RADIO BROADCAST

AUGUST, 1927

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Contributing Editor

Vol. XI, No. 4

CONTENTS

AMONG OTHER THINGS. . .

RADIO, or at least, its basic principles, be it known, is gradually influencing other fields, and one of the most interesting examples of this is told by James Millen in our leading article this month which describes the ingenious weightmeter developed by Albert Allen of Boston. While the theory of operation of this remarkable device is not complicated, many seemingly insurmountable problems were encountered and conquered before the instrument was practical enough for the strict requirements of commercial use.

A WORD about some of the authors in this issue may be of interest. Herbert G. Reich, whose shielded neutrodyne is described in these pages, is a member of the Department of Physics at Cornell University. A. V. Loughren, whose paper on vacuum tubes appears in this issue, is in the research laboratories of the General Electric Company at Schenectady.

THE Directory of Manufactured Receivers which appears in this number, beginning on page 250, should prove of wide interest. Tabulated data on receiving sets have appeared before, of course, but the information has been sketchy while our Directory is as complete in detail as it is possible to make it. From this listing, it is possible to determine much about the circuit of any receiver listed, how its volume is controlled, how many and what sort of tubes there are and how much current they take, what accessories are supplied and, important enough, the size of the cabinet. What is more, by using the Service Department coupon, more complete or additional information will be forwarded each inquirer with a minimum of trouble to him. The Directory will appear regularly and will be improved each month with additions and corrections. Naturally it has not been possible to include even nearly all the receivers on the market, but we believe that, with the monthly additions, the list will prove an adequate source of information to such as may find it necessary to refer to it.

WE SHALL soon publish a paper by B. F. Miessner, whose work with 2-amp. a.c. tubes has become so well known. There is wide interest in the characteristics and use of these tubes and Mr. Miessner has prepared a very interesting paper indeed. . . . The Laboratory has designed an inexpensive and extremely simple tube tester which for some time has been put to good use out here at Garden City. Complete constructional and operating information about this tester will appear soon.

—WILLIS KINGSLEY WING.

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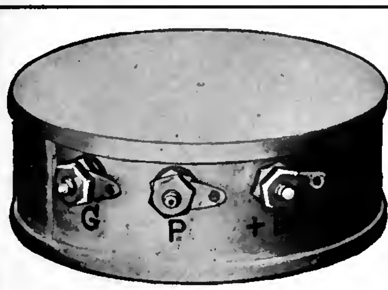

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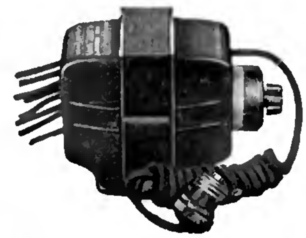

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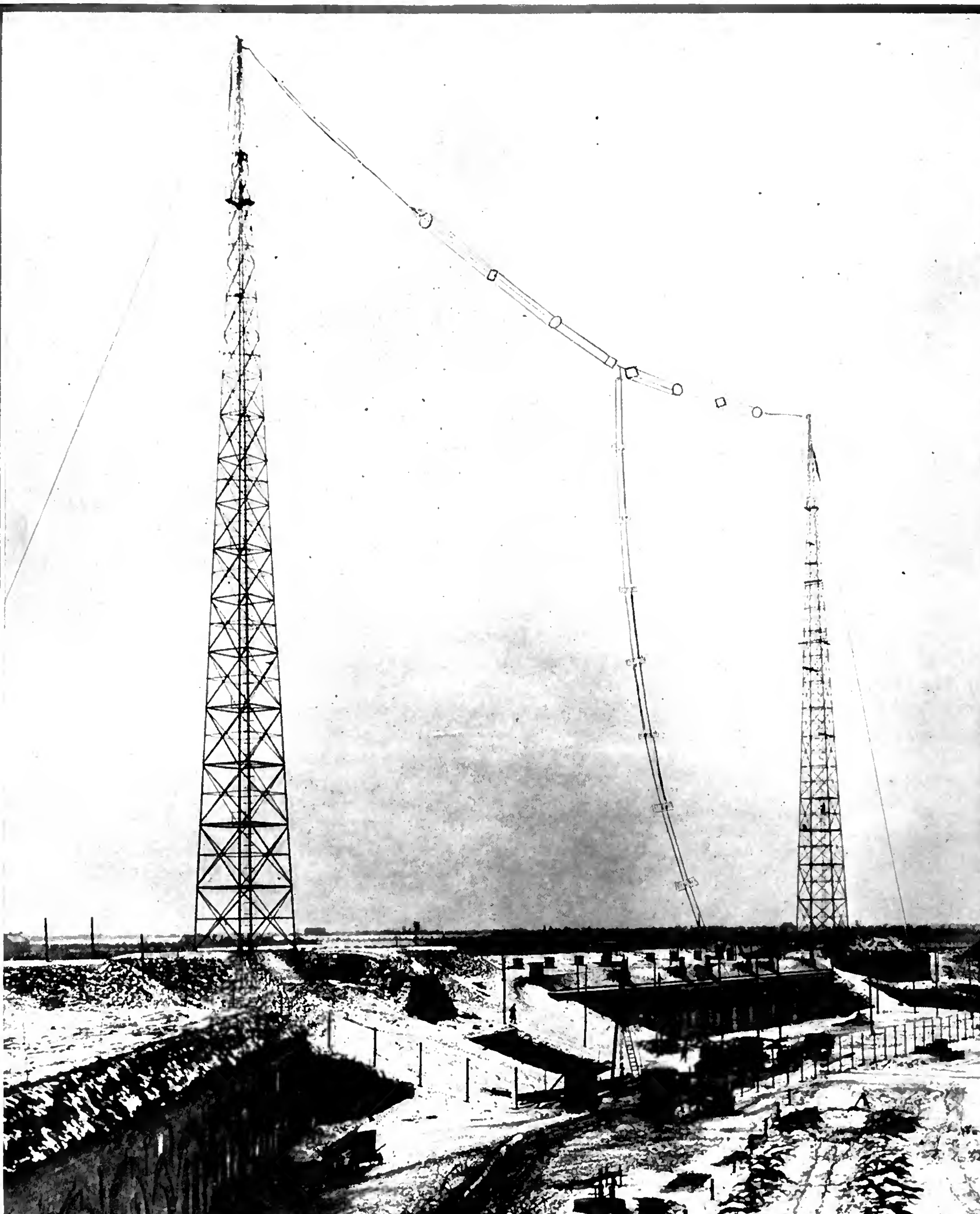


THE BROADCASTING STATION AT WARSAW

Located seven kilometers from Warsaw, this station is installed at Fort Mokotow. The Fort was built twenty-five years ago by the Russians, but has not been used for its original purpose for some years. The power is 8-kw. to the plates of the tubes. The antenna current is 30 amperes on a frequency of 269 kc. (1111.5 meters). The crystal range of the station is said to be 75 miles

RADIO BROADCAST

VOLUME XI — NUMBER 4

AUGUST, 1927

Saving Paper!

Millions of Dollars are Saved Annually in the Paper and Rubber Industries by the Use of a Magic Device Operating With Radio Principles

By JAMES MILLEN

WHILE rapidly assuming a deserving place as a separate science in itself, radio is fundamentally a branch of electrical engineering. During the last few years, in which such great strides have been made toward the present-day ideas of perfection, many new scientific theories have been developed. Instead of these developments coming from the parent science, they have come from the engineers and other workers primarily interested in radio. At first, many electrical engineers were wont to consider radio as a mere toy or public plaything not worthy of their attention. Then, as time passed and startling progress in the new field became apparent, well-known electrical engineers began to devote their skill to the furtherance of development in the new field. Where "cut and try" ruled before, calculus and electrical engineering theory began to come to the front. Thus resulted the neutrodyne and many other genuine developments.

But, no sooner had these fatherly gentlemen begun to aid their offsprings in the perfection of a new "toy," than they began to realize that much of the theory involved was not only new and unique, but that it might be applied to their own established science as a panacea for long-endured ills.

Perhaps the first indication the public had of progress along such lines was the press reports of a year or two ago regarding the use made of radio by large electric light and power companies to forewarn them, by means of static disturbances, of approaching thunder showers so that they might be prepared in advance for a sudden increased demand for power for lighting.

But while many such applications of radio principles to industrial use have been and are yet to be made, few indeed are as vitally important and yet seemingly impossible as that conceived some two or three years ago by a Maine man, then working as a cadet engineer in a large paper mill. To-day his devices are in use in paper and rubber mills throughout the country, automatically regulating the uniformity of the mills' sheet products.

THE "RADIO SCALES" IN OPERATION

Albert Allen, inventor of an instrument known as the weightmeter, shows a foreman in the paper mills of the Eastern Manufacturing Company at Bangor, Maine, how to weigh a strip of moving paper without actually touching it. Formerly it was necessary to tear a sample piece for weighing, with an ordinary pair of scales, from the edge of the moving paper

Several years ago, Albert Allen, like many other electrical engineers, realized that maybe there was something practical and worth while to this radio stuff after all.

He constructed a number of receiving sets and did much experimental work with them. One night, while his set was tuned to one of the local broadcasting stations, he took a piece of paper and inserted it between a pair of the plates in one of the tuning condensers that seemed on the point of short-circuiting. The result was that he immediately heard a different station from his loud speaker. Being a true electrical engineer, he realized that such was as might be expected. The paper, because of its different dielectric properties than air, had changed the electrical capacity of the condenser, and likewise the wavelength to which his set was tuned, bringing in a new station.

Later, when at his work in the mill, he stopped to watch the long sheet of new paper passing through numerous rollers and machines in an endless strip. Every little while, the foreman would tear a piece of paper from the strip, mark it, and send it off to the laboratory. Then a report would come back and he would readjust his machine. The purpose of this act was

TESTING THE EFFICACY OF THE WEIGHTMETER

The inventor of this remarkable device, Albert Allen, is to the right of this group in the laboratory. To the left is William Ready, of the National Company, while the author is in the center

to determine the weight per given area of the paper—whether it was up to the required standard, or overweight. If overweight, the company was losing money; if underweight, the customer might refuse to accept.

But just imagine how crude and costly such a process was? The piece torn out might not be representative. The strip was damaged, much time was wasted, and most important of all, all sorts of variations might take place between tests without anyone being any wiser.

Young Allen recalled his experience with his radio set and the piece of paper. Why not, thought he, apply the same principle to providing a continuous, instantaneous, check on the paper conditions. For two years, he devoted his entire time to the problem. At first he experimented alone, then, as success seemed certain, and as the president of the paper mill realized the tremendous value of his idea, he joined with a staff of competent research engineers in the engineering laboratories at Harvard University.

Finally, finished working models were developed to the point where they were considered reliable and practical enough to be installed in the paper mills of the Eastern Manufacturing Company, at Bangor, Maine.

Then came necessary re-design as a result of the information gained under operating conditions. Trouble with dust accumulation, trouble due to variations in temperature causing greater variations in instrument readings than variations in paper weight, trouble due to the tremendous variations in the line voltage from which the instruments were operated—all had to be overcome. Troubles of all kinds were encountered, but even so, the new method was far better than the old.

But every cloud has its silver lining, and it was not long before the difficulties were overcome and the initial idea carried a step further, so that the "weightmeter," as the new instrument was called, not only recorded the variation in weight of the stock being passed through it, but, by means of suitable relays, automatically controlled the paper machines so as to keep the stock at any desired weight.

HOW THE WEIGHTMETER WORKS

SOME may be interested in a more explicit explanation of just how the weightmeter functions—how a minute change in the capacity of an electrostatic condenser can result in the control of a several-horsepower motor operating the calenders in a rubber mill, for instance.

The fundamental principle by which a very minute variation in the electrostatic capacity of a condenser may result in a readily measurable change of current, is illustrated in Fig. 1. Here we have an oscillator, "A," coupled, by means of the coils "B" and "C," to a tuned circuit "D." Tuning the circuit "D" to resonance with the oscillator "A" results in a deflection of the thermal meter "E." By properly arranging the circuit constants, the sensitivity of the weightmeter, or in

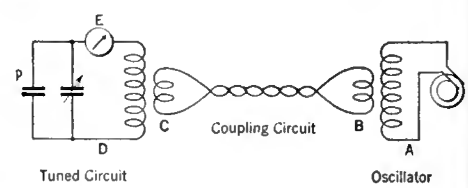


FIG. 1

The radio fan will readily recognize the elementary circuit of the weightmeter to consist of nothing more than an oscillator, wavemeter, and coupling circuit

this case, the response of the thermal meter, to minute capacity changes, can be any desired amount, from the condition illustrated by the peaked curve, "A," in Fig. 2, where even the very slightest capacity change results in a marked current change, to the other extreme condition illustrated by the low broad curve, "B," Fig. 2.

Now compare the elementary circuit diagram, Fig. 1, with the actual apparatus illustrated in the photograph on page 201. The oscillator "A," coupling circuit "B" and "C," and the tuned circuit "D," are located in the same case. The precision condenser, shown more clearly in a photograph on page 202, is used to tune the circuit

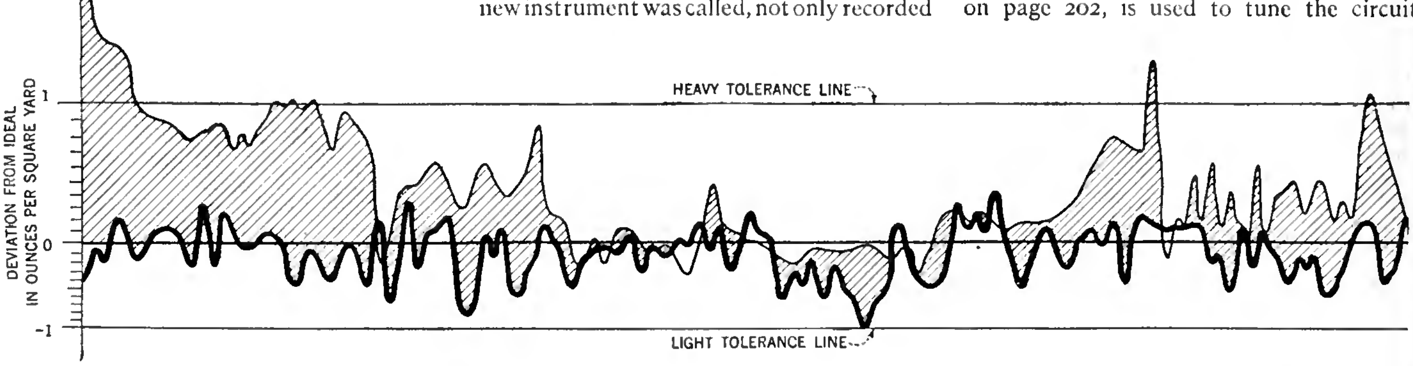


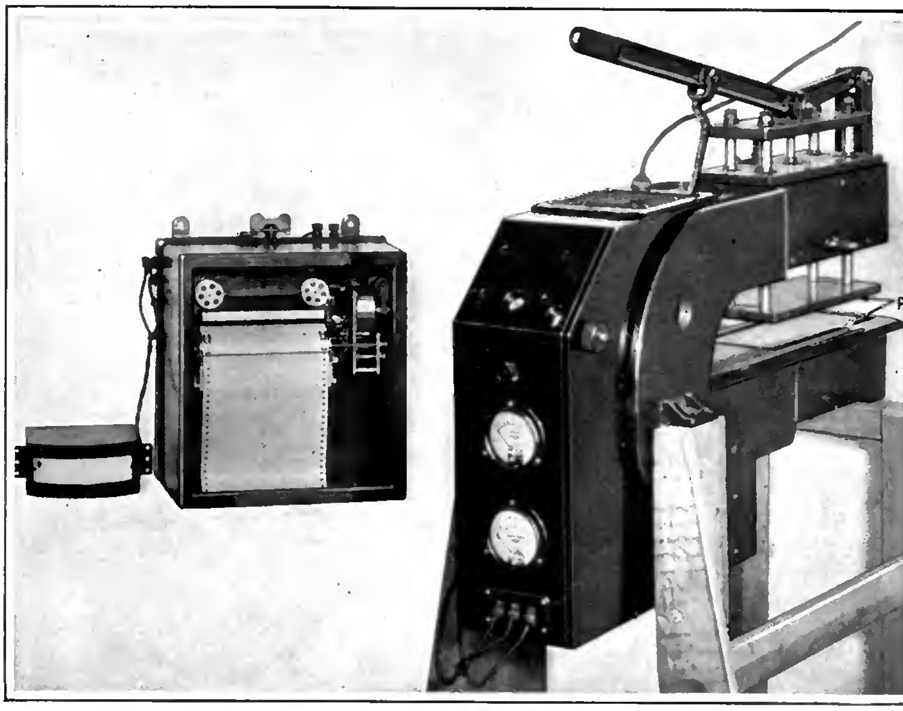
FIG. 3. A VISUAL INDICATION OF THE SAVINGS ACCOMPLISHED—

The straight center line shows the desired thickness of rubber, most economical production resulting from keeping the thickness as closely as possible—be tolerated. The heavy curve was made at a rubber mill when the weightmeter was in use, while the lighter one was made when no weightmeter—

"D" (Fig. 1) into a condition just off resonance. This condition is indicated by the arrow on the side of the curve "A" in Fig. 2. In actual practice, either side of the resonance curve may be employed.

In parallel with the precision variable condenser are two mechanically adjustable plates forming a condenser. These are indicated by the lettering "P," in the photograph and Fig. 1. If the capacitance of this condenser should change, due to a variation in the weight of the paper or other material passing through it, the tuned circuit "D" Fig. 1, either comes more closely into or further out of resonance, depending upon which side of the resonance curve is being used and whether the capacity change is positive or negative, thus changing the reading of the thermal ammeter.

By employing the recording type meter shown alongside the weightmeter in the photograph, a continuous curve may be traced, showing variations in weight of the material with time. A sample curve is shown



RECORDING METER AND WEIGHTMETER

The recording meter to the left is used to make curves similar to that of Fig. 3. The smaller instrument to the extreme left is an indicating meter, calibrated to read weight in desired units. The material to be weighed passes between the two horizontal invar plates marked "P," to the right. The upper invar plate may be varied when desired by the long handle atop the instrument

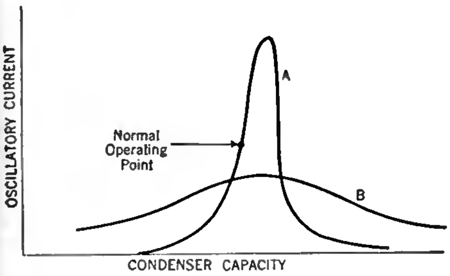


FIG. 2

The sensitivity of the weightmeter may be varied by changing the shape of the resonance curve. With a steep curve, a very minute change in weight of material (and thus condenser capacity) will cause a fairly large change in meter reading

in Fig. 3. The straight center line indicates the weight desired to be maintained. The light curve shows a rather wide discrepancy between the weight desired and the results obtained by hand feeding and the old method of actual weighing. The heavy curve indicates the results obtained when using a weight meter control. The shaded area between the two sets of curves illustrates the saving in material effected by the new control method. In addition to the actual saving in material, the product is ever so much more uniform. It will be noticed that the "light" tolerance line is nearer the "ideal" line than the "heavy" tolerance line. This variation in the two linear distances, however, does not represent a difference in upper and lower tolerance weights, but is the result of the changing slope of the resonance curve in either direction.

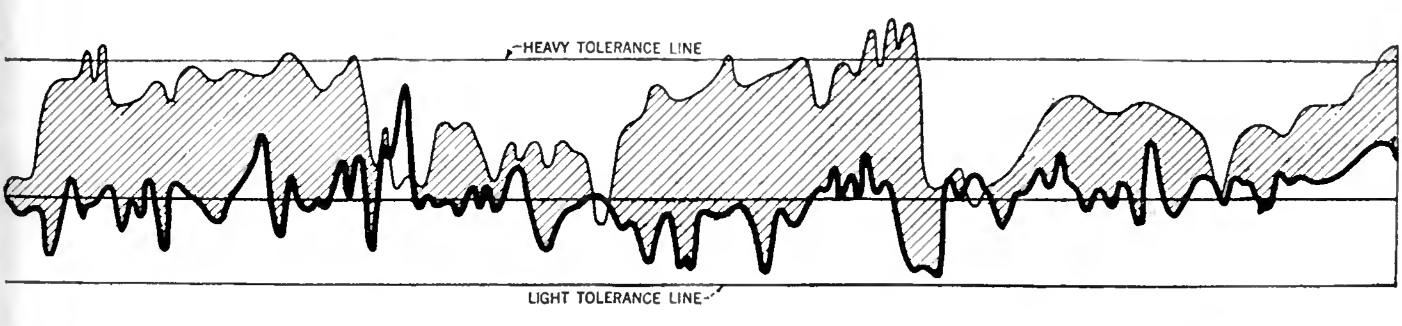
The many irregularities in the two curves in Fig. 3, are due to "feeding." Every time more rubber is fed, the stock tends to gain in weight, even though the calendar adjustments remain unchanged.

The absolute necessity for precision built apparatus cannot be over emphasized. Apparatus so substantial in design, and expertly made, as to hold its calibration under all kinds of abuse, in all kinds of climate and conditions of service, is absolutely essential if any appreciable saving is to accrue from its use.

Hence the massive cast iron frame for the fixed condenser, and also the invar steel rods and supports. If some other metal were to be substituted for the expensive invar, the least variation in temperature of the condenser would change its capacity far more than a little change in weight of the stock being measured. In the earlier weightmeters, compensating thermostatic condensers were used to correct any changes in temperature of the main condenser. Such a system was found, in practice, to be excessively complicated. The result was the design of the present invar steel unit which is not affected by temperature variations.

Another seemingly overwhelming difficulty encountered with the first commercial installation was the tremendous variations in the line voltage from which the oscillator received its power. Fluctuations of as much as 40 or 50 volts were not at all uncommon.

Ballast tubes, separate alternators, line transformers, and many other complicated and expensive remedies were tried. The final solution arrived at, however, was not only superior in performance to the other methods, but required no additional equipment of any type.



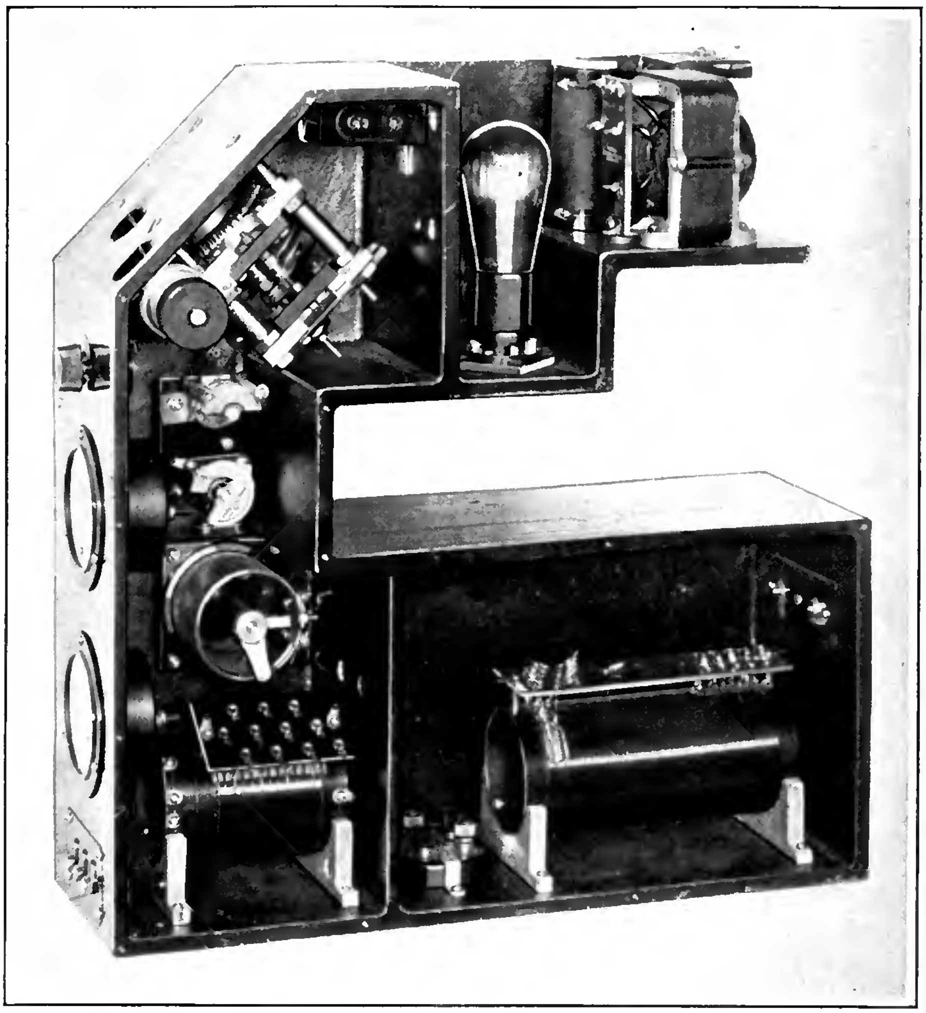
—BY THE USE OF THE WEIGHTMETER AT A RUBBER MILL

—to this value. The upper and lower horizontal lines show respectively the maximum and minimum deviation in ounces per square yard that can —was used. The shaded portions represent material saved by the use of the weightmeter. This curve represents 5950 yards of rubber $\frac{1}{20}$" thick

As a power oscillator of the type used in the weightmeter is in reality a miniature radio transmitting station, one might imagine that radio reception in the vicinity of a mill in which the weightmeters are employed would not be all that could be desired. This apparatus, however, in no way interferes with radio reception. The oscillator is tuned to a wavelength slightly in excess of 600 meters so as to be outside of the broadcasting frequency band and, also, the oscillator is so completely shielded that an exceedingly sensitive super-heterodyne located but a hundred yards away is unable to pick up the carrier. The often long exposed leads to the indicating meters do not carry radio-frequency current as the thermal-junction, belonging to each meter, is located within the shielded oscillator cabinet.

Just what the saving amounts to in dollars and cents when the weightmeter is used depends greatly upon the quality and quantity of material being manufactured. Thus, in the production of a low grade of newsprint stock in a low-speed paper making machine, the saving effected per year per machine might be as low as $10,000 or so. On the other hand, where a highly priced stock is being manufactured in a rubber factory, such as tire tread for automobiles, the saving brought about as a result of automatic weightmeter control may be ten times as great.

In one automobile tire factory, the average last year saving per weightmeter employed was approximately $80,000. As this particular rubber company employed many machines, it will be seen that automatic control was of considerable financial benefit, aside from its fundamental purpose of aiding in the making of a uniform product.

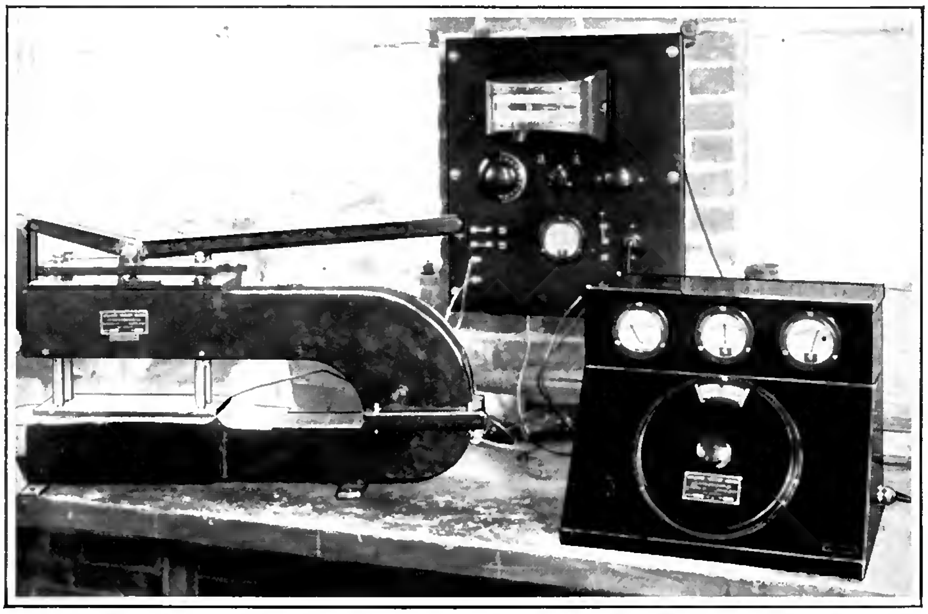


THE INTERIOR OF THE OSCILLATOR BEFORE WIRING

The case is of cast aluminum. The transformer at the upper right supplies A and B power for the UX-210 tube. The precision variable condenser is connected in parallel with the measuring plates and used to bring the tuned circuit to the desired point on the resonance curve

The weightmeter is but one of many applications of radio principles to industrial purposes—principles which, before the advent and recognition of radio broadcasting as a major art, were, perhaps, little understood. That the development of this instrument is not an isolated instance of such progress, we have only to consult our journals for adequate and frequent proof.

The ideas obtained from the radio industry by Albert Allen and so successfully applied toward the elimination of a seemingly almost unsurmountable handicap encountered in the manufacture of paper and rubber—the difficulty of accurately weighing moving objects—is but a vivid example of such progress.



A DIFFERENT SET-UP OF APPARATUS

The equipment is basically the same as that shown in the photograph on the preceding page. The oscillator is the instrument to the right

The March of Radio

News and Interpretation of Current Radio Events

Revolutionary Methods Which Fail to Materialize

ILL-CONSIDERED publicity statements are the bane of the radio industry and the despair of newspaper and magazine publishers. Receiving, as we do, numbers of poorly prepared and inaccurate statements from radio manufacturers in every mail, we plead for mercy, not only to spare our weary eyes but to discourage their harmful influence on the well-being of radio.

Almost each week, a revolutionary invention is heralded in the press to disturb the confidence of the hesitant radio buyer. Many of these inventions are promises never performed; others announce hoary practices and inventions as new discoveries; all of them conspire to discourage the non-technically informed from purchasing his radio to-day in order that he may have the advantages of these doubtful but glorified inventions to-morrow.

In the pile of material before the writer are three announcements from one of the largest manufacturers in the radio and electrical industry. Considering the source of these statements, they would certainly be regarded as authoritative by any newspaper editor who did not possess an extensive background of technical knowledge and an intimate familiarity with the history and progress of the radio art. Since most newspaper men quite properly lack such detailed knowledge of radio, they naturally make much of these extravagant statements, although they belong only in the editor's waste basket.

The first of these statements announces the exponential horn as "a new invention," which received "its first public test" on May 12, 1927. Then follows a glamorous account of the magnificent improvements in tone quality which the "discovery" brings to the world. The statement totally overlooks the fact that the exponential horn, developed ten years ago, has been used in some public address systems long before the first broadcasting station went on the air; that the merits of the exponential horn have been discussed before technical societies time and again; that exponential horns are in use in thousands of homes as a part of the orthophonic phonograph and of certain power loud speakers. But how many potential loud speaker buyers decided, upon reading that statement in the press, to postpone buying a radio or a reproducer until they might have this new horn, said to "broadcast the natural human voice or tones of musical instruments without distortion for the greater part of a mile?"

The second statement deals with the transmission of radio-frequency energy, heralding a new era of wireless transmission of power. It discloses nothing, however, which any amateur having a suitable wavemeter, cannot perform in his own home for the delectation of his friends.

The third effusion by this eminent manufacturer concerns itself with a new system of frequency modulation for broadcasting stations which enables one-half-kc. separation. Approximately 1900 broadcasters can operate simultaneously without sharing waves or splitting time. It is pointed out that this will solve the congestion problem which the Federal Radio Commission is now trying to overcome.

Extraordinary, absurd, and unwarranted claim! The statement entirely neglects the fact that this invention, before it can have any bearing on the work of the Radio Commission, must undergo the following tedious processes:

(1) Laboratory research and development; (2) standardization of transmitters and receivers utilizing the new principle and suited to quantity production; (3) remodeling of every existing broadcast transmitter to one using the new system and (4) the probable replacement or alteration of every existing receiving set for one of the new type receivers at a cost to the listening public of perhaps a billion dollars or so.

Each one of these problems has its share of hazards and pitfalls which those who issued the statement have reason to know as well as anyone. To state that the invention of frequency modulation has any bearing on the solution of present-day broadcasting problems is both absurd and well-nigh malicious, since it encourages small broadcasters, now gradually dying from neglect by the listener, to redouble their expiring efforts to remain on the air.

Some day, the radio industry will learn to restrain its blabbing tongue until it has the goods, ready to sell, on the dealers' shelves. The automobile industry does not announce a new type of car until every dealer all over the country has his demonstrator on hand. Thereby, motor car manufacturers capitalize public interest, aroused

TELEPHONING TO SHIPS AT VANCOUVER, B. C.

The installation in the Vancouver Merchants' Exchange Building, with J. E. Harker, chief operator. More than forty British Columbian tug boats are equipped with 50-watt telephone sets, operating on 1507 kc. (199 meters). Any one aboard ship can operate the sets, the average range of which is from 60 to 150 miles, giving loud speaker volume at the receiving station. The sets are used to facilitate the delivery of lumber being towed down the waterways. Much of this is sold while enroute. It is the only service of its kind in the world and is operated by the radio branch, Department of Marine and Fisheries by their announcements, and convert that interest directly into cash sales. The radio industry, on the other hand, childishly chooses to make its announcements prematurely, thus bringing to an immediate stop any buying activity which may be manifest at the time. Then, months or years later, when it finally has its new product ready for sale, it cannot again stimulate any real public interest because the publicity men have already done their croaking.

The publicity disease has gone too far to be quickly remedied. Some encouragement might be given by a more conservative attitude on the part of newspapers. Instead of accepting as gospel truth the publicity statements offered them, they might first check with their own radio staffs or, in absence of a competent radio staff, take advantage of high-grade radio feature syndicate services which offer them the protection of expert and conservative censorship.

The Commission Regulates Broadcasting for the Broadcasters Not the Listener

THE Federal Radio Commission, still occupying the center of the radio stage, has made its first comprehensive re-allocation, effective June 15. In the congested areas, stations are now separated by at least fifty kc.; time-sharing is enforced upon the lesser stations and some interesting power reductions have been made. These power reductions are announced by the Commission as experimental. We hope that the experiment may soon be concluded and plenty of power be permitted to all our outstanding stations—which is not now altogether the case.

