page 118 the selector cabinet may be placed in the wall to suit the surroundings of that particular room. No expensive cabinet is required. Any number of speakers may be used.

A photographic illustration of the device on which patent application has been made by Mr. Attardo is shown on page 119. According to the designer the mechanism consists of a distributor, a small motor, a few gears and a set of relays. To attach the control device no changes need be made in the set itself. The remote control unit is workable on any tuning chassis on the market, provided the tuning is accomplished by a single knob.

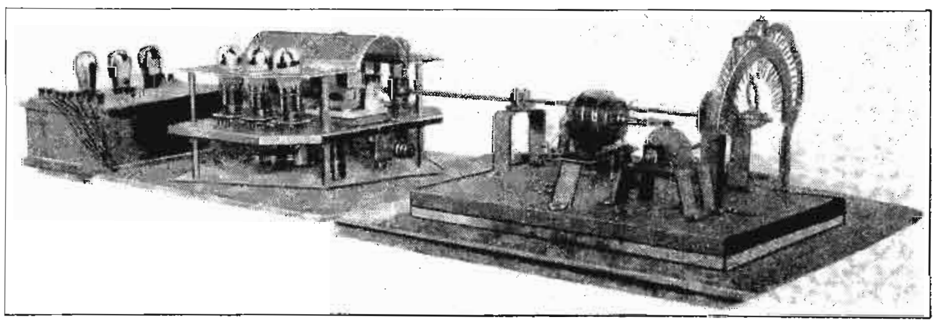
Mechanical Operation

The actual mechanical operation of this remote control device may be followed by tracing a single operation by means of a diagram shown in Figure 1. The on-off switch is numbered 43. Let us suppose that we wish to listen to WADC, which corresponds to push-button 25. We first close the on-off switch. This allows current to pass into the motor, 15, which is geared direct to the condenser shaft of the receiver. With the motor driving the condenser we press down button 25. This closes the contact at 21 and as the rotating switch point, 18, connected with the condenser shaft reaches contact 19 the circuit is established leading to the solenoid 40.

The solenoid exerts a magnetic force on the level 52, which in turn opens the motor contact at 47 and stops the motor driving the condensers. At the same instant the action of the solenoid is transmitted through a lever 61 to the second set of contacts at 63, closing them. These contacts are in the loud speaker circuit and when closed permit the signal to actuate the reproducer. It will then be understood that by following this



sequence the station desired is accurately tuned in before the loud speaker is made alive. This does away with the unpleasant effect of passing through carrier waves of undesired stations.



After the switch is thrown and the condenser has been revolved to the proper point to bring in the desired station and the motor has stopped, the radio receiver continues to function on that particular broadcast station until another push button is actuated or until the on-off switch is opened. If another program is preferred the only move is to select the proper button and push it. This automatically breaks the circuit on the first station, starts the motor and selector on its normal journey again which ends only when the new carrier wave is reached.

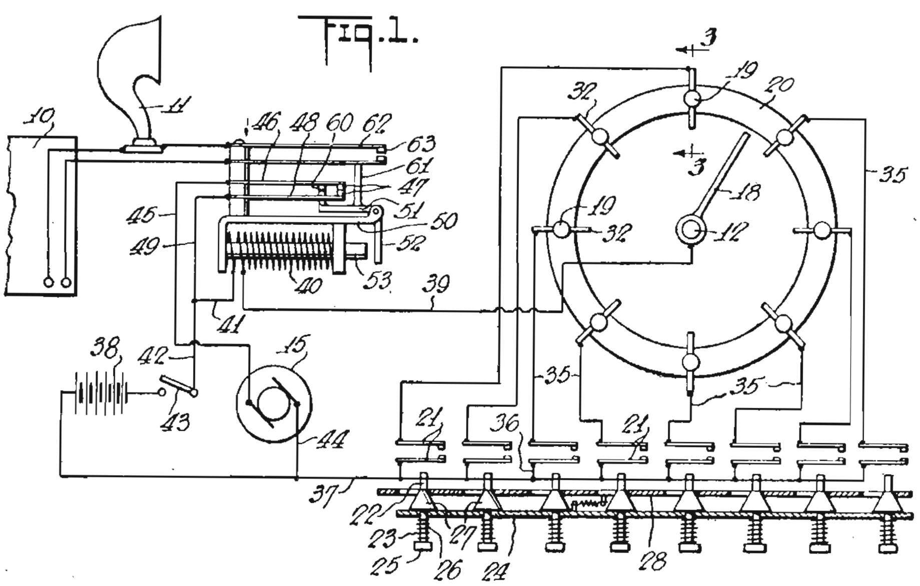


FIG. 1.

If the user is through with the set he merely opens the on-off switch which opens all circuits and apparatus but leaves everything in position for the next listener.

Reversing Motor

A means for reversing the motor when the plates have been rotated completely in or out of mesh has been found and is in the employment of a special relay which comes into play automatically at a predetermined point near the end of the scale. Of course if the old type condensers are used this relay is not necessary as the plates have no end stops and can be revolved completely around.

In the installation used as a demonstrator by Mr. Attardo the volume is controlled by a variable resistance located near the particular speaker to which the operator happens to be listening. If there is more than one speaker in use the volume of each can be controlled independently of the others by anyone of the numerous constant resistance devices now available on the market.

If an installation can be made while the house is under construction there is every reason for wiring the house for radio as well as light. The push button device being relatively inexpensive might be duplicated in all rooms where the radio should be controlled. Only one set would still be needed but a cable must extend from each panel of push buttons to the set itself.

KDKA Short Wave Receiving Station

THE listening post of station KDKA would be a dyed-in-the-wool radio fan's idea of Heaven. There, seated before three of the finest short wave receiving sets that engineers of the Westinghouse Electric and Manufacturing Company are able to build, he could listen to the high frequency stations of the world.

Holland, England, Australia, Java and other widely separated spots of the globe would all be within the reach of his delicately-tuned receivers. A polyglot program would be his. He would need to be a talented linguist to understand all he heard.

The present short wave receiving station of the Westinghouse Company is located on the William Penn Highway a short distance out of Pittsburgh and several miles from the KDKA transmitter in East Pittsburgh. It was established in 1928, although Westinghouse had done much short wave receiving work before that time. The small building that houses the sets, battery equipment and other necessary apparatus was erected in the fall of 1928 and checking of foreign stations began in October.

All the world has heard of some of the exploits engineered through this little station. Big Ben, the famous Westminister clock, has sent its deep tones to America via the short wave station and the KDKA transmitter. Holland, Germany and Australia have sent programs to the station which have been repeated for American listeners.

The KDKA listening post is equipped with three receiving sets. Two of them were built especially for the station. The other is of a type manufactured for the Government. The two special sets are so arranged that they can be hooked together and their incoming signals combined. At the same time the two are connected to different antenna sets. In this way, when the signal is fading on one set it may be full strength on the other. This makes possible more even reception.

Each set operates its own dynamic speaker. When the two sets which are used jointly have been tuned in satisfactorily their output is switched to a single speaker.

In addition to having three receiving sets the station has three separate antenna sets. Two are directional; that is, they will receive signals coming from only one direction. The other is a vertical non-directional antenna, of a type evolved by the Westinghouse Company in the early days of short wave work.

The two directional antenna sets are huge networks of wire suspended from wooden poles. The larger is 300 feet long by 80 feet wide and is hung 60 feet above the ground; the smaller is 150 feet long and 50 feet wide and is 20 feet above the ground. They are pointed toward England, Germany, Holland and Italy in a Great Circle route. In other words, the direction is Northeast across Newfoundland.

So well do these sets carry out the intentions of their designers that they will not receive signals efficiently from Canada despite the nearness of stations there. Signals from Commander Richard E. Byrd's camp in the Antarctic are received through the vertical antenna.

One of the interesting phenomena of the art is the amount of time the waves take to go from one point to another. Of course this is very short, yet it is noticeable. One of the most common examples at the short wave station may be demonstrated by tuning in on KDKA with a regular broadcast band receiver, and on a California station broadcasting the same chain program. In this case the program from KDKA is approximately one-tenth of a second ahead of the same one received by short waves from the West Coast. This time lag is mostly in the wires from New York to the short wave station rather than in the air time from the west, it is explained.

One of the most interesting examples is explained as follows: England was celebrating the recovery of King George with an all-Empire radio program. This was broadcast by 5SW in Chelmsford. From there it went to a Canadian Station and then to Australia. KDKA engineers listened to the program, not from England or Canada, but from Australia. This meant that the program traveled approximately 3,500 miles to Canada, 10,000 miles to Australia, then 9,000 miles to Pittsburgh. At the same time another short wave receiver was turned in directly on 5SW. The time lag was very noticeable in this case, the program reaching Pittsburgh by the way of Canada and Australia sounding like an echo to the direct program.

Governor Grid Amplifier System

THE circuit shown in the schematic diagram accompanying this article is contributed by Vincent J. Fabian, 1717 17th Street, N. W., Washington, D. C. According to the contributor patent applications have been made on this particuar circuit about which details are to be given in the following paragraphs.

According to the designer the coupling of the first two tubes is in every way unique. The grids are self biasing, no negative returns being used throughout and no C battery employed. According to a statement made by the designer the system is non-microphonic and the tubes cannot be made to oscillate internally or vibrate externally. The frequency response is said to be straight line where good transformer input is used and proper materials specified. According to the contributor the first two tubes receive a simultaneous signal. Both tubes amplify the initial signal. The amplified output of the first tube is superimposed upon the amplified stage in the second tube, which tube amplifies its own signal and the amplified input of the first tube. In other words, it is a first stage amplifier to the third stage tube and a second stage amplifier to the first stage tube. When the dotted-in resistor R-4 is used it also becomes still greater an amplifier by feeding back a portion of this combined signal upon both the first stage grids wherein it is utilized by these grids alternately in phase as in regeneration.

However, Mr. Fabian states this is not truly regeneration, as it is not fed back magnetically through a field feedback, but actual voltage, out of phase, is thrown directly in a physical circuit with a definite action.

According to an explanation made it is said that an incoming signal causes a change in internal resistance within the tube, the lowering and rise of I R drop permits the tube to leak off on one hand and become biased on the other. There is a great capacity in the circuit externally between the plates of these tubes and the grid. Internally the capacity is re-

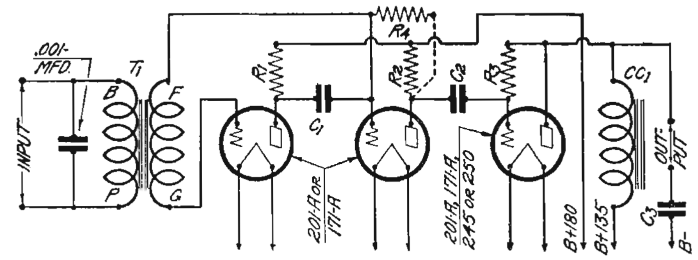


Fig. 1

moved. The larger capacity serves to isolate the d. c. proportion. The resistance between the grids and filaments is normally lower in operation and varies with the input in exact proportion to the input as this is the voltage amplifier.

