

F E B R U A R Y 1 9 3 0

RADIO BROADCAST

PUBLISHED FOR THE RADIO INDUSTRY



SPECIAL FEATURES IN THIS ISSUE

How the RCA Theremin Works
Design Data on Band-Pass Filter Circuits
The Multicoupler Antenna System

Service Data Sheets • A Study of the Battery Market • Production Testing Methods • Distortion in Push-
Pull Amplifiers • The 1930 Hi-Q • New Books • The Supreme Diagonometer • Recent Mergers in Radio

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RADIO BROADCAST

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The contents of this magazine are indexed in *The Readers' Guide to Periodical Literature*, which is on file at all public libraries

. . . among other things

FOR THE first time, complete data is presented on the "Multicoupler" antenna system, developed some months ago in New York. The system has been of great interest to engineers because of its simplicity and low cost. Mr. Amy and Mr. Aceves, co-designers of the system, describe it fully on page 206 of this issue.

ANOTHER OF Mr. Uehling's valuable mathematical articles on theory of receiver design is a part of this issue. Mr. Uehling was formerly a member of the research staff of Fada Radio in New York. Some months ago he returned to the University of Michigan for graduate study in physics.

RADIO BROADCAST readers will remember two interesting papers by J. M. Stinchfield of the Cunningham engineering department which appeared in our August and October, 1929, issues. The August article discussed "Calculating Detector Output" and the October paper "Grid Leak vs. Bias Detection." Mr. Stinchfield's article in this issue deals with push-pull audio-frequency amplifiers.

THE MARCH RADIO BROADCAST will contain contributions from H. D. Oakley, of the General Electric engineering department, a paper from the Ward Leonard Laboratory, the third article in Mr. Callanan's series on factory production test methods, a description of the ingenious and compact record-changer developed in the Techmidyne Corporation laboratories, and a number of other interesting articles, in addition to all our regular departmental features.

OF ESPECIAL interest is the article from Ward Leonard which describes for the first time anywhere the "Adaptoron." This is a compact motor-driven unit for the conversion of direct current of any of the common commercial voltages to alternating current. The article describes the unit technically and discusses its application. With this unit, which is approximately 80 per cent. efficient, a 32-volt d.c. farm-lighting system will provide 110 volts a.c. to energize a standard a.c. broadcast receiver. The conversion unit will perform the same function on any commercial d.c. supply. This article, we are sure, will be awaited with the greatest interest. Mr. Oakley will describe the signal generator developed by the General Electric Company giving full data on circuit and operation. We shall publish two other articles from Mr. Oakley dealing with applications of the device.

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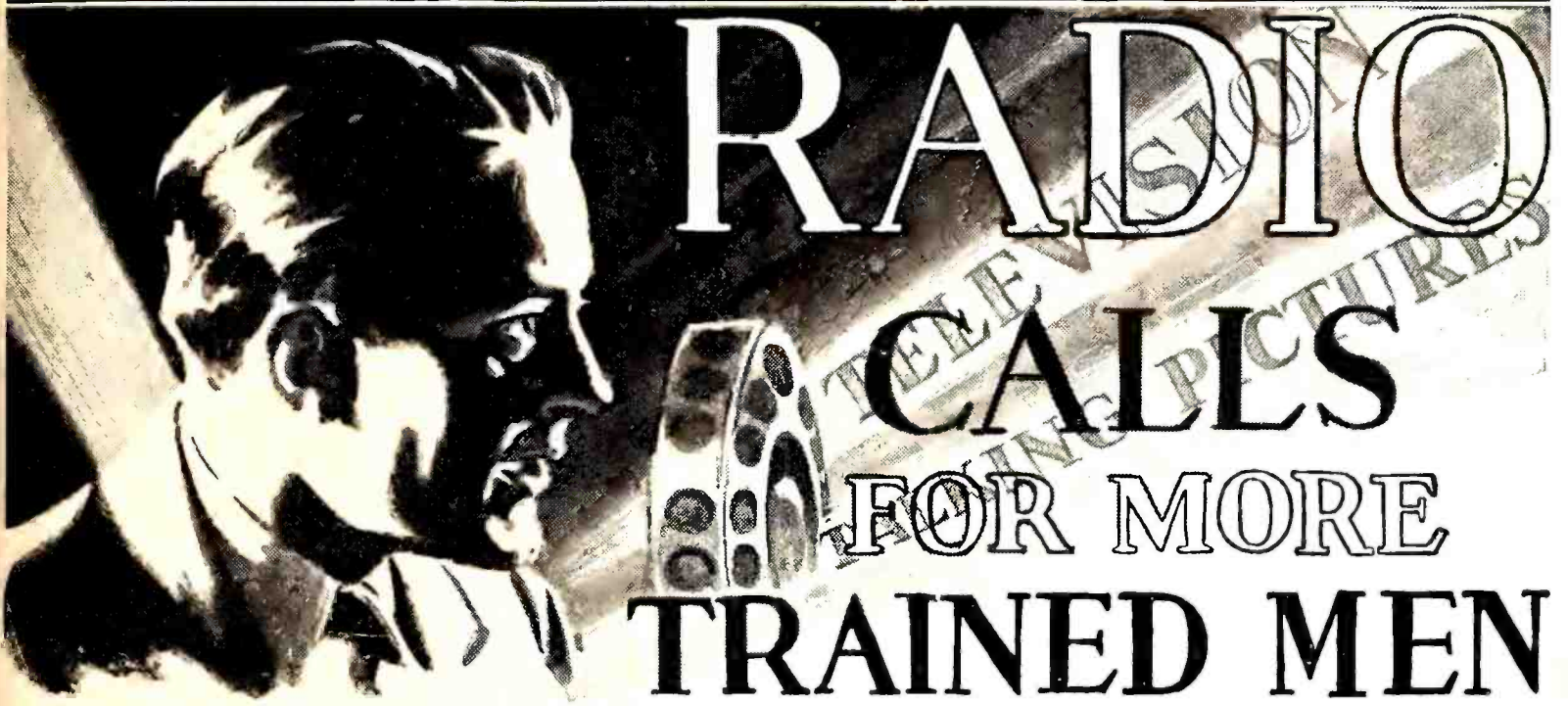
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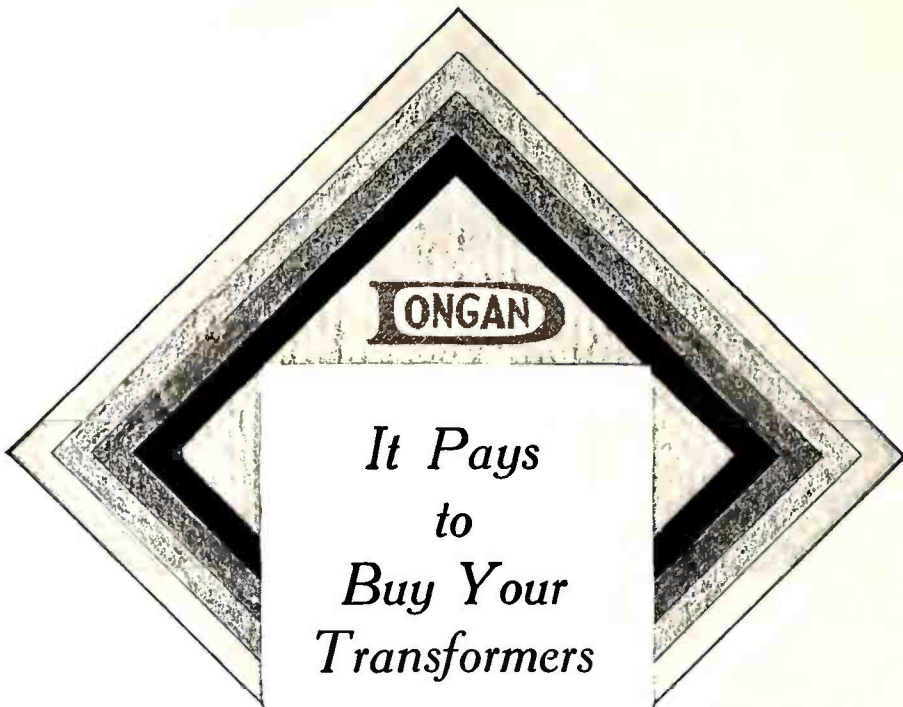
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The cycle has swung back in the automobile industry. One of the leaders, who formerly thought it good business to make all his parts in his own plants, has discontinued that practice and now contracts with outside manufacturers.

Transformers built by Dongan have the undivided attention of a 20-year-old company highly specialized and organized in Transformer engineering and manufacturing. Those who use Dongan as a source are certain of securing the very latest in sound development, a consistently first-class product, and the very lowest production price.

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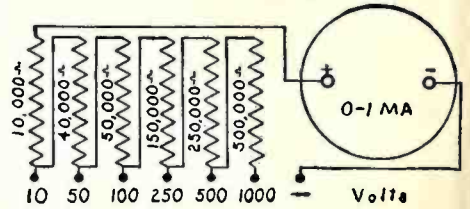
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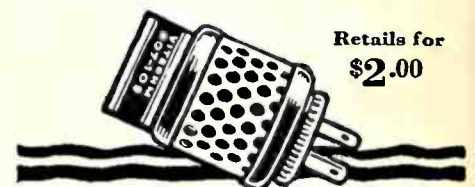
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REVIEW

◆ **FACTS REPLACE ESTIMATES.**—Every householder will be asked in the 1930 census "Do you own a radio set (Yes) (No)?" On completion of the census for the first time in radio history since broadcasting, the industry will know definitely how many sets actually are in use. The best present estimate gives 12,000,000 sets in use. Statistics are where the industry is weakest. Accurate consolidated figures have never been available to show the number of sets and tubes made annually, sales to distributors and dealers, and sales by dealers to customers. Companies all refuse figures on their manufacture and sale with the result that all do business in a thick haze of incomplete information. Sources of statistical estimates previously have been: McGraw-Hill Company (*Radio Retailing*); Department of Commerce (Electrical Equipment Division, aided by National Electrical Manufacturers Ass'n.); National Broadcasting Co.; Research Division, RADIO BROADCAST.

◆ **MORE TRUTH IN RADIO ADVERTISING.**—The National Better Business Bureau, an independent organization set up by advertisers themselves, calls set manufacturers to task for the present vogue of "circus advertising." Copy of 26 leading manufacturers has been analyzed showing most popular claims are: (1) "greatest"; (2) "finest"; (3) "biggest," "fastest," "clearest," "highest," "longest," "most beautiful." Manufacturers are urged to discontinue voluntarily practising these absurdities. Claims of not guilty were made by Edison and others.

Meanwhile inside the trade itself are charges and counter-charges that advertising concessions to dealers, large chains and others, have been one of radio merchandising's worst evils during 1929. Heavy "advertising" appropriations granted to dealers and distributors by set makers are said to be polite language for price cutting in the battle for distribution.

◆ **"PERMANENT COMMISSION."**—On December 19, the President signed the bill passed by Congress to extend the life of the Federal-Radio Commission from December 31, 1929, "until otherwise provided by law." The Act authorizes the Commission to establish an engineering department headed by a chief engineer at \$10,000 a year and two assistants at \$7500. Other much-disputed sections in the Radio Act were not disturbed, Congress being disposed

SOME OF the events in the world of radio in recent weeks may have escaped you. A few of the more important, to our way of thinking, are presented on this page.

to let these dogs sleep until the pending Communications Commission Bill (S.6) is disposed of.

The Commission is still in hot water over the enforcement of provisions of the so-called Davis "equalization" amendment to the Radio Act which the present Act does not mention, although many Senators and Representatives do not approve of the equalization feature nor the way in which the Commission has carried it out.

◆ **FLIRTATION.**—Bishop, McCormick & Bishop, Dodge distributors for New York City and suburbs, in December took on sales and service of Grebe radio exclusively. Bishop, McCormick & Bishop handle Transitone automobile radios on Dodge cars. Douglas Rigney, Grebe salesman, says: "Automobile Row, centrally located in every large city, will soon become a radio salon in addition. The public reaction is sure to be favorable. Sets will be sold amid engaging environment provided by substantial and outstanding concerns to whom people are accustomed to look for quality products. . . . Probably the service factor will appeal most strongly to the public, knowing, I mean, that a house especially trained in service is always at command when an emergency requires." The General Motors Radio Corporation have as yet made no announcement of their future distribution plans. While radio is aiding the automobile dealer, Copeland refrigerators are being advertised in dealer-trade papers as a line advantageous to radio dealers from sales and service standpoint.

◆ **RADIO BUSINESS.**—Overproduction and overcapacity are word-tags seized on by all in the radio business to explain away difficulties faced by the industry which began to be noticed just before the Wall Street débâcle. *Radio Retailing's* December number reveals an early-Summer survey of plant capacity showing tremendous increases. However, their warning of danger to the industry was presented two months after results of the industry's bad planning became apparent. Average set prices are lower than ever before and sales are generally

reported as holding up well during the holiday season. Public appetite for radio has not decreased but manufacturers' estimates of the public's capacity to absorb *their* products were generally overestimated. Radio advertising is slowing up with some cancellations in general and trade magazines.

Earl, Freed, Sonora, A.C. Dayton, Marti, Neonlite Tube, Buckingham, United Reproducers, and Erla are reported in receivership proceedings.

New models will probably not be shown by any manufacturer of importance this year before the Atlantic City Trade Show in June. In 1929, many new models were announced long before Trade Show. (Atwater Kent's screen-grid Model 55 was announced April 1, 1929).

Jenkins Television held a public demonstration early in January, preceded by a New York showing of Baird's English system. Sonora showed a home sound movie device which will sell around \$350. It contains a projector, disc phonograph, electrical amplifier, and loud speaker system in one cabinet.

◆ **NEW USES FOR RADIO?**—The start of a really intensive effort to cultivate new markets for radio is shown in current interest in radio sets for automobiles. A leader in this field is the Automobile Radio Corp. (Transitone), partly owned by Chrysler, which has already equipped some Dodge and Chrysler cars. All Cadillac and LaSalle closed cars now leave factory with concealed roof antennas installed, and a set complete with tubes and magnetic loud speaker, is available for these cars at \$150. Sonora recently announced a five-tube set for installation in any type of car. The trade as yet is not enthusiastic over the possibilities of the market, but signs seem to point to widespread efforts next season. Larger possibilities lie in the portable receiver field, in our opinion. A good portable can be used in the car, the beach, your summer camp, boat, while travelling by boat or train, or put in the house and used as an alternative set there. The difficulty here, as in the automobile set, is performance. More efficient tubes and loud speakers are required before the ideal can be approached.

Majestic has organized a railroad department and installations have already been made on some mid-western trains. Canadian National Railway trains have been radio-equipped for some time. The Broadway Limited and Century, however, are still radio-less.



By EDGAR H. FELIX

MERGERS IN THE

IN ITS original definition, merger meant the complete absorption and obliteration of a lesser unit by a larger one. Now that term is applied to even such loose combinations as those in which the component units maintain their individual identity, their freedom of policy, and their competitive relationship with the other associated units. Even with so broad a definition of merger, most of those which have taken place in the radio industry have not been of a far-reaching character. None are the equivalent of the United Cigar-Schulte merger for example, which joined the two largest and longest established retail tobacco chains.

Two Large Mergers

Only two mergers in the history of the industry may be termed as gigantic and both of them concern the same group. The first is the historic patent pool of leading electrical manufacturing interests which led to the formation of the Radio Corporation of America in 1920, and the second, the merger of the company so formed with the Victor Talking Machine Company in 1928. No other major units in the field reached a position of leadership as the direct result of merger operations.

For the purposes of analysis, it is convenient to classify mergers in the radio field according to the purpose accomplished, as follows:

- (1) Building of patent position
- (2) Diversion of music industry into radio
- (3) Expansion

The merger which led to the formation of the Radio Corporation of America in 1920 is the outstanding example of the first classification. Government officials encouraged its formation in order that there might be established an American

international communications system, independent of foreign-owned cable links or radio stations. To this end, the General Electric Company, the Westinghouse Electric and Manufacturing Company, the American Telephone and Telegraph Company, the United Fruit Company, and the Wireless Specialty Apparatus Company advanced capital and pooled patent rights in behalf of a new company, the Radio Corporation of America. The pooling of patent rights of the founding companies was considered necessary because no one of them had sufficient patent rights individually to embark upon the manufacture of radio transmitting and receiving equipment without fear of litigation brought by the others.

Having agreed on these first steps, however, the advantages of further extending the scope of the agreement became apparent. Each of the companies involved secured free license to the patents held by all the members of the group for specific fields; for example, the American Telephone and Telegraph Company in wire and radio telephony; the Westinghouse Company in non-commercial receiver equipment manufacture; the General Electric Company in the manufacture of commercial ship telegraph transmitters and receivers, and so on. They also remembered the then insignificant amateur radio experimenter business, which totaled about \$200,000 a year. Rights to manufacture equipment for this field was extended to the Westinghouse and General Electric companies and its sale was made a side line of the Radio Corporation.

The Mackay Group

The Mackay interests have attempted to build up a competitive communications system through the acquisition of Federal Telegraph. DeForest successfully sustained his vacuum-tube circuit patents over Armstrong recently and,



RADIO INDUSTRY

June—Stiner

through shop rights under them, owned by the Federal Telegraph Company, the Mackay interests have been able to establish a communications system with at least one trans-oceanic link already in operation. Extensive plans for the establishment of an intracontinental communications system have been formulated and frequencies have been allocated by the Federal Radio Commission to make its consummation possible. Allied with the Mackay group is the Kolster Radio Corporation, which possesses manufacturing facilities for making the receiver and transmitter equipment required, while the DeForest Company is available for production of the necessary tubes.

A number of other instances may be cited of the merger of companies by purchase for the acquisition of patent rights. For example, Grigsby-Grunow-Hinds (now Grigsby-Grunow, manufacturers of Majestic receivers) purchased the Pfanstiehl Company to secure its R.C.A. license. In the same manner, the Philadelphia Storage Battery Company bought the D. J. Murdock Company, a pioneer part and set manufacturer. These last two were true mergers in that they represented the extinction of the smaller units merged.

The United States Radio Corporation will be remembered as a similar combination, established to divide the obligations of an R.C.A. license among five receiver manufacturers. The U. S. Radio and Television Corporation is the successor to this group.

The Second Classification

In the second classification, the surrender of the music industry to its former rival, the radio industry, the most important is the merger of Victor and the Radio Corporation of America. In this instance, both companies contributed equally,

Victor having a well-established distribution position through the music trade, valuable contracts with world-famous artists, and excellently organized manufacturing facilities. The Radio Corporation of America contributed patent rights and experience in the radio field. Its close affiliation with the National Broadcasting Company offered a valuable outlet for the utilization of Victor artists. The substantial character of this merger is evidenced by the fact that Westinghouse and General Electric have recently transferred their radio engineering activities to the unified laboratories in Camden and that these companies are to discontinue the manufacture of receivers for distribution through the Radio Corporation of America in favor of concentrating that production in the Victor plant at Camden. RCA, not confining its alliance with the music field to this country alone, quietly purchased, not long ago, a controlling interest in His Master's Voice, "HMV," of London, which is quite the largest gramophone company in the world, exceeding even Victor in this country in size.

Radio-Phonograph Mergers

Each of the leading phonograph companies have established a radio connection of one kind or another. Brunswick is linked with Bremer Tully through a major purchase of stock. Edison entered the radio field through the acquisition of Splitdorf. Sonora recently purchased Federal. Columbia has a close contract arrangement with Kolster, somewhat similar to that which the Radio Corporation extended to Victor before the merger took place. Some of the piano companies have also gone into the radio field, for example, Everett Piano is merged with the Howard Radio Company, the latter moving

(Continued on page 243)



The MARKET for the

By T. A. PHILLIPS

Manager, Research Division, Doubleday, Doran & Co., Inc.

BATTERY-OPERATED receivers, with the sensitivity, selectivity, simplicity, economy, volume, and fidelity requirements comparable with socket-powered radio sets have been conspicuous by their absence from the market. Recent announcements from several manufacturers indicate that efficient battery-operated receivers, equal in every respect to the best screen-grid socket-powered set, have been developed.

How important is the need for this type of receiver? Will it actually greatly increase radio sales and where will it sell most readily?

It is estimated that 10,300,000 homes in the United States are unwired and that in at least 5,000,000 of these are live radio prospects. The National Carbon Company states that out of 5,371,000 farms owned by white families only 1,000,000 are served by electricity and only 25 per cent. are equipped with radio. In addition, many small towns do not have electric current. These homes constitute the primary battery set market.

How important is the present battery set market and where are battery sets now sold? This type of receiver represents about 12 per cent. of total set sales. More than one third are sold in towns under 10,000 population and one half in towns under 50,000 population. Only a little more than one quarter of all radio sales, however, are in towns under 50,000 population.

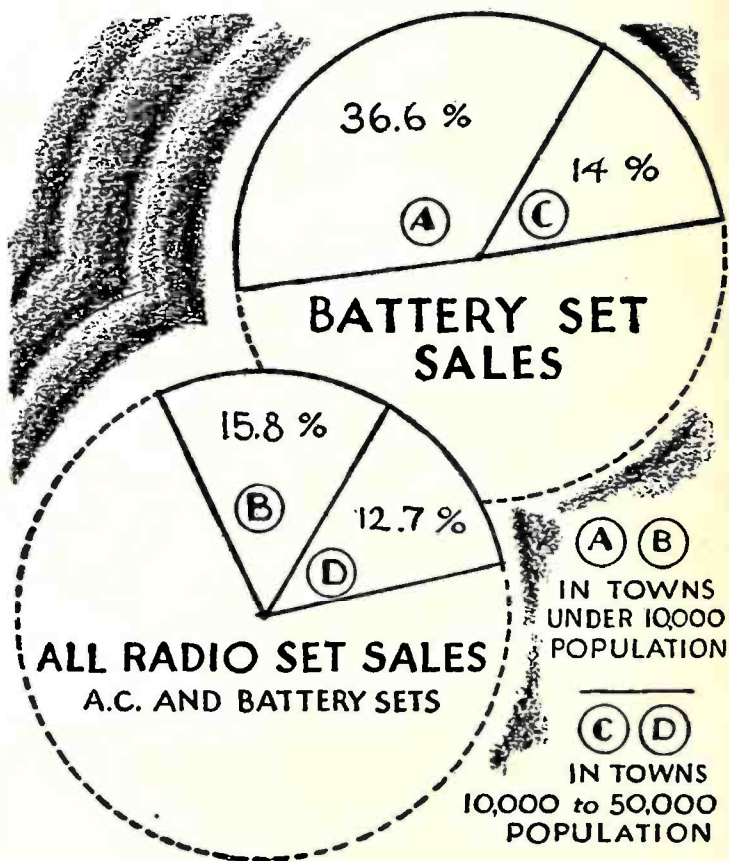
Further study discloses that battery sets constitute from 15 to 40 per cent. of total set sales in small towns and less than 5 per cent. of total set sales in towns over 50,000 population. It can be taken for granted, then, that battery sets will find their best market in the small towns of rural districts.

How important is the rural town market? If only 28 per cent. of all radio sales are in small towns and farms, and only 12 per cent. of all sets sold are battery sets, is it worth while to pay much attention to the small-town and farm market? The automobile manufacturers know the small-town and farm market is very important. Five out of six farmers own automo-

biles. Of the automobile registrations 55 per cent. are in towns under 10,000 population and 75 per cent. in towns under 50,000 population. Of all cars in use 25 per cent. are farm owned. It should be equally important to set manufacturers.

Let us take a bird's eye view of the wholesale trading area of four towns, all in the State of Indiana and within fairly close proximity of each other. Many other communities might be chosen but out of fifty towns studied these four cities are

Battery Set vs. Total Set Sales



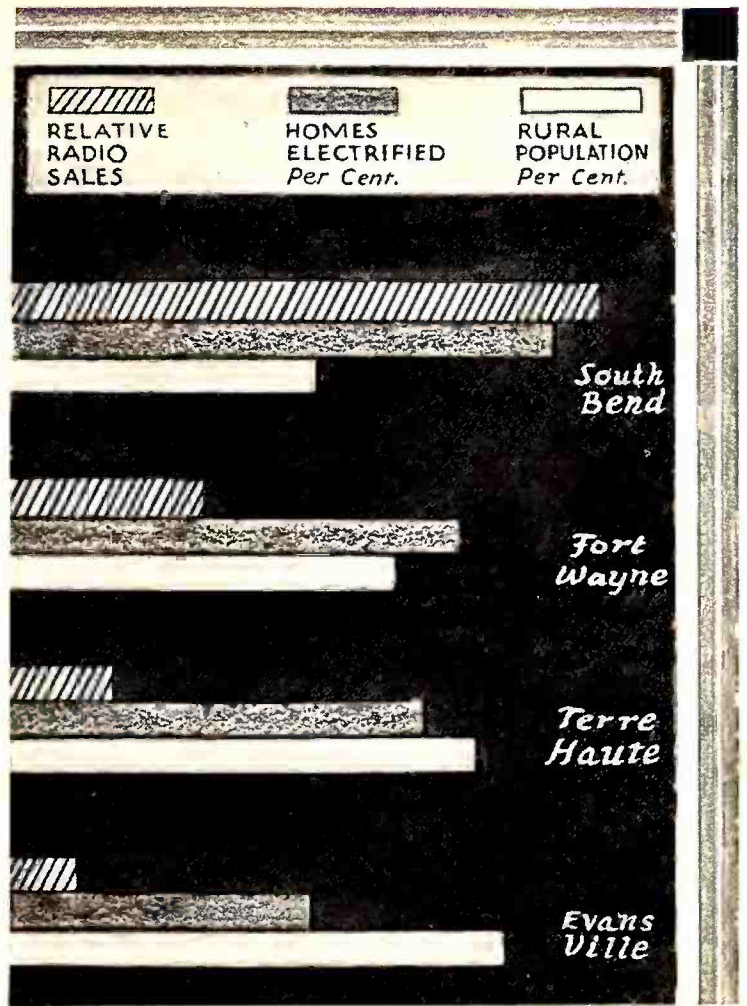
BATTERY SET

FOUR REPRESENTATIVE TRADING AREAS

	Evansville	Terre Haute	Fort Wayne	South Bend
City population (1920)	85,264	66,083	86,549	70,983
Trading area population	766,470	386,093	383,789	356,064
Rural population	536,150	250,503	207,521	155,311
Per cent. rural	70%	65%	54%	43%
Per cent. wired homes	42%	57%	62%	75%
Relative set sales*	193	198	765	1,789
Battery set sales†	20%	27%	5%	5%

*Relative radio set sales represent total set sales for a recent three months' period reduced to sets sold per 100,000 population.

†Battery set sales are given in per cent. of total set sales.



more typical of the various local conditions we will discuss. The towns to be studied are, Evansville, Terre Haute, Fort Wayne, and South Bend, Indiana. (A map on facing page illustrates the extent of the territories considered in the study.)

Here are four cities with many common attributes. They are all about the same size. Their trading areas are practically the same in population also, with the exception of Evansville. There are significant differences, however. Evansville and

How Various Trading Areas Compare

TOWNS WHOSE WHOLESALE TRADING AREAS SELL THE SMALLEST PROPORTION OF BATTERY SETS TO TOTAL SALES

Wholesale Territories of	Percentage Battery Set Sales	Wholesale Territories of	Percentage Battery Set Sales
1. Erie, Pa.	0.45	16. Detroit, Mich.	3.92
2. Corpus Christi, Tex.	1.27	17. St. Petersburg, Fla.	4.00
3. Scranton, Pa.	1.51	18. Chicago, Ill.	4.10
4. Charleston, N.C.	1.56	19. San Francisco, Cal.	4.20
5. New Orleans, La.	1.73	20. Lynchburg, Va.	4.26
6. Dallas, Tex.	2.47	21. Augusta, Me.	4.35
7. Huntington, W. Va.	2.68	22. Beaumont, Tex.	4.35
8. Charlotte, N. C.	2.74	23. New York, N. Y.	4.43
9. Cleveland, Ohio	3.06	24. Richmond, Va.	4.62
10. Sacramento, Cal.	3.28	25. Norfolk, Va.	4.63
11. Wilmington, Del.	3.33	26. South Bend, Ind.	4.68
12. Los Angeles, Cal.	3.39	27. Greenville, S. C.	4.76
13. Baltimore, Md.	3.53	28. Milwaukee, Wis.	4.82
14. Springfield, Mass.	3.58	29. Miami, Fla.	4.90
15. Denver, Colo.	3.71	30. Fort Wayne, Ind.	4.97

TOWNS WHOSE WHOLESALE TRADING AREAS SELL THE GREATEST PROPORTION OF BATTERY SETS TO TOTAL SALES

Wholesale Territories of	Percentage Battery Set Sales	Wholesale Territories of	Percentage Battery Set Sales
1. Grand Forks, N. D.	39.62	13. Evansville, Ind.	19.65
2. Orlando, Fla.	35.71	14. Altoona, Pa.	19.44
3. Mason City, Iowa	30.26	15. Davenport, Iowa	18.62
4. Charlottesville, Va.	28.57	16. Winona, Kan.	18.62
5. Savannah, Ga.	28.57	17. Ottumwa, Iowa	18.42
6. Sioux City, Iowa	28.37	18. Knoxville, Tenn.	18.09
7. Terre Haute, Ind.	27.17	19. Wichita, Kan.	17.26
8. Aberdeen, S. D.	26.84	20. Bloomington, Ill.	17.00
9. Minot, N. D.	26.32	21. Wilkes Barre, Pa.	16.29
10. Bismarck, N. D.	25.00	22. Cedar Rapids, Mich.	15.79
11. Hutchinson, Kan.	25.00	23. Atlanta, Ga.	15.09
12. Paducah, Ky.	25.00	24. Williamsport, Pa.	15.00

Terre Haute are surrounded by farming communities while Fort Wayne and South Bend are the focal points for small suburban towns. In other words, the two former cities are the shopping centers of rural communities, while the latter are the shopping centers of suburban homes. It naturally follows, also, that Fort Wayne and South Bend have more domestic lighting customers than Evansville and Terre Haute.

Note that as the rural population increases with a corresponding decrease in the number of domestic lighting customers, radiosales decrease tremendously. South Bend with the smallest rural population sold four times as many radios as Evansville and eight times as many as Terre Haute. Fort Wayne sold twice as many as Evansville and three times as many as Terre Haute.

The purchasing power in these four areas is practically the same. Is it not reasonable to suppose that a battery-operated set giving the same satisfaction as the screen-grid a.c. receivers would lessen the discrepancies between sales in these towns?

It is, of course, dangerous to draw any specific conclusions from a study of four cities but there is no question that this state of affairs can be duplicated many times throughout the United States. Is it possible that instead of a 3,000,000 production year we will have a 6,000,000 production year as soon as families not able to take advantage of the a.c. receiver discover a battery set that meets their requirements?

Why not? Let us quote from a letter sent to a radio manufacturer by a dealer in Shelbyville, Indiana:

"The farmers in this district have had two poor years and general business conditions in Shelbyville are considerably below average but the new battery set is helping to put radio sales ahead of last year. Our only regret is our failure to see the enormous possibilities of the market and make an earlier start. We had been under the delusion that the market for battery-operated sets was a thing of the past along with the crystal receiver.

"Inquiries from farmers concerning the new screen-grid battery sets opened our eyes and in October, and in November we sold them as fast as we could get them in stock. This profit is like finding money on the street."

The MARCH

A Purification Process is Under Way
Export—Another Avenue for Development

The New Day in Radio

ANDREW C. PEARSON, president of the National Publishers' Association, in a nationwide broadcast addressed by the United States Chamber of Commerce to business and industrial leaders of the country, remarked that only the radio and automotive industries are seriously inflated. It is easy to generalize upon the causes which have led up to this situation, but to appraise the position of individual manufacturers and the prospective developments of the immediate future is made exceedingly difficult by the limited statistical data available.

The leaders of the industry are given to buoyant optimism and to no small amount of exaggeration. Were we to credit the publicity issued by manufacturers during the last year, the production capacity of the industry would be computed at somewhere between 12,000,000 and 15,000,000 receivers. Unquestionably, the mere possession of these facilities represents an overhead which adds materially to the cost of receivers actually sold the public.

On the other hand, so large a proportion of radio manufacture is bench assembly, involving inexpensive tooling, that converting these excessive facilities to other uses is a task of small magnitude, considerably smaller than was required, for instance, to change over munitions plants to peacetime uses. Diversification of activities is one of the best ways to stabilize receiver manufacture and to defeat the seasonal character of radio production. Another avenue is the development of export business, necessarily a slow and difficult process, but one which will ultimately exert as great a stabilizing influence as it has already done for the automotive industry. None of these possibilities, however, bear upon the immediate situation because of the time and capital required to develop them. The industry must learn, in times of prosperity, to erect defenses against troubled times.

The measures being applied in the present emergency are not of a character to inspire confidence in their effectiveness. The most definite trend discernible at the present writing is reduction of list prices. That invites a broader market and also the maintenance of excessively large production facilities. It may exert an immediate curative tendency, but it also brings us nearer to the point of profitless production. The trend toward lower prices is of advantage only if accompanied by a reduction in the number of active manufacturing units.

Another measure stimulated by the emergency situation is the attempt to increase the number of selling outlets through consolidation with automotive distribution. This promises to doom us to another crisis as complex as that engendered by excessive expansion of production. The logic of combining automotive and radio distribution is irresistible but it cannot be accomplished on a widespread scale without painful disturbance of existing distribution relationships, and an educational process of no small magnitude. Desirable as the ultimate effects of such a readjustment may be, by reason of the



more efficient sales system resulting, the transition stage requires the elimination of the lesser radio retail outlets, with accompanying liquidation of their stocks under unfavorable conditions. The invariable effect of distress merchandising is to hold up the conservative buyer who waits for still lower prices.

Consequently, the adjustments required by the industry are of a fundamental rather than a superficial character. The problem is somewhat larger than waiting for a storm to blow over; it requires a complete realignment of production and distribution. Such a major readjustment is not effected in a day. Those organizations possessing far-seeing executive leadership, which can penetrate the fog that obscures the future, are destined to reap a tremendous reward. The opportunities in the radio industry are greater to-day than they have been at any time in its history. For once there is no band wagon upon which all may leap for an easy ride to success. The day of opportunism is over. Success requires intelligent direction and foresight. A process of purification is under way on a large scale, eliminating every weakness in the structure of the industry, the executive who is an engineer and not a business man, the optimist who knows only multiplication and has forgotten addition, the retailer who waits for customers, the manufacturer who imposes burdens upon the retailer too large for his abilities.

We venture to predict the coming of new leaders in the field, assuming management of existing companies with courage enough to support them. They will effect consolidations, diversification of manufacture into broader fields, reconstruction of selling outlets and distribution methods, and rounding out of receiver design to appeal to new markets. The radio market is still virgin territory, with less than one fourth of



American families owning radio receivers and only a small proportion of the receivers in use sufficiently modern to resist the appeal of revitalized merchandising. This is the day of opportunity in radio, opportunity for intelligence, ingenuity, and leadership.

revitalized merchandising. This is the day of opportunity in radio, opportunity for intelligence, ingenuity, and leadership.

Educational Broadcasting

The gradual growth of educational broadcasting is beginning to reflect itself in the number of schools which are equipped for radio reception and the distribution of programs through loud speakers in every classroom. Most of the new schools in the more progressive cities, constructed within the last year, are fully wired so that program distribution systems can be installed. Some enterprising manufacturers have taken advantage of this trend either to present programs for school purposes or through the preparation of promotion material to aid dealers in selling schools. Atwater Kent has issued a pamphlet, "The Value of Radio to and in the Schools," and the Grigsby-Grunow Company, aided by the advice of Commissioner of Education Dr. John William Cooper, is presenting a bi-weekly feature, "The American School of the Air,"

OF RADIO

Who Is the Radio Protective Association?
New Progress in Broadcasting for Schools

on Tuesday and Thursday afternoons at 2:30. The programs are addressed to junior high school pupils. Tuesdays are devoted to the teaching and development of American history and Thursdays to a diversified program of literature, political science, health hygiene, American music, and nature study.

The Payne Fund of New York City has issued a report, "Radio in Education," prepared by Armstrong Perry, outlining in detail the educational experiments undertaken by stations throughout the country.

A questionnaire, sent by the Fund to 3000 county superintendents, principals, and teachers, indicates that 441 of the 471 replying would like a school of the air for the benefit of the 12,905 schools with the 42,043 teachers which they represent. Of the schools represented 5741 would become radio equipped as soon as programs are assured.

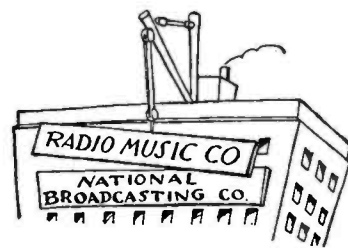
A check-up made by the Atwater Kent Company indicates that 360 sets have been sold to educational institutions for classroom broadcast reception. Some 20 to 45 per cent. involve multiple loud speaker installations, the largest being one of 30 loud speakers at Ferndale, Mich. The two educational broadcasts attracting the greatest attention are the Ohio School of the Air through WLW and the daily school programs of the Chicago Daily News through WMAQ. While the recognition of the Damrosch program has been widespread, the investigation did not disclose any schools in larger centers which have incorporated his lessons on music appreciation in their curricula. The same situation was found to apply to the music appreciation programs broadcast on the west coast by the Standard Oil Company of California.

Too Much Icing is Indigestible

Accompanied by a statement of altruistic objectives, the National Broadcasting Company announces that it has combined with Carl Fisher, Inc., and Leo Feist, Inc., to form the Radio Music Company. No one, after reading the statement, would be surprised if the R. M. Co.'s employees were required to wear white wings and halos. The object of the shrine of idealism which has been formed by this combination of interests is "the improvement of music in general, the advancement of American culture," and "to encourage young composers to write finer scores and to restore harmony and melody to music." Its operating policy is to be "almost revolutionary." We suspect that, if the company makes profits, the directors are pledged to commit suicide. It is peculiar to radio broadcasting that any enterprise which it undertakes must be labeled as a lofty inspiration, patently unattainable by persons not in close contact with the moral forces.

E. C. Mills, who will be remembered as the shrewd bargainer who held the radio broadcasting industry at his mercy as negotiator for the American Society of Authors, Composers and Publishers, is president of this majestic institution. It is

announced that there will be no boycotting of music not controlled by this new organization which should cause a sigh of relief to Friml, Schilkret, and Pasternack, if not to lovers of Beethoven, Wagner, and Puccini. The Radio Music Company will secure control of a sufficient number of composers so that it can dictate satisfactory terms for the vast amount of musical composition necessary to commercial broadcasting. It will profit not only through the payments made by radio advertisers for scripts and special arrangements, but by sharing in the profits made by merchandising the composer's works in every other field, such as music publishing and talking motion picture composition. In other words, it is to operate like the present N. B. C. Artists' bureau which bargains for radio talent at the lowest prices when it is the agent of commercial sponsors, assures artists, under its exclusive management, of maximum radio earnings and, to itself, commissions for every appearance of the artists under its control.



An Invitation to Mr. Schuette

There is no more mysterious character in the radio industry than that delight of the press, Oswald Schuette, spokesman for the Radio Protective Association and the public relations counsel to the newly founded Audio Research Foundation. Mr. Schuette makes a specialty of annoying the Radio Corporation of America and its associates by a skilfully executed policy of political palestrics and prolific publicity. He is seen frequently at the offices of the Federal Radio Commission, the Department of Justice, at the House and Senate, and the Federal Trade Commission. The utterances of certain public officials sometimes seem so remarkably like echoes of Mr. Schuette's whisperings that one is led to credit him with potent influence. Possibly monopoly baiting is so popular in political circles that scrutinizing the auspices under which monopoly baiters speak is not always carried out with the care which it deserves.

In fairness to the public and the press, Mr. Schuette should make public a complete list of his backers. These columns are open for the publication of such a list. Mr. Schuette's steadfast refusal to announce the membership of his Radio Protective Association lays him wide open to charges that he represents no one but himself, a charge which is probably entirely unfair.

The principal characteristics which commend Mr. Schuette are his zealotry and resourcefulness in his relentless fight against the predominant influences in the radio field. If there are monopolistic leanings in the radio field, Mr. Schuette is the watchful protector of the public interest. It is unfortunate that the foundation for his activities is so completely shrouded in mystery and that one cannot silence the suspicion that he does not speak for any of the leaders or any substantial element of the radio industry.

—E. H. F.



PROFESSIONALLY



SPEAKING

TWO NEEDED DEVELOPMENTS

TWO developments are needed to bring radio to the farmer; either one will do the trick, and both may revolutionize the entire radio business.

Of several characteristic radio receivers which are manufactured especially for the farm market, two require a plate current of 60 milliamperes from the B batteries, three require 25 milliamperes, one needs 20 milliamperes, and one operates economically on only 15 milliamperes. All need more than one ampere from the storage battery and most of them take about 1.5 amperes.

Considering a set which takes but 15 milliamperes from the B batteries, it is probable that one set of three batteries will last a year. This costs about \$12.00 and, when added to the cost of charging the storage battery (\$6.00 for the year), brings the farmer's cost of operating a set up to about \$1.50 a month. Such economy is secured by taking advantage of the superior sensitivity of the 200A special detector tube, and using a single 112A as power tube. Those sets which require 20 or more milliamperes of B power use the 171 type of power tube, and those which consume the uneconomical amount of 60 milliamperes use two of these tubes in push pull.

Contrast \$1.50 a month upkeep on the simplest farm set with a report of the Toledo Edison Company showing that 91 owners of a.e. sets on a 7-cent rate paid an average of \$6.02 per year for the pleasure of home entertainment via radio. Additional proof that the farmer must pay more than the city dweller for his radio is data from Stromberg-Carlson which states that Model 642 receiver consumes 90 watts, a charge of \$9.00 at a 10-cent rate for 1000 hours of service.

All of this points to the fact that the farmer pays heavily for his radio in spite of the fact that he needs it more than the city dweller, and should be able to get it at lower cost.

Without casting reflections on those set manufacturers who equip their farm radios with 112-type power tubes, it must be said that such receivers are reminders of the days of 1926. In order to supply a loud speaker from a single 112 tube the set must either operate at a very low level or at poor fidelity, so that overloading is not evident. It can be done by using a poor loud speaker, or by having an a.f. amplifier that definitely cuts off both high and low frequencies. In other words, an economical farm radio must operate at the expense of fidelity or volume!

What is needed is a new tube, one which will produce considerable power without the expenditure of 20-30 milliamperes of B battery current. Or, what is wanted is a new loud speaker, one that is much more efficient than present-day loud speakers so that on a power tube plate current of 10 milliamperes considerable volume at high fidelity will be possible.

The new tube will fix up the farmer; the new loud speaker may revolutionize the radio business. Suppose it were possible to obtain present-day volume and fidelity by using a 112 tube? Gone would be the day of 250-volt power packs taking 100 milliamperes; then the announcer could say of radio as he does of tobacco, "progress has been made."

REGARDING RADIOS IN AUTOMOBILES

Without appearing to judge the case before it is tried, we venture to offer an opinion on this business of radios for automobiles (see page 193). It seems to us that there are several people to be considered—the automobilist, the innocent bystander already bothered with noise from autos and in danger of being run over by one-arm drivers, and finally the set manufacturer.

The automobilist has about all he can do now to stay on the straight and narrow. Are we to have one-car drivers to add potential sources of accident? And we cannot see how anyone could enjoy much radio music while journeying about in an auto. The rumble of the motor and of other cars' motors would completely mask any low frequencies, even if they could be obtained from the small loud speaker that will be put in the ear. The pedestrian or dweller by the road side is already complaining about traffic noise. The din from autos that pass your house, if equipped with radio sets, would be worse than your neighbor's set which may be very loud—it usually is—but is tuned to one program. Instead you would listen to a dozen programs at once going up and down the street.

It is our opinion that the only people who will benefit by radios for automobiles are those who make—and sell—the sets. The technical difficulties of building a high-quality set for installation within the confines of the average ear are almost insurmountable. The loud speaker cannot be very efficient at low frequencies because there is not sufficient space available.

If manufacturers really want a new field to conquer, let them develop cheap portable sets that can be lugged about the house, into the garden, put in the car, taken to the camp, given to the children or merely plugged into a really good loud speaker when a high degree of fidelity is desired.

The magistrates and citizens of New York City are making a determined investigation of the sources of noise in that city. Loud speakers which blat forth day or night in dealers' doorways are coming in for their share of condemnation as being against the public health and comfort. Imagine the task if half the cars that tore along had radios going full tilt to add to the din. There is still plenty for engineering departments to do to perfect present-day radio without turning them loose on a field where radio is neither needed or wanted, and where it is almost certain to become a nuisance.

Attention—

A new and more efficient type of loud speaker could revolutionize the radio industry.