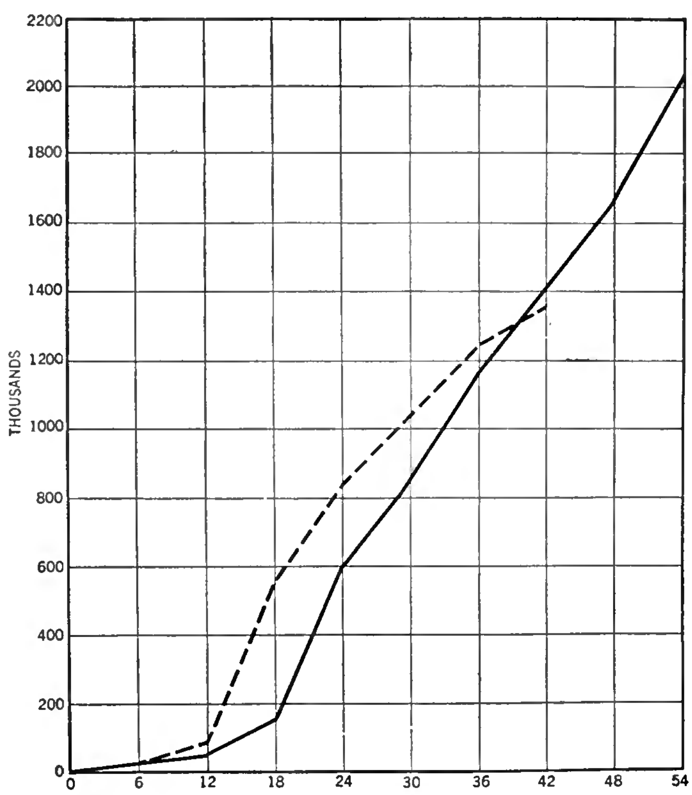
The enforced curtailment of the activities of the lesser stations has transferred much howling from the broadcast listener's receiver to the crowded doors of the Radio Commission. In deciding upon the case of individual stations, service to the public, as determined by program standards, quality of transmission, length of service, and orderly conduct through the late chaos, have been taken into consideration. Clean channels have been given to recognized old-timers and we are pleased to see the principle of priority of service, urged in these columns for more than a year, actually put into practice.

The New York allocation, for example, gives WNYC, WEAF, WJZ, WOR, WHN (with WQAO operating only on Sundays), WMCA (sharing with WEBJ which uses only six hours a week), and WABC (sharing with its own transmitter, WBOQ) practically undivided time. The most popular stations are therefore given a full opportunity to serve their respective audiences which, combined, probably include 90 per cent. of all listeners in the area. In the questionnaire which so many of our readers filled out, considerably more than half the New York listeners expressed themselves identically as to their favorite stations, placing WEAF first, WJZ second, and WOR third, while more than 96 per cent. of the replies included at least one of these three stations among their first, second, and third choices. Only WNYC, which ranked eleventh in popularity, seems to have received curiously favored consideration on the part of the Commission in being included in the list of seven stations with virtually exclusive channels.

A point brought out with striking emphasis by our questionnaire, regarding the stations which have been compelled to divide time four or five ways on the less desirable channels, is that they are nobody's favorites. Some of our readers listed as many as ten "favorite" stations, yet 21 New York stations were not mentioned as favorites by a single listener. These same 21 insignificant stations are most prominent in the listings of stations which the listener wished eliminated, receiving 25 per cent. of the demands for a "permanent signing off." And, mind you, this 25 per cent. does not include such widely disliked stations as WHAP, WKBQ, and WLWL, which three stations alone polled 20 per cent. of the demands for elimination. Hence, the Commission's judgment, in giving the two National Broadcasting chain stations, WEAF and WJZ, and the five independents, WNYC, WOR, WHN, WMCA, and WABC, virtually exclusive channels, is fully justified.

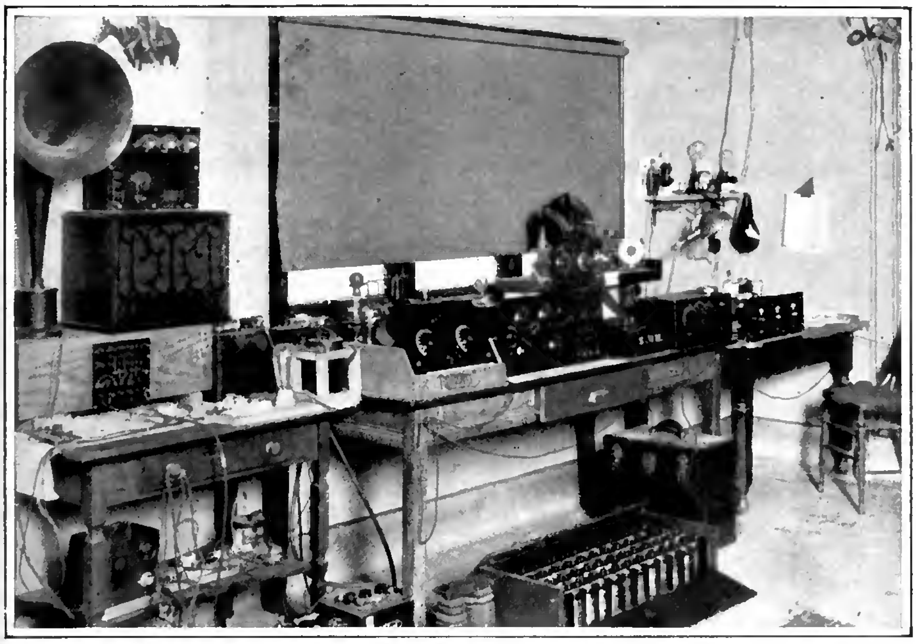
In the Chicago area, KYW is the only station favored with an exclusive channel. Our Chicago readers divided their first choices between KYW and WGN almost to the exclusion of other stations. Station WMAQ is the strongest second choice and WEBH the strongest third, while, strangely enough, neither of these latter two polled a substantial number of first choices. The superior standing of these four stations over all the others in the Chicago area is not, however, recognized by the Commission as in the case of the New York favorites. These four are treated no better than such wholly unpopular stations as WCFL, which is practically tied for first place with WGES in the demands for stations to be eliminated, and WJAZ, running a strong third in the unpopularity contest because of the prejudices aroused by its leadership in upsetting broadcasting conditions. It seems that the only discrimination made in the Chicago area, in deciding whether a station should divide time two, three, or more ways, is power and not service to the listener.

Considering the national situation as a whole, many assignments have been made which are impossible. Let us examine a few frequencies. The first on the list is 550 kc., shared by KSD and WMAK, the latter's 750-watt carrier certainly being sufficiently strong to cause serious interference with the former, at least in winter. The next channel, 560 kc., finds WNYC in the same bed with WHO, 5000 watts, which very likely will cause a steady whistle in New York. At 580 kc., we find an untenable assignment, WMC, Memphis, Tennessee, and WCAE, Pittsburgh, both 500-watt stations. The popular Philadelphia stations, WOO and WIP, must contend with a thousand-watt station, WOW, in Omaha, Nebraska, which probably limits the range of the former stations to their limited high-grade service area only. Two Baltimore stations, WCAO and WCBM, will not find WMBF's carrier, which pumps strongly into their locality, any improvement on their programs; nor will WCSH, the principal reliance of a large New England area, find its programs favorably affected by WSAI's powerful carrier. Unless WEW is sharing time with WOC, we cannot understand how either St. Louis, Missouri, or Davenport, Iowa, can be expected to enjoy its best local station with another powerful and nearby station sharing the 850-kc. channel. Nor can a listener enjoy WKRC's program in Cincinnati with WBZ, only six hundred miles to the east, sending its 15,000-watt carrier out on the same frequency. Station KMOX will



GROWTH OF LISTENERS IN ENGLAND AND GERMANY

The two curves, the plain one representing England and the dotted one Germany, show how licenses were issued for the reception of broadcast matter in those countries. A period of four and a half years is considered



A CORNER OF THE BUTTE, MONTANA, RADIO CLUB ROOMS

Among the complete equipment there is a broadcast receiver, a long-wave Reinatz receiver, a 50-watt short-wave transmitter using the call 7NT, and several short-wave receivers. The president of the Club is Judge W. E. Carroll; C. J. Trauerman is publicity director, M. E. Cooper, secretary, and J. R. Bartlett is vice president

probably sound like old times with WBAK in Harrisburg, Pennsylvania, on the air at the same time on the same frequency.

But, enough of this; all *local* heterodyning and cross-talk have been eliminated. Heterodyning carriers from distant stations will not cause serious annoyance during the summer, because of attenuation of the carrier. But these June 15 assignments leave us far from a solution of the broadcasting problem.

One might conclude that the Radio Commission has failed in its duty of regulating broadcasting in the interests of the listener because, on the face of things, it has fallen far short of eliminating the heterodyne squeal entirely. The Radio Commission has done the best possible job of trying to put a carload of apples into a bushel basket. No matter how you juggle some 600 stations, many of considerable power, they cannot be accommodated on the broadcast band without heterodyning. We have preached the doctrine of station elimination consistently because it is the only practicable answer to the problem. The number of stations must be reduced to 200 or 225 so that the listener may have clear programs no matter where he is located. The only alternative is to cut the power of 400 to 450 stations to 50 watts and allocate only 75 or 100 stations to favored channels.

The Commission has elected to avoid the closing of any station, presumably because it does not care to have its prerogatives tested in the courts. It realizes that one successful injunction would bring chaos even worse than that of the last season and, with it, the actual bankruptcy of the entire industry. The broadcasters have already shown that they act like small boys when the teacher is away—if the slightest fetters are placed upon the regulatory power. So the Commission is proceeding to do the impossible, namely, to accommodate the host of broadcasting stations in a frequency band which cannot hope to accommodate half of them properly; in effect, it is ruling broadcasting for the benefit of the broadcasting stations rather than for the broadcast listener.

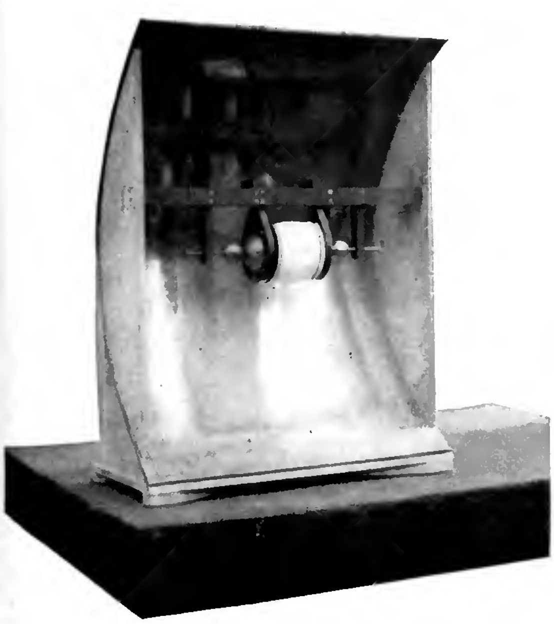
If the Radio Commission must wear gloves, we wish they would choose boxing gloves and hand out a few knockout blows.

What Commissioner Bellows Thinks About DX Listening

COMMISSIONER Bellows is credited with saying that DX listening must be abandoned. The DX listener is frequently scored by the radio engineers, particularly those who have an appreciation of good tonal quality. They realize, as does everyone who secures really good quality, that the range limit of high-quality reception for a 500-watt station is some thirty miles and, for a 50,000-watt station, one hundred miles. Anything beyond this distance the engineer considers DX reception and frowns upon as unnecessary.

It is not generally realized, however, that these frowns shadow nearly 80 per cent. of the area of the United States! Only about 20 per cent. of our area lies within the high-quality reception range of any broadcasting station! If the radio business and the radio listeners of 80 per cent. of the United States are of no account, it is fair to set down DX listening as of no value.

Fortunately, the engineers do not rule the world. Some listeners are willing to listen to a station three or four hundred miles distant in spite of them. Indeed, a great many are compelled to listen to



A REPLICA OF MARCONI'S FIRST EXPERIMENTAL APPARATUS

With similar apparatus, Senatore Marconi demonstrated in 1895 the possibilities of "beam" transmission and reception, and later confirmed his results officially before representatives of the British Post-office and the military on Salisbury Plains, in September, 1896, when he communicated over a distance of $1\frac{3}{4}$ miles. The transmitter is at the left, and the receiver, at the right

stations at such "great" distances because the nearest high-grade broadcasting is at least that far away. In our recent questionnaire, we asked our readers to list the favorite out-of-town stations which they wish retained. More than 60 per cent. of New York listeners asked for the continuation of KDKA; well over 50 per cent. cast votes for WGY. Preferences continued in the following order: WBZ, WSB, WTAM, WLW, WOC, WLS, WPG, KYW, WMBF, WSAI, WEBH, WGN, and WBAL. The lowest of these were mentioned by more than 15 per cent. of our readers as "long-distance" favorites.

And still they say DX listening is of no importance!

Never Again Without Radio!

TWO continents waited breathlessly for news of the hero-aviator, Charles A. Lindbergh, as he braved the immense solitude of the transatlantic sky. But a few days before, that same sky had conquered Nungesser, that great fighting aviator, enveloping him in a blanket of complete mystery. There would have been neither suspense nor mystery had these intrepid fliers carried a radio transmitter.

Radio has repeatedly demonstrated its service to long-distance flying from the day, more than ten years ago, that Irwin's SOS saved the crew of Vaniman's dirigible on the first transatlantic flight attempt. Lack of radio equipment nearly lost us the crew of the *Pn-9*. Radio made the whole world a by-stander as the *Norge* swept across the North Pole last summer. Where men venture into danger—whether it be transatlantic flight, polar expedition, or the conquest of equatorial jungle—radio has saved lives and removed isolation; without radio, they have vanished into heroic oblivion.

Why not profit from experience? We hope that never again will a transatlantic flight be undertaken without the protection which a radio transmitter affords. We cannot recall a single case in which a suitable radio transmitter has failed to bring prompt rescue to a plane which has made a safe forced landing on the sea.

Why We Need More Listeners

A NEWSPAPER report states that "one chain" of broadcasting stations will spend two million dollars for talent in the coming year. The cost for talent for a commercial hour ranges, on an average, between five hundred and two thousand dollars. Top-notch entertainers are said to receive from a thousand to two thousand dollars for a single studio appearance, while one jazz orchestra is booked for $1500 an hour. Still, one of the problems of radio is how the standard of programs may be improved. Commercial broadcasters cannot be expected to spend larger sums and to present better programs unless the numbers of the radio audience increase proportionately to their increased expenditures.

A most important problem of the radio industry is to make better known what it offers as an inducement to the purchase of a radio set. The sales barrage on the public has been concentrated upon selling the radio receiver as a perfected electrical instrument. The important work of making the big programs on the air better known has been more or less neglected. Broadcasting needs more listeners in order that programs may be improved and programs cannot improve unless there are more listeners. Advertising and sales effort, directed to the non-radio user, should stress the variety and quality of radio education and entertainment. On the other hand, the radio expert complains of the glittering generalities in the advertisements which are spread before him in the radio magazines. Why not recognize the distinction between radio users and non-radio users and plan advertising which appeals specifically to the radio user in the radio magazines and to non-radio users in the consumer magazines?

Unsnarling the Patent Tangle

THE National Electric Manufacturers' Association has appointed a committee to investigate the patent situation in the electric industry. Undoubtedly, this committee will deal with the radio situation, the branch of the industry now most seriously involved in the meshes of patent complication. Included in the membership of the committee are A. G. Davis of the General Electric Company, A. Atwater Kent of the Atwater Kent Manufacturing Company, and M. C. Rypinski of Federal-Brandes. It is unlikely that much progress can be made until certain important patent cases are adjudicated. Considering the tremendous cost of research and litigation and the long period before the various basic patents have become royalty producing, it is likely that there may be difficulty in restraining patent holders to sufficiently moderate royalties. In this respect, the committee can be very useful because the industry cannot suffer such burdens as 10 per cent. of the sales price of the receiver, which was once collected by one important patent holder. Considering that it would be difficult to make a radio set which does not infringe from twenty to thirty patents, the ultimate cost to the consumer may become prohibitive unless an agency, such as the N. E. M. A. committee, takes the situation in hand.

John V. L. Hogan has set an excellent example by charging only a modest royalty for the use of his single-control patent, which covers the combination of several interdependent resonant circuits, having an element which changes their respective electrical period equally and simultaneously. Thereby it covers every type of single-control receiver. In spite of its wide scope, evasions of royalty payment and legal costs have been reduced to a minimum because few, if any, manufacturers have attempted to evade Mr. Hogan's modest license fees. One of the principal reasons why radio patents are litigated to the bitter end and every obstacle is raised to avoid payment of royalties is because licensing has been restricted wherever possible to a few manufacturers, and royalties have been exceedingly high. It is likely that, if a modest scale of royalties is established for all radio patents, few manufacturers will be unwilling to give the inventor his just due.

"Canned" Programs Good and Bad

JAMES C. PETRILLO, President of the Chicago Federation of Musicians, has started a crusade against Station WCRW of that city because it has been broadcasting dance music programs with the aid of a phonograph rather than with paid union musicians. A diet of phonograph records, so long as standard commercial records are used, is an imposition upon the listening audience. It would be unfortunate, however, if this crusade should result in a regulation against the use of any phonograph records in broadcasting. A suggestion made in Edgar H. Felix's new book, *Using Radio in Sales Promotion*, points out that special broadcasting programs may be rendered in recording studios and "assembled" and "cut" in the same way that motion picture films are perfected in the film laboratories. Every part of the program, by this recording process, may be rehearsed and fitted together to make the most perfect broadcasting performance. Numbers may be shortened or lengthened, re-rendered for more perfect reproduction, and worked over until the program is worked out to the utmost satisfaction. If such a carefully rehearsed and perfectly balanced program wins popular acceptance, it can be repeated at any time through any station or stations merely by running off the records again. The use of phonograph records as a program source in this manner is quite different, however, from broadcasting ordinary four- or six-minute commercial records. A station indulging in this practice is simply giving evidence of its incompetence in securing artists, and a way should be found to cancel its broadcasting license.

The Month In Radio

P. S. HILL, Vice-President of Herbert H. Frost, Inc., parts manufacturers, makes pertinent observations as to the value of the parts business, which indicate a larger total volume than is generally conceded to that branch of the industry. During 1926, the aggregate sale of complete receivers was $225,000,000 and of parts, $75,000,000. Accessories amounted to $230,000,000. Since the cost of parts of a home-built receiver, is, in general, less than that of a manufactured receiver, it is only reasonable to assume, says Mr. Hill, that half of the accessories, which include tubes, batteries, loud speakers, and power supply devices, were used in connection with home-built receivers. Making this division in accessory sales, the total business in manufactured sets, with the necessary auxiliaries, totalled $340,000,000 in 1926, while that of parts and their associated accessories was $190,000,000. In other words, reasons Mr. Hill, the sale of parts and their accessories was slightly more than 50 per cent. of the total sale of complete sets. This accounts for the prosperity of those dealers who learn to sell parts intelligently and concentrate upon that phase of the business.

THE appointment of distinguished music leaders to executive positions in broadcasting program direction, on both sides of the Atlantic almost simultaneously, is a striking recognition of radio as a force in the music world. In England, Sir Henry Wood, perhaps the foremost conductor of Great Britain, was retained by the British Broadcasting Company to develop its musical programs. On almost the same day, it was announced that Walter Damrosch had accepted the position of music counsel for the National Broadcasting Company. The two largest broadcasting organizations in the world called upon distinguished musical leaders and entrusted them with the guidance of the now most potent force in musical education.

LEGAL representatives of the American Radio Relay League successfully attacked the municipal regulation established by Portland, Oregon, which attempted to control federally licensed amateur radio stations. The municipality revised its ordinance so as to except amateur stations from its jurisdiction and the matter did not therefore become a test case in the courts.

ALTHOUGH New Zealand's two broadcasting stations are privately owned, the Government exercises close supervision over the broadcast listener. Before any make of radio set can be placed on the market, government inspectors test and pass upon its radiating qualities. If it fails in these tests, it cannot be sold without subjecting the dealer to penalties of the law.

THE Fourth Radio World's Fair will be held at the New Madison Square Garden in New York, September 19 to 24, under the direction of G. Clayton Irwin, Jr. In addition to an impressive collection of manufacturer's exhibits, many of the newest developments of the radio art will be featured, including, it is rumored, the first general public demonstration of telephotography. Last year, a quarter of a million people attended the exposition. Many favorite broadcasting artists will appear at the glass-enclosed studio, which will be the program source for the principal New York stations during show week.

THE opening of a 1000-watt broadcasting station in São Paulo, Brazil, has greatly stimulated the radio business in that country. The 55 per cent. ad valorem duty is a serious barrier to complete set sales, but the parts business is flourishing. While German and British headsets are selling in large quantities, other parts, such as rheostats, condensers, sockets, and binding posts, are largely imported from the United States.

A FEATURE of the Citizens' Military Training Camps, being conducted at Plattsburg, Fort Niagara, and Fort Ethan Allen, in the Second Corps Area this summer, will be a special evening course on advanced commercial radio practice, thus fitting those attending for the attainment of first-grade commercial radio licenses. Consequently, enrollment in the Signal Corps course at the Citizens' Military Training Camps will offer, in addition to the usual advantages, an opportunity to become a commercial radio operator.

ALFRED E. WALLER

New York

Managing Director, National Electrical Manufacturers Association. A statement especially prepared for RADIO BROADCAST:

"*Constant vigilance is essential if the radio industry is to keep its own house in order. As I see it, there are immediately required: (1.) A cleaning of the air; (2.) an organization of our manufacturing and distributing effort to level out buying and production; (3.) time, money, brains, and courage to provide for improved programs and their reception.*

"*The last-mentioned need is dependent upon the first two. The second point can be achieved most effectively through group action and constant, steady development of the product by the manufacturer, and by more competent selling and maintenance.*

"*The Federal Radio Commission has already worked marvels in clearing the air of what I have called 'electrostatic katy-dids.' The power company, the manufacturer, and the owner of noisy wave-generating equipment will be equally interested in a cleaning up process if we have sold him a good set, and provided him with continuously attractive programs.*"

ANNOUNCEMENT has at last been made of the much-rumored broadcasting chain, promoted by the Paramount-Famous-Lasky Corporation. It is understood that the network, which is to comprise about a dozen stations, will be known as the Keystone Chain. Most of the stations are to be in cities already served by the National Broadcasting chain. It is understood that KMOX, WHT, and WMAK are included in the chain, while several New York stations have been named as possible key stations.

Nothing would be better for radio than a real rival to the National Broadcasting chain. The fact that the new organization is sponsored by a motion picture group, and probably by other companies, rather than by an independent company seeking to establish a commercial broadcasting business on a profitable basis, may cause it to concentrate so much on motion picture publicity that it will fail to offer real competition. But we hope for the best.

THE Circuit Court of Appeals reversed the decision of the District Court, unfavorable to the Radio Corporation, in its action to restrain the Twentieth Century Radio Company from further infringements of the Hartley and Rice patents. The decision affects the Hazeltine patents, the Twentieth Century Corporation being a distributor of Garod sets.

THE Indianapolis Broadcast Listeners' Association has been giving a series of twenty talks through WFBM on the general subject of radio interferences and how to identify, locate, prevent, and remedy them. A printed copy of one of these addresses reveals a most constructive attitude, urging the coöperation of listeners with power companies through the medium of listener organizations. Instead of wholesale abuse and fanatical antagonism to power companies and public pressure to bring about restricting municipal regulation of interference noises, the Indianapolis Association urges more effective measures, *i.e.*, the employment of experts, remunerated by the contributions of broadcast listeners, to locate interference. Since radio listeners are their best customers, the power companies welcome their intelligent and helpful coöperation.

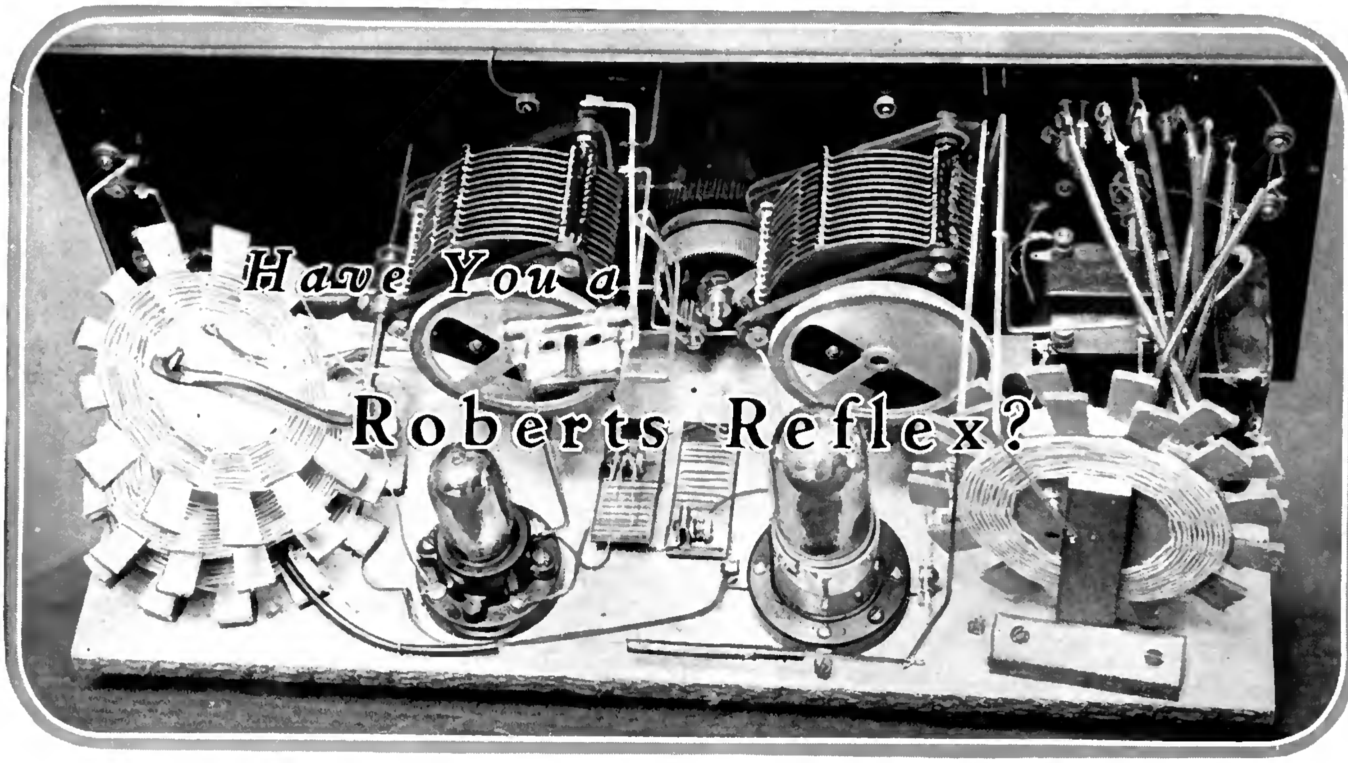
It has been frequently demonstrated that 90 per cent. of the noisy reception in any city can be eliminated or reduced to an unimportant minimum by an expenditure of less than $100 per square mile for an engineering investigation. In some instances, the broadcast listeners themselves, through a local radio club, have made this expenditure; in others, radio dealers have combined to do the work; and, in other instances, the power companies themselves have sought and cured the trouble. Any city troubled by notably poor reception, due to "man-made" interference, can, by coöperative means, eliminate most of it.

TEX RICKARD, who, not so long ago, was rated as an opponent of broadcasting, has become converted. "I have found," he says, "that the radio has done more to create new fans for sporting events than any amount of advertising could possibly do."

Accordingly, he has made arrangements to use the red and blue networks for important events, still maintaining WMSG for minor fistic combats. A tribute to the popularity of fight broadcasts was found in many of our questionnaire returns. Practically all of those who favored the continuance of WMSG qualified their approval by the statement "for prize fight programs only."

THE National Electric Manufacturers' Association has issued the second Nema Handbook of Radio Standards. This covers such items as tests and necessary tolerances for cords, plugs, jacks, cable terminals, rheostats, variable condenser mountings, shaft extensions, standard tests for audio coupling devices, color codes for outside connections to set, battery dimensions and tests, socket power device markings, vacuum tube sockets, and constants for standard tubes. It establishes the frequency range of broadcast receivers from 550 to 1500 kilocycles, a most important requirement which many manufacturers are not yet regarding.

Have You a Roberts Reflex?



Radio Broadcast Photograph

AS IT WAS IN THE BEGINNING!

We would blush to introduce our friends to a receiver such as that depicted above in these days of low-loss apparatus. Yet this is a very typical example of pre-contemporary days. The Robert reflex, for it is none other, created quite a sensation at the time of its introduction a few years ago. The picture shows a two-tube model, a more popular one consisting of an identical circuit arrangement but with the addition of a push-pull audio stage

Modern Apparatus, Simple Changes, and Latest Tubes Will Rejuvenate This One-Time Most Popular of Receivers

By JOHN B. BRENNAN

TO COUNT up the number of circuits which have remained in the public's eye over a lengthy period of time does not require many fingers. Such familiar names as Browning-Drake, Roberts, Haynes Super, Knockout Reflex, are all indelibly fixed in the minds of Radio Broadcast readers.

The most outstanding of these, at least to Radio Broadcast readers, is the Roberts circuit in its several forms. It was first brought to the attention of receiving set builders through a modest article by Dr. Walter Van B. Roberts in the April, 1924, issue of this magazine. Since then, the circuit has attained such prominence that those who have built it are numbered in the tens of thousands and, according to some estimations, approach the hundred-thousand mark. The most popular form of this circuit has probably been the Knockout four-tube Roberts reflex, a circuit diagram of which is shown in Fig. 1. Now, since April, 1924, considerable refinement has taken place in radio apparatus. Selectivity, sensitivity, volume, and ease of operation have all improved since that date and the thought has probably occurred to many owners of a Roberts receiver of the vintage of 1924, that some modern improvements might be made to bring the receiver more or less up to date. The questions the owner should ask himself are these:

(1.) Is my Roberts receiver sensitive and selective enough?
(2.) Does it tune sharply enough?
(3.) How is the quality compared with receivers of to-day?
(4.) Do I secure sufficient volume from it?
(5.) Is it stable on the shorter wavelengths?
(6.) Is it difficult to operate compared to more modern receivers?

If the answers to these questions indicate to the reader and owner of the receiver that he is perfectly satisfied, there is no necessity for him to read further in the present article. On the other hand, if his receiver seems to suffer somewhat compared to what he is led to expect is the best of present-day development, then the suggestions to follow may be useful. Boiled down to a simple, straightforward statement, this means that the owner of a Roberts receiver, if he desires, can bring it up to date in every respect so that it will be on a par with the latest receivers described, and incorporate all the niceties and refinements of present-day receiver design. It is possible that the answers to these questions indicate that the receiver in question needs a general overhauling. It is also possible that only one or more of the respective units need attention.

The sensitivity and selectivity of a receiver using the Roberts circuit go hand in hand; that is, a sensitive receiver will probably be selective and on the other hand, if it tunes broadly so that the signals desired have as a background signals from several other stations, it is probable that the receiver suffers on the side of sensitiveness as well. The old Roberts receiver used spiderweb coils, and these quite often were wound with wire having enamel insulation. Frequently the enamel wears off the wire at a point where it bends around the spiderweb form and if another adjacent turn is bared, a short-circuited turn results. As soon

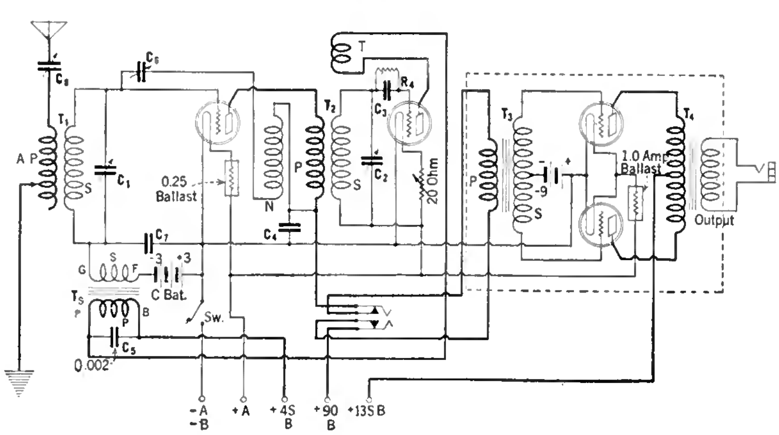


FIG. 1

as this happens, the set begins to tune broadly and signals are not as loud as they might be.

In the Roberts receiver there are two tuning controls, one on the antenna or radio-frequency stage, and the other on the detector. If either of the condensers seem to tune broadly, the coil should be looked at to see whether short-circuited turns are present on it. Sometimes it is impossible to determine definitely whether this is the cause of broad tuning or not and it is well, under such conditions, to remove the wire and either wind new coils or to substitute a more modern type of winding, such as a good solenoid inductance.

The antenna coil consists of 40 turns of No. 24 double cotton-covered wire with taps taken off about every 10 turns. The two secondary coils consist of 45 turns of the same size wire. The NP coil is wound with No. 26 double cotton-covered wire for 40 turns with a tap taken off at the 20th turn. This tap connects, via a jack, to the plate post of the primary of the input transformer of the push-pull unit and thence through that primary to the B battery. One end of the NP coil connects to the neutralizing condenser while the other connects to the plate of the radio-frequency tube. The tickler consists of 20 turns of No. 26 double cotton-covered wire. Incidentally, these same specifications will hold true whether the coils are to be wound in spiderweb, basketweave, or solenoid fashion. For the solenoid type of coil, the diameter of the form should be approximately 3 inches.

NEW COILS FOR THE ROBERTS

AMONG the manufactured coils which have been successfully used in the antenna stage of the Roberts receiver are those of Hammarlund, Sickles, Aero, General Radio, Bruno, and Silver-Marshall. Undoubtedly there are others which have the same characteristics and which may be employed in the antenna stage satisfactorily. The substitution of more up-to-date inductances for the interstage spiderweb coil will also be a step toward modernization. The F. W. Sickles Company and the Hammarlund Manufacturing Company make coils intended specifically for the Roberts Circuit while the Silver-Marshall and Bruno coils consisting of primary, secondary, and tickler, may be used after the primary coil on the form has been removed and a new one wound according to the specifications given above. All of these coils have carefully been tried in a model of the receiver built in RADIO BROADCAST Laboratory according to the specifications contained in the September, 1924, issue of RADIO BROADCAST. No difficulty was experienced in substituting these coils for the original spiderwebs.