While three stages are shown more may be used, the additional stages being coupled in the same method as in the third stage as shown. The theory of the last stage, according to Mr. Fabian, is quite simple. The resistor shunting the plate-grid is calculated at a mean to just bring this tube into a balanced position with the grid at zero. Thus there are two resistances between the grid and the plate. One a fixed resistance of from .25 to 10 megohms, depending upon the type of the tube, and the other the internal resistance of the tube, grid-plate. Capacity has been eliminated by the shunt resistor across this space but remains from filament to grid. There is an internal resistance from filament to grid which becomes materially lower in this arrangement. Thus the final balanced resistance internally in this tube is the square of the shunt resistor, the internal resistance of the tube grid plate in this condition, the elimination of capacity from grid to plate and the lowered resistance filament to grid.

Mr. Fabian says "the square will be found to be a semi-variable resistance from filament to plate, zeroed in the grid territory. An incoming a. c. sine varies the variable portion of the resistor in equal proportions at both halves. The fixed resistor, of course, remains constant. This is satisfactory for a normal operation and tubes in maximum operative state. Thus as the plate varies going negative and from positive to normal the internal resistance varies likewise, the shunt resistor maintaining grid at zero. When the plate varies the voltage drop across this resistor varies likewise and the voltage flows across it in an opposite direction and on the reversal it reverses and flows in opposite sine, out of phase. Thus again we have the voltage fed back to the grid."

According to the designer the constants of the circuit illustrated schematically in this article are as follows:

R-1 non-inductive Lavite 75,000 ohm,
R-2 non-inductive Lavite 57,000 ohm,
R-3 5 to 10 meghoms, 7,000,000 ohms average.
R-4 2 to 5 megohms (R-3 and R-4 should be measured),
R-5 Rheostat,
R-6 Rheostat,
R-7 with three tubes and using a Raytheon tube in the eliminator the value is about 1500 ohms. With two tubes approximately 2200 ohms is about the right value, wire wound type,
R-8 Centralab 250,000 or 500,000 maximum.
C-1 .005 to 1/10 mfd. or an average of .01 mfd.,
C-2 the same as C-1,
CC-1 for 201-A and 171 type tubes an output audio choke designed for the 120 power tubes is about right and not critical,
C-3 3 to 5 mfd.,
T-1 Amer-Tran DeLuxe.

Those interested in this particular circuit and wishing further information may secure it from the designer whose address is given at the beginning of this article.

Television—1930

An Analysis of Recent Television Progress and General Prospects for 1930

By JAMES W. GARSIDE
President, Jenkins Television Corporation

WHAT is the present status of television? That is a question paramount in the minds of radio fans today. People recalling how the automobile, telephone, radio, talking movie and other inventions developed from the laboratory to great industries, have been following television progress with more than normal interest.

Until a year ago, television was a subject of almost universal discussion. Today, one hears comparatively little about it, both in the press and in general conversation. Perhaps the best way to account for this reticence is to say that television is now looked upon in the cold light of a problem, rather than in the poetic vein of a glowing promise. A year or so ago, television workers fired with enthusiasm, were eager to expound the marvels that seemed practically within their grasp. They felt that the big job of achievement was done and that commercial application was the least of their worries—an after-thought to be speedily dispatched. But when they buckled down to real engineering development preparatory to actual production, they found that simple theory was easier than practice. Many became disillusioned and left the field entirely. Certain radio organizations, quickly convinced of the tremendous amount of pioneering still to be done, gave up all thought of immediate exploitation and assumed what may be termed a negative attitude. Those who remained in the field were thoroughly conversant with the multitude of technical problems yet to be overcome and, consequently, were those to overcome them first and talk later, which explains the lack of accurate information at the present time. Those organizations actively engaged in the development of television at present, are pushing ahead. They are making real progress. They prefer to talk of achievement rather than anticipation.

In television, as in radio broadcasting, the prime requisite is the transmission of suitable program material. Refinements in receivers and receiving practice will keep pace as a matter of course. In substantiation of this, it will be noticed that of the organizations actively engaged at present, practically all operate transmitters of some sort. In our own case, that is to say, the Jenkins Television Corporation, we have found it expedient to operate several transmitters continuously, while developing the embryo receiver or radiovisor into a practical instrument of home entertainment.

One of our transmitters, Station W2XCR, is located on the roof of our production plant in Jersey City. A second transmitter, Station W3XK, is located in Montgomery County, Maryland, just outside of Washington, D. C. Both stations are licensed for outputs up to 5 K. W., and, due to the efficiency of short waves, have a wide coverage.

At present our programs for the most part consist of "radio movies" or animated cartoons, following the ideas of C. Francis Jenkins, television pioneer and our vice-president in charge of research. The shadowgraphs or animated cartoons are permanently recorded on standard motion picture film. The film is run through a pick up device resembling a standard motion picture projector, and, in the case of W2XCR, broadcast on a wave length of 107 meters. This wavelength, incidentally, was recently changed from 139.5 meters by authority of the Federal Radio Commission, to avoid interfering with other television broadcasters. Simultaneous with the new wave length change, the Jersey City transmitter has been materially improved. To begin with, a new transmitter has been designed and put in operation, which will enable us to obtain 100 per cent modulation of the carrier wave over the 30 kilocycle side band width. This will provide detail for our images and will greatly facilitate the transmission of half-tones. The power of the transmitter has aso been increased to the point where advantage can be taken of the full output allowance. A regular schedule of transmission has been arranged, and the station is on the air on week days from 3 to 5 in the afternoon and from 8 to 10 at night. The Washington transmitter, W3XK, also maintains a regular schedule, broadcasting from 8 to 9 P. M. on week days. Both stations operate at the maximum power allowance consistent with minimum interference with other radio services.

The Jenkins programs consist of vocal announcements, explaining the picture to follow and what adjustments should be made if certain characteristics are present. Thus if a certain portion of the picture is white instead of black, or if it is streaked or spotted, or if certain details fail to appear, the receiving operator knows what to do. Following this, a number of specially prepared animated cartoons such as prize fights, domestic comedies and so on, are broadcast. By this time the receiving operator should have his apparatus properly adjusted. A reel of standard moving picture film with half-tone detail, is next transmitted. It will usually be found that this does not come in quite as clearly as the animated cartoons, for several reasons. It is, of course, far more complicated to transmit, but the chief drawback is to be found in the short-wave receiver used in conjunction with the home radiovisor. Most of these receivers are of the regenerative type and consequently have a frequency cutoff of about 3000 cycles. Incidentally, we are working on the development of a short-wave receiver that will be non-regenerative yet powerful enough to intercept fairly distant or weak signals. The problems confronting us in this task can be readily appreciated.

In the past year we have made a number of important improvements in our commercial home radiovisor. Jenkins radiovisors have been set up at various points in the field with a view to checking the operation of the transmitter. Many interesting effects have been achieved by means of the radio road tests, so to speak, and considerable progress in transmission as well as reception is directly due to our findings.

Among other improvements, we might mention the erection of a vertical, non-directional aerial at station W2XCR. This aerial consists of a copper mast 110 feet high, located on the roof, operating in conjunction with a counterpoise ground. The copper mast antenna comprises a number of sections of corrugated copper tubing such as is used for leader pipe on the outside of buildings, reinforced with soldered brass bars and joined together with wooden plugs. The vertical antenna thus formed is guyed in all directions and reinforced with wire bracings so that it cannot buckle or collapse. The copper mast rests on an insulated platform. Connection to the transmitter is made at the bottom of the mast. The resultant antenna system, being a single vertical conductor and radiator, is absolutely non-directional, which is most desirable for mass communication or broadcasting. The ground equivalent is in the form of a counterpoise made of many parallel wires supported a few feet above the roof, and surrounding the base of the copper mast antenna. The efficiency of this system has been attested by television lookers-in in Chicago, who report nightly reception of the radio movies.

Inductive interference is the bane of the television broadcaster. The most intense measures must be taken to eliminate it. In radio broadcast reception, interference of an electrical nature is not pleasant, but at least it does not render the program indistinguishable. In television, however, interference makes itself manifest in the form of streaks and smears. We have found it necessary to shield everything in our transmitting stations, and, to this end, not only are the various circuit components enclosed in aluminum and copper shields, but entire units, operators and all, are enclosed in copper mesh cages. All the critical conductors are copper sheathed as well, and the entire assembly grounded.

In the matter of television receivers, we feel that with the advent of some 12 to 15 transmitters in the television field, broadcasting experimental programs, the interest in home television is bound to increase rapidly. Accordingly, there will be need not only for a complete television receiver for those who do not understand or care to undertake the construction of such a receiver, but also for a moderately priced and practical kit for assembly by the experimentally inclined.

With such requirements in view we have developed a simple radiovisor, completely built and ready to operate, that will be made available to the public very shortly. In addition to the complete radiovisor, we shall provide a practical television kit or set of matched parts, with which any handy man or boy may make a satisfactory receiver. This kit will contain all the necessary parts such as scanning drum, neon tube, and an ingenious form of synchronous motor.

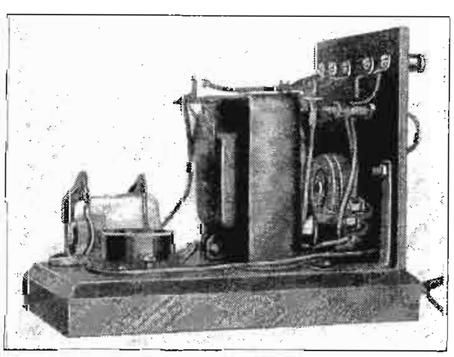
Because of the relatively poor results obtained with the usual short-wave receiver, particularly with half tones signals, we are developing a non-regenerative short-wave receiver which will eliminate distortion caused by regeneration as well as the 3000 cycles as in the usual type.

From the foregoing it is evident that television is making genuine progress. Nothing spectacular—no world-rocking developments—but good steady headway, based upon the sound experience of actual practice and many disappointments. It must be realized that television has a long way to go. It is heartening knowledge, however, that it is getting there slowly but surely, and has reached the stage where it may be offered to the public.

We grew up with radio. So shall we grow up with television. We believe it sound, therefore, to state that 1930 will see many thousands of radio enthusiasts in the United States enjoying the novelty of this art. Figuratively, these television fans will remind us of the pioneer radio listeners with headphone and crystal detector, enjoying, building and contributing to the progress of the young science. Thus we may hope in several more years to have television in the hands of the uninitated, non-technical, average man, solely on its merits as a medium of home entertainment, when it shall be incorporated with the sound broadcast receiver for complete radio enjoyment.