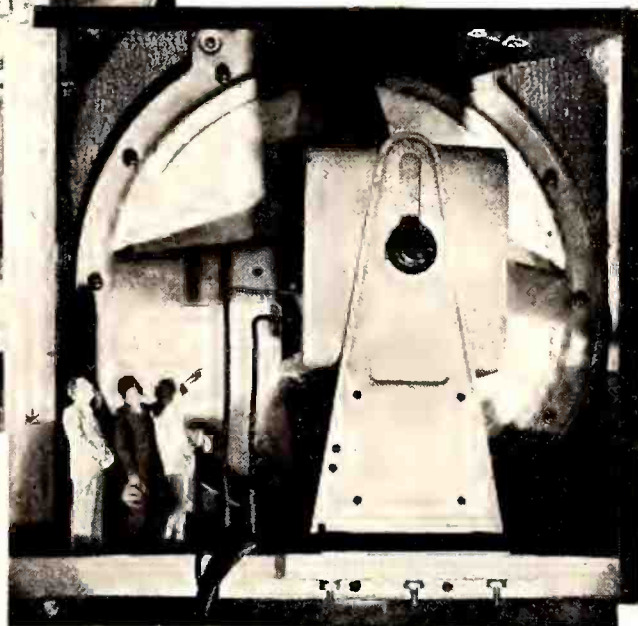
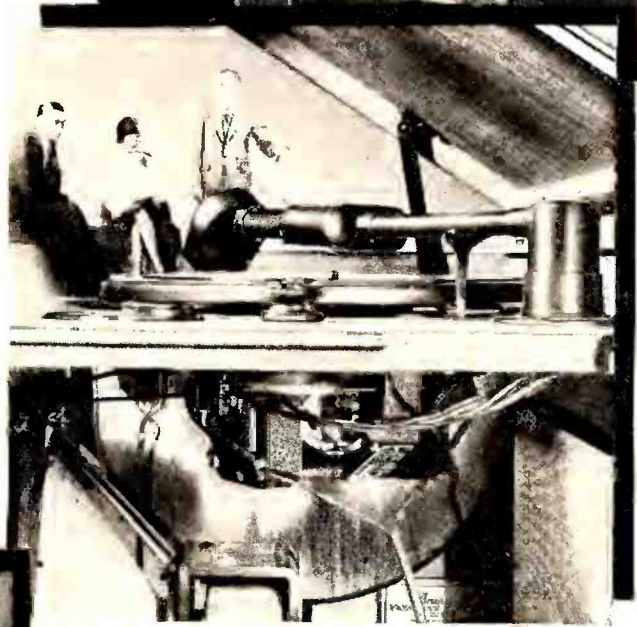
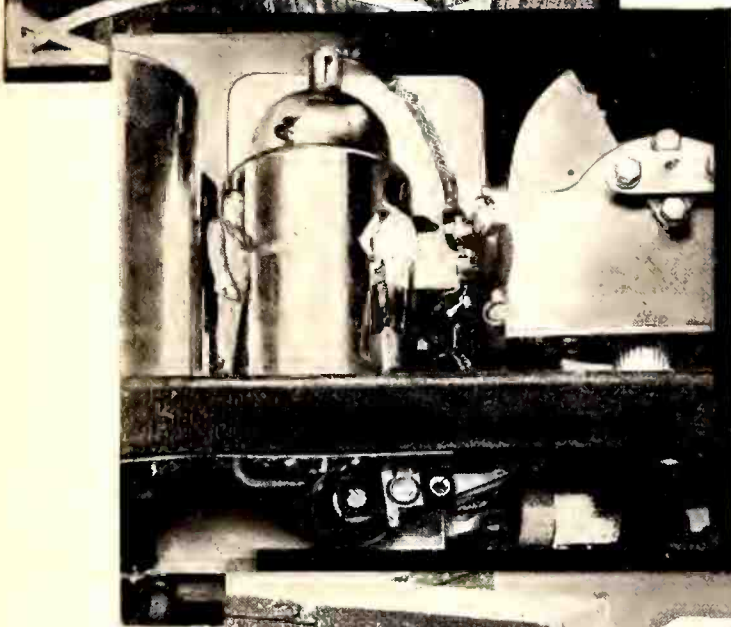
Wanted—A power tube which requires only 10 mA. of B current and provides ample output.

Let's not add one-ear automobile drivers to our long list of potential dangers in cities.

An efficient, inexpensive portable receiver would solve many of our problems.

THE INSIDE STORY OF THE BRUNSWICK

The six pictures on this page were taken from a booklet, "The Inside Story of Brunswick," which is published by the Brunswick-Balke-Collender Co., Chicago, Ill., to illustrate and describe the all-electric radio and Panatrope which they manufacture. The pictures are so filled with human interest that we considered them well worth reprinting. It is hoped that they will suggest other interesting forms of advertising.



☛ Above left: "Upon entering the set the ease of operation is demonstrated; three convenient control knobs, illuminated dial."

☛ Center left: "Every part of the receiver chassis is as delicately attuned as a fine pocket watch."

☛ Below left: "Both inside and out the transformers and tuning coils of the receiver are built with absolute precision."

☛ Below right: "Vibrationless tone is assured in the Brunswick by the mounting of the super-electrodynamic loud speaker."

☛ Above right: "Careful doweling in cabinet construction prevents any possibility of warping after the set leaves the factory."

☛ Center right: "Modern electrically cut records are reproduced faultlessly with a new magnetic pick-up unit."

A New Musical Instrument for the Home

THE R. C. A. THEREMIN

THE RCA THEREMIN is a development of the Thereminvox, an invention of Professor Leon Theremin, of the Institute Physico-Technique of Leningrad. It was first demonstrated before a small and select audience of musicians and critics and soon after (January 31, 1927) before a much larger (and enthusiastic) audience at the Metropolitan Opera House.

It is a musical instrument operating entirely by electrical circuits. It has no stops, key boards, or any of the other mechanical contrivances with which musicians on other instruments must labor. The music which can be obtained from the device depends upon the operator only, and the motion of his hands with respect to two electrodes, one for controlling volume, and the other for controlling pitch. The highest tone that can be secured is about 1400 cycles which is about the limit of the average soprano or the oboe. The lowest note is some three and one half octaves below. In other words, the approximate range is from the second G below middle C to the F sharp two octaves above middle C. This is somewhat greater than the viola.

Principle of Theremin

The principle of the Theremin is that of the beat-frequency oscillator, i.e., two oscillators whose outputs are mixed and amplified. One oscillator is fixed in frequency and the other is variable by changing the capacity of the tuned circuit. This change is produced by movements of the operator's hand. An additional oscillator furnishes filament current for a ux-120 tube which acts as volume control.

The pitch-control rod is connected to a coil having a very high inductance. In addition there is connected to this coil a small condenser and a small concentrated coil. This entire circuit is tuned by the distributed capacity of its coils and resonates at approximately 172 kc. Not having any fixed capacitor connected across it for tuning, the ratio of inductance to capacitance is very high. Thus the small increase of capacity caused by the hand close to the pitch rod will cause the circuit to change its natural period considerably, a great deal more than if a large capacity and small inductance were used.

Pitch-Control Circuit

This pitch-control circuit is connected to the grid side of the variable pitch-control oscillator, the frequency of which is slightly greater than that of the pitch-control circuit. Bringing the hand close to the pitch rod will increase the parallel capacity in that circuit and thus reduce its frequency. As this capacity is reflected in the oscillator circuit a similar decrease in frequency will result in that circuit, the amount of decrease depending on the proximity of the frequency of the two circuits. Thus a greater decrease in the frequency of the oscillator circuit is obtained when the pitch-control circuit is close to the oscillator circuit in frequency than when it is at a greater frequency difference.

The fixed-pitch oscillator operates at a frequency, when correctly adjusted, at a maximum of 1400 cycles greater than the variable-pitch oscillator. The amount

of this difference is dependent on the frequency of the variable-pitch oscillator the frequency of which is determined by the position of the operator's hand in relation to the pitch-control rod. The frequency of the fixed-pitch oscillator does not change while playing.

Circuit Functions

An example of the functioning of these three circuits follows:—

The hand approaches the pitch-control



Prof. Leon Theremin demonstrating his new invention.

rod and increases the capacity across the pitch-control circuit. This capacity is reflected across the variable pitch-control oscillator and thus reduces its frequency. This causes an audible frequency difference between this oscillator and the fixed-pitch oscillator, the frequency of this note depending on the position of the hand. Bringing the hand close to the rod will increase the capacity in the pitch-control circuit, reduce the frequency of the variable-pitch oscillator, and increase the difference between the frequency of this oscillator and the fixed-pitch oscillator. Thus an audible note is obtained, the note increasing in frequency as the hand approaches the pitch-control rod.

The two oscillators are uy-227 tubes. The oscillator grids are connected to the control and screen grid respectively of a uy-224. As the screen grid has the largest area, a 10,000-ohm resistor is connected in series with it to balance the input to this tube and to make each oscillator have the same effect on the detector action. This tube is a detector or combining tube that functions much in the same manner as the first detector in a super-heterodyne

circuit. The output of the detector is then amplified by a two-stage audio-frequency amplifier using a uy-227 and a ux-171A, the output of which goes to the loud speaker.

Volume-Control System

The remaining two tubes, ux-120 and ux-171A, together with the first audio-frequency amplifier constitute the volume-control system. The ux-171A is in an oscillating circuit that operates at about 420 kc. Connected to the grid side of the oscillator is the volume-control loop circuit. This circuit resonates at a frequency below the oscillator frequency when the hand is entirely removed from the volume-control loop. This is done for two reasons. If the two circuits were in exact resonance, the load on the oscillator would be too great and operation would be unstable. Also the pick-up current would be high and might damage the tube. The ratio of inductance to capacity in this circuit is also quite high. A small pick-up coil is wound around the inductance coil of the volume-control circuit comprising a looped control rod of low capacity to frame, in series with the high-inductance primary of a r.f. transformer. This circuit resonates at a frequency below (but close to) the oscillator frequency when the hand is entirely removed from the volume-control loop. The circuits are not put in exact resonance because the load on the oscillator would be too great and operation would be unstable. The secondary winding is a small pick-up coil of few turns wound around the low end of the primary winding.

When the oscillator and hand-tuned primary circuits are nearly in resonance (hand entirely removed) sufficient radio-frequency current flows in this pick-up coil to light the filament of the ux-120 to which it is connected. When the hand approaches the volume-control loop, the natural period of its circuit is decreased in frequency, the circuit is out of resonance with the oscillator by an amount depending on the proximity of the hand, and less current flows in the pick-up coil resulting in a decreased brilliancy of the ux-120 filament.

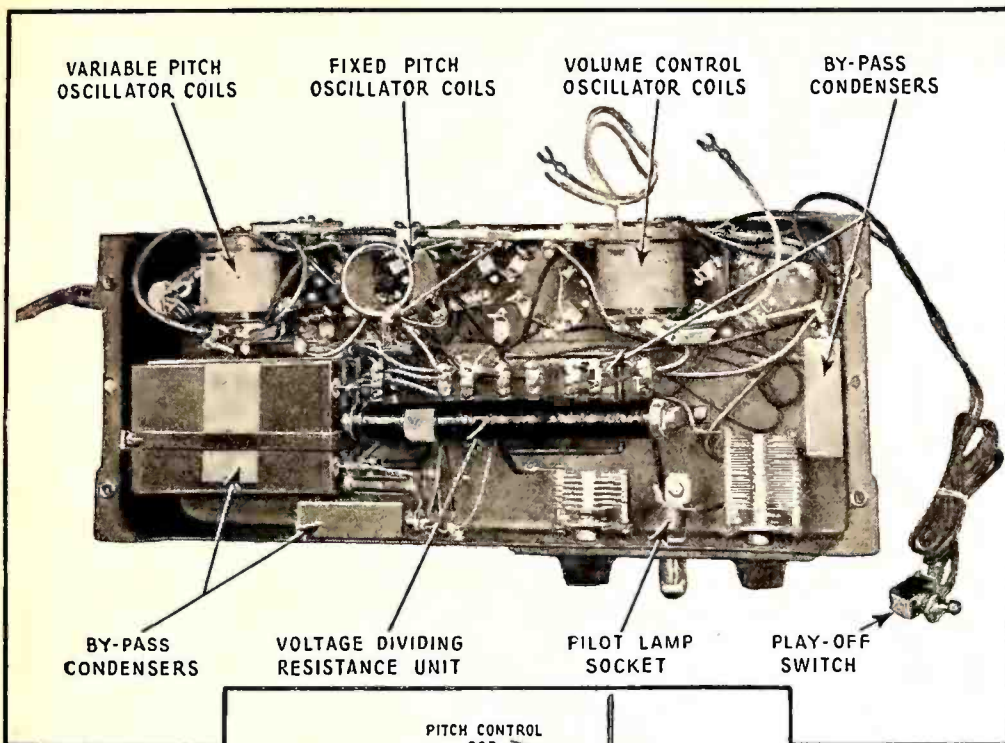
The plate current of the first audio-frequency amplifier tube (uy-227) is fed through the ux-120. Thus if the ux-120 were at maximum brilliancy, maximum volume would be obtained. Likewise if it were not lighted, no signal output would be obtained due to the fact that amplifier plate current would not flow.

A condenser and resistor are placed in the plate voltage supply to the first audio-frequency tube which regulates the time constant of the volume control. They are adjusted to prevent any undue lag in operation of the volume control, while preventing quick accidental variations in volume due to a slight unsteadiness of the hand. The condenser also increases the efficiency of the audio-frequency amplifier by preventing a loss of a.c. voltage across the ux-120. The low side of the resistance instead of being connected to ground is connected to a tap on the grid leak of the volume-control oscillator. This supplies a small negative potential to the plate of the first a.f. tube and insures that zero

(Continued on page 245)

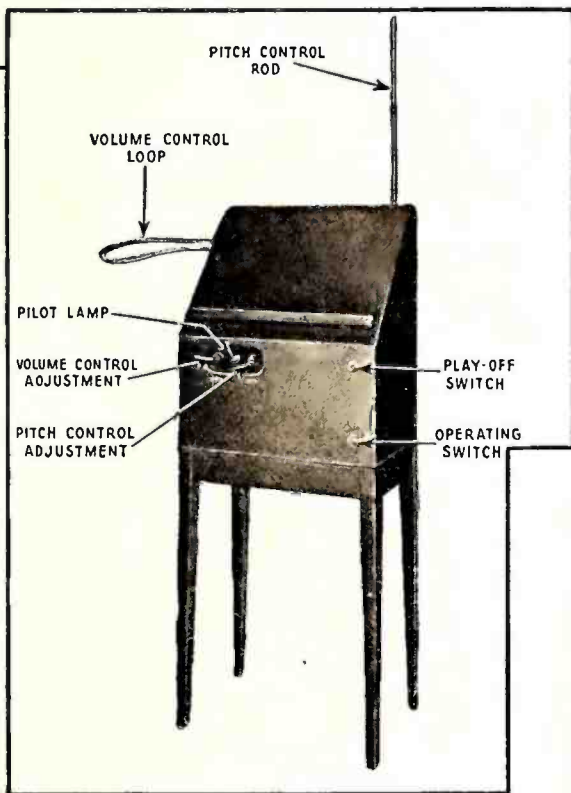
Q-3

The THEREMIN IN PICTURES

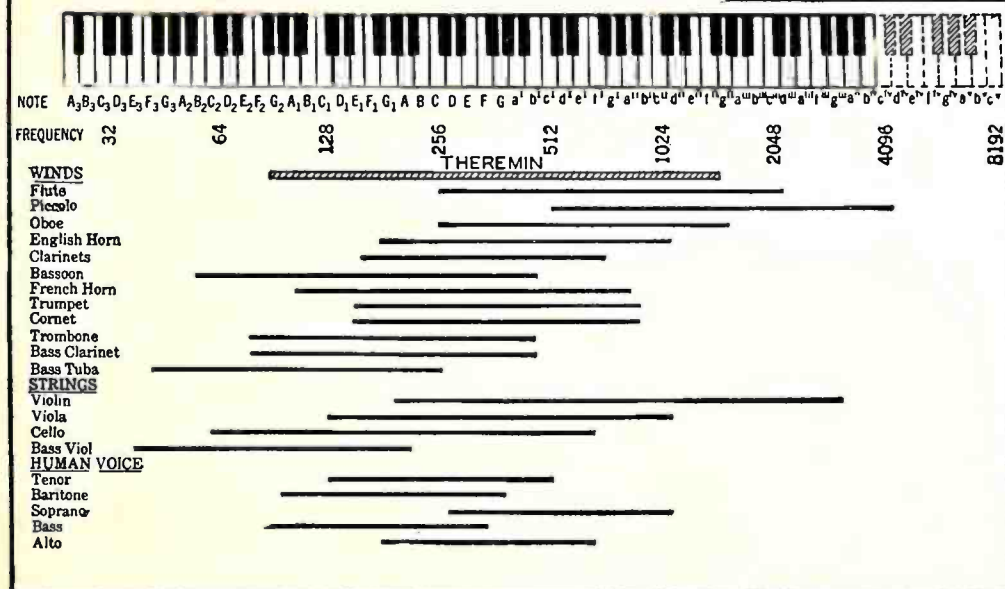
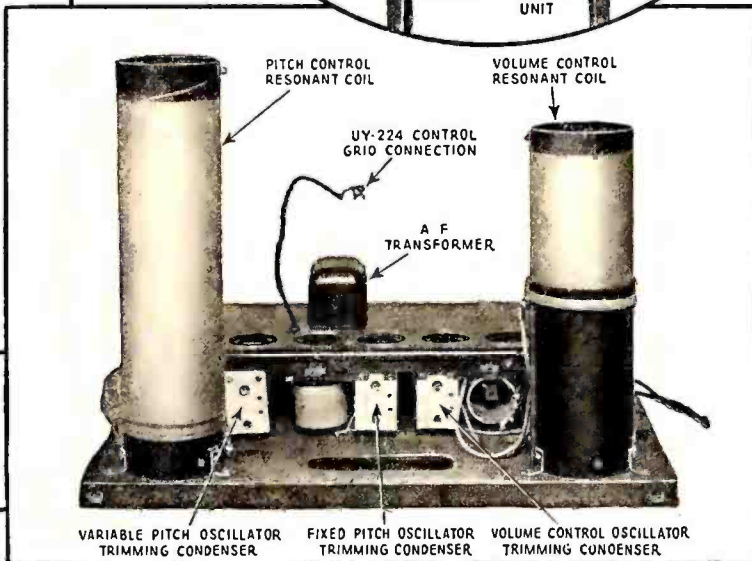
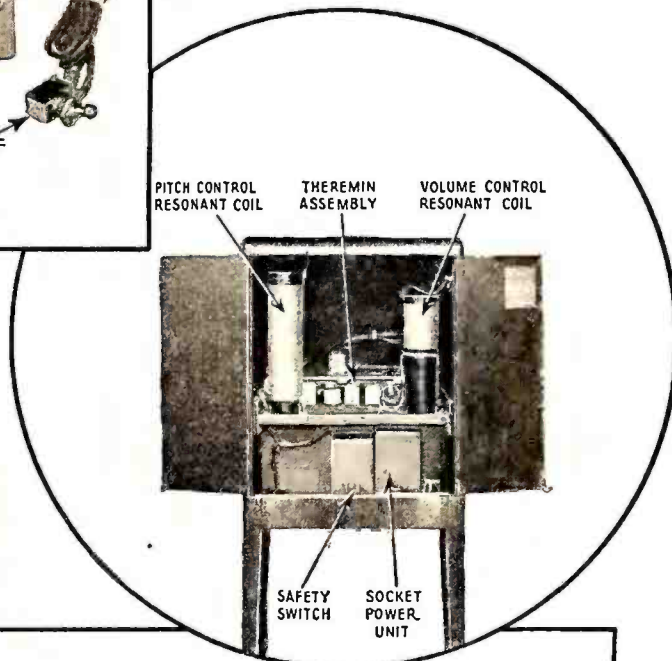


Below: The location of the chassis assembly and the power supply unit is clearly shown in this rear view of the Theremin cabinet.

Above: The Theremin chassis as viewed below, clearly showing the wiring and location of parts.



Above: View of R.C.A. Theremin with all operating controls labeled. Right: Top view of Theremin chassis. The five tube sockets are located between the coils and in front of the a.f. transformer.



Left: The frequency range of the Theremin is indicated by the shaded line directly under the piano scale. The chart also shows how the new instrument compares in range with the human voice and other musical instruments.

2-4

A PRODUCTION TESTING SYSTEM

By J. A. CALLANAN

Stewart Warner Corporation



The choke coil test set.



The output transformer test set.

IN THE FIRST article of this series which appeared on page 152 of January, 1930, RADIO BROADCAST the testing of all types of condensers—compensating, variable, by-pass, filter, etc.—that are used in the construction of a broadcast receiver was considered from the viewpoint of the manufacturer's production department. In this article we will continue the discussion of production testing and various iron-core items, such as transformers, choke coils, etc., will be considered.

The testing of iron-core items may be divided into three distinct classes as follows:

- (1) The testing of power-pack transformers
- (2) The testing of audio-frequency input and output transformers
- (3) The testing of audio-frequency choke coils.

With these items it has been found that severe tests are very much worth while, the reason being that after the unit has been sealed with pitch in a container, as is the usual practice, replacing a defective part is both costly and difficult.

Power-Pack Transformers

Following the order of the above listing, the tests on power-pack coils and transformers will be considered first. These parts, upon receipt from the coil-winding department, are immediately tested for

opens and shorted turns with an ordinary continuity meter and a short-circuit-turn test set. Complete details of the shorted-turn test set are given in Fig. 1 and the apparatus is pictured on the next page.

The shorted-turn test merely consists of placing the coil over the solenoid and noting whether or not the meter deflects, deflection indicating shorted turns. Simply described, when there are no shorted turns the flux density of the two legs is equal and the potential across each coil is the same. Then, as the two circuits are bucking, there is no potential difference across the rectifier indicator circuit. However, when shorted turns are added current flows through them and generates an opposing

flux, thereby lowering the potential across the coil on one leg while that of the other remains unchanged. This causes a potential difference across the rectifier which, in turn, is indicated by the meter. The windings are not tested for number of turns as this is determined by automatic winding counters.

After the test described above has been completed the winding is assembled with the core, leads are attached and the assembly is tested by the power-pack tester shown in a picture and in Fig. 2. When the transformer leads are connected to this apparatus the primary is connected to the 110 a.c. supply through a resistor, R_1 , by throwing a switch to "test" position. The resistor used is of the order of our ballast so that imperfections in the windings may be indicated by an incorrect reading of the primary current meter. If a ballast were used here it would tend to give identical readings for all transformers even though the winding or core were faulty.

The secondaries of the transformers are connected across loads R_2 , R_3 , etc., which simulate those of the receiver and the potential drops across them are measured with a.c. voltmeters. Switch No. 2 is used to connect the high-potential meter, V_2 , across either half of the rectifier secondary and to switch the 0-3 voltmeter, V_3 , from one 2.5-volt filament winding to the other. This scheme not only affects a

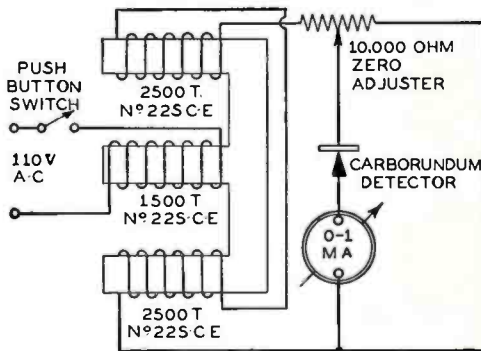


Fig. 1—Shorted-turn test circuit for output transformers.

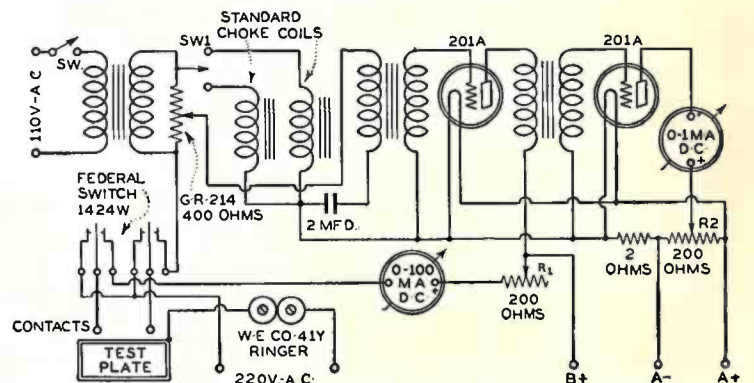
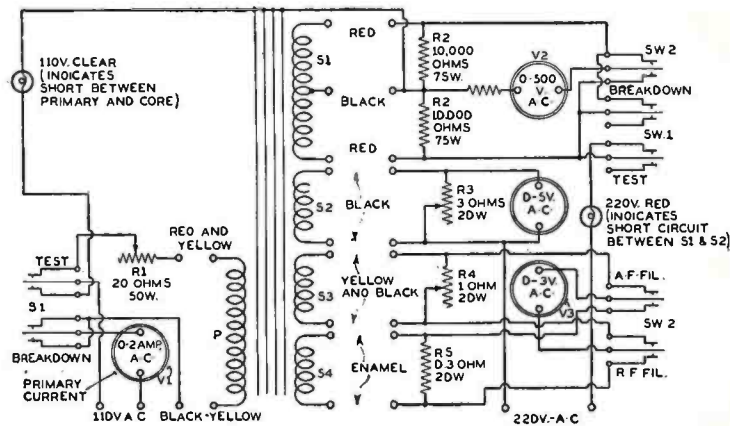


Fig. 2 (left)—Power transformer test circuit; Fig. 3 (above)—test for choke inductance.

saving of meters but also, as in the case of the rectifier winding, where the limits are less than 1 per cent., guards against possible error due to differing meters. The test limits are painted on the meter scale. When switch No. 1 is thrown to the break-down position a continuity test is made with 110 volts a.c. between the primary winding and the core. a shorted condition being indicated with a 25-watt clear lamp. At the same time a continuity test is made with 220 volts a.c. from the high-potential winding to the adjacent filament winding. In this case a shorted condition is indicated with a 220-volt 25-watt red lamp. While other break-down combinations are possible, we have as yet to experience one coil which passed this test and did not perform satisfactorily in a receiver. The design of such apparatus, however, depends upon the characteristics of the coil and the points of greatest stress; the proximity of the leads, etc., must be taken into consideration when building similar test equipment.

A. F. Transformers (Input)

Testing audio-frequency input and output transformers is a simpler matter. While we test 3 per cent. of the entire production

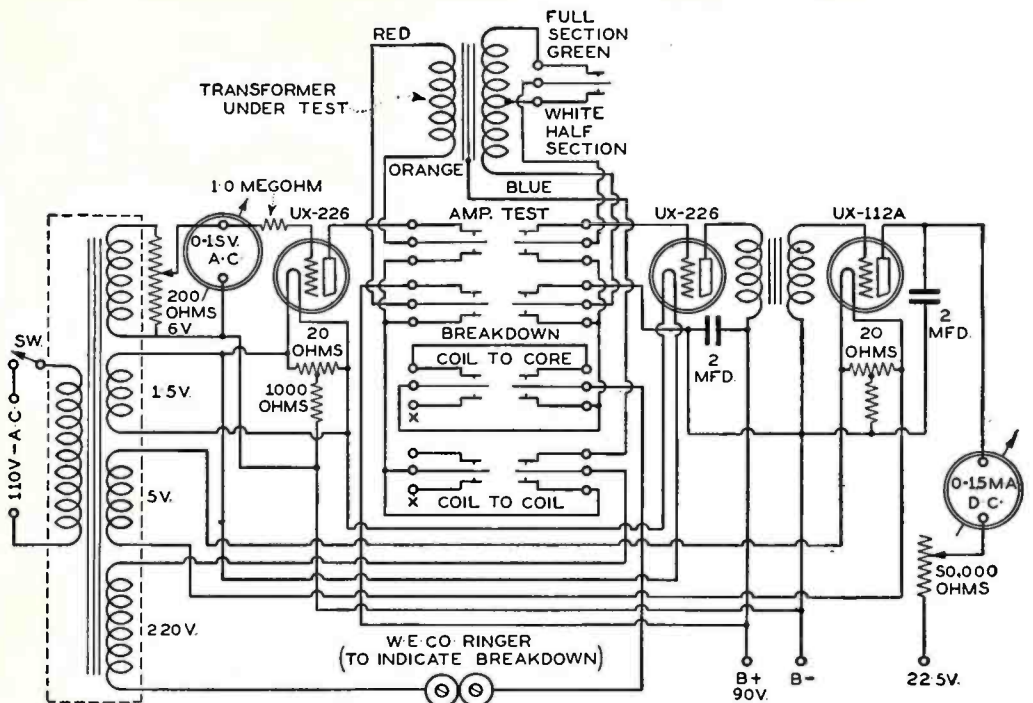


Fig. 5.—Audio-frequency input transformer test circuit.

type are tested by omitting the switching. When the switch is thrown to break down continuity at 220 volts a.c. is first made from coil to core and then from coil to coil, with the aid of a third switch as shown in the diagram and picture. Adjustment of the input potential is made with the 200-ohm potentiometer while the sensitivity of the V.T.V.M. is controlled with a 50,000-ohm resistor connected in the plate lead of the tube. The circuit is shown in Fig. 5.

Output Transformers

The output transformer test fixture is very similar to the input as can be seen by reference to Fig. 4. It differs only in that a larger a.c. input is used and that the output is connected to a thermogalvanometer rather than a V.T.V.M. as the load is more nearly correct. In this case we first test one half of the primary and then the other. The input potential is controlled by a 200-ohm potentiometer and the galvanometer reading by a 30-ohm rheostat. The filament and break-down potential of both these machines are obtained from a.c. lines while the B supply is from
(Continued on page 243)

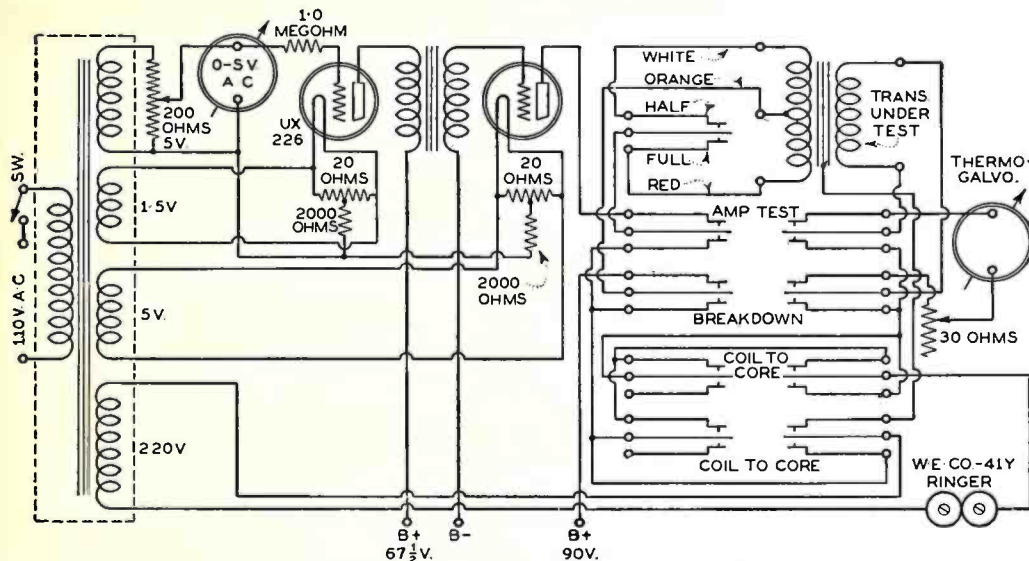


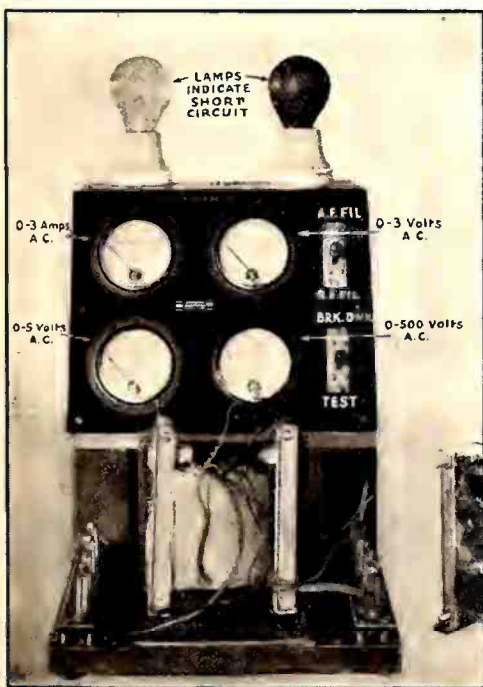
Fig. 4—Circuit for testing output transformers.

at three frequencies, 60, 500, and 5000 cycles, the production test is made with 60-cycle supply and conducted in the following manner.

Upon receipt of the coils they are tested

for shorted turns, break-down between windings, and the number of turns. This is accomplished in one operation by placing the coil on a partial core, connecting the primary to the output of a bell-ringing transformer, and connecting the secondary to a vacuum-tube voltmeter. Spring clips make the connecting quick and positive. The deflection of the V.T.V.M. indicates whether or not the coil has been correctly wound while a possible short between primary and secondary is indicated by a 45-volt B battery and a meter connected between the low sides of these windings. After the assembly has been completed the transformers are placed on one of two conveyors, depending upon whether they are input or output transformers. The conveyors take the units to the test fixture shown in Figs. 4 and 5 and the accompanying pictures. The input transformer test fixture tests the circuit by connecting it between two tubes and measuring its gain at 60 cycles with a V.T.V.M. The transformer is placed in the jig and the leads are connected to spring clips. When the switch is thrown to test position one half of the secondary is first connected and then the whole secondary. The reader would no doubt expect that each half would be tested, but we have found coils in which one half the secondary was bucking the other half so the above method was selected.

Coils which are not of the push-pull



Power-pack transformer test set.



The shorted-turn coil tester.

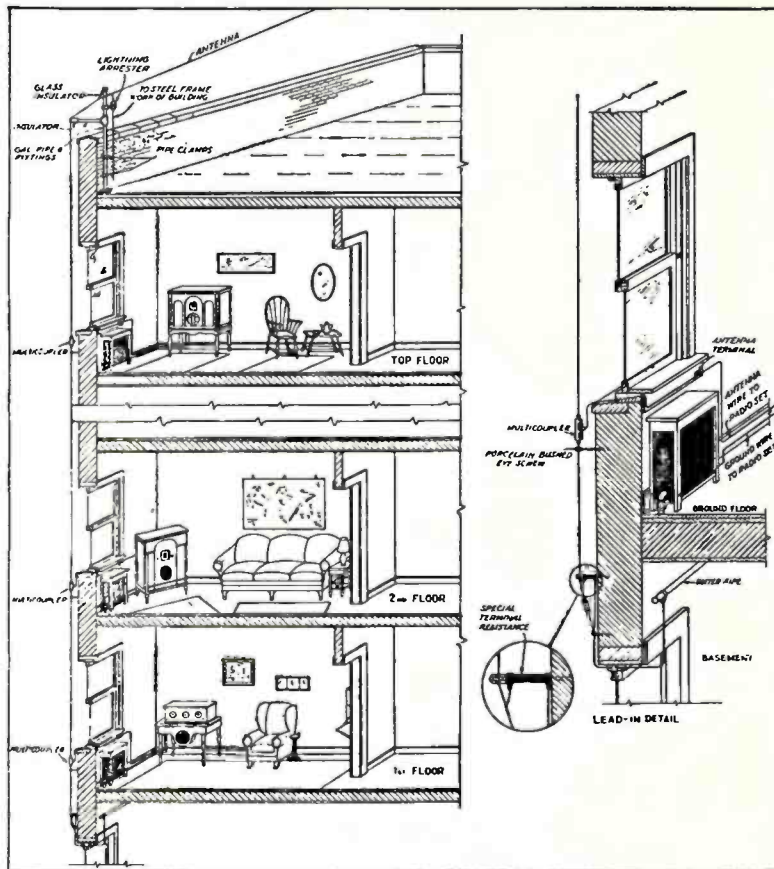
THE MULTICOUPLER ANTENNA SYSTEM

By ERNEST V. AMY and J. G. ACEVES

Amy, Aceves, and King, Inc.

NO LONGER need committees of civic beautification rack their brains to find ways and means of ridding the housetops and apartment house roofs of their maze of unsightly poles, antennas, wires, and cables. The multicoupler antenna system, a group antenna for the operation of from 1 to 15 radio receivers, is both sightly and simple. It makes use of a small coupling device between the common antenna and each radio set, requiring no additional equipment or pre-amplification.

The system comprises a pick-up device, such as an antenna, preferably mounted on the roof of the building, and a lead-in conductor passing from floor to floor and, if desired, to a plurality of locations on one floor. A number of radio sets are coupled to the lead-in by running the antenna connection of each receiver to the binding post on a device called the multicoupler, which is a combination of inductance and capacity enclosed in a bakelite cylinder some six inches long. These multicouplers are inserted in the lead-in, one for each radio set to be operated. The antenna connection of the radio receiver goes to a condenser in the multicoupler, which in turn goes to the center of two loading coils interposed in the lead-in conductor between the various receivers. The values of the condensers and loading coils are chosen so that the lead-in conductor and apparatus attached to it will act like a loaded transmission line, the upper frequency of



Showing how the multicoupler system is installed in an apartment house.

mission line, the end of the line or lead-in is grounded through a resistance, approximating the line surge impedance, that is, $R = \sqrt{L/C}$. We have found that very satisfactory results are obtained when the intermediate loading coils have inductances of 80 microhenrys, the initial and final loading coils have 40 microhenrys, the coupling condensers for the various receivers have capacities of 250 mmfd., and the terminal resistors have a value of from 500 to 1000 ohms. Under such conditions the transmission line will pass frequencies as high as 1600 kilocycles.

The insertion of the radio receiver in series with the coupling condenser will change the value of the resistance as well as the reactance of the shunt element at that point. But it is desirable that this change be so small that the effect on the other receivers will not be greater than the interaction present were each receiver connected to its own antenna.

In order to determine the reaction of a number of typical radio sets upon the properties of the loaded line to which they were connected, a number of tests were made which are herein classified under three main headings: First, when the sets were not connected to the line and the condensers (C in Fig. 3) grounded; second, with all the sets connected to the line but not tuned to the same frequency; third, the same measurements repeated with the sets all tuned to the same frequency.

which is equal to $\frac{1}{\sqrt{LC}}$. The intermediate

loading coils all have substantially equal inductance, while the initial and final loading coils have an inductance equal to one half that of the intermediates. (Figs. 1 and 2).

To prevent standing waves on the trans-

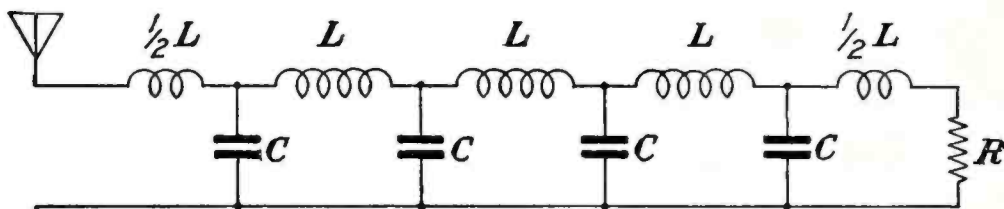


Fig. 1—Circuit arrangement in test where coupling condensers C are grounded and transmission line is terminated in resistor R

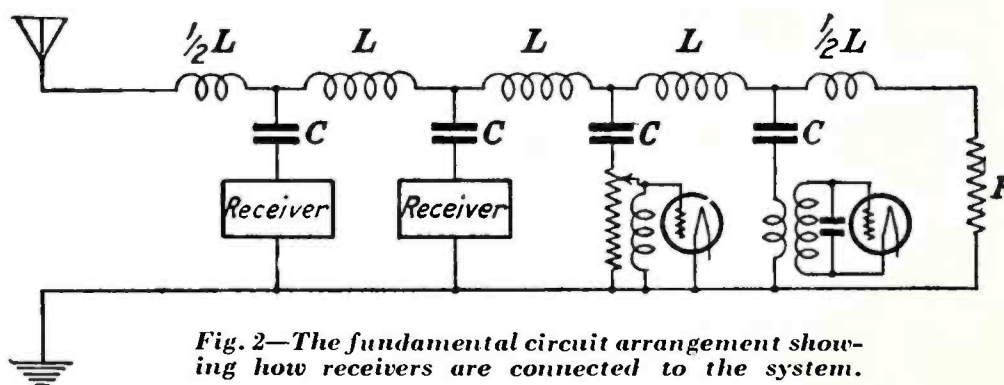


Fig. 2—The fundamental circuit arrangement showing how receivers are connected to the system.

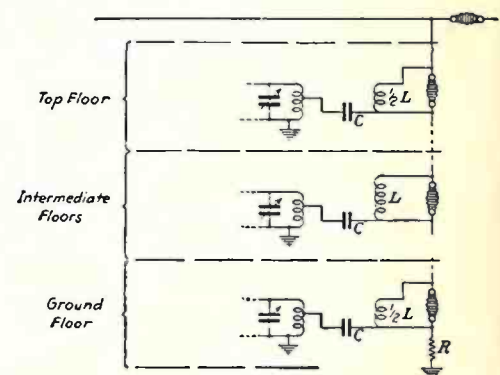


Fig. 3

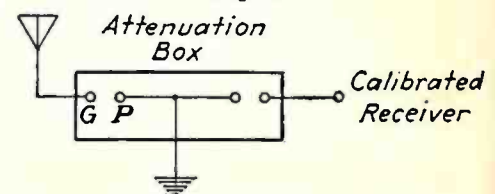


Fig. 4—Connections to the attenuator used in calibrating the apparatus.

Since the tuning of one set may affect the rest of the line when the resonance point is just reached, some tests were also made with all sets except the one under observation slightly detuned, first to a higher and then to a lower frequency. A second series of tests was made, to determine the effective resistance and reactance of typical tuned input circuits such as are used in the average commercial radio receiver. Following this, a third series of experiments was conducted to measure terminal impedance of the loaded transmission line with different values of terminating resistances, to show whether or not the line acts as a uniformly loaded conductor with minimum terminal reflection. Briefly, then, these tests may be classed as; first, e.m.f. measurements under various conditions along the loaded line; second, effective constants of typical tuners; third, effective constants of the loaded line.

First Series of Tests

In the first series of tests the receivers were located at the second, third, fourth, fifth, and sixth floors of the building, the terminating resistance being located at the ground floor. The lead-in came down the side of the building with a glass insulator inserted at each floor, leads being run from either side of the insulators through the windows to the rooms where the coupling condensers and tuner units were located, as illustrated in Fig. 3. Each tuner consisted of an auto-transformer, tuned by means of a variable condenser of 500 mmfd. The auto-transformer inductance contained about 50 turns in the secondary circuit and five to eight turns in the primary circuit.

A portable receiving set (see Fig. 5) with a volume control calibrated in dB and an indicating instrument acting as volume indicator was built for these tests. The receiver was carried to all floors and connected in place of the tuner unit. It will be noted that in the circuit of this receiver, Fig. 5, the input contains a series resistance which makes the input impedance almost constant for all wavelengths. It was adjusted at approximately 600 ohms. The primary of the first tuning transformer was in the form of a tickler coil, the controlling

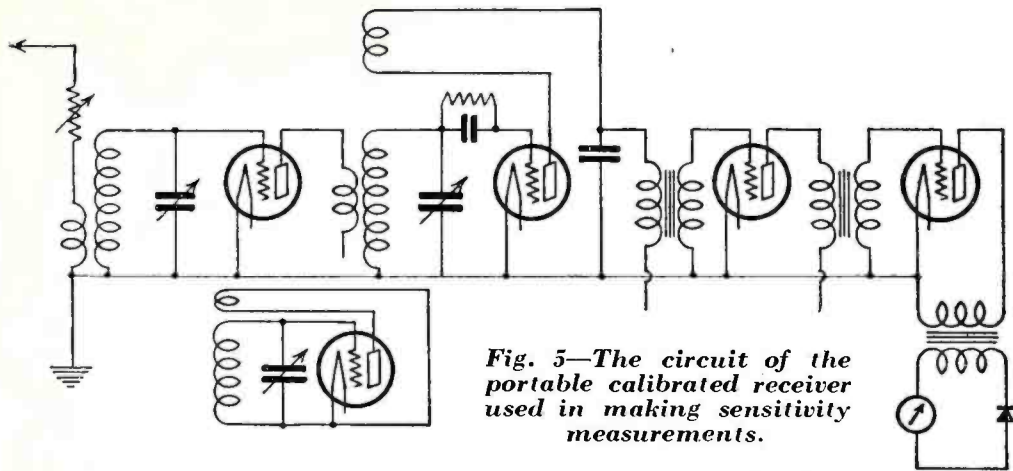


Fig. 5—The circuit of the portable calibrated receiver used in making sensitivity measurements.