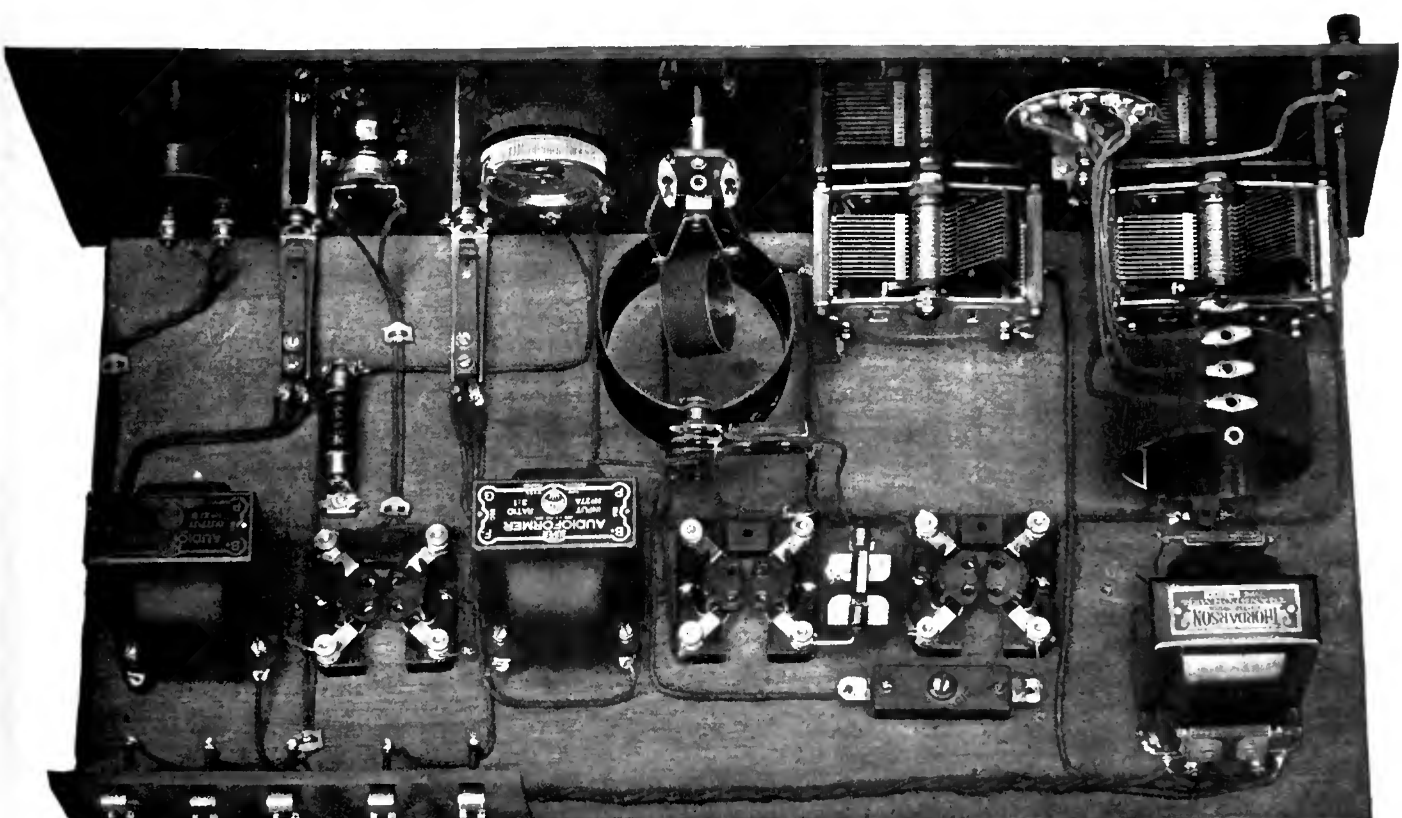
Broadness of tuning may be caused by poor connection between wires which are supposed to be making perfect contact. It is always advisable to solder such wires and even in soldering occasionally there exists high-resistance joints due to the failure of the constructor to clean properly the wires which are to be joined together. A good soldering flux, together with a soft wire solder, is a definite necessity in the wiring of a radio receiver.

It has been demonstrated since the early days of the Roberts receiver that no coil is more efficient than the solenoid of the proper dimensions. Efficiency with regard to coils means high inductance, low resistance, and low distributed capacity. These factors, in turn, mean high sensitivity and selective tuning circuits, and the owner of a Roberts receiver using old style spiderweb coils cannot make a better move than to substitute a highly efficient solenoid winding. This is especially true of the antenna stage where every bit of voltage amplification is useful. In the interstage coils, resistance is not so important and a coil of somewhat lower efficiency will not have the same importance as it would in the case of the radio-frequency amplifier. In other words, the first coil changed is the antenna coil and if the set's sensitivity and selectivity are still to be improved, the detector coil should follow the antenna coil into the scrap basket and a new one be substituted.

Another remedy for broadness in tuning lies in the use of an antenna series tuning condenser as shown in Fig. 1. This condenser should preferably be of the variable type and have a value of about 0.0001 mfd. However, if a variable type condenser of this value is not available, it will be found quite satisfactory to use a good make of fixed condenser of about the same value, such as those manufactured by Dubilier, Sangamo, Aerovox, Electrad, Tobe, etc.

There are other causes of broad tuning. As Fig. 1 shows, the input coil to the radio-frequency amplifier has between it and the tube a high-resistance winding—the secondary of the audio reflex transformer. This transformer secondary, unless properly bypassed, broadens the tuning of the antenna stage and it has been found in practice that it is advisable to shunt this secondary with a 0.0001-mfd. fixed condenser. It will be noticed that, when this shunt condenser is connected in the circuit as explained, the radio-frequency amplifier usually oscillates, particularly on the higher frequencies, and therefore it is more difficult to neutralize.

It will be found that the possibility of erratic action of the regeneration control is quite remote if coils such as those listed or manufactured specifically for use in the Roberts circuit are used. On the other hand, if the constructor is still employing his spiderweb type of coil and modern tubes, and cannot obtain smooth regeneration, he may experiment with the detector plate voltage and decrease the number of turns on the tickler coil one by one until the desired smoothness of regeneration is obtained. It was found in the receiver experimented upon in the Laboratory that $22\frac{1}{2}$ volts was quite satisfac-



RADIO BROADCAST Photograph

THE REVISED ROBERTS REFLEX

The layout of parts for the three-tube arrangement. The circuit differs from Fig. 1 in that the push-pull audio arrangement has been omitted in favor of a straight audio stage tory and about 6 turns had to be removed from the old 20-turn spiderweb tickler coil before the circuit was really satisfactory. Under these conditions the detector could be made to oscillate easily on 500 kilocycles, and be thrown out of oscillation on 1500 kilocycles. Experiments should be made with various sizes of grid leaks to obtain smooth control of regeneration. Grid leaks of a value of from 1 to 8 megs. may be used, smoother regeneration resulting from the use of higher valued leaks. The quality of reproduction, however, improves as lower grid leak values are used.

Where there is something wrong with the reflex part of the receiver it manifests itself in a number of ways. Perhaps the loud speaker will still continue to blare forth even though the detector tube is removed from its socket. Or perhaps reception is accompanied by a raucous squawk or howl when tuning-in to a station. Low volume is a good indication of trouble in the reflex stage and is often caused by the use of a cheap transformer in the circuit.

Besides having a good make of transformer in the reflex stage, it is essential that both the primary and secondary be bypassed intelligently. A 0.002-mfd. condenser across the primary and a 0.0001-mfd. one across the secondary will suffice, although other neighboring values should be tried and one selected which produces most satisfactory results, as it is always probable that no two similar circuits will require exactly the same condenser values to make them work properly.

THE AUDIO CHANNEL

IN THE few years since the appearance of the Roberts circuit, audio transformers have been developed which have much greater primary impedance than was necessary a few years ago. The reflex transformer may be one of the high grade units now on the market, such as Ferranti, Amertran Deluxe, Pacent 27-A, Samson, Thordarson, Silver-Marshall, or General Radio. The push-pull stage may be eliminated in favor of a straight stage employing one of the transformers used in the reflex stage, or a new push-pull amplifier may be used utilizing special Silver-Marshall or Samson transformers. Two 112 tubes in parallel, as shown in Fig. 2, will give somewhat greater output than a single tube

In a push-pull amplifier, the quality can be materially improved by substituting semi-power tubes of the 112 type for the two 201-A tubes. When this substitution is made, it is necessary that the plate voltage applied be 135 with 9 volts of C battery. The 171 type may be employed, but the volume will not be as great as with the 112 because the 171 has an amplification factor of 3 whereas the 112 has an amplification factor of 8. However, the 171 type tube has much greater handling capacity.

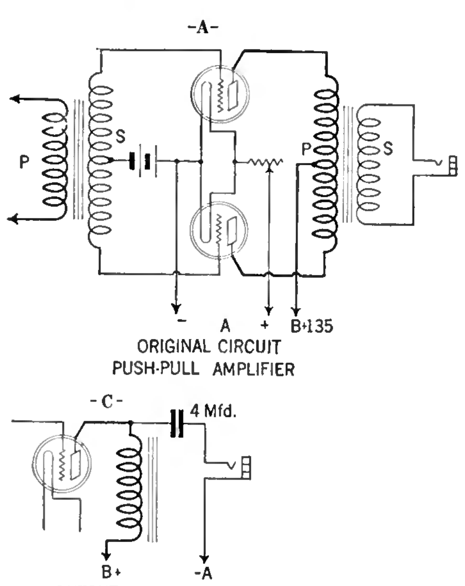
To determine whether the quality of the output from the reflex stage in your present Roberts receiver is everything that it should be, connect a pair of phones in series with the primary of the first push-pull transformer, or connect the phone tips in place of the terminals of the primary of this transformer. If the signal quality is not good here, then it is evident that the audio reflex transformer is at fault and the simplest way to improve the quality is to substitute another transformer of a better type.

If the tickler coil is adjusted up to the point where the detector is just about to spill over, it cannot be expected that the quality of the signal in the loud speaker will be everything that is desired and the tickler should always be backed off to prevent this condition.

Tubes offer a fertile field for the investigation of poor quality. A poor tube in the radio-frequency reflex stage may affect the tone quality and volume appreciably and the builder should switch around the tubes in the various sockets until the most satisfactory position for all tubes is found.

There are a number of unit amplifiers on the market which may be readily substituted for the second stage audio originally employed. Such units as the Pacent "Powerformer," the Silver-Marshall "Unipack," those of Receptrad and General Radio, and several resistance amplifiers such as the DeJur, Heath, Daven, etc., will be satisfactory for this purpose.

Fig. 2 shows two audio amplifier systems which may be constructed and also an output device to couple an ordinary transformer stage to the loud speaker.



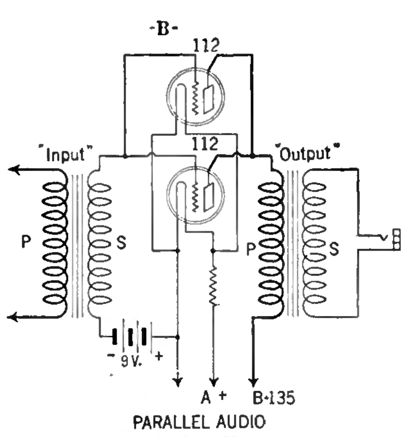


FIG. 2

In this figure are shown three arrangements of the power stage that can be satisfactorily used. At "A" is shown the original push-pull amplifier that was used in the old Roberts receiver. New push-pull transformers are now available and can be used with excellent results in this circuit. At "B" is an output arrangement consisting of two 112 tubes connected in parallel, both of them feeding into an output transformer. At "C" is an arrangement using a single 171 type power tube. In the plate circuit is a choke-condenser combination used to eliminate the direct current from the windings of the loud speaker.

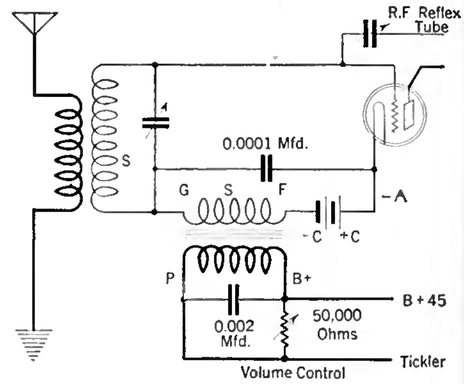


FIG. 3

VOLUME CONTROL

THE volume of the receiver may be controlled by shunting the primary of the reflex audio transformer with a variable resistance of the value of 50,000 ohms, as shown in Fig. 3. The compression type of variable resistor, such as the Clarostat, may successfully be employed here.

In making the change to power tubes, it is not necessary to control the filaments with a rheostat since a fixed filament ballast will suffice. This, therefore, leaves one hole on the panel vacant by the removal of the rheostat which controls the tubes in the push-pull amplifier. In this hole may be mounted the volume control. Since no adjustment of the filament of the tube in the radio-frequency reflex stage is required, the rheostat originally provided may be dispensed with and a filament ballast substituted for it, thus making vacant another hole on the main panel. It is suggested that the rheostat for the detector tube be transferred to the hole formerly occupied by the rheostat for the radio-frequency reflex tube and in the hole made vacant by the rheostat on the detector tube, a filament switch be mounted. This switch should be connected in series with the minus A lead to the various tubes.

There are a number of neutralizing condensers now available which may take the place of the home-made tubular neutralizing condenser originally specified in the construction of the Roberts reflex receiver. These new condensers are of the variable plate or screw type and are much easier to adjust and to maintain adjusted than the tubular type. The primary requisite in neutralizing is to keep the connecting leads between the coil, neutralizing condenser, and tube, as short and direct as possible and not let these leads parallel any other leads. Satisfactory neutralizing condensers are those manufactured by Precise, Hammarlund, Cardwell, and XL Laboratories.

The changes as outlined here have centered mainly around the original popular Knockout four-tube reflex receiver and deal particularly with the substitution of new and improved parts for old ones, with one or two circuit changes. In its revamped form, it is a very fine receiver, worth the efforts of any home constructor.

It will give good quality and if the changes suggested are carefully made the receiver should equal, in sensitivity and selectivity, any of the more recent receivers which have been described. For best results the receiver should be used with some good cone-type loud speaker.

The Balsa Wood Loud Speaker

Constructional Hints on a New Loud Speaker Which Was Found in the Laboratory to Give Very Excellent Quality

By THE LABORATORY STAFF

A NEW LOUD SPEAKER
The Balsa wood loud speaker is now obtainable in fully assembled form. The picture to the right shows a typical example

IT IS generally conceded that the loud speaker is the present weak link in broadcast receiving systems. It is possible to build excellent amplifiers both for transmitters and for receivers, and from the pick-up device in the radio broadcasting studio to the output of the final amplifier there is little to be desired as far as true reproduction of various frequencies is concerned. It is true that programs are still compressed somewhat as regards volume, partly because of the limited carrying capacity of the telephone lines connecting pick-up and transmitter, partly because of the limited power range of the transmitter, and partly because of the limited volume range of receivers; but the ear will stand for a great deal of distortion due to these causes without rebelling. The loud speaker, however, is far from perfect.

For this reason, when anything new in the way of loud speakers develops, the average radio engineer registers considerable interest. The latest idea in this realm is the Balsa wood loud speaker. The story goes that the Western Electric engineers, in whose laboratories have developed some of the best known translating devices of the present time, "played" for some time with Balsa wood and, like all good things the Western Electric engineers "play" with, sooner or later the idea got about. It is now possible to purchase in kit form the necessary Balsa wood, hardware, driving mechanism, and frame to put together a very excellent loud speaker.

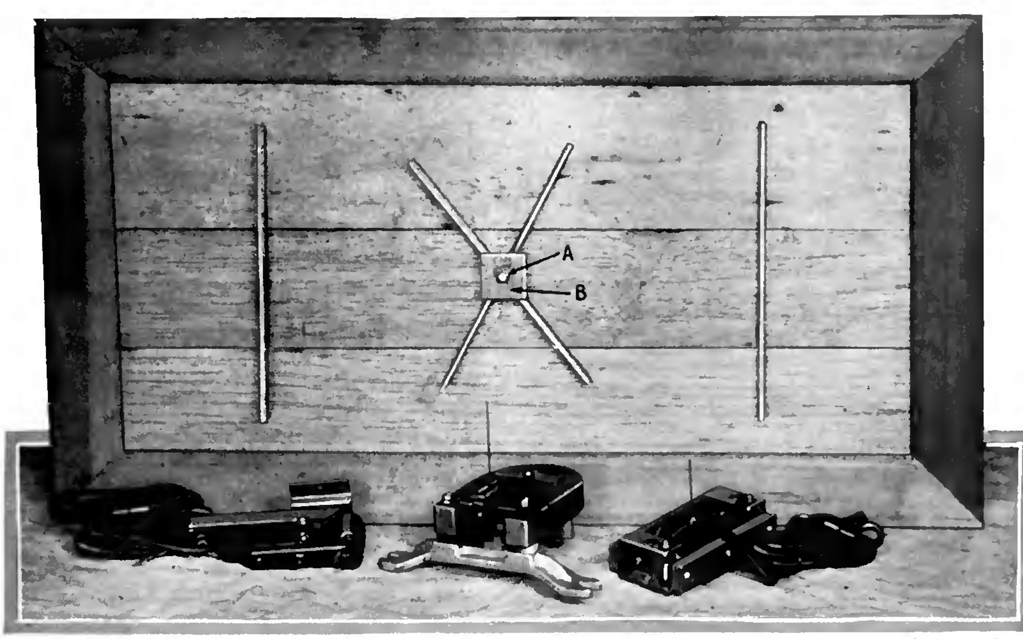
Balsa is the lightest known wood, averaging about six or seven pounds per cubic foot, while cork averages about fourteen pounds. It grows in Panama and other tropical countries, and is used widely in the airplane industry. Because it is 92 per cent. air, it makes an excellent insulating medium against heat.

The Balsa wood slats in the kits for loud speaker construction come in three sizes ready to be assembled as diaphragms of one by two feet, two by three feet, or two by four feet, approximately. The middle sized one is the one most people build, and, in fact, is the best of the three. The smallest is too small; the largest is too awkward. Photographs of the medium sized one are shown here.

Heretofore, the best loud speaker that could be made was an elliptical cone with about four feet as its longest dimension. This, driven with a Western Electric 540 AW unit, seemingly left little to be desired. It was, in many peoples' estimation, better than the 540 AW loud speaker purchased on the open market. The new Balsa loud speaker, if carefully made, is on a par with the elliptical cone.

Balsa wood is useful for loud speaker construction because of its extreme lightness and because it is possible to make the radiating part of the loud speaker extremely rigid. Lightness contributes toward the efficiency of the loud speaker, which means that a greater percentage of the input power is radiated as sound energy and not wasted in friction. Rigidity is necessary in order that considerable energy can be fed into the device before anything begins to rattle or to fall apart. When it is considered that the best loud speaker now obtainable is less than five per cent. efficient, it may be seen that anything contributing toward greater efficiency is worth while.

The Balsa loud speaker consists of three boards or slats which are held together mechanically by smaller strips, as shown in the photographs. These strips should be stuck on with Ambroid cement. Glue is bad since it is hard, brittle, and heavy. In practice, the slats may be placed either with their edges flush or not. If they touch, they must be firmly cemented together. The strips may radiate from the center of the loud speaker, they may be placed at right angles to the long dimension of the speaker, or they may be curved as shown in one of the accompanying photographs. In the Laboratory, little difference was noted whichever way they were placed as long as everything was rigid and light.



Radio Broadcast Photograph

ONE OF THE BALSA LOUD SPEAKERS CONSTRUCTED IN THE LABORATORY

With several units in front of it. The Western Electric 540 AW unit was found to give most satifaction. "A" in the photograph is the top of the bushing arrangement which grips the pin of the driving unit. The complete bushing unit is shown in Fig. 1. "B" is a piece of cedar shingle, afterwards replaced with a piece of Balsa wood. Since the Laboratory made tests on the Balsa loud speaker, a driving unit specially designed for it has been announced by the Balsa Corporation

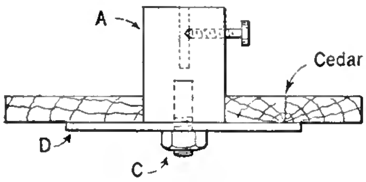


FIG. 1

The bushing arrangement, or "gadget," which grips the pin of the driving unit employed. "A" is the shank into which the pin is placed and held by the set screw; "D" is a very thin piece of copper or aluminum sheet; "C" is a hex nut to hold "A" to "D." "B" should preferably be of Balsa wood and not cedar

Some Balsa loud speakers have been found to give better results than the 540 AW cone while others with the same unit and with the same care in construction are not so good, for some unknown reason. Reports have come to the Laboratory to the effect that not everyone is satisfied with the Balsa loud speaker after it is constructed. In our opinion, however, there is nothing better at the present time than a carefully constructed Balsa loud speaker, rigidly put together with Ambroid, and driven with a 540 AW unit. The following experience will reveal some of the difficulties.

A Balsa loud speaker of the familiar two-by-three-foot size was constructed of standard material consisting of slats, strips, and the "gadget," or bushing arrangement, which holds the drive rod of the unit, glue being used in the assembly. This "gadget" is shown diagrammatically in Fig. 1, and also at "A" in the photograph on page 211. In practice it varies somewhat in size and appearance. It was glued to the center of the diagonally radiating strips which were in turn glued to the slats, as shown in the photograph. A piece of cedar shingle, "B" in the same photograph, about two inches square, was also glued onto the strips with the shank and set screw of the "gadget" protruding through a hole in it. The purpose of the shingle is to hold the bushing arrangement rigidly to the diagonal strips.

The loud speaker was very fine until a certain power input, which was not very high, was exceeded, and then the thing rattled unmercifully. The first point of attack was the glued strips, which seemed to have a habit of breaking loose when certain frequencies were placed on the loud speaker. These glued strips were ripped off and re-cemented with Ambroid which not only stuck better than glue but was lighter. It formed a homogenous connection between slat and strip. Then the bushing which held the 540 AW unit drive rod to the Balsa wood was removed, the cedar shingle thrown away, and part "D" (see Fig. 1) of the bushing assembly cut down to its smallest possible dimensions, until it was about the size of a dime but thinner. Then a small piece of Balsa was placed over this dime dimensioned piece of thin copper sheet, to take the place of the cedar shingle, and the driving unit was replaced. This process seemed to release a great load from the unit for the high frequencies (which before had been about equal to the 540 AW 18-inch cone) were now much better, and the low frequencies, which before had been much better than the cone, were not changed. It was possible to put the full output of an amplifier using a 210 type tube into it.

SOME SUGGESTIONS

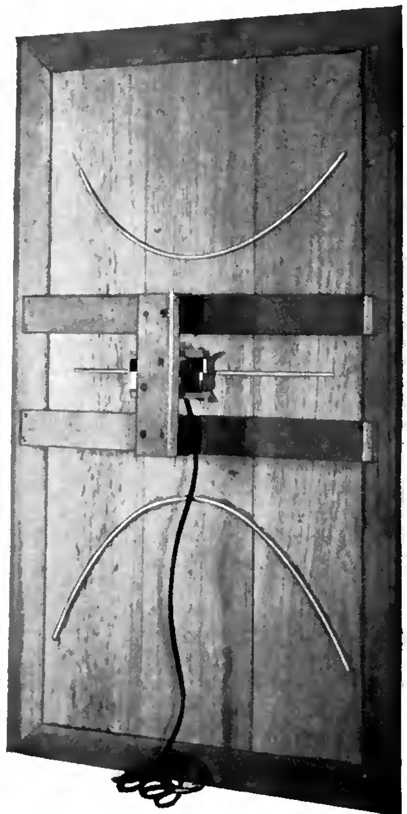
THERE are several kinks that may be tried on this loud speaker. One is to drive the Balsa not at the center, but somewhere between the center and one end. Another idea is to place felt strips between the ends of the Balsa slats and the frame, insuring good contact and preventing any possible rattles.

In constructing a Balsa loud speaker from the standard kit, the procedure is as follows. The slats are first firmly fixed to the frame with Ambroid and then the moulding that is furnished is cemented in place. Next, the strips are cemented to the slats, again using Ambroid in sufficient quantities to insure perfect connection but not enough to run over the slats and increase the weight or spoil the appearance. At the center of the two diagonal strips, if they are arranged as shown in the photograph on page 211, and if the unit is to be placed there, a small depression will have to be cut in the strips in which the hexagonal nut, "C" in Fig. 1, is to fit; then the bushing assembly of Fig. 1 is cemented to the strips. Some means of mounting the driving unit must be provided, and since there are no two units that have the same dimensions, the constructor will have to exercise his own ingenuity at this point. The photograph on this page gives an idea of how it was done in one case in the Laboratory. The Balsa Corporation has an aluminum bracket that simplifies this problem considerably. Weights may be balanced on the strips, etc., while the Ambroid is drying to insure firm contact.

The loud speaker should not be tried until several hours after the final cementing has been completed. Then the weights, if these are used, should be removed from the strips, and the whole instrument looked over carefully for places where the strips might not be securely fixed to the slats.

Radio Broadcast Photograph

PREPARING TO REMOVE THE 540 AW UNIT



Radio Broadcast Photograph

ANOTHER ASSEMBLY

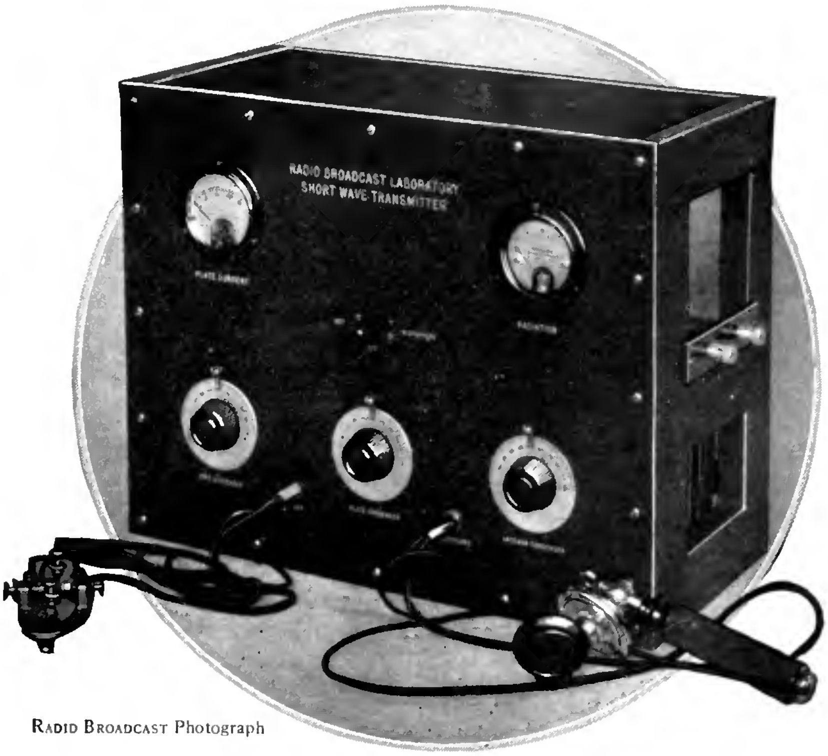
The mounting of the unit is clearly shown in this illustration. This loud speaker differs in detail from that shown on the previous page

The matter of units is an important one. Several have been tried in the Laboratory, some of which are probably not representative of the best on the market. None so far tried can compare with the 540 AW, but as soon as the unit field has been covered by the Staff, the results of the investigation will be made known. Anyone who has a 540 AW loud speaker can experiment with the Balsa wood loud speaker for five dollars, which is the price of the Balsa wood. Unfortunately, the Western Electric 540 AW unit is not obtainable except in the complete cone loud speaker form. The Balsa material can be procured in New York from the Balsawood Reproducer Corporation, 331 Madison Avenue. Ambroid liquid cement is a product of the Ambroid Company, 1227 Miller Avenue, Brooklyn, and a 35-cent can is plenty.

In building a Balsa wood loud speaker, one should spend not less than three or four hours cementing slats to strips, and must bear in mind that the Balsa wood is easily broken or punctured. A moment's lack of care may cost a beautiful loud speaker. It should be remembered that it takes a very good power amplifier, and a very good program from a very good station to enable the average ear to tell the difference between the 18-inch 540 AW cone loud speaker and the Balsa wood loud speaker. Completely assembled Balsa loud speakers, attractively decorated and containing a specially constructed unit, are now on the market.

Operating Characteristics and Constructional Details of a 38- to 113- Meter Transmitter

Either Battery or A. C. Operation Possible—Transmits C. W. Signals or Phone at Option



Radio Broadcast Photograph

A FRONT VIEW

Of the short-wave transmitter described in this article. It can be used to transmit either c.w. or telephone signals, the changeover from one to the other being accomplished by merelv throwing the switch in the center of the panel

A Flexible Short-Wave Transmitter

By HOWARD E. RHODES

Facts About This Transmitter

Circuit: Tuned-plate, tuned-grid
The set can be used on either phone or c.w.
Tubes: One 210 oscillator and two 210 modulators
Wavelength Range: 39 meters (7900 kc.) to 112 meters (2500 kc.)
Power Input to Oscillator: 40 Watts

This transmitter can be operated from batteries or from a compact a.c. power unit also described in this article. The set is entirely controlled by a single master switch. The transmitter is not difficult to construct and is easily adjusted for efficient operation.

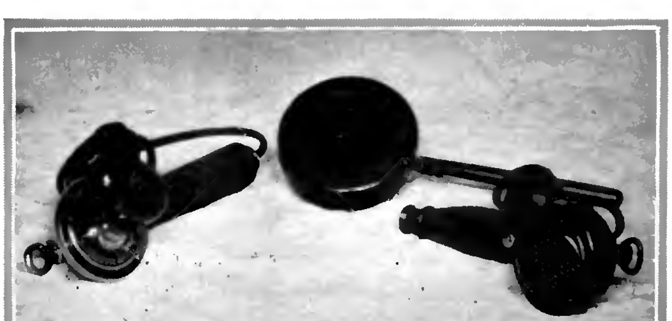
THIS article describes the construction and operation of a low-power short-wave transmitter, designed for use on either c.w. or phone. The transmitter, which is illustrated in various photographs in this article, was designed and constructed in the Radio Broadcast Laboratory.

It uses the tuned-plate tuned-grid circuit, a type of oscillatory circuit which is very likely one of the easiest to adjust. The three dials on the front of the transmitter are used to tune the grid, plate, and antenna circuits, and properly setting these three condensers is all that is necessary in adjusting the transmitter. In this article considerable data will be given regarding the general characteristics of this type of circuit.

The transmitter is designed so that, by merely throwing a multiple-pole switch, it can be connected for use on either phone or c.w. On c.w. work this switch, located at the center of the panel, is thrown to the left, and then one of the 7½ watt tubes functions as an oscillator and the other two tubes are turned off. The set is keyed by connecting a pair of leads between a telegraph key and the two telephone tip jacks on the front of the panel (the photographs show an ordinary jack for this purpose but in practice it was found that the voltages were high enough to break down the insulation on the jack, and therefore two pin jacks, one above the other, were substituted for the telephone jack).

When the control switch is thrown to the right, or "microphone," position, one tube functions as an oscillator and the other two tubes function as modulators in a Heising modulation system. The grids of the two modulator tubes are fed from the secondary of a General Radio modulation transformer, in the primary circuit of which is the microphone in series with two dry cells. The microphone is connected in the circuit through a telephone jack on the front of the panel. When the control switch is thrown to the "off" position it not only turns off the filaments of the tubes, but also opens the microphone circuit so that the microphone telephone plug can be left in the telephone jack without any danger of exhaust ing the two dry cells.

An accompanying photograph shows a group of microphones that are satisfactory for use with this transmitter. In all cases very good quality signals were transmitted using these microphones powered from two dry cells, although somewhat higher modulation can be obtained using three dry cells instead of two.



Radio Broadcast Photograph

THREE EXCELLENT MICROPHONES

To use on phone work. The Federal unit (price $7.00) is at the left. The Globe type E microphone (price $15.00) is the center one, and the microphone at the right hand is made by Kellog (price $8.90). The latter unit is equipped with a push button which is used to open and close the microphone circuit

When the transmitter was first constructed, the control switch was arranged so that in the "key" position all three tubes worked as oscillators. It was found, however, that with this arrangement, a considerable change in frequency took place on throwing the switch to microphone, and the circuit was then revised so as to have only one oscillator with the control switch in either position. With this latter circuit no change in frequency takes place on switching from microphone to key. It is therefore possible with this set to call an amateur on c.w. and then talk to him on phone without making him change his receiver adjustment except to take it out of oscillation, as modulated signals, unlike c.w. signals, cannot be satisfactorily received with an oscillating detector.

The transmitter is so wired that it can be operated from batteries or from a compact a.c. power unit, also described in this article, which

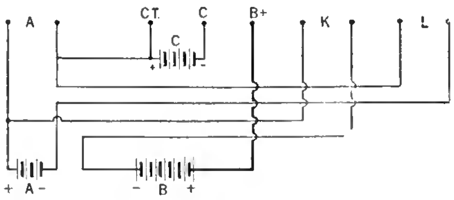


FIG. 2

will supply it with all the necessary filament, plate, and grid voltages. The circuit diagram of the transmitter is given in Fig. 1, and the connections for battery operation are given in Fig. 2. Fig. 3 is the circuit diagram of the power unit. No changes in the transmitter itself are necessary in changing from battery operation to a.c. operation; it is merely necessary to connect the various binding posts somewhat differently so as to obtain proper operation.

The transmitter can be operated on any wavelength between 38 and 113 meters (7900 kc. and 2650 kc.). The tuning chart shown in Fig. 4

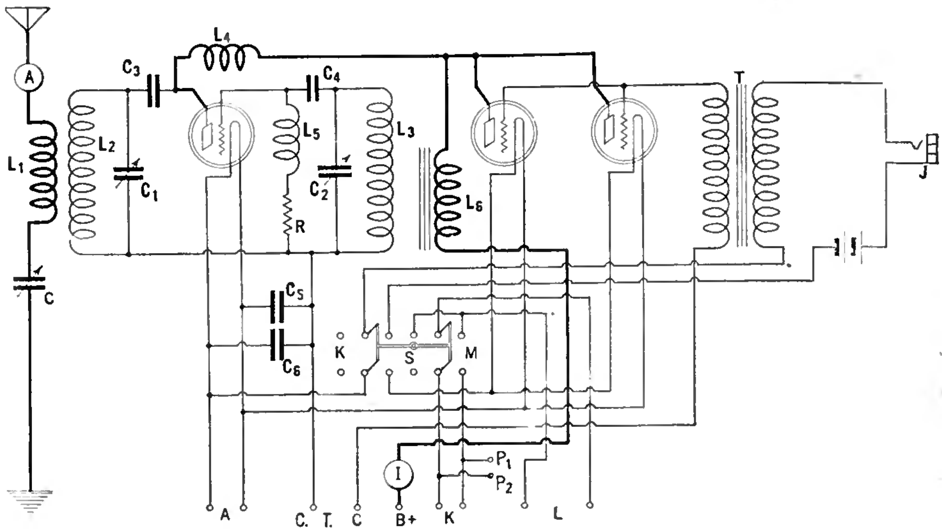


FIG. I

was obtained by plotting wavelength against the settings of the grid (left-hand) tuning condenser dial. In adjusting the set, the grid-circuit tuning condenser is set at the desired reading, and the plate and antenna condensers are then adjusted for maximum efficiency as indicated by the plate milliammeter and antenna ammeter.

The transmitter has been carefully constructed so as to present a good appearance and its size and weight are such as to make it readily portable. It measures 18 inches long, 14 inches high, and 8 inches deep, and only weighs about 28 lbs. The a.c. power unit in its container measures 16 inches long, 8 inches high, and 8 inches deep, and also weighs about 28 lbs.

The entire transmitter can be duplicated at a cost of about $90.00 without tubes. If the set is to be operated from a.c., it will be necessary to build the power unit, which costs about $50.00.

Before the final model of the transmitter was laid out and constructed, a temporary affair was put together on a large baseboard and a series of tests made to determine the characteristics of the circuit. Specifically, it was desired to determine: (a) The effect of varying the grid leak resistance; (b) the effect of varying the resistance of either the tuned grid or plate circuit; (c) the effect of varying the coupling between the plate and antenna coils; and (d) the effect of variations in plate voltage. Data were also obtained which showed how the plate current, antenna current, and the frequency, vary as the plate condenser is adjusted.