Speech Amplifier Attachment

THE speech amplifier attachment described below is a contribution of Karl F. Oerlein, of Fred F. Oerlein & Son, radio service specialists, 1246 N. 12th Street, Philadelphia, Pa. Mr. Oerlein says he has found the device very convenient and handy and thinks that it might be of interest to readers of our magazine.



It is often found desirable to amplify speech such as in public address systems. The expense of a good address system often prohibits its use, as the cost usually runs to several hundred dollars. Here is an attachment which will perform in a first class manner and can be constructed for less than fifteen dollars. Its volume and clarity depend solely on the audio amplifier of the radio with which it is to be used. Most modern sets will give good

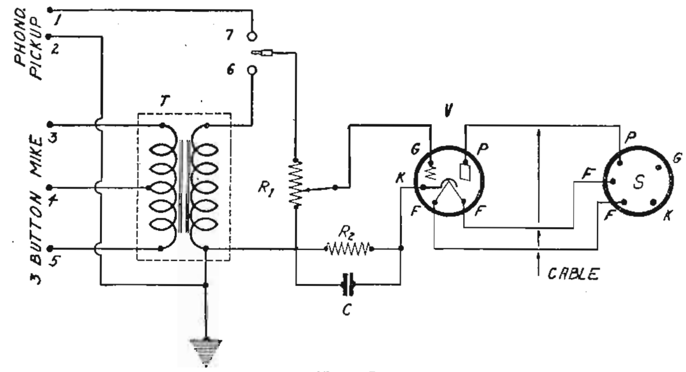


Fig. 2

volume as well as clarity. The uses to which this device may be put are numerous, especially in schools, churches and the home. In schools it may be used for class nights, small dances where an occasional announcement is to be made, socials, or at any public gathering.

Many modern electric radio sets are now equipped for phonograph reproduction. By means of a telegraph jack it is only necessary to insert the plug which is connected to the pick-up device into the jack. This utilizes the audio amplifier of the radio. It is, however, generally unsatisfactory to insert a microphone such as a telephone transmitter in place of the pick-up because the impedance of the transmitter is very low compared with the impedance of the tube or the transformer into which it is to work. Hence, an external impedance matching transformer is necessary for good reproduction when a microphone is used. The primary of the transformer should match the impedance of the microphone while the secondary should match the impedance of the tube.

Constants Shown

A description of the constants appearing in the schematic diagram, Fig. 2, is as follows:

Terminals 1 and 2, connection for phonograph pick-up, throw switch to 7.

Terminals 3 and 4, connection for single button microphone; throw switch to terminal 6.

Terminals 3, 4 and 5, connection for double button microphone, throw switch to terminal 6.

T is a microphone transformer, Silver-Marshall No. 242.

R-1 is a volume control, Electrad Royalty 200,000 ohms.

R-2 is an Electrad grid suppresser of 1500 ohms.

C is a Tobe 200-volt ½ mfd condenser.

V is a 227 detector tube, while *S* is the base of an old detector tube with five prongs.

The device is simply an arrangement whereby an impedance matching transformer is inserted between the microphone and the detector tube of the set. If the set is not already provided with a phonograph pick-up jack this arrangement will make it available. Even if the set has a pick-up arrangement it is usually connected after the detector tube and since this device makes use of the detector tube, a much greater amplification is obtained from the set.

Either a single button hand microphone or a double button studio microphone can be used. To change from microphone to records one need only thrust the jack from 6 to 7. This is so quickly done that it is possible to intersperse record playing with announcements.

Parts Needed

The parts used in the writer's device were as follows:

1 Silver-Marshall No. 242 microphone transformer
1 UY socket, Eby
1 Electrad Royalty 0-200,000 ohms volume control
1 Electrad grid suppressor—1500 ohms
1 ½ mfd condenser—Tobe, 200 volts
2 Phone tip jacks
1 Phone tip
5 Binding posts
25 feet rubber covered hook-up wire
1 4 x 4½ x 3/16 wood panel
1 base of burned-out detector tube

See Music Waves Produced

BY means of a new device, known as the projection osiso, it is now possible for singers, speakers, actors, pianists, violinists, and other vocal and instrumental artists to see the sound waves they produce dance visibly across a screen, just as they dance invisibly through the air to the ears of their audience.

This device was developed by C. Anderson, engineer of the Westinghouse Eectric and Manufacturing Company, Newark, N. J., in collaboration with William Braid White, acoustic engineer of the American Steel and Wire Company, a subsidiary of the U. S. Steel Corporation, who is using it in a series of studies of musical sounds at Steinway Hall with the co-operation of Messrs, Steinway and Sons. It consists of several different parts. The sound waves are caught by a microphone, which can be placed in any convenient location, and are conveyed electrically to an osiso, which consists essentially of a delicately suspended mirror that is oscillated in unison with the received sound waves. A beam of light, directed on this mirror, is reflected by it to a system of revolving mirrors, which, in turn, project it upon a screen where it can be viewed by any number of people.

When all is quiet around the microphone, a long white line is seen on the screen, but as soon as any kind of a sound reaches the sensitive electrical ear, the white line on the screen is thrown into waves, much as a clothes line is thrown into waves when its end is shaken. The form of these waves varies with the sound producing them, and they range from gentle ripples, produced by low pure tones, to the most intricate of patterns produced by loud complex cords and noises.

"Two practical investigations are now being carried on with the aid of the projection osiso," stated Mr. White, "although its possibilities seem almost endless.

"In the first place, we are using it to study the construction of pianos and other musical instruments in order to improve them. You need only watch the waves formed on the screen to notice that when I strike successive keys on this piano, though I strike each with approximately the same force, some notes produce distinctly larger waves than others. This means that those particular notes produce louder sounds than the rest due to some peculiarity in the construction. Your eye can see it although, if you are not a musician, your ear may not detect the difference. Secondly, when I strike various notes and then hold the loud pedal down after each, you can readily see that the vibrations last longer in some cases than they do in others, which shows that the sounding board reverberates better at some points in the scale than at others. Such characteristics, together with others which only an expert would notice, are investigated when once detected, and in due course eliminated.

"Another application of this instrument," continued Mr. White, "is to help the student improve his technique. The sound waves produced by the touch of a master pianist differ from those produced when the same keys are struck by an unskilled hand. Permanent records of the wave patterns produced by such distinguished musicians as Harold Bauer, Rudolph Ganz, Ernest Schelling, Josef Lhevinne, Mischa Levitski, Olga Samaroff, John Powell, and others have been made by means of the older photographic type of Osiso in the acoustical laboratory of the American Steel & Wire Company at Chicago, and, with these before him, the student can endeavor to reproduce them on the screen of the Projection Osiso. It seems certain that improvement can be attained in this way, but it also seems certain that no amount of effort will transform a good clerk into a great artists, for one of the things that the Osiso has demonstrated is that each artist produces patterns as individual as his signature, and though others may be able to imitate these patterns fairly well, as a good forger can imitate a signature, apparently no one else can reproduce them exactly. The artist's personality, therefore, remains the principal element in the secret of the power he exerts over his audience.

"Obviously, however, the grosser errors in playing, singing, and speaking can be overcome with the help of this instrument, since, with the eye to aid the ear, an error can be more readily appreciated and its correction effected.

"Master musicians are also interested in studying the details of their own technique. For example, one well-known pianist has learned by osiso sound-wave photographs that he can produce a single note with at least 18 different gradations, each individual both in tone color and loudness. He can thus determine the actual difference between his 'cantabile' and his accompanimental notes, between his 'forte' and his 'Fortissimo,' and so on. Though great artists are in many ways beyond instruction, they nevertheless gain much from accurate information as to their own work, and the osiso is capable of showing them many things that have heretofore escaped direct observation. To mention one small detail, we were able to show one musician that his finger nails made little clicks when he struck the keys in a certain way, and though he probably never realized that fact, this certainly had an effect, however minute, on his playing, whether favorable or unfavorable is something for him to determine."

Mr. White's chief interest lies in the improving of wire for musical instruments, since the American Steel & Wire Company is a large producer of wires for pianos and other instruments, but in order to distinguish between effects produced by the artist and those due to the construction of the instrument, he has been compelled to analyze the work of artists and is thus laying the foundations of a new method of art study.

The osiso in its older form, which is suitable for photographing waves and for scientific work, has been used extensively in a wide variety of electrical and acoustical investigations. It is, for example, the instrument used by Byrd's radio experts on the Antarctic Continent in their study of the behavior of radio waves, and it is also being employed by Dr. Max Goldstein for instructing the totally deaf to speak correctly. The present development, by magnifying the wave forms to any desired extent, enlarge its range of usefulness, especially in the educational field.

Theremin Produces Musical Tones by Beat Frequencies

(*Continued from page* 56)

be found in Figure 3 which is another of the Theremin devices, similar to an electrical cello. The instrument is played on by means of a finger board and the volume of the tones is controlled by a lever. The instrument is built for volume exceeding that of an orchestra.

Still another combination is the one shown in Figure 4 which is a combined radio receiving set and a theremin device. The photograph in Figure 4 shows the internal construction of the device.

There is practically no limit to which the principles laid out by Dr. Theremin can be carried. It would not be very difficult to visualize in the future an entire orchestra made up of electrical devices producing musical sounds, the performers being able to duplicate tones not possible with the ordinary instrument.

Generating Sounds

According to the patent application the invention relates to sound generating apparatus or instruments of the type em-

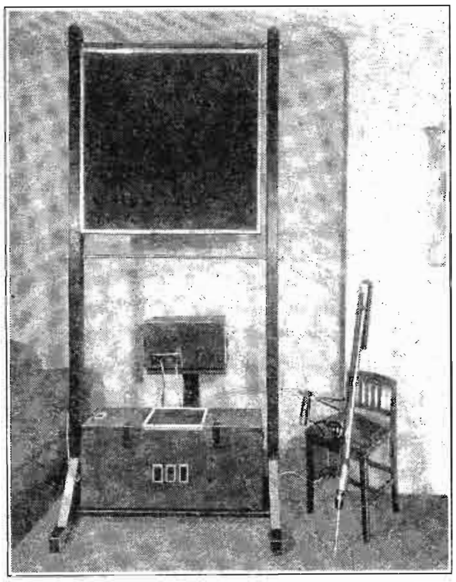


Fig. 3. In this photograph may be seen another electrical instrument which produces sounds similar to the Theremin. This is, however, an electrical cello which is played upon by a finger-board. This was designed to produce a volume far in excess of an orchestra

bodying an electrical vibrating system. It aims to provide a novel method of and means for producing sound in musical tones or notes of variable pitch, volume and timber, in realistic imitation of the human voice and various known musical instruments. One object of the invention is to provide a simple and inexpensive instrument capable of producing musical tones according to the method embodying the same, the pitch, volume and timbre sounds may be varied over a wide range, and with delicate graduation.