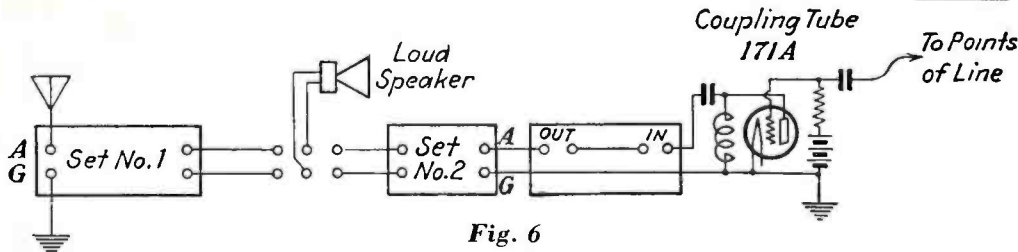


Fig. 6

knob of which was located outside of the box and had a scale calibrated in dB. The calibration was obtained by means of a G.R. attenuation box connected between antenna and input circuit, as shown in Fig. 4. By reducing or increasing the number of dB in the box, the scale of the volume control was determined, while

(with rectifying crystal in series) and the pitch of that note was kept constant throughout the tests. A second volume control was provided in the regenerative detector to produce a suitable deflection in the meter from very weak signals. The calibration of this control was achieved in the same manner as that of volume control No. 1, but was slightly different for the various wavelengths. The sum of the two readings of the volume controls gave an arbitrary "level" for any particular broadcast station, the measurements showing only differences in level.

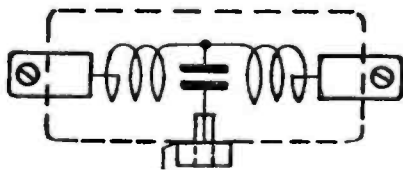


Fig. 9—Fundamental circuit arrangement of a multicoupler.

keeping the reading of the volume-indicating instrument constant.

In order to avoid fluctuations of the meter with the modulations of the broadcast program, the measurements were made with the carrier wave. An auxiliary oscillator was provided so that the resultant audio-frequency beat was impressed upon the volume-indicating galvanometer

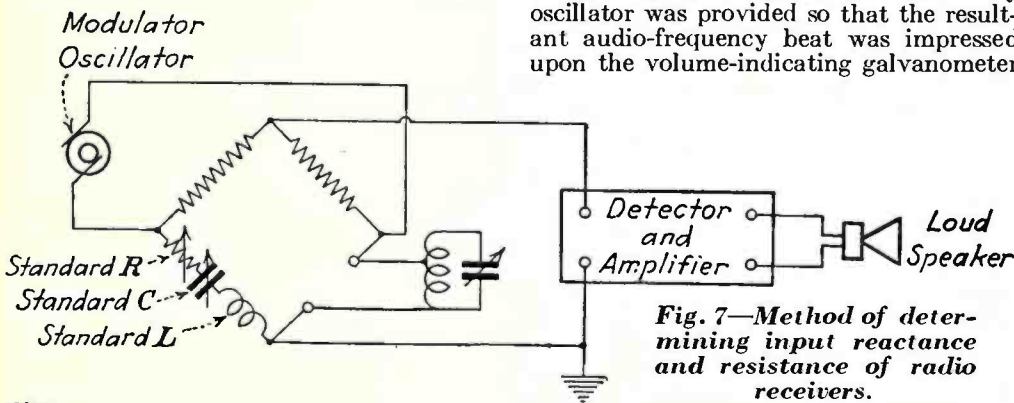


Fig. 7—Method of determining input reactance and resistance of radio receivers.

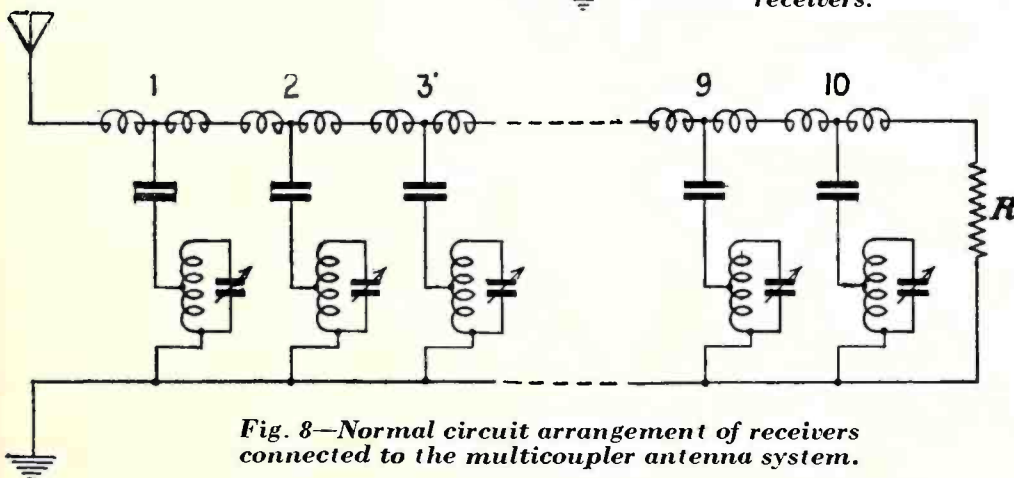


Fig. 8—Normal circuit arrangement of receivers connected to the multicoupler antenna system.

Conditions of Test

Tests were conducted with all the sets disconnected, then with all the sets tuned to a given station, and finally with all the sets detuned by a very small amount. Following these tests, the terminating resistances were varied and the tests repeated. It was found that with a 750-ohm terminating resistance, and coupling condensers in the multicouplers of 500 mmfd., there was a sufficient degree of freedom from interference for all the low-frequency broadcasting stations, but not quite enough for those high ones above 1000 kc.

It was realized that by applying the loaded line to sets on the same floor, the action of the short vertical wires connecting two consecutive floors might help the signal transmission. It was decided to try the same experiments with all the tuners in the same room, and the loaded line located therein and supplied from an antenna on the roof above the sixth floor. The tests were made in the laboratory on the third floor. This would considerably simplify the problem of measuring voltage distribution, since it would eliminate the necessity of carrying the portable receiver to each floor and making innumerable re-calibrations. Also, the results could be obtained directly in terms of the G.R. attenuation box, without calibrating the radio set controls. To this end, two radio sets were used; one fed from an independent antenna and the other from a coupling tube through the attenuation box, as shown in Fig. 6.

First, the two sets were tuned to a given station and the volumes equalized by throwing the loud speaker from one set to the other while manipulating the attenuation box for equal intensity. With the free grid terminal of the coupling tube, set No. 2 could be connected to any point in the loaded line. By connecting the free

terminal of the coupling tube to the secondary of the tuners, resonance was obtained in these circuits for any desired station. In later tests a local oscillator, modulated with a 1100-cycle audio frequency, was used instead of the regular broadcasting station. An a.c. instrument with a suitable step-down transformer was connected in place of the loud speaker, or in multiple with it, and its indications registered the volume within less than $\frac{1}{2}$ DB. There being no longer any need for set No. 1, it was

up a practical case, a standard commercial radio receiver—a Kolster d.c. set—was selected and measurements were made of the effective resistance of the input of that set at various frequencies when the set was sharply tuned to each particular frequency. In each instance, by definition, the reactance was zero and the resistance assumed the values shown in Fig. 13, where the dotted line represents the effective resistance of the input of the set when tuned to each of the frequencies given by the abscissae. The line in full gives the reactance of a 250-mmfd. condenser at the same frequencies. It will be noted that they are not very much different from each other, and consequently the effect would be that of condenser with a leakage having the same admittance as the condenser, or a 45-degree phase circuit with most unfavorable conditions. When sets with tuned input circuits are connected to the loaded line, it may be expected that the adjustment of one of them may alter the signal energy level at the input of the others to some extent. Therefore, in order

this set was tuned nearer and nearer to the frequency of the supplied e.m.f. and the attenuation box was correspondingly adjusted so that the indicated volume in the V.T. voltmeter remained the same.

Detuning Effects

The readings of the attenuation box showed the effect upon the volume of set C caused by the tuning and detuning of set D. The results are shown graphically in Fig. 12 where the line in full represents energy gains or losses in DB over an arbitrary level, versus scale divisions of the tuning equipment of set D. It will be noted that the maximum deviation from normal does not exceed ten DB, which is about as much reaction as has been found to exist between parallel running antennas in, say, a six-story building. However, this amount seemed too much for good performance, and it was reduced materially by the insertion of a series resistor in the antenna connection to the interfering set D at point F (See Fig. 14). The dotted lines in Fig. 12 show the effect of resistors of 1000 and 1500 ohms, respectively, upon the amount of interference of set D upon sets C, and, by inspection, it will be seen that it was cut down to 3 DB maximum deviation from normal volume. The insertion of the 1000- and 1500-ohm resistors reduced the sensitivity of the interfering set D by 5 and 6 DB, respectively, which is a very small amount. The replacement of individual antenna wires, as a rule badly installed, by a good receiving antenna, will more than bring back the energy level lost due to the insertion of these resistors in isolated cases, where special radio sets need them.

The difference in DB level between the various sets from beginning to end is given in the accompanying tables. It will be noted that the line acts almost perfectly whenever the sets are not tuned to exact resonance. When only half of them are tuned to one station and the other half detuned, there is a negligible amount of interference, even in the high-frequency end of the broadcast band. The tables refer to the normal circuit arrangement as indicated in Fig. 8. The terminal resistor R was 500 ohms and the tests were made with the local oscillator modulated at 1100 cycles.

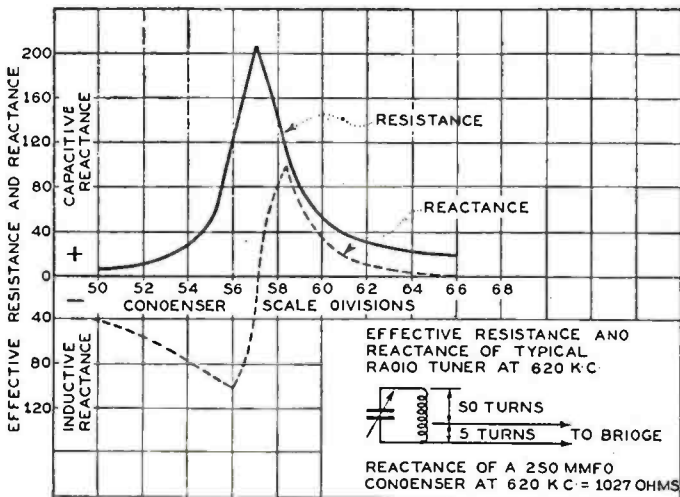


Fig. 10

dispensed with since the input frequency remained constant.

Tests were conducted to determine the performance of the tuners when the condenser was varied, to see whether the effective impedance of the combination was small enough in comparison with the reactance of the coupling condensers of the loaded line. For this purpose the primary of one of the tuners was connected to an a.c. Wheatstone Bridge, as shown in Fig. 7. The bridge was balanced for various positions of the dial of the tuning condenser. Figs. 10, 11, and 13 show the results in graphic form.

Resistance vs Reactance

It will be noted that the effective resistance and reactance of the tuner, as it appears from the primary side, is used as ordinates, while the abscissae represent scale divisions in the tuning condenser. The condenser is of the straight-line-capacity type. At 620 kc., Fig. 10, the resistance is a maximum at 57.2 divisions and reaches a value of 200 ohms; at the same position, the reactance is zero. The maxima of the reactance were 100 ohms and occurred at 56 and 58.5 divisions, almost symmetrically located with respect to the zero reactance point. As the reactance of a 250-mmfd. condenser at 620 kc. is 1027 ohms, it will be seen that the effect of the tuner in series with the condenser of the loaded line, Fig. 10, is negligibly small at all values of the condenser in the tuner of a typical radio receiver.

Fig. 11 shows exactly the same relations that Fig. 10 indicates, but at 1100 kc. instead of 620. It will be noted that the effect is more pronounced at this frequency as might be expected from theoretical considerations. However, the maxima of the reactance, which occur at 16.2 and 15.8 scale divisions, reach a peak of 265 ohms which is smaller than the reactance of the coupling condenser of 250 mmfd., namely, 579 ohms. The effective resistance at 16 scale divisions is fairly large—730 ohms—but in practice it would require a considerable number of sets, all tuned to receive a station operating on 1100 kc. to produce an undesirable amount of interference with each other. In order to take

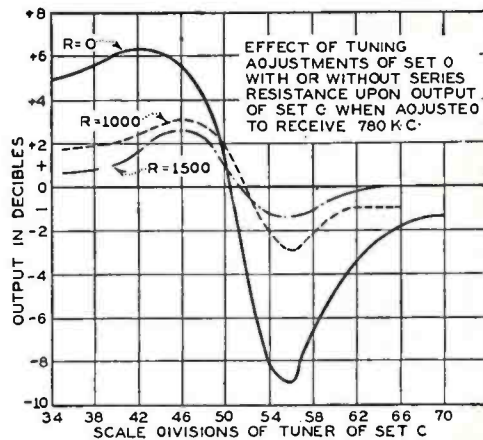


Fig. 12

to determine how much reaction a set of this type will produce in the energy distribution of the line, a test was made as follows: A set with a tuned input circuit (without series condenser other than the one at the multicoupler) was connected to the loaded line, and another set of any character at another point of the same line. The volume of the output of the second set was determined for various positions of the tuning condenser of the first set as shown in Fig. 14, where A is a modulated oscillator supplying the antenna system with r.f. energy through an attenuation box B graduated in DB. The output of set C, the performance of which may be influenced by adjustments made on set D, is to be studied, measurements being made by means of a V.T. voltmeter, E. A certain arbitrary level was chosen to start with, and the set under test was tuned to the particular frequency of the modulated r.f. supply, with set D far out of tune or disconnected from the line. Then

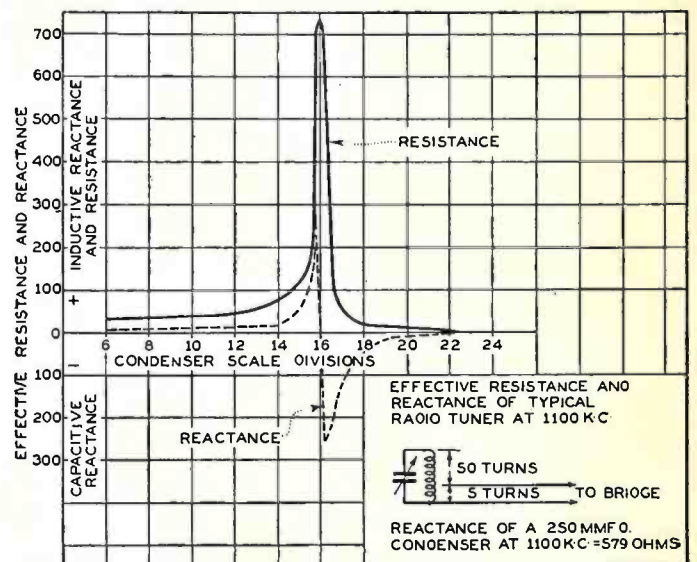


Fig. 11

It will be noticed that the level changes from point to point. The variation is quite tolerable and the departure from the average value is smaller than the coupling effect of two antennas running side by side, six feet apart, namely 10 DB.

The figures given in these tables represent arbitrary levels and were obtained as

Table I

STATION WOY, 1130 KC.		Condition of tuners		
Point in Fig. 8.	Short circuited	Tuned to WOY	Detuned + 1	Detuned - 1
1	33	28	33.5	30
2	32	27	33	30.5
3	31	18	31	30
4	31	16.5	31	28
5	33	16	33.5	31
6	33	11	33	27
7	27	2.5	27	27
8	27.5	6	27.5	28.5
9	26.5	4	26.5	27
10	25.5	1	25.5	27.5
R	26.5	1/2	26.5	28

Table II

STATION WABC, 860 KC.		Condition of tuners		
Point in Fig. 8	Short circuited	Tuned to WABC	Detuned + 1	Detuned - 1
1	29.5	28	30	29.5
2	29	27	29.5	29
3	29	24	29	28
4	29.5	21	29	28.5
5	29	21	28	29
6	29	18	27	29
7	29	17	25.5	29
8	29	15.5	26	28.5
9	29	12	24.5	27
10	30	10.5	22	26.5
R	30	10	22	27

follows; first, the oscillator was very loosely coupled to the antenna lead-in and the radio set carefully tuned to the impressed frequency, while the volume control was adjusted so as to be far above noise level, but sufficiently low to permit the detector to act under normal conditions. A certain value of DB. was inserted in the attenuation box to obtain sufficient margin on each side. After that, the lead connecting the free grid of the 171A coupling tube (Fig. 6) was made to touch the various points in the line, with all the tuners short-circuited and the figures of the first column of the tables were obtained. Then all the tuners were inserted as in Fig. 8, with the grid wire attached to the non-grounded end of the primary of the tuning coils. The tuning condenser was adjusted to resonance by listening in on the test set for maximum response. After the tuners were adjusted the grid wire was again touched to each point of the line, as before, and the figures of the second column were obtained. By detuning the various condensers of the tuners by 1 or -1 condenser scale division, and repeating the process of measuring the levels at the various points of the line, the figures in the third and fourth columns of Tables I,

seriously considered. A subsequent test was made, however, in which the odd numbered sets were tuned and the even numbered ones tuned away, from a particular station. Thus, No. 1 was tuned to wov, No. 2 detuned, No. 3 tuned to wov, No. 4 detuned, etc. The results of this test are shown in Table IV.

We conducted one final test to determine if the transmission line acts as a true infinite line when the terminating resistance has a suitable value. To accomplish this, Wheatstone Bridge measurements of terminal impedance were taken and graphs plotted from the calculated results. The results are shown in Table 5, which gives the values of effective resistance of the loaded line terminated by a 600-ohm resistor. This is shown graphically in Fig. 15.

The results of the investigations described warranted the application of the loaded supply line to commercial installa-

mutual induction did not affect the operation of the system, there being no difference in performance between separate coils or coils of half the same inductance, placed close together, so that the effective

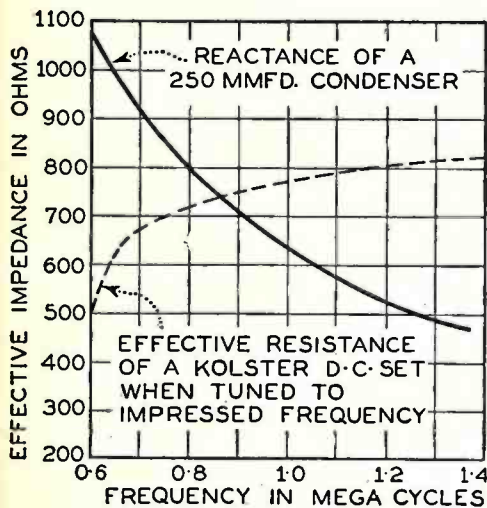


Fig. 13—Input impedance characteristic of Kolster receiver.

II, and III were obtained. It will be noted in Tables I, II, and III, that the loaded line performs very satisfactorily except when all the sets are tuned to the same short wavelength station. But this is such a rare occurrence that it need not be

Table III

STATION WMCA, 570 KC.		Condition of tuners		
Point in Fig. 8	Short circuited	Tuned to WMCA	Detuned + 1	Detuned - 1
1	21	19	19	20
2	21	18	19	20
3	21	17	18.5	20.5
4	20	17	18	20
5	19	16	17	18.5
6	19	14.5	17	19
7	21	14	17	20
8	21	12	17	18.5
9	20	10	15	18
10	19	7.5	14	18.5
R	19	10	14	19

Frequency in kc.	600	700	800	900	1000	1100	1200
Effective Resistance	635	526	452	418	400	385	370
Effective Reactance	Negligible at all frequencies						

Table V

Table IV

Point in Fig. 8	All sets detuned	Every other set tuned to WOY, 1130 k.c.
1	33	38
2	32	37
3	31	28
4	32	31
5	32	29
6	31	24.5
7	32	22
8	32	22
9	32	22
10	33	22.5
R	33	23

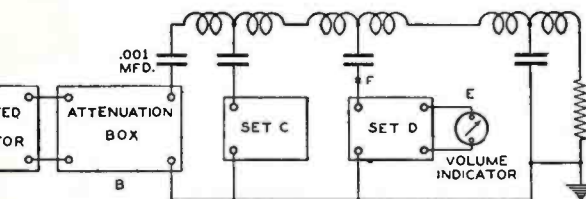


Fig. 14—Method of determining amount of interaction between receivers.

tions, and, to that end, suitable units, known as "multicouplers" were designed. With the idea of simplifying the construction and installation of these units, instead of employing a coil of half the inductance at the beginning and end of the line, as outlined in the theory of operation, a universal "T" unit was devised. It consists of two coils of 40 microhenrys each, with a 250-mmfd. condenser connected to the mid-point, enclosed in a bakelite cylinder for outdoor as well as indoor installation. Fig. 9 shows the circuit as well as the outside appearance of the multicoupler.

Tests covering the same properties of transmission, impedance, etc., were made with the completed units in which the two coils of the "T" filter together had the required 80 microhenry inductance, with a certain amount of mutual induction included. It was found that the presence of

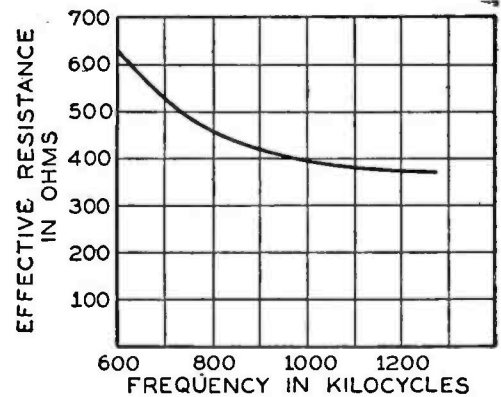


Fig. 15—Effective resistance of the loaded line terminated in a 600-ohm resistor.

total value would be 80 microhenrys.

With the construction of the antenna couplers standardized, many practical applications will suggest themselves. Installations made in New York City are proving more than satisfactory. We consider this a truly practical solution to the apartment house congested-antenna problem.

In conclusion a few words regarding the sale of multicoupler systems may be of interest. Newly erected apartments offer the easiest market for sales. These buildings, being new, the owners must offer every modern convenience. In Greater New York and New Jersey estimates are made upon request and submitted after a general survey of the building, including a careful inspection of the roof and floor plans to determine the number and location of down leads and associated aerials. Price per outlet is the form usually used in submitting quotations, and the length of the inside runs and where the owner wants the lead-in to terminate govern to a great extent the amount of the cost. The average cost for an installation of about fifty outlets is \$15.00 per outlet, but the cost may be as low as \$10.00 per outlet or as high as \$25.00. Out of town, a multicoupler system complete with plans and specifications is sold to electrical contractors and radio companies who have an adequate force to do this type of work.

THE 1930 MODEL HI-Q RECEIVER

By CURTIS W. HAMILTON

Hammarlund-Roberts, Inc.

THE MANUFACTURE and sale of kit receivers have seen a gradual change from the old days when a circuit was designed, the parts of half a dozen different manufacturers specified in a construction article, and the radio-constructor invited to go to the corner radio store and purchase them. To-day the kit manufacturer designs a circuit, and puts all the units into a single box together with complete assembling data and operating instructions—and, further, the kit manufacturer now goes to considerable effort to design complete tested units so that the construction of a kit becomes, not a matter of assembling a large number of individual parts, but rather that of wiring together a few major units. This practice has been followed by Hammarlund-Roberts, Incorporated, in the design of the Hi-Q receiver. All of the major units required for the assembly of the receiver are received by the constructor completely wired and carefully tested.

Eight Features

Eight major features stand out in the new 1930 model of the Hi-Q receiver. They are as follows:

(a) A three-stage band-pass selector preceding the first screen-grid r.f. amplifier tube. This gives high selectivity and prevents cross talk.

(b) A three-stage, screen-grid, radio-frequency amplifier using screen-grid tubes coupled by tuned r.f. transformers.

(c) Single-control tuning. All of the six variable condensers of the receiver are controlled by the single tuning



The Hi-Q 30 mounted in an attractive console cabinet.

dial. The only other control is for the volume. The volume control uses a potentiometer arrangement to vary the screen-grid voltage of the first and second r.f. amplifiers.

(d) A grid leak-condenser type detector of high sensitivity. The detector is coupled to only part of the tuned circuit feeding it so as to compensate the differences in impedance between the input circuit of the tube and the impedance of the tuned circuit.

(e) Complete shielding of the tuned circuits composing the pre-selector unit and the tuned circuits coupling the r.f. amplifier tubes.

(f) Filter circuits consisting of r.f. choke coils and by-pass condensers in the plate circuits of all the r.f. amplifier tubes. Filtering of the supply to the screen grids of these tubes is by means of series resistors and by-pass condensers.

(g) A two-stage, transformer-coupled a.f. amplifier using a 227-type tube in the first stage and two 245-type tubes in push pull in the output.

(h) A phonograph-radio switch which, when closed, connects the pick-up unit to the grid circuit of the detector.

The Band-Pass Filter

The most important feature of the Hi-Q 30 is, probably the band-pass filter connected ahead of the first r.f. amplifier. It is a characteristic of the screen-grid tube that it can handle but comparatively small input voltages before it begins to overload and produce "cross talk" so that a powerful local station is heard when listening to a weaker station. One solution of

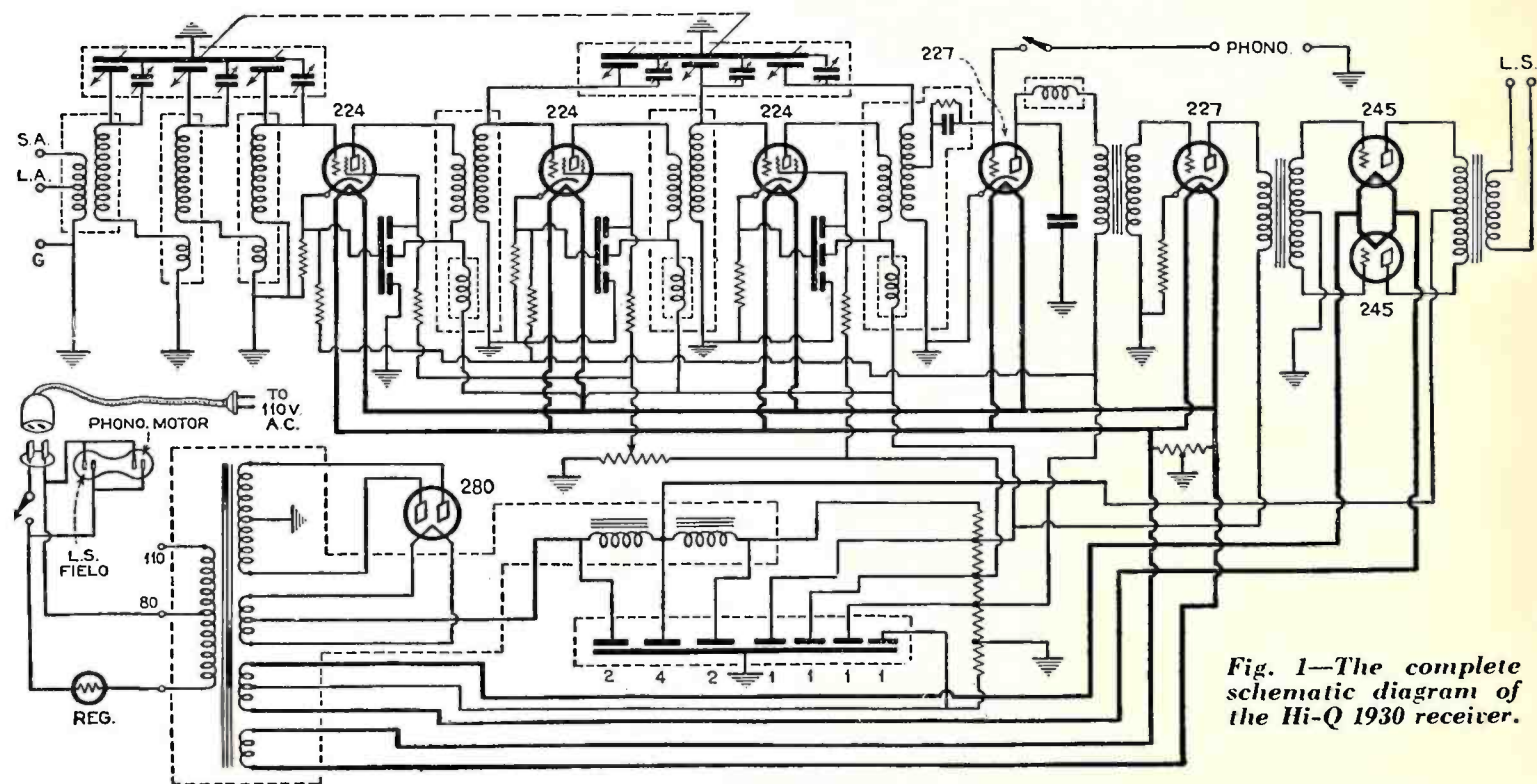
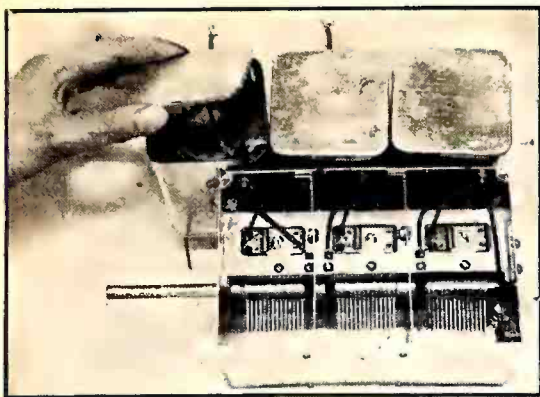
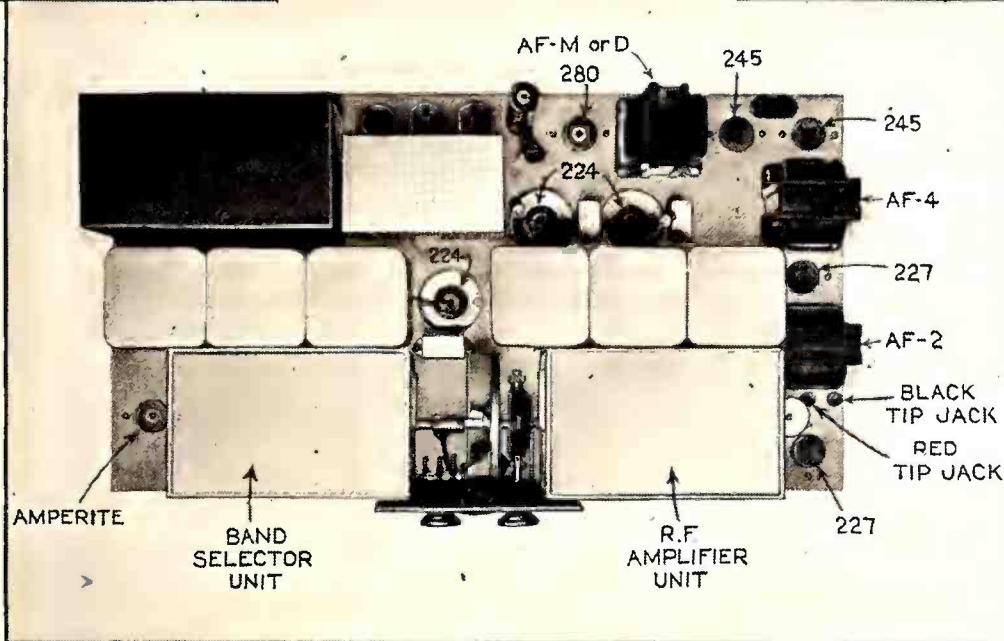
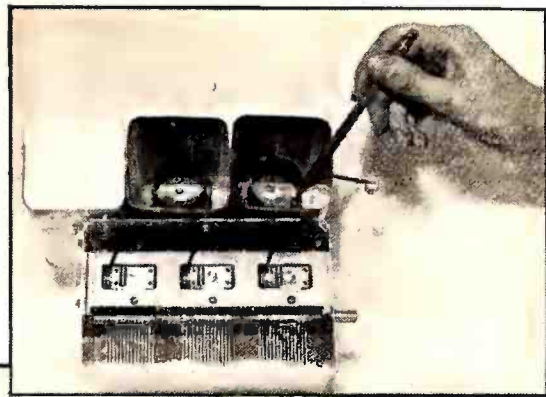


Fig. 1—The complete schematic diagram of the Hi-Q 1930 receiver.



The picture below shows the chassis of the Hi-Q 30 as viewed from above. All shields are in place and the important parts are labeled. On the left is a close-up view of the r.f. amplifier unit and on the right is shown the pre-selector unit.



this difficulty is to incorporate sufficient selectivity in the receiver between the antenna circuit and the first r.f. amplifier tube so that all signals but the desired one are reduced in strength to a point where they cannot produce "cross talk"—and this is the function of the band-pass filter in the Hi-Q 30, i.e., the band-pass system is used to give the selectivity necessary ahead of the first 224 tube to prevent "cross talk." The required selectivity might have been obtained by the use of ordinary tuned circuits, but, then, the side-band suppression would have been greater. In a sense, therefore, we can consider the r.f. circuits as being composed of two parts; first the pre-selector circuit functioning to reduce undesired signals as much as possible, thereby preventing "cross talk," and second the following tuned circuits associated with the r.f. amplifier tubes functioning to complete the selection of the desired signal and at the same time to couple together the various stages of r.f. amplification. The output of the r.f. amplifier feeds into a grid leak-condenser detector. This type of circuit was used because of its greater sensitivity and because it was considered that for all around use it was entirely satisfactory.

The task of the constructor of a Hi-Q 30 receiver is simplified because the receiver is purchased in the form of several completely wired units which need only be connected together. For example, the pre-selector unit consists of three shielded compartments for the coils and another shielded compartment for the three variable condensers associated with the band-pass unit. The three-stage r.f. amplifier consists of three shielded compartments for the tuned r.f. transformers (the necessary r.f. choke coils and by-pass condensers that com-

pose the filter circuits are also located in the shields) and another shielded compartment for the three variable condensers used to tune the three r.f. transformers. Leads are brought out of the shields for connection to the tubes and other parts of the circuit. Both of these units are completely wired and tested at the factory so that the constructor doesn't have the problem, generally of major importance in the construction of a receiver, of securing coils and condensers which will gang together accurately.

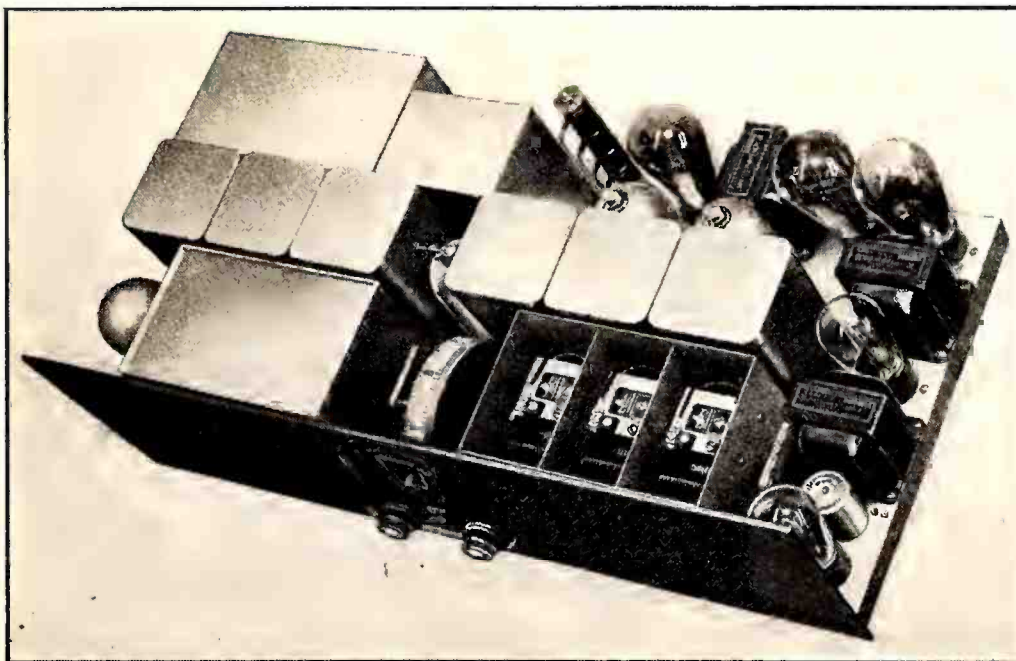
The kit includes a completely drilled metal sub-panel to which the band-pass unit and r.f. amplifier units can quickly be attached. In addition the sockets, a.f. transformers, and a few other small units

unit directly to the grid of the detector tube, it was not considered advisable to run a long lead from the detector grid to the center of the panel where the control is located. As a result, the switch actually controlling the connection to the phonograph pick-up is located on the sub-panel close to the detector socket and this switch is connected by a wire link to another switch on the front panel. The phonograph-radio switch on the front panel, therefore, makes the necessary change in the electrical circuits through the additional switch located near the detector socket.

In previous years kit receivers were usually sold either without a cabinet or complete with a metal cabinet and the constructor who desired to build a set into a console had to arrange to purchase the console separately. This season, however, Hammarlund-Roberts, Inc. has had designed several special cabinets and consoles, especially for use with the Hi-Q 30.

The receiver itself is available in various models for a.c. or d.c. operation, and either complete with a.f. amplifier or just the tuner circuit up to and including the detector.

Hammarlund-Roberts, Inc., has issued a complete 48-page manual (Continued on page 239)



View of the Hi-Q 30 chassis.

BAND-PASS FILTER CIRCUITS

By E. A. UEHLING

COUPLED CIRCUITS are among the most common of the phenomena with which the engineer has to deal. Very often he will consider this phenomenon to be among the most useful as well, and one without which he would attain with great difficulty the results that are achieved easily with the aid of this principle. On the other hand, the phenomenon of coupling is so prevalent in nature that its complete isolation under certain experimental conditions is often a serious obstacle, with the result that errors in measurement of which the experimenter is not aware are often introduced. Coupled circuits are not confined to electrical work alone. They are probably even more common in mechanics, and perhaps in this field they are even more difficult to control.

Importance of Phenomenon

There can be no question about the importance of this phenomenon. This importance becomes especially apparent when we realize that the band-pass filter is but a specialized case of a general condition of coupling existing everywhere in nature where electrical oscillations or mechanical vibrations are to be found. Systems may be coupled to one another either electrically or mechanically, and under certain conditions the coupling between them will be felt in each of the circuits as an actual change in the impedance of the circuit, without, however, any evidence of the band-pass phenomenon. Very specialized conditions must be applied to the circuits to produce the latter results. These conditions and the exact nature of the effects produced form the subject matter of any discussion of band-pass filters.

In this article we consider such band-pass circuits as are suitable for use in radio broadcast receivers, remembering, however, that the subject has been artificially narrowed, and that the same methods can be and are readily applied to other fields of work, one of these being the subject of mechanical vibratory structures. The latter application as well as the former has been given a very thorough experimental treatment within recent years.

It seems hardly necessary to point out the advantage of a rectangular selectivity characteristic in a radio broadcast receiver. It is true that the width of the rectangle must fall within very narrow limits to be valuable, and its failure to do so in many cases is responsible for a certain amount of skepticism regarding the value of the band-pass circuit itself. This method of signal selection is only slightly more complicated than ordinary tuned circuits, and from the mechanical point of view is more complicated only in the requirement of an additional one or two condensers, depending on the number of sections of filter used and whether or not the band-pass filter is to constitute the entire signal selection unit of the receiver or whether it is to be combined with tuned circuits. At the same

time there may be certain simplifications in mechanical design introduced, especially if there are many sections of filtering used. The shielding requirements in the filter itself need be only such that the coupling between circuits should be as calculated and designed, and these requirements may not be nearly so rigorous as are the requirements of shielding in the stages of amplification. In such a receiver the amplification unit may consist only of r.f. tubes and untuned r.f. coils, making

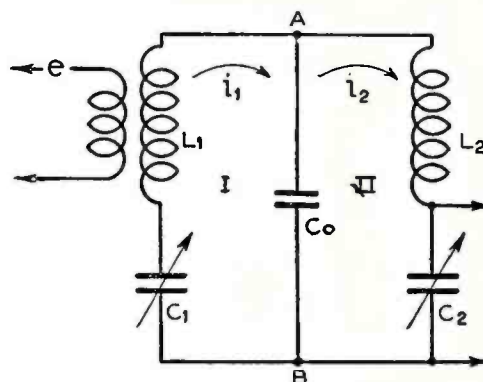


Fig. 1

possible a mechanical design that is very compact and economical.

Explanation of Operation

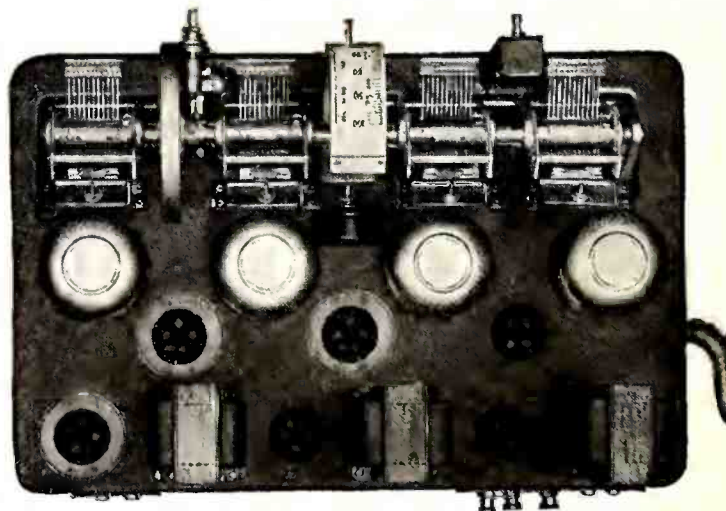
To be appreciated the band-pass filter must be understood physically. We should desire to know what it is that causes a system of circuits of this type to offer an extremely low impedance to currents of a given range of frequencies, and then to change its characteristics very sharply, offering for another and a very narrow range of frequencies a very high impedance, and then, at a certain frequency, to return to its former characteristics for all remaining frequencies and offer again a low impedance. A typical circuit having characteristics of this kind is shown in Fig. 1. L_1 and C_1 are resonant at a certain frequency, f . If L_2 and C_2 are equal to L_1 and C_1 respectively, the entire series cir-

cuit that includes these four reactance elements is resonant at the same frequency, f . Points A and B are then at the same potential and there can be no current flowing through the capacity C_0 . This zero current through C_0 can be replaced by two currents 180° out of phase with each other flowing through C_0 giving a resulting current in C_0 that is zero. Then what we have said regarding the equality of the potentials at point A and B is equivalent to saying that the current I_1 of circuit I is in the same phase as the current I_2 of circuit II at this frequency, f . For frequencies lower than f the reactance of L_1 , and C_1 , and L_2 and C_2 is negative and the capacity C_0 acts as a short circuit across both reactances so that there can be no current flowing in L_2C_2 . But as the frequency is increased above f the reactances of L_1C_1 and L_2C_2 become positive. If the frequency is only slightly higher than f , this positive reactance is low in value and a low value of potential is developed across C_0 . Current then flows in C_0 , the value of this current depending on the potential across C_0 , which in turn depends upon the positive reactance of L_1C_1 , and L_2C_2 . Since this current through C_0 is the resultant of two currents, that in circuit I and that in circuit II, the relative phase of the currents in circuits I and II must have changed from zero to some other value less than 180° . As a consequence there is no change in the actual magnitude of the current in either circuit, and, therefore, the voltage across either L_2 or C_2 , which is the voltage to be amplified, is approximately equal to its value at frequency f . As the frequency is further increased the relative phase of currents I_1 and I_2 continues to increase with no change in the actual magnitude of either I_1 or I_2 , and consequently with no change in the voltage that is to be amplified, until the frequency has been raised sufficiently high above f that the currents I_1 and I_2 are 180° out of phase. Then, for any further increase in frequency, the positive reactance of L_1C_1 and L_2C_2 is so high that the potential developed across them and across C_0 can no longer be given as the product of the impedance of the condenser C_0 with the vectorial sum of I_1 and I_2 unless both I_1 and I_2 are reduced in value. This reduction in the value of I_1 and I_2 for further increases in frequency is a very rapid one.

This explanation of the physical operation of a band-pass filter can be shown even more graphically by the use of an application of the filter in mechanical structures. But, as we are concerned at this time principally with the band-pass filter as used for the purpose of selecting a given band of radio-frequency signals, an explanation of its operation in mechanical structures would not contribute a great deal to the present subject.

Electrical Characteristics

Several important conclusions become obvious when the principle of the band-pass



The Fada Model 35 chassis which uses a band-pass input circuit; the cable at the right connects with the power unit.