In all of the tests a single DeForest type DL9

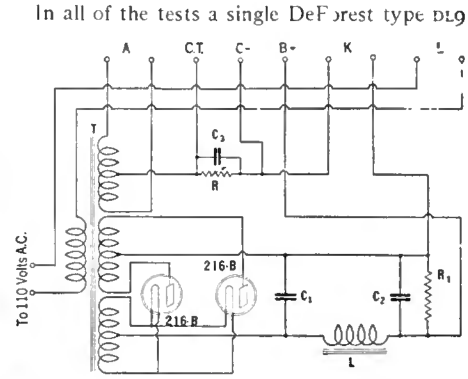


FIG. 3

tube was used, this tube being similar to a 210 type tube. The circuit used in making these tests was exactly the same as that given in Fig. 1 and all the data were taken at a frequency of 3750 kc. (80 meters). The plate potential was 385 volts, obtained from a bank of Exide storage batteries. A non-inductive resistance was used to represent the antenna. The coils and r.f. chokes used were those made by the Aero Products Company. The inductance of coils L_2 and L_3 is about 7.5 microhenrys each at 3750 kc. (80 meters). Fig. 5 shows how the inductance of either L_2 or L_3 varies with the wavelength.

RESISTANCE VARIATIONS OF THE GRID LEAK

WHEN a vacuum tube breaks into oscillation, it operates over its entire characteristic, and during part of each cycle the grid draws current. This current flowing through the grid leak resistance develops a voltage which impresses a negative bias on the grid of the tube. The group of curves given in Fig. 6 show the effect of using different values of grid leak resistance. Curve No. 1 shows how the average voltage across the grid-bias resistance varies

Radio Broadcast Photograph

THE SHORT-WAVE TRANSMITTER

As viewed from the rear. The upper and lower compartments into which the set has been divided makes possible a very compact arrangement. The Heising choke coil, modulation transformer, variable condensers, and microphone batteries, are all placed beneath the shelf

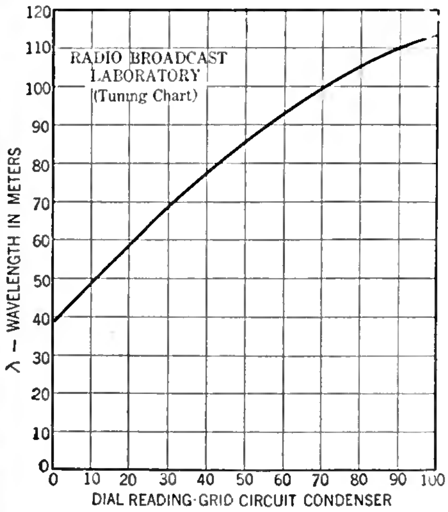


FIG. 4

with different values of resistance. At low resistance values the grid current is large but because of the small resistance only a low voltage is developed. With increasing resistance the voltage Eg also increases and reaches values as high as 124 volts when the grid leak resistance is 26,000 ohms. The plate-current, curve No. 2, is very large with low values of resistance but gradually decreases with increased resistance and reaches a minimum value with a grid leak resistance of about 16,000 ohms and then increases again. The current in the antenna circuit reaches a maximum with a grid leak resistance of about 9000 ohms although there is little change in antenna current between 4000 and 14,000 ohms.

The power input, Pi, is equal to the plate voltage times the plate current, and the power output is proportional to the square of the antenna current. The efficiency can therefore be expressed as:

$$\text{Efficiency} = \frac{\text{Power Output}}{\text{Power Input}} \times 100$$

$$= \frac{I_A^2}{P_i} \times 100 = \frac{I_A^2}{E_b \times I_p} \times 100$$

This expression is plotted in curve No. 4, Fig. 6, and shows a maximum with a grid leak resistance of between 12,000 and 14,000 ohms. It appears evident, then, that most efficient operation can be obtained with a grid leak resistance of about 13,000 ohms.

RESISTANCE IN THE GRID AND PLATE CIRCUITS

IN ORDER to obtain the most efficient operation from a tuned-plate, tuned-grid transmitter, it is essential that the coils used be carefully constructed so as to reduce to a minimum all losses. The curve in Fig. 7 shows the effect of increasing the resistance of either the tuned-plate or tuned-grid circuit, and it indicates the quite rapid decrease in efficiency that occurs when resistance is added to either of these circuits. In a tuned-plate, tuned-grid transmitter, the tuned-grid circuit is coupled capacitively to the plate circuit through the inter-electrode capacity of the tube, the grid circuit acting more or less as a driver to keep the tube oscillating. It might appear, at first thought, that some loss in the grid circuit could be tolerated without any great decrease in efficiency. It appears likely, from the tests made, that increasing the resistance in the grid circuit is practically as effective in reducing the efficiency, as is resistance in the plate circuit. The test was made by connecting small straight pieces of high-resistance manganin wire in series with the tuned circuit. The resistance of the small pieces of wire was measured on a d.c. bridge and their r.f. resistance was considered to be the same as their d.c. resistance. This procedure was followed because it is difficult to make accurate resistance measurements at very high radio frequencies.

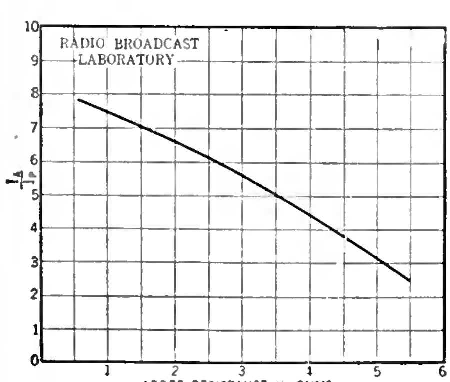


FIG. 7

VARYING ANTENNA AND PLATE COIL COUPLING

IN FIG. 8 are curves showing the effect of varying the coupling between the plate coil and the antenna-coupling coil. In the Aero coils the antenna coil is hinged at the bottom and in measuring the coupling merely the distance between the top of the plate coil and the top of the antenna coil was measured. The curves show that there is a considerable increase in efficiency when using very loose coupling. With very close coupling and with a coupling of $4\frac{1}{2}$ inches the antenna current is practically the same but the difference

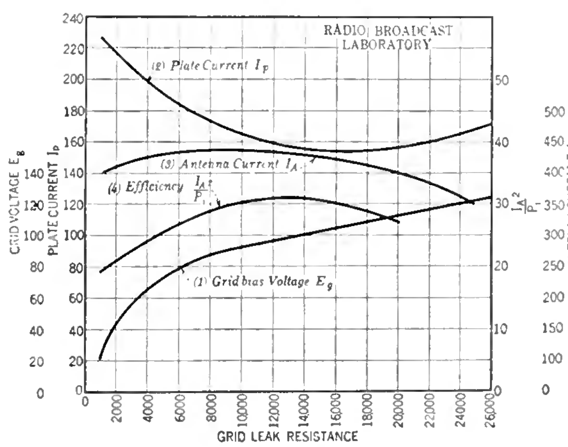


FIG. 6

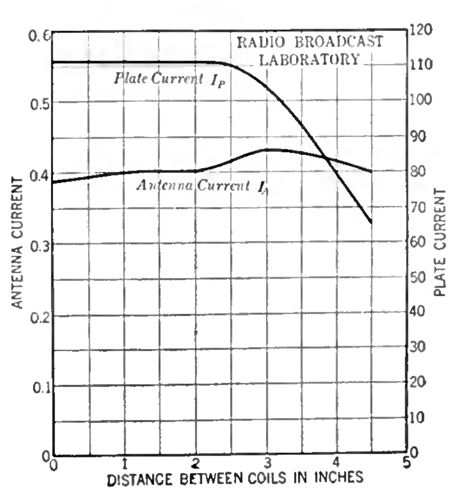


FIG. 8

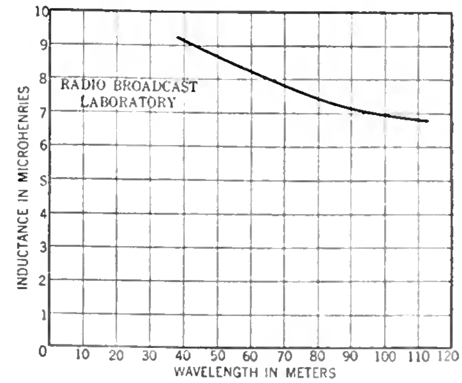


FIG. 5

in plate current between the two settings is of a ratio of 112 to 65, or practically 2 to 1. While 112 milliamperes at 385 volts is equivalent to an input power of 43 watts, with decreased coupling we are able to obtain practically the same antenna current with a reduction of input power to 25 watts. As the coupling between the two coils is decreased it will be found that the tuning of the antenna circuit becomes much sharper, but that, even with a coupling distance of $4\frac{1}{2}$ inches between the coils, the coupling is still sufficiently close to produce two resonance peaks (a characteristic of coupled circuits). For example, in one of the tests, the grid condenser was set at the correct point for 80 meters, and with the antenna disconnected, the plate condenser was varied to a point where the tube oscillated most vigorously. With a coupling of $4\frac{1}{2}$ inches between the antenna coil and the plate coil the antenna circuit was closed and the antenna condenser, starting at minimum capacity, was gradually increased. The antenna current gradually increased until it reached a peak and at this point the wavelength was measured and found to be 84 meters. Turning the antenna condenser only a fraction of a degree more, however, produced a very large increase in antenna current and on measuring the wavelength again it was found that it had decreased to 80 meters. This double effect will not be found if the tuning of the antenna circuit is done in the opposite direction, that is, starting with the antenna capacity at a maximum and bringing the circuit into resonance by decreasing the capacity of the antenna tuning condenser. When tuning is done in this way the antenna current will gradually increase until the maximum is reached and after the antenna tuning condenser has been adjusted for maximum current, a slight readjustment of

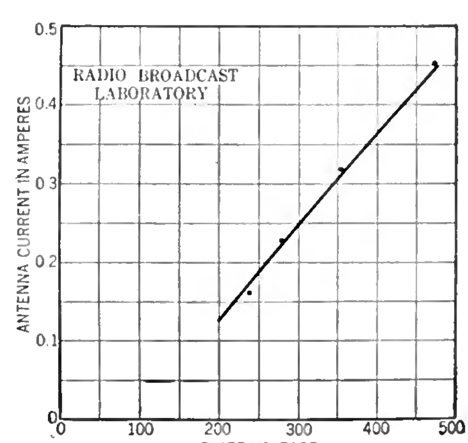


FIG. 9

the plate condenser is generally necessary to obtain maximum efficiency.

VARIATIONS IN PLATE VOLTAGE

THE power output from the transmitter of course increases with an increase in plate voltage, and Fig. 9 shows how the output power varies with plate voltages between about 200 and 500 volts. If the efficiency remained constant we would expect the power output to vary as the plate voltage squared. Doubling the plate voltage would then give four times as much *power* in the antenna circuit. The power in the antenna is proportional to the antenna current squared. Actually, however, doubling the plate voltage gives nine times as much power in the antenna, indicating that the efficiency also increases with increasing plate voltage and it is therefore advisable to use fairly high plate voltages in the operation of the transmitter. Every time the plate voltage is changed it is necessary to slightly readjust the condensers to obtain maximum power output.

In the operation of a tuned-plate tuned-grid transmitter it will be found that variations in the coupling between the antenna coil and the plate coil, and variations in the plate voltage, are the only practical means to control the amount of power going into the tube. Without any antenna load the input power to the tube is about 9½ watts. With the antenna connected, the input power can be made to go as high as 163 watts although most efficient operation was obtained with an input power of about 25 watts. The set operates very inefficiently with the high power and the plate of the oscillator tube gets very hot.

SOME GENERAL CHARACTERISTICS

IN FIG. 10 are given a group of curves which show in detail how the various quantities—plate current, antenna current, etc.,—vary as the plate condenser is tuned, the grid and antenna condensers having first been set at the correct point. With the plate condenser set at 100 (maximum capacity) the tube will not oscillate and the plate current is 85 milliamperes. The antenna current is, of course, zero, because the tube is not oscillating. If the tube is permitted to operate under these conditions for any length of time it will be ruined because the plate current is quite large and all of the power is dissipated on the plate, which becomes very hot. When the plate condenser dial is reduced to 50 the tube begins to oscillate and the plate current rapidly falls to 57 milliamperes. Further adjustments of the condenser cause the plate current to again increase. The plate current reaches a minimum when the dial reads 46 and the antenna current reaches a maximum with the dial set at 48.5 .The efficiency (antenna current divided by the plate current) as shown by the small curve, is at a maximum with the dial set at 47.5 and this point does not correspond with the maximum of either the plate current or the antenna current. All this means that an accurate adjustment is necessary to obtain maximum efficiency. If the transmitter is operated from B batteries, the increase in efficiency resulting from accurate adjustment is well worth while. In this particular case it would mean a reduction in B battery current drain from 80 milliamperes to 62 milliamperes (18 mA.), and this means longer battery life.

Radio Broadcast Photograph

A PHOTOGRAPH OF FIG. 3

The power unit is constructed on a baseboard with the power transformer on the left and the filter chokes and filter condensers at the right. The C-bias potentiometer can be seen at the rear center

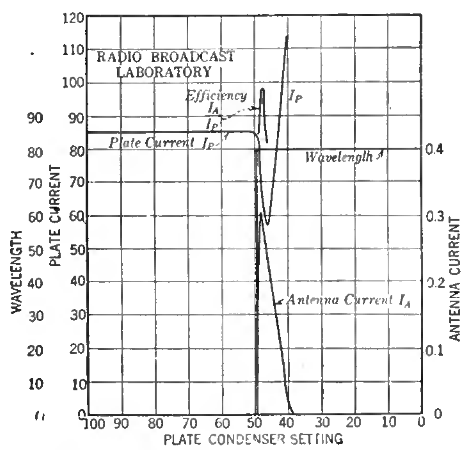


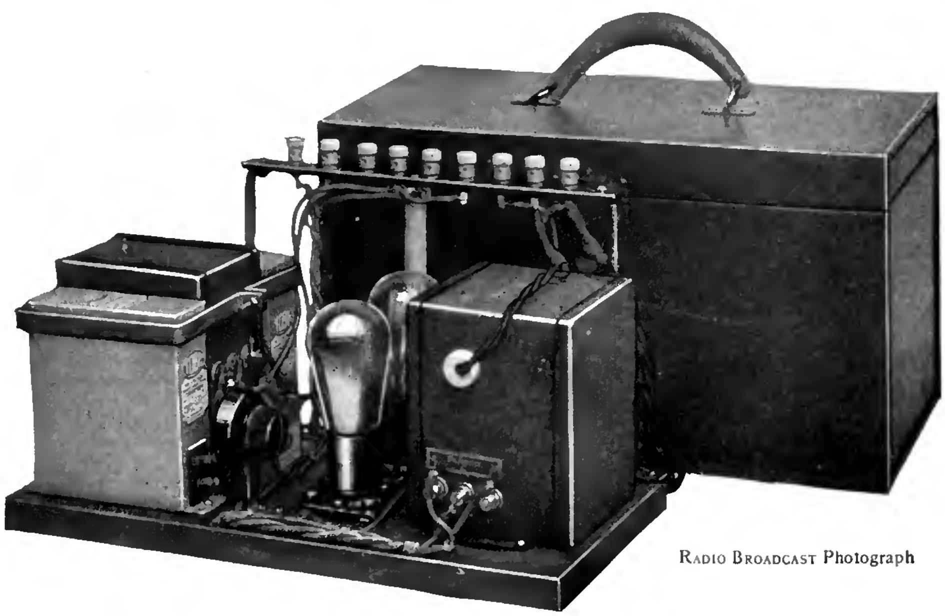
FIG. 10

In the course of the experiments, data were also taken on the effect of varying the size of the grid- and plate-coupling condensers. It was found that any.size between 0.0001 mfd. and 0.001 mfd. would give equally efficient operation, values less than 0.0001 mfd. giving somewhat less efficient operation. These values of course vary with the frequency at which the transmitter is being worked. They hold for 80 meters.

It is likely that most efficient operation will be obtained at any given wavelength with some particular value of inductance and capacity in the tuned circuits. In a transmitter of the type illustrated in this article, which is designed to cover a wide band of wavelengths without changing the coils, the inductance-capacity ratio cannot be considered because the actual value of the inductance is that value which will tune with the various capacities in the circuit to the shortest wavelength on which it is desired to transmit. The variable condenser must be of such a size that it will tune with the coil to the longest wavelength to be used.

A decided advantage of the tuned-plate tuned-grid transmitter is that it is possible to calibrate it so that it is a simple matter to set the transmitter on any desired wavelength. The procedure in adjusting the transmitter is about as follows:

First, the grid tuning condenser is set at the correct point according to the tuning chart, Fig. 4, and then, with the antenna circuit detuned, adjust the plate condenser to that point at which the plate current is at a minimum. With a coupling of about four inches between the plate coil and the antenna coil, the antenna tuning condenser is now adjusted for maximum antenna current. After the antenna circuit has been adjusted, a slight readjustment of the plate condenser is generally necessary to secure maximum efficiency. In making the preliminary adjustments on the set it is best to use somewhat low plate voltages so that the tube will not be damaged.



Radio Broadcast Photograph

A SIDE VIEW OF THE POWER UNIT

This photograph plainly shows the layout of apparatus. The center support of the binding post strip also acts as a holder for the 50,000-ohm fixed resistor. In the rear is the Kennedy tool case in which the power unit can be placed

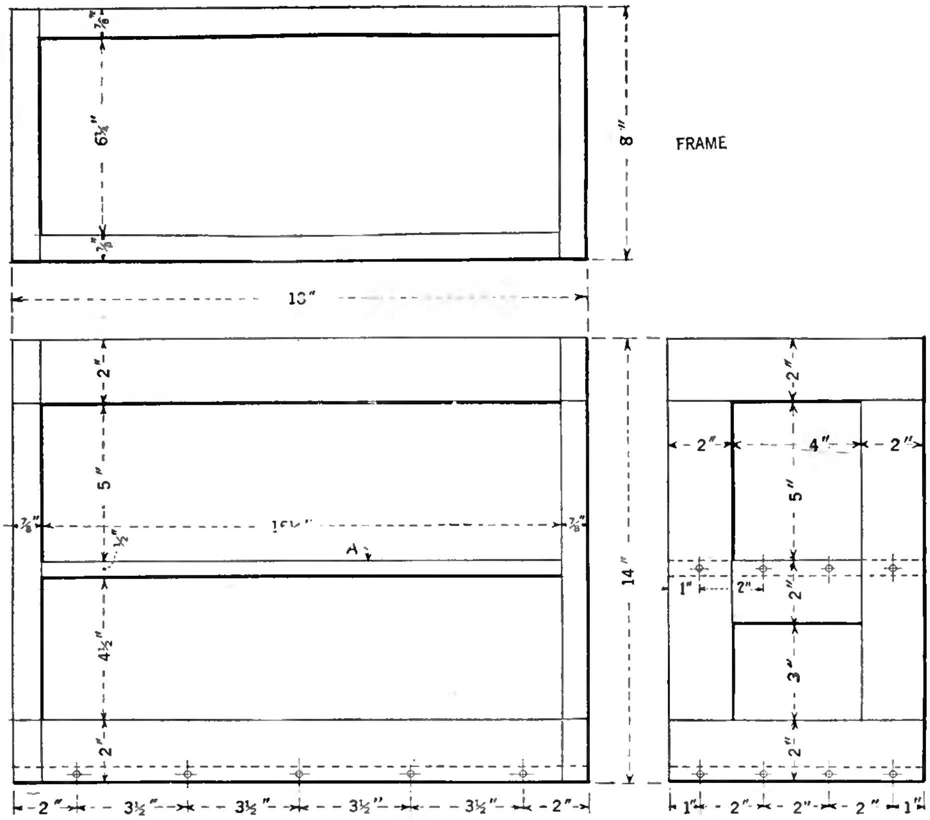


FIG. 11

PARTS USED IN THE TRANSMITTER

L_1, L_2, L_3, L_4, L_5—Aero Coil Kit, Type 4080	$12.00
L_6—Amertran Choke Coil, Type 709	10.00
C, C_1, C_2—Three Cardwell 0.0005-Mfd. Variable Condensers, type 173-C	15.00
C_3, C_4—Two Sangamo 0.00025-Mfd. Fixed Condensers	1.00
C_5, C_6—Two Tobe 1.0-Mfd. Bypass Condensers	1.80
T—General Radio Modulation Transformer	6.00
R—Mountford 12,000-Ohm Grid-Leak Resistor	1.50
S—Federal Four-Pole Double-Throw Switch	3.20
J—Yaxley Open-Circuit Jack	.50
P_1, P_2—Two Carter Telephone Pin Jacks	.60
A—General Radio 1-Amp. Antenna Ammeter Model 127-A	7.75
I—Weston 200 MA. Milliammeter, Model 301	8.00
Westinghouse Micarta Panel, 14 Inches x 18 Inches	5.00
Three General Radio Sockets, Type 156	3.00
Three General Radio Dials, $2\frac{3}{4}$ Inches in Diameter with Indicators	1.80
Nine X-L Binding Posts	1.35
Two Burgess Radio A Batteries	1.00
Federal Microphone	7.00
TOTAL	$86.50

The transmitter requires three 210 type tubes (DeForest type DL9) and the power supply employs two single-wave rectifiers of the 216-B type.

POWER UNIT PARTS

T—Thordarson Power Transformer, Type T-2098 (containing two filament windings and a center-tapped high-voltage winding)	$20.00
L—Thordarson Double Choke, Type T2099	14.00
C_1—Tobe 2-Mfd. High-Voltage Condenser	3.50
C_2—Tobe 4-Mfd. High-Voltage Condenser	6.00
C_3—Tobe 1-Mfd. Bypass Condenser	.90
R—Yaxley 1000-Ohm Potentiometer	2.00
R_1—Lynch 50,000-Ohm Fixed Resistance	3.00
Two Eby Sockets	1.00
Nine X-L Binding Posts	1.35
TOTAL	$51.75

The parts given in the two lists were used in the two units designed by John B. Brennan and illustrated in this article, but the parts of any other reputable manufacturers may be used if they are electrically similar.

CONSTRUCTION

IN THE actual physical layout of the transmitter considerable care was taken to keep the size of the unit as small as possible so as to make it easily portable. The method of construction will be evident from the various photographs in this article. The transmitter was built around a wooden framework having the dimensions given in Fig. 11. The tube sockets, coils, fixed condensers, grid leak, radio-frequency choke coils, and filament bypass condensers, were mounted on the shelf "A," Fig. 11. On the floor of the framework are mounted the two dry cells for the microphone, the Heising choke coil, and the modulation transformer. Extending from the rear of the shelf is a terminal strip holding nine binding posts. At the end of the transmitter is another small strip on which are mounted two additional binding posts for the antenna and counterpoise connections.

The following procedure should be followed in constructing the transmitter:

(1) Assemble the wooden frame in accordance with the data given in Fig. 11. Do not fasten the shelf very tightly.

(2) Lay out and drill the main panel in accordance with Fig. 12.

(3) Mount the various instruments on the panel and then fasten it to the wooden frame.

(4) Remove the shelf from the frame and mount the various instruments as shown in the illustrations.

(5) On the floor of the frame mount the batteries, choke, and modulation transformer.

(6) Drill $\frac{3}{16}''$ holes through the shelf at the points where connections are to be made to the tuning condensers.

(7) Run long bus bar connections from the terminals of the three tuning condensers to points tallying with the position of the holes previously made in the shelf.

(8) Mount the shelf in place, passing the wires from the condensers through the holes in the shelf.

(9) Complete the connection of these wires to the coils.

(10) Wire the rest of the transmitter using No. 18 lamp cord for the power and filament leads and bus bar for the "hot" connections—i.e., grid and plate leads.

THE POWER SUPPLY UNIT

IN THE first part of this article mention was made of the fact that a power unit had been designed to supply this transmitter. This power unit is illustrated in photographs on page 216. The construction is very simple. The power transformer, filter chokes, filter condensers, and tube sockets are all mounted on a baseboard measuring $7\frac{1}{4}''$ x $15\frac{1}{4}''$. The binding post strip is mounted on two brass supports so as to come even with the top of the Kennedy Tool Kit case in which the power unit is finally placed. The center support of the binding post strip is a piece of round brass, and this support is used as a mount for the 50,000-ohm discharge resistance. C bias for the grids of the two modulator tubes is obtained from a 1000-ohm potentiometer placed in the negative plate circuit, and with it, voltages up to about 100 volts are available for grid bias. The binding posts on the power unit are arranged in the same sequence as those on the transmitter so that in connecting the two together it is merely necessary to connect wires between the corresponding binding posts. The main switch on the panel of the transmitter has one set of contacts connected in series with the 110-volt lead so that, with the switch in the center position, the power unit is off, and with the switch thrown to either the right or left, the power is on.

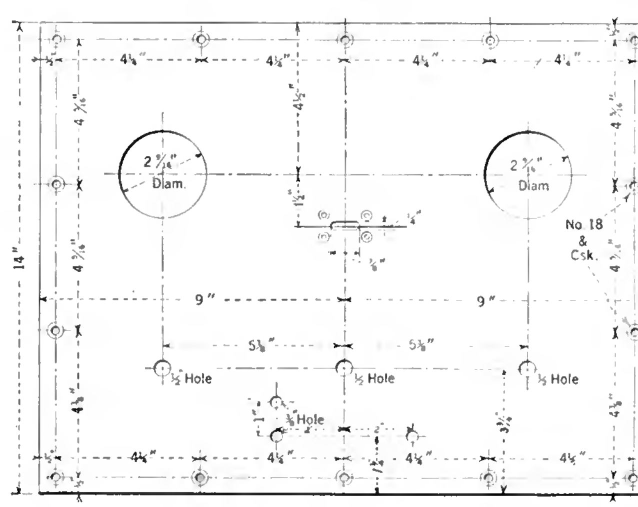


FIG. 12

THE LISTENERS' POINT OF VIEW

Conducted by John Wallace

Radio Is Doing a Good Job in Music

WITH all our skeptical remarks about radio education we have never yet expressed any mistrust of the important rôle radio can play, and is playing, in educating the populace in music appreciation. And when you get right down to it, even if the educational force of radio extends no further than this, there is small cause for complaint. Far more is gained by the initiating of ten people into the pleasures of music than by filling ten hundred with a miscellany of facts about economics or hog raising.

In the particular day and age in which we live there is a howling need for educating people in things esthetic and a very slight need for educating them in things practical. That is, there is very slight need for radio's exerting itself to educate them in practical things for a plethora of existing agencies is already busily engaged in bearing this burden.

Colleges and universities have increased their number and enlarged their enrollments to such a degree that it has come to be no longer a mark of distinction to attend one, but on the contrary rather classifies one as a member of the herd and the Babbittry. Technical schools, business colleges, night schools, and correspondence courses are likewise flourishing in a way never dreamed of a generation ago. The cities, through their health departments and citizenship bureaus, are daily educating thousands, and the bigger businesses and industries maintain after-hours schools for their employees. Even the newspapers devote columns to educational features and of course the current question book vogue is doing its bit toward equipping the man in the street with a knowledge of the date of the Battle of Waterloo and the specific gravity of lead.

In short, the man in the street is nowadays quite surrounded by persons who are both willing and anxious to educate him in any branch of practical knowledge, and who will do it for a song and at hours to suit his convenience. So even if radio does add its voice to those of the other practical educators it will augment the present clamor by only a small chirp.

Education in the useful arts is not to be railed at. In the nature of the present Western civilization it is as inevitable as tall buildings and prohibition. But it is not amiss to point out that for all the good it accomplishes, it in no wise assists in making more pleasurable man's journey through this terrestial sphere. In the good old days before we became so highly civilized the average man found in his day's labor not only the means to support himself in the world, but also the means to escape said world. Almost everyone was a craftsman of some sort. If an individual's job happened to be the making of door hinges, it earned him his daily bread; but more, it enabled him to escape into the realms of fancy in inscribing on the hinge elegant bits of embellishment. A man in the hinge business to-day, if he be among the higher ups, is embroiled in an unvarying routine of paper transactions, or if he be lower down, passes his days before a whirling bit of machinery, pressing a specified lever at a specified time and thus drilling a specified hole in a specified hinge on an endless belt. So occupied, there is little chance for his spiritual half to go wandering about in the great unmowed spaces of the fancy.

Of course means of escape still exist, but such specialists has our civilization made of us that they seldom exist in our day's routine. The impractical, and hence wholly pleasurable things, have themselves succumbed to civilization and become departmentalized. The arts, as we find them to-day, have been isolated like mumps and typhoid germs, tucked away into tightly sealed compartments and, like a bottle of strychnine, have been plainly labeled "Music," "Drama," "Painting," "Poetry," and so forth.

In the middle ages, before man was thoroughly educated, he got his drama by putting on a costume and cutting up on the great public festival days. Now the drama has been segregated and is to be found only in certain buildings labeled "Theaters." In those same days if a great and artistic cathedral were being built every man in the village would have a hand in it. Now all living art is cloistered away in "Latin Quarters" or placed under glass in gloomy and forbidding museums.

This is an unfortunate state of affairs, for if there was ever a time when mankind stood in need of the arts it is mankind of the Western civilization to-day. Being more highly civilized than his ancestor, man of the Twentieth Century is entitled to more highly civilized forms of recreation. The incongruous fact of the case is that his progress in pleasurable pursuits has not kept apace of his progress in practical pursuits. In his day's work he may be able to do things with a column of figures or with a lathe that would have completely mystified his prototype of the Thirteenth Century, yet when the five o'clock whistle blows he finds himself with no wit more knowledge of how properly to divert himself than did his ignorant forbear.

Logically, and by all rights, the arts should be enjoying their greatest usefulness to-day. They should rank high among man's various means of gaining pleasure and escaping dull routine. Evidently they are not so doing. Never in the history of the present culture have they been more exclusive, snobbish, and aloof.

But while these preceding remarks may hold true for the majority of the arts, they can no longer hold true for music. While the art of painting has steadily increased in complexity until it has reached a state where it is utterly beyond the grasp of the ordinary man, the art of music has intruded itself into his daily routine and once again become a part of his living.

There is no need to trot forth statistics, to quote questionnaires, or to tabulate radio station correspondence; the fact is beyond dispute that music is enjoyed and appreciated in the West to-day in a degree immeasurably greater than it was five years ago. Music is being heard to-day from all sorts of stations and on all sorts of programs that a few years ago would have been essayed only by the most highbrow station on its most highbrow hour.

We do not delude ourself that radio has been able to contribute a highly sophisticated taste in music to very many people. But (what is vastly more important as an opening wedge), it has given a taste for music to millions of people who previously hardly knew it existed.

However, great as the development has been, so far only the surface of music's possibilities has been scratched. The most radio has done so far is to acquaint the great mass of people with the fact that there is such a thing as music and that it is pleasant to listen to. Its next step is to cultivate the taste of its listeners to

ENTHUSIASM AT KPO

If this is the sort of thing you like, Hugh Barrett Dobbs, physical culture mentor, will be glad to put you through some pre-coffee exercises from KPO at some unearthly hour of the morning the point where they may get the most—or at least more—out of it. For any given piece of music will yield a hundred times more enjoyment to the person who "knows what it's all about" than to the person who simply listens to it as a vaguely pleasing succession of sounds. Yet an understanding of music is never gained by accident but can be realized only as the result of definite instruction in music appreciation.

What with all the zeal there is to-day for the imparting and securing of "education" there seems to be no good reason why some of this zeal may not be turned to the interest of music appreciation education. Radio is the best fitted agent to do this work and can function to its own best advantage by forgetting all its silly aspirations to supplant the technical college and by devoting itself to this equally large and far more important task.

Not all the millions of people in the United States who own receiving sets have the intelligence to really get the low-down on what music is, but that does not controvert the fact that there are thousands upon thousands of people in the land who have got the mental equipment to enjoy music if they put themselves to it. It is amazing how many people who are apparently cultivated, well educated, and surrounded by opportunities, and who profess to enjoy music, can be discovered, by a couple of well-directed questions, not to have the remotest idea of what music really means.

There are many excellent books on the market and in the public libraries which offer primer courses in the understanding of music. A very acceptable one, devoting itself primarily to radio listeners, was recently reviewed in this magazine. The only objection to learning music from a book lies in the fact that the book can't play the music it is talking about. It can quote measures but if you are unable to read music this is of little use.

Herein lies the unique advantage of radio; it can offer explanations and at the same time illustrate them. There have been a number of music appreciation programs on the radio already but the saturation point has been far from reached. An impetus in this direction is furnished by the report, new at the time we write, that Walter Damrosch has accepted the post of Musical Counsel for the National Broadcasting Company and has already under way a comprehensive plan for promoting fine music through the medium of radio broadcasting. This plan provides for a series of concerts supplemented by talks which can reach the majority of the 25,000,000 students in American schools and colleges. At the time of the announcement Mr. Damrosch made a statement, which, in case you have not read it, we will here quote:

> My experiences of the past winter in broadcasting orchestral concerts with the New York Symphony Orchestra and in giving Wagner lecture recitals at the piano have so amply borne out my belief in the extraordinary possibilities of radio broadcasting that I have accepted with the greatest interest the position offered me as Musical Counsel of the National Broadcasting Company.
>
> The plan which I propose to follow is the outcome of over 25,000 letters which I received not only from the larger cities, but from the smallest country towns and Western farms and ranches. In many of these letters the wish is expressed that orchestral music by radio should be extended to our schools and colleges—that my concerts and explanatory comments could thus supplement the work done by local teachers in the schools. This suggestion appealed to me greatly. The possibility of playing and talking to an audience of 25,000,000 young people fascinates me to such an extent that I shall gladly carry out the plan if it proves acceptable to the school authorities.
>
> I propose to give twenty-four orchestral concerts with explanatory comments on the works presented and on the instruments of a symphonic orchestra. These concerts shall be broadcast to every school and college in the country that chooses to accept them. There will be three series of eight concerts each, with carefully graded programs, one for the elementary schools, another for the high schools, and the third for colleges.
>
> Previous to each concert I would send to every school that desires it a questionnaire on the music to be performed and on my explanatory comments, together with the proper answers. These answers would, of course, be intended only for the eyes of the music teachers. After each concert the pupils could be examined by them and rated accordingly. If the parents are interested as well, the questionnaires could be distributed to them also, either through the school authorities or the local newspapers. The papers could print the answers a few days later.

MICKEY MCKEE
An accomplished lady performer on the whistle—her own—and heard in the "Roxy and His Gang" broadcast on the Blue Network Monday evenings

The "Continuity" Program

WEAF Network. The "Coca Cola Girl!" The opening program of a new series. Advance notices prepared us to expect great things of this new weekly serial. It would, we were told, "combine drama and music in a manner never before used in radio." At last, we told ourself, we are to hear the ideal continuity program. So much for our expectations—we are still looking for the perfect "continuity" hour. The soft drink damsel's program is not it.

The saddest part of it is that it could have been. The general idea of the new feature is not bad at all—in fact, it's very good. But its execution is—terrible.

Each broadcast in the series is to present an episode in the life of one "Vivian," a beautiful young Southern girl. The first one saw her at her "coming-out" party, an occasion which brought back to her home town her friend of childhood days, Dick Amberson, accompanied by his friend James. Jim promptly fell in love with her, and, it is to be presumed, will pursue her through the remaining episodes. During their conversations snatches of music are introduced illustrative of what they are saying. So you see, the idea had marvellous possibilities.

But neither the actors nor their lines are good; though acting and lines would seem to be two important elements in drama. The lines are amateurishly written and horribly stiff. Jim being presumably an average American youth would probably have said, upon viewing Vivian, "Pretty swell-looking bimbo!" or something equally inelegant. Instead he is made to say: "I suppose everyone that lays eyes upon her is captivated by her." And on one occasion he is made to ejaculate "Capital!" To the actor's credit, whenever he has a line that isn't too infernally impossible he puts quite a bit of conviction into it. But the Vivian, aside from the handicap of poor lines, is ill suited for the part. She may *look* young, and beautiful and Southern, but all we have to go by is her voice, which, though not displeasing, is certainly not young or Southern. It is decidedly matronly and decidedly eclectic in its accent.