An instrument embodying the invention comprises a sound receiver, such as the telephone receiver or loud speaker, connected to an oscillating system adapted to be controlled or effected by an object or objects, such as the hand or fingers of an operator held in relative position in proximity to an element of the system. For example, an electrical oscillating system including oscillator tubes of the electro-ionic type may be employed, and the circuits of the system may be so correlated that the frequency or frequencies of the electrical oscillation will vary in accordance with the variations in the electrical capacity or other characteristics of the controlling circuit caused by the movement of external objects such as an operator's hand or fingers as above stated. The operator's hands, or the objects moved by him are not required to make physical contact with the instrument, but if the instrument is arranged to permit such contact the generation or production and control of the sound is not affected directly thereby as is the case with the ordinary musical instrument.

Two Oscillators Used

In order to generate clear sound or musical tones and permit ready control thereof, a plurality of oscillators are employed, having a frequency above the audible range but interacting with each other to produce interference or beat notes of audible frequency. The frequency of one or more of the oscillators is controlled by the operator to produce beat notes of the desired pitch. The apparatus in preferred form also embodies means for controlling the volume and timbre of the music.

The improved method and means of this invention producing sound or musical tones possesses great advantages over ordinary musical instruments of the prior art. Apart from the simplicity in construction and operation of an instrument embodying the invention, it is capable of producing clear and pure musical tones in realistic imitation of a known instrument, such as the violin for example, and may be so constructed that the characteristics of the sound or music produced thereby may be changed as desired in imitation of various other instruments, whereas the ordinary musical instrument such as the violin produces sound tones of fixed and well known characteristics. The instrument is not limited, however, to the production of music but may be employed to generate sound or operate signals for various purposes.

Other Objects

Other objects and advantages of the invention particularly with reference to electrical elements and circuits and their arrangements in systems for securing various results in different constuctional embodiment which have been devised, will appear from the following description considered in connection with the accompanying drawings in which are shown several modified forms of the invention. Various practical embodiments of the invention are hereinafter described in order to make a full and complete disclosure, but the invention obviously is not limited to the specific arrangement shown and it is to be understood that no limitations thereon are intended beyond those set forth in the appended claims.

Numerous Elements

A preferred form of instrument embodying the invention and operable according to the method of embodying the same comprises the following elements:

A control element or electrode with relation to which an object such as the hands or fingers of an operator are moved to control the pitch and the character of the sound tones emitted by the instrument. Said element does not function like the antenna in a wireless receiver or apparatus, i. e., it does not receive or detect radiant energy transmitted from a distant station, but has a novel and radically different function that will appear from the details in connection with the various circuit arrangements.

Oscillating circuits adapted to produce one or more deep notes of audible frequency.

Means for regulating the volume of the sound tone.

Means for switching individual sound tones on and off as desired.

Means for controlling the timbre of the sound tones.

Means for eliminating or nullifying the natural oscillations of the amplifier or reproducer to prevent the production of undesirable noises or distortion of the sound tones.

In broad aspect the means of the invention comprises an oscillating system capable of producing audible sound tones and adapted to be influenced or affected by an object or objects such as the hands or fingers of an operator moved in proximitive relation to an element thereof, together with a sound reproducer operatively connected to some system. Stated differently, the invention embodies a method and means for producing sound or musical tones characterized by an oscillating system in which the period is varied and the characteristic sound emission from which is changed by the movement of an object or objects in proximitive relation to an

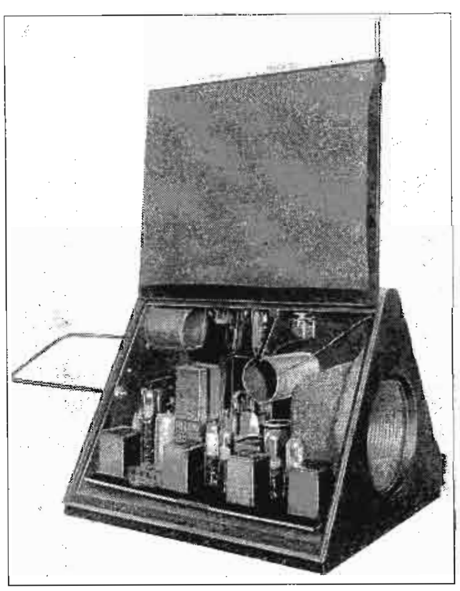


Fig. 4. Another extension of the Theremin idea is depicted in this picture where the reader may see the internal construction of a combined radio receiving set and Theremin. The loop at the left is one of the control elements while the rod extending upward at the right of the raised cover is the other controlling electrode, one being for volume control and the other being for tonal control

element thereof. The said system may be electrical and so arranged that movement of an operator's hands or fingers will change the electrical characteristic thereof such as the electrostatic capacity between certain elements which determine the period of the oscillator. It is obvious that other types of oscillating systems and other means of control may be employed to accomplish the same results.

Above Audible Range

The oscillating frequencies of the oscillators are preferably above the range audibility but are nearly the same so that the interference frequencies produced in the circuit of the tube will be relatively low and produce a deep note of audible pitch in the loud speaker. The frequencies of vibrations in the circuit of the tube may be called audible frequencies as they will have substantially the same number of vibrations as the vibrations of an audible sound wave. The pitch of this note and the presence and strength of the overtones are controlled by selection and arrangement of the condensers, inductances and other elements in the circuit in a known manner.

The frequencies of an oscillator may be of the order of 500,000 cycles per second, the precise frequency being so chosen that no interference with broadcast reception is produced. The values of inductance and capacity employed in the oscillating circuit are selected in accordance with well known principles to provide the desired frequencies and the variation of the capacity of the variable oscillator is affected by the change of capacity of the control electrode which change in capacity in instruments that have been built is of the order of 10^8-10^8 microfarads. It will be understood that this change in capacity affected by external control is so correlated with the capacity in the oscillator circuit that the resulting range in pitch of the musical instrument covers several octaves.

The sound generated in and emitted through the loud speaker is also controlled by the movement of an object or objects such as an operator's fingers in proximitive relation to the electrode or control element which is connected to the oscillating circuit and to the grid of the oscillator. The electrical characteristics of the set control element influence the period of frequency of the oscillator and the character of the deep note in the reproducer. As the operator's fingers are moved in suitable relationship with set control element the pitch of the deep note in the reproducer is varied and continuous variation may be produced with most delicate graduations for the continuous movement of the fingers.

Capacity Changes

This control is primarily the result of a change in the electrostatic capacity between the control element and the ground potential, or between the control element and the other elements of the circuit. Therefore, it is obvious that other objects than the operator's fingers would be operable to vary the tone produced. Furthermore, it will be appreciated that the amount and direction of the controlling movement will depend somewhat upon the dimensions and arrangements of the control element which may be of such character that movement of the fingers to the extent required to play an ordinary instrument such as the violin, will produce a corresponding effect and note change in the present sound generating instrument, so that one who has learned to play the violin or some other instrument will have little difficulty in playing the present instrument.

Lincoln DeLuxe Ten Now Using Five Tuned Intermediate Stages

(*Continued from page* 53)

Tuning the Primary

After determining that the primary of the transformer be tuned there is still left one remaining possibility, namely, tuning both the primary and secondary. Tuning the secondary, of course, would eliminate the short circuiting effect of the input capacity of the tube. When both the primary and secondary are tuned a maximum transfer of energy no longer takes place with close coupling. The condition for maximum transfer of energy, to the contrary, a very loose coupling. Since space limitations eliminate the possibility of separating the primary and secondary by a space of 6 or more inches, depending upon the type of coil used, it was necessary to run one of the coils so that it was practically at right angles to the other. It was found, however, that there is no such thing as perfect shielding. The gain which can be obtained with the tuned primary transformer is more than can be successfully used. The tuned primary transformer gave a gain of 75 per stage at a frequency of 475 kilocycles with complete copper shielding and by-passing. It was found, however, that this gain had to be reduced for stable operation. For this reason the tuned primary and secondary transformer was found to offer no advantages, from a standpoint of the amount of amplification which could be used in the set, and, had the distinct disadvantage of an additional adjustment for each stage.

The consistent performance of this new receiver has entirely revolutionized the designers' ideas of the possibility of radio reception. The high noise level in the past has made this distant reception very unpleasant to listen to, and the high amplification in the Lincoln DeLuxe 10 with ability to tune below the noise level, and, at the same time, its extreme selectivity allowing every channel to register, has come closer to producing the ideal receiver.

A. C. Self-Modulated Oscillator May Be Help in Servicing Sets

(*Continued from page* 108)

device for maximum deflection of the meter. When this condition is had the receiver is in line. This point of adjustment should be checked at approximately two places on the dial, some place preferably near 700 kilocycles and 1200 kilocycles.

Parts Used

The list of parts as used in this tester was:

1 Hammarlund aluminum shield
3 X-L type G-5 vario-densers
1 Hammarlund 50 m. m. f. midget variable condenser
1 Frost 1000-ohm rheostat
1 Benjamin 9040 4-prong socket
1 10-watt 110-volt lamp
1 Standard porcelain base receptacle
1 Silver-Marshall No. 121 shielded .00035 coil
1 Thordarson 2902 transformer
1 Frost 30-ohm rheostat
1 Jewell pattern 64 current squared thermo coupled galvanometer
1 General radio switch arm
3 General radio switch contacts
1 Bakelite panel to fit
3 Eby binding posts

S-M 722 D. C. Now Designed For Use on Batteries With High Gain

(*Continued from page* 51)

1 Silver-Marshall 30X selector coupler
1 Silver-Marshall 122 shielded r. f. coil
2 Silver-Marshall 123 shielded r. f. coils
1 Silver-Marshall 275 r. f. choke
1 Silver-Marshall 270U push-pull input transformer
1 Silver-Marshall 258S push-pull output choke
1 Silver-Marshall 818 hook-up wire
3 C-R 222 tube sockets
3 C-R 112A tube sockets
2 Potter 30B condenser blocks
1 Polymet .006 large moulded condenser
1 Polymet .00015 condenser
1 Polymet .0005 condenser
1 Yaxley 10 MJP 10,000 ohm potentiometer
2 Yaxley 422 insulated tip jacks
1 Carter 2A closed circuit jack
3 Yaxley 815C 15-ohm center-tapped resistor (red)
2 Durham 2 megohm 1-watt resistors
1 Durham 60,000 ohm 1-watt resistor (blue)
1 Carter sub-base rheostat
1 Durham 20,000 ohm 1-watt resistor (orange)
1 H & H 1565 on-off switch
1 5-lead battery cable, 54-in.
2 KK 817 brown wood knobs
3 Moulded binding posts
1 Set of hardware

Engineering Show Might Take Place of Annual Consumer Show

(*Continued from page* 82)

an engineering show would be received favorably, although I shall be much interested to see the results of any such movement as you may be able to imitate in this respect."

Walter E. Holland, chief engineer, Philadelphia Storage Battery Co., Philadelphia, Pa.: "Good idea to cut out consumer's shows, but there is no real need for an engineering show in my opinion. If held at all it should come about six months ahead of the June trade show."