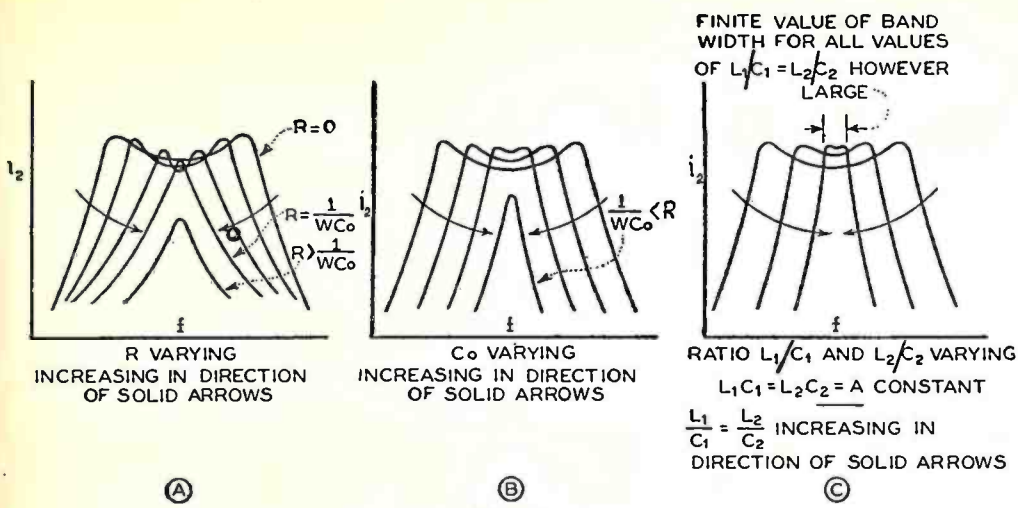


Fig. 2

filter is understood. The first of these concerns the slope of the sides of the band-pass transmission characteristics, on which the selectivity advantage of the band-pass filter depends. The radio engineer is especially interested in the nature of the characteristic at the lowest and the highest frequencies of the band-pass transmission characteristic. It has been shown that for circuits coupled capacitatively the lowest frequency transmitted by the filter occurs when the reactances of each of the elements, L_1C_1 and L_2C_2 , is equal to zero. In practice L_1C_1 and L_2C_2 contain resistance and therefore the current through C_0 at this frequency is not quite zero, and I_1 and I_2 as a consequence do not have quite a zero phase relationship. At the upper frequency of transmission they do not for the same reason have quite a 180° phase relationship before there is a reduction in the value of I_1 and I_2 . We see that with increasing resistance we have not only a reduction in the width of the transmitted band, but we have also a more gradual approach to the maximum value of the currents as well as a reduction in the actual value of I_1 and I_2 throughout the band. The result is reduced selectivity and reduced transmission.

In Fig. 2 there is a graphical representation of the changing frequency characteristic with variation in the circuit constants of the filter. The voltage acting in circuit I is held constant, and I_2 is plotted as a function of frequency for each of several conditions of the circuits. It becomes obvious at once that the maximum value of I_2 depends only on the circuit resistances, that the slope of the sides of the characteristic at the lower and higher cut-off frequencies depends on the resistances, and that for a given value of C_0 the width of the transmitted band depends on the circuit resistances.

Though the entire discussion so far has been on the capacitatively coupled filter it is probably obvious that these statements hold, qualitatively at least, for filters with any type of coupling, the difference being usually one of sign, or degree, or both. Before entering into a discussion of the relative merits of the different types

of filters we shall need certain design equations which can be applied to any type of filter regardless of coupling and regardless of the number of sections, the discussion being confined, however, to successively coupled circuits as distinguished from lines with lumped constants. In other words, the equations that will be given are directly applicable to typical circuits used in broadcast receivers.

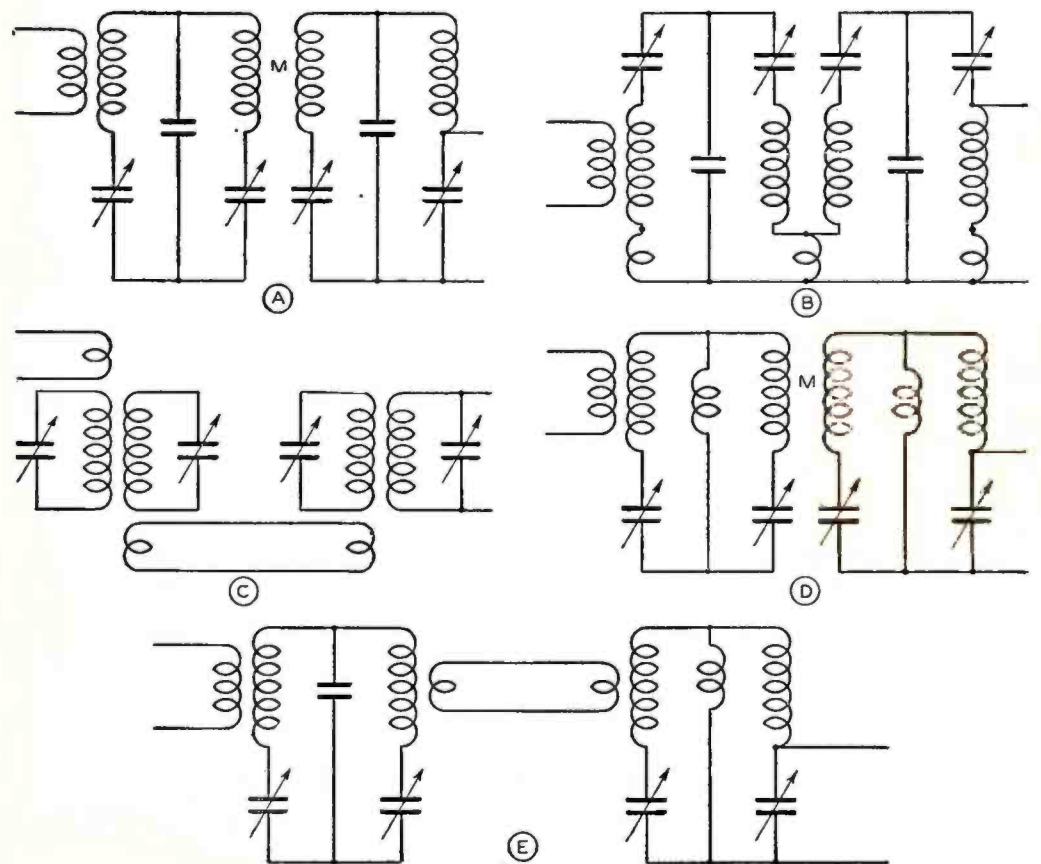


Fig. 4

Design Equations

The design equations relating to band-pass filters are obtained directly from

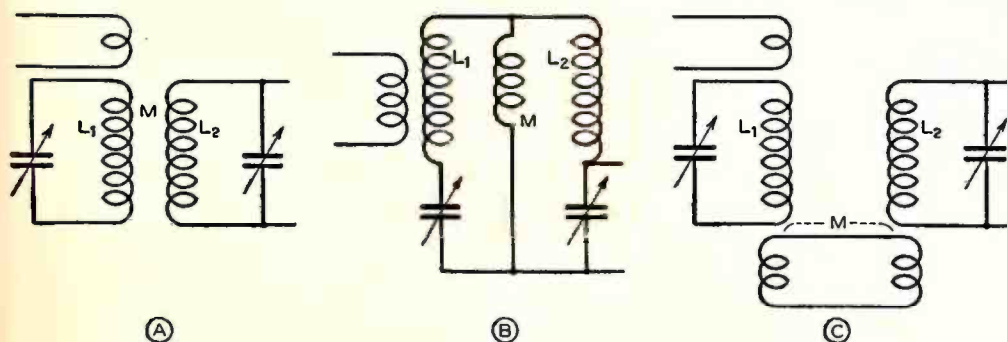


Fig. 3

standard equations for a chain of circuits. These equations can be fitted to any specific case by omitting the unnecessary factors and substituting the proper values. Consider the circuit of Fig. 1. The maximum values of I_2 and I_1 , are given by the equations—

$$I_1 = \frac{E}{z_1 - \frac{m^2}{z_2}} = \frac{E}{z_1'} \quad (1)$$

$$I_2 = \frac{mI_1}{z_2} = \frac{mE}{z_1' z_2} \quad (2)$$

where E is the equivalent voltage acting in circuit I due to the voltage e , m is the complex mutual impedance which may be capacitive, inductive, or a combination of both, and z_1 and z_2 are the total complex impedances of circuit I and II. Rationalizing z_1' we obtain a more convenient expression for the denominator of the equation which expresses the value of I_2 —

$$z_1' = z_1 - \frac{m^2}{z_2} \quad (3)$$

and if the coupling is inductive

$$z_1' = R_1 + \frac{\omega^2 M^2}{z_2} R_2 + j(X_1 - \frac{\omega^2 M^2}{z_2} X_2) \quad (4)$$

The current I_2 is a maximum when the

denominator $z_1' z_2$ is a minimum. To determine the minimum value of $z_1' z_2$ we must eliminate j and differentiate with respect to the reactances. Then—

$$Z_1^2 Z_2^2 = \omega^4 M^4 + 2 \omega^2 M^2 (R_1 R_2 - X_1 X_2) + R_1^2 R_2^2 + X_2^2 R_1^2 + X_1^2 X_2^2 + R_2^2 X_1^2 \quad (5)$$

As used in a radio receiver R_1 is usually equal to R_2 and X_1 is equal to X_2 . Then—

$$Z_1^2 Z_2^2 = \omega^4 M^4 + 2 \omega^2 M^2 (R^2 - X^2) + R^4 + X^4 + 2 X^2 R^2 \quad (6)$$

$$\frac{\partial [Z_1^2 Z_2^2]}{\partial X} = 4 X^3 + 4 X R^2 - 4 X \omega^2 M^2 \quad (7)$$

For a maximum value of I_2 this quantity

is equal to zero. Then the following formulas apply—

$$4X^2 + 4XR^2 - 4\omega^2 M^2 = 0 \quad (8)$$

$$X^2 = \omega^2 M^2 - R^2 \quad (9)$$

$$X = \pm \sqrt{\omega^2 M^2 - R^2} \quad (10)$$

and if the coupling is capacitive

$$X = \pm \sqrt{\frac{1}{\omega^2 C^2} - R^2} \quad (11)$$

The upper and lower cut-off frequencies of the transmitted band occur when the reactances of the circuits take on the positive and negative values given by these equations. Then the frequency width of the band is given by—

$$f = \frac{\sqrt{\omega^2 M^2 - R^2}}{2\pi L} \quad \text{for inductive coupling} \quad (12)$$

$$f = \frac{\sqrt{\frac{1}{\omega^2 C^2} - R^2}}{2\pi L} \quad \text{for capacitive coupling} \quad (13)$$

$$f = \frac{\sqrt{B^2 - R^2}}{2\pi L} \quad \text{for any type of coupling where B is the absolute value of the coupling impedance} \quad (14)$$

The value of I_2 at the upper and lower frequencies is—

$$I_2 = \frac{E}{2R} \quad (15)$$

These equations, together with the design data relating to ordinary radio-frequency circuits, are sufficient for the design of any two-section band-pass filter. The performance of the filter at various values of ω is expressed implicitly, and some consideration of these equations is necessary for a complete understanding of the most suitable type of filter for a given purpose. The principal requirement in a radio receiver is that for variations in ω over the broadcast range there should be as little variation in the width of the transmitted band as possible. An approximation to this ideal can be obtained in several ways, each of which will be discussed with a little detail.

We have to deal first of all with the inductively coupled filter. The mutual impedance is obtained by coupling two circuits together very loosely by any one of three or more different methods as shown in Fig. 3. In this type of filter the mutual impedance varies considerably with frequency, and as a consequence the frequency width of the transmitted band varies with frequency. There are, however, conditions under which this variation in band width can be considerably reduced. Well-known methods in the design of the r.f. coils can be used to obtain coils that have a considerable variation in resistance with variation in frequency. Such coils will have a rather high resistance at low frequencies as well, and the transmission characteristic of the filter will not, in general, be very good at any frequency. But if a number of sections of band-pass filter are used, and if the function of signal selection is performed by this filter alone without the aid of ordinary tuned resonant circuits the overall characteristic may be very good with respect to both selectivity and constancy of width of the band-pass characteristic.

Similar results can be obtained using a single-section, capacity-coupled, band-pass filter in conjunction with several stages of tuned-radio-frequency amplification. The width of the transmitted band of a capacity-coupled filter decreases with increasing frequency. The selectivity of ordinary tuned circuits, on the other hand, decreases with increasing frequency. As a result, the combination of these circuits may have a very good frequency characteristic, and the selectivity may not vary appreciably over the broadcast range.

A third type of two-section, band-pass

filter has a coupling between sections that is a combination of capacitive and inductive elements. It has a very useful application for certain kinds of work but is not suitable for multi-frequency purposes as in a radio receiver. This is true because the variation of reactance with frequency of any combination of inductances and capacities is greater than that of either inductive or capacitive coupling. Of the two latter types of coupling the arithmetic variation of reactance with frequency of the capacitive type of coupling is less than that of inductive coupling. (See RADIO BROADCAST, page 171, July, 1929.)

Another Type

We will now leave the two-section filter and consider several types of circuits that are capable of performing the entire function of signal selection. Such a circuit would constitute one unit of a receiver, distinct in every particular from the amplification unit which would follow it. The most obvious method, and the one we will consider first, of attaining this result is to couple together several such filters as already discussed by means of a coupling unit in which the value of coupling is deficient. Several such circuits are shown in Fig. 4. If the coupling between alternate sections is deficient, the overall characteristic will be similar to that of a two-section filter of the same type as the component members and superior to the characteristic of one such member in the same way that two or more resonant circuits are superior to one. Four resonant circuits grouped together in this way will provide a filtering system that will meet the selectivity requirements of all but the most exacting conditions. The characteristic of such a filter will consist of two frequencies of maximum transmission with a frequency region of slightly reduced transmission between them, and external to this region and sharply divided from it are two regions of practically zero transmission. Uniformity or lack of uniformity in performance over the broadcast range will depend upon the same factors as those which influence the separate units as already discussed under the heading of two-section filters.

A very interesting type of structure is shown in Fig. 4E. Filter circuits of different characteristics are coupled to each other deficiently. In this filter the capacitatively coupled section would probably be adjusted to have the same width of transmitted band at 200 meters that the inductively coupled section has at 545 meters. The characteristic of the entire circuit at one end of the broadcast range would then be almost identical with its characteristic at the other end. The selectivity of this circuit is not exceptionally good but there is a close approximation to uniformity over the entire broadcast range. Such circuits present many interesting possibilities, and many such combinations have been found to be more successful in practice than would be anticipated from theoretical considerations alone. Results closely approaching a good band-pass transmission characteristic that is maintained over the entire broadcast band have been obtained with circuit arrangements similar to those shown in Fig. 4.

Conclusions

It is not absolutely essential that the coupling between groups of circuits be deficient. If this coupling is not deficient, however, the band-pass characteristic will be altered in a manner difficult to estimate or to express in equations. Under circumstances of sufficient coupling between all circuits more than two frequencies of maximum transmission will exist. The

characteristic may, however, be well suited to radio broadcast reception purposes, the principal consideration when more than two peaks exist being that the maximum width of the transmitted band be less than the 10,000 cycle limit generally accepted as the frequency width of the channel. If, on the other hand, the coupling between any two of the entire group of circuits is far below that of sufficient coupling the transmission loss will be high and the amplification required following the signal selector will be greater than otherwise necessary.

Circuits that give more than two frequencies of maximum transmission give results superior to those obtained with circuits similar to the ones already discussed in that the curve is more nearly flat between the lowest and the highest transmitted frequency. Characteristics of this nature are obtained if three or more consecutive tuned circuits are coupled to one another with approximately equal values of coupling. Such circuits have not become very important in receiver design, but for the sake of completeness they should be mentioned. The design characteristics might be determined in the same manner as used in determining the design equations for two-section filters, using corresponding equations for the currents in the individual circuits, as for example—

$$I_1 = \frac{E}{z - \frac{m^2}{z - \frac{m^2}{z - \dots}}} \quad (16)$$

where there are as many (z)'s appearing in the chain of the denominator as there are circuits in the chain of the filter. These equations for a three-section filter are—

$$I_1 = \frac{E}{z - \frac{m^2}{z - \frac{m^2}{z}}} = \frac{E}{z''} \quad (17)$$

$$I_2 = \frac{m I_1}{z - \frac{m^2}{z}} = \frac{m I_1}{z'} = \frac{m E}{z' z''} \quad (18)$$

$$I_3 = \frac{m I_2}{z} = \frac{m^2 E}{z z z''} \quad (19)$$

when the individual circuits are identical and equal coupling is used between circuits.

Rationalizing the expressions for z' and z'' we have—

$$z = R + jX \quad (20)$$

$$z' = R + \frac{\omega^2 M^2}{Z^2} R + j(X - \frac{\omega^2 M^2}{Z^2} X) \quad (21)$$

$$= R' + jX' \quad (22)$$

$$z'' = R + \frac{\omega^2 M^2}{Z'^2} R + j(X - \frac{\omega^2 M^2}{Z'^2} X) \quad (23)$$

$$= R'' + jX'' \quad (24)$$

Of the various band-pass filters considered, the double two-section type has been found most satisfactory. If designed according to the principles discussed above, filters of this type can be made to provide all the signal selection required in a radio receiver, and these properties can be made practically uniform over the entire broadcast range. Uniform signal selection is a property that is very imperfectly realized at best, and tuned circuits are subject to the same criticism in this regard as band-pass filters. Band-pass filters have the great advantage that they are subject to manipulation, as has been shown, and compromise characteristics can be obtained under certain conditions without any sacrifice in actual selectivity, and without a very large loss in transmission properties.

TUBES AS AMPLIFIERS

TUBES IN modern radio receivers serve three functions, they amplify, they detect, and they rectify. Although many sets have six or seven tubes only one of them detects and one, or at most two, rectify. All the rest amplify.

The question that interests the person who wants to know more about tubes is, how does the tube amplify, and how much?

To understand how the process goes on, consider Fig. 1 which represents the plate current in milliamperes at any value of grid voltage. Thus, at 3.0 volts on the grid, the plate current is 3.0 milliamperes. If this voltage changes, the current changes. If the voltage is made to change at some regular rate, at 60 cycles, for example, the plate current will go up and down from some average value in unison with this changing grid voltage. This changing plate current must flow through the internal resistance of the tube and with any external resistance (called the load) connected in the plate circuit. This changing current in flowing through these resistances causes a voltage drop to appear along the resistances.

For example, a change of one volt, plus and minus from the average value of the grid bias, may cause a change of one milliampere plus and minus in plate current. If the internal (plate) resistance of the tube is 12,000 ohms, one milliampere flowing through it causes a potential drop of 12 volts. But note that only one volt on the input of the tube results in 12 volts appearing in the plate circuit. The tube has amplified a voltage.

In the above case there is a total of 12 volts available. If a load resistance is in series with the tube, the changing plate current must flow through it too, and thus a voltage will appear across this external load resistance. This voltage may be utilized. That lost within the tube itself cannot be usefully employed. But 12 volts is the total available. How much can be made to appear across the load?

If two equal resistors are in series and 12 volts appear across them, 6 volts will be across one resistor and 6 across the other. If, however, one resistor is much greater than the

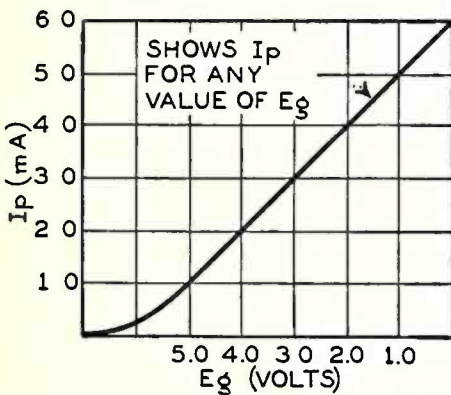


Fig. 1

other, say 5 times as great, a much greater proportion of the total voltage will appear across it. Its share will be correspondingly greater. If, then, a 12,000-ohm tube (201-A) has in series with its plate circuit a 36,000-ohm resistor and 12 volts are available, 9 volts will appear across the resistor and 3 volts will be lost in the tube.

The actual relation between useful voltage and the two resistances is shown in equation (1) in which R_p is the tube resistance and R_o is the output resistance.

$$\text{Useful voltage} = \text{Total voltage} \times \frac{R_o}{R_o + R_p} \quad (1)$$

Now the fact that more voltage (a.c.) appears in the output of the tube than is put into its input is expressed in one of the so-called defining constant of the tube, the amplification factor or mu (μ). Thus if the mu of the tube is 8, there will be a total a.c. plate voltage of 8 when 1.0 volt (a.c.) is put on its grid. The voltage amplification, G , that results from using a tube and load resistance is given by

$$G = \mu \times \frac{R_o}{R_o + R_p} \quad (2)$$

and the total available a.c. voltage is equal to μE_g because an input voltage E_g is multiplied by μ and reappears in the plate circuit as μE_g .

If the second part of Equation (2), $\frac{R_o}{R_o + R_p}$ is very large (i.e. approaches unity) the value of G will be very nearly equal to the mu of the tube.

When there is a voltage of μE_g in the plate circuit the current (a.c.) that will flow is equal to—

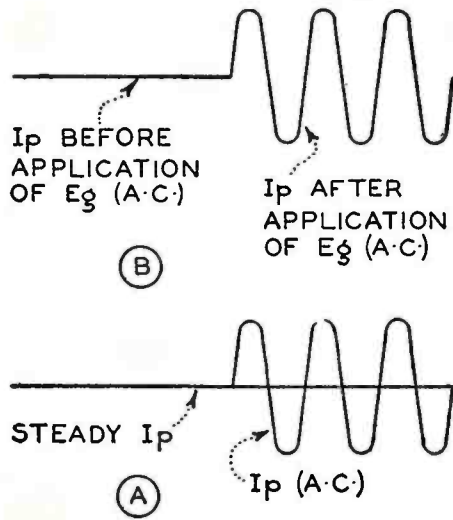


Fig. 3

$$\text{plate current (a.c.)} = \mu E_g / R_p \quad (3)$$

or it is equal to $E_g \times G_m$ in which G_m is the symbol for mutual conductance, another of the factors which describes a tube to an engineer.

Thus if one volt (a.c.) is put on the grid of a tube whose mu is 8 and whose plate resistance is 8000 ohms, an a.c. plate current of one milliampere will flow. Thus $I_p = (E_g \times \mu) / R_p$ or $(1 \times 8) / 8000 = 0.008$ amperes or 8 milliamperes. This does not mean that if there is some external load resistance there will be 8 milliamperes flowing for such is not the case. The current will fall off according to Ohm's law and the mutual conductance of the circuit decreases as the load resistance increases. If, in the above case, an 8000-ohm load is in series with the tube, the plate current (a.c.) will be only 4 milliamperes because the total resistance, through which μE_g must force current, has been doubled. Thus an input of 1 volt (a.c.) will cause an a.c. current of only 4 mA. and the a.c. plate current. They may be summarized as in Table I.

We now know all the major factors of the tube and their relation to the input and output voltages, and the a.c. plate current. They may be summarized as in Table I.

A. C. plate current

The fact that there may be an a.c. current in the plate circuit as well as a current which affects a d.c. meter mystifies many readers of radio articles. Is it possible for a d.c. current and an a.c. current to flow through the same circuit? Yes it is. Look at Fig. 2 which is the familiar output coupling system of a power tube. A. C. currents are prevented from going through the choke L by its high impedance to these currents; d.c. currents are prevented from going through the loud speaker by the condenser C; but both currents must flow through the tube.

There are two ways of looking at this alternating plate current business. One is to say that when an a.c. grid voltage is put on the tube, an a.c. plate current flows in addition to the direct current (Fig. 3A). Another way is to state that when an a.c. grid voltage is applied, it adds to or subtracts from the steady or d.c. voltage already there due to the C bias. When this steady bias is decreased because the a.c. voltage is positive, the plate current increases; when the steady bias is increased because the a.c. input is negative and adds to the C bias, the plate current decreases. Thus the no-signal value of the plate current goes up and down in unison with the changes occurring in the grid voltage (Fig. 3B). A plate current meter is too sluggish in its motions to follow these variations, and so indicates the average value.

So long as the plate current increases and

Table I

Total a.c. plate voltage	μE_g
Useful a.c. plate voltage	$\mu E_g \times R_o / (R_o + R_p)$
Voltage (a.c.) lost on tube	$\mu E_g \times R_p / (R_o + R_p)$
Voltage amplification in tube circuit	$\mu \times R_o / (R_o + R_p)$
Alternating plate current	$\mu E_g / (R_o + R_p) = E_g \times G_m$
Mutual conductance G_m ($R_o = R$)	$(R_o = R)$
	$\frac{\text{a. c. plate current}}{\text{a. c. grid voltage}}$
Mutual conductance ($R_o = 0$)	μ / R_p

Note. Answers to these problems will be found on page 239.

decreases equal amounts from the steady no-signal value, there will be no change in the value of current indicated by the d.c. meter. If, however, the current on the positive half cycle increases more than it decreases when the grid is less positive, the average current will change and the plate current meter will show an increase in plate current. Such a change is an indication that the plate current (a.c.) is not an exact replica of the a.c. input voltage. In other words, distortion is taking place.

Screen-Grid Tube

Suppose a tube has such a high plate resistance that whatever you put in series with it makes little difference to the plate current (a.c.). For example, a 227 with 10,000 ohms would have almost the same alternating plate current if 1000 ohms were added to the plate circuit. But if you were to add another 10,000 ohms, or even more, the alternating plate current would decrease. In other words, the mutual conductance of the circuit, i.e., the relation between alternating current output and input alternating voltage, decreases.

The plate resistance of the screen-grid tube (6Y224) is about 400,000 ohms. Its mutual conductance is about one 1000 micromhos. Now if you put 50,000 ohms in series with the tube the a.c. plate current will only decrease by about ten per cent, and the mutual conductance will decrease the same extent.

We can say, then, that with a high-resistance tube, the mutual conductance of the circuit is about the same as for the tube with no-load resistance, that the alternating plate current in the entire circuit is equal to the alternating grid voltage multiplied by the mutual conductance, and that the voltage amplification from such a tube is equal to the product of the mutual conductance and the load resistance. Thus—

$$\begin{aligned} \text{A. C. current (with or without load)} &= E_g \times G_m \\ \text{Voltage amplification} &= G_m \times R_o \end{aligned}$$

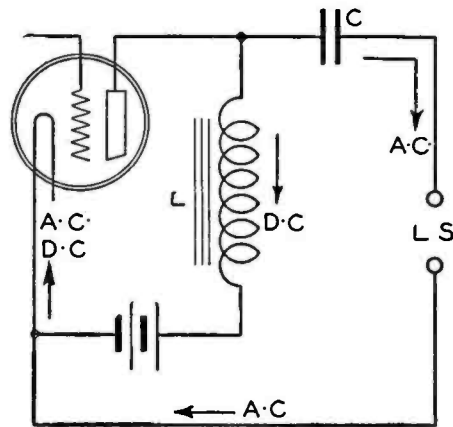


Fig. 2

It is interesting to note that the maximum amplification that can be secured from a three-element tube working into a resistance is the mu of the tube, but that the maximum amplification attainable from a screen-grid tube depends not so much upon its amplification factor but upon the mutual conductance. This is because the load resistance that can be built up for the tube to work into is limited—we cannot get resistances beyond perhaps 200,000 ohms in an r.f. circuit at broadcast frequencies, or much less than this figure at higher frequencies.

Problems

1. A 227-type tube ($R_p = 10,000$ ohms, $\mu = 9$) is worked into a load of 30,000 ohms. What is the voltage amplification?
2. It is desired to use 90 per cent. of the possible amplification from a 240-type tube. Its $\mu = 30$, $R_p = 150,000$ ohms. What load resistance is required?
3. The plate resistance of a tube is 2000 ohms; its amplification factor is 3. If 10 volts were put on its grid what would be the a.c. plate current? What would be the a.c. current through a load of 4000 ohms?
4. A 250-type tube with 450 volts on the plate requires a C bias of 84 volts. If a peak input voltage of 75 could be put on the tube, what would be the actual grid voltage range? The amplification factor of the tube is 3.8; its R_p is 1800 ohms. If it were worked in to 3600 ohms, what would be the a.c. current through the load and the a.c. voltage across it under the above conditions?

SIMPLE L x C MEASUREMENTS

HOME STUDY SHEET" No. 20 in April, 1929, RADIO BROADCAST gave directions for winding an inductance which could be used as a standard in the serviceman's or the experimenter's laboratory. In "Home Study Sheet" No. 21 (May issue) is a description of a bridge for use in comparing unknown inductances to this laboratory standard, or in measuring unknown capacities in terms of a standard made according to "Home Study Sheet" No. 24; the following Sheet, No. 25, described a buzzer which may be used to good advantage in the laboratory.

It is a simple matter to measure unknown inductances or capacities if a standard and a grid-dip meter oscillator is available, but frequently such an oscillator is not handy. If the laboratory has a high-pitched buzzer and the above mentioned standards, an unknown capacity or inductance can be measured by a very simple experiment. In addition to the above apparatus, it requires only a crystal detector and a pair of headphones. As a matter of fact the method described in the following paragraphs is often of greater convenience than the bridge since it takes up less room, requires less apparatus, and measures the coil under operating conditions.

The Crystal Detector

There is probably nothing about the laboratory that can be more annoying or more satis-

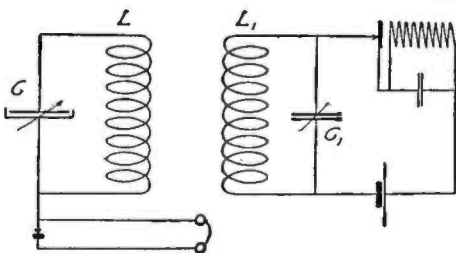


Fig. 3

factory than a crystal detector. When the latter condition is the case, it provides, in connection with a telephone receiver, a means of detecting radio currents that are almost infinitesimal. Almost invariably when trouble is experienced in using a contact detector, it is due to the use of inferior crystals. If about an ounce of fairly fine grained steel galena of good quality can be procured, no further trouble will be encountered. Many crystals, more often the smooth surfaced cubes are practically worthless, but with galena of the proper sort, it is more difficult to find an insensitive point than one that is sensitive. In this so-called steel galena the rough surface is simply due to the thousands of minute crystals that form its structure, and when it is used, the cat whisker is not displaced easily.

As the crystal detector in laboratory work is frequently connected to the circuit with only one wire, it is very convenient to provide a small inclosed detector that may be snapped onto the binding post of a condenser or some other piece of apparatus. Fig. 1 will prove suggestive. The shell is a piece of tubing cut from a small fountain pen or rubber pen-holder. On one end a heavy brass cap is forced on, and is threaded for a set screw to hold the crystal. Soldered to this cap is a spring clip, which holds the detector in place and makes the one-way connection. On the other end is another cap, held by friction, but not so tightly that it cannot be removed with the fingers. Through the center of this runs a small brass rod, tipped with a springy cat whisker of fine bronze wire, about number 30. The rod is surrounded by a compression spring, which, with the flange outside the brass cap, operates to hold the rod in position, but by pulling on the rod and turning it a little, a new spot on the crystal may be found quickly. This fact is not very apparent from the illustration, but it is so in actual use, as the cat whisker is never exactly central, and numerous points are accordingly found. To hold the tips of the receiver cord, spring clips should be provided and soldered to the two brass caps.

Such a detector, being small and condensed, adds but little capacity to disturb the circuit. It is dust proof, and, with good galena, it may be removed and replaced repeatedly without losing the sensitive point. Inclosed detectors may now be purchased, but usually they are so large as to be inconvenient.

Sometimes it is desirable to avoid an outside connection with a circuit involved in some

quantitative determination, and, in such a case, the detector must be provided with a little pick-up coil of its own, so that the necessary current may be secured through induction. Fig. 2 shows a convenient way of arranging this. A small spiderweb or diamond-weave coil is attached to a base block in any convenient manner that will permit of its being replaced by another coil if desired. This will be necessary only in dealing with very short waves, when the natural wavelength of an ordinary coil might be identical or very close,

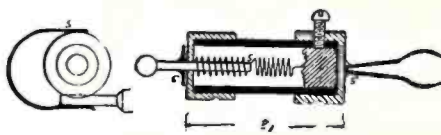


Fig. 1

and thus draw so much current as to disturb seriously the circuit under consideration. In any event it is not advisable to use more turns than are necessary—sometimes three or four are sufficient.

The crystal is snugly packed with tinfoil into the bottom of a brass tube or cartridge shell that has been well polished inside and out. This is held in position by inserting it into a suitable hole drilled into the base block about a quarter of an inch, and connection is made to it by bending into the hole the end of the spring clip which holds the tip of the receiver cord. The cat whisker is in the form of a spring, and comes up through a smaller hole in the base block. To obtain a new contact point on the crystal, it is only necessary to withdraw the cartridge shell partly, turn it a little, and push it down again. Such a detector is dust proof, and will give practically no trouble when good steel galena is used.

The tips of the receiver cord are held by slipping them under two strips of spring brass or bronze. The one referred to above makes connection with the crystal holder, and the other is placed crosswise on the base block and is connected directly to the coil, the other terminal of which goes to the cat whisker. By cutting a half-round groove in the base block under each spring clip, the cord tips will be held securely in position.

In using such a detector, a single receiver is sufficient and much more convenient than a pair with a head-band. The combination constitutes a sort of electrical divining rod, responsive to all wavelengths.

Measuring L or C

As shown in Fig. 3, a high-pitched buzzer and one or two dry-cell batteries are used to generate radio currents in the oscillatory circuit LC. It is not necessary that the values of this inductance and capacity be known, and if an extra variable condenser is not available, C₁ may be a fixed condenser. L is the inductance standard, and C is a calibrated variable condenser to the shielded side of which is connected a crystal detector and telephone receiver.

If the buzzer is now started, and the capacity

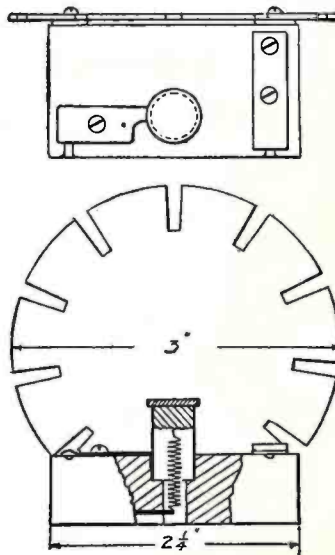


Fig. 2

of C is varied, a point on the dial will be found where the buzzer note is clearly at a maximum. As the coils are separated, this point will become sharper. Therefore, the coils should be separated as far as will permit of a definite determination—say to a distance equal to about twice the diameter of the coils being used.

Having noted the point on the dial where resonance occurs, replace the known inductance with the unknown coil and retune, carefully noting the second point. Then the inductance of the unknown coil will be found from $L_x = L_s \times \frac{C_x}{C_s}$. That is, to obtain the unknown inductance, multiply the inductance of the standard, L_s, by the capacity at which it was found resonant, C_s, and divide by the corresponding capacity, C_x, for the unknown coil. If this seems a little complicated, just remember that the same wavelength was used in both cases, in consequence of which L x C is the same in both cases. Therefore, if one coil requires half as much capacity as the other, its inductance must be twice as great.

In making such a determination, it is desirable that the inductance and capacity used in the generating circuit (L₁ C₁) be chosen so as to yield fairly high readings on the calibrated condenser, as the errors in reading small values are proportionately larger.

Simple though the foregoing procedure may seem, it is very significant, and illustrates the fundamental fact that for any given wavelength

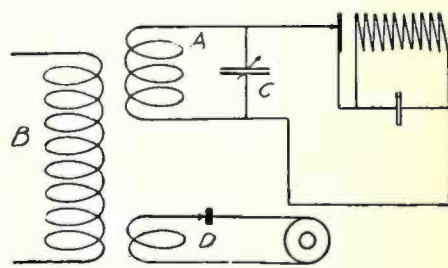


Fig. 4

there is only one value for the product of the inductance and capacity that will result in a maximum current.

If the laboratory worker has calculated, as he eventually should, the inductance of more than one coil, and has used the bridge to transfer his capacity values to another condenser, he may then use known values in the generating circuit. As a result he will have an additional check on his work.

Sometimes it is convenient to provide a coil with a fixed condenser, and then carefully determine the value of L x C and the corresponding wavelength, so that when they are used in a generating circuit, it will only be necessary to divide by the value of the calibrated condenser, at the point at which resonance occurs, in order to obtain the inductance of an unknown coil. Thus, if a coil has an inductance of 200 microhenries and the fixed condenser a capacity of 0.0005 microfarads, L x C would be 0.1 and the corresponding wavelength a little under 600 meters. Such a combination would not only serve the above purpose, but would immediately show whether a given coil and condenser would cover the upper limit of the broadcasting range.

The foregoing is all strictly true if the capacities C and C₁ are the total capacities across each coil, but we have purposely omitted to state that these capacities are not entirely within the respective condensers, but are, to a slight extent, found in the coils themselves, and are termed distributed capacity. If, however, the fixed or tunable capacities across the coils are fairly large (100 mmfd.) we can neglect the distributed capacity except in experiments where great accuracy is required.

The distributed capacity of a coil arises from the fact that each turn is composed of a metallic conductor separated from its neighboring turns by a non-conductor. This forms the essential elements of a condenser. All of these elemental capacities are in series so that a long lean coil has a lower distributed capacity than a short fat one.

Coils for use in the broadcast frequency band have capacities of less than 10 micro-microfarads.

It has been found by experiment that coils whose length is twice the diameter have a distributed capacity of 0.64 R where R is the radius of the coil in centimeters. If the length is half of the diameter the distributed capacity will be about 0.6 R.

Other experiments indicate that the distributed capacity of good coils is always less than the radius of the coil in centimeters.

An Instrument for Diagnosing Trouble in Radio Sets

THE SUPREME DIAGNOMETER

By FLOYD FAUSETT

Supreme Instrument Company

THE QUALITATIVE performance of a radio may be appreciated by the ear, but there are times when a radio suffers from certain ailments which the ear can diagnose only by stating that the radio sounds terrible, or does not sound at all.

In such instances diagnosis of the difficulty must depend upon meters which can be read by the eye. The Supreme Diagnometer ("diagnosis by meter") has been designed for this purpose. It is a consolidation into a single unit of many different instruments each performing a distinct and useful function.

In addition to plate voltage and current readings which are obtainable with any set-tester, the Supreme instrument is equipped with an oscillator, a thermocouple meter, and other equipment so that the widest possible range of measurement is possible. There are more than forty different circuits in the Diagnometer with ready access to them all. The optional Weston or Jewell meter equipment of the Diagnometer consists of three instruments:

(1) a d.c. voltmeter of the "1000-ohms-per-volt" type, having 750/250/100/10/0 voltage scales and an a.c. thermocouple range of 250 milliamperes; (2) a d.c. ammeter-milliammeter of 2½/0 ampere and 125/25/0 milliamperes scales; and (3) an a.c. voltmeter of 750/150/16/4/0 scales. Nine scales of these meters are brought into the desired circuits by a special plunger selector "wiping-contact" switching system, and all of the eleven scales are available at external pin jacks for test uses.

The Diagnometer performs the functions of five separate units; namely, (1) tube-socket analyzer, (2) tube-tester,

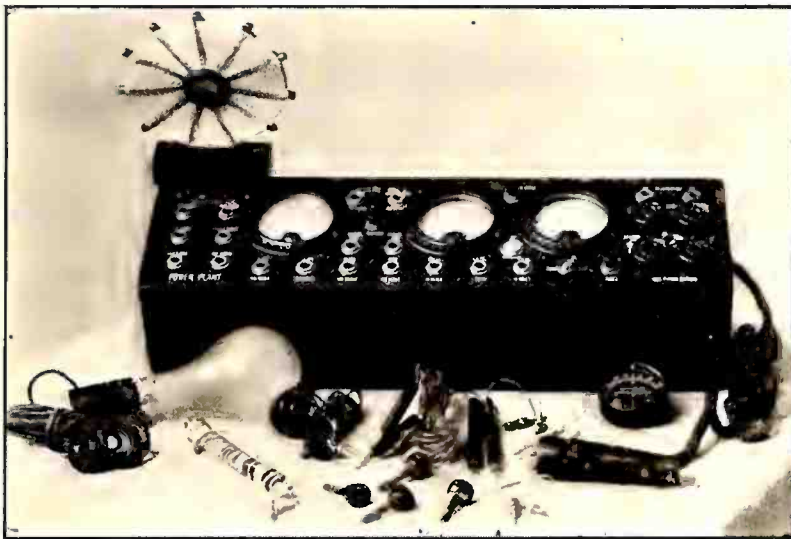
(3) modulated oscillator, and (4) continuity indicator. All of these four essential measurements are performed without the necessity of batteries by utilizing a built-in transformer designed for operation with a 110-volt a.c. supply through a protective

of making comparative tests of tubes, and is preferable to testing tubes with power supplied by an operative radio. In fact, the serviceman quite frequently finds that a radio is inoperative so that no radio power is available for tube testing. Not

being able to ascertain the conditions of the tube equipment in such a case, the customer cannot be given a fair estimate of the total cost of putting the radio equipment in a satisfactory operating condition. Even where operative radios are available, the tube socket potentials differ between different sockets, and are affected by the differences of load conditions imposed by the transposition of tubes of more or less non-uniform characteristics among the different sockets of the receiver, one tube with poor characteristics being sufficient to make a material difference in the load carried by all other tubes. While the power plant feature is unquestionably advantageous, the Diagnometer oscillator circuits may be supplied with the conventional

battery power for tube testing where desirable, as in the rare situations where a 110-volt, 60-cycle a.c. supply is not available.

The tube socket analyzer utilizes a plug which affords analysis from the sockets of all radios, including screen-grid and "top-heater" types, all connections being brought into the Diagnometer through a single 6-wire cable, the design affording screen-grid analysis without causing these tubes to oscillate while the tubes and circuits are under test. Screen-grid, control-grid, positive and negative cathode, a.c. or d.c. filament, and plate potentials may be read by manipulation of corresponding switches while the plate current is simul-

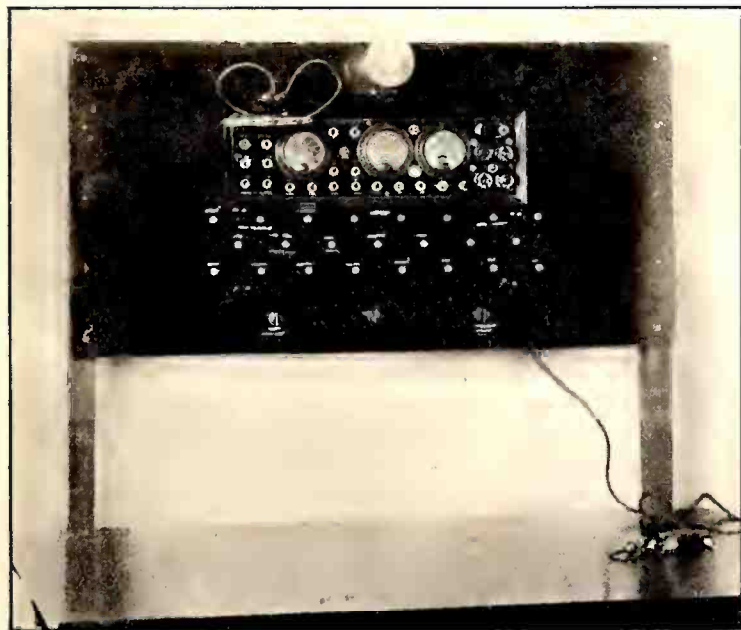


The Diagnometer and its accessories.

lamp and radio-frequency by-pass filter, and delivering secondary potentials of 1.5, 2.5, 3.3., 5.0, 7.0, 7.5, 10.3, and 15.0 volts. The protective lamp affords protection to the meters and circuits and offers visual indication of tubes having shorted elements. The a.c. line voltage may be observed during tests utilizing the power plant where the a.c. voltmeter is not otherwise employed.

The Power Plant

The power plant embodied in the Diagnometer provides circuits of definite characteristics, affording a reliable means



For use in the shop the Diagnometer may be mounted on a test panel.



In general service work the Diagnometer is carried in a compact leather case of the type shown above. The case also provides space for accessories and tubes.

taneously indicated on the milliammeter. The single analyzer adapter required for 6Y sockets is provided with a snap catch to prevent the separation of the adapter from the plug in radio sockets.

The Diagonometer analyzer arrangement is useful in the preliminary analysis of radio faults, its usefulness extending to power-pack analysis through the rectifier tube socket for isolating power-supply troubles where plate voltages are not delivered to the radio tube sockets. Where a rectifier tube is good, shorted filter condensers or shorted voltage dividers are indicated by full or excessive rectifier plate current readings, while open filter chokes and open plate-supply secondary circuits are indicated by low or no rectifier plate current readings. The 750-volt a.c. voltmeter scale is very useful for locating open and shorted rectifier plate transformer secondary windings.

The Circuit

The schematic diagram of the Diagonometer's modulated radiator and self-rectifying tube-testing circuits shown in Fig. 1 shows the simplicity of its various functions. The closely-coupled plug-in radiator coil is shown separated from the power circuit. The grid circuit is tuned with a fixed 0.0005-mfd. condenser and may be shunted by depressing the "stop-oscillation" switch shown. A biasing toggle switch is shown for shifting the grid return from either side of the power transformer secondary to the other side for changing the grid potential as a mutual conductance test for tubes. A by-pass condenser is connected across the line supply to keep the radio-frequency currents from the a.c. line. Fixed tuning of the oscillator circuits, with close coupling to afford several harmonics over the broadcast band, is utilized to maintain constant circuit values for matching and classification of tubes with the oscillation test.

The mutual conductance test with the Diagonometer is accomplished by keeping the "stop-oscillation" button depressed while changing the grid potential of the tube under test by means of the "zero-bias" switch, and observing the amount of change in plate current as read on the milliammeter. A tube which is within 25 percent of the average mutual conductance index for the type of tube under test is a good tube and should not be discarded.