THE MUNICIPAL BAND OF BALTIMORE
Heard over WBAL every Friday night at nine o'clock E. S. T.

We dwell thus long on a feature which certainly doesn't deserve the space simply because of the great possibilities which it has left unrealized and because it paves the way for some other advertiser to take up the same idea and handle it properly.

How is it to be done properly? Well, it would take a considerable outlay of funds. In the first place, it would take an expert to compose the lines. It seems to us that the best writer available would be none too good. To suggest a couple of names, either Mary Roberts Rhinehart or Booth Tarkington could do the job handily. Either one could, without much effort, compose a series of thirteen episodes that would be not only true to life and entertaining but which would provide an interesting commentary on the contemporary younger generation.

Next a couple of talented, well-seasoned actors would be necessary to acquit the lines convincingly. The program here reviewed lacked what is known to the stage as "click." That is, the speakers didn't follow, overlap, or interrupt each other in a way characteristic of natural conversation. It can be done, and the proof of it is "Sam 'n' Henry." Whether you like these two WGN entertainers or not you must admit they deliver their stuff in a most expert and realistic manner. These actors would not have to be the same ones who furnished the singing bits as it is an easy matter for radio to double a singer without anyone knowing the difference.

As to the interwoven theme of music, we think in this phase of the program, at least, the "Coca Cola Girl" did itself proud and any subsequent imitation of this program could study its method of handling the "score" to advantage.

We offer these suggestions for an ideal continuity program to whomsoever will take them. To engage the services of a "best-seller" author would, we grant, cost a lot of money. But we think it would be repaid in the prestige it lent the program. Moreover, it would intrigue many thousands of the more sophisticated radio set owners into listening without in any way diminishing the pleasure of the low-brow listeners who gobble up anything like this, good or bad.

Tolerating Jazz

VARIOUS readers of this department have belabored us for what they call our "leniency" toward jazz. But if "leniency" is not the attitude to adopt toward jazz we do not know what is. There is no use getting mad at it. It is no unnatural, monstrous thing to be shunned like a two-headed dog, but a perfectly normal manifestation of the present age. Jazz, as jazz, is no more reprehensible than a hot dog. Hence our failure to rant against it periodically. To be sure, we should not like to have a steady diet of jazz any more than we would like to have a steady diet of hot dogs. But there are times when the lowly weenie hits a spot that even a sirloin smothered in onions cannot reach.

There is still too much jazz on the radio, we grant; especially in the hinterlands. But fortunately most of it occurs at hours when good folk have gone to bed so it bothers us not. Those who like jazz are, we believe, entitled to it, and are not to be too much reviled for liking it. Those who understand real music realize, as no jazz addict ever can, that jazz is indeed a namby-pamby substitute for music; *but*, by way of vindicating them, list to what Paul Whiteman says in an article contributed to the New York *Times* Magazine:

I sincerely believe that jazz is the folk music of the machine age. There was every reason why this music sprang into being about 1915. The acceleration of the pace of living in this country, the accumulation of social forces under pressure (and long before the war, too), mechanical inventions, methods of rapid communication, all had increased tremendously in the past 100 years—notably in the past quarter century. In this country especially the rhythm of machinery, the over-rapid expansion of a great country endowed with tremendous natural energies and wealth, have brought about a pace and scale of living unparalleled in history. Is it any wonder that the popular music of this land should reflect these modes of living? Every other art reflects them.

Like the folk songs of another age, jazz reflects and satisfies the undeveloped esthetic and emotional cravings of great masses of people. Such music in any age has not been entirely negligible. Jazz is a spirit, not a manner. Crude, unmusical perhaps, but as healthily vulgar and sincere as were the vulgarities of the Elizabethan age—the music of an uneducated, vigorous man struggling ungrammatically to express his response to the age in which he is living. Since when in music have these forms of music been pronounced dead and worth ignoring?

THUMB NAIL REVIEWS

XXX—Due to a perhaps commendable reticence on the part of the broadcaster we were unable to discover what station was offering the program, but it was one of the best variations of the informational program we have yet heard. The two speakers were presumably touring in Alaska. The one asked the other various questions about the scenes and properties peculiar to that region with well-feigned curiosity. For instance: "What are those carved telegraph post things up in front of the houses?" Whereupon the other, who knew his Alaska, launched forth into a lucid and conversational explanation of the totem pole, and, led on by further questions, discussed their history, related how they were the personal insignia of the great families, just as are our family crests, explained why some are higher than others and included a bit of native gossip as to why one of them featured the bear among its carven decorations. By some hook or crook, music was worked into the feature to lighten it up a bit. We found ourself thoroughly interested, though ordinarily we loathe being "eddicated" by radio, and picked up quite a number of miscellaneous facts about Alaska that we had never heard of before. Only pressing duties at other parts of the dial induced us to desert it before the concluding announcement.

WJZ and the Blue Network—George Olsen and his Stromberg-Carlson orchestra. Of all its departments radio is probably best represented in its "light" orchestral section. There are no end of first-rate dance orchestras, hotel orchestras, and advertiser sponsored orchestras that can be regularly relied upon to play what they play well. Of these the Olsen organization is among the very best. Its program of popular numbers on this occasion was made up of some juicy and not-too-often-played tunes, among them: A Shady Nook; An Olsen Tango; Puszta Marden Waltz; An American Fantasy; and Melancholy Melody.

WJZ and the Blue Network—One of a series of operatic concerts under the direction of Cesare Sodero, featuring as soloists, Astrid Fjelde, soprano; Elizabeth Lennox, contralto; Julian Oliver, tenor; and Frederick Baer, baritone. Another chain feature that can always be counted on to be exceedingly good. The ordinary operatic program is inevitably made up of only the most popular arias of the various operas and fails to consider the second most popular and third most popular arias, which are often quite as good. The WJZ operatic hour gives the second string tunes a chance. For instance, on this program "Samson and Delilah" was represented by "Printemps qui Commence" instead of by the customary "Mon Cœur à Ta Voix." The "Mon Cœur" aria is certainly a "wow" but it shouldn't be allowed eternally to displace the "Springtime" song, which is every bit as musicianly and even more interesting on repeated hearings.

Broadcast Miscellany

ONE of the high spots in the history of KFI's broadcasting was the program contributed last spring by John Barrymore—a Shakespearian Hour. Mr. Barrymore is probably the foremost American Shakespearian actor. He included the soliloquies from Hamlet and King Richard the Third.

THERE ARE FEW BASS VIOL SOLOISTS

RADIO certainly permits you to hear musical curiosities which ordinarily wouldn't be stumbled across in a lifetime. Witness: the Edison Hour program from WRNY which featured Leon Ziporlin as soloist on the bass viol! There are only a handful of players in the country to-day who have mastered this ponderous instrument to the point of virtuosity.

WHAT A WINDOW-DRESSER THINKS ABOUT

OCCASIONALLY our name gets on the wrong mailing list and we are privileged to get in on some of the trade talk of the radio beezness, with frequently laughable results. This contribution to genuine and heartfelt sentiment by a "Dealer Bulletin:"

Another opportunity for ———— dealers. Possibilities of unusual window displays and newspaper ads selling the idea of remembering Mother by giving her a ———— Radio. Mother's Day comes but once a year—make the best of this opportunity. Dress up those windows—suppose you use a few photos of typical mothers, flowers, etc.

MISCHA ELMAN TALKS A BIT OF NONSENSE

A LOT of red-hot hooey contributed by Mischa Elman to the *Amplion Magazine* (London):

Can an artist give his best over the wireless? Judging from some sets I have heard, the best modern receivers are capable of reproducing the tone of a violin—even that of my £10,000 Strad—almost perfectly, but I am afraid an artist's personality suffers loss when he broadcasts.

The question of personality and broadcasting has been discussed a great deal since the introduction of wireless. I believe that a speaker can develop to a very high degree what is generally called "wireless personality," but in the case of a musician, it is inevitable that a great deal must be lost in transmission through the ether. If you consider the question carefully you will find that in listening to a violinist in a concert hall you use all your senses—chiefly your eyes and your ears, but your other senses also to some extent. The combination of these feelings enables you to appreciate the music to the full—to "sense" the artist's personality to the full, and, after all, that is the object of going to hear him.

Sight is very important—not because it enables you to admire his virtuosity in a set of Paganini variations, but because it enables you to "take him in"—to sense his personality.

THE book review and literary period presented over WOW every Saturday evening from 8 to 8:30 has proved one of the popular features of the station. The period is conducted by Eugene Konecky, of WOW's staff. The latest books are reviewed by Mr. Konecky.

WALTER MALLORY AT WCCO, MINNEAPOLIS-ST. PAUL

Mr. Mallory, a popular tenor, sings with the Buick Gold Seal Vagabonds from WCCO each Monday from 9 to 10 P. M. Central Time

GILBERT SELDES in the *New Republic:*

I have tried again and again to make myself a picture of the air at one of those moments when every tiny turn of the dial brings something new to the loud-speaker. It hardly seems possible that so many things could be of interest, that so many people would be trying to sell or persuade or exploit. Maxwell House Coffee presents old Southern melodies; Mrs. Augusta Stetson talks about God-de; *Collier's Weekly* transposes its forthcoming issue into music and drama; the political situation is summarized by Frederick William Wile; dinner music is broadcast direct from Janssen's Midtown Hofbrau House; Aimee MacPherson wishes that she could tell you how lovely Jesus has been to her; specialists speak on recondite subjects which suggest that they have collaborated with Robert Benchley; a lesson in Spanish from the municipality's own station; a plea for Jews to speak Hebrew; how to take care of an Airedale; Al Smith addresses newsboys and can't remember what year this is—waves, voices, personalities crowd each other, interfere with each other; a faint hum of jazz accompanies a Catholic priest; a prize-fight cuts into Bach; as you rapidly turn the dial from one end of the gauge to the other, you hear grunts and shrieks and the wild whistle of static. It is everything that America is interested in; it is America.

WARNINGS TO PURCHASERS

AN INCREASING number of local organizations of the National Better Business Bureau are taking up broadcasting as a means of disseminating their findings. The Bureau, as you probably know, busies itself at the ferreting out of dishonest practices in advertising or in selling, and its exposes are generally interesting and always valuable. The following stations are now used by Bureaus:

WNAC—Boston	KFJR—Portland, Oregon
WMAF—Chicago	WJAR—Providence
WSAL—Cincinnati	KFSD—San Diego
WTAM—Cleveland	WIAN—Scranton
WAIU—Columbus	WSBF—St. Louis
WWJ—Detroit	KWG—Stockton
WOWO—Fort Wayne	WFBL—Syracuse
KPRC—Houston	WIBX—Utica
WOQ—Kansas City	WRC & WMAL—Washington, D. C.
KFON—Long Beach	

A POPULAR WGN FEATURE

THE Salernos—Frank and Lawrence—are one of the best of WGN's several twenty-minute regular features. Their program opens with Lawrence, the vocal member of the pair, singing an old Neapolitan street song, to his own guitar accompaniment, while Frank supplies an accordion accompaniment in the background. Then they go into old Italian folk-songs, Frank interjects several accordian solos, and Lawrence devotes his excellent baritone voice to classical and popular numbers.

Correspondence

NARRAGANSETT, RHODE ISLAND.

SIR:

It is primarily for the more technical articles that I read *R. B.*, but nevertheless your department is always interesting. Was pleased with your grilling at the "Radio-Pest," but your rules for operating a radio set, like too many of the suggestions and informative articles appearing in the radio magazines, are all very well for the city listener, but how about us, provincials? In my own case, the nearest broadcasting station with any power is 35 miles away with 500 watts. There is no high-powered station within 125 miles. Our first move in the evening is to find out whether the static is bad. If it is we go to the show, or maybe read. At any rate we have no local station to fall back on when a bad night comes along.

Suppose there is no static. Do we pick out a good program and wait for that time before tuning in on the set? We do not. We have learned better. Although I knew better than to try it, one Wednesday evening, recently, I decided to read until time for the Maxwell House program. There was little or no static, so that one should have no doubt about being able to enjoy the program. The concert started at 9:00 P. M., and all was fine until about 9:10 when a ship with a spark set started calling Tuckerton, WSC. The operator called almost steadily until 9:30. At that time another ship called and got WSC and QSQ'd; received instructions to QSR from the other ship, and did so. At 10:00 P. M., when the Maxwell House concert was presumably at an end, the tail end of the QSR'd message was just getting into Tuckerton.

The above is just one instance. Every evening we are bothered by spark sets. Since the S.S. *Boston* and *New York* started the season, conditions are worse than ever. WJK will call WEL for some time, then will start sending long dashes and the "three dot dash dot" combination. This is often kept up for the duration of a feature program, one which has been anticipated, maybe, for a week.

We don't mind the harmonics of the c.w. sets, but the sparks spoil the program on any wave down to 300 meters or below. This looks so much like a complaint that perhaps it should go to the Commission; but I will send it to you to show how we, in the outlying districts, need a little help.

H. C. Dow.

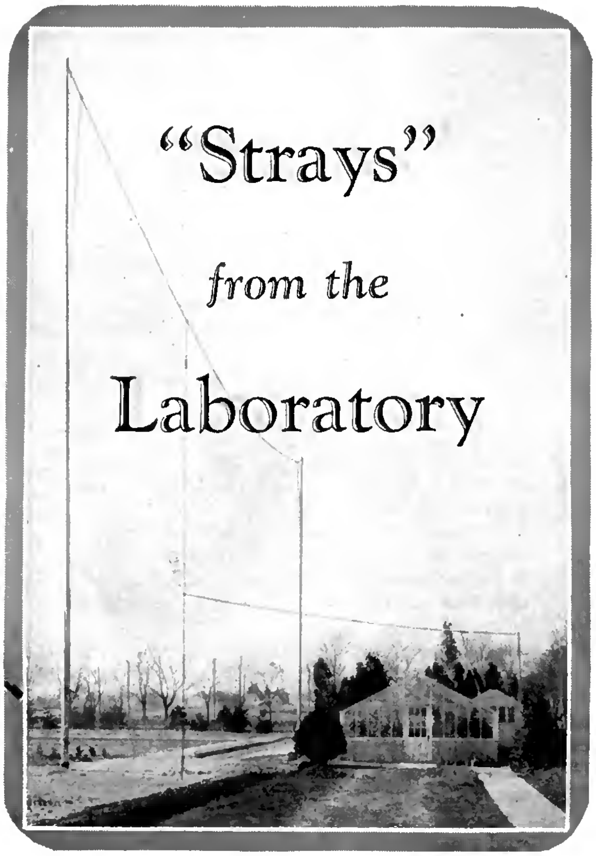
PARK V. HOGAN

Organist heard from WJZ during the Estey Organ Recital on Sundays at 7.00 o'clock

THE CROSLEY MOSCOW ART ORCHESTRA

A recent bi-weekly feature broadcast on Sunday afternoons over twenty-two stations of the Red Chain. This feature was on the air between 5:30 and 6:30, a time which had been practically open until the institution of the Crosley feature last winter. The violinist standing before the microphone is Arno Arriga, Director of the Orchestra. This group specialized in semi-classical selections, which were found to suit the popular taste best. They are scheduled to return in September

"Strays" from the Laboratory



The "Myracycle"

AMONG the many suggestions made to the newly created Federal Radio Commission is that of a gentleman from the Middle West whose wishes, if they came true, would do away with the term "kilocycle" in favor of a new and perhaps more useful expression, the "myracycle." The myracycle would represent a unit of ten kilocycles, and since stations on the familiar broadcasting band are to be separated by ten-kilocycle—or one-"myracycle"—intervals, the suggestion should not be dismissed without a hearing.

Using the term myracycle would mean that a station operating on 660 kilocycles would be rated at 66 myracycles, and at the top of the broadcasting band a station now on 1500 kilocycles would be known as a 150-myracycle station. This term would do away with the final cipher in our present listing of stations.

It should be remembered, however, that it has taken a number of years to bring the term kilocycle into even the outer consciousness of the average radio listener who still prefers to think in terms of wavelengths, and to introduce another term might put the whole business of frequency designations back into the middle age method of designation by meters. There is already another frequency term, the "megacycle," which represents a thousand kilocycles (one million cycles). We first heard it used in Doctor Pickard's study after his summer spent in measuring the polarization of high-frequency signals, and although it sounded strange at first, it proved to be very useful in speaking of amateur frequencies. The relation between these several units is shown in the table below:

1 cycle = 10^0 cycles = 1 cycle
1 kilocycle = 10^3 cycles = 1000 cycles
1 myracycle = 10^4 cycles = 10,000 cycles = 10 kilocycles
1 megacycle = 10^6 cycles = 1,000,000 cycles = 1000 kilocycles

The Use of Exponents

WHICH brings up another interesting point—the use of exponents in the arithmetical calculations in which all radio engineers must indulge from time to time. Exponents are among the mathematician's most useful shorthand symbols, as the table below will indicate:

1	=	10^0	= Units
10	=	10^1	= Tens
100	=	10^2	= Hundreds
1000	=	10^3	= Thousands (Kilo.)
1,000,000	=	10^6	= Millions (Mega.)

1	=	10^0	= Units
.1	=	10^{-1}	= Tenths
.01	=	10^{-2}	= Hundredths
.001	=	10^{-3}	= Thousands (Milli.)
.000001	=	10^{-6}	= Millionths (Micro.)

Now the rules dealing with these complicated looking figures are simple, and when mastered, provide an exceptionally easy method of handling large numbers, or numbers in which the decimal point of the answer is in doubt. The rules are as follows:

When multiplying numbers, add exponents.
When dividing numbers, subtract exponents.
When squaring numbers, double exponents.
When getting square roots, halve exponents.
When transfering an exponent across the dividing line, change its sign.

For example the following problem may be simplified and solved:

$$\frac{1234 \times 0.02 \times 1000 \times 64}{2468 \times 800 \times 0.001 \times 100}$$

$$= \frac{1.234 \times 10^3 \times 2 \times 10^{-2} \times 10^3 \times 64}{2.468 \times 10^3 \times 8 \times 10^2 \times 10^{-3} \times 10^2}$$

$$= \frac{1.234 \times 2 \times 64 \times 10^3 \times 10^{-2} \times 10^3}{2.468 \times 8 \times 10^3 \times 10^2 \times 10^{-3} \times 10^2}$$

$$= \frac{1.234 \times 2 \times 64}{2.468 \times 8} = 8.0$$

As a somewhat more practical problem, let us consider the formula which states that the resonant frequency of a tuned circuit in cycles is as given below, when the inductance is in henries and the capacity in microfarads. If the coils and condensers in question are rated in millihenries and micro-microfarads, what will the constant above the line become?

$$f \text{ cycles} = \frac{159.2}{\sqrt{L \text{ h } C \text{ mfd.}}}$$

and since mh. = 10^{-3} hand mmfd. = 10^{-6} mfd., this formula becomes:

$$f \text{ cycles} = \frac{159.2}{\sqrt{L \times 10^{-3} \times C \times 10^{-6}}}$$

$$= \frac{159.2}{\sqrt{(L C \times 10^{-3}) \times 10^{-3}}}$$

$$= \frac{159.2 \times 10^3}{\sqrt{L C} \times \sqrt{10^{-3}}}$$

$$= \frac{159.2 \times 10^3 \times 31.6}{\sqrt{LC}}$$

$$= \frac{5.033 \times 10^3}{\sqrt{LC}}$$

$$f \text{ kc.} = \frac{5.033}{\sqrt{L C}}$$

The Telephone Transmission Unit

THE use of exponents is the basis of our logarithms, as well as the foundation of the transmission unit, TU, which has been explained by Carl Dreher on several occasions in his department "As the Broadcaster Sees It." For example the exponent of 10^2 is 2, that of 10^3 is 3, and all numbers between 100 and 1000 have logarithms to the base 10 somewhere between 2 and 3. This amounts to saying that all numbers between 10^2 and 10^3 have exponents between 2 and 3.

The need for the transmission unit may be explained as follows. Let us suppose we have an electrical circuit—a telephone wire—connecting two points, and at the end of the first mile, the power has dropped to 0.9 of its original value. At the end of the second mile it has lost another 0.1 or is 0.9 of what it was at the end of the first mile, or 0.9 x 0.9, or 0.81, of its original value, and so on, to the end of the line. What is it at the end of eight miles? It is not only unwieldy to manage numbers of this sort but we must multiply them, which is less easy than addition.

Let us assign a unit to the ratio between the power at the end of the first mile to the original power, say A. This then represents the loss in that mile. Likewise, the ratio between the power at the end of the second mile to what appears at the end of the first is also A. In other words, at the end of the second mile we have lost twice A, or two units. If the line is eight miles long we shall have lost 8 units, and as Table No. 1 shows, the power will be 0.43 of its original value.

Reversing the direction of procedure along the line, as we approach the starting point we gain one unit for each mile of progress.

Again let us suppose that at the end of each mile as we go toward the end of the line we interpose an amplifier—a repeater as the telephone people call them—and that it boosts the power back to its original value. It is certainly much simpler to state that the amplifier has a power gain of A units than that it amplifies the power 1.111 times, for it must do such to raise 0.9 of the power back to its original value. The total gain of eight such repeaters will be 8 units.

The telephone engineer's foot rule, the transmission unit, is defined as ten times the logarithm to the base ten of the ratio between any two powers, or twenty times the logarithm of the ratios of voltages or currents into equal impedances. In mathematical language:

$$TU = 10 \log_{10} P_1/P_2 = 20 \log_{10} E_1/E_2 = 20 \log_{10} I_1/I_2$$

Thus an amplifier with a power gain of 100 has a gain of 20 TU since the exponent, or logarithm, of 100 is 2.0. Two of these amplifiers in series will have a gain of 40 TU or a power gain of 100 x 100, or 10,000. When a full orchestra plays fortissimo it is roughly 60 TU's more powerful than when playing pianissimo, a power ratio of 1,000,000. It is fortunate that the ear hears according to a logarithmic scale!

To become more familiar with the TU business the following facts may be useful. The average two-stage amplifier as used in broadcast receivers has a voltage gain of about 300, or 50 TU. The difference in power between a 500-watt station and one of 5000 watts is ten TU, and the latter enables a listener equidistant from the two to use 10 TU less amplification to get the same volume, which means that the receiver will be less susceptible to extraneous noises such as static. A variation of 10 TU at the two extremes of the audio-frequency spectrum, say at 100 or 5000 cycles, can be noted by the ear but will not make such an extraordinary difference in quality as some amplifier parts manufacturers would have us believe. That is, the volume at 100 cycles can be reduced by 10 TU, *i.e.*, the power can be reduced to $\frac{1}{10}$ or voltage to 0.316 of its former value before the ear notes it. A further reduction of 10 TU is appreciable.

Another example of the use of the TU, and one which merits very careful study, is shown in Fig. 1; it was taken from the *Bell System Technical Journal* for January, 1927, from an article by Lloyd Espenschied. The data for these curves which show the relative selectivity of several popular types of receivers were taken in the following manner. A laboratory oscillator was modulated at a fixed voice frequency, the receiver was tuned to the carrier, and the detected audio current measured as the oscillator was tuned in 10 kilocycles steps away from the original frequency.

The first significant point to note is that all receivers have a distinct cut-off within 10 kilocycles of resonance. Even at 5000 cycles the better grade receivers are 10 TU "down," which means that audio frequencies of this value will be down, and that a rising characteristic amplifier is probably a good idea. The curves show that the super-heterodyne or double-detector is considerably more selective than the others, and, as was to be expected, the simple single-circuit affairs have very little discrimination between wanted and unwanted signals.

Mr. Espenschied points out that undesired signals may not be bothersome when only 40 TU below the desired signals when the latter are strong, but when the program happens to call for a pianissimo passage the unwanted signals are disturbing. Reducing the level of the unwanted station to 60 TU eliminates this trouble.

The chart shows what may be expected in an area where stations are separated by 50 kilocycles and put an equal field strength about a given listening station. The sets with radio- or intermediate-frequency amplification give a 60-TU discrimination against unwanted signals with some to spare to take care of signals from more powerful stations. If the listener wants to "get out" he imposes a much greater task on his receiver. Suppose he receives 50,000 microvolts from a local station and 500 from a distant station (the example is Mr. Espenschied's). This represents a difference of 100 to 1, or 80 TU in favor of the local station. To reduce the local signals to the same level as the distant station, then, requires a selectivity of 80 TU and to take care of the added 60 TU necessary to reduce the local to the point where its signals will not bother during weak musical passes makes a total discrimination of 140 TU which the receiver must possess. This means a current reduction of the order of 10,000,000 to 1—a high order of selectivity.

MILES	0	1	2	3	4	5	6	7	8
POWER	1	0.9	0.81	0.729	0.657	0.59	0.531	0.478	0.43
"UNITS LOSS"	0	1	2	3	4	5	6	7	8
POWER TO BASE 0.9	0.9^0	0.9^1	0.9^2	0.9^3	0.9^4	0.9^5	0.9^6	0.9^7	0.9^8

TABLE NO. 1

Colored Sockets and Bases

ONE of the most interesting items of news from the "Nema" convention at Hot Springs, Virginia, is that regarding the new color arrangement for sockets and tube bases. According to this code, which was proposed by the Benjamin Electric Company, the bases of radio-frequency and first-stage audio tubes, and the receiver sockets into which these tubes are used, will be colored maroon; the detector will be green, while the final tube, the power amplifier, and its socket, will be colored orange. The arrangement is, therefore, as follows:

Maroon: R. F. and 1st amplifier — 201-A, 199, 226

Green: Detector only — 200-A, 199, 227

Orange: Power tube only — 112, 171, 210, 120

If we wanted to be facetious, we would suggest a crimson tube for Harvard and one for Lindbergh in whatever his favorite color may be.

We wonder what will be done with the other special-purpose tubes, such as the r. f. amplifier tubes with higher amplification factors and consequently higher impedances, rectifier tubes, high-mu tubes for resistance or impedance amplifiers, etc.?

The suggestion, admittedly, provides precaution against the danger of wrecking tubes or receiver through unfamiliarity with the inner workings of a complicated electrical machine. The average user of tubes has very little idea of the functions of the individual parts of his set. In receivers with an unusual arrangement of sockets, he can not know that the third tube from the end is not the detector unless he is warned before, either by reading a more or less dull and technical booklet, or by noting the color of the socket. While this color scheme has much to commend it, it seems somewhat inadequate in its present form.

New A. C. Tubes

THE new R. C. A. tubes marked 226 and 227 operate from raw a. c.; their existence was vigorously denied by representatives of both the R. C. A. and Cunningham staffs only a short time ago. One day, seemingly, the very thought of new tubes is abhorrent to these companies, while the next day complete operating data, photographs, etc., drop into the Laboratory, by special delivery, like a bolt from the blue. In the meantime—that is, between our statement last month and the time of going to press this month—a. c. tubes have been received and tested from the Armstrong Electric and Manufacturing Company, the Van Horne Company, the Sovereign Company, and the makers of the familiar Marathon tubes. Others proposed or available are the Arcturus, the Schickerling, the Quadrotron, the Zons, and probably others.

These tubes in general use are of two types, those using a low-voltage high-current filament, and those employing an extra heater which is not electrically connected to the receiving circuit. These latter tubes require several seconds to heat up and "get under way." The others are ready for reception as soon as the current is turned on. The R. C. A. has tubes—ready perhaps early in July—of both types; the R. C. A. high-current tube is for all positions except detector, and the heater type is for the detector socket. All of these tubes require different values of filament voltage and current, making the problem for the transformer manufacturer, or the home constructor, difficult, to say the least.

The new a. c. tubes can be used in place of d. c. tubes now in use, but we must admit that with a high-quality amplifier and a high-quality loud speaker, we have not heard a receiver using the a. c. tubes which was as "absolutely without hum" as the advertising would indicate. This, however, may be the fault of the receiver or plate-supply unit design. Time will tell.

Complete data on the various a. c. tubes will be prepared in time to appear in the September RADIO BROADCAST, we hope.

New Apparatus Received

DURING the month of May, the following apparatus has been received in the Laboratory: Frost's new line of rheostats, jacks and sockets; resistances from American Resistor Company, Arthur H. Lynch Incorporated, De Jur, Electro-Motive Engineering Corporation, Aerovox, International Resistance Company, and Amsco; condensers from Aerovox, John E. Fast Company, Dubilier, and Globe Art Manufacturing Company; sockets and cables from Howard B. Jones; A. C. tubes from Marathon, Van Horne, Armstrong, Sovereign Electric and Manufacturing Company; d. c. tubes from the Allan Manufacturing Company, Supertron, Magnavox, and Cable Supply Company; a pair of push-pull, high-quality transformers from Samson; a midget cone speaker from the Alden Manufacturing Company; a fine supply of Benjamin apparatus, including sockets, switches, condensers, etc.; a "Baritone" loud speaker unit; output filters from Federal, Erla, Muter, and Centralab; a new dry rectifier unit from Kodel; X-L binding posts; the Varion, a Raytheon A, B, C unit made by the Morrison Electric Supply Company, and recently described in *Popular Radio*; Marathon's new rectifier tubes; and as this is written, two very beautiful Westinghouse high-resistance volt meters.

The General Radio transformer type 285-N is for use as a coupling device between the element of the string oscillograph and a high-impedance bridge or tube circuit, and not as mentioned recently in these columns.

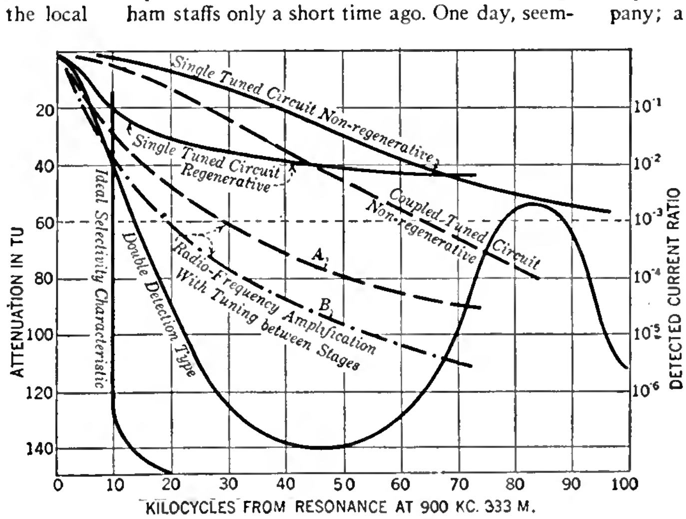


FIG. 1

Judging Tone Quality

Training the Ear to Discriminate Between Good and Poor Quality—How Harmonics Cause Different Instruments to Be Distinguishable—Practical Hints for the Potential Set Purchaser

By EDGAR H. FELIX

APPRECIATION of good tonal reproduction is an art rather than a science. Scientific analysis of amplification curves are valuable to the engineer in determining possible causes of distortion, but the best and final test of reproduction quality is the ear of a trained and practiced observer. In working for good tone quality from a radio receiver, whether manufactured or home built, half the battle is understanding what good tone means.

In spite of the average radio enthusiast's opinion, not one in a thousand listeners is a discriminating judge of tone quality. Only most unusual exaggeration or the complete absence of low, high, or middle frequencies in the sound output of a receiver registers emphatically on the consciousness of the average observer. The most precise judgment which the self-appointed expert is able to pass upon a receiver's tonal capabilities is usually confined to such generalities as "good," "fair," and "poor." Yet the brain center of hearing is capable of making the most delicate discriminations. Only by learning to judge tonal defects with precision is one able to analyze the numerous possible causes of distortion in a radio receiver.

Much has been said and written regarding the causes of distortion. Oftentimes a particular make of transformer or a certain brand of sound reproducer is recommended as the panacea for deficient tone quality. But no one part of a radio set can, of itself, produce good tone. On the other hand, there is hardly a link in the radio chain which cannot exert a damaging influence on an otherwise perfect reproducing system.

In general, there are three kinds of distortion: (1.) Exaggeration of a particular frequency, causing a blasting effect; (2.) overloading, distorting all loud music of any pitch; and (3.) under or over amplification of a broad range of frequencies, such as the low, middle, or upper registers. Each of these is caused by specific faults in the design or operation of the receiver.

Simply that the causes of distortion may be viewed comprehensively at the outset, here is offered a partial list of the possible causes of distortion which may adversely affect the tonal output of a receiver, no matter what kind of audio and radio system is employed:

(1.) Antenna
- (a.) Too long, causing overloading of detector tube with sets lacking effective radio-frequency amplification control.
- (b.) Inadequate, requiring overworking of radio-frequency amplifier.

(2.) Radio-Frequency Amplifier
- (a.) Regenerative or near-regenerative.
- (b.) Incorrect grid or plate voltages.
- (c.) Imperfectly synchronized circuits.
- (d.) Wrong type of tubes.
- (e.) Magnetic coupling with alternating current elements of power supply or with audio-transformers.
- (f.) Insufficient filtering or inadequate bypassing of power supply leads.

(3.) Detector
- (a.) Overloaded:
  - (1.) By radio-frequency amplifier.
  - (2.) Because of incorrect grid voltage.
- (b.) Over-regeneration.

(4.) Audio Amplifier
- (a.) Incorrect grid or plate voltages.
- (b.) Tube output impedance incorrect for load impedance.
- (c.) Audio-frequency regeneration due to:
  - (1.) Magnetic coupling between transformers or coupling devices.
  - (2.) Conductive coupling through imperfectly bypassed power leads.
  - (3.) Acoustic or mechanical coupling of tube elements with resonant cabinet.
  - (4.) Magnetic coupling with power circuits.
  - (5.) Acoustic or mechanical coupling with reproducer.

(5.) Reproducer
- (a.) Saturation of magnetic element.
- (b.) Incorrect adjustment of vibrating element in relation to electro-magnet.
- (c.) Mechanical resonance in moving element.
- (d.) Discrimination against or favoring of certain frequencies in the electro-magnetic unit.
- (e.) Acoustic resonance or filtering of certain frequencies in sound radiator.
- (f.) Limited frequency range of magnetic or acoustic elements.

This seemingly endless variety of possibilities may appear discouraging, so numerous are the hidden causes which may contribute to distortion. Nevertheless, modern amplification systems permit of relatively perfect reproduction, implying the conquest of each one of these possible causes of distortion. An optimist may be inclined to dismiss most of the list as unimportant and confine his attention to reproducer and transformers—favorite subjects for condemnation. But even the most superficial analysis will reveal that a few precautions in connection with the power supply, in the placing of the reproducer, and in the use of recommended tubes, will overcome most defects. Oftentimes, a slight readjustment will bring marked improvement in a receiver's tonal output. Other adjustments may make no perceptible contribution to improved tone quality, yet they may be, in fact, causing a really valuable improvement. Herein lies the most important obstacle to the attainment of true reproduction—the fact that the average listener is affected only *subconsciously* by most of the distortion to which he is subjected.

THE DELICATE SENSE OF HEARING

HOW delicate the discriminations which the ear can make, consciously or subconsciously, is indicated by the fact that there are 24,000 separate nerve endings in the ear membrane which may report impressions to the brain simultaneously. Each of these, habituated to the detection of conventional sounds of voice and musical instruments, is ready to report to the brain any deviation from the accustomed tone. Indeed, so complex and numerous are the impressions to which the sense of hearing may respond that we think definitely and specifically of only a very minute part of the actual impressions which the brain senses. If a loud speaker rattles harshly on a high note, you may notice it consciously and speak of it, but your trained ear has probably detected the existence of that rattle or harshness a thousand times a minute before it was sufficiently acute to be perceived consciously! The millions of subconscious recognitions of distortion which your highly-developed hearing sense impresses upon your brain each minute of listening to a "fair" receiver are of great importance because they make radio music sound tiresome and unpleasant. They cause it to be mysteriously unreal and are the reason why you sometimes shut off your receiver without being able to offer a valid reason.