J. W. Million, Jr., chief engineer, Bremer-Tully Mfg. Co., Chicago: "The logical program as followed by motors is new developments introduced twice a year. The automotive trade show is in January. The radio in June might well be July, I believe. Automotive improvements are introduced in August to stimulate sales in the declining fall period. New improvements in radio are and should be introduced in January to stimulate sales in the declining sales period. Engineering conventions and shows should precede such periods by two to three months."

F. J. Marco, chief engineer, Audiola Radio Co., Chicago: "It seems that if you hold such a show earlier than March (or February at the earliest) most parts manufacturers will not be ready with their new products. We have had this experience in the past, particularly with manufacturers of the larger units, such as tuning condensers, new designs of r. f. coils, etc. While I am sure that the engineering fraternity will be almost unanimous in its response favoring such a show, I wonder if it would be economic from the standpoint of the exhibitors. It seems to me that there would be almost as many exhibitors as potential customers, since there are certainly less than fifty radio manufacturers in the country who are quantity purchasers of parts."

Arthur Moss, president, Electrad, Inc., New York: "It is our opinion that a show of this type would be very valuable to the entire radio industry and should be held in the early part of November under the auspices of the I. R. E. and R. M. A. combined. The place should be carefully chosen preferably not in New York or Chicago but a location convenient to both. It, of course, will be essential to have suitable facilities for the show, for in my opinion this would be a very popular show. Would be very much interested in obtaining a report covering this entire matter.

R. H. Langley, director of engineering, Crosley Radio Corp., Cincinnati, Ohio: "I can see a considerably potential value in such a show provided it was properly managed and sponsored."

Henry G. Richter, vice president, Electrad, Inc., New York: "It is quite evident that two shows as outlined would be of great value to the industry. I believe that the most logical time for an engineering show would be in the early part of November because the engineers at that time, in my opinion, are laying the groundwork for their circuit design. This show, I think, should be held at some point convenient to the middle west and eastern parts and set manufacturers. Do not think it should be in Chicago or New York but at some place where the necessary arrangements could be made. This show should be held in my opinion under the auspices of the I. R. E. or the R. M. A. in conjunction with the I. R. E. Do not believe that the R. M. A. should have complete charge of an engineering show but it might be well for them to work with our engineering society on this matter"

In the following paragraphs we are indicating the opinions of the various engineers listed below. In each paragraph the date is shown first, next the city where the show might be held and last the organization under whose auspices it should be held.

How They Replied

K. E. Rollefson, Chief Engineer, National Electric Products Co., Chicago: (September or October) (Chicago and New York alternately) (R. M. A.)

A. A. Woods, Chief Engineer, All-American Mohawk Corp, Chicago: (First quarter) (Chicago) (R. M. A.)

A. Crossley, Chief Engineer, Howard Radio Co., South Haven, Michigan: (January) (Chicago or New York) (R. M. A.)

W. J. Schnell, Chief Engineer, Electrical Research Laboratories, Chicago: (January or February) (Chicago) (Parts manufacturers and engineering services.)

E. R. Stoekle, Chief Engineer, Central Radio Laboratories, Milwaukee, Wis.: (December) (Chicago) (R. M. A. or I. R. E.)

W D. Pack, Chief Engineer, Utah Radio Products Co., Chicago: (Not later than February 1st) (Chicago) (R. M. A.)

Roger Williams, Chief Engineer, Triad Mfg. Co., Inc., Pawtucket, R. I.: (May or before) (New York) (R. M. A.)

W. A. Ellmore, Chief Engineer, Carter Radio Co., Chicago, Ill.: (November) (Middle West) (R. M. A. or I. R. E.)

Roger M. Wise, Chief Engineer, Sylvania Products Co., Emporium, Pa.: (January or February) (New York) (I. R. E., R. M. A. or both.)

Leslie F. Curtis, Chief Engineer, American Bosch Magneto Corp., Springfield, Mass.: (March or April) (New York or Chicago) (R. M. A.)

E. E. Collison, Chief Engineer, Capehart Corp., Ft. Wayne, Ind.: (March) (Chicago) (R. M. A.)

R. L. Osborne, Chief Engineer, Dongan Electric Mfg. Co., Detroit, Mich.: (June) (Chicago and New York alternately) (R. M. A.)

Ford Studebaker, Chief Engineer, A-C Dayton Co., Dayton, Ohio: (December) (Chicago or Cleveland) (Engineering Division R. M. A.)

C. F. Wolcott, Chief Engineer, The L. S. Gordon Co., Chicago: (March) (Chicago) (R. M. A.)

Robert S. Doak, Chief Engineer, Premier Elec. Co., Chicago: (January) (Chicago) (R. M. A.)

F. E. Johnston, Chief Engineer, Amrad Corp., Medford Hillside, Mass: (December or January) (Chicago or New York) (R. M. A.)

C. F. Stromeyer, Chief Engineer, Cable Radio Tube Co., Brooklyn, N. Y.: (January) (Chicago) (R. M. A.)

David Wald, Chief Engineer, United Scientific Laboratories, Inc., New York: (January) (New York) (R. M. A.)

Nathan Goldman, Chief Engineer, Duovac Radio Tube Corp., Brooklyn, N. Y.: (March or April) (New York) (I. R. E.)

M. Bjerndal, Chief Engineer, c/o Hardwick Hindle, Inc., Newark, N. J.: (December or January) (New York) (I. R. E.)

V. A. Johnson, Chief Engineer, Supreme Instruments Corp., Greenwood, Miss.: (January) (Chicago) (R. M. A.)

R. H. Caldwell, Chief Engineer, Colin B. Kennedy Corp., South Bend, Ind.: (January) (Middle West) (R. M. A.)

C. C. Eickhardt, Chief Engineer, Igrad Condenser & Mfg. Co., Rochester, N. Y.: (November or December) (Chicago) (R. M. A.)

Geo. B. Horn, Chief Engineer, Dudlo Mfg. Co., Ft. Wayne, Ind.: (February) (Chicago or Pittsburgh) (R. M. A.)

Paul Hetenyi, Chief Engineer, Polymet Mfg. Corp., New York City: (March or April) (New York or Chicago) (R. M. A.)

E. S. Pridham, Chief Engineer, The Magnavox Co., Chicago: (April) (Chicago) (R. M. A.)

C. P. Mason, Chief Engineer, Stewart-Warner Corp., Chicago: (November) (Chicago) (R. M. A.)

N. C. Schellenger, Chief Engineer, Chicago Telephone Supply Co., Elkhart, Ind.: (May) (Chicago) (R. M. A.)

E. J. Doyle, Chief Engineer, Transformer Corp. of America, Chicago: (December) (Middle West) (R. M. A.)

W. A. Fricke, Chief Engineer, Yaxley Mfg. Co., Chicago: (April) (R. M. A.)

M. Heald, Chief Engineer, Thordarson Elec. Mfg. Co., Chicago: (February) (R. M. A.)

E. K. Oxner, Chief Engineer, High Frequency Laboratories, Chicago: (January) (Chicago) (Parts Manufacturers)

J. W. Million, Chief Engineer, Bremer-Tully Mfg. Co., Chicago: (October and March) (New York and Chicago) (I. R. E.)

R. H. Langley, Director of Engineering, Crosley Radio Corp., Cincinnati, Ohio: (January) (Cleveland) (R. M. A.)

Henry G. Richter, Chief Engineer, Electrad, Inc., New York: (November) (Middle West) (I. R. E. or the R. M. A. in conjunction with the I. R. E.)

F. J. Marco, Chief Engineer, Audiola Radio Co., Chicago: (February or March) (Chicago) (R. M. A.)

C. E. Stevens, Chief Engineer, Stevens Mfg. Co., Newark, N. J.: (April) (New York or Chicago) (R. M. A.—Good Idea.)

P. G. Andres, Chief Engineer, Temple Corp., Chicago: (January) (New York or Chicago) (R. M. A.—Excellent idea.)

D. E. Replogle, Chief Engineer, Jenkins Television Corp., Jersey City, N. J.: (January) (New York) (R. M. A.—Excellent idea.)

W. E. Holland, Chief Engineer, Philadelphia Storage Battery Co., Philadelphia, Pa.: (November) (New York) (R. M. A.)

Analysis of Choices

An analysis of the time when the engineering show should be held seems to indicate that January has the preference with thirteen choices, next comes March with six choices, then December with five and November with five.

Among the cities, Chicago seems to have first choice with seventeen, New York with seven and alternate New York or Chicago comes next with six, and no city specified being four.

As to the auspices under which the show should be held, the R. M. A. leads with twenty-nine, followed by the alternate R. M. A. or I. R. E. with three and the I. R. E. itself with two.

Tabulation

In the tabulation below may be seen the manner in which replies were received as to time, city and auspices.

TIME		CITY		AUSPICES	
November	5	Chicago	17	I. R. E.	2
December	5	New York	7	R. M. A.	29
January	13	Cleveland	1	R. M. A. and I. R. E.	2
February	4	Chicago or New York	6	R. M. A. or I. R. E.	3
March	6	Chicago or Cleveland	1	Parts Manufacturers and Engineering Service	2
April	3	Chicago and New York (alternately)	1	Not specified	1
May	2				
June	1	Chicago or Pittsburgh	1		
First Quarter	1	Not specified	4		
		Elsewhere	1		

With the Accessory and Parts Manufacturers

(*Continued from page* 109)

These small units are designed for rivet, one hole mounting directly to chassis member and will be furnished in two types, wire pigtail on one end, other end grounded or wire pigtails on both ends.

Compo Mfg. Co. is located at 217 W. Illinois St., Chicago, Illinois.

New Radio Course

AFTER years of preparation, research, study and investigation, the Radio and Television Institute now offers a radio course which has been pronounced by certain members of radio trades organizations to be of the very highest order, thorough, covering every branch of radio and representing just what is needed for making thorough service men.

Unique in the R. T. I. organization is what is known as the R. T. I. Round Table. This round table is made up of F. G. Wellmann, director of the school; F. H. Schnell, chief of staff; Allan C. Forbes of the Triangle Electric Company, in charge of the service end of the course; Homer Hogan, general manager of KYW, Chicago, in charge of the broadcasting division; Harold P. Manley, a prominent engineer, and Ira E. Rice, in charge of talking pictures.

This round table, which is beginning to draw considerable comment, meets regularly, when the big problems in radio are threshed out and new things are moulded in shape to be sent out to students. The round table keeps this training up-to-date. Its members include some of radio's brainiest men; and as a group they represent a great educational force, entirely new in the science of home study instruction.

The R. T. I. course also includes talking pictures, their installation, etc., and television. Television is slowly progressing and the time is coming when it will be the biggest thing in radio. That is why R. T. I. trains its students on the rudiments of television and keeps them up-to-date with its many new phases and developments.