In an effort to determine the effect of tube variations upon receiver performance the following test was made. A large quantity of new 226-type tubes were tested under identical conditions with "bias" oscillation plate current readings varying between 12 and 30, and averaging 18 milliamperes. These tubes showed little difference in mutual conductance and seemed to be equally sensitive by audible tests in a.f. amplifiers, and were all classified as good tubes. However, as each tube attained its maximum reading under the oscillation test, the signal produced by the oscillating tube was tuned to maximum audibility on an accurately calibrated receiver, and the fundamental radio frequency was determined. A variation of 60 kilocycles was noted between the extremes mentioned, the signals from the tubes showing identical oscillation test readings tuning at practically the same reading on the radio receiver. A receiver of the "band-pass" type was then equipped with tubes picked at random, and its sensitivity compared to the sensitivity of the same set

equipped with tubes of matched oscillation test readings, the sensitivity being observed by ear and also by utilizing the meter output measurements with the thermocouple method and with the a.c. voltmeter method. During the sensitivity observations, the same tube was used as the oscillator in the Diagonometer. The sensitivity of the radio was greater when matched tubes were used, irrespective of whether or not the tubes used were matched from tubes chosen at test ratings above or below the average.



Rear view of Diagonometer showing external pen jacks.

Matching Tubes

These studies in tube variations led the writer to the conclusion that the careful matching and allocation of tubes is advantageous where it is desired to insure maximum radio performance, and this procedure has been followed in practice to the extent of using tubes of identical oscillation test ratings in the tuned stages of a receiver and utilizing the tubes of more radical oscillation ratings having good non-oscillation plate current ratings in a.f. stages. However, matched tubes are used in push-pull stages so as to eliminate or minimize hum and distortion, and full-wave rectifier tubes are chosen which have identical plate current readings for the two plates. Comparison of the plate current readings of both plates of full-wave rectifier tubes is interesting and often important in hum minimizing.

These service observations have been conducted in a territory in which practically every radio is sold by demonstration

in competition with other receivers in the prospective customer's home. Under these conditions it is very important that a radio be operating at its maximum efficiency before being installed. In practice, a radio is "tuned up" with well-chosen, tested, and matched tubes. Neutrodyne sets are always re-neutralized with the tubes which are to constitute the radio-frequency and detector tube equipment of the receiver. For this purpose the special neutralizing adapter, marketed as an accessory to the Diagonometer for either four or five-prong tubes and sockets, is used in lieu of "dummy" neutralizing tubes. This adapter provides a means for neutralizing a radio-frequency stage to the tube which remains in that stage for the operation of the radio, thereby removing the possibility of inefficient neutralization through the use of a "dummy" tube, the inter-electrode arrangement and capacities of which may not match those of the tube which will normally operate in the neutralized stage.

Checking Condensers

After neutralizing, the tuning condenser adjustments are checked by means of one of the output meter synchronizing methods, such as the a.c. voltmeter method which is recommended in the service literature of some of the leading radio manufacturers. It is an excellent method, the a.c. voltmeter being rugged and the current required for a full low-scale deflection (about 100 milliamperes) being safely beyond the full-load output of any commercial power tube. With the model 400-B, the output of the moving-coil speaker terminals of the receiver may be connected directly into either of the low-scale movements of the a.c. voltmeter of the Diagonometer, or the output may be coupled to the meter through the primary and third windings of a special built-in a.f. transformer.

The thermocouple output meter synchronizing method available in late models offers the advantage of enabling the operator to control the range of deflection on the meter during the procedure by means of the 30-ohm rheostat. For neutralizing and synchronizing, harmonics of the modulated oscillator are chosen within the frequency limits recommended by the manufacturer of the receiver under test.

The continuity testing methods available with the Diagonometer are very useful. The thermocouple method is especially valuable for a comparative indication of resistor values from 0.1 ohm to 20 ohms, enabling one to check accurately the center tapping of transformer secondaries and filament resistors, to locate short circuited variable or fixed condensers without removing them from their position across radio-frequency transformers, to locate poorly soldered joints, etc. The a.c. voltmeter, in series with one of the power transformer secondary windings, is useful for continuity testing and comparative measurements of non-reactive resistors ranging between 10 ohms and 100 ohms. The d.c. milliammeter in series with the plate supply of a rectifier tube is used for continuity and comparative resistance measurements in non-reactive circuits of from 150 ohms to 30,000 ohms. Resistances up to several megohms can be calculated from readings obtained with the d.c. voltmeter in series with one or more B batteries. This hook-up is also useful in detecting

(Continued on page 245)

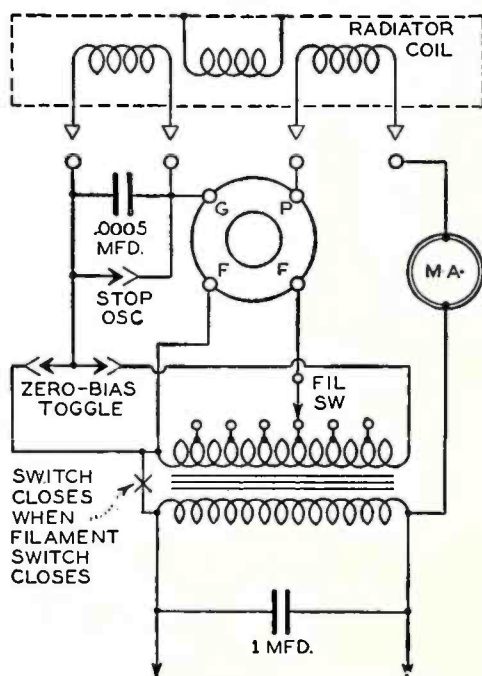


Fig. 1

PUSH-PULL A.F. AMPLIFIERS

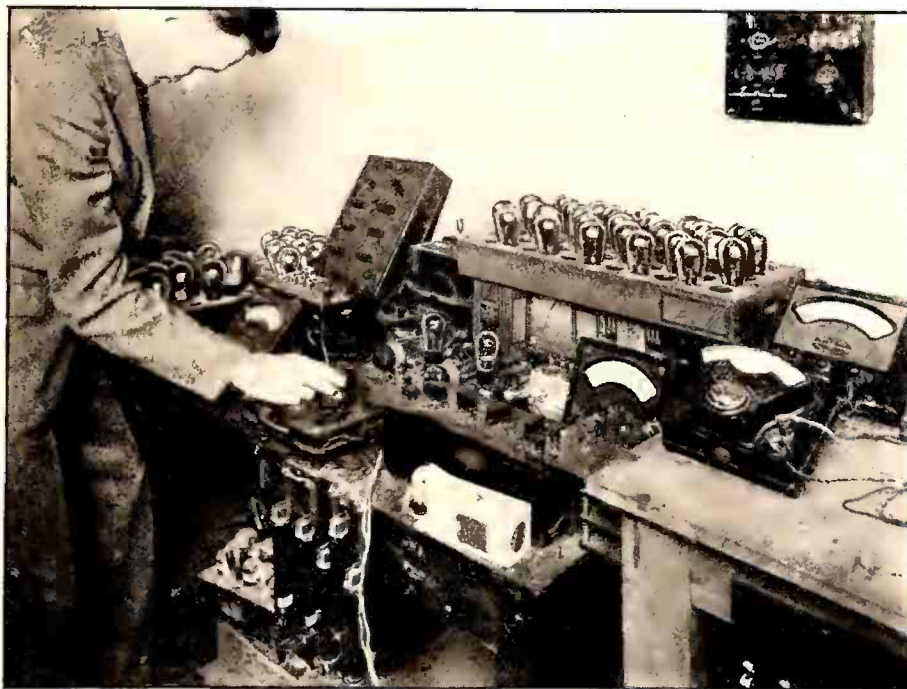
By J. M. STINCHFIELD

E. T. Cunningham, Inc.

THE ALMOST universal adoption of the push-pull output stage for loud speaker operation indicates that it must possess advantages from the viewpoints of economy of design and performance. These advantages probably outweigh any consideration of the amount by which the maximum undistorted power output may be increased beyond twice that obtainable from a single tube. It is, however, interesting to see how much power output can be obtained from the push-pull stage and what distortion will result. Reproduction of voice and music having not over 5 per cent. harmonics added to the original is generally admitted to be distortionless high-quality reproduction. As a matter of fact, by comparing the original sound by means of a quick change-over switch with the reproduced sound containing 10 per cent. of harmonics, it was difficult in the experiments described to hear any audible difference in quality. It was also difficult to determine whether second harmonics are more or less objectionable than third harmonics.

Measurements of the undistorted power output are usually determined for 5 per cent. of harmonics and no grid current flow. Until the signal voltage is large enough to start a flow of grid current, practically the entire harmonic output of a single three-electrode tube is second harmonic. When two tubes are connected in a push-pull circuit the second harmonics and all even harmonics introduced by the tubes should largely balance out in the output circuit leaving only harmonics which are odd multiples of the signal frequency.

When a sine wave of signal voltage is applied to the grid circuit of a single tube and gradually increased in value, the wave-form of the current in the load appears to be a sine wave initially, and then gradu-



The author at work in his laboratory.

ally flattens on one side and continues to rise on the other side. This effect is most noticeable when the load resistance is about equal to, or less than, the tube resistance. Fig. 1 shows such a wave-form. It is equal to the sum of a sine wave and

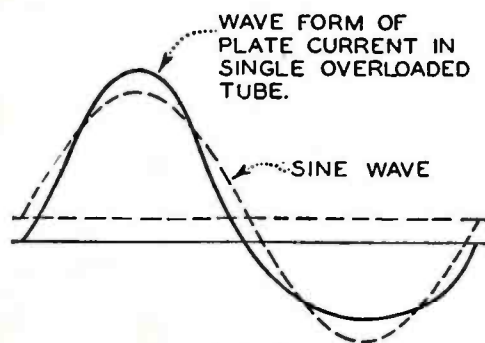


Fig. 1

a second harmonic. The dotted curve in Fig. 1 is the sine wave. If a sine wave of signal voltage is applied to the grid circuit of Fig. 6 the wave-form of the output

current appears to be a sine wave until the signal is quite large. The load resistance had very little effect on the wave form.

To determine how the distortion increases with increasing signal voltage, two 6X112A tubes were connected in a push-pull circuit as shown in Fig. 6. The signal voltage was taken from the 60-cycle supply and was connected through a low-pass filter to eliminate harmonics, so that a 60-cycle sine wave of voltage was applied to the grids. The wave form of the output alternating current through the load resistance, R_p , was observed on a G.E. oscillograph. The meters for reading the effective d.c. grid voltage, E_c , and d.c. plate voltage, E_p , each consisted of a million-ohm wire-wound resistor and a microammeter so that

they could remain permanently connected. Some of the oscillograms were analyzed by measuring the ordinates at 12 equally spaced points per cycle and computing the coefficients for a Fourier's series.

The inductance across the output (plate to plate) was about 180 henries. The exact value depended, of course, upon the a.c. and d.c. values through the chokes. The impedance measured 98,000 ohms when 100 volts at 60 cycles and no d.c. were applied and 123,000 ohms when 200 volts at 60 cycles and no d.c. were applied across the inductance. The tubes for these tests were similar in a.c. characteristics. A preliminary check showed that the plate currents and grid currents were nearly the same for each tube. On other tests we found that tubes with matched plate current and a.c. characteristics showed nearly the same percentage of distortion as with two tubes with plate current and a.c. characteristics as much different as could be found in normal good tubes.

A 1.5-mA. meter (not shown) was used with a battery and low-resistance potentiometer in series with the load to balance



Fig. 2

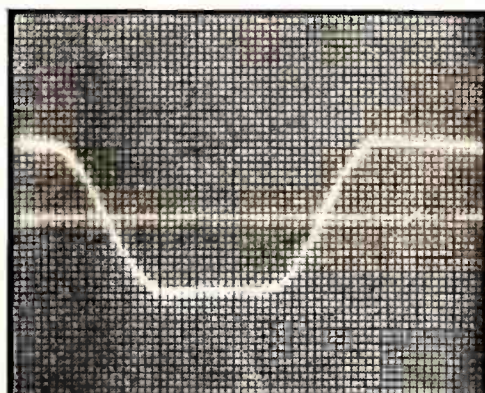


Fig. 3



Fig. 4

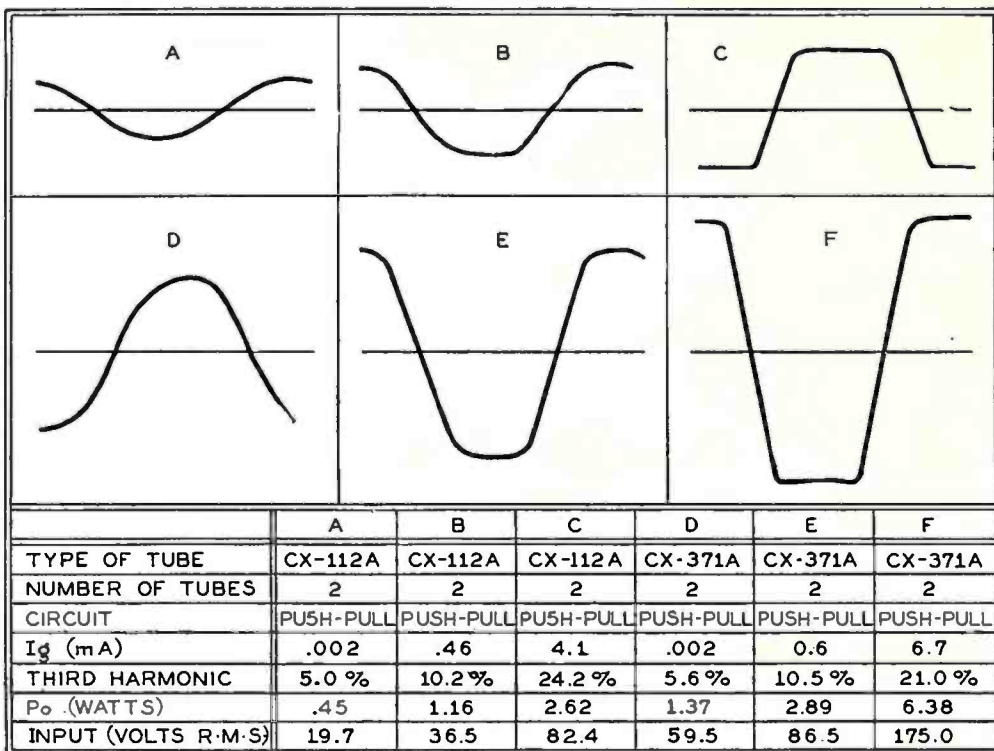


Fig. 5

out a small fraction of one milliamper d.c. which flowed through it.

In some earlier listening tests we used resistors bridging the input and output to overcome a slight tendency to sing at some high frequency. While no difficulty was experienced with singing in the set-up shown in Fig. 6, we continued the use of bridging input and output resistors.

The percentage of harmonics registered by the oscillograph may be somewhat high because of loss of fundamental in the output inductances, but it is not believed that this discrepancy is very great.

In Fig. 5A is shown the wave form of the output current when 19.7 volts (r.m.s.) is indicated on the meter, E_g , in Fig. 6. The load resistance R_p was 18,100 ohms. The peak value of the 19.7-volt (r.m.s.) signal is 27.9 peak volts. This is slightly over twice the bias voltage which was 13.5 volts. Each tube was drawing about 2 microamperes of grid current.

On increasing the signal voltage the grid current increased rapidly and both the upper and lower peaks of the output current were seen to flatten somewhat. When the signal reached 36.5 volts (r.m.s.) each tube had an average d.c. grid current flow of 460 microamperes. (Fig. 5B.)

The r.m.s. plate current in Fig. 5A was 5.0 milliamperes and the power output 450 milliwatts, or 225 milliwatts per tube. In Fig. 5B the r.m.s. plate current was 8.0 milliamperes and the power output 1160 milliwatts or 5.15 times the output per tube obtained in Fig. 5A. Fig. 5C shows the result of increasing the signal to an extreme value of 82.4 volts (r.m.s.). The power output is 2620. milliwatts or 11.6 times the output per tube obtained in Fig. 5A.

The data and the results of an analysis of Fig. 5 (A, B, and C) are shown in Table I. The second harmonics in Fig. 5 (A, B, and C) in order of increasing signal, are, respectively, 2.6 per cent., 6.8 per cent., and 4.8 per cent. The percentage was calculated from the ratio of harmonic to fundamental. Considering second harmonics alone as a measure of the distortion,

the quality is good for any signal amplitude. The corresponding amounts of third harmonic were, respectively, 5.0 per cent., 10.2 per cent., and 24.2 per cent. The percentage of higher harmonics was relatively small. Evidently the third harmonic is the principal distortion component from a push-pull amplifier, the

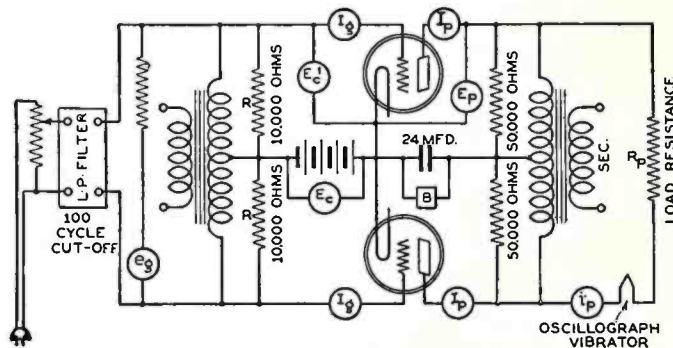


Fig. 6

percentage increasing (roughly) in direct proportion to the signal voltage. Similarly it will be found that with a single-tube amplifier the percentage second harmonic (principal distortion component) increases in direct proportion with the signal voltage. As the operation of the single tube extends into the grid-current region, or into the region of plate-current saturation, and the second derivative of the plate current with respect to plate voltage is negative, third harmonic distortion is

produced and the second harmonic distortion will not increase in direct proportion to the signal voltage.

These tests were repeated with two cx-371A tubes. Fig. 5 (D, E, and F) shows the wave form of the output current. The corresponding data are given in Table I. The results indicate, as in the tests with the cx-112A tubes, that for highest quality output the signal voltage amplitude should not exceed twice the normal bias voltage for the tube.

The load resistance required for maximum undistorted power output from a single tube, considering 5 per cent. of second harmonic as a criterion of distortion, is equal to approximately twice the plate resistance of the tube. In the push-pull stage the load resistance has less effect upon the percentage of harmonics. Since the maximum power output from a tube (or any source of power) is obtained when the resistance of the load equals the resistance of the tube (source), the maximum power output will be obtained from the push-pull stage when the load resistance equals the sum of the plate resistances of the tubes.

With the load resistance equal to twice the plate resistance of one tube and normal bias voltage, the distortion is usually negligible until the signal is large enough to start a flow of grid current. The flow of grid current lowers the grid-filament resistance of the tubes putting a load on the input transformer. In Fig. 6 the input impedance was shunted with two 10,000-ohm resistors. The effect of loading the input transformer was then eliminated. The data, Fig. 5 (A to F) in Table I, show an increase in the bias voltage due to the flow of grid current through the d.c. resistance of the input. Figs. 2, 3, and 4 and the data of the table show an interesting result due to the flow of the grid current through the impedance of the input circuit. Fig. 2 shows the wave-form of the output current when the resistances R in Fig. 6 are 100 ohms. The signal was 39.0 volts (r.m.s.), the d.c. grid current 1.05 milliamperes, and the output alternating current 10 milliamperes. The resistances R were then changed to 10,000 ohms. For the same signal voltage, 39 volts, the grid current was reduced to 0.45 milliamperes and the output alternating current was reduced to 9.15 milliamperes (see Fig. 3). Increasing the signal until the d.c. grid current rises to 1.05 milliamperes, as it was initially, the required signal voltage is found to be 52 volts (r.m.s.) The output is 10.4 mA. a.c. The output is 8.3 per cent. higher than was obtained with the low-impedance input, though the signal voltage was increased 33 per cent. Fig. 4 shows the wave-form of the output current. It is apparent that the distortion also is greater. In other words, a low-impedance input circuit is to be preferred.

Table I—Data and Results of Analysis

Figure	D.C. Plate Cur. (I_p) Milliamperes	D.C. Grid Bias, (E_c) Volts	D.C. Grid Cur. (I_g) Milliamp.	Grid Signal (E_g) R.M.S. volts	A.C. Plate Cur. (I_p) R.M.S. Mil.	Power Output ($2P_p R_p$) Milliwatts	Per cent. 2nd	Per cent. 3rd	Per cent. 4th	Per cent. 5th
5A*	26.4	13.5	.002	19.7	5.0	450.	2.6	5.0	1.7	2.3
5B*	34.0	11.7	.460	36.5	8.0	1160.	6.8	10.2	1.8	2.0
5C*	46.0	21.1	4.1	82.4	12.0	2620.	4.8	24.2	1.3	0.9
5D**		40.5	.002	59.5	12.9	1370.	3.1	5.6	.3	2.0
5E**	60.	40.8	.60	86.5	18.7	2890.	.4	10.5	1.1	7.5
5F**	81.	56.7	6.7	175.0	27.9	6380.	1.2	21.0	1.3	3.7
							Input resistance			
2†	33.5	11.5	1.05	39.0	10.0	1612.	100 ohms			
3†	30.5	16.8	.45	39.0	9.15	1350.	10000 ohms			
4†	33.7	19.1	1.05	52.0	10.4	1745.	10000 ohms			

*2 - cx-112A tubes in push pull. $E_p = +180$ volts. $E_c = -13.5$ volts. $R_p = 18,100$ ohms.
 **2 - cx-371A tubes in push pull. $E_p = +180$ volts. $E_c = -40.5$ volts. $R_p = 8260$ ohms.
 †2 - cx-112A tubes in push pull. $E_p = +180$ volts. $E_c = 13.8$ volts. $R_p = 16,120$ ohms.

From now on—



THE set manufacturer to stay in business will be the one who plays safe by refusing to take the risk of using parts of uncertain performance or dependability. When competition whets its blade and selling costs go up, it becomes increasingly important to hold assembly costs as low as possible.

Take mica condensers for example. Unless capacity ratings are accurate, a terrible burden is thrown on the inspection department and "rejects" pile up until

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When you order Sangamo Condensers you need not make over-allowances for "rejects." The reliability of Sangamo ratings is attested to by a number of nationally known radio manufacturers.

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SANGAMO High Voltage Condensers

Tested at 5000 volts d. c. and 3500 a. c. and built to Sangamo standards, known throughout the radio world, amateurs, commercial men and manufacturers have learned to depend on Sangamo High Voltage Condensers. Accurately rated and adequately tested—these condensers offer the maximum protection in high voltage, high frequency circuits.

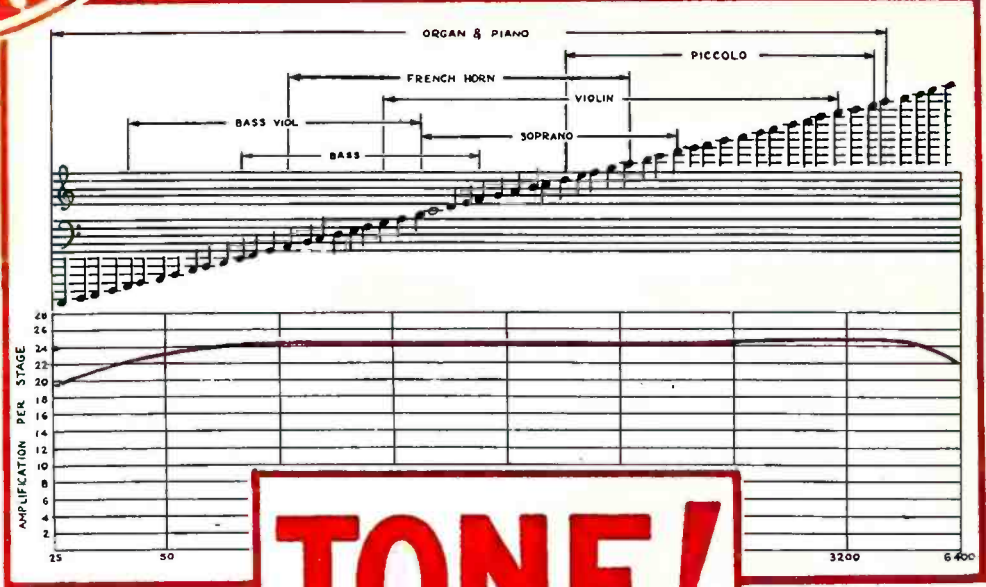
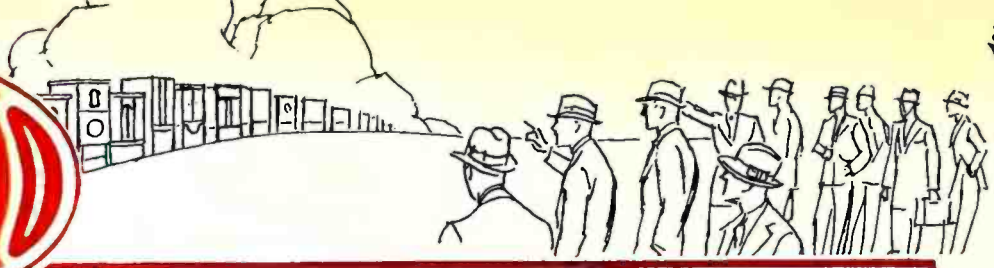
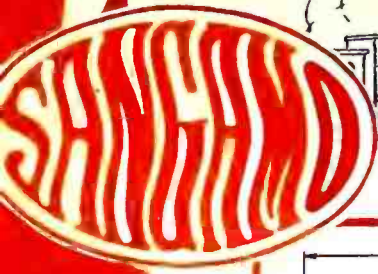
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Manufacturers of Precision Electrical Apparatus for 30 Years



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TONE!

Curve of Type "A" Sangamo Straight Audio Transformer showing uniformity of amplification at all audible frequencies.

What happens out on the "skirmish line"?

When your set goes up to the front line to meet prospective buyers—does it have an outstanding strategic advantage over competition or is it just a "long, hard pull" for your dealers?

Radio receivers must satisfy two different types of buyers. One is the amateurs who not only know the difference between good and indifferent performance but who understand what causes the difference. They are also an important recommending factor in the final purchase of all receivers.

The other type is not technical-minded but regards a radio receiver simply as a musical instrument.

To both classes *tone quality* is all-important. When a dealer tells an amateur that your set has Sangamo Transformers in the "audio end" he *knows* that the tone will be right. He also has more confidence in your set all the way through because he knows that no manufacturer who uses Sangamo Transformers will jeopardize their performance by using inferior parts elsewhere in the set. When equipped with Sangamo Transformers, your set need only be demonstrated to sell those who judge by ear alone.

Sangamo "A" Line Transformers are built for the custom set maker or manufacturer who wants a "tone" advantage over competition. The cost is slightly higher but is more than offset by the increased salability of the receiver.

"A" Line Transformers

- Type A straight audio amplification, list price, \$10.00
- Type B Push-pull Input Transformer for all tubes, list price, 12.00
- Type C-171 Push-pull Output, for 171 or 250 type power tubes with cone speaker list price, 12.00
- Type D-210, same as C except for 210 and 112 power tubes list price, 12.00
- Type H-171, Push-pull Output for 171 or 250 power tubes for Dynamic Speaker list price, 12.00
- Type G-210, same as type H except for 210 and 112 tubes, list price, 12.00
- Type F Plate Impedance for use as a choke to prevent oscillation and for impedance coupled amplifiers, list price, 5.00

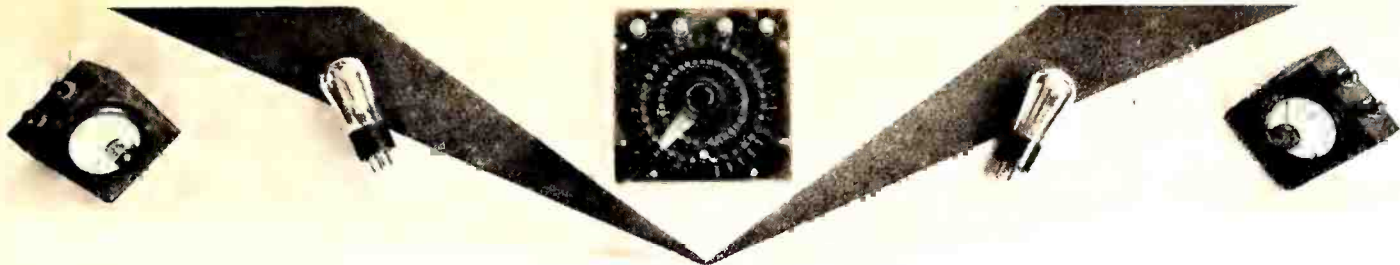
Unusual facilities for furnishing transformers with or without cases ready for mounting and quick assembly with the receiver. Prices on application.



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(For manufacturers) I am interested in engineering data regarding your transformers and condensers.

(For set builders) Please send circulars describing your apparatus and latest audio hook-ups. I inclose 10c to cover cost of mailing.



STRAYS FROM THE LABORATORY

A Radio Manual

The second edition of *Sterling's Radio Manual* contains much material that was not in the first edition. It is now a book of nearly 800 pages on theory and practice. It has material not generally available, such as the circuit diagrams and operation data on Western Electric transmitters of the latest type, receivers used for ship-to-shore traffic, and much other practical matter of interest and value to radio operators, engineers, servicemen, and others who want descriptions and other data on modern radio equipment. Airplane apparatus, beacons, automatic SOS transmitters, the International Laws relating to radio communication, the "Q" signals, tables of LC products, conversion tables of wavelength and frequency—all are in this big book with the soft covers. It is published by Van Nostrand and was edited by Robert S. Kruse.

Causes of A.C. Hum

The following statements are digested from an article in the *General Electric Review*, "The Operation of Radio Receiving Tube Filaments on Alternating Current," by Dr. K. H. Kingdon and H. M. Mott-Smith, Jr.

Hum due to operating a tube filament on a.c. comes from three sources,

1. a fluctuating potential drop along the filament.
2. a fluctuating magnetic field about the filament,
3. fluctuations in filament temperature.

Hum due the first cause is of two kinds, one having a frequency equal to the frequency of the supply voltage, and the other having a frequency twice that of the supply, e.g., for a 60-cycle supply, 60 and 120 cycles. The first can be balanced out by returning the grid and plate circuits to the proper place along the filament by means of a variable center-tapped resistor. The amplitude of the fundamental frequency hum is proportional to the ratios between the maximum value of the filament voltage and the approximate "lumped voltage" on the plate, while the second harmonic is proportional to the square of this value. Since this ratio is small, it is important to balance out the fundamental component of the hum.

A tube adjusted to minimum hum when the supply is sinusoidal will not be balanced if the supply contains even harmonics, although it will be in balance for odd harmonics in the supply. If the double-frequency component has been reduced—by proper construction and operation of the tube—to one tenth some given value, the introduction of a second harmonic of an amplitude of five

per cent. of the fundamental supply will cause an increase in the hum of 100 per cent. If the filament transformer also supplies power to a plate-supply unit variations in the load on the rectifier may cause considerable corresponding variations in the amplitude of the hum.

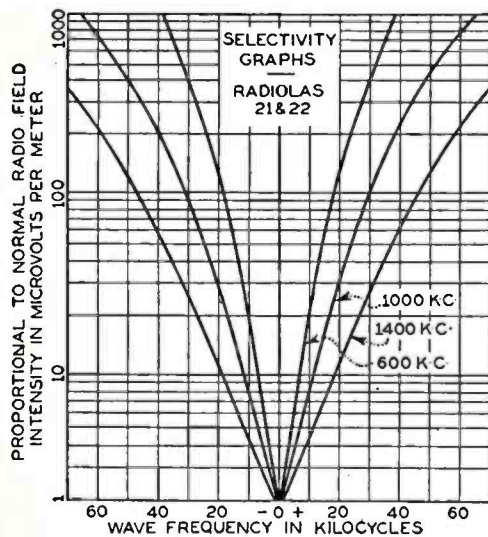


Fig. 1

It happens, fortuitously, that the hum due the magnetic field is opposite in phase to the hum due the first cause, and so a tube can be constructed and operated so that these effects partially balance out.

The third source of hum occurs only when the plate current is appreciable compared to the filament current, for example, if a 199-type tube with a 60-milliamper filament is operated from an a.c. supply.

Calculations show that for a 226-type tube operated with a plate potential of 135 volts, the magnetic and potential ripple voltages will cancel out when the grid bias is minus 11.8 volts. However, in practice the hum voltage is of the order of 7 millivolts across a 26,000-ohm load.

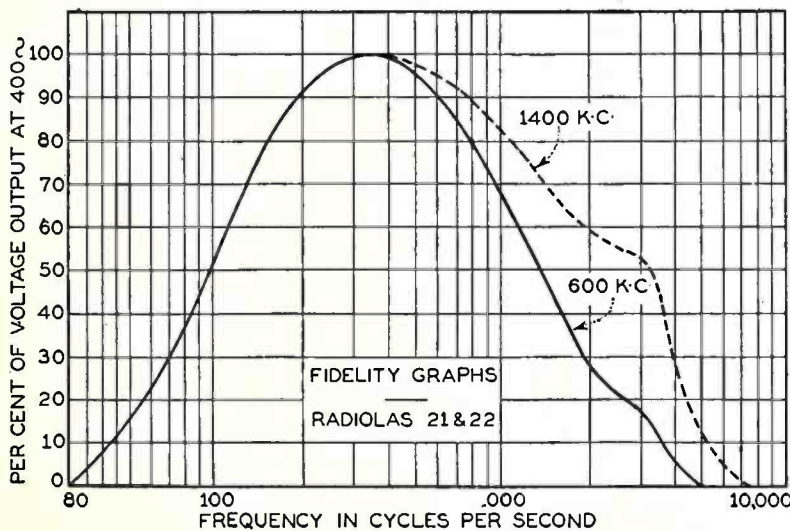


Fig. 2

The Radiola 21

In January, 1930, RADIO BROADCAST there appeared a description of the Radiola 21 and 22 battery-operated radio sets designed for the farm market. Figs. 1 and 2 on this page show the important characteristics of these sets; the selectivity at standard radio frequencies, 600, 1000, and 1400 kc; and the fidelity of response at two radio frequencies, 600 and 1400 kc.

The Radiola 21 is a table model, uses 5 tubes, and costs \$69.50; the Radiola 22 is a console model using the same equipment plus a Radiola 100B loud speaker. It sells for \$135.00.

All About Electricity

An excellent series of articles on the nature of electricity, originally published in *Power Plant Engineering* in 1928 and 1929 by Andrew W. Kramer, editor of that magazine, has been collected into book form under the title of *Electricity, What It Is and How It Acts*. In a small volume the author seems to have collected more material than ordinarily goes into a book of double its size. It is most readable by those who think they know what it is all about and by those who admit they don't know much about electricity. In other words, it is a book that tells you all about electricity, whether you are a power engineer or a tyro in the field of communication. The illustrations are excellent and quite frequently are of the simple and graphic form that many serious writers seem afraid to use. We recommend the book highly. The publishers are Technical Publishing Company, 53 West Jackson Blvd., Chicago.

Wire Communication

A book of interest to those who work with wire communications instead of the more, in the popular mind, "wonderful" radio medium is Shea's *Transmission Networks and Wave Filters*. This is the most recent of the already-long series of books known as the *Bell Telephone Laboratories Series*. It deals with the calculation and design of telephone networks and wave filters. In addition mathematics and electrical theory have not been neglected; in fact, a radio man looking at this book will be amazed to learn how simple his own mathematics are compared to what a full-fledged telephone engineer must wrestle with. One entire section of the book (there are three in all) is devoted to transients. Others deal with terminal networks, losses due to impedance mismatching, filters of all types, Fourier series analysis, etc. The book is published by Van Nostrand.



TWO BOOKS FOR ENGINEERS

ELEMENTS OF RADIO COMMUNICATION, by John H. Morecroft, 269 pages, John Wiley & Sons, 1929, \$3.00.

RADIO TELEGRAPHY AND TELEPHONY, by Rudolph L. Duncan and Charles E. Drew, 950 pages, John Wiley & Sons, 1929, \$7.50.

Here are two new volumes, both broadly concerned with radio technology, both issued by the firm of John Wiley & Sons, and both presenting a valid claim for admission to the progressive radio engineer's library, yet differing considerably in their contents and mode of presentation. The difference in contents would follow naturally, of course, from the fact that the two books are issued by the same publisher at about the same time. Another point of similarity is that all the authors are well known as radio educators, although in different fields. Morecroft is professor of electrical engineering at Columbia University, and author of the classic *Principles of Radio Communication*. Duncan is director of the Radio Institute of America, in which Drew occupies the position of instructor in radio.

The Duncan-Drew work is almost as long as Morecroft's *Principles of Radio Communication*. The difference between the two books may be inferred from the statement that a professional radio engineer, if he could secure only one of them, would unhesitatingly choose the *Principles* while a radio serviceman or operator would be likely to pick the work of Duncan and Drew. This is consistent with the object of the authors, and the fields in which they have done their work. Similarly, a student radio engineer would naturally take to Morecroft's *Elements*, although he might also get valuable material out of *Radio Telegraphy and Telephony*. He would find in all of Morecroft's writings a firm, highly evolved theoretical grasp of the type which forms the only reliable basis for practical results in engineering, and less concern with the details of contemporary equipment. The tendency of Duncan and Drew is to present the elements of the subject in much detail and to break down all subjects into easily comprehended fundamentals, and then to leap directly to lengthy apparatus description.

Radio Telegraphy and Telephony starts off with a brief introductory chapter which is rather badly arranged. The following chapters are concerned with the elements of magnetism and electricity, motor-generators, meters, storage batteries, etc. Chapter IX, a comprehensive review of the elements of alternating current theory, is followed by a treatment of "Condensers—Electrostatic Capacity—Capacity Measurements," preparatory to a hundred-page chapter on "Vacuum Tubes" and a 126-page chapter on "Receiving Circuits." Considerable text is devoted after this to alternating current receivers and tubes, and receiving accessories, especially loud speakers. Various commercial types, from the venerable 106-D to modern tube receivers in the communication field, are described at length.

With Chapter XVII the discussion turns to transmitting equipment. High voltage condensers, antennas, the phenomena of resonance, transmitter adjustment, and the characteristics of commercial broadcast and telegraph tube transmitters are considered in turn. Spark transmission is relegated to a place behind short-wave transmission and reception. The arc trans-

mitter and the radio compass have later chapters of their own. The last chapter, XXVI, is concerned with "Radio Telephone Broadcast Transmitter Equipment," although much material on this topic is included previously in Chapter XX ("Commercial Broadcast and Telegraph Transmitters"). An appendix and index complete the text.

The somewhat confusing arrangement of broadcast transmitter material mentioned above is a characteristic fault of Messrs. Duncan and Drew's otherwise meritorious effort. The descriptions are badly arranged in places and give an appearance of imperfect digestion of the material. As a specific instance, the carbon microphone, including the broadcast type, is discussed on pages 610-614 of Chapter XX, while the condenser transmitter is described on pages 719-720 of Chapter XXI and again on page 894 of Chapter XXVI. Figs. 370 and 447A, in separate chapters, show views of condenser transmitters and stands differing only slightly in external design.

The fault of illogical arrangement is not found in the Morecroft text. At times the terminology is open to criticism, as when the author refers, on page 10, to "distorted waves," when he means complex or non-sinusoidal waves. Otherwise the book sustains throughout the impression of mature reflection on the author's part. The first three chapters present the underlying laws governing the behavior of audio- and radio-frequency circuits and the principles of radiation. "The Vacuum Tube and Its Uses" is the title of Chapter IV. Then follow chapters on radio telegraphy and radio telephony, and a final chapter, VII, on "Receiving Sets." Pages 257-266 contain, in small type, problems arranged by chapters. The index is somewhat brief.

Morecroft's *Elements of Radio Communication* contains no plethora of material, but at every turn Morecroft's wide physical knowledge is exhibited, to the profit of the student and even the experienced engineer. Such points as the calculation of the capacity of the earth on page 35, the fine range of comparative data in the discussion of "What Is a Good Vacuum?" on page 104, and the illustration, beginning on page 248, of how ordinary alternating current equations may be used to solve simple filter problems, are examples of this invaluable trait.

—CARL DREHER.

SERVICE MATHEMATICS

MATHEMATICS OF RADIO, by John F. Rider. Published by the Radio Treatise Company, New York. Price: \$2.00.

John F. Rider has promised a manual for servicemen for some time. It develops that there are to be two books. The first book contains the *Mathematics of Radio*; such is its title, and it has in it tables, formulas, and examples of radio circuits galore. The book tells how to solve all types of radio problems involving the three graces of radio, resistance, inductance, and capacity. It deals with power circuits, filament circuits, iron-core chokes, power amplifiers, screen-grid tube circuits, etc.

When a serviceman can work all the examples the author gives in this 127-page book, he can make up a few for himself, and be assured that he has a pretty good working knowledge of radio circuits. There is no better way to learn radio than by solving radio problems. It is a much

less expensive pastime than playing in a laboratory with sensitive meters and other apparatus that will burn or wear out.

The second volume of the *Service Man's Manual*, of which this book is the first, deals with commercial circuits and, according to the author, uses circuit diagrams of popular receivers and power equipment as the background of its work.

—KEITH HENNEY.

A THRILLING NARRATIVE

INTERNATIONAL ASPECTS OF ELECTRICAL COMMUNICATIONS IN THE PACIFIC AREA. By Leslie Bennett Tribolet, Ph.D. The Johns Hopkins Press. 282 pages. Price: \$2.50.

That a volume with this unpromising title should prove to be a thrilling narrative of cunning and intrigue was a surprise to the reviewer confronted with this assignment. The volume reviews the half-century of secret agreements and manoeuvrings which have hampered the establishment of American communications in the Pacific. Decentralized American interests, unsupported by a definite government policy, have faced foreign governments and hostile commercial interests with far-sighted plans, so far quite successfully carried out, to control trans-Pacific communications. Only the recent success of the Radio Corporation of America in establishing direct radio communication with Japan and the Philippines has bettered the American position. In contrast to the struggle on the Pacific, the eminently successful disposition of a four-corner competitive struggle of European and American enterprises in South America demonstrates how successfully unified international action has coped with an equally difficult situation.

The recent testimony before the Senate Interstate Commerce Committee considering the Couzens Bill, is ably supported by the experiences reported in this authoritative volume. The necessity for unified American policy in foreign international communications interests is so markedly brought out that any serious reader of this volume would regard as a misfortune any attempt to continue a competitive situation. The support which certain foreign governments give their commercial interests engaged in extension of international communication is an amazing contrast to the treatment accorded by our own Government to those active in this field. Experience has proved that the only reliable safeguard to uninterrupted international communication is the extension of American-owned cables and radio systems, working in coordinated and non-competitive harmony, aided and supported by an alert and forceful government policy.

—EDGAR H. FELIX.

PRACTICAL DATA ON TUBES

RADIO RECEIVING TUBES (Including Applications for Distant Control of Industrial Processes and Precipitation Measurements) by James A. Moyer and John F. Wostrel. McGraw-Hill Book Company, New York. 297 pages, \$2.50. 1929.

The partnership of Moyer and Wostrel is responsible for *Practical Radio* and *Practical Radio Construction and Repairing*, from the press of the same publishers. These books have been previously reviewed in RADIO BROADCAST. *Radio Re-*

(Continued on page 233)

Now D-C Tubes

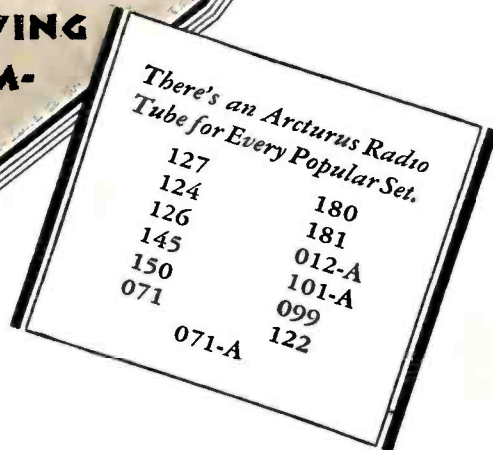
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AND 2 NEW A-C TUBES GIVING
ARCTURUS DEALERS A COM-
PLETE LINE OF TUBES
FOR EVERY SET



PROVED PERFORMANCE

Demonstrate Arcturus' quick action, clear tone and long life... there will be no question which tube your customers will buy.



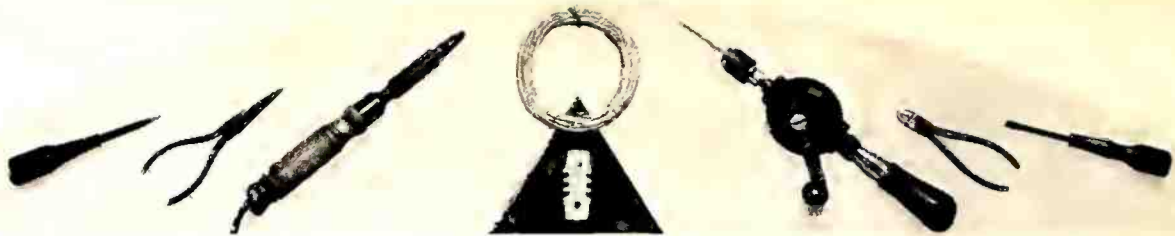
YOU know what the name Arcturus means on an A-C tube. Quick action, clear tone, long life. This kind of service has made Arcturus Tubes famous throughout the radio industry... a symbol of dependable tube performance wherever A-C sets are made, used or sold... Now we offer Arcturus *Direct Current* tubes, built to the same high standards that made possible Arcturus' A-C superiority. In addition, 2 *new* A-C tubes have been added to the Arcturus line, giving dealers complete Arcturus equipment for any popular radio set... Thousands of Arcturus dealers know that Arcturus A-C quality has helped them increase their set and tube sales. Now, with a complete line of Arcturus Tubes for D-C and A-C sets, Arcturus offers better profit possibilities than ever before. Your business, too, can benefit by Arcturus' *proved performance*. Stock and sell the entire Arcturus line.