The sense of hearing is a creature of habit and, after a few hours or even a few minutes of listening, it can accustom itself to a persisting form of distortion. This is the cause of most of the misjudgments made with regard to tone quality. After listening habitually to a receiver having certain distorting characteristics, listening to a better set without that same distortion may be, at first, quite disagreeable. At the same time, a receiver having the opposite characteristics (one exaggerating the "lows," for example, after the listener has become habituated to one with marked absence of "lows") sounds peculiarly pleasing, although it is also a distorting receiver.

As evidence that habit accustoms one to distortion, the first telephone conversation in any individual's experience is generally quite difficult because the lower voice frequencies, which contribute mellowness, resonance, and sympathy in tone, are strangely absent. After a little practice, however, the ear accustoms itself to this form of distortion, so that almost any voice can be understood over the telephone without difficulty.

Obvious distortion in radio reproduction, such as rattles, whistles, and howls, etc., or the wholesale absence of low or high frequencies, can be appreciated by the most untrained ear, but the radio receiver that attracts admiration is the one designed not only to eliminate obvious causes of distortion but to bring out the many hidden fine points of tone quality which impress only the subconscious mind of the average listener. Once the earmarks of certain kinds of distortion are clearly understood, the trained observer becomes competent to distinguish forms of distortion otherwise felt only subsconsciously. Appreciation of subtler kinds of distortion often enables you to find their cause in the radio-frequency amplifier, detector, audio-frequency amplifier, or loud speaker.

Mr. George Crom, Jr., of the Amertran engineering staff, has stated that the final test of a reproducing system is its effect upon the listener as measured over a period of several hours. If the loud speaker can be kept on continuously for many hours without wearying those within hearing or interfering with their regular occupations, it is likely to be reproducing with good quality.

Distortion due to resonance peaks and overloading is obviously distressing and most easily analyzed. But elimination of these obvious forms of distortion by correct adjustment of neutralization, elimination of undesirable interstage couplings, correction of overloading, and substitution of non-distorting couplingdevices and reproducer, may yet fail in producing faithful reproduction.

Although there may be neither resonance peaks nor overloading, a receiver may still not give true music. In that case there is either insufficient or exaggerated reproduction of low, middle, or higher registers. Consequently, before proceeding with detailed analysis of causes, one must be able to recognize true reproduction—full, equal, and natural amplification of all of the essential range of frequencies.

Excellent reproduction is attainable in both transmitter and receiver, provided every element accomplishes its function properly. Perfect reproduction is not confined to any one system of amplification, such as resistance, impedance, or transformer, or to any one loud speaker. If this article appears to lay much stress, at first, on *what* good tone is, rather than *how* it is attained, it is because the understanding of this point is of great importance in analyzing the causes and capabilities of radio receivers and their audio-amplifiers and loud speakers.

INDEFINITE QUALITY TERMS

THERE is ample evidence in the advertising columns of any radio magazine that we speak of tone quality in most general and casual terms. Claims of instruments producing rich tones, mellow tones, and brilliant tones, and claims of good reproduction of low tones or upper harmonics, reduce frequently to admissions that such instruments distort. Yet tone is so little understood that a distorting quality may be claimed as a virtue. There is only one kind of reproduction which is to be sought as ideal and that is faithful reproduction, without any embellishments, exaggerations, or special qualities added to the original. Rich tone, for example, may be a pleasing contrast to thin tone, but it is a species of distortion which, in the end, is as tiring as thin tone.

True reproduction requires that the sound waves released from the loud speaker possess precisely the same characteristics as to frequency and amplitude as exist electrically in the audio-frequency modulation of the incoming carrier waves. This entails equal amplification of all the frequencies essential to good tonal reproduction, their transmission through all the various units of the reproducing system with equal facility, and their ultimate release as sound impulses, without any alteration. It means equal amplification of low, middle, and high registers, without marked resonance peaks. All these invisible qualifications of the perfect reproducer are manifest in its ultimate output—the music and speech impressed on the listener's consciousness.

Such faithful reproduction as described above is an attainable ideal but one quite beyond the reach of the average set owner. Satisfactory reproduction, however, requires fairly uniform amplification of the low, middle, and high registers rather than precisely equal amplification throughout the range, complete absence of sharp resonance peaks in the low and middle registers, and entire avoidance of overloading. But even granting these concessions to economy and simplicity from the ideal standard—true reproduction—it is surprising how far below the standard of satisfactory reproduction the average radio receiver falls.

Fundamentally, we are concerned with tone reproduction, with variations in air pressure, and with tiny air impulses mechanically set up by an electric machine. These impulses cause the diaphragm of the ear to vibrate, which, in turn, acts upon 24,000 sensitive nerve endings within the ear. Musical sounds are rhythmic variations in air pressure; noises or unmusical sounds are interrupted and irregular.

The most recognizable quality of tone is pitch. Pitch is the only characteristic of music which we record in printed form as notes upon the musical staff. Melody is a pleasing succession of pitches. The clear, colorless, sound of the tuning fork is perfectly "pure" tone.

Pitch is our conscious recognition of the fundamental vibration of musical sound. The fundamental of the middle C on the piano, for example, is one of 256 impulses per second. So, also, is the fundamental set up by every instrument or musical sound sounding that particular pitch. The greatest amount of sound energy released by a musical instrument is concentrated on the fundamental.

The chart on page 226 shows the range of fundamental pitches set up by various instruments and voices. The lowest tone of a giant organ actually goes down to sixteen impulses per second. No commercial reproducing instrument goes so far down in frequency; in fact, only a few radio receivers respond to less than 100 cycles frequency, while most of them confine their attention only to frequencies higher than 150. Yet even these latter receivers reproduce a sound when the organ is broadcasting its lowest tone. That sound is due to the harmonics—energy released as double, triple, and higher multiples of the fundamental frequency.

The individual characteristics of different instruments, which enable a hearer to distinguish one from the other, even when sounding the same pitch, are embodied in these harmonics. When three instruments, for example, sound the same tone, not only is the fundamental alike in frequency, but so also are the harmonics. It is the *proportion* in which energy is distributed among these harmonics of identical frequency that gives instruments their individuality. The highest note of the French horn has a fundamental frequency of about 850. If the reproducer cut off at 900, you could recognize the highest pitch, but you could not distinguish what kind of an instrument was being broadcast. In the case mentioned, the French horn's individuality lies in the proportion of energy distributed among the fundamental frequency and higher harmonics. In a good reproducer, the French horn is distinguishable from the clarinet, for example, because the latter ranges the energy among the harmonics in a different way.

It is on account of the harmonics that it is important for a reproducing system to cover a wide frequency range, at least up to 6000 cycles. In judging the capabilities of an amplifier, the easiest method is to observe how clearly and easily distinction can be made among various instruments.

The following table, showing the relative energy distribution among fundamental and harmonics of the harp, piano, and violin, was calculated by Helmholtz:

HARMONICS AND THEIR RELATIVE INTENSITIES

Harmonic No.	1	2	3	4	5	6
Harp . . .	100.0	81.2	56.1	31.6	13.0	2.8
Piano . . .	100.0	99.7	8.9	2.3	1.2	0.01
Violin . . .	100.0	25.0	11.0	6.0	4.0	3.0

An amplifying system which is very weak in the region of the first harmonic of a certain note of the piano but which gravely exaggerates its third and fourth, might well make the piano sound like a harp. The existence of resonance peaks may so greatly alter the tonal quality of similar instruments, without however affecting the melody, that the instruments cannot be distinguished, and subtleties of composition and orchestration are thereby lost.

Perhaps the importance of unimpaired and unaltered reproduction of harmonics is best appreciated by considering the mechanism of our organs of speech. Through the so-called vocal cords and diaphragm, we set up a fundamental tone or pitch and a wealth of harmonics. The different vowel sounds are produced by increasing or decreasing certain of these harmonics at will. In the mouth and throat are several resonance chambers, the size and shape of which we can alter with the aid of the tongue and jaws. "E," for example, is sounded by placing the tongue in such a position that one of the higher harmonics of the fundamental tone is stressed and the energy in intermediate harmonics reduced. It would be quite possible to make "ah" sound like "e" on a radio receiver for voices of a certain pitch by introducing a resonance peak at the proper point. Oftentimes the inability to understand speech from a radio set easily and without tiring is due to some such effect. Although we are never specifically conscious of a harmonic, the fundamental thing that makes a Stradivarius worth thirty thousand dollars and a cheap violin worth six dollars lies in minute percentage differences in the distribution of energy in their respective harmonics.

Certain instruments reproduce well on the poorest radio sets because their fundamental tones lie in the frequency range most easily reproduced and their harmonics are not important. A Hawaiian orchestra is particularly popular with the owner of an inferior radio set because distortion affects that particular musical combination the least. If an organ, concentrating as it does on the lower frequencies, sounds magnificent with a radio set, but sopranos are strangely colorless and without feeling, it is due usually to absence of high frequencies in the reproduction.

The characteristic of radio sets prior to 1925 was the almost entire absence of low tones. The reaction which followed resulted in an era of exaggerated low tones, a much pleasanter form of distortion. We are about to enter upon an era of true reproduction. This involves curbing of the present trend to excessive booming mellowness and richness, when these are not present in the original music reproduced; and also the curbing of their predecessors, brilliance and sharpness of tone, the product of excessive amplification of high tones.

JUDGING QUALITY

THE expert sound critic, in testing a receiving system, listens to different kinds of music because each kind brings out the ability of the receiver with certain frequencies. The easiest way to learn to judge the deficiency of any reproducing system is to listen to distortion-free music and then to apply filters of known characteristics which take out various frequency bands. A little training will enable anyone of musical discrimination to analyze what is missing in music upon hearing it. An attempt will be made here to do this for you in words, describing familiar forms of distortion in the hope that you will be able to recognize them.

When a radio set is being demonstrated in a store, the most likely thing which you will hear is the male voice of an announcer. Fortunately, a male voice can reveal the principal characteristics of a sound reproducing system because it has a great wealth of harmonics. An absence of adequate amplification of the low tones, a characteristic of cheaper receivers incapable of great volume, is manifested by undue prominence of the consonants of speech. As we have seen, the lower frequencies give the pitch characteristic, the volume, and power, but it is the harmonics which give intelligibility and distinction. Hence, loss of the low tones does not detract materially from intelligibility. You could clearly understand what the announcer says if everything below a frequency of 500 cycles was cut off. If the announcer sounds as if he were talking over the telephone rather than speaking to you in person, it is likely that the "lows" are not adequately reproduced. The absence of "lows" detracts from the sympathy and resonance of the voice and makes it difficult to distinguish between individuals.

The other extreme is exaggeration of "lows" and loss of the "highs." If the male voice sounds throaty, booming, husky, muffled, and hashy, so that you think the speaker has asthma or needs a cough drop, you are likely to be listening to a receiver which exaggerates the low tones. Even with a moderate priced receiver, the male voice should be so clear that, when you turn from the loud speaker, you have difficulty in determining whether someone is speaking in person or whether you hear radio reproduction. The characteristic "radio speech" that makes you comment "it sounds like a radio," instead of "that sounds like a man speaking," is a recognition of distortion in one form or another.

A second form of radio reproduction likely to be heard at a demonstration is the piano. The piano has long been the most elusive instrument so far as reproduction is concerned. A majority of broadcasting stations are incapable of reproducing that instrument. Consequently, when listening to it critically through a radio receiver, you must be certain that you are tuned-in to a first class station. If that is the case, you will be able to detect inadequate amplification of low tones. If the piano sounds tingly, bell-like, sharp, and thin, and if the melody in the treble is prominent while the bass is weak, you can be sure that the low notes are not adequately reproduced. If you are fortunate enough to hear a fortissimo passage in the bass and find those low, crashing notes are only moderately reproduced and none of the grandeur of the piano is felt, you may rightly attribute these characteristics to imperfect reproduction of the lower frequencies.

If you are familiar with the tone of the clavichord, and piano reproduction reminds you of it, you may be certain that the low notes are not adequately reproduced. The essential improvement of the piano over its predecessor, the clavichord, lies in its possession of a large, resonant sounding board, which gives strength and body to the fundamental tones. If the lower frequencies are not reproduced by the radio receiver, obviously the piano will sound like the clavichord.

On the other hand, absence of the upper frequencies and exaggeration of the "lows" makes the fortissimo in the bass sound rich —almost organ-like. Reproduction in this case lacks the brilliance and brightness of the piano and possesses excessive richness and booming qualities. Fine trills in the treble or upper notes sound garbled and mixed, lacking entirely the penetrating brilliance characteristic of the piano.

A jazz orchestra also gives you opportunity for critical observation. The most prominent instruments, saxophone and cornets, use principally the middle registers. Reproduction in which the saxaphone is permitted to dominate over piano, violin, and banjo, so that the latter form only a hazy background, exaggerates the middle registers. Usually, there is a set of instruments strumming time in the jazz orchestra, sometimes a piano, sometimes the banjos. It requires good reproduction of the higher harmonics to enable you to distinguish between piano and banjo instantly and decisively. If you have to stop and think about it before deciding whether piano or banjos are keeping time, the upper harmonics are not adequately reproduced.

When the piano contributes significantly to the melody by taking a lead in the treble, it should stand out prominently and clearly with its bright tingle. If it is submerged by the instruments in the low frequencies, the "highs" are being neglected. When the drums and the tympani come in, they should be emphatic and crashing, but a receiver which neglects the low frequencies makes the drums sound wooden and lacking in depth, instead of booming and rich. It is a good test of the power of the reproducing system with low tones.

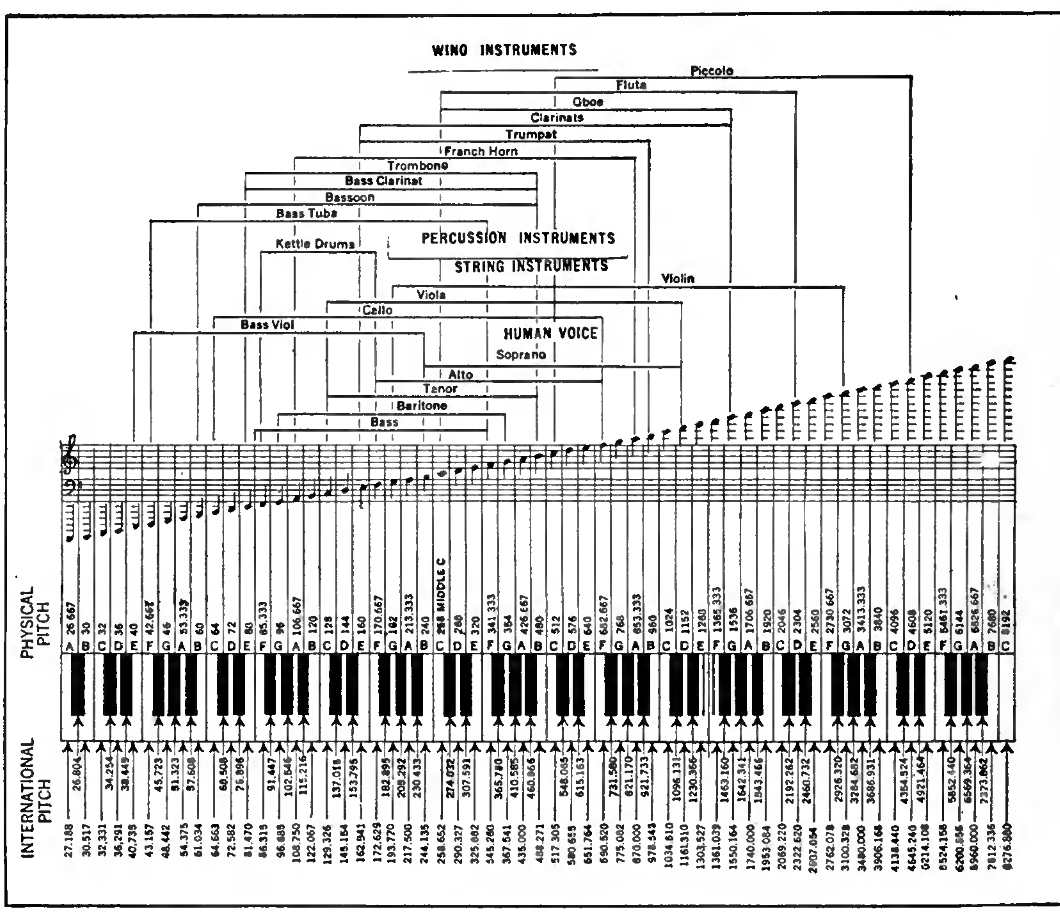
Reproduction of the symphony orchestra should be sufficiently clear as to the upper harmonics so that there is not the slightest hesitation or difficulty in forming conscious distinction between the cellos and the violin. Given a good broadcasting station with a careful pick-up, the crashing of the tympani in the finale should be thoroughly imposing to the radio listener. When the violins take the lead and come forward busily, they should be sweet and strong and not scratchy and penetrating like an army of mosquitoes.

The last word in a test of reproduction of low tones is given by the organ. Few broadcasters are capable of sending out this instrument with anywhere near its true worth. Nevertheless, the organ should have majestic power reflected in its radio reproduction. Failure to reproduce the low notes makes it sound much like the flute or saxophone. An organ recital places the most severe test, not only upon the loud speaker and audio amplifier system, but also on the capacity of the plate potential supply to furnish the necessary current to accommodate the peaks of modulation present when the music of this instrument is broadcast.

It is not necessary to discuss in great detail that distortion due to sharp resonance points, because they are quite obvious. The listener notices an indefinable but disagreeable flatness in a certain pitch, usually a high note on the piano. That instrument, because of its sustained quality, brings out resonance points with particular emphasis. If that pitch is identified in the listener's consciousness, he will observe that a soprano singing that note sounds flat and slightly off key. Resonant points are most likely to be due to defective coupling devices in the audio-amplifier and mechanical resonance in the loud speaker or cabinet.

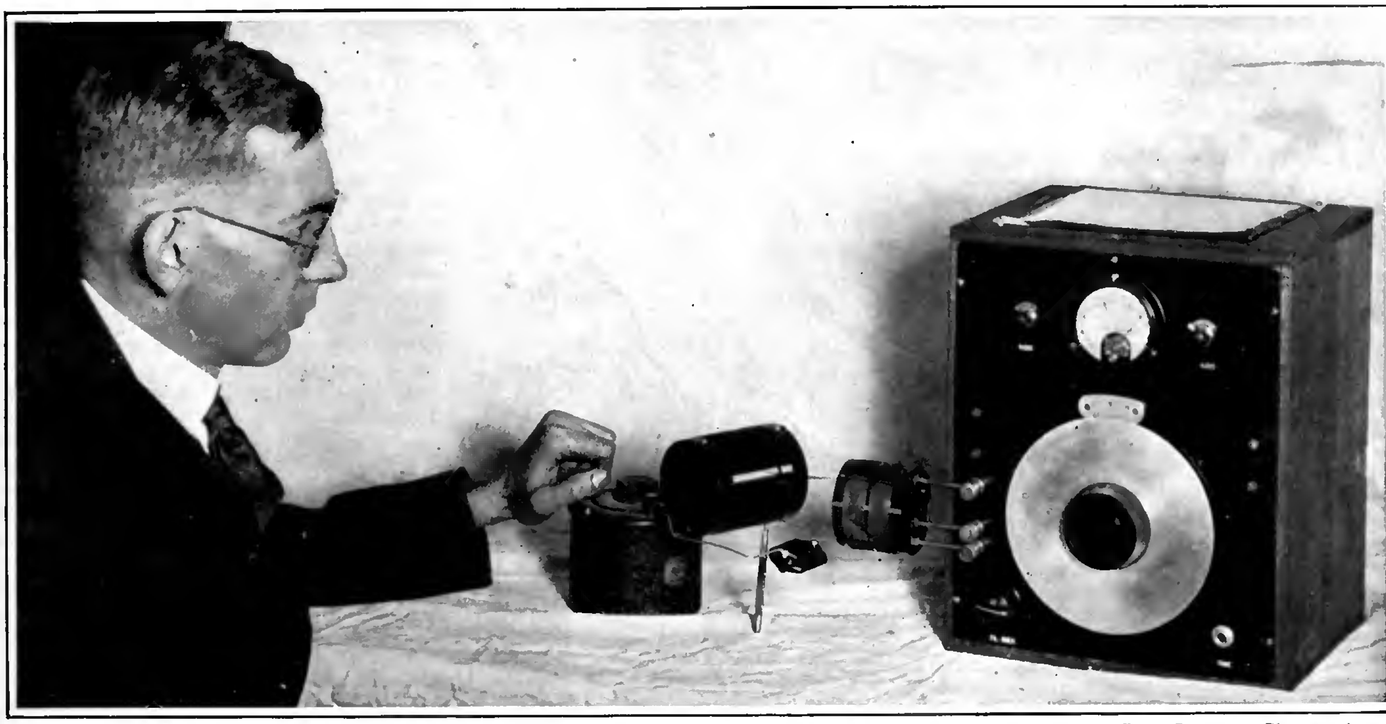
Overloading, also, is more easily considered as we go over the radio receiver part by part, to identify the causes of distortion. A receiver offering excellent tone with soft music but scratchy and blaring when it is turned on full, is likely to be suffering from overloading. Certain requirements with regard to tube output capacity, loud speaker volume capacity, and power supply, must be met to avoid distortion due to overloading. These points are fully discussed in an article on tone quality in the next RADIO BROADCAST.

For the present, if the reader has learned how to listen to a radio receiver, to appreciate its tonal quality, and to identify its weaknesses—whether they lie in the lower, middle, or upper registers—he will have taken an important step forward in judging the faithful reproduction qualities of a receiver.



THE RELATION BETWEEN THE MUSICAL SCALE AND PIANO KEYBOARD

The organ range, not shown, is from 16 to 16, 384 cycles. The chart is published through the courtesy of the Waverly Musical Products Company, Long Island City



RADIO BROADCAST Photograph

MEASURING THE CAPACITY OF A MICA CONDENSER BY MEANS OF THE MODULATED OSCILLATOR SHOWN IN FIG. 1

Condenser, Coil, Antenna Measurements

Some Simple and Practical Uses of the Modulated Oscillator—Comparing Its Accuracy with Other Systems of Measurement

By KEITH HENNEY

Director of the Laboratory

AMONG other uses to which the modulated oscillator described in the June RADIO BROADCAST and shown schematically here in Fig. 1 may be put, is that of comparing or measuring the capacities of small condensers. For example, it may be necessary to measure the maximum and minimum capacity of a variable condenser in terms of a standard, or it may be desirable to calibrate such a condenser. The modulated oscillator is very useful for this purpose, making it possible to substitute visible measurements for the audible indications of a bridge balance.

It is necessary only to have an inductance and a condenser whose capacity is definitely known. This latter should be a variable air condenser whose calibration is not likely to change with time, with as low a resistance as is practicable, and whose maximum capacity is from 500 to 1000 mmfd. Such a condenser is the General Radio Type 239 E or even the "can" condenser, type 247, made by the same company. The 247 E is inexpensive, has a dial calibrated in micromicrofarads, and can be read to within about 2 per cent. It has a maximum capacity of 500 mmfd., and as an all round instrument it is to be highly recommended, although a better instrument is the 239 type. The latter is naturally more expensive.

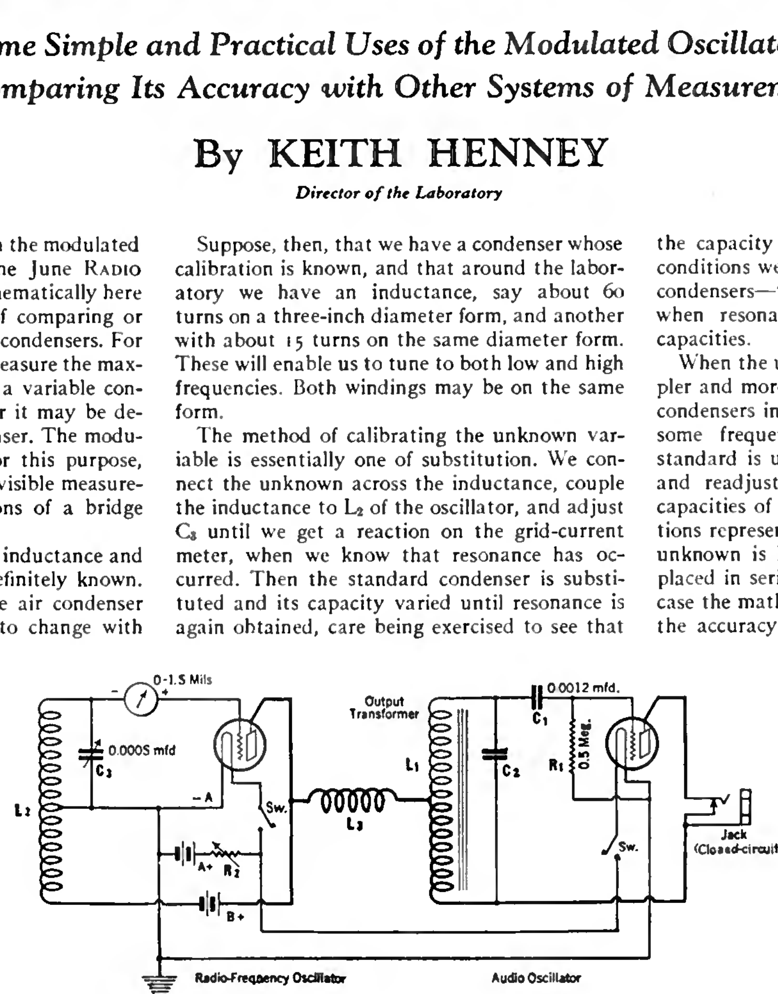


FIG. 1

Suppose, then, that we have a condenser whose calibration is known, and that around the laboratory we have an inductance, say about 60 turns on a three-inch diameter form, and another with about 15 turns on the same diameter form. These will enable us to tune to both low and high frequencies. Both windings may be on the same form.

The method of calibrating the unknown variable is essentially one of substitution. We connect the unknown across the inductance, couple the inductance to L_2 of the oscillator, and adjust C_3 until we get a reaction on the grid-current meter, when we know that resonance has occurred. Then the standard condenser is substituted and its capacity varied until resonance is again obtained, care being exercised to see that the capacity of C_3 is not altered. Under these conditions we know that the settings of the two condensers—the standard and the unknown—when resonance is obtained, represent equal capacities.

When the unknown capacity is small it is simpler and more accurate, probably, to place both condensers in parallel, to resonate the circuit to some frequency so that about half of the standard is used, then to remove the unknown and readjust for resonance, the difference in capacities of the standard under the two conditions representing the unknown capacity. If the unknown is large, the two condensers may be placed in series and resonance obtained. In this case the mathematics is not quite so simple, but the accuracy is the same and provides a good check on the parallel arrangement. In the series case the two should be connected and tuned first to some frequency so that the standard is near its top dial reading. Then the unknown is removed, and the standard lowered in value to a new resonance. The unknown value may then be found by using the formula and examples given below, where Cx represents the unknown capacity:

PARALLEL CASE

Standard alone, $88° = 910$ mmfd.
Standard and Cx, $52° = 415$ mmfd.
$Cx = 910 - 415 = 495$ mmfd.

SERIES CASE

Standard alone, $37^\circ = 215$ mmfd.
Standard and Cx, $48^\circ = 380$ mmfd.

$$Cx = \frac{\text{Product}}{\text{Difference}} = \frac{380 \times 215}{380 - 215} = 495 \text{ mmfd.}$$

Provided the dial on the condenser, and the calibration chart, could be read accurately, the percentage of accuracy of the unknown condenser, which was marked 0.0006 mfd., is as follows:

$$\text{Percentage Accuracy} = \frac{\text{Measured Value}}{\text{Rated Value}} \times 100 = \frac{495 \text{ mmfd.}}{600 \text{ mmfd.}} = 82.5\%$$

and the percentage "off" is:

$$\frac{\text{Difference}}{\text{Rated Value}} \times 100 = \frac{105 \text{ mmfd.}}{600 \text{ mmfd.}} = 17.5\%$$

If it is impossible, however, to read the condenser dial closer than 5 mmfd. or to read the calibration closer than this figure, our error of reading may be 10 mmfd. and if the maximum capacity is 500 mmfd. the total error will be 2 per cent. With a large dial, and correspondingly large calibration chart, much greater accuracy may be obtained. If, in addition, the condenser is accurate to within 2 per cent., our total error of measurement may be 4 per cent.

MICA CONDENSERS

WHEN one comes to measure small fixed mica condensers by the method outlined above, curious results are obtained. At high frequencies, the distribution of charge on the condenser differs from that at 1000 cycles, and certain changes seem to occur in the dielectric. Manufacturers rate their condensers according to readings taken at 1000 cycles. It is also true that the equivalent series resistance of the condenser becomes appreciable at high frequencies. The result of all of these factors is that the apparent capacity of the condenser is smaller at high frequencies than at 1000 cycles. For example, the figures below give the values of several condensers measured at 1000 cycles and by the above method at 1000 kilocycles:

RATED	1000 CYCLES	1000 KC.
250 mmfd.	230 mmfd.	220 mmfd.
250 "	200 "	190 "
500 "	405 "	350 "
500 "	500 "	480 "
600 "	530 "	500 "

TO MEASURE DISTRIBUTED CAPACITY OF COILS

ANOTHER interesting use for the oscillator is that of determining the natural wavelength, effective inductance, and distributed capacity of coils. The procedure is simple. The coil under test is resonated to various wavelengths by tuning it with known capacities, say with the variable standard. Then the added capacity is plotted against wavelength squared, as is illustrated in Fig. 2.

The data for this curve are given below:

TABLE NO. 1

ADDED CAPACITY	FRE-QUENCY	WAVE-LENGTH	(WAVE-LENGTH)²
500 mmfd.	562 kc.	534 meters	284,000
400 "	625 "	480 "	230,000
300 "	725 "	414 "	170,000
200 "	892 "	336 "	113,000
100 "	1290 "	243 "	59,000

The actual method of finding the inductance and distributed capacity is explained by the formula in Fig. 2. Where the line crosses the wavelength squared axis is the natural wavelength, squared, of the coil. The values for a certain coil, the dimensions of which are given below, as read from the graph, are given herewith, together with the figures obtained when different methods of measuring were employed:

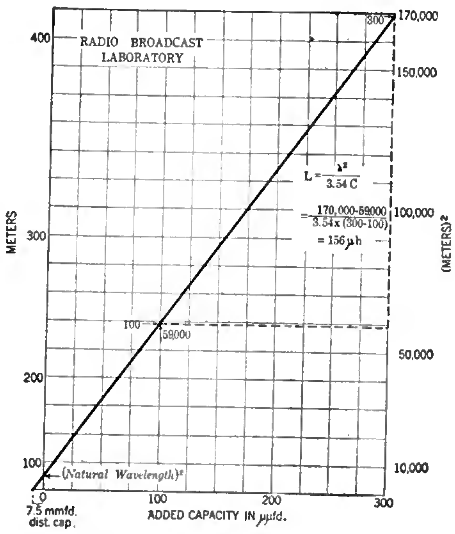


FIG. 2

Natural wavelength (by graph)	67.0	meters
Natural wavelength (by mod. osc.)	59.5	"
Distributed capacity	7.5	mmfd.
Inductance at 1000 cycles (bridge)	170	microhenries
Inductance at 1000 kc. (graph)	156	"
Coil diameter	$2\frac{5}{8}$	inches
Length of winding	$1\frac{7}{8}$	"
Number of turns	60	

TO MEASURE ANTENNA CAPACITY AND INDUCTANCE

THE oscillator can also be used to measure the capacity and inductance of antennas by the following methods. In the first method, two known inductances are inserted in the antenna system, and resonance obtained with the oscillator. If the inductance is in microhenries, and the capacity of the antenna is in microfarads, we shall have two equations:

$$\lambda = 1884 \sqrt{(L + La) \times Ca}$$
$$\lambda^1 = 1884 \sqrt{(L^1 + La) \times Ca}$$

where L and L^1 are the two known inductances, C_a is the antenna capacity, and L_a, the antenna inductance. C_a may be eliminated from the two equations, and after solving for L_a we have:

$$La = \frac{L^1 \lambda^2 - L \lambda^1_2}{\lambda^1_2 - \lambda^2}$$

After getting L_a, its value may be substituted in either of the two original wavelength equations and C_a obtained.

The second method, whose similarity with that mentioned above to determine the capacity and inductance of coils is apparent, consists in plotting wavelength squared against added inductance, as shown in Fig. 3. The intercept on the inductance axis represents the apparent inductance of the antenna; the intercept on the wavelength squared axis represents the square of the natural wavelength. The capacity of course is the slope of the line as shown in the illustration.

The third method of determining the apparent capacity is to measure the wavelength, or frequency, of the antenna system with a certain, but not necessarily known, inductance, in series with it. Then the antenna and ground, or counterpoise, are removed and a calibrated condenser connected to the inductance. When resonance is obtained by tuning the condenser, its capacity is equal to the apparent capacity of the antenna.

All of these measurements at high frequencies will differ from those at audio frequencies, and will in general be true only at the frequency measured. They indicate an important class of experiments and measurements, however, that can be performed with the high-frequency part of the modulated oscillator. Care must always be taken that too close coupling to the oscillator does not vitiate the operation. Resonance should be indicated on the grid meter with as small a deflection as possible. The accuracy of measurements using these methods lies in the accuracy with which the oscillator is calibrated and read, and the accuracy of the standards.

Inductance standards are simple to construct. Their inductances at low frequencies may be calculated with sufficient accuracy for all home laboratory measurements. The interested experimenter is referred to the Bureau of Standards Bulletin 74 which gives formulas and descriptions of small standards of inductance. A subsequent article will describe a series of coils for use in the home laboratory as inductance standards.

The data for a short-wave antenna are given below and show how the values secured by the several methods compare:

ADDED INDUCTANCE	FRE-QUENCY	WAVE-LENGTH	(WAVE-LENGTH)²
162 microhenries	1612 kc.	186.6 meters	34,500
100 "	2030 "	147.5 "	21,800
18 "	3938 "	76.2 "	5,850

C_a = 55 mmfd. by method No. 1
" = 55 " " " No. 2
" = 54 " " " No. 3
L_a = 7.1 microhenries by method No. 1
= 12 microhenries by method No. 2
Natural λ = 47 meters by method No. 2

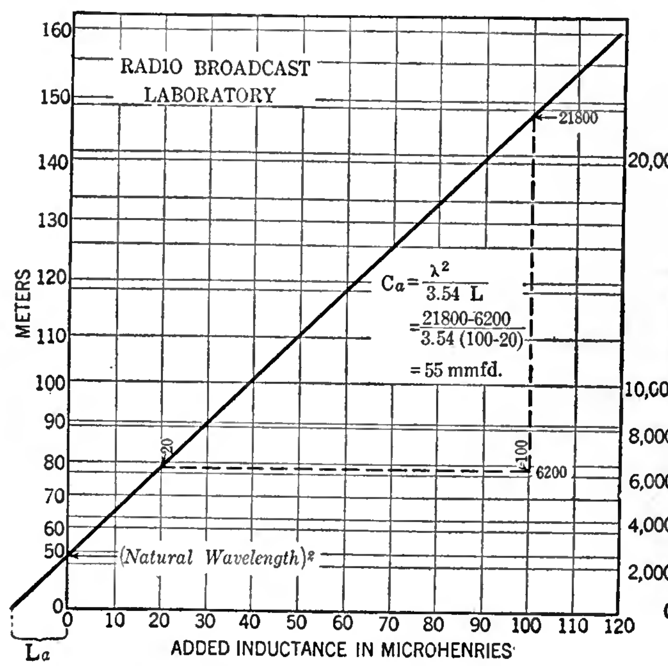


FIG. 3

A Super-Sensitive Five-Tube Receiver

Constructional Data for the Home Builder Who Desires a Selective Shielded Tuned Radio-Frequency Receiver with Controlled Regeneration in the Detector Circuit

By HERBERT J. REICH, M. S.