Durham Has New Resistor

THE new unit recently designed by International Resistance, has an overall length of 5/8 in. and a diameter of 3/16 in., making it a very small and compact unit where space saving is essential and low power dissipation is in order. It is called type MF 4⅓.

The unit is excellent for use in connection with faders, attenuation controls, and where a number of resistors are required for controlling the volume output of amplifiers used in theatre installations, radio sets, heavy duty amplifiers, etc.

The resistor is manufactured in all ranges from 100 ohms to 3 megohms, with wire leads two inches in length; has a normal rating of ⅓ of a watt and is available for customer's requirements immediately.

New Junior Model Noise Eliminator

THE Insuline Corporation of America announces the development of an improved compact noise eliminator, for all-electric radio receivers, known as the new model Filtervolt, Jr.

The new Filtervolt, Jr., while retaining all the points of superiority of the original model, has been improved in a number of important respects. A recently developed filter system, operating on an entirely new principle of resonance, permits the use of much smaller condensers and chokes. This makes it possible to incorporate greatly increased noise eliminating properties in the same compact space. This method of filtering out line noises is the result of months of research work on the part of Alex G. Heller, chief engineer of the Insuline Corporation of America.

The Filtervolt, Jr., is particularly adapted for use in eliminating the more common disturbances from household appliances, such as vacuum cleaners, sewing machines, electric fans, electric heating pads, the switching "on" and "off" of electric lights, electric toasters, floor polishers, drink mixers, dial telephones and all appliances using small motors of one-sixteenth horse-power or less.

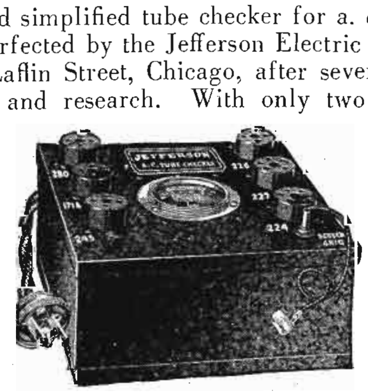
The application of the Filtervolt, Jr., to the radio receiver, is simplicity itself. It is merely necessary to remove the receiver plug from the house-current receptacle and plug the Filtervolt, Jr., in its place. The connection from the radio set is then made to a receptacle at the other end of the Filtervolt, Jr. No other controls are provided, nor are any further adjustments necessary. The receiver is turned on and operated in the usual way. In cases where the interference persists after the Filtervolt, Jr., has been put into the circuit, it is often possible to eliminate this by utilizing the extra binding post on the side of the device to make a ground connection. This is done by connecting a wire from the binding post to a steam pipe or a water pipe.

In some instances, better results may be obtained by placing the Filtervolt, Jr., between the source of current and the particular appliance which is causing the disturbing noises in the radio set. Of course, if the interference emanates from the antenna system, rather than from the a. c. mains, the Filtervolt, Jr., would not be effective, as this type of interference comes under the heading of "static." It is possible to check up on the antenna system, by tuning the set to a strong local station and removing the antenna and ground wires. If the crackling interference still persists, the use of the Filtervolt, Jr., is recommended.

Filtervolt, Jr., can be installed by any layman, however, since it is plugged in just like a floor lamp. It makes an ideal eliminator for every a. c. set owner, since the improvement in radio reception will be noticed and appreciated every day in the year.

Jefferson Announces Checker

A NEW and simplified tube checker for a. c. tubes has just been perfected by the Jefferson Electric Company, 1500 South Laflin Street, Chicago, after several years of experimentation and research. With only two readings, it is



possible to determine the condition of all popular makes of a. c. tubes.

The test is extremely simple. Place the tube in the proper socket and note the reading. Then press the small button and note the second reading. The difference between the two readings indicates accurately the amplification and the mutual conductance of the tube. The greater the difference in readings the greater the amplification.

Each tester is furnished with complete instructions, including a scale which will enable the user to determine whether the tube is good, fair, or poor. By other indications, it is possible to know whether the plate and grid are shorted, whether the plate is open, and whether the filament is open or shorted. The initial reading is an indication of the filament emission and plate resistance. The tester consists of six sockets, one each for the 226, 227, 224, 245, 171A and 280 type tubes, a milliammeter, a push button, and the connection for testing screen grid tubes.

The Jefferson a. c. tube checker is built to the high Jefferson standards. It is guaranteed against defects in material and workmanship.

Eby Takes Larger Space

THE H. H. Eby Manufacturing Co., Inc., formerly located at 4719 Stenton Avenue, Philadelphia, has moved into very much larger quarters right beside Shibe Park, the home of the World's Champion Philadelphia Athletics, at Twenty-second Street and Lehigh Avenue.

This change was made necessary by a substantial increase in the company's business during 1929, and plans for even greater expansion during 1930.

The Eby Company manufactures radio parts and is one of a group of parts manufacturers recently merged with the Utah Radio Company of Chicago.

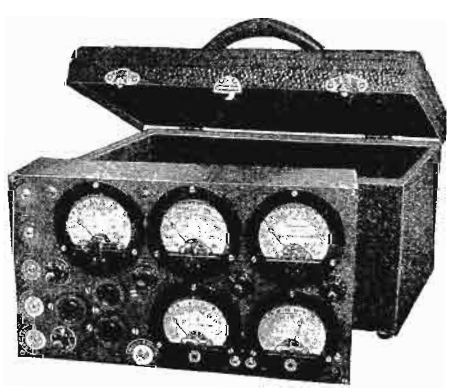
The Eby Company, which is the only eastern manufacturer in the group, will in future manufacture some of the products of the other merged companies for sale, distribution and warehousing in the eastern states.

With the Atwater Kent Company and the Philadelphia Storage Battery Company already located in Philadelphia, and with the concentration of all manufacturing activities of the combined Victor Company and Radio Corporation in Camden, Philadelphia is rapidly becoming one of the most important radio centers in the United States.

Hickock Has New Tester

ILLUSTRATED in this column is the Hickock Models SG-4600 radio set tester which consists of five Hickock instruments and two types of tube holders mounted in a solid bakelite case. The instruments are conveniently arranged and so interconnected that all circuits of all radio sets, whether using a. c. or d. c. tubes, can be quickly and easily tested.

The use of five meters in the SG-4600 radio set tester enables the operator to read all the circuits and functions of the radio set and the tube under test simultaneously. The plate voltage, heater or filament voltage, grid bias and plate current are



shown at one time, thus obviating the necessity of using push buttons or switches to get these four different readings on one meter.

The new SG-4600 model indicates simultaneously all the voltages and plate current entering screen grid tubes. Indicates the control and screen grid voltages simultaneously.

The use of a new type connector cable with 5-prong plug for connecting to set tester makes the operation of connecting the matter of a few seconds, also eliminates all liability of error.

The service man can more quickly and accurately service any set with the SG-4600 radio set tester employing five meters. The only switches to operate are those changing the range of the plate voltmeter, plate milliammeter and a. c. filament voltmeter. Usually in testing any individual set no change of switches is necessary as the switches may be set for the proper range of the instrument before the test is begun and the complete test may usually be made without further movement of the switches.

Mistakes are further guarded against by printing on the dial of each meter, the circuit which it measures, such as "plate volts," "a. c. filament volts," etc. This is only possible when a separate meter is used for each circuit. The liability of burning out or damaging any of the meters or tubes under test by operating the meters on the wrong scale is made impossible by the use of five meters.

The plate voltmeter incorporated in this device is a special high resistance type, having a sensitivity of 1,333 ohms per volt, which gives a resistance for the 300-volt scale of 400,000 ohms and for the 600-volt scale of 800,000 ohms. This instrument is so connected that it can be used either separately or in conjunction with the other instruments in making tests of circuits in radio receiving sets. To use this instrument separately, connect to the jacks marked "Positive 'B' battery" and "Negative 'A' battery." The switch for changing the scale range is located at the right of the meter. The grid switch, located at the right of the grid voltmeter, should be set on position marked "— Fil."

The a. c. filament and line voltmeter is used only when testing sets using a. c. tubes. The scale ranges are 3.3 and 15 volts and are selected by means of the three-position switch located at the left of the meter. The meter is entirely disconnected from the circuits of the tester when the scale changing switch is set in the "0" or central position. When testing sets using d. c. tubes, this switch should always be in the "0" or central position, as this meter must be out of the circuit for all d. c. tests. To use this meter as a separate instrument, connect to jacks marked "Positive 'A' battery" and "Negative 'A' battery," setting the scale changing switch in the proper position for the voltage to be measured.

The 150 scale on this meter is used for measuring line voltage and is connected to line with the leads provided in which are permanently connected a suitable resistance. These leads should be connected to set tester by inserting the small plugs on the end of the cable into the jacks located above the meter. The other end of the cable should be inserted in line socket. Make sure that the scale changing switch is on the "0" position when reading line voltage. Do not leave the meter continuously in circuit when reading line voltage.

The d. c. filament voltmeter is the same type as the plate voltmeter and has a scale range of 15 volts. The sensitivity of this meter is the same as the plate voltmeter, viz., 1,333 ohms per volt, which gives a resistance for the 15-volt scale of 20,000 ohms. To use this meter as a separate instrument, connect to jacks marked "Positive 'A' battery" and "Negative 'A' battery," setting the a. c. filament voltmeter switch in the "0" or central position. The filament reversing switch should also be set on the left-hand position.

The d. c. filament meter is also used to indicate the control grid bias when testing sets using screen grid tubes. The insertion of the phone plug connected to end of the No. 6A adapter into the phone plug in tester entirely disconnects this meter from the filament circuit and connects same to control grid and cathode.

The grid voltmeter is a companion instrument to the plate and filament voltmeters and has the same sensitivity. The scale is 100-0-80 volts and the resistance 200,000 ohms. This high sensitivity allows the grid bias to be read correctly through the secondary of all audio transformers. To use this meter as a separate instrument, set the grid switch, located at the right of the meter, on the position marked "— Fil." and connect to jacks marked "Negative 'A' battery" and "Negative 'C' battery."

The plate milliammeter is of the double scale type, having ranges of 20 milliamperes on the low scale and 200 milliamperes on the high scale. The switch for changing the scale range is located at the left of the meter. To use this meter as a separate instrument use the jacks marked "Pos. B" battery and Neg. milliameter.

Pierce-Airo Battery Chassis

PIERCE-AIRO, Inc., manufacturers of the well known Pierce-Airo a. c. chassis, announce the introduction of a screen grid battery chassis for which they report a considerable demand.

This battery chassis has three stages of radio frequency including one stage of screen grid amplification. It has an illuminated drum dial, compartment for B and C batteries, and is of rugged steel construction. The tubes required are one 222 screen grid and five 112-A power tubes. The manufacturers are Pierce-Airo, Inc., 117 Fourth Avenue, New York City.