ARCTURUS RADIO TUBE COMPANY
Newark, New Jersey

ARCTURUS

LONG LIFE
RADIO TUBES



THE SERVICEMAN'S CORNER

Points on the Victor

Hum Potentiometer: "A Victor 32 operated satisfactory if the hum control in the R. P. A. unit was not adjusted to balance out the hum perfectly. Operation ceased when the hum was perfectly balanced out. The contact arm was deformed in such a manner as to permit it to make contact with the resistor strip at all points except at the exact center where the hum should have been negligible. As this resistor is the means of providing the grid return to the first a.f. tube, an open effectively disables the unit."

R. L. MINOR, O. K. Houck Piano Co., Little Rock, Ark.

NO PLATE VOLTAGE

"I had a Victor 'Micro-etc' with no plate voltage on the 226's. All the dope in the service notes and the diagram didn't help a lot.

"Another set was torn down to obtain actual values of resistors and other parts. This didn't do much good either and we went into a huddle with the circuit. Hey! Where's that other choke the service notes don't mention? It's the loud speaker! Absolutely right the first time. Another loud speaker did the trick.

"Another Victor oddity that will give a bad five minutes is two wire-wound volume controls ganged to one shaft. Maybe they are tracking together and then again—well look 'em over if volume seems spotty."

P. E. ROBINSON, Augusta, Me.

MECHANICAL HINTS

ARTHUR E. STARKWEATHER, of Starkweather Radio, dealer in Brunswick, Fada and Philco, of Chatham, Mass., still finds time to service Victors. He remarks:

"Just a word to servicemen who might be called to service Victor 'Combs.'

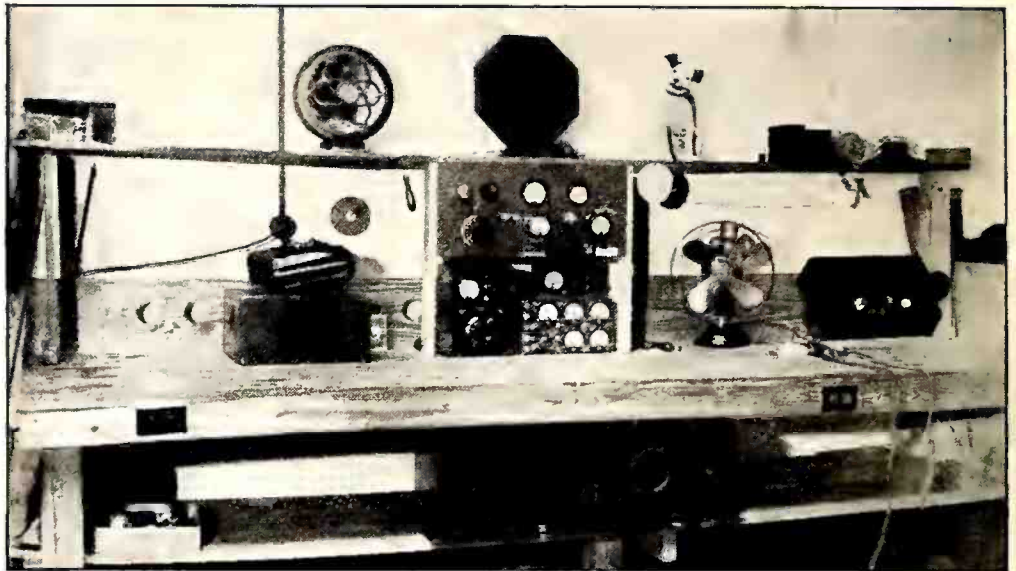
"First: I want to say that it is not necessary to remove the tuning knobs or a.c. switch from panel to remove the set chassis as the panel pulls back with the chassis when the two wood strips are removed from in back.

"Second: Sometimes the tuning knob will only cover either the higher or the lower range of the dial and then will stick about one third the way across. This may be corrected by removing the tuning knob, taking a pair of heavy pliers and giving the tuning shaft a slight pull. This will allow the groove on the tuning shaft to snap into place on the tuning raceway."

Short Cuts to Neutralization

Balancing The Majestic Chassis: "I often run across a Majestic chassis that is very obstinate to balance. This is the way I go about it.

"First remove shield housing over the condenser gang. Remove all trimmer adjusting screws, and, with a pair of long-nosed pliers buckle the trimmer plate in the middle so that when the trimmer screws are replaced the center of the plate will come about $\frac{1}{4}$ inch away from its other plate. Proceed to balance set in usual manner with oscillator and resonance indicator,



R. L. Minor, of the radio service department of O. K. Houck Piano Co., Little Rock, Ark., sends this photo of his laboratory with his contribution.

and by taking out the r.f. tubes stage by stage it is very easy to peak each stage.

"I have found this method to be very effective and it results in a highly efficient receiver."

H. A. GRATIX, Electric Service Laboratory, South Portland, Me.

RAPID NEUTRALIZATION

YERN PETERS, radio technician of Havre, Montana, contributes the following generalities on the technique of rapid neutralization:

"Most servicemen possess a diagnoser similar to the Weston Model 537. A set analyzer of this type may be used for neutralization, and for the lining up of condensers in a single-dial set. This is accomplished by using the tester as a

vacuum-tube voltmeter in the first a.f. or the output stage.

"The lead to the grid connection on the analyzer is broken, two leads are brought out, and clips are put on the end of them. By clipping the two leads together the tester may be used in the ordinary manner. On the Weston 537 the green wire is the grid lead.

"To use the tester as a vacuum-tube voltmeter, the leads brought out are connected to a C battery to place an additional bias on the tube so that it will act as a detector. On the 171A and the 245 tube I find $19\frac{1}{2}$ volts the proper additional C voltage required when they are used in push pull, and $22\frac{1}{2}$ volts when they are used singly. When the measurement is taken in the first a.f. stage $4\frac{1}{2}$ volts negative additional is satisfactory. Care should be taken not to overload the tube from which the reading is being taken. The plug from the set analyzer is inserted in the first or second a.f. socket and the switch on the tester is set to measure plate current. The tube is put into the socket on the tester.

"A modulated oscillator is necessary to furnish a signal. To line up sets with compensating condensers it is only necessary to adjust for the highest reading on the plate milliammeter. For neutralizing the conventional dummy tube and lowest reading method is employed. For accurate results use the lowest scale possible on the plate meter."

SPARTON SETS

"The Sparton models 62, 63 and AC7 which were built about two years ago, have a radio-frequency amplifier system which is so much different from the general run of T. R. F. sets, that a serviceman must understand the principles of its operation before he can successfully resonate the tuned circuits or neutralize the set.

"I have seen a serviceman work steadily for three hours with an oscillator trying

(Continued on page 228)

In the Department this month we publish a short article describing how an alarm clock can be used to turn a receiver on and off automatically.

This clock device is an elementary remote-control proposition. The problems of remote control should be cropping up in the serviceman's routine more and more consistently this radio season. In their more simple ramifications, remote-control jobs include turning a receiver on and off from different rooms, and adjusting volume, generally with two or more loud speakers operated simultaneously or singly from one receiver. The more complicated problems involve remote tuning.

We solicit contributions from servicemen whose efforts have been applied in this direction.

—THE EDITOR.

SM

How Somers Sells Satisfaction in Custom Receivers

F. B. SOMERS, General Merchandise
Saginaw, Michigan

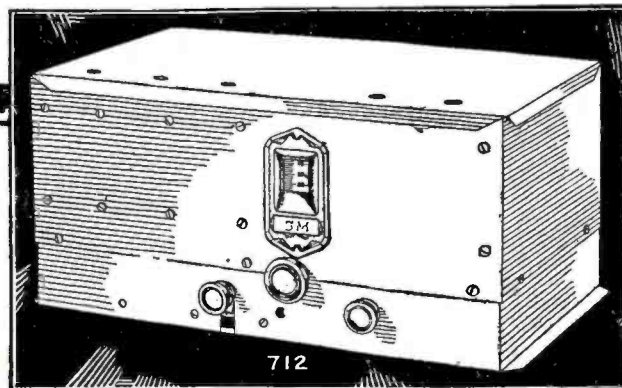
Silver-Marshall, Inc., Chicago

A short time ago I built a set for a man who wanted "something good." From my experience with S-M kits I ordered the complete outfit, 712 tuner, 677 amplifier, and the 851 speaker.

I just delivered the set and I think I have "hung up" something for the "other fellow" to shoot at. At night I could register a station on every frequency in the broadcast band. Between nine and ten in the morning I tuned in WGY, WFAF, WCCO, WOC, KTNT, KMBC, WFAA, and WBAP. The last named is a little more than 1100 miles air line from Saginaw. This did not "just happen," as I repeated it several times and you could not tell the distant station from the nearer one by the volume.

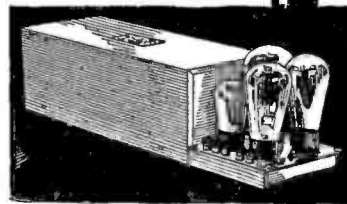
I have built, remodeled and repaired hundreds of radios, including ten-tube supers, and this 712 is the first one to give me a real thrill. I am going to build one for myself now.—F. B. Somers.

The all-electric S-M 712 Tuner, with band-filter and power detector, stands far beyond competition regardless of price. It uses 3—'24 tubes and 1—'27. Price only \$64.90, wired, less tubes, in shielding cabinet shown. Component parts total \$40.90.



712

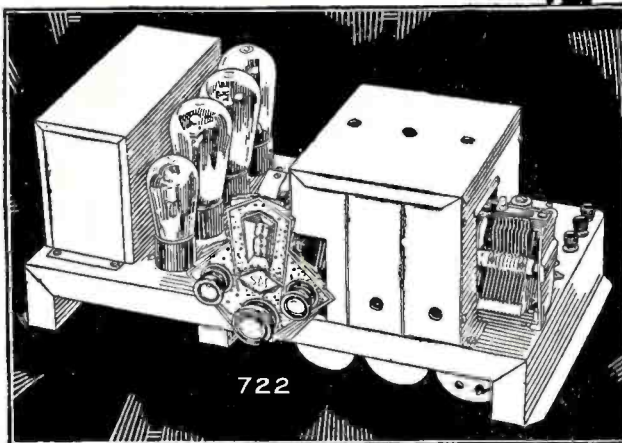
The new S-M 677 forms a perfect power supply, as well as an audio amplifier of appropriate superior quality, for use with the 712, or for records. Special input transformer has high ratio, ideal for phonograph pickup. Tubes required: 1—'27, 2—'45, 1—'80. Power comes from any 105 to 120 volt, 60 to 50 cycle source. Wired complete, less tubes \$58.50. Component parts total \$43.40. (For 25-40 cycle current S-M 67725 costs \$72.50 wired.)



S-M 722 and 735 Show Marvelous Performance at Surprisingly Low Cost

The first complete a.c.-operated short-wave receiver is the new S-M 735, which costs, wired complete with built-in ABC power unit, less tubes, only \$64.90. Tubes required: 1—'24, 2—'27, 2—'45, 1—'80. Component parts total \$44.90. 735DC, for battery use, is also described completely in the new S-M catalog—see coupon.

Broadcast reception approaching wonderfully close to the 712's magnificent standard can now be had in the S-M 722 (using 3—'24 tubes, 1—'27, 2—'45, 1—'80) at only \$74.75 net, complete with ABC power unit, less tubes.



722

The handsome 707 table cabinet, finished in rich crystalline brown and gold, suitable for 722, 735, or 735DC, is only \$7.75.

If you are reading S-M's publication, the **RADIOBUILDER**, you're months ahead in your knowledge of what is going on in the S-M laboratories. Fill in the coupon NOW!

Custom builders have profited immensely through the Authorized S-M Service Station franchise. If you build professionally, write us.

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6403 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

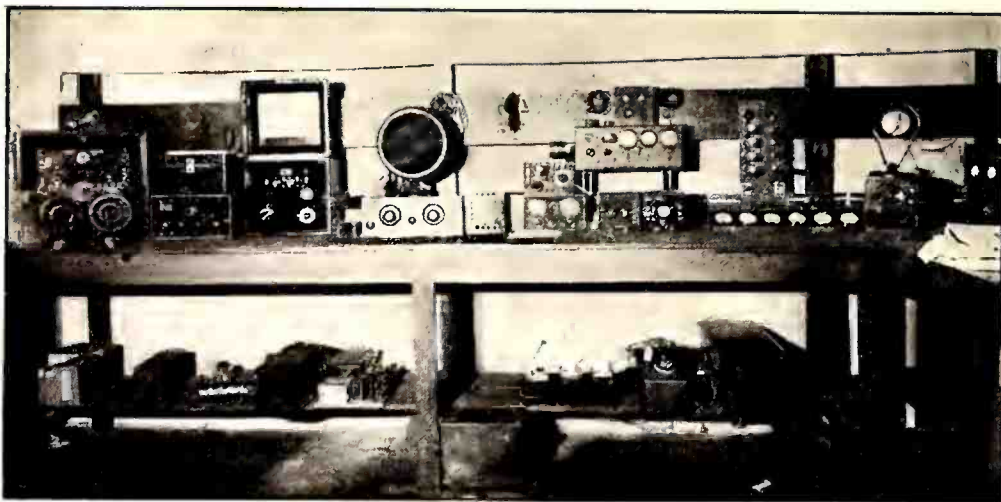
..... \$1.00 Next 25 issues of The Radiobuilder.

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. 678FD Phonograph-Radio Amplifier
- No. 10. 720AC All-Electric Screen-Grid Six
- 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

Name

Address



A new view of the Clarke Laboratories, Danville, Va.

(Continued from page 226)

to neutralize one of these sets, and, although he was able to balance out the oscillations in each stage, still the set would go into oscillation on certain parts of the band.

"Looking at the set from the bottom, a brass plate will be seen under three of the tuning condensers. This plate is insulated from the frame of the condenser by a very thin square of bakelite. On the side of each tuning condenser is a small leaf similar to a book-type condenser, which is adjustable. At first glance the serviceman will put these down as trimmer condensers, and here is where the big surprise comes in. Of the four tuning condensers equipped in this way, only one of them is connected as a trimmer condenser, and that one is in the detector input. On the other three, the brass plate under the tuning condenser is connected to the movable leaf, and this constitutes a variable radio-frequency bypass condenser to the filament.

"By choking off the r.f. currents from the C-bias lead, and providing a variable bypass to the filament, the engineers of this clever system have incorporated a lossier adjustment, which is necessary in conjunction with neutralizing, to prevent oscillations. This is probably necessary due to the fact that the set is unshielded, and although neutralizing will prevent coupling due to tube capacities, this still leaves the coupling due to coil feedback and circuit capacities.

"However, the main point of interest is how to adjust this system for maximum sensitivity, selectivity, and freedom from oscillations. Fortunately, the largest part of the job is the understanding of what goes on in the circuit. My method is to neutralize the set first. If it oscillates after this is done, I then loosen all the condenser plates very slightly, or until oscillation stops. Unfortunately these little by-pass condensers do act as trimmers at the same time, and this fact must be kept in mind. So if it were necessary to stop oscillation by loosening these condensers, and at the same time the circuits went out of resonance, I would re-resonate the circuits by continuing to loosen one or two of the condensers, as needed, until selectivity is regained. Then the circuit is reneutralized with the oscillator, and the job is done. If at first, after neutralizing the set, I find, instead of a tendency to oscillate, that the set lacks pickup and selectivity, I introduce more radio-frequency gain by tightening all the condensers a little. Care must be taken to keep the circuits in resonance at the same time. The adjustment is right when the set hisses slightly as it is tuned into a carrier wave, and tunes sharply. I finish by neutralizing again, and make a final check on the

resonance, by pushing slightly with a screw driver on the tuning condenser end plates.

"I have found that most of these sets can be tremendously improved by the intelligent use of these adjustments, and the customers are delighted in every case."
A. H. GOUD, So. Portland, Me.

An Automatic Switch

Try suggesting to some of your customers the utility and convenience of having their sets turned on or off automatically at a predetermined time. Your service editor finds it quite in accord with his general indolence to roll into bed at ten P. M., listen to the slumber music waft in from the living room, with the serene knowledge that it will turn itself off at midnight. More ambitious fans may put the device to the perverted use of an alarm clock, substituting setting up exercises for the bell.

VERNON W. PALEN, an engineer with the Telephone Company shows how easy it is to do.

"The clock described in the following paragraphs was constructed because a certain member of my family had the bad habit of falling asleep at night with the radio going. As a result, I found my batteries prematurely exhausted on several occasions.

"The time clock shown in the illustration effectively ended the above evil since it is always set to turn the radio off at some hour after midnight at which time the household is usually fast asleep and most radio programs are 'Off the air.'

"A dollar alarm clock furnishes the backbone of the mechanism. The clock is mounted in a small wooden box which is constructed to fit. A circular piece is cut from the front of the box through which the face of the clock protrudes. The rear of the box is then fitted with the switch mechanism.

"The face of the clock extending through the circular hole of the box helps materially to hold it securely in position. A strip of wood placed across the back of the clock and fastened to the box with screws holds the clock fast. It is convenient to mount the brass contact springs on the strip of wood above mentioned as

will be seen in the illustration, Fig. 1.
"To the alarm winding key, a piece of sheet brass (bent 'U' shaped to give it rigidity) is either soldered or bolted. A wire is connected to each of the two stationary brass contacts and brought out to the radio set and these are used to connect the contacts in series with the A of the set supply or a.c. line. The brass contacts are adjusted so as to touch the brass arm on the alarm key when the key is rotated to wind the clock. The alarm is set in the usual manner and when the alarm sounds, the key rotates the contact arm, breaking the connection with the two stationary brass contacts. It will be noted that the brass arm on the alarm key will strike the side of the box after approximately a half revolution. This stops any further unwinding or ringing. A half turn of the winding key is all that is necessary to reset the switch since it never completely runs down.

"By a slight variation in the contacts, the device can be used to turn the receiver on at a given time.

"I finished the box in black lacquer and by means of the two screw eyes hung it under the edge of my radio table. There it serves conveniently as a safety device for my radio set and as a timepiece for the living room."

In the Service Laboratory

Determining Transformer Ratios: "As a rule there are several power transformers in operating condition laying around the service shop that have been taken from power packs, sets, etc. At a time when one of these transformers would come in handy for replacement on a rush job, the serviceman is often ignorant of its high-voltage characteristics. And as a rule the a.c. voltmeter at hand reads only to 150 volts.

"A quick and easy way to obtain the high-voltage reading is as follows. First measure the line voltage. Connect the secondary leads to the line. (In the case of a full-wave transformer, connect one outside terminal and the center tap.) Take a voltmeter reading across the usual 110-volt primary. The line voltage divided by the voltage across the primary will then give

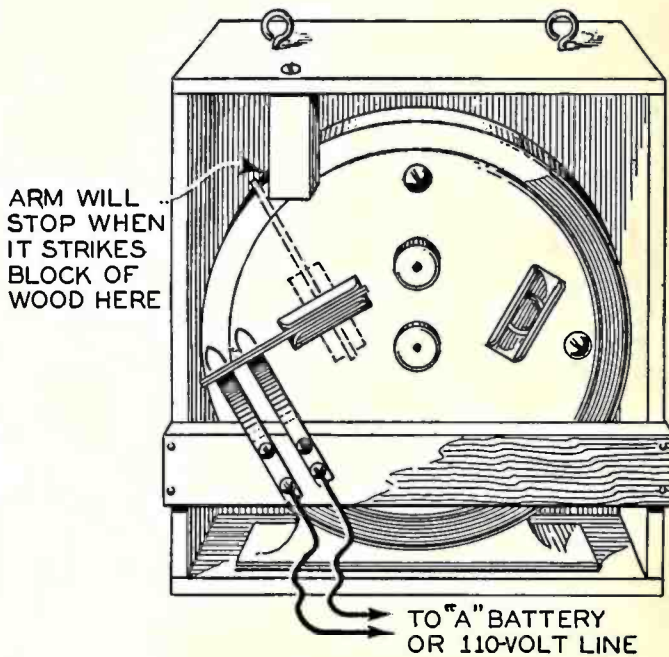


Fig. 1

the ratio of transformation. In other words, if the line voltage is 108 and the voltage across the primary is 36, the ratio is 3 to 1 and the transformer, when connected properly, will give 324 volts on the high side (108 volts times 3).

"The same method may be utilized to ascertain the ratio of an unmarked a.f. transformer. Connect line across the secondary and read the voltage across primary.

"It is always good policy to test for short circuit or grounding before proceeding."

JOHN H. STEURER, E. E., Rockville Centre, N. Y.

A NON-METALLIC SCREW DRIVER

The serviceman will often find use for a non-metallic screw driver, particularly in adjusting and aligning tuning condensers. E. G. CORTON, manager of the Quick Radio

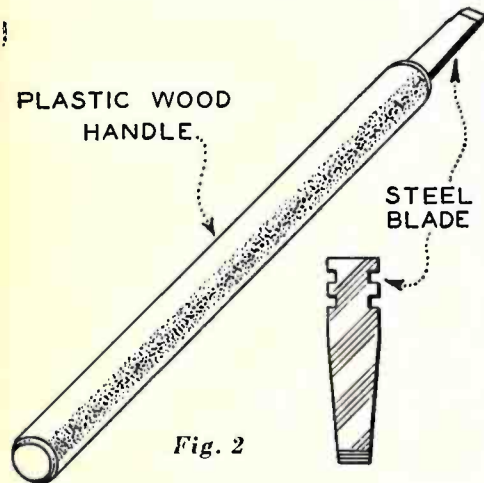


Fig. 2

Service, of Norman, Oklahoma, suggests molding a handle of plastic wood and inserting a thin piece of steel in one end before the wood sets. The idea is sketched in Fig. 2.

SIMPLE TEST PRODS

"In making test prods I take two six-inch pieces of bus wire, round or square, solder same to the desired length of Belden Colorubber wire, and then slip a length of spaghetti over the bus. Cut the spaghetti so as to expose about an eighth of an inch of bus wire and, of course, long enough to cover the remainder of the bus wire and the soldered joint. Fasten the spaghetti to the insulation of the test wire with cement or by tying."

H. W. HUDELSON, Radio, Auto Service and Merchandise, Vandalia, Mo.

CALIBRATED CAPACITY METER

R. W. SHELTON, specializing in radio service, of Paducah, Ky., suggests a somewhat unusual addition to the serviceman's test equipment in the way of a simple calibrated capacity meter. The apparatus he describes is effective in measuring capacities between 0.1 and 12 mfd., and should prove most useful in determining the capacities of those filter and by-pass condensers that shed their labels like a duck does water.

"The calculation of capacity may be expressed in the following formula:

$$C = \frac{I \times 1000}{2\pi f E}$$

where C is the capacity in microfarads, I is the current in milliamperes, E is the voltage, and f the frequency in cycles.

"The number 100 readily lends itself to calculations, and, as it is may be obtained easily by dropping the conventional 110-volt house supply through a suitable resistor, 100 volts at 60 cycles will be used in making our measurements.

"The circuit is shown in Fig. 3. The milliammeter and the voltmeter are a.c. instruments having respective ranges of from zero to 500 mA. and from zero to 150 volts. The resistor, R, may be any convenient value that will drop the line voltage to 100 volts. A high-range power Clarostat is ideal for this purpose.

"To measure the value of a condenser, the first step is to ascertain that the con-

(Continued on page 231)



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 De Luxe 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
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AmerTran Power Transformer Type PF245A
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Transformer builders for over 29 years

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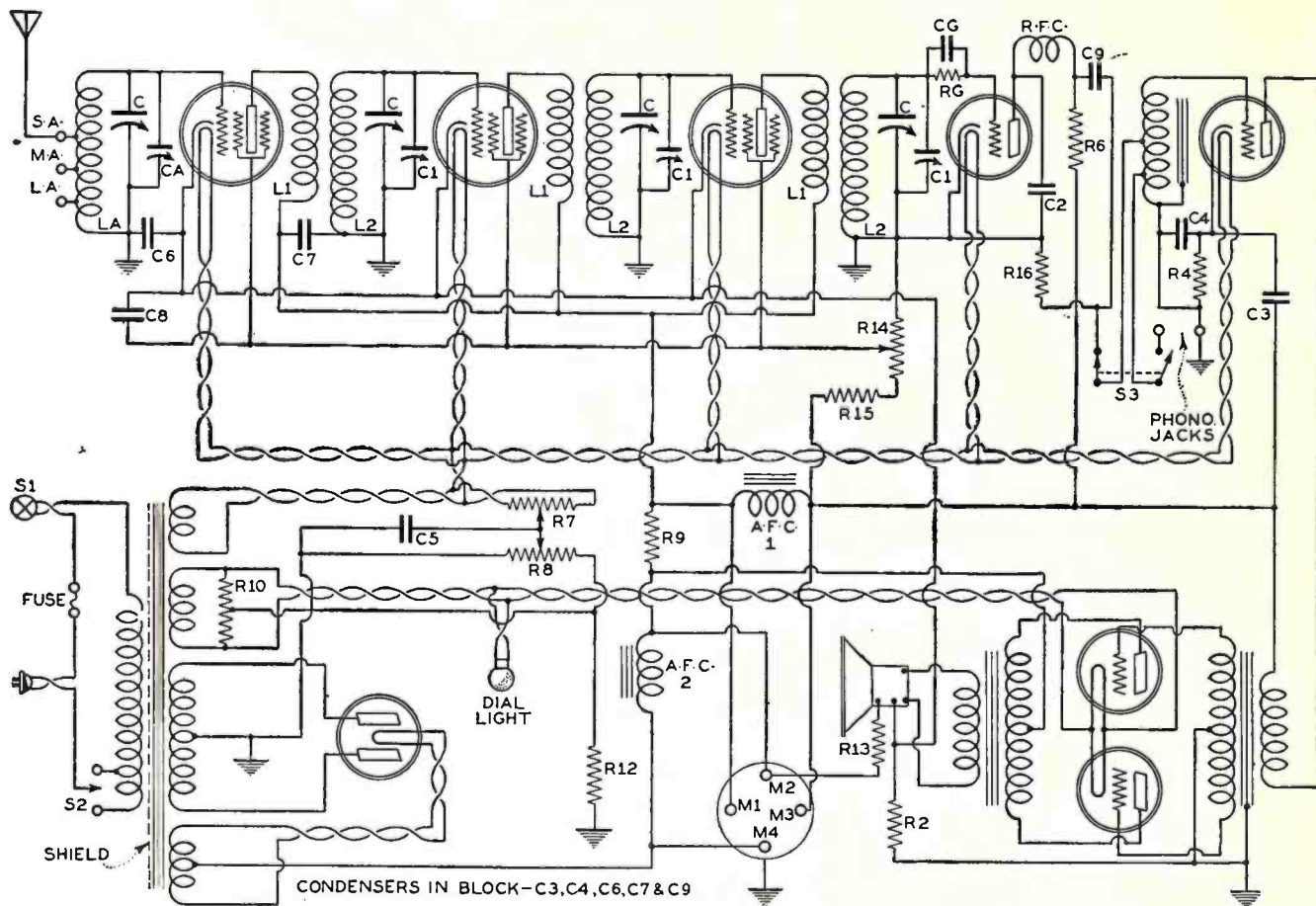
Please send me the following Bulletins (Check (✓) those you want).
Bulletin 1084 () ; 1087 () ; 1088 () ; 1076-A () ; 1075-A () ; 1065 () .

Name.....

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

THE AMRAD MODEL 81 RECEIVER



IN THESE notes on the Amrad Model 81 receiver we have two purposes, first to give a general description of the receiver and secondly to bring to the attention of readers the excellent service manual which has been prepared by the Amrad Company on this set. The manual contains some ninety pages which give valuable data on the importance of service and an excellent description of the engineering basis for the design of the Model 81. It is supplied in a leather binder and can be obtained for \$1.50 by writing directly to the Amrad Corporation. The following notes on the Model 81 have been obtained from the manual.

Three Screen-Grid Stages

The Model 81 receiver is designed to use three screen-grid tubes as radio-frequency amplifiers in special circuits of such characteristic as to match the operating characteristics of the screen-grid tube. In this way a design is obtained which gives the receiver a uniform sensitivity over the entire broadcast band, the gain actually varying less than ten per cent. The r.f. transformers are wound with a large number of turns on the primary, the winding being placed at the top end of the secondary. This type of primary does two things; first it gives higher amplification at 500 meters than at 200 meters, and secondly it changes the relation of the feedback due to capacity between leads so that oscillations are prevented by such couplings rather than assisted as is the case with ordinary radio-frequency transformers. The amplification per stage varies from 30 at 500 meters to 16 at 200 meters. This change in amplification is just the reverse of that obtained in the antenna stage, the result being uniform sensitivity. The overall gain up to the detector measures 23,000 at 500 meters, 28,000 at 300 meters, and 20,000 at 200 meters.

The Detector Circuit

A grid leak-condenser detector is used because a large number of tests by the engineering department of the Corporation indicated that its advantages more than offset its disadvantages. Some of the advantages which are obtained through the use of a grid leak-condenser detector are:

- A. Greater sensitivity
- B. Does not cause detector tube overloading provided sufficient a.f. amplification is used in order to make the output power tubes overload first.
- C. Has no appreciable effect on the fidelity as the selectivity of the r.f. tuning circuit starts to cut off high

audio frequencies before the grid leak-condenser detector starts to cut them off.

- D. The greater sensitivity of the circuit permits supplying the power tubes with maximum a.f. voltage without the possibility of overloading last r.f. amplifier tube.

The A. F. Circuits

Two stages of audio-frequency amplification are employed. Between the detector and first a f. stage a special coupling system is used, the detector being shunt fed through a 100,000-ohm resistor, a tapped impedance being used in the grid circuit of the first a.f. amplifier tube and an 0.5-mfd. condenser functioning to couple the detector to the first a.f. tube. An r.f. choke and by-pass condenser are connected in the plate circuit of the detector to keep all audio-frequency currents out of the r.f. amplifier. The various audio-frequency components used in the set are

designed to give uniform amplification. This receiver has sixty-two per cent. as much output at 60 cycles, and twenty-five per cent. as much output at 4000 cycles, as at 400 cycles. The lower output at 4000 cycles is largely compensated by a rising frequency characteristic in the loud speaker used.

Volume Control

Volume control is obtained by varying the positive voltage supplied to the screen grids of the r.f. amplifier tubes. Reducing the voltage, of course, reduces the gain and thereby lowers the volume. The resistance unit used is of the graphite type which does not corrode and cause noisy operation.

In the receiver circuit two hum adjusting potentiometers are provided. The first potentiometer permits the adjustment of the amount of positive bias applied to the heater and the other provides a mid-point connection to the heaters.

READING WITH A SUPREME RADIO DIAGNOMETER

Type Tube	Tube Position	"A" Volts	"B" Volts	"C" Volts	Nor'l mA.	Screen-Grid Volts
224	1 R.F.	2.25	180	1.5	4.0	80
224	2 R.F.	2.25	180	1.5	4.0	80
224	3 R.F.	2.25	180	1.5	4.0	80
227	Det.	2.25	30	0	1.5	
227	1 A.F.	2.25	160	10.5	4.1	
245	2 A.F.	2.25	250	50.0	28.0	
245	P. P.	2.25	250	50.0	28.0	
280	Rect.	4.65			110.0	

Line voltage = 120. Set on 120-volt tap. Volume control in full-on position. Note: Hum-control potentiometer turned to ground side.

READINGS WITH JEWELL SET ANALYZER MODEL 198

Readings with Plug in Socket of Set and Tube in Tester

Type of Tube	Position of Tube	Tube Out Volts	A Volts	B Volts	C Volts	Cathode-Heater Volts	Normal Plate mA.	Plate mA. Grid Test	Plate Change mA.	Screen Grid Volts
224	1 R.F.	2.32	190	2.25	180	1.5	4.0	7.5	3.5	80
224	2 R.F.	2.32	190	2.25	180	1.5	4.0	7.5	3.5	80
224	3 R.F.	2.32	190	2.25	180	1.5	4.0	7.5	3.5	80
227	Det.	2.32	140	2.25	30	0	1.5	1.6	0.1	
227	1 A.F.	2.32	190	2.25	160	10.5	4.1	5.2	1.1	
245	2 A.F.	2.32	300	2.25	250	50.0	28.0	32.0	0.4	
245	2 A.F.	2.32	300	2.25	250	50.0	28.0	32.0	0.4	
280	Rect.			4.65			110.0			

Line Voltage = 120. Set on 120 Volt Tap. Volume control in full-on position. Note: To get the 10.5 V reading (4-8) the hum-control potentiometer must be turned to ground side.

(Continued from page 229)

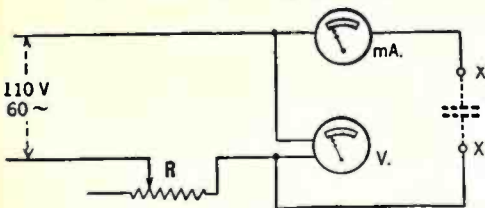


Fig. 3

denser is not shorted, by testing with d.c. and a high-resistance voltmeter. The condenser is then connected at the points marked "X" in Fig. 3, and the potential is adjusted to 100 volts. The reading on the milliammeter is noted, and the value of the condenser calculated from the formula given above.

"The capacity meter is, of course, easily calibrated, and Fig. 4 shows the calibration for a 100-volt 60-cycle current, the capacities at different current readings being indicated. In calibrating the chart for different voltages or frequencies, it is necessary only to obtain two points and connect them with a straight line, extending the line to the limits of the chart. Intermediate and interpolated values will be indicated correctly on the line.

"It is, of course, possible to measure smaller condenser values by lowering the voltage and using a microammeter. However, for accurate measurements of small values a capacity bridge is preferable."

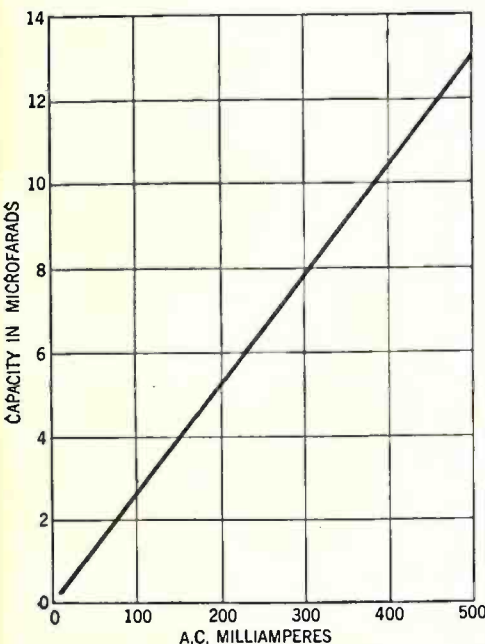


Fig. 4

RESONANCE INDICATOR

"The following arrangement may be readily built up in the average service shop and is most useful in checking the output of receivers and as a resonance indicator in aligning tuning condensers. The circuit is shown in Fig. 5. I use a Jewell 0-1 milliammeter and a fixed carborundum detector.

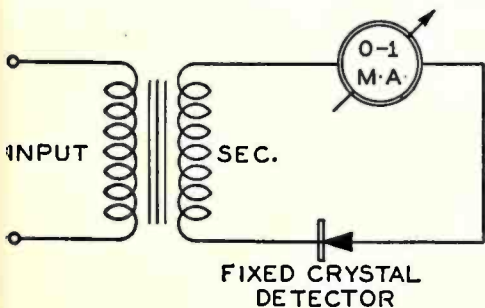


Fig. 5

The ratio of the a.f. transformer is four to one. An oscillator, of course, is used with the indicator for condenser adjustments."

O. E. FAULKNER, N. Little Rock, Ark.
(Continued on page 233)

SOUND REPRODUCTION

SINCE the inception of modern radio amplification the engineering laboratories of Thordarson have developed hundreds of transformers used in solving the problems of sound reproduction.

Standard units include those for coupling a microphone, a phonograph pickup or a radio tuner into any type of audio frequency amplifier.

Other units are available for coupling the output of an amplifier into transmission lines or directly into loud speakers.

Still other units allow coupling from any line into loud speakers or into additional amplifiers.

Your own work may be made easier and more profitable if you make use of Thordarson engineering service as applied to Thordarson transformers, chokes and amplifiers.

Tell us of your requirements and let us submit suggestions for an installation which will add to your good reputation.

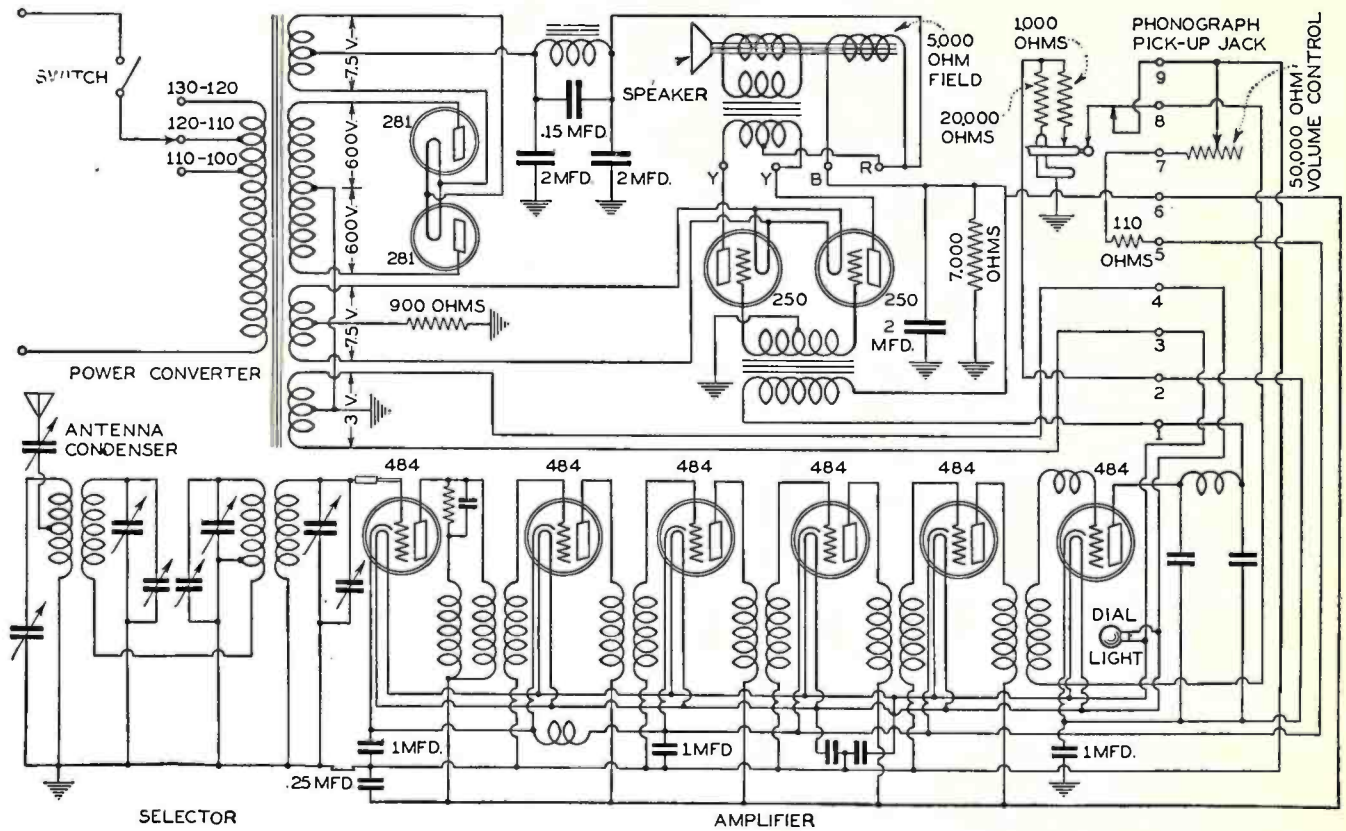
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- Mixing Transformers Coupling Reactors Filter Chokes
- Impedance Matching Transformers
- Speaker Coupling Transformers
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Thordarson Electric Manufacturing Company
Huron, Kingsbury and Larrabee Streets, Chicago, Ill., U. S. A.

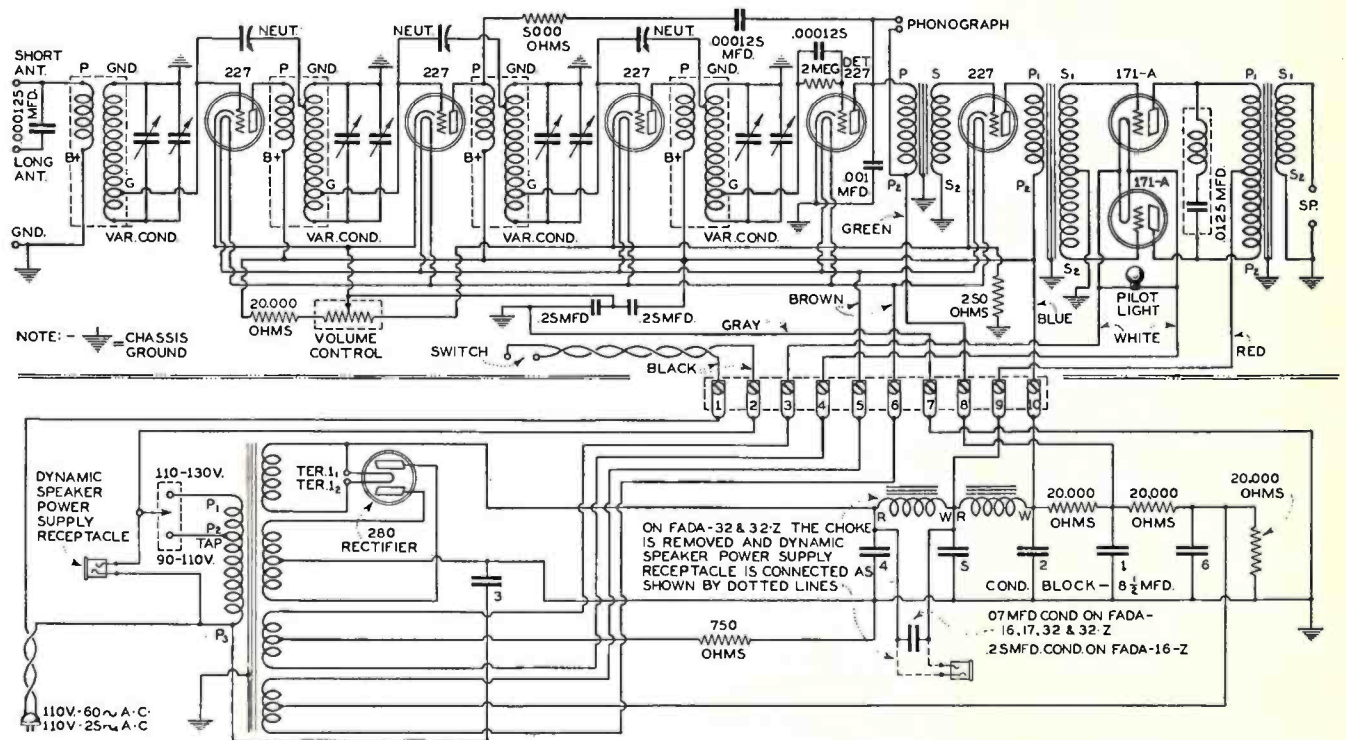
SPARTON MODEL 301 RECEIVER



This receiver uses two 250-type amplifier tubes feeding into an electrodynamic loud speaker. In the filter circuit of the rectifier a tuned circuit consisting of a filter choke coil shunted by an 0.015-mfd. condenser is used. This circuit is tuned to the fundamental frequency of the output of the 280-type rectifier and eliminates practically all of the

ripple voltage. The field winding of the electrodynamic loud speaker constitutes the second filter choke coil. The schematic drawing shows how the untuned radio-frequency transformers are connected in the receiver circuit but it does not accurately indicate their unusual construction.

FADA MODELS 16, 17 AND 32



A three-stage tuned-radio-frequency amplifier is used in this set. It is interesting to note that the input circuits of the r.f. tubes are connected across only part of the tuned circuits. Neutralization is accom-

plished by connecting the neutralizing condenser from the grid of a tube to the secondary of the following r.f. transformer. The volume control is connected across the antenna-ground circuit.

(Continued from page 231)

Items of Interest

An Idea For Live Wires: L. M. Linde, of the Akron Radio Installation Service, contributes one of the brightest ideas that has found its way to the Service desk.

"We have found a successful means of securing more business for our installation department and believe that it can be applied by dealers in other cities.

"Through arrangements with a local public utility we have access to the names and addresses of people who are moving each day, and we solicit the installation of their antennas by sending them a post-card offering to erect an antenna and properly install their sets at a reasonable price.