Physics Department, Cornell University

THE simplicity and selectivity of the various types of tuned radio-frequency receivers have for some time placed them in the foremost rank of popularity among the many receivers available to the radio enthusiast. A great deal of constructional data on receivers of this type has been published and a large percentage of the tuned radio-frequency receivers now in use are probably home-built.

The chief difficulty that has to be overcome in the design and construction of a good tuned radio-frequency receiver is the tendency for the radio-frequency stages to oscillate. Oscillation in this type of set is obviously undesirable—for several reasons. In the first place oscillation ordinarily takes place at fairly low values of signal amplification, so that the overall efficiency of the receiver is low. Quality also suffers, and the tendency toward oscillation makes tuning critical, and when the set is in the hands of an inexperienced or thoughtless operator, it can cause serious annoyance to other receivers for miles around. If losses are introduced to prevent oscillation, the efficiency drops still further.

The use of some form of neutralization, and the careful placing of coils and other apparatus, partially overcomes this tendency toward oscillation. In spite of these precautions, however, there still remain capacitative and inductive feed-backs which careful placing of parts cannot prevent, and the obvious way to overcome these leakage feed-backs is to shield completely the individual stages. Many tests by the author and the recent appearance upon the market of several completely shielded neutrodynes indicates the value of properly designed shielding.

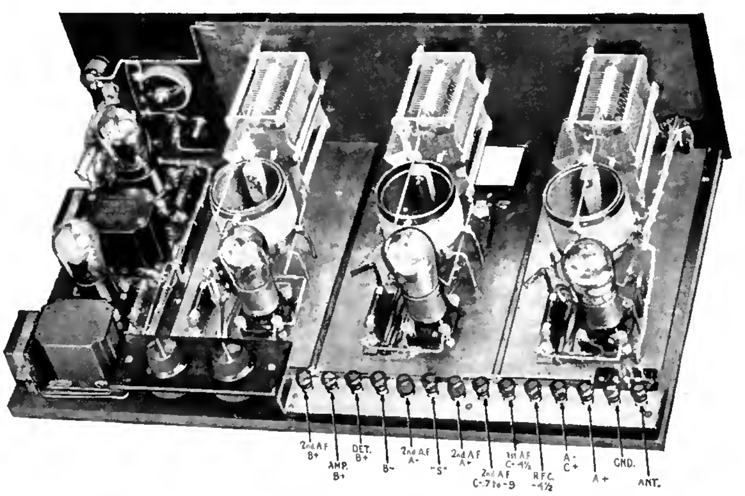
A receiver developed by the writer consisted of two stages of completely shielded and neutralized tuned radio-frequency amplification, a shielded regenerative detector, and two stages of high-quality audio-frequency amplification. From the standpoint of sensitivity and volume, this receiver is the equal of any tuned radio-frequency set and on a loop, or a ten-foot indoor antenna, it will give all the volume desired on local stations. Station WEAF is a rather difficult station to get with good volume at Ithaca, yet the writer has frequently had it with sufficient undistorted volume at 6:30 in the evening to be understood 400 feet from the cone loud speaker. Mexico City can often be heard with almost equal volume. Any time of day, from setting-up exercises to midnight dance orchestras, two or three stations at least may be had with as much loud-speaker volume as desired and with excellent quality on both local and DX. The limit of sensitivity is the general noise level, and the best evidence of a poor night is the number of whistles and yowls emitted by less fortunate neighbors. The receiver is simple to construct, extremely easy to operate, and comparatively inexpensive.

Fig. 1 shows the wiring diagram for the receiver. It will be seen that the circuit differs from the ordinary neutralized tuned radio-frequency circuit mainly by the addition of controlled regeneration in the detector stage. The means of controlling regeneration, i. e., by means of a midget condenser, C_7, results in extreme simplicity and makes possible a wide variation in the amount of regeneration with only a very slight change of the tuning of the detector stage variable condenser. Regeneration also makes possible high amplification at the long wavelengths, where the gain would ordinarily tend to fall off.

The double-pole double-throw switch in the first radio-frequency stage is for the purpose of cutting out this stage when desired and connecting the antenna to the primary of the second stage. This can frequently be done on good nights and somewhat simplifies tuning. The obvious objection is that selectivity is not so good.

Ordinarily, volume is controlled by means of the rheostat of the first r. f. stage, which is mounted on the panel. The regeneration control can usually be set at zero, but when additional volume is desired for weak stations or for daytime reception, additional amplification, equal to that of a third stage of radio-frequency, is instantly available with a turn of the midget condenser. The rheostat control makes possible the variation of volume from a mere whisper to the maximum the loud speaker can carry. When the first stage is cut out, volume is controlled by the midget condenser.

Separate terminals have been specified for the filaments of the second audio tube and the loud-speaker return, S, in order to make possible the operation of the power tube filament with a. c. from a transformer winding in a socket power device if this is desired. If the power tube is to be operated from the common A battery, these extra filament leads are connected directly to the main A terminals, and S, the loud speaker return, to A minus. The choke coil, L_{10}, may be put in any place in the B+ 180 volt lead if there is insufficient room in the set.



THE RECEIVER CONSTRUCTED BY THE AUTHOR

COIL CONSTRUCTION

THE coils are probably the most vital parts of the whole receiver, and particular care must be taken in their construction. Fig. 2 shows the design of the coil assemblies and the arrangements of the terminals, which are so placed as to give the most simple and direct wiring. The letters distinguishing the terminals correspond to those in the wiring diagram. At "A" and "B" is shown the detector stage transformer assembly, which contains three concentric tubes. The second stage radio-frequency transformer is identical with this except that the inner 2″ tickler coil, and the M and T terminals, are omitted. The proper position for the terminals on the second and third stage transformers is determined by dividing the circumference of the outer tube into eight equal parts, as is indicated at "B." At "C" in Fig. 2 is given the arrangement for the first-stage transformer.

The secondaries are wound upon $2\frac{3}{4}''$ tubing and the primaries upon $2\frac{1}{2}''$ tubing placed within the secondaries and spaced by means of washers

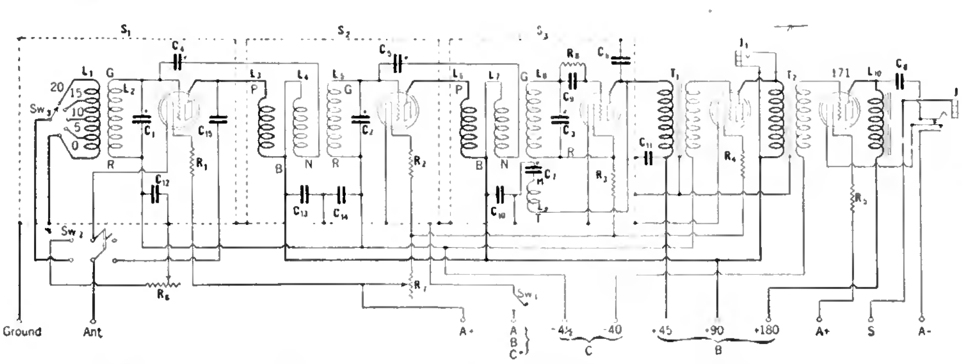
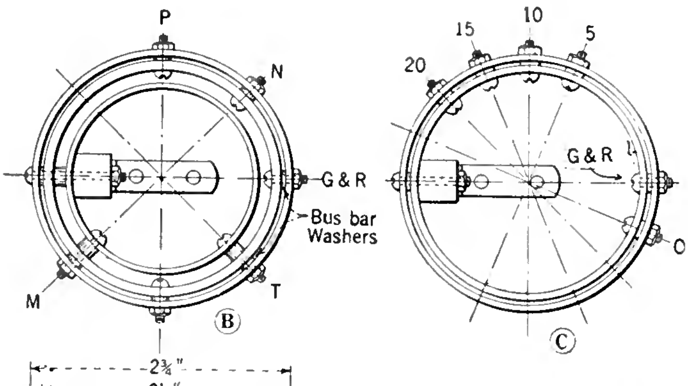


FIG. 1



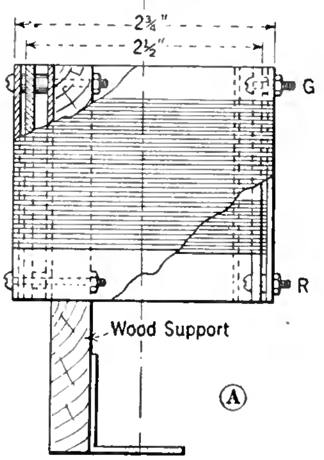


FIG. 2

made of bus bar placed over the terminal posts as they are inserted. The best length for the tubing is 2¾", although 2½" can be used. The tubes should be assembled temporarily and the terminals located before the coils are wound. In order to insure the proper lining up of the holes in the different tubes, it is well to drill those in the outer tube first and locate the holes in the inner tubes by means of these, inserting the terminal posts and washers as each hole is completed. The tickler coil may be held by means of the screws which fasten the coils to the wooden upright and spaced with nuts or small pieces of panel. It will not matter if the tickler coil is not accurately centered. Round-head brass machine screws, 6-32 and ½" long, make excellent terminal posts.

The secondaries, L_2, L_5, and L_8, consist of 50 turns of No. 24 double cotton-covered wire. The upper ends of these windings should be started just far enough from the ends of the tubing to allow about a sixteenth of an inch clearance between the wire and the nut which holds the terminal post.

The primaries of the second and third stage transformers, L_3 and L_4, L_6 and L_7, consist of double windings of No. 28 or No. 30 double cotton-covered wire wound simultaneously, *i. e.*, with the two wires side by side, turn for turn. Fig. 3 may help to make clear the proper way to make the primary connections to the terminals. One wire is fastened to the inside tubing at a point just above the "N" terminal, to which it should be connected after the coil has been wound; the other wire is fastened at a point just above the "B" terminal to which it will ultimately be connected, at the same distance from the lower end of the tubing as the lower end of the secondary is from the bottom of the outer tubing. The two wires are then wound simultaneously in the direction which carries them from "N" toward "B," the one connected to the "N" terminal above the other, until thirteen complete turns have been made with the upper wire (the one started at "N"). This will bring the free ends of the wires above the "N" terminal. A small hole should then be drilled in the tubing just above the "P" terminal at such a height that the lower wire can pass into it and be fastened to the "P" terminal below. It is well to mark the proper point for the hole and unwind the upper turn of both wires while drilling the hole, or to determine the proper location and drill the hole before starting to wind. The upper wire should then be unwound a half turn, which will bring the free end above the "B" terminal. Another small hole should be drilled and this wire passed down to the "B" terminal, where it is finally fastened. If the terminals have been properly placed and the winding done as directed, there will be approximately 12½ turns on each coil, and the lower ends of the coils will be at the same height as the lower ends of the secondaries.

The primary of the first-stage transformer, L_1, consists of a single winding of 20 turns of No. 24 d. c. c. tapped at 5, 10, and 15 turns. A neat way to connect the taps is to drill holes in the tubing at the proper points before starting the winding, and to bare the wire at these points when it is being wound, passing the tap wires through the holes and twisting them around the main wire. The joints can be soldered when the winding is completed.

The tickler winding, L_9, consists of 50 turns of No. 28 or No. 30 d. c. c. wire wound on the 2" tubing in the same direction as the primaries and secondaries. The lower end is connected to the "T" terminal and the upper end to the "M" terminal. The lower end of the winding is at the same level as the lower end of the secondary.

A good way to hold the ends of the wires to keep them from loosening up is to drill three holes close together and thread the wire in and out through them. A coat of collodion should be applied to the windings to hold them firmly in place. It is preferable to solder the ends of the windings directly to the heads of the machine screws rather than to terminal lugs, as this will save quite a few joints.

Wooden posts about ½" square with angle brackets at the bottom will serve to support the coils. The method of fastening the coils to the uprights is shown in Fig. 2, "A." The proper height is that which gives equal clearance from the shielding above and below the coils.

PARTS REQUIRED

THE choice of apparatus to be used in this receiver depends somewhat upon personal preference. In order to obtain the quality described in the discussion of performance, however, it is absolutely essential to use the very highest grade of audio transformers. Uniform amplification of all the frequencies necessary for the faithful reproduction of voice and all forms of music can be expected only if each individual element of the receiver, including the audio transformers and loud speaker, is in itself capable of passing these frequencies. The use of old transformers salvaged from another receiver is to be discouraged.

The list below indicates what parts are necessary to construct the receiver; any standard makes may be used that have the proper characteristics:

C_1, C_2, C_3—Hammarlund Variable Condensers, 0.0005 Mfd.
L_1, L_2—, L_3, L_4, L_5—, L_6, L_7, L_8, L_9— } Home Constructed Coils. Specifications in Text
C_4, C_5—Hammarlund Neutralizing Condensers, 0.000015 Mfd. Approximately.
C_6—Sangamo 0.0001-Mfd. Fixed Condenser
C_7—Hammarlund Midget Variable Condenser, 0.00005 Mfd.
C8—Sangamo 4-Mfd. Output Condenser
C_9—Sangamo 0.00025-Mfd. Grid Condenser
C_1, C_{11}, C_{12}, C_{13}, C_{14}—Sangamo 1-Mfd. Bypass Condensers
C_{15}—Sangamo 0.001-Mfd. Fixed Condenser
R_1, R_2, R_3, R_4—Amperite Filament Resistors for 201-A Tubes, Type 1A
R5—Amperite Filament Resistor for Power Tube, Type 112 (not necessary with A. C.)
R_6—Yaxley 20-Ohm Rheostat
R_7—Yaxley 6-Ohm Rheostat
R_8—Tobe 2-Megohm Grid Leak
L_{10}—General Radio Output Choke Coil
J—Yaxley Single-Circuit Filament-Control Jack
J1—Yaxley Single-Circuit Jack
S_1, S_2, S_3—Copper Shields
SW_1—Yaxley Filament Switch
SW_2—Kresge Double-pole Double-Throw Switch
SW_3—Carter Antenna Tap Switch
T_1, T_2—Amertran Audio Transformers
Five Benjamin "Cle-ra-tone" Sockets
Nine Binding Posts. Twelve if A. C. is used.
Three Dials
7" x 24" Panel
Copper Panel Shield, 6" x 18"
Three Base Shields, 6" x 11"
13" x 23" Baseboard

The antenna coupling switch is best mounted within the shielding and should therefore be small enough to clear the tuning condenser and the side of the can.

SHIELDING

FIG. 4 shows the design of the shielding cans. Sixteen-ounce, or heavier, sheet copper should be used for all shielding. The cans are 10½" long, 5" wide, and 5½" high, and are open at the panel end. A ⅜" or ½" flange around the bottom affords the most satisfactory method of fastening the cans to the baseboard. A 3" hole in the top with its center 3½" from the back and right edges, makes it possible to insert and remove tubes without taking off the cans. The holes should be supplied with lids. Most builders will find it better to have a good tinsmith make the cans than to attempt to make them at home.

The panel shield (see photograph) is a single sheet 6" high and 18" long. It is a little better to use three separate 6" x 11" base shields for the three stages than one large one.

The general layout of apparatus may be discerned by references to the photograph. The condensers should be so placed as to allow as much clearance as possible on all sides of the stator plates and sufficient clearance for the rotor plates to insure freedom from short-circuits to the shielding cans. It is best to allow equal clearance on both sides of the coils and to allow at least ¾" clearance between the coils and condensers.

The three shielded stages should be spaced just far enough apart so that the can flanges do not make contact with one another. As the frames of the first and second condensers are connected to C minus and that of the third to A plus, whereas the shielding is connected to A minus, it is necessary to cut holes in the panel shield around the condenser shafts and mountings. If metal dials are used, care should be taken to make certain that no short-circuit occurs between the dials and the screws which hold the shielding in place.

The screws which hold the sockets and coils will serve to fasten the base shields. The panel shield is held by four brass machine screws behind each condenser, placed so that they will be hidden by the dials. The base shields are soldered to the panel shield at two points in each stage.

If possible, the midget condenser should be placed within the shielding of the third stage, but it will probably be impossible to obtain sufficient clearance from the tuning condenser. The panel shield must be cut away where the antenna switch is mounted. The output condenser may be mounted on edge beside the second audio transformer, and the detector B plus bypass condenser, C_{11}, beside the first audio transformer. This will leave room for the r. f. amplifier B plus bypass condensers, C_{10} and C_{13}, within the second and third stage cans, and for the C minus bypass condensers, C_{12} and C_{14}, within the first and second-stage cans.

In fastening the filament resistors it is best to separate the mountings from the shielding by means of strips of gasket rubber or similar insulation. Short-circuits are likely to occur if this precaution is not observed.

Little difficulty will be experienced in wiring the receiver, as most of the connections within the shielding are short and direct. Flexible wires tied into a cable will be found both neat and convenient for filament and battery leads leaving the cans, and for filament and battery leads going from the audio-frequency end of the board to the terminal strip at the rear of the set. Different colored insulations for the different leads will make it easier to check the wiring. Busbar should be used for all connections within the shielding, particularly for grid and condenser leads and for interstage plate and neutralizing leads. The rigidity of this type of wire will insure permanence of neutralization and of tuning condenser calibration.

There are two simple and equally good methods of leading wires out of the shielding. Probably the easier and neater way is to drill holes through the base shielding and board and cut short grooves in the underside of the baseboard under the edges of the cans to take the wires. The wires should be covered with spaghetti in the holes and grooves. After wiring, the grooves may be filled with tar or sealing wax taken from the tops of old dry cells. The two sets of interstage plate and neutralizing leads should be run in separate slots spaced about an inch or so apart.

The second method is to run the wires above the base shielding and cut notches in the bottom edges of the cans. The wires may be protected under the edges of the cans by means of bridges of copper soldered to the base shields. The notches in the bottoms of the cans should be as small as possible. If they are made too large, they form closed paths for eddy-currents and a slight amount of interstage coupling is likely to result. To minimize capacity to shielding, the neutralizing and plate leads should be kept a quarter to a half an inch above the base shielding except where they pass out of the cans. For the same reason, the copper bridges should be just long enough to afford protection to the wires.

The antenna, midget condenser, and detector plate leads may also be taken out of the shielding in either of the ways described, but as directly as possible. Each should be taken out individually through separate holes and grooves in order to prevent undesirable feed-back and capacity.

All leads within the shielding should be as direct as possible and close parallel wires should be avoided. The wires connecting the grid terminals with the secondaries and the condensers should be short and placed so as to keep them well away from the tops of the cans. This precaution will prevent the narrowing of the tuning range as .he result of high minimum tuning capacity.

Obviously, since the shielding is connected to A minus, negative filament terminals, bypass condensers, midget condenser, etc., may be connected directly to the shielding, thus simplifying the wiring.

ADJUSTMENT AND OPERATION

BEFORE inserting the tubes into the sockets, it is well to check all connections by means of a battery and phones, buzzer, or voltmeter. The tubes should be inserted and lighted before the plate voltage is applied to the set. Another good test is to connect the A battery to the B-battery terminals and make sure that the tubes do not light. After this, all connections to the set may be made. If all connections are correct, the familiar microphonic ring will be heard when the detector tube is tapped. As the set has not yet been neutralized it will probably oscillate as soon as the three dials are brought into resonance, particularly at the shorter wavelengths, and tuning will be very critical.

Neutralization is a very simple process. The carrier wave of any fairly strong station at the short wavelength end of the dials will serve for this purpose. The regeneration control should be turned up far enough so that a strong heterodyne whistle is obtained when the first and second stages are detuned sufficiently to stop them from oscillating. The receiver should then be tuned so that the whistle is at maximum volume. The radio-frequency stages may be prevented from oscillating by turning down the rheostats. The first-stage shielding should be removed and the filament of the first tube disconnected by moving the filament resistor or turning off the volume control rheostat on the panel. It will be found that the whistle is still fairly loud and varies in intensity with the adjustment of the neutralizing condenser in the first stage. The neutralizing condenser should be adjusted until the whistle cannot be heard, or, at least, is at a minimum. It may be necessary to re-tune the first-stage tuning condenser slightly during this adjustment. The replacing of the can will probably upset the balance slightly. This difficulty may be avoided by adjusting the neutralizing condenser through a small hole in the can, but if this is done, the screw-driver must be thoroughly insulated by means of tape where it passes through the can. Failure to take this precaution will result in the short-circuiting of either the B or the C battery.

If neutralizing has been carefully done, it will be found that the receiver will not oscillate with any setting of the tuning condensers or antenna switch, providing detector regeneration is turned off. It should be possible to turn up the regeneration quite a bit without causing oscillation, and tuning should be very smooth. If the set oscillates when brought into resonance, there is some error in the construction of the coils or in the wiring, or neutralization has not been perfectly accomplished.

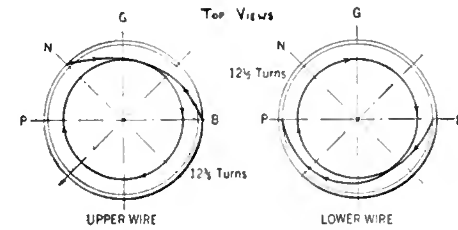


FIG. 3

The antenna coupling switch serves several purposes. Primarily it affords a means of adjusting the set to antennas of different lengths. It will, however, be found necessary to change the switch setting for stations of different wavelengths in order to obtain best results. The longer wavelength stations require a much greater amount of coupling for maximum volume than do those of short wavelengths. The antenna coupling tends to raise the wavelength of the first stage and broadens the tuning. This becomes very noticeable below about 300 meters (1000 kc.), and hence it is necessary to reduce the antenna coupling to ten or even five turns for the lower stations. With five turns, the tuning will be very sharp, down to the lower limit of the receiver. Decreasing the antenna coupling increases the selectivity; it also increases the volume of short wavelength stations but decreases that of long wavelength stations. This decrease of volume may be largely compensated by the use of regeneration, which also sharpens the tuning of the detector stage.

If the coils have been carefully constructed and the wiring carefully done, so that the three stages are as nearly alike as possible, the three dials should tune the same to within half or three-quarters of a degree over at least three-quarters of the broadcast band. At the lower end of the band, where the effect of the antenna circuit necessitates the change of antenna coupling, the first dial may read slightly different from the other two. For an average antenna the fifteen-turn tap will give the best coördination of dial settings. The use of regeneration will vary the detector dial setting by not more than half or three-quarters of a degree.

Fair results will be obtained if 199 tubes are used in the first three stages, but the volume will not be anywhere nearly as great as when 201-A tubes are used, and the quality will also suffer somewhat. In fact, much of the improvement that results from the use of shielding will be lost if small tubes are used, and it is therefore strongly recommended that 201-A tubes be employed. A 201-A tube must be used in the first audio stage, and either a 112 or 171, with proper plate and grid voltages, in the second audio stage. A 200-A detector tube will give slightly greater volume but is inclined to be quite noisy and microphonic, and broadens the detector tuning noticeably. A 2-megohm fixed grid leak of the best manufacture should be used with the 201-A tube. Excellent volume will be obtained if a loop is used in place of the secondary coil, L_2, of the first r. f. stage.

The set is not an experiment. It has been developed by a series of careful tests of various types of apparatus and circuits. Following the publication of data on an earlier model of the same receiver, the writer received a large number of letters from successful builders, some of whom have built a second and third set. It is partly in response to requests for data on modifications and improvements that the present article has been written.

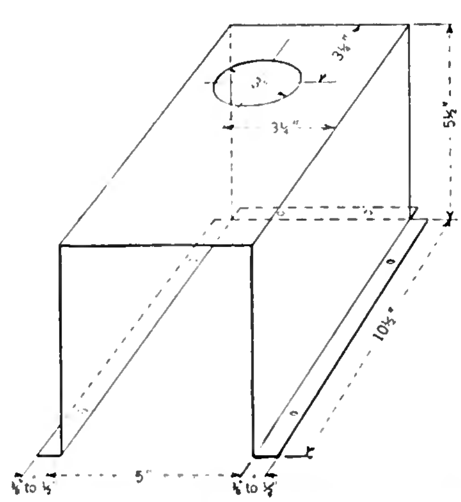
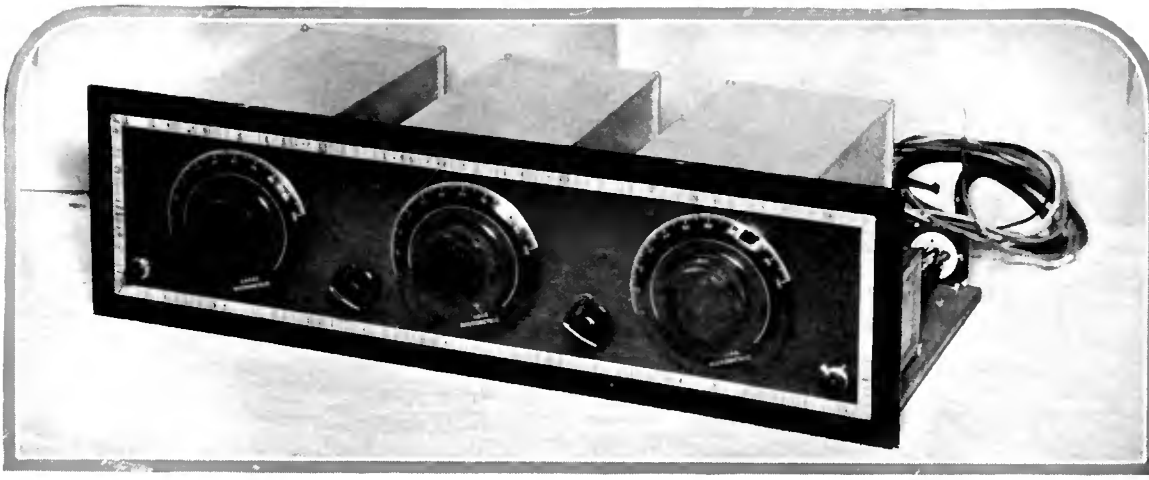


FIG. 4



RADIO BROADCAST Photograph

Constructing a Five-Tube Neutrodyne

Selectivity, Sensitivity, Ease of Operation Embodied in this Shielded Receiver—A Circuit for the New A C. Tubes

By HOWARD E. RHODES

IN THE preceding article Mr. Herbert J. Reich described the construction of an efficient five-tube neutrodyne type tuned radio-frequency receiver. Mr. Reich's receiver, using home-made coils and shields, will appeal to experienced home-constructors, but there are also many who would prefer to construct the set using standard manufactured parts. Such a receiver has been constructed in the RADIO BROADCAST Laboratory and is illustrated herewith. In building this receiver some slight circuit changes were made which simplify the construction. For example, the circuit has been altered so that the variable condensers need not be insulated from the shields; insulating them was necessary in order to get a $4\frac{1}{2}$-volt grid bias on the r. f. tubes. In the revised circuit shown in Fig. 1, the r. f. tubes have only one-volt bias on the grid and consequently the total plate current drain is about 4 milliamperes greater than it would be with a $4\frac{1}{2}$-volt bias. The change from $4\frac{1}{2}$ volts to 1 volt for r. f. grid bias does not result in any loss of efficiency.

Some loss in efficiency possibly results through the use of coils not having the specifications recommended by Mr. Reich (which is the case with the receiver herein described), but even so, the completed model gave excellent results, it being possible during several tests at the Laboratory in Garden City to hear WGY, Schenectady, and WJAR, in Providence, R. I., during the daytime. Excellent local reception can also be had using a loop or a 12-foot piece of wire thrown across the floor.

The circuit diagram of the receiver given in Fig. 1, and the various photographs illustrate very clearly how the receiver was assembled. The following parts were used in the construction:

L_1, L_2, L_3—; L_4, L_5—; L_6, L_7, L_8— Three Silver-Marshall Coils, Type 116-A
L_9—Samson R. F. Choke Coil, Type 85
C_1, C_2, C_3—Amsco 0.00035-Mfd. Variable Condensers
C_4, C_5—Hammarlund Neutralizing Condensers
C_6—Sangamo 0.00025-Mfd. Grid Condenser
C_7—Hammarlund 0.00005-Mfd. Midget Variable Condenser
C_8, C_9—Aerovox 1.0-Mfd. Bypass Condenser
C_{10}—Aerovox 4-Mfd. Condenser, Type 200
T_1, T_2—Thordarson R 200 Audio Transformers
T_3—Thordarson R 196 Choke Coil
S_1, S_2, S_3—Alcoa Aluminum Box Shields
R_1, R_2, R_3, R_4—Amperite Filament Resistors Type 1-A

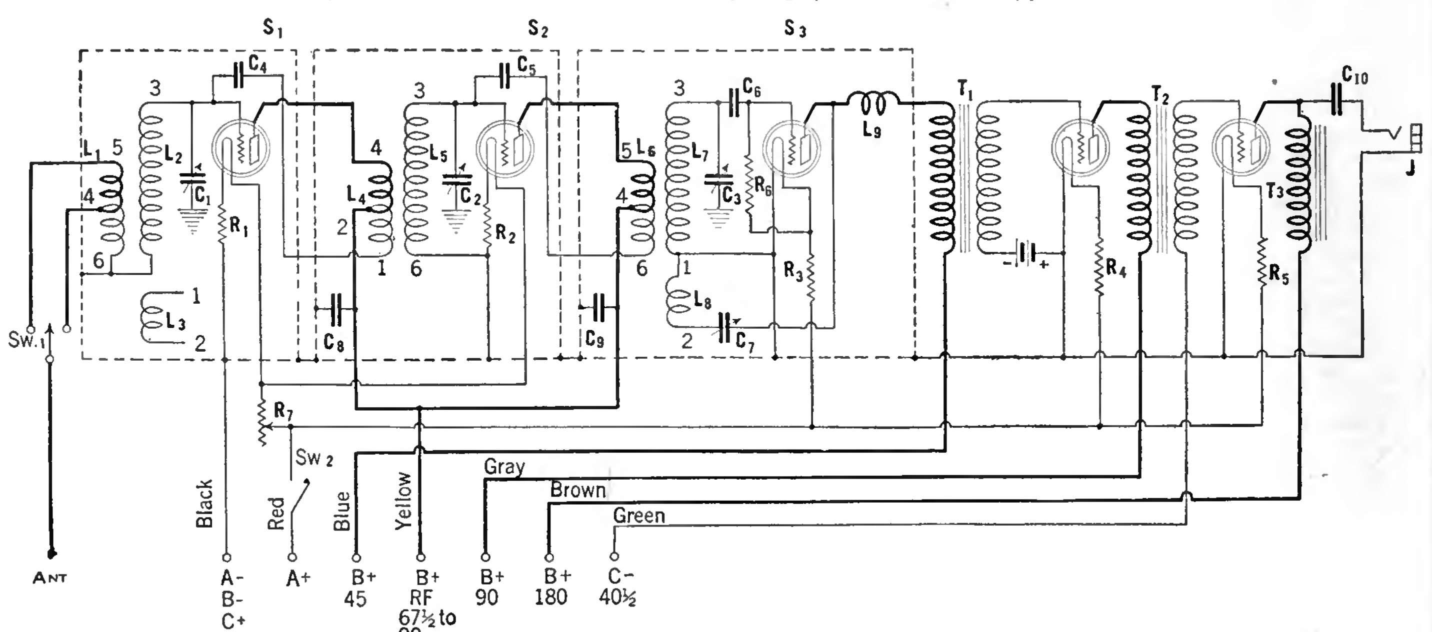


FIG. 1

R_5—Amperite Filament Resistor, Type 112
R_6—Lynch 4-Meg. Grid Leak with Mount
R_7—Carter Imp. 15-ohm Rheostat, Type IR-15
J—Yaxley No. 1 Single-Circuit Jack
SW1—Yaxley No. 730 S. P. D. T.
SW2—Yaxley No. 10 Filament Switch
Five Frost Sockets, Type 530
Three Karas Dials
Lignole Panel 7" x 24"
Three Silver-Marshall Coil Sockets, Type 515
Yaxley No. 660 Seven-Wire Battery Cable and Plug
Kellogg Switchboard and Supply Co. Hook-up Wire
Kester Rosen Core Radio Solder
Hardwood Baseboard, 23" × 12".

In order to adapt the Silver-Marshall 116-A coils to this receiver, some slight changes in two of them are necessary. In drawing No. 1, Fig. 2, is shown the way in which the coils are connected when they are purchased, the numbers on the coil terminals corresponding to the numbers on the Silver-Marshall type 515 coil sockets. It should be noted that the lower end of the secondary coil "A" is connected to terminal No. 6 and that the lower end of coil "B" is also connected to the same terminal. The Silver-Marshall coil can be used without any changes whatsoever for the antenna stage and by referring to the circuit diagram, Fig. 1, it will be found that the various coil terminals are marked with figures indicating the terminals on the coil socket.

In sketch No. 2, Fig. 2, we show the coil revised for use ahead of the second r. f. tube of the receiver. The small winding connecting to terminals Nos. 1 and 2 should be removed entirely and then the three leads connecting the coil "B" terminals Nos. 4, 5, and 6 of the coil socket should be removed and the leads of this coil connected instead to terminals 1, 2, and 4, as indicated in drawing No. 2.

The detector coil is shown in sketch No. 3 and the 116-A coil should be so altered as to conform with this sketch. Coil L_8, connecting to terminals Nos. 1 and 2, is not the same coil as "C" in sketch No. 1 because this coil has not sufficient turns to produce regeneration. Coil "C" should be removed and a new coil wound in the same slot. It should consist of 40 turns of No. 30 wire and the winding should be started at terminal No. 1, which is also the terminal to which the lower end of the secondary is connected, and should be wound in the same direction as the secondary winding, until the required number of turns has been placed in the slot and then the winding should be completed at terminal No. 2. Those home-constructors desiring to make their own coils will find the necessary data in the preceding article by Mr. Reich.

The various photographs given herewith will be very helpful in constructing the receiver since they show very clearly the layout of the apparatus. It will be found best to first lay out the apparatus in the three shielded stages and then drill holes in the aluminum bases of the shield cans at the correct points. The apparatus can best be fastened to the bases by means of 6-32 machine screws. The coil sockets should be mounted on 1¼" 6-32 brass machine screws and in this way the coil socket can be supported so that it is about 1" from the bottom of the can. The coil, when it is placed in the socket, will be more or less centered within the shield. In fastening the 6-32 screws that hold the coil sockets to the base it is a good idea to place a lug under each nut, which can later be used for making connections between the apparatus and the shield. The mountings for the Amperites should be prevented from touching the aluminum base by placing a couple of small washers between the mounting and the base when the former is fastened.