Huge Sun Spots Presage Good Radio Conditions

GREAT activity on the sun visible from the earth as a 700,000 mile row of sunspots, has brought poor radio reception in recent weeks but it will probably be followed by a gradual return to the good conditions of 1923, Dr. Harlan T. Stetson, director of the Perkins Observatory at Ohio Wesleyan University here, declared in a statement to Science Service. He believes the recent solar disturbance probably represents the peak of the present eleven-year sun spot cycle. In collaboration with Dr. Greenleaf W. Pickard, radio engineer of Newton Center, Mass., Dr. Stetson has been studying the relation between sun spots and radio.

"The year 1930 should see a general decrease in solar activity, with a corresponding decrease in the ionization of the earth's atmosphere," Dr. Stetson declared. "This will favor the return of radio reception to normal conditions. During the subsidence period spasmodic outbreaks in the sun are to be expected at intervals, but with lessening intensity over the next five or six years.

"Scientists differ in their ideas as to just what happens when a broadcast wave travels over the earth. Some believe that an ether wave is propagated which is reflected back to earth from an ionized layer of the earth's atmosphere known as the Kennelly-Heaviside layer which lies some 70 kilometers above the earth's surface. Others maintain that the electric wave is refracted rather than reflected from such a layer.

"Whatever the mechanism, the wave appears to be turned back by this ionized layer of the earth's atmosphere. Any change in the intensity or degree of this ionization of electrification of the earth's upper atmosphere would have the effect of bending the ray more abruptly or less abruptly towards the earth and would at once be noticed in the intensity of radio reception. The more rapid changes of this sort are doubtless responsible for the phenomena of fading with which every radio fan is thoroughly familiar.

"According to our theory, the sun constantly bombards the earth's atmosphere with electrons or bundles of energy of high frequency which, in turn, tear apart the positive and negative charges of the atmospheric molecules. In other words, they ionize the atmosphere to a very considerable extent, thus producing the Kennelly-Heaviside layer. If the sun is more active on occasions, as when large spots appear on its surface, the degree of ionization increases, producing substantially the effect of lowering the Kennelly-Heaviside layer and upsetting the radio reception. When the sun is again less active, the atmosphere tends to return to its normal state of ionization and radio broadcasting reception tends to improve as the ionized layer lifts.

BUY RADIO *at* WHOLESALE PRICES!

EVERYTHING at AMAZING DISCOUNTS

Here is your opportunity to buy standard Radio Equipment at TREMENDOUS DISCOUNTS. Greatest bargains ever offered on SCREEN GRID RADIO SETS, DYNAMIC SPEAKERS, LATEST KITS, PARTS, TUBES, ETC.

Screen Grid LAFAYETTE
All Electric A-C—9 Tubes

Wholesale presents the newest achievement in radio receivers—the 1930 LAFAYETTE. Screen-Grid, 245 Push-Pull, Dynamic Speaker. THE GENUINE LAFAYETTE CAN BE PURCHASED ONLY FROM WHOLESALE RADIO SERVICE COMPANY.

30 DAYS FREE TRIAL

You can try a genuine LAFAYETTE in your home for 30 days free trial. If it does not sell itself to you on sheer performance you are under no obligation to buy! Full details of this offer with our catalog.

Big FREE Catalog!

Every item listed in the 1930 Wholesale Catalog—the bargain book of the radio field—represents REAL VALUE. New, modern merchandise at startling reductions. No "closeouts" obsolete or distress merchandise! Everything you buy from WHOLESALE is unconditionally guaranteed.

Rush Coupon Today!

Mail the coupon below for a copy of the new 1930 WHOLESALE catalog. Yours for the asking. We guarantee prompt service, courteous co-operation and quick deliveries. Our Service Department will be glad to help you with your radio problems.

WHOLESALE RADIO SERVICE CO.
36 Vesey Street, Dept. C-19
New York, N. Y.

Please RUSH free copy of your new 1930 WHOLESALE catalog. This does not obligate me in any way.

Name..............................

Address..............................

Town.......................State.......................

Smashing Radio BARGAINS!

BUCKINGHAM 4
Screen Grid 8 Tube A-C Chassis

Here is a REAL BARGAIN. Genuine Buckingham 8 Tube A-C Chassis. 4 Screen-Grid Tubes. 245 Push-Pull Amplification. Utah Dynamic Speaker. Write for our special price.

Big Price Reductions:

HAMMARLUND HI-Q
Write for Our Special Price

NATIONAL MB-29
Write for Our Special Price

WEBSTER PICK-UPS
Write for Our Special Price

Public Address Systems with latest equipment. Racon and Wright DeCoster Exponential Horns. Pam Amplifiers. Jensen, Rola, Utah, Wright DeCoster, Magnavox Dynamic Speakers. Microphones. REL Short Wave Receiving and Transmitting Apparatus. Latest Type Set Analyzers, including Jewell, Readrite, Weston, and new Supreme Diagnomter. Everything at **bargain prices.**

Special Offerings in Consoles
Write for special bargains now available in consoles.

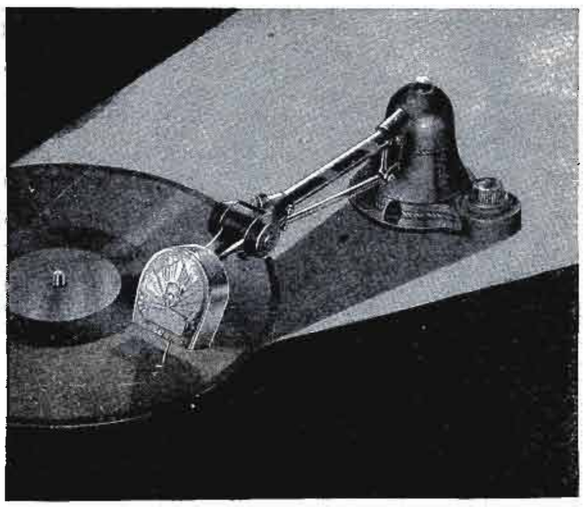
WHOLESALE RADIO SERVICE CO. INC.
36 VESEY ST. *Dept.* C-19 NEW YORK

Upco Electric Pickup

THE Upco electric pickup has been designed to meet, in a practical way, the exacting requirements of sound reproduction from records. Splendidly uniform frequency response throughout the useful audio frequency range of from 5000 to 50 cycles together with its high voltage output more than sufficient to meet the demands of any amplifier condition insures an amazing fidelity of reproduction and tremendous volume range.

The pickup structure embodies many mechanical features which combine their beneficial effects to make this unit the general standard of comparison. Its graceful, beautifully finished structure is supported laterally and vertically on hardened steel balls—developing an effortless, almost frictionless response to the complex record variations. This complete freedom in mechanical action minimizes record wear and objectional needle-scratch.

The pickup armature is cushioned and balanced in an ingenuous manner which provides a remarkably free needle action without sacrificing the slightest degree of stability. This



unit bears a very enviable record of remaining in adjustment.

Securely mounted in the base of the Upco pickup structure is a sturdy, non-inductive constant load volume control whose resistance taper is so graduated as to secure perfect output from the merest whisper to full, crashing volume.

In addition to phonograph service types, the Upco electric pickup is assembled in a theatre model, similar in structure to the standard types and of sufficient overall length to operate with the sixteen-inch records of talking picture work.

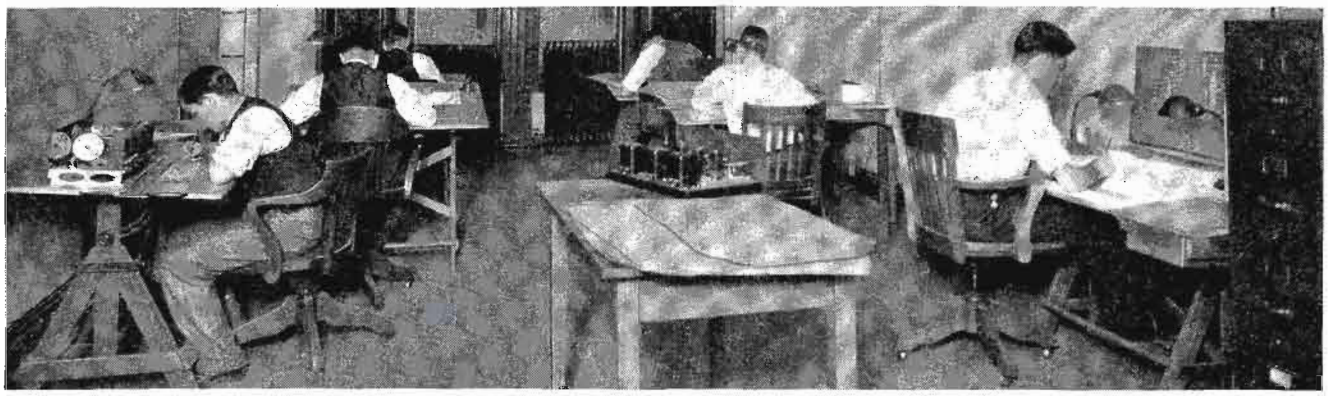
To provide a splendidly practical link between the acoustic phonograph and the radio, the Upco Pickup Type D is designed to be mounted upon tone arms in place of the acoustic sound box of old. Supplied with a volume control mounted in a black bakelite housing, it connects to the first audio stage of the radio set, thus enabling one to reproduce his phonograph records electrically through the radio loud speaker.

Vacuum Tube Produces Artificial Radium Rays

ARTIFICIAL radium rays, produced by 1,600,000 volts of electricity in special vacuum tubes, have now been achieved by physicists at the Department of Terrestrial Magnetism of the Carnegie Institution of Washington.

The tubes are really X-ray tubes, and by applying voltages of from one-half to several million, rays similar to the gamma rays of radium are emitted. The other kinds of radium rays, known as alpha and beta rays, can be produced by suitably modifying such a tube. With the aid of these rays, physicists are studying the structure of the heart of the atom.

OUR DRAFTING ROOM



This staff of highly trained draftsmen is continually preparing the most accurate and complete full size blue prints of radio receivers and power packs obtainable.

Blue prints are available on all circuits described in the CALL BOOK. Each set of prints is composed of all the necessary drawings prepared in such complete detail and accuracy as to enable an inexperienced builder to duplicate in every respect the receivers built in our laboratory, thus assuring positive success and the greatest satisfaction.