"In this city of 200,000 there are about fifty families moving each day, and we find that we can get orders from about 10 per cent. of these.

"The cost of soliciting the business is very nominal for we use a government post-card with a printed announcement.

"We find that the income derived from this type of business aids considerably in maintaining our service department, and does not require additional help for the work can usually be done at times convenient to us."

OPPORTUNITIES FOR SERVICEMEN

A recent daily edition of a New York newspaper carried in its regular "Help Wanted" section sixteen advertisements offering positions to radio servicemen. This was not a radio section nor a special radio edition. The lowest salary offered was \$40.00 a week and the highest definitely mentioned was \$60.00. The average salary was \$50.00 per week. About half the jobs were on a straight salary and half on a drawing account and commission basis. Several positions promised rapid advancement to store manager.

The majority of jobs were offered by large concerns requiring servicemen in their radio departments. These were, for

the greater part, music dealers and department stores.

A driver's license was required in nine instances; a preference was indicated for a man with a car in six cases; and an automobile was essential in three jobs.

THE SERVICEMAN'S STATUS

The economic position of the serviceman in the radio industry was reasonably well established by the replies to the questionnaire sent out by the National Radio Institute. The N. R. I. explains the questionnaire as follows:

"On April 18, 1929, the National Radio Institute forwarded a questionnaire to a list of radio dealers doing business in every state. The questionnaire read as follows:

"We are trying to get some information about conditions in the radio business and send this to you as a representative dealer in your community.

"Will you be good enough to write your answers to the questions below and send this back to us in the enclosed stamped addressed envelope?"

"It is not even necessary that you sign your name. It is merely the information we are after and your hearty co-operation will be appreciated."

"A list of 1000 dealers was used and 283 answers were received—all from radio dealers actively engaged in the radio business, and all of whom gave answers to the questions asked. The answers, carefully tabulated, revealed:

"(1) That the 283 dealers employed 975 servicemen or an average of over four men to each dealer.

"(2) 45 dealers out of the 283, 17 per cent., do not have a service department but contract for service through outside organizations."

This is all rather corroborative in a general way of the replies to RADIO BROADCAST's own inquiries to establish the extent to which service departments were self supporting. The results indicate that about seventy per cent. of such departments more than pay their own way.

BOOK REVIEWS

(Continued from page 224)

ceiving Tubes is a practical work of the same nature, containing only enough theory to make the subject comprehensible, and crammed with immediately useful information and allusions to equipment in actual use. The object of such books is to teach radio servicemen, salesmen, operators, etc., the things they require in their daily business, and also to include within the limits of one volume a considerable amount of data useful to design engineers or specialists in other fields.

The historical introduction to *Radio Receiving Tubes* contains, on page 5, a picture of one of the antediluvian De Forest audions at which I gazed, first in glad recognition, then with a vague feeling of uneasiness which I traced back twenty years. This bulbular audion had the filament leads brought out to a standard miniature Edison lamp base, while the grid and plate terminals came out at the other end by means of insulated wires. Moyer and Wostrel, not being of the first generation of radio experimenters, illustrate the tube in an Edison base, filament outlet underneath. In those days, however, the good Doctor's filaments had a habit of sagging unless they were allowed to hang down, so we almost always suspended the tubes from a gooseneck fixture. The point may seem trivial, but I mention it because in 1910 the loss of five dollars through such an oversight was enough to bring most of us amateurs to the brink of suicide.

In the second chapter the authors plunge into constructional details, followed, in Chapter III, by a discussion of fundamental electrical relations, later applied in the chapter on "Vacuum Tube Action." The physics of boiling electrons off a filament is discussed, and such factors as mutual inductance, interelectrode capacity, etc., are considered for two-, three-, and four-element tubes. Reactivation and testing occupy separate chapters. Circuit considerations follow in the sections dealing with vacuum tubes as detectors, amplifiers, and oscillators. The chapter on "Specifications for Vacuum Tubes" contains useful numerical data.

The greater and best part of the last chapter on "Industrial Applications of Vacuum Tubes" is that dealing with telephone applications. The use of tubes in physical measurements, elevator control, electrical prospecting, etc., is also described, but more applications are omitted than included. Indeed, anyone who tried to enumerate and describe all the applications of even small vacuum tubes would have a large order to fill.

An appendix showing symbols generally used, and containing electrical data, with an index following, complete the contents of this text, which should find a ready sale among the numerous engineers, technicians, and semi-technical workers interested in the applications of lower power vacuum tubes.—C. D.

"Here at last is The Book that we of the Radio profession have needed for a long time. It is the best and most complete handbook ever published," says J. H. Bloomenthal, Chief Radio Operator, U. S. S. B. Steamship "East Side,"

THE RADIO-MANUAL

A New Edition

Complete new chapters on aircraft radio equipment; Practical Television and Radiomovies with instructions for building a complete outfit; radio Interference; 100% modulation; latest equipment of the Western Electric Co.; the Marconi Auto-Alarm System; and many other developments of the past year. All this information is added in the new edition and, besides, the entire book has been brought right up to date with much new material. *The Radio Manual* continues to be the one complete and up-to-the-minute handbook covering the entire radio field.



A Handbook for Students Amateurs Operators Inspectors

20 big chapters cover: Elementary Electricity and Magnetism; Motors and Generators; Storage Batteries and Charging Circuits; The Vacuum Tube; Circuits Employed in Vacuum Tube Transmitters; Modulating Systems and 100% Modulation;

Wave-meters; Piezo-Electric Oscillators; Wave Traps; Marine Vacuum Tube Transmitters; Radio Broadcasting Equipment; Arc Transmitters; Spark Transmitters; Commercial Radio Receivers; Marconi Auto-Alarm; Radio Beacons and Direction Finders; Aircraft Radio Equipment; Practical Television and Radiomovies; Eliminating Radio Interference; Radio Laws and Regulations; Handling and Abstracting Traffic.

An immense amount of information never before available including detailed descriptions of standard equipment is presented.

Prepared by Official Examining Officer

The author, G. E. Sterling, is Radio Inspector and Examining Officer, Radio Division, U. S. Dept. of Commerce. The book has been edited in detail by Robert S. Kruse, for five years Technical Editor of QST., the Magazine of the American Radio Relay League. Many other experts assisted them.

Free Examination

The new edition of "The Radio Manual" has just been published. Nearly 900 pages. 369 illustrations. Bound in Flexible Fabrikoid. The coupon brings the volume for free examination. If you do not agree that it is the best Radio book you have seen, return it and owe nothing. If you keep it, send the price of \$6.00 within ten days.

Order on This Coupon

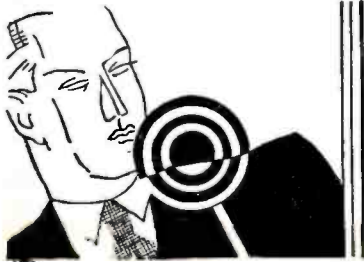
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Send me the Revised edition of THE RADIO MANUAL for examination. Within ten days after receipt I will either return the volume or send you \$6.00, the price in full. (Radio Broadcast 2-30)

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RADIO

RCA-RADIOTRON COMPANY ORGANIZED

New Company Will Take Over the Development and Manufacture of Vacuum Tubes for RCA-Victor Company

Manufacturing, engineering, research, and merchandising of RCA Radiotrons are now centered in a new corporation, a subsidiary of the Radio Corporation of America. It is called the RCA-Radiotron Company, Inc., and is headed by T. W. Frech as president. Mr. Frech was formerly a vice president of General Electric. Ownership of the company, it is reported, will be divided as follows: Radio Corporation of America, 50 per cent., General Electric, 30 per cent., and Westinghouse, 20 per cent.

Radiotron manufacture, it is said, will continue in the same plants as at present. Tubes in the past have been manufactured in various General Electric and Westinghouse plants with a large part of the production concentrated in the Harrison, Newark, and Bloomfield factories. The official announcement follows:

"As a reorganization of a part of the vacuum tube activities of the Radio Corporation of America, General Electric, and Westinghouse, a new company will be formed to be known as the RCA-Radiotron Company, Inc. Beginning with Jan. 1, 1930, the new company will carry on research activities, as well as the engineering, manufacturing, and selling activities in connection with vacuum tubes for use in radio receiving sets in the home entertainment field, now sold by the Radio Corporation of America and manufactured by the General Electric and Westinghouse Companies.

"The new RCA-Radiotron Company, Inc., will continue to receive full benefit, in its field, of the broad research facilities of the General Electric and Westinghouse Companies. The unification of vacuum tube development, manufacture, and sale in the new company will undoubtedly enable it to meet fully and effectively the responsibility of leadership which rests upon the founders of the radio industry in America. It will mean greater flexibility of manufacturing and closer responsiveness to the changing needs of the public and of the merchandising situation. It will make possible added economy in merchandising and manufacturing and will accelerate the commercial development of the great technical advances assured by the closer cooperation of the companies.

"The president of the RCA-Radiotron Company will be T. W. Frech, now a vice president of the General Electric Company."

"The formation of the RCA-Radiotron Company will in no way affect the present or future plans of E. T. Cunningham, Inc.," said George K. Throckmorton, executive vice president of Cunningham to RADIO BROADCAST.

The organization of the subsidiary tube

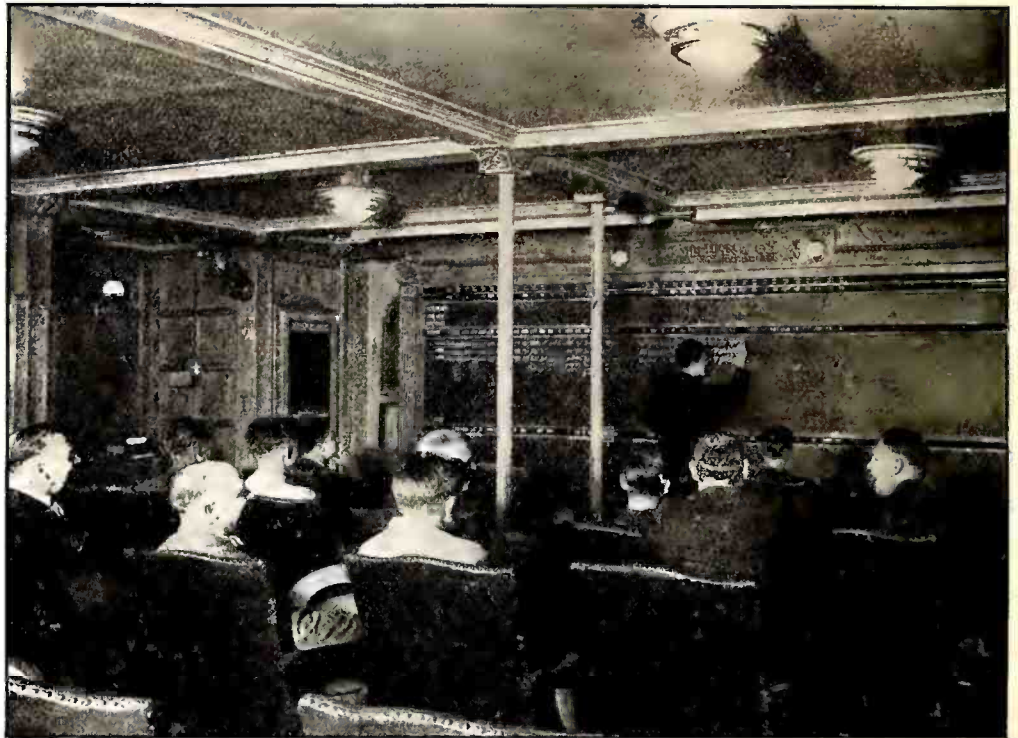


Photo courtesy United States Lines

Every day radio is proving of even greater aid to men in the business world. Now it is possible to cross the Atlantic on the Leviathan and at the same time be in constant contact with the latest financial news and a stock broker. The above picture shows the mid-Atlantic brokerage office of M. J. Meehan & Co., New York City

sales and manufacturing company by RCA follows closely on the organization of the RCA-Victor Company, also a subsidiary of RCA. The latter company will concentrate sales, engineering, research, and manufacturing in the Camden, New Jersey, plant, acquired from the Victor Talking Machine Company on its merger with RCA more than a year ago. Other subsidiaries of RCA, which is now purely a holding company, are: RCA-Communications, Inc. (national and international communication); Radio Marine Corporation (ship to shore communication); RCA-Photophone (sales and service, sound motion pictures); National Broadcasting Company (broadcast stations, network service, artists' bureau), Radio Music Company (including Carl Fisher, Inc., Leo Feist, Inc.). Of the above, RCA Communications and Radio Marine Corporation are wholly owned by RCA. RCA also has forty-nine per cent. stock ownership of the new General Motors Radio Corporation.

Contract for Radio Receptor

A Powerizer sound system will be installed in the United States Veterans' Hospital at Little Rock, Arkansas. The installation will include radio, phonograph pick-up, power amplifiers, loud speaker, and head phones. Centralized receiving sets will deliver programs to a central amplifying system.

Majestic Has Railroad Dept.

A railroad department has been organized under R. L. Maurer of Majestic. Sets are now installed in more than sixty of the nation's finest trains, according to the company. Frank A. Delano is head of the Majestic sales school now in regular session in Room 2500, Stevens Hotel, Chicago. The course lasts five days. Majestic's *Voice of the Air*, a rotogravure news-picture publication for general public distribution, reached a circulation late in 1929 on issue number 11 of 2,500,000 copies.

The 1930 Census

When the 1930 census is completely tabulated there will be definite figures on the number of radio sets in use throughout the United States. This was definitely settled early in December when William M. Stewart, director of the census, announced, among other additional questions, the inclusion of the following question:

No. 4. Radio Set? Yes— No—

Airplane Radio

More than 100 airplanes have been equipped with radio apparatus during the last year according to W. D. Terrell, chief of the Radio Division, Department of Commerce. Permits have been granted to 44 air ports for the installation of radio transmitters.

Q-5

Personal Notes

Stuart Mahanay, formerly radio editor of *The Country Gentleman*, and of the sales department of the Kolster Radio Corporation, is now managing editor of our contemporary, *Radio News*.

R. W. Bennett has recently joined the Trav-Ler Mfg. Corp., St. Louis, Mo., as vice president in charge of sales and advertising. For the past two years he was vice president and general manager of the A-C Dayton Company.

Edward K. Mac Ewan has been appointed secretary of the RCA-Victor Corporation. He was formerly a Victor official. Francis S. Kane (formerly of RCA) is assistant secretary.

Paul W. Morency has resigned as manager of field service of the National Association of Broadcasters to become general manager of the Travelers Broadcasting Service Corporation, owners and operators of station wtrc, Hartford, Conn.

O. F. Jester, formerly assistant sales manager, Radio Division, Stewart-Warner, has been appointed sales manager. He succeeds R. H. Woodford.

S. M. Doak is now general sales manager, United Reproducers. Mr. Doak was formerly Western district manager for Sonora.

Bethuel M. Webster, Jr. and Paul M. Segal have resigned as general counsel and assistant general counsel, respectively, of the Federal Radio Commission. Both attorneys will enter private practice of law in Washington.

Tbad H. Brown, of Ohio, chief counsel of the Federal Power Commission, has been appointed general counsel of the Federal Radio Commission, it was announced recently. Mr. Brown, a former secretary of state of Ohio, succeeds Bethuel Webster, Jr.

Irma Lembke is the first television program director, according to the Jenkins Television Corp. Miss Lembke will have charge of the Jenkins radio-visual programs flashed from w2xcr and w3kx.

Corson Kneezel has been appointed advertising manager for the Kolster Radio Corporation. Mr. Kneezel was associated formerly with Evans, Kip, and Hackett, Inc., of New York, and previous to that with the Foster and Kleiser Company.

Carroll Van Ark, publicity manager for Kolster for a number of years, has resigned.

SARNOFF AND HARBORD REPORT BEFORE SENATE COMMISSION

The royalty payments due the RCA from some of the thirty-eight set manufacturers now licensed are in arrears \$561,621 said David Sarnoff, executive vice president of RCA, before the senate interstate commerce commission on December 14th in Washington, D. C. The committee is holding hearings on the bill introduced by Senator Couzens to establish a communications commission. Mr. Sarnoff went on to say that although there is no definite policy as to the licensing of manufacturers, the practice is not to license any additional ones because there "already is overproduction in the industry, we don't want to extend the licenses any more." On the whole, he said, the industry "is in fairly good condition" although certain licensees owe royalty payments to the extent of \$561,621.

Mr. Sarnoff admitted that the retail receiving-set business of RCA showed disappointing returns. "The Corporation," he declared, "has earned a smaller profit than its licensees have earned on their sets, after they have paid their royalties."

Describing the formation and growth of RCA, General Harbord, president, said during the course of his appearance before the senate committee: "As conceived and organized in October, 1919, RCA was a communications company. The great commerce in the entertainment field had then no existence. During the corporation's first year, 1920, radio in the entertainment field was the plaything of amateur operators. In that year RCA's sales amounted to \$500,000. During the next year broad-

casting had small beginnings and sales were \$1,500,000.

HOW SALES HAVE INCREASED

"In the seven years I have served the corporation," continued General Harbord, "its sales of radio apparatus have mounted from \$11,000,000 in 1922 to \$87,000,000 in 1928. Not radio telegraph devices but broadcast devices have brought about this vast increase. Radio telegraphy, its field originally conceived, has been responsible for a fraction over 9 per cent. whereas merchandising radio receiving sets, the field newly developed since RCA was created, has been responsible for over 86 per cent. of the corporation's total revenue from its organization up to June 30, 1929."

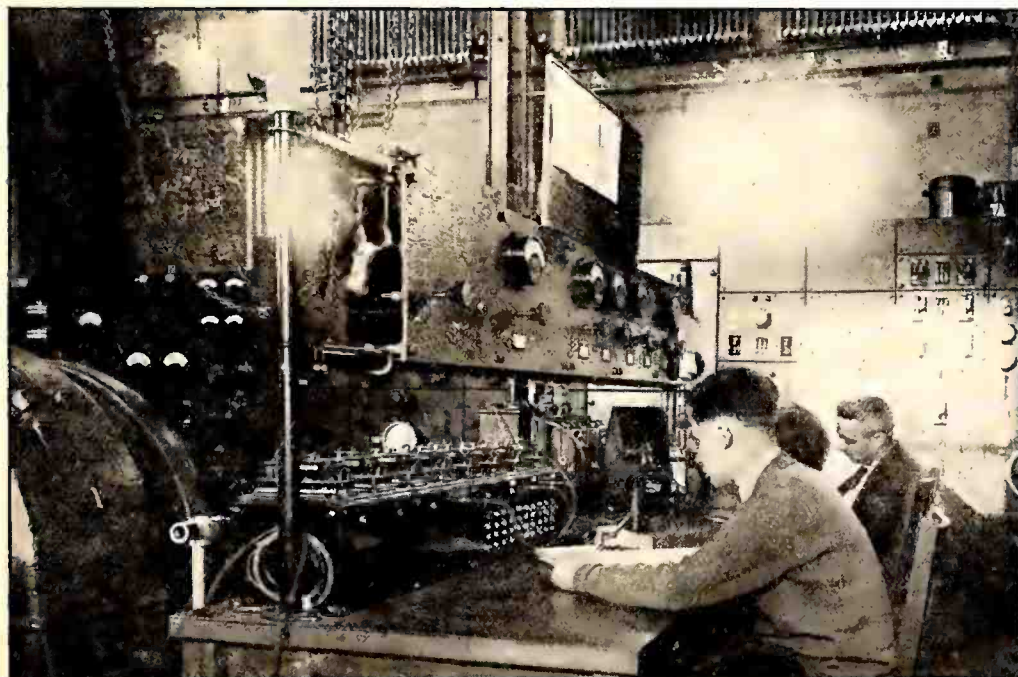
Saying that RCA's licensees have prospered, General Harbord declared that their sales in 1927 totalled \$46,000,000, in 1928 \$128,000,000, and during the first six months of 1929, \$64,000,000. "Some whose voices were once loudest in the chorus of denunciation have since become licensees, and their denunciation ceased with their licensing. Some remain but the goal they seek is not the remedy for which they ask you but licenses under the very patents they decry."

Speaking further of the license situation, General Harbord continued: "Under patents acquired and developed at vast expense, the Radio Corporation has elected to license many radio manufacturers, insisting always that an apparent ability to serve the public well should be a condition to the granting of a license. License fees are but the reasonable contribution of those who pay them to those whose efforts and money brought about the development and purchase of the inventions, joint use of which must be made in the manufacture of modern radio devices.

"Let this patent unification be at an end tomorrow," concluded General Harbord, "let each organization use only the radio patents it actually owns; let licensees operate only under their own inventions, and not use those licensed to them by others, and on that day will topple the whole structure of service which radio is rendering for the benefit and entertainment of the American public."

NATIONAL UNION MERGER

Discussing the recent formation of the National Union Radio Tube Corporation, Mr. Sarnoff said at the same hearing that RCA had acquired an option on the company's stock to the extent of 12 per cent. The corporation comprises four independent tube manufacturers now operating under an RCA tube license. The organization was arranged through bankers. These companies, Magnatron, Sonatron, Televocal, and Marathon, Mr. Sarnoff said, agreed to take a license under RCA patents and avoid litigation. Subsequently a loan of \$2,000,000 from RCA to the new
(Continued on page 236)

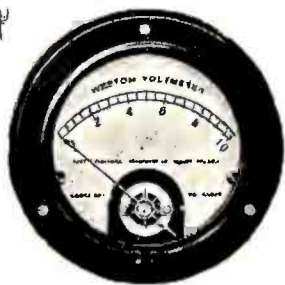


The famous pre-war German trans-Atlantic radio station at Sayville, L.I. has recently been modernized by the Postal Telegraph Company and is being used for transcontinental telegraph service. The operator's control table is shown in the above picture.

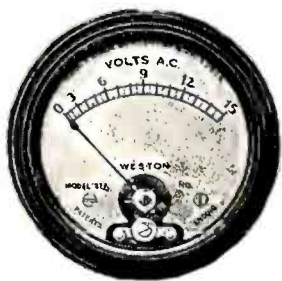
Service

Big Profits in it with Reliable Equipment

"A penny saved is a penny earned" is not true in purchasing instruments for radio servicing work. The small difference in cost between the best obtainable meters and those of secondary value comes back to you many times over in the money you can make and the business reputation you acquire through the use of reliable equipment.



Shown herewith are two designs of miniature panel instruments—2" and 3 1/4" diameter—for use in the repair shop and in portable testing work. These are the instruments selected by Commander Byrd for his Polar expeditions. Preferred for their nicety of construction and superior electrical characteristics.



Made in A. C., D. C. and Thermo-Couple Types, and in all the required ranges. Open scales almost to zero position. Designed for flush panel mounting. Write for Circular JJ, containing complete descriptions and prices.



WESTON ELECTRICAL INSTRUMENT CORPORATION

604 Frelinghuysen Ave. Newark, New Jersey

(Continued from page 235)

corporation was made and this was secured by the option on National Union stock. At this point Senator Hawes of Missouri asked of Senator Dill the reason for this trend of inquiry into the financial activities of the corporation. Senator Dill replied that he had heard stories that the RCA was endeavoring to "browbeat" companies into effecting license agreements with it on patent infringement grounds but that the facts, as explained by Mr. Sarnoff, "disprove" these reports. In concluding, Mr. Sarnoff said that the 7 1/2 per cent. royalty on receiving sets is levied on the "full completed article," and not on the cabinet or chassis. RCA could have placed a 15 per cent. royalty on the selling price, he said, which represents about one half the cost of the radio set. Senator Couzens observed that the policy adopted by RCA is that it is better to charge a flat rate on the whole rather than a high rate on the chassis alone. This has been found effective in the automotive industry also, he declared.

Aerovox Sues Dubilier

The Aerovox Wireless Corp. sued Dubilier on patent number 1,736,764 on the use of mineral oil as a cooling agent in the manufacture of condensers. In addition to damages asked on the alleged infringement, a counter suit has been filed against Dubilier for damages totalling \$500,000.

Sonora Acquires Home Movie

Before the involuntary bankruptcy action brought against Sonora Products late in December, it was announced that the company had in production a home movie unit including motion picture projector, synchronized phonograph, and radio receiver. It was also announced that the company had a compact six- and seven-tube radio set for installation in automobiles.

DeForest Sues RCA

"Under the Clayton Act the DeForest Radio Company is entitled to triple damages for the period in which Clause 9 of the RCA contract with receiver manufacturers was in operation," said James W. Garside, president of DeForest, recently. The DeForest suit for damages, it was said, was not to bring about loss of RCA radio licenses as provided for under the radio act of 1927, but merely to press the suit for damages.

Radio Interference Manual

A 64-page booklet combining all engineering data secured by the Tobe Deutschmann Corporation on radio interference prevention and a catalog of Tobe apparatus for many special purposes in this connection has just been issued. Copies can be had at 25 cents each postpaid from the company at Canton, Mass.

Dayrad—a New Name

Radio service equipment manufactured by the Radio Products Company, of Dayton, Ohio, will, in the future, be made under the trade name Dayrad. E. T. Flewelling, formerly associated with the company, has resigned. Dayrad radio service instruments have been developed by an engineering personnel working independently of Mr. Flewelling and additions to the line will be announced shortly.

Bosch Dispute Settled

Settlement of litigation between American Bosch Magneto and Robert Bosch Magneto has been made. American Bosch secures the sole right to the use of the single word "Bosch" on automotive products, radio and all its other products in the United States, Canada, Mexico, Cuba, and American dependencies.

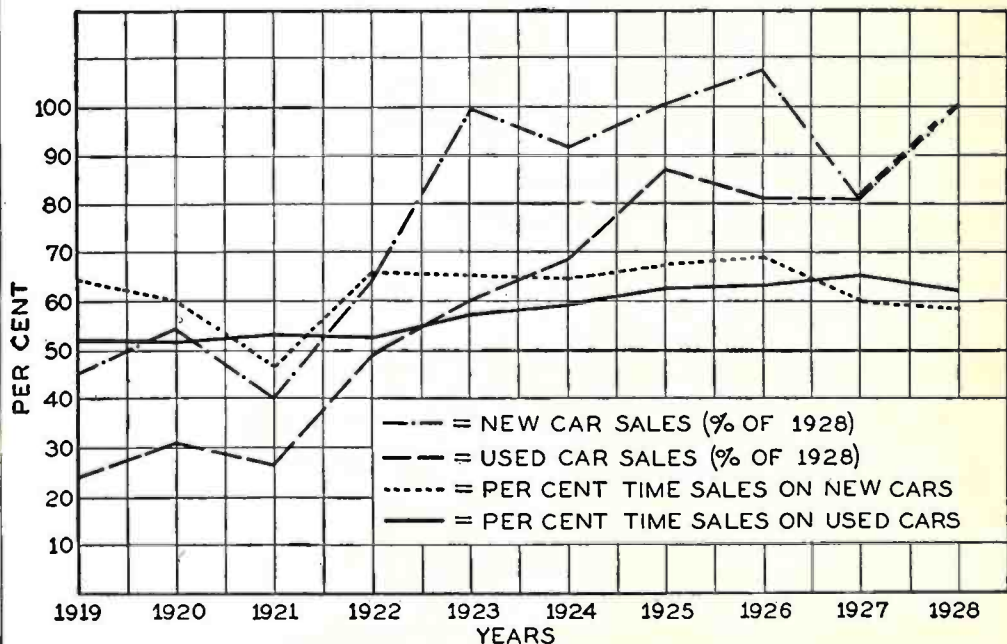
Remote Control Patents

As announced recently by E. F. McDonald, Jr., president of Zenith, the following patents are held by his company covering remote tuning and immediate tuning or the combination of both, providing that such tuning is done automatically.

Vasselli	No. 1,581,145—issued April 20, 1926
Heath	No. 1,638,734—issued August 9, 1927
Flocco	No. 1,591,417—issued July 6, 1926
Marvin	No. 1,704,754—issued March 12, 1929
Vasselli	No. 17,002—issued June 19, 1928
Gould	No. 1,695,919—issued Dec. 18, 1928

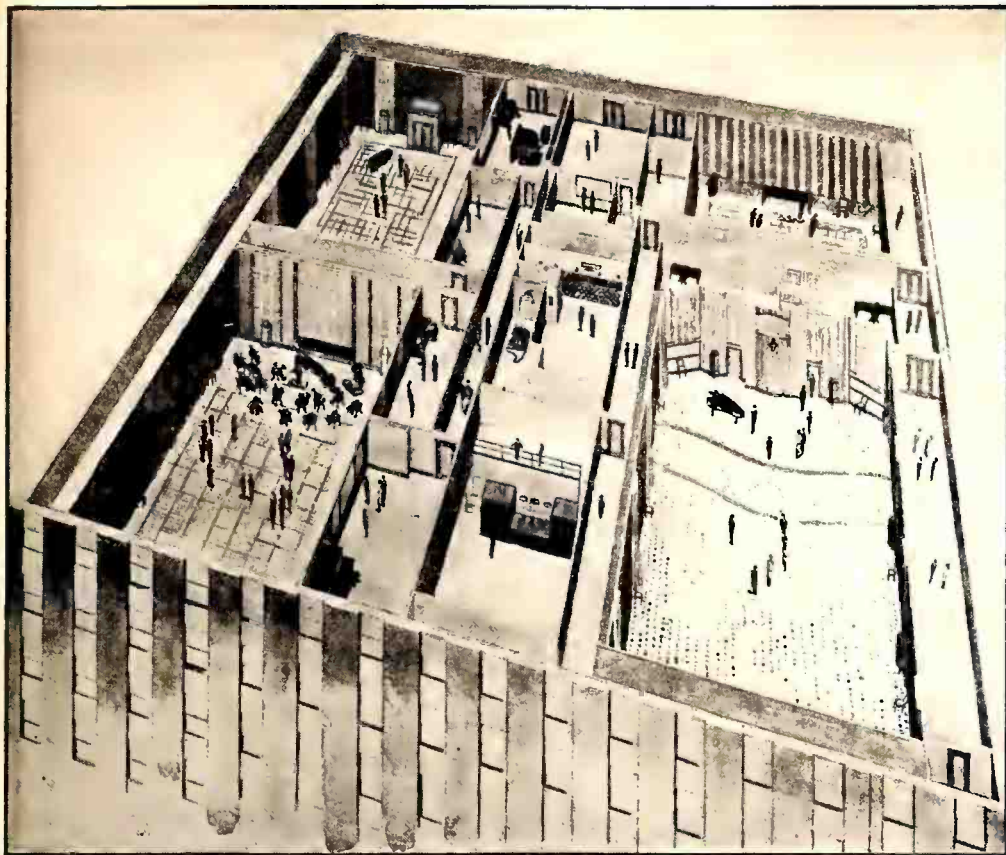
Production Figures

The Electric Specialty Company, Stamford, Conn., is increasing its manufacturing capacity approximately 40 per cent. through the construction of an addition to its Stamford factory. According to E. W. Berry, Esco's sales for 1929 will exceed those of their best year, 1928, by approximately 40 per cent. Officers of the company are: J. M. Wright, president; M. L. Bickart, treasurer; D. G. Shepherd, general manager.



The curves in the above illustration show several interesting facts regarding the automotive industry, and, as the radio industry faces similar problems, a study of the graph should be of interest. The data for these curves were obtained from The Credit World, October, 1929.

2-7



The National Broadcasting Company has made plans for installing the world's most pretentious radio studio atop the Merchandise Mart Building in Chicago. The drawing above indicates the arrangement of the studios which will occupy 10,228 square feet of floor space.

Industry Briefs

EARL SETS BOUGHT: Walter L. Eckhardt, formerly president of the Music Master Corporation, has purchased the entire stock of Earl sets from the receivers of the Earl Radio Corporation. This includes 9000 completed sets and 29,000 in the process of manufacture.

BRUNSWICK: The physical assets and patents of the Vitavox Company, manufacturers of sound-on-film devices, have been purchased by Brunswick.

PACIFIC RADIO TRADE ASSOCIATION: The second radio interference investigator has been employed by the P.R.T.A. through financial aid of Pacific Gas and Electric and Great Western Power Company. Four other San Francisco utilities now contribute to expenses of investigators. More than 350 complaints are handled monthly by the association.

TELEVISION DEMONSTRATIONS: The Baird Television Corporation, American headquarters, 145 West 45th Street, New York, demonstrated Baird's British system in December. Jenkins held a showing in New Jersey, early in January, with voice and picture actually transmitted to the demonstration receiver via radio.

NATIONAL UNION RADIO: A free course of instruction under Professor E. Gordon Taylor, College of the City of New York, for servicemen, engineers, and students in the New York area has been started by National Union.

AMERICAN STANDARDS ASSOCIATION: Among the radio standards agreed on and established during 1929 one fixes the dimensions governing the fit of four-pin vacuum-tube bases, it was announced.

INVENTOR DEAD: On December 12 Dr. James Harris Rogers, known for his work in radio under-ground and under-water communication, died in Hyattsville, Md., at the age of 79. A patent for under-sea radio communication was granted Dr. Rogers on May 13, 1919.

Doubles Size of Plant

The Leeds and Northrup Company, 4901 Stenton Ave., Philadelphia, doubled the size of their plant and increased the number of employees from 750 to 1150 during 1929. They make precision instruments, many of which are used in radio laboratories and factories.

Change of Address

DE FOREST: The executive offices of the DeForest Radio Company have been moved from the Jersey City plant to the main plant at Passaic, N. J. New and larger quarters are now available.

EBY: The H. H. Eby Mfg. Co. Inc., formerly located at 4710 Stenton Ave., Philadelphia, has moved into very much larger quarters at Twenty-Second St. and Lehigh Ave. This change was made necessary by a substantial increase in the Company's business during 1929. Plans are being formulated for even greater expansion during 1930.

SPRAGUE: Some time ago an announcement was made of the removal of the Sprague Specialties Company from Quincy to North Adams, Massachusetts. This removal, however, does not apply to the executive offices and laboratories which remain in Quincy.

Coming Events

February 10-11, 1930, Cleveland, Ohio. Fourth Annual Convention of National Federation of Radio Associations, Radio Wholesalers' Association, Statler Hotel.

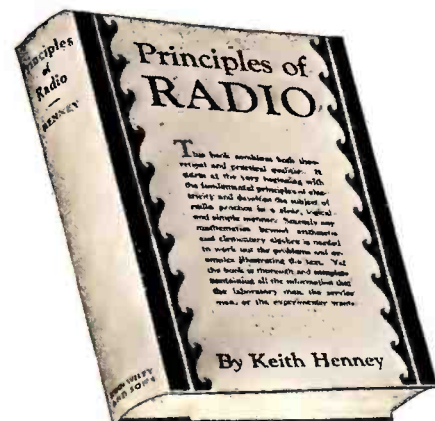
Week of June 2, 1930. Atlantic City. Annual Trade Show and Convention Radio Manufacturers' Association. Convention Hall.

Dealers Association Formed

Seven radio dealers of Auburn, Indiana, have formed the Auburn Radio Dealers Association. Orris Wise, local Crosley radio dealer was responsible for its organization.

(Continued on page 238)

Just Out . . .
Keith Henney's
Book on
Radio



Principles
of
Radio

By **KEITH HENNEY**
Director of the Laboratory
Radio Broadcast Magazine

Readers of Radio Broadcast, long familiar with the work of Keith Henney in his capacity as Director of the Magazine's Laboratory, will be eager to secure his first book, just released from the press.

This book brings together within one cover the kind of information on radio which will appeal to the practical interest of every radio experimenter, technician, engineer, and fan. It contains the latest data and the most modern methods. It treats in a thoroughly practical way everything from the production of radio currents to their reception and transmission. Many problems, examples, illustrations, experiments, are here presented in book form for the first time.

Keith Henney, by reason of his wide experience as an operator, engineer, and writer, has the gift of making technical information readily understood by the reader.

See a Copy on Ten Days' Approval

Price \$3.50

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440 Fourth Ave., New York City

Gentlemen: Kindly send me on approval Henney's "Principles of Radio." I agree to remit the price (\$3.50) within ten days after its receipt or return the book postpaid.

Name

Address

Reference

(Continued from page 237)



PILOTRONS

These tubes, built to satisfy professional radio engineers and custom set-builders, will surely satisfy your customers. "Good Sets Deserve Pilotrons, Others Need Them"! Pilot Radio and Tube Corporation, 323 Berry Street, Brooklyn, N. Y.

Favorable Business Indications

The radio dealers' survey conducted by the Department of Commerce and the NEMA indicates that average sales of radio equipment for the third quarter of 1929, as reported by 6237 dealers out of a total of 38,000, showed an increase of 14 per cent. over the same period in 1928. The average value of the sets sold showed a decline of from \$167 to \$155 as compared with the same period in 1928. Average sales per dealer compared as follows: 1928, \$3030; 1929, \$3450. An increase in fall stocks is shown by the rise in average inventory for dealers from 9 a.c. sets on July 1, 1929, to 14 on October 1 of the same year.

TRIAD: Increased business and enlarged volume of orders now on hand is the report of H. H. Steinle, sales manager of Triad, in December. More than two hundred jobbers and factory distributors are now on the company's books.

R. M. A.: "While 1930 may not exceed the record-breaking sales volume of 1929," says Herbert H. Frost, chairman RMA Merchandising Committee, "there is every reason to believe that there will be fewer manufacturers and fewer dealers, which is a guarantee that those who remain and do a sound and sane merchandising job will profit to a greater extent than has been possible in the past. No matter what may evolve from the present manufacturing situation, the public will continue to buy radio receiving sets and the retail trade to sell them."

ATWATER KENT: In the early part of December, Mr. Kent wired his distributors: "We will continue to manufacture and sell the present Atwater Kent line throughout the spring season."

News of the N. F. R. A.

The Cleveland Convention of the N.F.R.A. is occupying the center of the stage and at the February meeting reports of committees on accessories, better selling, market study, and trade relations, will be made. Reports will also be given by the Tube Committee, headed by J. M. Blackman of New York, the Set Committee, headed by Harry Alter of Chicago, and the Traffic Committee headed by Francis E. Stern, Hartford.

The Stanton Motor Company, of Columbus, Ohio, and the MacGregor Radio Corporation, New Haven, Conn., are new members of the Radio Wholesalers Association.

The Radio Guild of Cincinnati has recently joined the N.F.R.A. Within the last nine months, nearly forty new local associations have been established in various points throughout the country.

The N.F.R.A. has reprinted its booklet, *How to Organize a Local Radio Trade Association*. Copies can be secured from H. G. Erstron, National Federation of Radio Associations, 32 West Randolph Street, Chicago, Ill.

Television Schedule

Two stations of the Jenkins Television Corporation are now in operation. They are w2xcd, Passaic, N. J., 500 watts, 1604 kc. (187 meters), and w2xcr, Jersey City, N. J., 1000 watts, 2150 kc. (140 meters). The hours of operation are:

w2xcd 8 to 10 p. m. daily except Sunday (E. S. T.)

w2xcr 8 to 10 p. m. daily except Sunday. (E. S. T.)

At present the Passaic station is sending out the sound accompaniment for the shadowgraphs transmitted on the 140-meter wavelength by the Jersey City Station.

Financial Notes

GRIGSBY-GRUNOW: Earnings for the six months ending November 30, 1929, were above dividend requirements at the rate of \$2.00 a share for the full year. The Regular quarterly dividend of 50 cents a share on the common stock was declared. The company has acquired the plants of the General Motors Corporation, which it formerly occupied under lease. On December 6 president Grigsby said, "Sales to consumers are running double the present rate of production, which will permit distributors and dealers to clear their inventories of merchandise by the first of the year."

WESTINGHOUSE: On December 11th this company raised its dividend rate on common and preferred stock to the rate of 10 per cent. per annum, declaring a quarterly dividend of \$1.25.

TEMPLE: Payment of the regular quarterly dividend (45 cents) on convertible preferred stock was passed December, 1929.

RADIO PRODUCTS CORPORATION: Ten months ending October 31, 1929, net earnings \$540,370. This is equivalent to \$5.40 a share on 100,000 outstanding shares. Net earnings for this period, \$195,472.

POLYMET: January 2d this company declared its regular quarterly dividend in cash and stock at the rate of \$1 and 4 per cent. in stock. Total net sales August 1 to November 30, 1929, \$2,002,359. Total fiscal year net sales estimated at \$4,000,000.

POSTAL TELEGRAPH: Postal Telegraph Cable and Radio operating revenues nine months ending September 30, 1929, \$29,558,577.10.

RCA Tube Licensees

At the close of the year eleven independent tube manufacturers had been licensed by the Radio Corporation of America for the manufacture of vacuum tubes for radio receiving sets. The first company to accept a license was the Raytheon Manufacturing Company in March, 1929. The complete list of companies and their presidents follows:

- Allan Mfg. and Electrical Corp., Clark Bldg., Central Ave., Harrison, N. J. Henri Sadacca, president
- Ceco Manufacturing Company, Inc., Providence, R. I. Ernest Kauer, president
- Champion Radio Works, Inc., Danvers, Mass. F. W. Marsh, president
- Hygrade Lamp Company, Salem, Mass. E. J. Poor, president
- The Ken-Rad Corporation, Owensboro, Ky. Roy Burlew, vice president
- Matchless Electric Company, 1500 N. Ogden Ave., Chicago, Ill. Paul C. Dittman, president
- National Union Radio Corporation, 400 Madison Ave., New York, N. Y. Nathan Chirelstein, president
- Nilco Lamp Works, Inc., Emporium, Penn. Ben Erskine, president
- Raytheon Manufacturing Company, Kendall Square Bldg., Cambridge, Mass. L. K. Marshall, president
- Tung-Sol Radio Tubes, Inc., 95 Eighth Avenue, Newark, N. J. H. W. Harper, president
- United Radio & Electric Corporation, Irvington, N. J. J. G. Weiss, president

AMERICAN BOSCH IN ITALY: Fabbrica Italiana Magneti Marelli, Milan, Italy, has contracted with American Bosch for manufacture and sale of radio sets and radio products in Italy and other European countries for a period of five years. The agreement provides also for interchange of designs, inventions, manufacturing processes, and advertising, selling and servicing.

By the author of

"Principles of Radio Communication"

An independently written introduction to the subject of Radio



John H. Morecroft

Elements of Radio Communication

BY JOHN H. MORECROFT

"We can highly recommend 'Elements of Radio Communication' to those of our readers who want a book that will give them a strong, elementary grounding in radio and leave them with few questions to ask save those which may be born of a desire for more knowledge."
Boston Post Radio Section

\$3.00

JOHN WILEY & SONS, Inc.

440 Fourth Ave., New York

Please send me Morecroft's "Elements" for free examination. Within ten days after its receipt I will either return the book or send you \$3.00.

Name.....

Address.....

Firm..... RB 2-30

G-8

SHALL WE BUY OR MAKE PARTS?

By DAWSON J. BURNS

Vice-President and General Manager, Ward Leonard Electric Company

IN ANY manufacturing business involving the assembly of a number of component parts, the question frequently arises as to the economy of manufacturing these components, rather than buying outside. Naturally, an alert production department is anxious to add new processes which will level off production peaks, and the cost department feels certain that the labor and material costs will be kept well below the best outside supplier's quotation.

A careful analysis shows three major premises in favor of internal manufacturing, rather than outside buying: first, better utilization of employed labor; second, lower final costs; third, closer contact with, and consequently better control of production. The idea of improving the quality of a part through internal manufacturing, rather than outside purchases, seldom enters into question. The parts manufacturer is generally recognized as best able to turn out his specialized product. A manufacturer who contemplates making a part inside his own plant, almost invariably has the idea of turning out a part which will do the job satisfactorily, even though it may not be equal to a job of an outside manufacturer.

As a general premise I shall say that a manufacturer can buy parts more cheaply than he can make them. However, this must be qualified by saying that it is broadly true only if the process of making that part is fairly difficult and if technical skill and background enter into its design and manufacture. Take, for example, the case of a resistor manufacturer with which, naturally, I am most familiar. The manufacture of high-grade resistors, while it may appear a rather easy task, really involves extensive engineering background, not to mention any number of production problems, which at first glance are not apparent. From the standpoint of cost, we feel that no one can manufacture, as a component part, resistors of the high quality demanded in radio work, and produce them at a lower price than we do, without losing money in the end.

A brief analysis serves adequately to illustrate the point. To set up for internal production of an item, let's say resistors, a manufacturer must automatically increase the personnel or place a burden on many departments. The purchasing department must gather materials and return defective parts; the technical staff must closely supervise and test the quality of incoming materials, and the engineering department must design the desired product and follow it through production. All departments concerned must handle and be responsible, not for one item, but for a multiplicity of items. The executive management of the company must correlate the work of the several departments. Personnel must be greatly increased or there is bound to be a costly and even a disastrous slip somewhere along the line, which will delay the final production of the completed unit.

If a radio company adds executives to cover each minor manufacturing process it finds itself involved in a mass of production details far removed from its primary function of turning out and selling radio receivers. Where the manufacture of new items is undertaken inside the plant, the risk to the merchandising success of the completed receiver becomes greater. Things which looked easy turn out to be difficult and there is apt to be one costly delay after another.