PLEASE ORDER BLUE PRINTS BY NUMBER AND NAME

No. 12	Madison-Moore Super-heterodyne Receiver using 201-A Tubes	$1.00
No. 14	Browning-Drake 4 Tube Receiver Using Audio Frequency Amplification	1.00
No. 32	Scott "World's Record" Super Eight	1.00
No. 37	Madison-Moore "One-Spot" Receiver	1.00
No. 56	Improved Browning-Drake	1.00
No. 58	"World's Record" Super Nine	1.00
No. 64	Aero Seven Tube T. R. F. Receiver (5 drawings)	1.00
No. 68	Improved Remler 45 K. C. Super-heterodyne Receiver (5 drawings)	1.00
No. 73	Magnaformer Super-heterodyne Receiver (5 drawings)	1.00
No. 79	Silver-Marshall High Amplification Super-heterodyne Receiver (5 drawings)	1.00
No. 93	Knickerbocker Four (5 drawings)	1.00
No. 99	Magnaformer 9-8 A. C. (5 drawings)	1.00
No. 115	Tyrman Amplimax "70" Shielded Grid (6 drawings)	1.00
No. 123	World's Record Super Ten & Power Pack (6 drawings)	$1.00
No. 147	Custom-built Model Madison-Moore International One-Spot A. C.—Sub-panel Job (6 drawings)	1.00
No. 162	National Screen Grid Five (5 drawings)	1.00
No. 167	Scott World's Record SG Nine "Power Pack Operated" (4 drawings)	1.00
No. 172	Remler 1929—115 K. C. SG Super (3 drawings)	1.00
No. 179	Lincoln 8-80 One-Spot Super—(3 drawings)	1.00
No. 198	Tyrman 72 A. C. Super	1.00
No. 218	Aero International Four Receiver (4 drawings)	1.00
No. 226	Hammarlund-Roberts Hi-Q 29 Receiver, Master A. C. model (5 drawings)	1.00
No. 231	Custom-built Model World's Record Shield Grid A. C. 10 (4 drawings)	1.00
No. 241	Capacity Bridge (3 drawings)	1.00
No. 246	Pilot Super-Wasp Short Wave Receiver (3 drawings)	1.00

GRAPHIC WIRING DIAGRAMS

No. 20	Silver-Marshall Improved 7 Tube Super-heterodyne Receiver	$0.60
No. 101	World's Record Economy Super 8	.60
No. 134	Nine-in-Line A. C. Operated	.60
No. 136	Citizens Crystal Receiver	.60
No. 154	Silver-Marshall 4 Tube Shield Grid Receiver	.60
No. 160	Thordarson 210 Power Compact	.60
No. 165	Citizens SG Booster Stage	.60
No. 166	Silver-Marshall SG Six (no output choke)	.60
No. 170	Silver-Marshall SG Super Nine	.60
No. 174	Sargent-Rayment Seven Receiver	.60
No. 178	Silver-Marshall 731 Short Wave Adapter	.60
No. 182	Halldorson A. C. 56—T. R. F.	.60
No. 183	National Short Wave Receiver	.60
No. 185	Silver-Marshall "Coast to Coast" Four	.60
No. 187	Citizens Special Short Wave Receiver	.60
No. 195	Junior 2 Tube Receiver	.10
No. 196	Aero A. C. Short Wave Converter	$0.60
No. 200	Silver-Marshall Phonograph Amplifier	.60
No. 202	Silver-Marshall 730 Four Tube Receiver	.60
No. 204	Sangamo Push-Pull Lab. Amplifier	.60
No. 210	Silver-Marshall 6 Tube Receiver (using output choke)	.60
No. 213	Junior 4 Tube Receiver	.10
No. 221	Modulated Oscillator	.60
No. 223	Silver-Marshall 720 A. C. Shield Grid Six	.60
No. 225	Hollister A. C. Super Eight	.60
No. 236	S-M 722 A. C. Screen Grid Receiver	.60
No. 237	S-M 735 Short Wave Receiver, A. C.	.60
No. 242	National Screen Grid MB-29 Receiver	.60
No. 244	S-M S. G. A. C. 712 Rec. (to be used with 677 Power Pack)	.60
No. 245	S-M 677 Power Pack (to be used with 712 Receiver)	.60
*No. 232	Thordarson 245 push-pull power pack	.60

SCHEMATIC WIRING DIAGRAMS

No. 164a	Thordarson 250 Power Supply and Amplifier	$0.50
No. 170a	Silver-Marshall SG Super Nine	.50
No. 171a	Thordarson Dealer's Amplifier	.50
No. 174a	Sargent-Rayment Seven Receiver	.50
No. 183a	National Short Wave Receiver	.50
No. 185a	Silver-Marshall "Coast to Coast" Four	.50
No. 187a	Citizens Special Short Wave Receiver	.50
No. 191a	Scott World's Record SG Nine "Battery Operated"	.50
No. 196a	Aero A.C. Short Wave Converter	.50
No. 197a	Aero A. C. 21 Chronophase Receiver	.50
No. 202a	Silver-Marshall 730 4 Tube Receiver	.50
No. 206a	HFL Special Nine A. C. Super	.50
No. 211a	Magnaformer 1929 A. C. Super	.50
No. 220a	Thordarson R-480 Power Amplifier (171 Push-Pull)	.50
No. 221a	Modulated Oscillator	.50
No. 223a	Silver-Marshall 720 A. C. Shield Grid Six	.50
No. 225a	Hollister A. C. Super Eight	.50
No. 233a	Keystone Electric 67 Receiver Kit	.50
No. 234a	HFL Mastertone Receiver, A. C.	$0.50
No. 236a	S-M 722 A. C. Screen Grid Receiver	.50
No. 237a	S-M 735 Short Wave A. C. Receiver	.50
No. 238a	Lincoln 8-40 Screen Grid A. C. Super	.50
No. 239a	C. R. Leutz "Seven Seas" Console Receiver	.50
No. 240a	Remler Type 111 Screen Grid Receiver and Amplifier	.50
No. 242a	National Screen Grid MB-29 Receiver	.50
No. 243a	Citizens 3 Tube Rec. using 224 Tube as Power Detector	.50
No. 244a	S-M S. G. A. C. 712 Rec. (to be used with 677 Power Pack)	.50
No. 245a	S-M Power Pack (to be used with 712 Receiver)	.50
No. 249a	Hammarlund-Roberts Hi-Q 30	.50
No. 250a	Braxton-King A. C. S. G. Super Model A	.50
*No. 232a	Thordarson 245 push-pull power pack	.50
*No. 254a	Lincoln DeLuxe Ten A. C. S. G. Receiver	.50
*No. 255a	Silver-Marshall 722 S. G. D. C. Receiver	.50
*No. 256a	Pilot 6 Tube T. R. F. A. C. S. G. No. PE6	.50

FACTORY BUILT RECEIVER SCHEMATICS

No. SR 1	All-American Mohawk 6 and Power Supply	$0.50
No. SR 2	All-American Mohawk 8 and Power Supply	.50
No. SR 3	Acme A. C. 7 and Power Supply	.50
No. SR 4	Acme A. C. 4 and Power Supply	.50
No. SR 5	Crosley Gembox A. C. Model 608 and Power Pack	.50
No. SR 6	Crosley D. C. Showbox, Model 705	.50
No. SR 7	The Majestic Receiver, Model 70	.50
No. SR 8	Kolster 4 Tube Chassis and Supply	.50
No. SR 9	Sparton A. C. 89 Receiver and Pack	.50
No. SR10	Bremer-Tully Model 7-70 and Supply	.50
No. SR11	DayFan 5080 Receiver and Supply	.50
No. SR12	Balkite Model A Receiver and Pack	.50
No. SR13	Fada 7 A. C. Model and Type C Unit	.50
No. SR14	Freshman 2-N-12 and Power Unit	.50
No. SR15	Steinite Model 261 and Supply	.50
No. SH16	Howard Green Diamond Set, Model 8	.50
No. SR17	Grebe Synchrophase 7 A. C. Set	.50
No. SR18	Stromberg-Carlson 635-636	.50
No. SR19	Federal Model "H" A. C.	$0.50
No. SR20	Freed-Eisemann NR-80	.50
No. SR21	Bosch Model 28 and 29	.50
No. SR22	Amrad Model 70 A. C.	.50
No. SR23	Brunswick No. 3KRO	.50
No. SR24	A. C. Dayton Navigator	.50
No. SR25	Sonora DeLuxe Model 5-R	.50
No. SR26	Philco Model 86 and 82	.50
*No. SR27	Slagle Model 9	.50
*No. SR28	Atwater-Kent Model 38	.50
*No. SR29	Colonial Radio Model 31 A. C.	.50
*No. SR30	RCA Model 60	.50
*No. SR31	King Radio Model J	.50
*No. SR32	Gilfillan Model 100	.50
*No. SR33	Erla Model R-2	.50
*No. SR34	Stewart Warner Model 900	.50
*No. SR35	Silver-Marshall Model 30	.50
*No. SR36	Splitdorf Model E-175	.50

* Circuits described in present issue.

Any of the above blue prints will be sent postpaid by return mail upon receipt of the proper amount or they can be obtained from any of the Radio jobbers advertising in this publication. C. O. D. orders not accepted.

CITIZENS RADIO SERVICE BUREAU 508 SOUTH DEARBORN STREET 7TH FLOOR—CHICAGO, ILLINOIS

STATEMENT OF THE OWNERSHIP, MANAGEMENT, CIRCULATION, ETC., REQUIRED BY THE ACT OF CONGRESS OF AUGUST 24, 1912

Of CITIZENS RADIO CALL BOOK MAGAZINE AND TECHNICAL REVIEW, published four times yearly at Chicago, Illinois, for October 1, 1929. State of Illinois, County of Cook, ss.

Before me, a notary public in and for the state and county aforesaid, personally appeared Chas. O. Stimpson, who, having been duly sworn according to law, deposes and says that he is the Publisher of the CITIZENS RADIO CALL BOOK MAGAZINE AND TECHNICAL REVIEW and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management (and if a daily paper, the circulation), etc., of the aforesaid publication for the date shown in the above caption, required by the Act of August 24, 1912, embodied in section 411, Postal Laws and Regulations, printed on the reverse of this form, to wit:

1. That the names and addresses of the publisher, editor, managing editor, and business managers are: Publisher, Chas. O. Stimpson, Chicago, Ill.: Editor and Managing Editor, Fred A. Hill, Chicago, Ill.; Business Manager, D. H. Bell, Chicago, Ill.

2. That the owner is (if owned by a corporation, its name and address must be stated and also immediately thereunder the names and addresses of stockholders owning or holding one per cent or more of total amount of stock. If not owned by a corporation, the names and addresses of the individual owners must be given. If owned by a firm, company, or other unincorporated concern, its name and address, as well as those of each individual member, must be given): Citizens Radio Service Bureau, Chicago, Ill.; Chas. O. Stimpson, Chicago, Ill.; D. H. Bell, Chicago, Ill.; H. Anheiser, Chicago, Ill.

3. That the known bondholders, mortgagees, and other security holders owning or holding one per cent or more of total amount of bonds, mortgages, or other securities are (if there are none, so state): There are none.

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

5. That the average number of each issue of this publication sold or distributed, through the mails or otherwise, to paid subscribers during the six months preceding the date shown above is (this information is required from daily publications only).

CHAS. O. STIMPSON,
Publisher.

Sworn to and subscribed before me this 22nd day of September, 1929.

(SEAL) NELLIE E. RYAN.
(My commission expires July 25, 1932.)

Index to Advertisers