Let us take the case of Ward Leonard

The development of the radio industry has seen a gradual trend towards the manufacture rather than the purchase of many of the component parts necessary in the production of radio receivers. However, the economics of this problem are not entirely settled, and it is for this reason that we present the following comments by Mr. Burns on some of the factors that must be considered.

The question, we realize, is a controversial one. It can only be answered by a careful and complete study of all the factors that are involved and we expect in a future issue to present more complete data on the subject. Meanwhile the Editors would be glad to have the opinions of engineers and other executives who have given the matter some consideration.

—THE EDITOR.

as an example. Our company consists of specialists in resistors. We have and maintain executive, engineering, and research staffs. At present there are some 75 electrical engineers devoting their entire time to designing, improving, and supervising the manufacture of resistor units. We would no more presume that these men could turn out a really well-engineered radio set, than we would expect a radio manufacturer to turn out really well-engineered resistor units.

THE HI-Q 30 KIT

(Continued from page 211)

describing in detail the design of the Hi-Q 30 and it is suggested that interested experimenters send for this booklet. It can be obtained for 25 cents directly from Hammarlund-Roberts, Inc., 424-438 West 33rd Street, New York City.

Cost of Kit

The following is a list of the Hi-Q 30 models, numbers, and prices:

Kit	Code	Price
A. C.	30-R-A.C.	\$162.50
Battery	30-R-Bat	119.15
A. C. Tuner	30-T-A.C.	138.65
Battery Tuner	30-T-Bat	93.80

A list of the cabinets available for the Hi-Q 30 receiver is as follows:

Name of Cabinet	Price
Milan	\$600.00
Arden	96.50
Raleigh	75.00
Stratford	55.00
Cambridge	96.00
Yorkshire	75.00
Oxford (Table)	28.50
Windsor (Phono-Radio)	175.00
Blackstone	150.00

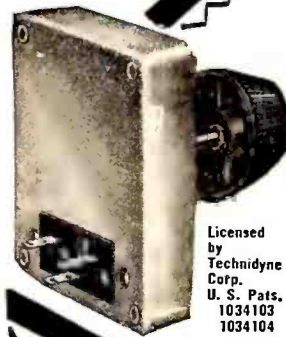
ANSWERS TO PROBLEMS

Answers to problems given in "Engineering Review Sheet" No. 29 (page 215) are as follows:

- (1) Approximately 7.
- (2) 1.35 megohms.
- (3) 15 milliamperes; 5 milliamperes.
- (4) From -9 to -159 volts; 53 milliamperes; 190 volts.

ELECTRAD PERFORMANCE

Your Protection Against High SERVICE COSTS



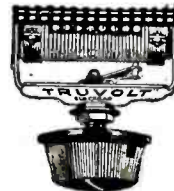
Licensed by Technidyne Corp. U. S. Pat. 1034103 1034104

ELECTRAD Super-TONATROL

A volume control designed especially for use with the high voltages of modern receivers. Made on a new and superior principle. The resistance element is permanently fused to the surface of an enameled metal plate. A pure silver contact gives marvellously smooth action. 7 types for all usual uses. List Price, \$2.40 to \$3.50.

You can recommend ELECTRAD Resistances and Voltage Controls for every radio purpose—because they are built to PERFORM. Highest Quality—prices made possible by ELECTRAD'S tremendous production — are your guarantee of satisfaction to your customers, greater profits from your parts department, and lower service costs. Mail the Coupon today for information about the complete ELECTRAD Line.

U. S. Pat. 1676869 and Pat. Pend.



TRUVOLT The Safe Resistance for Eliminators

Heavier-than-usual Nichrome resistance wire. Air-cooled—perfectly insulated—accurate values—longer life. Variable models (illustrated) simplify eliminator construction. 22 sizes, list, \$2.50. Fixed models have exclusive sliding clip for exact setting. All usual sizes.

ELECTRAD, Inc., Dept. RB-2
175 Varick Street, New York, N. Y.
Please send data on following products:
 Super-TONATROL TRUVOLT Resistances All Products.
Name _____
Address _____

175 Varick St., New York, N. Y.

ELECTRAD INC.

IN THE RADIO MARKETPLACE

News, Useful Data, and Information on the Offerings of the Manufacturer

Gulbransen Model 291

GULBRANSEN COMPANY: The Gulbransen Model 291 embodies the same principles of construction and mechanical features as the



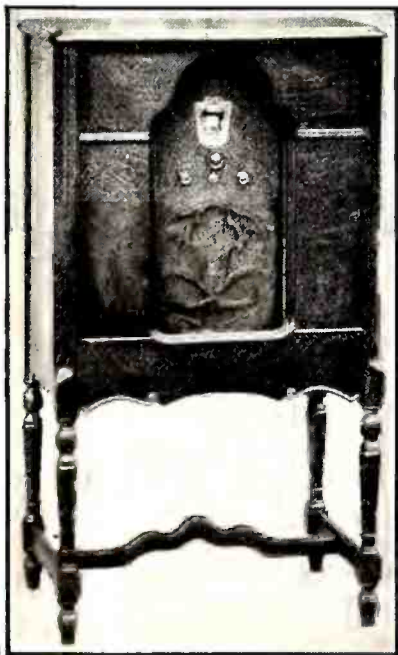
Model 292. Screen-grid tubes, 245 power tubes, accurately matched condensers and filters, local- and long-distance switch, and a phonograph-radio switch operated by the knob that controls the a. c. switch, (patent applied for) are distinctive features of this new radio model. Price: \$139.50.

Eveready Series 30

NATIONAL CARBON COMPANY, INC.: Features of the series 30 Eveready receivers are: sturdy, rigid mechanical design and permanent all-metal construction of the chassis foundation; variometer associated with the gang condensers; rugged three-gang condenser, dual loud speaker provision, giving the customer his choice of electrodynamic or magnetic operation (Table Model, only); simplified, trouble-free condenser drive, with automatic slack take-up, rugged, "flapper-type" condenser antenna trimmer; grid-bias method of volume control.

New Erla Receiver

ELECTRICAL RESEARCH LABORATORIES, INC.: The Erla receiver is a seven-tube set, one-dial control, using two 224-type screen-grid tubes, two 227's, two 245's, the latter being push pull, and one 280 rectifier tube. Tip jacks are em-



ployed in the receiver for the connection of a phonograph pick-up unit, and arrangements have been made to provide ample power to operate the pick-up properly. The long and short antenna control is located on the panel.

Radiola 47

RADIO-VICTOR CORPORATION OF AMERICA: This is a four-tube phonograph radio combination using two stages of r f amplification and a power detector, followed by a single 245-type tube. Screen-grid tubes are used in the two r f. stages and a third screen-grid tube is used as the detector.

New Parts Catalog

ALDEN MANUFACTURING COMPANY: A booklet entitled "Something Lower Priced That is Actually Better" has been published by this company. It gives complete data on the various parts which this company manufactures. These parts include sockets of all types, multiple wire attachment plugs, special adapters, etc.

Bosch Model H

AMERICAN BOSCH MAGNETO CORP.: The Model H console recently added to the line of Bosch receivers has tall sliding doors with the grill for the loud speaker located above the



tuning control. Equipped with a Bosch screen-grid chassis and electrodynamic loud speaker this model lists at \$198.50.

Crosley 30-S and 40-S Sets

CROSLEY RADIO CORPORATION: Among the features of the Crosley 30-S and 40-S screen-grid receivers are improved type of volume control, combined range control and switch, power detection with resistance-coupled audio-frequency amplification, push-pull output with 245 tubes. These chassis may be obtained with the front panel only for console mounting, in metal table-type cases, or in wooden console cabinets.

The Ware Model J5

WARE MANUFACTURING CO.: A new chassis, the J5, in which a screen-grid tube is used as an a. f. amplifier has been developed by this company. Other features of the receiver are Vreeland band tuning, duplex sensitivity control, phonograph switch, and complete shielding. The J-5 chassis lists at \$75.

Stewart-Warner

STEWART-WARNER CORPORATION: The latest Stewart-Warner receiver uses the company's standard eight-tube screen-grid chassis in a Tudor period console. Less tubes this model is priced at \$131.50.

Victor Model RE-75

RADIO-VICTOR CORPORATION OF AMERICA: The newest addition to the Victor line is the Model RE-75, a combination phonograph and



radio. Several leather-back record albums are provided with the instrument.

New Power Amplifiers

THE RAULAND CORPORATION: In collaboration which Jenkins and Adair, several power amplifiers have been designed especially for use in public-address systems and talking movies. Several new transformers have also been announced including a standard shielded model listing at \$4.50, a laboratory grade model listing at \$7.50, and an unshielded replacement transformer priced at \$2.25. The Rauland Corporation has purchased all the dies, tools, and other materials formerly owned by the All-American Mohawk Corporation and used in the manufacture of All-American transformers. It is understood that the latter corporation has discontinued the manufacture and sale of transformers except those used in connection with its regular line of radio receivers.

New Brunswick Models

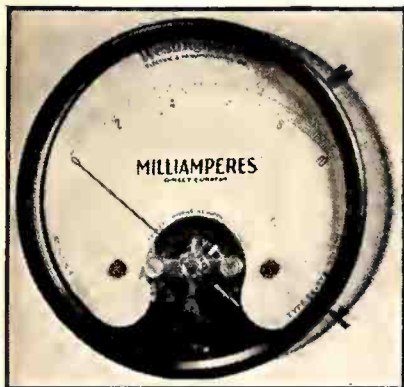
BRUNSWICK-BALKE-COLLENDER COMPANY: The Models S-14, S-21, and S-31 are recent additions to the line of Brunswick radio receivers. The Models S-14 and S-21 are complete a. c.-operated radio receivers, the Model 14 being a lowboy listing at \$148 and the Model 21 being a highboy listing at \$174. The Model S-31 is a radio receiver in combination with a Panatrophe and lists at \$272.



New Westinghouse Meters

WESTINGHOUSE ELECTRIC AND MANUFACTURING COMPANY: This company is manufacturing a new line of meters designed for production testing where high accuracy is required. The production testing of vacuum tubes, for example, is a field in which these new instruments might be used. The accuracy required in this work is generally 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 will result in a very large difference in the plate current. Switchboard instruments are not primarily intended for close measurement work and the calibration accuracy of such 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.

In order to provide a line of instruments especially intended for high accuracy, production testing engineers have carefully studied the problems of testing measurements 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 and highly accurate inspection readings or tests are necessary.

Briefly the "panel standard instruments" consist of the combination of a panel or switchboard type cases and mountings into which are placed high-accuracy portable instrument mechanisms. The dial marks are hand calibrated of the fine line type enabling close readings to be taken. The calibration is performed with the same painstaking care and by the same experts that perform the calibration on the high-grade portable instruments.

The illustration clearly show the scale and pointer of one of these panel standard instruments. The scales are 4" long and very clearly divided. The cases are only 4 1/2 inches in diameter and, therefore, the instruments are very compact, taking up the least possible space on the panel. A large amount of experience, particularly in actual production of radio tubes, has shown that this size of instrument is the best suited for general production testing purposes.

New Sonora Models

SONORA PHONOGRAPH COMPANY, INC.: The Sonora models, designed expressly for screen-grid operation, each have three screen-grid radio-frequency tubes, a power detector, and one stage of push-pull amplification employing two 245-type tubes. The chassis is completely shielded, including interstage condenser isolation.

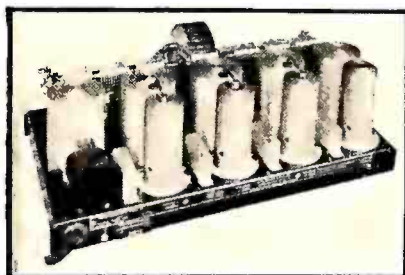
The Sonora power electrodynamic loud speaker includes a special filter that eliminates a. c. hum. All Sonora cabinets were designed and are being manufactured entirely by Sonora, as is every other part of the new Sonora radio. The Sonora line also includes three radios of full unitized construction—tuner and detector, a. f. amplifier, power rectifier and electrodynamic loud speaker, each in separate units. There are



two types of chassis—the Studio and De Luxe. The former employs nine tubes and the latter eleven tubes. In addition, the Sonora line includes two Sonora Melodion combinations for radio and electrical record playing. One of the Melodions is equipped with the Studio chassis, the other with the De Luxe chassis. All of these models are equipped with auxiliary antenna, which may be used in place of the conventional outside antenna.

Super Synchronphase SK-4

A. H. GREBE AND COMPANY, INC.: The Super-Synchronphase SK-4 receiver is designed to operate on a 110-volt, 50-60-cycle, alternating-current supply. Special power units are available for use on lines of like voltage but 25-33-cycle frequency. The instrument consists of two major units or chassis. The r. f. amplifier chassis illustrated is the unit to which the operating controls are attached and the a. f. power-amplifier chassis is the one to which is



mounted the different type consoles. The circuit employs three tuned radio-frequency stages, a power detector, a single push-pull output stage, and a full-wave rectifier. The design of the receiver and circuit employed is entirely new.

New Brandes Receivers

KOLSTER RADIO CORPORATION (BRANDES DIVISION): The chassis used in the low-priced Brandes receivers manufactured by Kolster consists of a three-stage r.f. amplifier using 227-type tubes, a 227-type detector, and a two-stage a.f. amplifier with 245's in pushpull in the output. B power is obtained from a 280-type full-wave rectifier.



Phonograph Motors

STEVENS MANUFACTURING CORP.: The electric motors used in the small battery-operated portable phonographs manufactured by this company are of the single impulse unipolar type, completely housed in die-cast aluminum. An especially designed governor is contained within the housing. The shaft runs on ball bearings and is connected by means of a rubber pulley to the rim of the turntable, being held under constant tension against the inside edge of the turntable. The motor requires 0.2 amperes from three 1 1/2-volt dry-cell batteries. Under ordinary use the cells are good for the playing of more than 1000 records. In the portable phonographs designed for 110-volt a. c. operation a step-down transformer and a Kuprox rectifier are used to supply the necessary d. c.

Radio Equipped Dodge

DODGE BROTHERS CORPORATION: The Dodge Brothers Senior Six automobile is equipped with a radio receiver built into the dashboard. The antenna is concealed in the roof of the car



and a small loud speaker is installed just above the windshield. The two tuning dials are located on the dash within easy reach of the driver.

Polymet Parts

POLYMET MANUFACTURING CORPORATION: This company manufactures a complete line of all types of fixed condensers and fixed and variable resistors. A new catalogue illustrating these parts has just been issued. Another pamphlet has also been issued showing the use of Polymet parts in various well-known circuits.

Airplane Apparatus

PAN-AMERICAN AIRWAYS, INC.: For exclusive use on all of their multimotored airplanes the radio engineers of this company have developed a compact two-way radio system. The receiver and transmitter used on the planes have a total weight of 42 pounds. The apparatus has been designed primarily for CW transmission and reception, although the sets can be adapted for phone work. All important adjustments on both the transmitter and receiver are, of course, made before the plane leaves the ground. The apparatus is supplied from a dynamotor which is operated from the regular 12-volt storage battery. A 5-ampere, 15-volt, wind-driven generator functions to charge the storage battery during flight. In cases of forced landing the apparatus can be kept in operation for about 8 hours of continuous use. For 32- or 54-meter work an antenna running from the wing tip to the fuselage is used. For work on longer wavelengths use is made of the trailing antenna. The transmitter employs a master oscillator and power amplifier using 210-type tubes. The receiver uses a 222-type screen-grid tube with aperiodic coupling to the antenna followed by a 112A regenerative detector and a two-stage a. f. amplifier consisting of one 222 and one 112A tube. The apparatus has proven satisfactory for communication up to a distance of 1400 miles.

THE RADIO DEALER'S DIRECTORY OF RECENT PRICE CHANGES

Company	Model No.	Former Price	New Price	Reduction	Company	Model No.	Former Price	New Price	Reduction
Bremer-Tully Mfg. Co.	81	\$164.00	\$134.00	\$30.00	Graybar Electric Co.	68	\$169.50	\$129.50	\$40.00
	82	195.00	165.00	30.00		69	225.00	195.00	30.00
	S-81	164.00	134.00	30.00		72	175.00	135.00	40.00
	S-82	195.00	165.00	30.00		73	65.00	60.00	5.00
Brunswick-Balke-Collender Co.	S-14	148.00	129.00	19.00		74	119.50	109.50	10.00
	S-21	174.00	154.00	20.00		93	189.50	159.50	30.00
	S-31	272.00	249.00	23.00		94	240.00	210.00	30.00
The Crosley Radio Corp.	61-S	85.00	74.85	10.15		500	110.00	75.00	35.00
	62-S	140.00	135.00	5.00		550	179.00	130.00	49.00
	63-S	130.00	121.00	9.00		330	130.00	98.00	32.00
Earl Radio Corp.	31	139.00	116.00	23.00	520-L		133.00		
	32	169.00	142.00	27.00	523	250.00	175.00	75.00	
	41	225.00	162.50	62.50	524	295.00	225.00	70.00	
General Motors Radio Corp.	66	115.00	85.00	30.00	526	260.00	185.00	75.00	
					527	305.00	235.00	70.00	

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No. 319

RADIO BROADCAST Laboratory Information Sheet

February, 1930

Apparent Demodulation of Weak Signals

IN NOVEMBER, 1929, *Experimental Wireless and the Wireless Engineer* S. Butterworth published a short article entitled "Notes on the Apparent Demodulation of a Weak Station by a Stronger One." In this article the author treated mathematically the effects which occur when two modulated carriers are applied to a linear detector of perfect characteristics, i.e., the detector that completely suppresses one half of the applied signal.

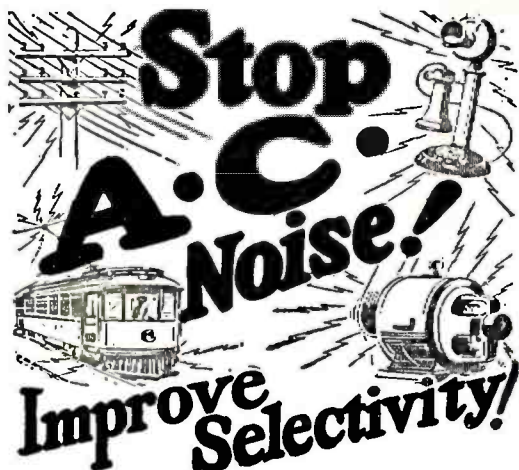
With such a detector it is found that the intensity of the two audio-frequency signals produced by demodulation do not bear the same ratio as do the carriers of the applied signals. Instead it is found that the ratio of the audio-frequency outputs is greater than the ratio of the carriers, the differences in these two ratios becoming greater with increases in the ratio of the two carriers. The only point at which the carrier ratio and the audio-frequency ratio are equal is where the two carriers have the same value. When the two carriers have a ratio of 10 to 1 the audio-frequency signals produced by the demodulation of the carriers have a ratio of 200 to 1. In other words, if two modulated carriers have a ratio

of 10 to 1 and the stronger carrier produces an audio-frequency output of 1 volt then the output due to the weak carrier is only 0.005 volt. The net result of this apparent demodulation of a weak signal by a strong signal is that the apparent selectivity, as judged by the ratio of the two audio-frequency outputs, is greatly increased.

The figures given in Mr. Butterworth's article have been plotted in the form of a curve which appears on Laboratory Sheet No. 320. From this curve it is possible to determine quickly the audio-frequency ratio for carrier ratios of from unity to 10.

The audio-frequency ratios indicated on the curve are, of course, only obtained when the detector is perfect, and, as the detector departs from this characteristic, the apparent demodulating effect decreases.

This same effect treated mathematically by Mr. Butterworth was illustrated graphically and experimentally by F. E. Terman in his article entitled "Linear Power Detection" published on page 49 of November, 1929, *RADIO BROADCAST*.



PLUG in a Falck Claroceptor between wall socket and radio set and eliminate "static" from motors, street cars, telephones and electrical appliances. This new improvement by a pioneer radio parts manufacturer grounds and thus blocks out line interference noise and radio frequency disturbances. Also improves selectivity and distance. Requires no changes in set. Measures just 3½ x 5½ x 2½ inches. Thousands now all over America use the Claroceptor for clearer A. C. reception. Get one right away—at radio parts dealers. Write for descriptive folder.



\$7.50 complete with cord and plug

Falck CLAROCEPTOR

Built by ADVANCE ELECTRIC CO. 1260 W. Second St. Los Angeles, Calif. JOBBERS and DEALERS, GET OUR PROPOSITION

Give Your Radio Set a Chance Install De Forest Audions in your radio set and you will note the difference right from the start—purer tones, more volume and hum-free reproduction.

DE FOREST RADIO CO. NEW JERSEY PASSAIC

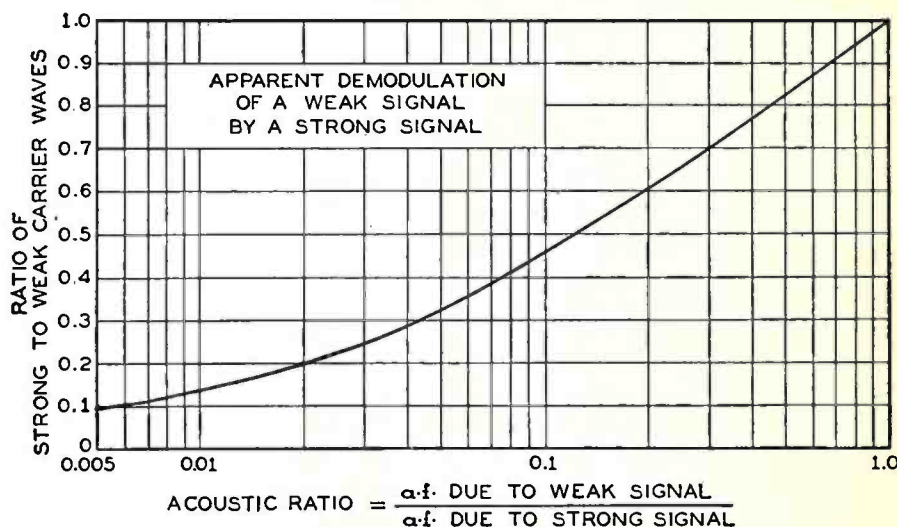


No. 320

RADIO BROADCAST Laboratory Information Sheet

February, 1930

Apparent Demodulation of a Weak Signal



No. 321

RADIO BROADCAST Laboratory Information Sheet

February, 1930

Service Procedure

IN THE servicing of radio receivers a sensible, systematic method of testing is most essential. Testing this, that, and the other thing—testing haphazardly, in other words—will finally lead one to the fault, but it can hardly be called the proper method of procedure. In servicing, as in most everything, there is a proper place to start and a proper procedure that will locate most quickly the thing we are looking for.

Voltages delivered to the tubes should first be checked. This should usually be done.

If there is some definite indication of the trouble it is usually a simple matter to fix it, but if there are no indications of what part of the circuit is at fault, it is generally best to proceed somewhat as follows:

First check the a.f. amplifier. Lightly tap the detector tube and listen for a response from the loud speaker. If the set has a phonograph connection (and most receivers have) connect a pair of headphones to the circuit, tap the diaphragm of the phones and listen for an answering tap from the loud speaker. If there is no response from the loud speaker, the fault must be in the a.f. amplifier, the power tubes, the loud speaker, or the voltage supply to these tubes.

The next part of the circuit to test is the detector. It is usually possible to disconnect the antenna from its usual location and connect it instead directly to the stator plates of the variable condenser tuning the detector circuit. By tuning the set it should then be possible to pick up powerful local stations providing the detector circuit is functioning properly. If the a.f. amplifier works satisfactorily but no signals can be picked up with the antenna connected as indicated above, there is probably some fault in the detector circuit.

After checking over the a.f. amplifier and detector circuits, it is then possible to check the r.f. amplifier, the simplest method being to touch the antenna to the plate terminal of the r.f. amplifier tube preceding the detector, then to the plate circuit of the preceding r.f. amplifier, etc., until the normal antenna connection is reached.

By systematically testing in this manner it is generally possible to locate quickly the point in the circuit where the fault lies and then to take whatever measures are necessary to correct it. The need of a good set tester in such work is, of course, obvious, for without one it is hardly possible to determine accurately the condition of the tubes and whether or not they are receiving proper voltages.

A PRODUCTION TESTING SYSTEM

(Continued from page 205)

batteries. We have found that a.c. B-supply systems fluctuate too much to insure consistent readings.

Iron-Core Choke Coils

The testing of filter choke coils, while important, is not difficult and we have found that these coils invariably function satisfactorily when passed by our final test fixture. In our receivers two chokes are used, one having an inductance of approximately 7 henries with 70 mA. d.c. flowing through it and the other 70 henries with 15 mA. Both of these coils have a cardboard gap which, in production, is sometimes omitted, so it is imperative that they be tested with their normal d.c. component.

The coils upon receipt by the inspection department are first tested for shorted turns by the shorted-turn tester previously described. The coils and cores are then assembled and tested for inductance and resistance by the test fixture shown in a picture and the schematic circuit (Fig. 3).

The fixture consists of a simple inductance bridge having two standard legs either of which may be inserted by a selector switch. The resistance or limit legs consist of a 400-ohm potentiometer to which a dial is attached with limits painted on it. Balance or minimum signal is recorded by a V.T.V.M. The single-stage amplifier is used to give greater deflection of the V.T.V.M. The d.c. component is kept out of the coupling coil by a blocking condenser and adjustment of it is made with a 200-ohm rheostat. The sensitivity of the V.T.V.M. is controlled by a 200-ohm potentiometer connected across the A battery with the lever to the potential. Possible continuity between the coil and core is tested for by throwing a switch from the test to the break-down position, the latter applying a potential of 220 volts a.c. between the core and coil. Continuity is indicated by a W.E. 41Y ringer. This fixture uses one A battery and one 45-volt B battery, the latter serving as plate supply for the amplifier and the source of d.c. for core saturation.

[Editor's Note: Mr. Callanan's third article will discuss the testing of radio-frequency coils, radio-frequency chokes, loud speaker coils, and resistors.]

MERGERS IN THE RADIO INDUSTRY

(Continued from page 195)

its manufacturing facilities to the excellent plant of the former at South Haven, Michigan. The American Piano Company is purchasing chassis of the band-pass type by contract with the Ware Manufacturing Corporation, a revival of the once-predominant Ware Radio Company. Other mergers of this character represent the same objective, the maintenance of a musical industry which could not survive without radio and the strengthening of a radio company by association with the capital, experience, manufacturing facilities, and distribution channels of an existing music company.

The Third Group

The third grouping of mergers, mergers for expansion, promises soon to become the most significant and active in the radio field. Up to now, such mergers have been principally the union of a strong unit with one or more decidedly weaker ones. An outstanding exception to this rule is the merger of Newcomb-Hawley with Peerless to form the United Reproducer Company. Both were strong companies at the time of merger, leading manufacturers of repro-

(Continued on page 244)

Wright-De Coster Reproducers

The Perfection of
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— For the Home —



Model 117 Jr. Consollette

Beauty and clearness of tone. Fidelity of reproduction.

The same wonderful reproduction as our nationally famous theatrical reproducers with volume diminished for homes or small halls.

Beautiful Cabinets

This model may be used for a table or, with handsome spinnet legs added, makes a most attractive console.

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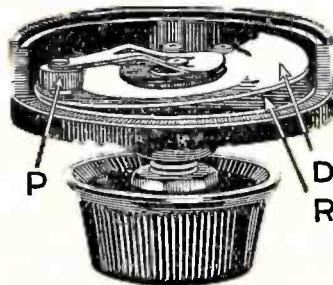


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Smooth Flowing—

POWER!



THIS shows the exclusive rocking disc construction of Centralab volume control. "R" is the resistance. Contact disc "D" has only a rocking action on the resistance. Pressure arm "P" together with shaft and bushing is fully insulated.

Like a deep smoothly flowing stream the volume control on your radio, if it is a CENTRALAB, delivers a constant, uninterrupted flow of power that results in the purest, finest tone.

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CENTRAL RADIO LABORATORIES

Dept. 218-E, Keefe Ave., Milwaukee, Wis.

Inductance of Coils

LABORATORY SHEET" No. 323 contains a set of curves by means of which the inductance of a coil in microhenries may be determined if the size of the tube, size of the wire, and number of turns are known; or conversely, a coil of any given inductance may be constructed using the number of turns indicated by the chart for the particular size of tube and size of wire to be used. The chart covers tube sizes of three and four inches and wire sizes of No. 16, 18, 20, 22, and 24. In all cases the wire is double cotton covered.

The curves are based on the simplified formula for the inductance of a coil—

$$L = \frac{a^2 n^2 K}{10 v}$$

where L = inductance in microhenries
 a = tube radius in inches
 v = length of winding in inches
 n = number of turns of wire
 K = a constant

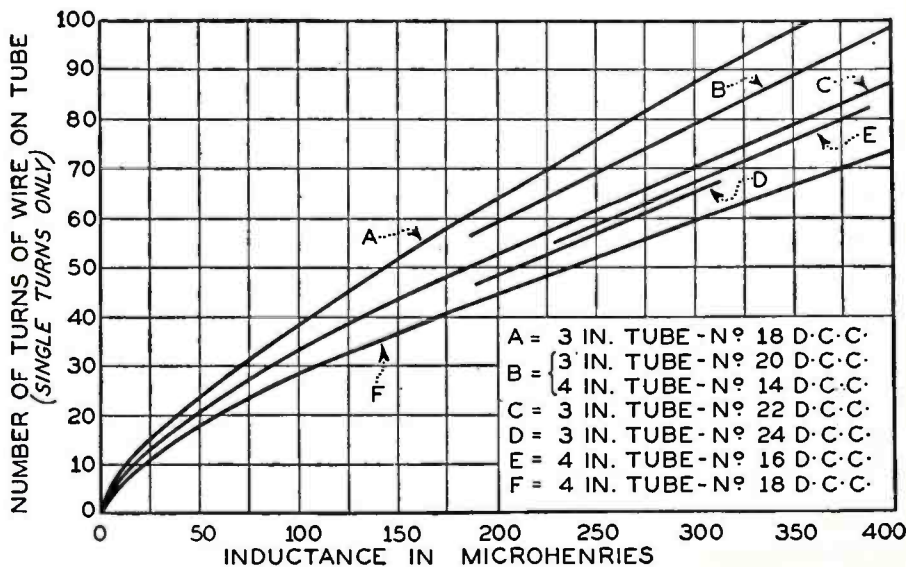
Using the chart on "Laboratory Sheet" No. 323

in conjunction with the chart given on "Laboratory Sheet" No. 286, it is possible to determine quickly how many turns of a particular size of wire are necessary on a given tube to cover the broadcast band with a certain size variable condenser.

For example, suppose a coil were made for use with a 0.0005-mfd. variable condenser. The chart on Sheet No. 286 indicates that 170 microhenries of inductance are required, to tune up to about 550 kc. Suppose we wanted to use a 3-inch tube wound with No. 22 wire. By referring to the chart on the following sheet we find that in order to obtain an inductance of 170 microhenries the coil must have 47 turns of wire.

With these two charts it is also possible to work back and find the size condenser necessary to tune a given coil over the broadcast band. Suppose we had a coil wound with 65 turns of No. 24 wire, the tube size being 3 inches. What size variable condenser will tune it over the band? By referring to the chart below we find that such a coil will have an inductance of 295 microhenries. Then, referring to the chart on Sheet No. 286, we can determine that a 0.0003-mfd condenser will be required.

Inductance of Coils



Hum vs Volume Control

THERE IS a characteristic difference in the operation of receivers with and without automatic volume control circuits which has a fundamental effect on the amount of a.c. hum from the loud speaker.

In a receiver in which the volume control is located in the r.f. amplifier the detector must function at a level depending upon the setting of the volume control. At high volume levels the detector must work at r.f. input voltages large in comparison with those applied to the detector when the desired volume level is low. Now, in a set using an automatic volume control, the manual volume control is usually located in the a.f. amplifier and the automatic circuits function to apply a constant r.f. voltage to the detector. As a result the a.f. output from the detector is constant and volume is adjusted by impressing more or less of this constant detector output on the following a.f. amplifier tube. The fundamental difference between these two arrangements is, therefore, that in one case the detector input varies and in the other case it is constant.

The hum from the detector circuit is responsible for a large part of the hum finally impressed across the loud speaker. The hum voltage from the detector is constant—it does not depend on the setting of

the volume control. Therefore, if the desired signal is much louder than the hum at all volume levels it is necessary to operate the detector at signal levels such that the desired a.f. output is always much greater than the hum output. With the volume control in the r.f. amplifier this is not always possible, for, when the volume is turned down very low, the desired signal output may become comparable with the hum output of the detector. If, however, the volume control is in the a.f. amplifier the detector is operated at high signal levels at all times regardless of the setting of the volume control. As a result, in receivers with automatic volume the ratio of desired signal to hum in the plate circuit of the detector tube is always high, and, other factors being equal, the hum from receivers using automatic volume control will be less than that from receivers not using automatic volume control, provided the manual volume control is in the a.f. amplifier.

It is, of course, at low volume levels that the difference in hum will be most noticeable, for it is at such levels that the hum voltage from the detector will be largest in comparison with the desired signals. At high volume levels there is no reason why the hum from sets without automatic volume control should not be equal to that from sets with automatic volume control.

(Continued from page 243)

ducers. The new company is exploiting the Kyle condenser loud speaker and has embarked upon the manufacture of receivers employing the new reproducer. To enter the receiver field, the reproducer company acquired the Arborphone Company, an R.C.A. licensee. Whether the outcome of this fundamental change of policy means the abandonment of leadership in the reproducer field in order to concentrate on the receiver business is not yet determined.

Another merger which held hope of becoming of major significance was that of the Charles Freshman Company with the Freed-Eisemann Radio Corporation. Both of these companies were operating in rented manufacturing plants, unsuited to expansion. As a result of the merger, they acquired a new plant in which both brands of receivers are made, exchanged directors, but otherwise maintained their separate identities through competitive advertising and merchandising. The Charles Freshman Company recently changed its name to Earl Radio Company; Freed Eisemann is Freed Radio Corporation. Both are pioneer radio companies which have been, at different times, among the topnotch producers. The effect of combination has not yet manifested itself as advantageous; both companies are in the hands of a receiver.

Tube Makers Merge

A merger of several successful tube companies, some of them rather small units, resulted in the formation of the National Union Radio Corporation, a combination of Sonatron, Televocal, Marathon, and Magnatron tubes. It is not yet determined whether this merger is merely a pooling of the capital stock of the various companies which are to operate as individual units through a combined merchandising department, or whether the brand names will be submerged under a new brand name. It requires an outstanding merchandising success to establish the importance of this merger, but potentially this is a major independent tube company.

Another smaller merger in the same field is that represented by the present Marvin Tube Company. The essential units of the present company were six scattered and small companies, now unified, but already under partial control of the Studebaker interests, of South Bend, who are the leading financial factors in Colin B. Kennedy.

One of the most notable events in the tube field is the association of the Raytheon Manufacturing Company with National Carbon, the latter having an exclusive merchandizing contract and general supervision over the operations of the former.

A different character of merger is represented by the combination of interests of Utah, Eby, Carter, and Caswell Runyon, each suppliers of different elements of radio receivers to set manufacturers, Utah being an outstanding reproducer manufacturer; Eby, binding posts; Carter, small parts; and Caswell Runyon, cabinets. Substantial sales economies are promised as a result of this merger because each of these companies has heretofore maintained a separate sales force, each catering to the same trade. The merging of Easton Coil Company with Polymet can also be included in the miscellaneous classification.

The acquisition of the Aucrian Radio & Research Corporation, makers of Amrad sets, by the Crosley Radio Corporation is merely an acquisition of stock ownership. Both companies are operating separately without coordination of their respective sales departments or distribution systems.

One retail distribution merger indicates a trend which may gain headway on a very extended scale in the immediate future. This is the merger of Davega, Abe Cohen, Exchange, City Radio Stores, Atlas Stores

G-12

Corporation, and Fanmill, making a total of 61 retail outlets distributing in the principal radio centers of the East and Central West. With the prospective competition of well-established automotive retail distribution systems, widespread merger of the small independent radio retailer in equally well-organized chains is not an unlikely prospect.

The characters of mergers in the radio industry, up to this time, have, with but a few exceptions noted above, been more or less of a distress nature and do not represent greater efficiency in distribution or the combination or elimination by absorption of important companies. The time is now ripe for merger conversations and the writer has noted, in his contacts about the industry, that this thought is becoming uppermost in the minds of many radio executives.

THE R.C.A. THEREMIN

(Continued from page 202)

volume is secured when the UX-120 emission is zero, or nearly so.

Thus, a movement of one hand in relation to the pitch-control rod will cause a variation in pitch and allow the playing of music. A movement of the other hand in relation to the volume-control loop will cause an increase or decrease in volume. The combination of these two movements constitutes the technique of playing the RCA Theremin.

The tables below give the electrical and physical characteristics of the Theremin.

ELECTRICAL SPECIFICATION

Voltage Rating	105-125 Volts
Frequency Rating	50-60 Cycles
Power Consumption	90 Watts
Type of Circuit	Special beat-frequency oscillator with a.f. stages
Number and Types of Tubes	Three UX-227, 1 UX-224, 1 UX-120, 2 UX-171A and 1 UX-280—Total 8
Number of Oscillators	3
Type of Detector	Two-grid detector modulator
Number of A. F. Stages	2
Recommend Loudspeaker	RCA Loudspeaker 106
Musical Range	—3½ Octaves
Lowest note of loudspeaker	to 1400 cycles approximately

PHYSICAL SPECIFICATIONS

Height to top of Pitch-Control Rod	64 in.
Height of Cabinet	46½ in.
Width, including Volume-Control Loop	31½ in.
Width of Cabinet	19 in.
Depth	12 in.
Dimensions of Packing Case	14½ in. x 24 in. x 51 in.
Weight, Net	67½ lbs.
Weight, Shipping	99 lbs.

THE SUPREME DIAGNOMETER

(Continued from page 218)

open, shorted, or leaky by-pass condensers by observing the voltmeter response to the potential applied in series with the condenser under test. This method is in addition the means for testing condensers by a charge and discharge through the d.c. voltmeter.

Regardless of the technical knowledge possessed by a serviceman, he needs the proper equipment to make his task—keeping radio receivers happy—simple and efficient. The writer has found that the Supreme Diagonometer enables all necessary measurements that are necessary in service to be made expeditiously and without stumbling about to discover where trouble lies.

TYPE 360 TEST OSCILLATOR



One of the new test oscillators for the radio service laboratory is now ready. It will deliver a modulated radio-frequency voltage at any point in the broadcast band (500 to 1500 kilocycles) and at 175 and 180 kilocycles. The tuning control is calibrated with an accuracy of 2 per cent.

The Type 360 Test Oscillator is intended to be used for neutralizing, ganging, and tuning of the radio-frequency stages in a receiver, and it is fitted with an output voltmeter for indicating the best adjustment. This voltmeter is of the copper-oxide rectifier type, and by means of a switch it may be connected across a 4000-ohm load or across the dynamic speaker of the receiver when making tests.

Price \$110.00

GENERAL RADIO COMPANY

30 State Street

Cambridge, Massachusetts

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Consultant and Technical Writer

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SMOOTHES OUT RADIO VOLTAGE "BUMPS"

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Condensers Resistors Volume Controls
Coils Transformers Magnet Wire

No. 325

RADIO BROADCAST Laboratory Information Sheet

February, 1930

Beat-Frequency Oscillator

AN ARTICLE entitled "The Frequency Characteristics of Telephone Systems and Audio Frequency Apparatus, and Their Measurement," written by B. S. Cohen, A. L. Aldridge, and W. West, and published in the September, 1926, *Proceedings of the Wireless Section of The Institution of Electrical Engineers*, England, gives the circuit and constants of a beat-frequency oscillator for use in making measurements on telephone apparatus. This circuit is reproduced on "Laboratory Sheet" No. 326.

Each high-frequency oscillator circuit comprises a grid coil, L_2 , of 50,000 microhenries coupled to a plate coil, L_1 , of 20,000 microhenries and tuned by a fixed condenser, C_1 , of about 0.001 mfd. A variable condenser, C_2 , with a maximum value of 0.0005 mfd. is connected in parallel with condensers C_1 to cover a frequency range of about 5000 cycles. The output coils, L_3 , each of 10,000 microhenries, introduce the high frequencies from each oscillator into the high-frequency amplifiers, V_2 —the use of these high-frequency amplifiers serves to prevent interaction between the two oscillators. The coupling between the output of the high-frequency amplifiers and the detector is obtained through a coupling condenser, C_4 , and the two-megohm leak in the grid circuit of the detector tube. The detector,

V_3 , is of the plate-rectification type. In the plate circuit of the detector is a low-pass filter having a cut off at about 20,000 cycles. The filter functions to reduce to negligible values the high frequencies in the output of the oscillator. Two stages of resistance-coupled amplification are used between the detector and the output of the oscillator.

With a special output transformer it was still found that there was a tendency for the output to fall off at high frequencies. This was corrected by reducing the output at low frequencies to the value obtained at high frequencies. This was accomplished by means of an 0.2-henry air-core inductance, L_4 , in the plate circuit of the amplifier V_4 . In series with the inductance is the variable non-inductive resistor, R_4 , which in combination with the choke coil produced the desired rising frequency characteristic so that a uniform output could be obtained.

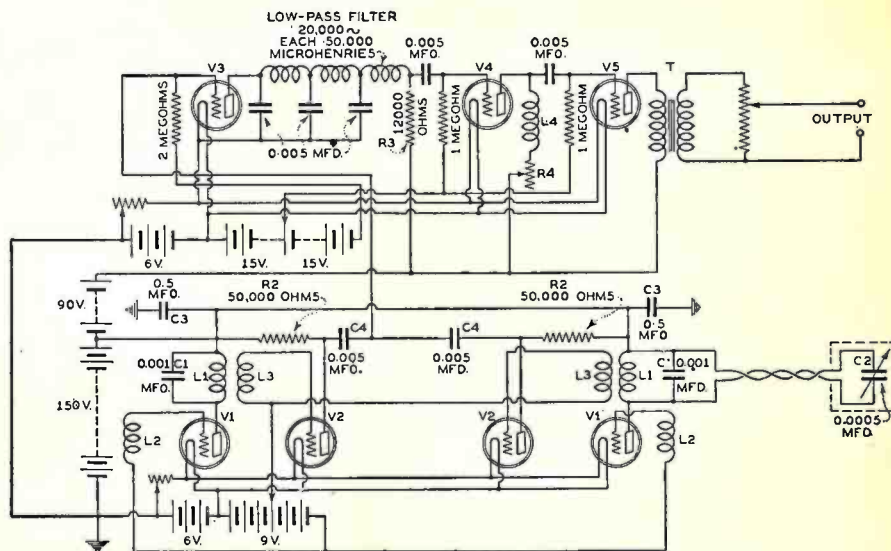
The harmonic output determined by means of an oscillograph was found to be less than 5 per cent. and could be further reduced by connecting a condenser in shunt across the input to the detector tube. This provided in the plate circuit of the high frequency amplifier tubes a lower impedance for the harmonics than for the fundamental and tended to improve the wave form of the high frequencies impressed on the detector tube.

No. 326

RADIO BROADCAST Laboratory Information Sheet

February, 1930

Beat-Frequency Oscillator



No. 327

RADIO BROADCAST Laboratory Information Sheet

February, 1930

Fidelity in Modern Receivers

THE ONLY way the user of modern radio apparatus can make his receiver distort is by (a) not tuning it accurately to the station to be received and (b) increasing the volume to the point where overloading occurs in one or more of the tubes. Distortion due to (b) rather than (a) is most generally found in practice, but trends in receiver design are gradually leading to receivers in which the tubes cannot be overloaded. Such receivers cannot be made to produce distortion other than that inherent in the characteristics of the circuit or that produced by improper tuning.

Tube overloading generally takes place in the detector and power tube long before it becomes serious in any of the other tubes. The task, therefore, is to design sets in which the amplified audio-frequency output of the detector is sufficient to apply the maximum permissible voltage to the grid of the power tubes (the maximum permissible voltage being limited by distortion in the power tube) and to include some method making it impossible to apply signal voltages in excess of the maximum permissible value to the power tube.

To design such a set we must first determine the maximum a.c. voltage which may be impressed

across the power tube before distortion occurs. We then work back through the a.f. amplifier and determine how much a.f. voltage is required from the detector tube. Then, knowing the rectification characteristics of the detector tube, we can determine the maximum r.f. voltage which must be impressed on the detector. In order to impress on the detector a value of r.f. voltage which, when rectified and amplified, will impress the maximum permissible voltage across the power tube, automatic volume control circuits must be used. In such sets it is a function of the automatic control circuits to limit the detector input to this predetermined value regardless of the value of the field strength. Therefore, such a receiver cannot be overloaded.

The manual volume control in such a receiver is located in the a.f. amplifier so that the desired portion of the a.f. voltage from the detector may be impressed on the power tube. However, the design should be such that it is impossible to apply sufficient a.f. voltage to overload the power tube. The automatic volume control circuit which limits the maximum value of the a.f. output from the detector makes such a design possible.

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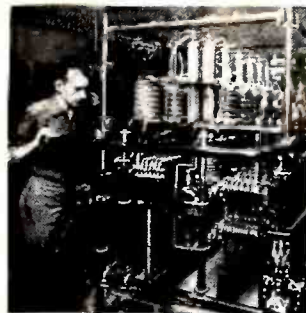
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