It is not at all essential that the apparatus be laid out in any exact fashion and for this reason no drilling template is given for the base of the aluminum cans. It will be found easier and in most cases more accurate to actually lay the apparatus on the base and mark with a center punch the various holes that must be drilled. The drilling dimensions for the front panel are given in Fig. 3. The panel is held to the receiver proper by means of six flat-head machine screws which are passed through the six No. 28 holes indicated in Fig. 3 and then passed through six corresponding holes in the fronts of the three shields and finally held with a nut. In this way the fastening screws for the main panel will be concealed under the dials and the appearance of the front panel thereby improved.

In wiring the receiver, full advantage should be taken of the fact that the shields connect to the negative A. This makes it unnecessary, for example, to connect any wires between the rotor plates of the variable condensers and the lower end of the secondary windings. It is merely necessary to fasten the lower end of the secondary winding to the shield and then, since the variable condenser is also connected to the shield, the circuit will be complete. The leads connecting between the various stages can be run out of the shields by making small notches in the lower edge of the side of the shield and then passing the wire under these notches.

The C battery on the first audio stage is placed in the set itself, as can be seen in the accompanying photographs.

In connection with the building of this receiver, it is suggested that the reader carefully read Mr. Reich's manuscript because it contains many constructional hints that will be helpful. After the construction is completed it will be necessary to neutralize the receiver in order to obtain most efficient operation. The process of neutralizing the receiver should be the same as that explained by Mr. Reich except that with

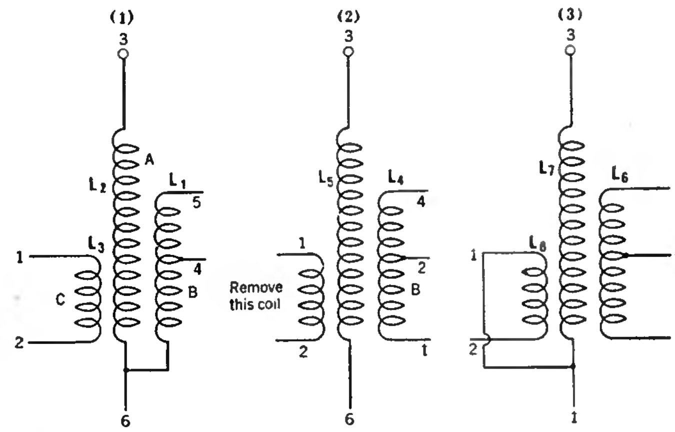


FIG. 2

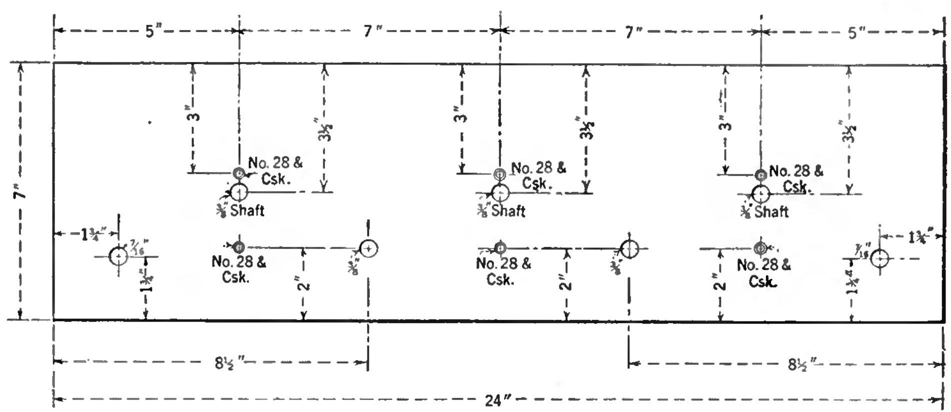
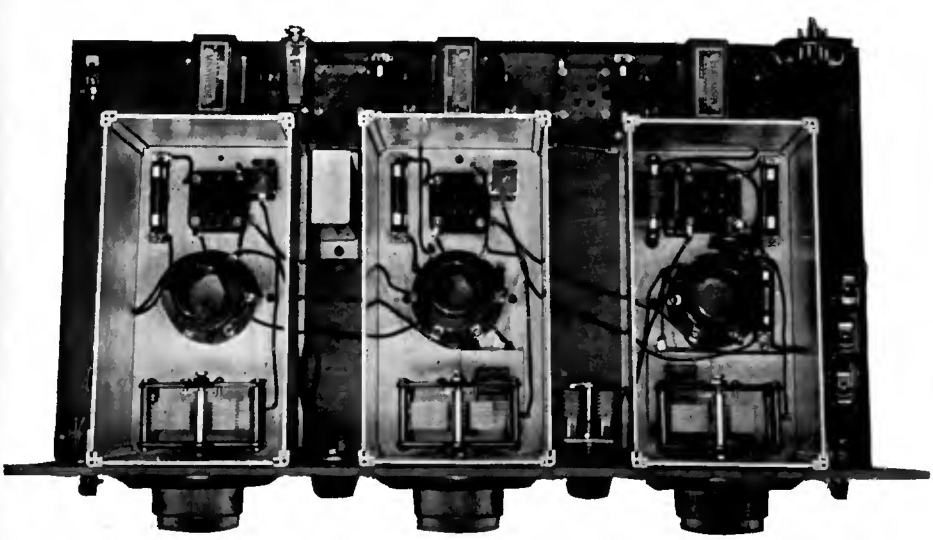
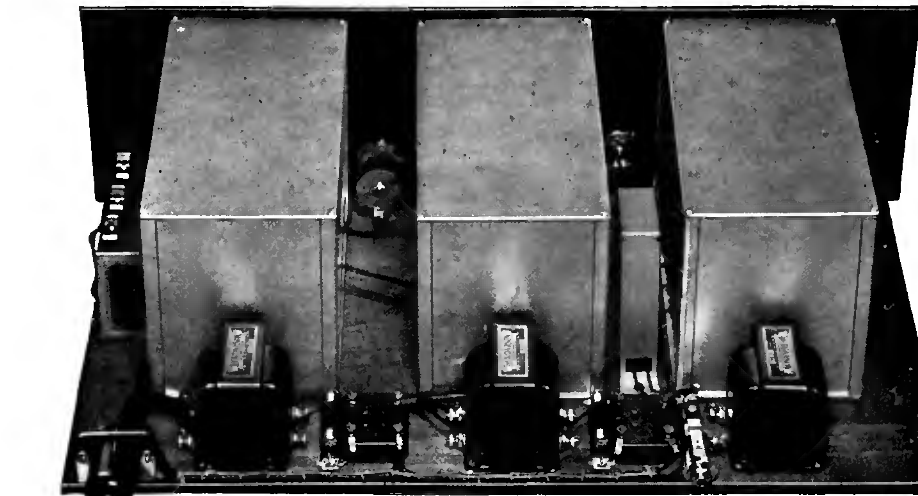


FIG. 3



COMPLETE EXCEPT FOR THE LIDS OF THE SHIELD CANS



RADIO BROADCAST Photograph

A REAR ASPECT OF THE COMPLETED RECEIVER

this receiver the filament of the tube which is to be neutralized should not be turned off by removing the Amperite but, instead, should be disconnected from the circuit by removing from the socket the positive filament lead. This change in procedure is necessary because in Mr. Reich's receiver the Amperites are in the positive filaments and in this receiver they are in the negative filaments.

A. C. OPERATION

THERE have been announced several new tubes designed for operation on alternating current. Four types of these tubes have been received by the Laboratory and are illustrated in a photograph on this page. Many readers will doubtlessly be interested in the possibility of using these new tubes in conjunction with the shielded receiver described so as to make a complete a. c. receiver out of it. The Laboratory experimented with these tubes and all of them proved quite satisfactory when used in the receiver.

The Marathon and Sovereign tubes at the left are of the heater type, while the Van Horne and Armor tubes at the right are of the a. c. filament type. In the case of the first two tubes, of the heater type, the alternating current flows through a filament which becomes hot and heats up a special cathode which, when hot, emits electrons and acts similarly to an ordinary filament in a 201-A tube. In the case of the latter two tubes, the alternating current passes through a heavy filament which is itself the source of electrons necessary for the operation of the tube.

When using any of these a. c. tubes it was found best to change the detector circuit so as to make it a C-battery type detector because, with a grid leak and condenser for detection, there was a small amount of hum which practically disappeared when C-battery detection was used.

To use the Marathon tubes, no changes in the filament circuit of the receiver are necessary. These a. c. tubes are merely placed in their sockets and then extra filament wires are run from a filament transformer to the several tubes, which are connected in a parallel arrangement. These tubes have characteristics similar to the 201-A type tubes and are therefore suitable for use in the two r. f. stages, the detector, and first audio stage. An ordinary 171 should be used in the last stage with its filament operated on a. c.

The Sovereign tube can also be used without any filament circuit changes in the receiver except that the filament terminals on all the sockets, except that one holding the 171 power tube, should be strapped together. The tubes are then energized by connecting the heater terminals in parallel and supplying them from a small transformer.

To use the Van Horne or Armor tubes it is necessary to slightly change the filament circuit of the receiver. The revised circuit diagram for these tubes is given in Fig. 4. It should be noted that both sides of each filament are connected across two terminals of a small transformer. A low-resistance potentiometer should be made from a 10-ohm. rheostat and is shunted across the transformer, negative B, plus C, and ground connecting to the movable arm of the potentiometer. This circuit also indicates a C-battery type detector. The second winding on the filament transformer supplies 5 volts to the 171 power tube in the output stage. Transformers satisfactory for use in conjunction with these various tubes are made by Mayolian, Amertran, Dongan, Thordarson, Samson, and Enterprise.

RADIO BROADCAST Photograph

SOME NEW A. C. TUBES

They are described in the text on this page

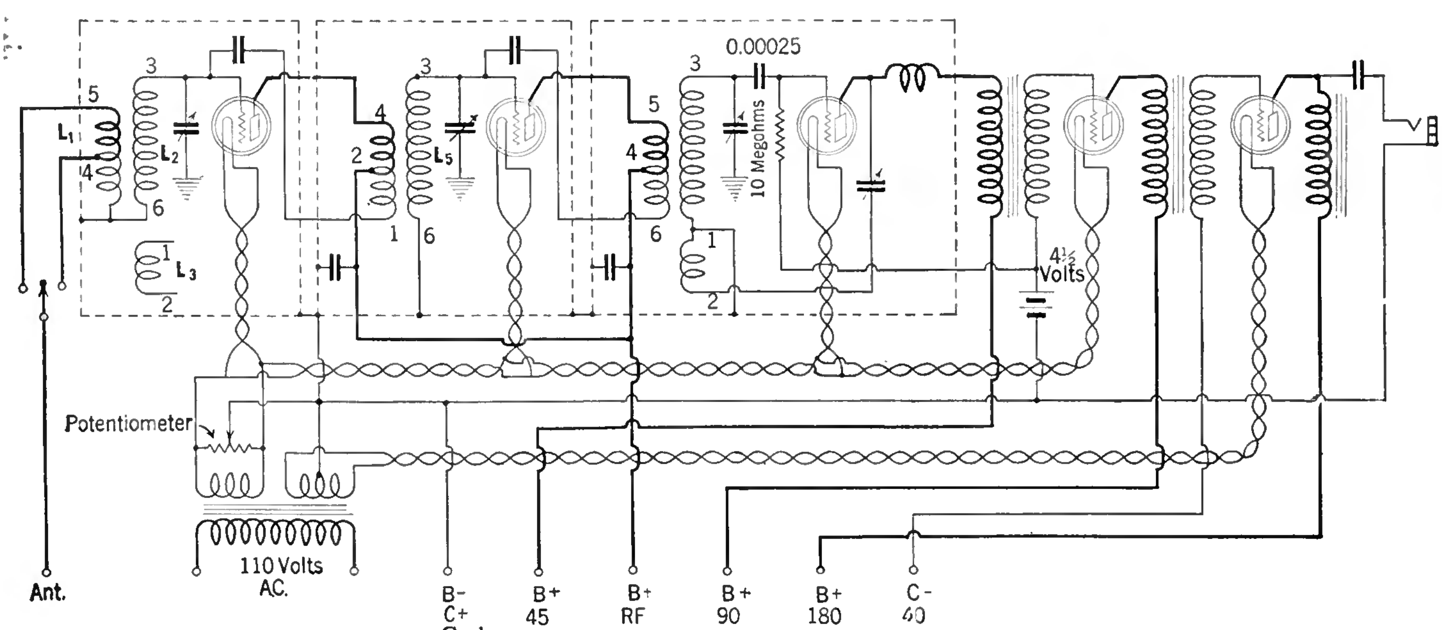
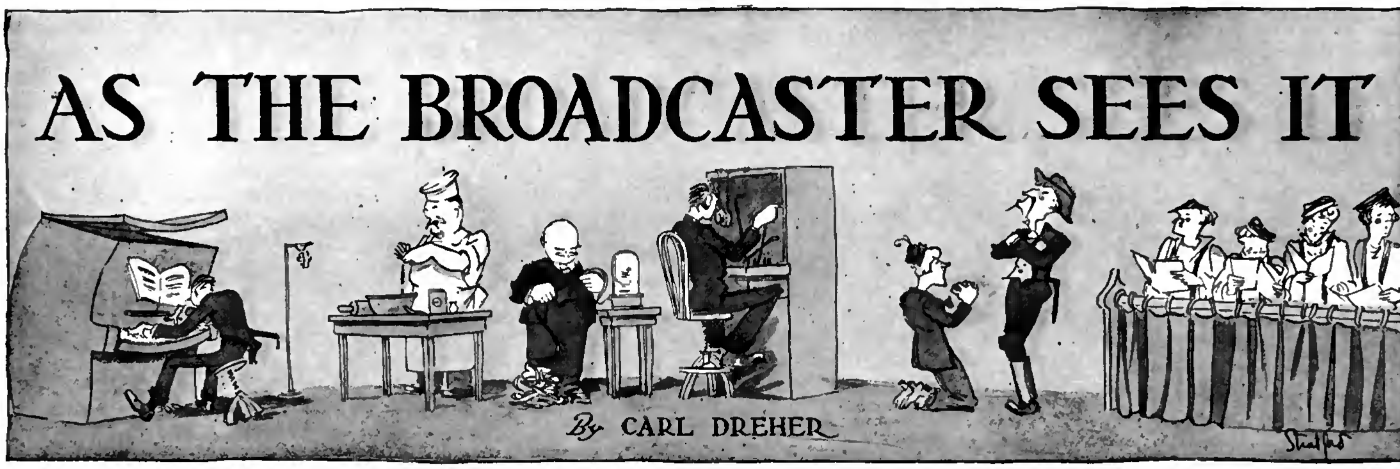


FIG. 4



Drawings by Franklyn F. Stratford

The Future of Television

IN THE July issue we discussed at considerable length the place of television among the communication arts, from what might be termed a metaphysical viewpoint. We tried to outline the fundamental relationships of the different branches of electrical, acoustic, and optical communication and reproduction in time and space. A moving picture showing Charlie Chaplin being hit in the nose by a custard pie, or a television apparatus reproducing for observers in New York the smile of a pretty telephone operator in Washington, may not seem very promising subjects for an analysis of this nature, but the content of the reproduction has nothing to do with the abstract functions of the machinery involved. Having disposed of these fundamentals to the best of our ability, we may proceed with an examination of the practical aspects of television. What part may it be expected to play in the industrial and social life of countries like the United States?

One thing should be noted before we embark on our self-appointed mission of prophecy. Practical television is not around the corner. Many moons will wax and wane before televisor screens in our homes show us distant events and people. Many sleepless nights are ahead of the engineers and scientists charged with the task of putting the new art on a production and commercial basis. If I had at this moment, in a lump sum, the money I expect to earn in very modest annual increments before television becomes a practical reality, I should depart forthwith for a pleasant winter in Algiers and live on the interest for the rest of my life. Anyone who hesitates to buy a radio receiver, for example, because he fears that one equipped with television features may be put on the market before he can realize on his investment, is taking a position almost as ludicrous as that of a man who decided not to buy a gasolene-driven automobile because some inventor might devise a vehicle which would run ten centuries on the intra-atomic energy of a pound of sodium bicarbonate. The everyday application of television is a remote possibility in five years, a fair possibility in ten, a probability in fifteen. Many good radio receivers, appealing to the ear only, will issue from the factories, play their melodies in millions of homes, and succumb to old age and new tastes, in that time. Or, if a slight mutilation of Horace is permissible: "To-morrow do thy worst, for I have listened to-day!"

But when the day arrives, and the engineers produce, for a reasonable expenditure, a television apparatus capable of reproducing distant events in a life-like manner on a sufficiently large screen, what then? Will the accomplishment be a blessing? Not always—take that from one who has seen many broadcast artists. For others, I wish we could have it to-morrow. Sometimes I have seen and heard some beautiful girl with an equally beautiful voice rehearsing her program in the afternoon, and, at the receiver in the evening, have had to be satisfied with hearing her only, and it has certainly been a deprivation. To be limited to one sense is more or less of a hardship in such cases. On the other hand, as I write this article I am listening to a capable group of musicians playing dinner music at one of the hotels. I hear the music and the announcements, although primarily my attention is focused on the typewriter. If my receiver had a television attachment now I should turn it off. In the first place I have no optic interest in the hotel musicians. They are probably just as homely as I am. In the second place, I don't want to look at anything; it would distract me. The ear is happily capable of carrying on its function soothingly and pleasantly, given the right material, without interfering with other activities. Many people rarely listen to a radio program with great concentration. Everyone does, at times, but, as frequently, radio music forms a background for conversation or reading. Often people talk during the music and pause to listen to the announcements. I generally read during the whole evening's program of a given station, but I hear the announcements and know pretty well what has happened afterwards. Obviously in such cases television is not a remarkable boon. It is even possible that when television has come to stay that some programs will be transmitted with the visual component and others without it.

"MANY SLEEPLESS NIGHTS ARE AHEAD OF THE ENGINEERS"

The movie theatres, it would seem, can do without television. As we saw in the preceding article on television, the motion picture is primarily an art for transferring the past, optically, into the present. The moving picture audience finds no difficulty in attaining a feeling of being in contact with reality, even though the actors went through their parts months ago. There would be nothing gained by substituting television in such a case, and something would be lost. In the recording arts there is always the advantage of being able to try over and over until one gets the right results, and offering to the public only a finished product. Both the phonograph and the motion picture have this advantage. However, television in conjunction with telephony might be employed to reproduce distant spectacles, not only in the home, but in theatres. For example, a movie house might interrupt its program for a short speech, reproduced visually and audibly, by the President—an appeal for aid, for example, in time of national disaster. The theatres have not used broadcasting to any extent to serve their actual audiences; it has been merely a medium of advertising to them, a means of attracting audiences. If the visual component were added to broadcasting as we now know it, the motion picture theatres might find it a useful adjunct to their shows, probably in a form we do not foresee now. But it will not be a necessity; they can probably keep on doing a tidy business without it. Aural broadcasting has affected the motion picture industry only to a moderate extent. In the larger centers the hunger for amusement is so avid that every form of diversion is eagerly soaked up. Most families in a city like New York have radio receivers and use them, and yet colossal theatres continue to spring up and the patrons besiege the box offices as soon as they are finished. Adding television to telephone broadcasting will probably not alter this condition.

In point-to-point communication, television may be used to supplement telephony, for sentimental or other purposes. A good deal of the expensive conversation which passes over the Atlantic radio telephone link is not acutely essential. People call each other up between New York and London for a thrill as much as in the way of business, it is probable. A young man calling up his sweetheart would, on the same basis, find use for the television service in conjunction with the telephone, even though it cost money. But, as Mrs. Herbert Hoover remarked during the television tests between New York and Washington, sometimes one would rather not be seen as well as heard. Everyone is free to imagine his own situations in verification. In the largest number of cases, television, as it would not add much to the communication value of the connection, would not be called into use. One business man calling up another to ask for a quotation on forty kegs of wire nails would certainly not pay for television service; all he wants is the price of the nails, if he knows what they are like—and he usually does. If he does not, then a sample nail might be shown him, of course. It is a terrific job to compare curves or observations involving circuit diagrams, by telephone, as every technical man knows. In such cases television would come in handy. But in most cases the mouth and ear form an adequate communication circuit; for this reason, as the wire or point-to-point telephone is primarily a means of communication, television will probably be limited to the rôle of an adjunct in this field, an important adjunct, however.

It is interesting to note, in conclusion, that television, as now realized, involves no startling new discoveries. The principles on which it is based were understood decades ago. The same holds true for photoradiograms and the like. Ranger, at the beginning of his paper on "Transmission and Reception of Photoradiograms" (*Proceedings of the Institute of Radio Engineers*, April, 1926) says disarmingly: ". . . the art of picture transmission . . . is as old as the communication art itself." And Ranger goes on to state that the 1842 scheme of Alexander Bain "is so basically correct that it is only right at the start to show the simplicity of his plan and, how, generally, we are all following in his footsteps." Modern inventors marshall all the forces of modern industry to accomplish ends which were visualized imaginatively years ago, but which previous generations lacked the technique to carry out in actuality. This should not be construed as a reflection on the capacity of contemporary research workers. It is simply that their ingenuity is of another kind and utilizes other tools. They have as much courage, determination, and resourcefulness as the inventors of any previous generation. In the case of television they have needed all they have of those qualities to bring them to the present stage of achievement, and they will need no less to achieve the practical applications looming on the industrial horizon.

Another Broadcast Fatality

CONSIDERING the fact that there are only a few thousand broadcast operators in the United States, the fatal accidents among them are too frequent, as I have remarked before in this place. Another case occurred on May 12th at a New Jersey station. A young man (he was twenty-two years old) was instantly killed while working on a transmitter panel at 4 o'clock in the morning. The circumstances, as nearly as they can be ascertained, are worth recounting, in the hope that the analysis will lead some of the boys to take precautions which they might neglect otherwise.

The station in this case was not on the air. Repairs or alterations were being made during the night in order to avoid interference with program service. The man who was killed was working behind the panel, where there were two-thousand volt terminations fed from a generator in the basement of the building. This generator could not be heard running in the transmitter room. It is not known whether the victim of the fatal accident was working on live circuits with confidence that he could avoid getting across the high tension, or whether he imagined that the machine had been shut down. He took hold of the bare copper of one of the high-tension cables, while he was partially grounded through his shoes. This put him across the 2000-volts, but probably would not have killed him in itself. He exclaimed, "Wow, it's hot!" causing a fellow worker, who was in front of the panel, to run to his aid. In the meantime the man on the circuit,

"A YOUNG MAN CALLING UP HIS SWEETHEART WOULD FIND USE FOR THE TELEVISION SERVICE"

unable to let go of the wire, was thrown by the violence of his own reflex action into the panel itself, where he must have made better contact with live parts and grounded metal, so that the current through his body rose to a fatal level. His co-worker, rushing behind the panel, seized the cable by the insulation, apparently without shutting down the machine, and tore it out of the fallen man's hand. The wire was rubber-insulated against high tension, and the rescuer got away with his effort, which was both heroic and foolish. A third operator who was present attempted artificial respiration without success. The young man was dead.

What is the moral? There is only one: Be sure that the high tension is shut down before you do any work on potentially live parts of the transmitter. Two thousand volts is not terribly high; many of us have taken it and remained among the living. But if you make a good contact you are as good as dead on a much lower potential. Furthermore, once you are caught you may be thrown into any part of the machinery; you no longer have any control over your movements, and in a few seconds the tragedy is complete. It is perfectly possible for a man to receive a shock on 110 volts which in itself would only be moderately painful, but if the high-tension portion of the equipment is running he may be flung onto a 10,000-volt circuit before anyone realizes what has happened.

But sometimes one thinks the juice is off when it is not off. Or someone may throw it on while a man is working on the circuits, through a misunderstanding. The remedy for that is simple; the cost is about five cents, and a little thought. Take a stick of dry wood one inch by one inch by, say, twenty inches. Screw on one end of this stick a piece of copper an inch wide, an eighth of an inch thick, and about six inches long, bent in the form of a hook. Let this copper hook be permanently grounded through a heavy, well-insulated flexible wire. When the set is running on program let the contraption lie under the frame or beside the panel. When anyone is going to work on the transmitter, take the copper hook by its insulating stick and hang it gently on the plate bus. If the bus is alive, by chance, there will be an explosion, but you won't get hurt. A new hook can be made in five minutes. If someone turns on the current while the plate bus is shorted, the hook will take the bulk of the flow, and a man's body, with its relatively high resistance, will not receive enough to kill him, perhaps not even enough to hurt him.

One more point is worth taking up. A great deal of testing is done at radio stations during the early morning hours, for obvious reasons. In fact, the regulations restrict broadcast stations to the hours between midnight and 11:30 A. M. for testing. During the early hours of the morning, what with fighting sleep and fatigue, a man does not think as clearly as he might at other times. He is at a lower tension of consciousness, and not as distinctly aware of the outside world and its perils as he might be after eight hours of sleep. That is the more reason why a simple automatic device like the bus hook described above should be provided in every station and its use made mandatory, until it becomes so habitual that no one thinks of working without it. Even then, of course, there is no substitute for prudence and conscious direction of all one's movements when one is in the vicinity of a radio transmitter. The thing is dangerous, highly dangerous, and for innocently taking a chance with it one is apt to pay with one's life. And that chance need only be taken once.

Local Regulation of Broadcasting

DURING the partial interregnum between the Zenith decision and the passing of the Dill-White bill to provide for adequate Federal regulation of broadcasting, there was manifest a tendency on the part of some states and municipalities toward local handling of interference problems and the like. Now that Federal administrative machinery is once more functioning, this development will probably peter out by itself. It is worth discussing, however, because in at least one case—that of the City of Minneapolis—an ordinance possessing broad regulatory powers was adopted (on February 11, 1927), and may still be in force.

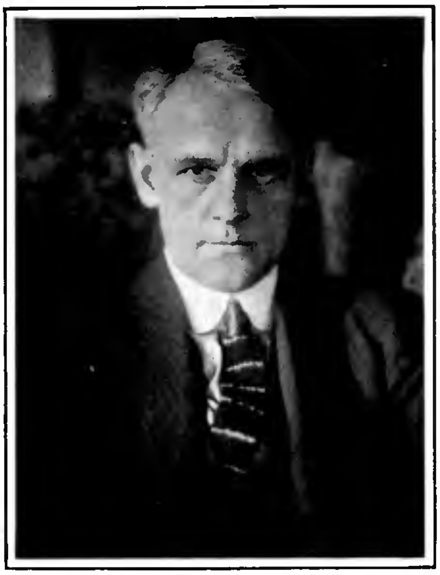
The Minneapolis ordinance provides for annual licensing by the City Council of all broadcasting stations within the city, the fee being $50.00. Transmitters located within the city limits, or less than two miles outside, are limited to an antenna power of 500 watts. Between 500 and 1000 antenna watts the transmitter must keep at least four miles from the nearest city boundary line, or at least eight miles if the antenna power is 1000–5000 watts, and so on up to output power of the order of 50,000–100,000 watts, when the prescribed distance is increased to 25 miles. There are also provisions limiting the total number of hours of evening broadcasting allowed to any station in the city or within two miles thereof, to twelve per week; and the Building Inspector of the City is assigned power to regulate the hours of such stations. Another section is directed against radiating receiving equipment, violet ray machines, X-ray apparatus, and vibrating battery chargers of types capable of interfering with radio reception. Fines between $15.00 and $100.00, or imprisonment up to 90 days, are prescribed for violations. "Each and every day's continuance of any violation of this ordinance," reads the punitory section, "shall be deemed a separate offense." Another section forehandedly provides: "In case any section or any part of this ordinance is declared invalid, it shall not affect the validity of the remainder of this ordinance."

The manner of enforcement contemplated against transmitters outside of the city limits is of interest. The relevant section reads, "It shall be unlawful for any owner, lessee, or licensee of any metal wires, after written notice from the Building Inspector, to permit the use of such wires in the operation of any broadcasting station which is being operated by the owner or operator thereof in violation of the provisions of this ordinance." In other words, if the transmitter, located outside of the City of Minneapolis, does not conform in location, or otherwise, to the regulations of the municipality, the City will cut it off from electrical connection with any studio within the City, if the courts permit.

Obviously Federal regulation must intervene in all the major questions of broadcasting. The radiation of a broadcasting station does not proceed to the bounds of any city, state, or country and then drop dead. It is an interstate affair if there ever was one. Since there must be centralized regulation of the most complicated sort, it is not a very sapient procedure to attempt decentralized regulation at the same time. The two are bound to overlap. State and municipal control is probably unconstitutional. Professor Frank S. Rowley, of the University of Cincinnati College of Law, in a valuable article on "Problems in the Law of Radio Communication" (*University of Cincinnati Law Review*, January, 1927), writes as follows on the general principle involved:

> . . . even though we concede that such stations (of low power and normal intrastate range) operate on a purely intrastate basis, there is excellent authority for sustaining Federal regulation of the same, by analogy to decisions governing regulation of other instrumentalities of intrastate traffic. The Commerce Clause of the Constitution necessarily excludes the states from direct control of subjects embraced within the clause which are of such a nature that, if regulated at all, their regulation should be prescribed by a single authority. That such a doctrine applies particularly in the case of regulation of radio communication is very apparent. A chaos of interference and confusion would result if powers of regulation were divided between federal and state authorities. To avoid such a possibility, a single authority must be given complete control.

Professor Rowley's discussion, although not written with the Minneapolis case in view, seems to me to say all that needs to be said about this or similar attempts. The Radio Commission, or the Secretary of Commerce, can take care of the radio needs of municipalities quite adequately. Such agencies possess much more effective means for compelling interference-causing transmitters to move out of congested districts than any municipality or state body can create or use. Whatever good might be accomplished locally would be overbalanced by possible evils which any layman can foresee. Local authorities had best keep their hands off, in my view. And I might add that I am a rabid states-rights exponent, a natural Jeffersonian, and a natural anti-Hamiltonian—in everything but radio. Radio is not a town-meeting affair, and can't be made one by the best of town legislators.



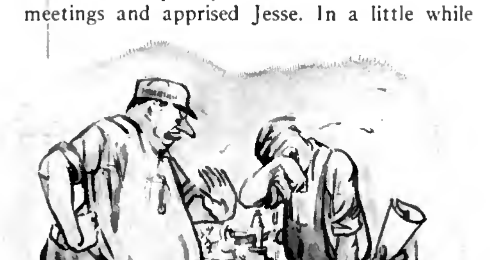
ROY A. WEAGANT
Said: "The salary will be $10.00 per week as a beginning"

Memoirs of a Radio Engineer. XIX

ON A sunny afternoon in May my classmate, Jesse Marsten, and I, fresh from college, sat in an ante-room of the Marconi Company's factory at Aldene, waiting for Mr. Weagant, the Chief Engineer. The year was 1917. Did I say we sat? We stood, as a matter of fact. The office force, unimpressed by our appearance and demeanor, did not invite us within the enclosure wherein high-powered office managers, assisted by beautiful secretaries, guided the Marconi Company's destinies. Mr. Weagant was expected, so we waited. We had an appointment. We waited about an hour and a half. Mr. Weagant came in, accompanied by Adam Stein, Jr. He did not know us and passed into the office quickly. I had seen him at I. R. E. meetings and apprised Jesse. In a little while Mr. Weagant came out again. He looked preoccupied; there was reason enough for it, as a matter of fact. In a small stone building, with a few bungalows scattered about it, the Marconi Company was trying to meet war-time demands for apparatus which would have overtaxed a plant six times as large. As Mr. Weagant passed the second time, going out, Marsten stopped him and reminded him of the appointment Doctor Goldsmith had made for us. Mr. Weagant looked dazed for an instant, then, recollecting, he apologized with his usual grave courtesy, and, dropping far more important business, took us to his office in the small wooden engineering building near the main plant. He questioned us and told about the engineering course which the Marconi Company had planned for such aspirants as ourselves. The idea was to move the student engineers about in the various departments of the plant, so that they could become acquainted with all the intricacies of design and manufacture of radio apparatus. We murmured our approval. The salary, continued Mr. Weagant, would be $10.00 per week as a beginning, with an increase of $1.60 per week every six months. If we had commercial operator's licenses, he added, six months' credit would be extended. I thereupon produced my first-class ticket, for which I had undergone the ordeal of examination at the Brooklyn Navy Yard some years before. Mr. Weagant seemed surprised; he examined the document carefully, and granted me the increase in salary which it rated.

Next, with the assistance of two of the engineers at the Marconi plant who were graduates of the City College, Messrs. Barth and McAusland, we secured board and lodging in the near-by village of Roselle, with a very charming middle-aged couple, a retired ship's purser and his wife. The lady was childless but maternal, so she lavished attention on the canary bird, Jesse, and me, and really made things unusually comfortable for us during our stay at the Aldene factory. The room and board amounted to $8.00 a week apiece. Each of us had a very nice room in a good neighborhood, with typical suburban streets shaded by old trees, and we were not badly off, except, of course, that we were not quite self-supporting on our respective salaries of $10.00 and $11.60 per week. This worried us considerably, and we felt that the world is very cruel to newly fledged college students. It is. Why shouldn't it be? But, as a matter of fact, we were able to knock down an average of fourteen dollars a week by working overtime. Some weeks I climbed to the dizzy height of sixteen dollars and fifty cents. A young man could live quite well on that sum in 1917.

We started to work on a Monday. Marsten, I believe, was relegated to the drafting room. I became a tester. I worked from seven in the morning to three in the afternoon, with a half-hour for lunch, punched a clock, and wore overalls. There were no halfway measures, either. If I came five minutes late in the morning my card showed it and I was docked fifteen minutes' pay. The overalls were dirty at the end of the first day I wore them. I was a factory hand like any other, subject to the same discipline, the same savage laying-out by the nearest foreman when I did anything wrong, the same difficulties of organization and manufacture which beset the other cogs in the machine. My B. S. was hidden under the overalls; nobody knew about it except my immediate superior, and he did not hold it against me after a few weeks. I forgot it. My life differed from that of my fellows only after 3 P. M., when, washed and arrayed in white flannels, I played tennis on the turf courts of Weequahic Park in Newark, and spent the evenings reading H. G. Wells.



"I WAS SUBJECT TO SAVAGE LAYING-OUT BY THE NEAREST FOREMAN"

Use of Tubes Having High Amplification

A Discussion of the Theory Underlying the Functioning of High-Mu Tubes—A Paper Delivered Before the Radio Club of America

By A. V. LOUGHREN

Research Laboratory, General Electric Company

THE amplifier tube has, within the last two years, undergone a notable change. In 1923 all amplifier tubes were of the general-purpose type and all were alike. To-day, on the other hand, we have, in addition to this general-purpose tube, two distinct groups of special-purpose amplifier tubes.

One of these groups—that having a low amplification factor and low plate-to-filament resistance as its chief characteristics—was brought into being to satisfy the demand for more speech power which arose when reception on the loud speaker became common. The performance of this group of tubes has already been discussed in some detail ("Output Characteristics of Amplifier Tubes," J. C. Warner and A. V. Loughren, *Proceedings Institute of Radio Engineers*, Vol. 14, No. 6, Dec., 1926).

The second group, consisting of tubes having amplification factors of 15 or more, will be treated in the present paper. It should be understood, of course, that tubes with high amplification factors are not at all new, as such tubes have been built since 1912. Some of their uses have not been completely investigated, however, until recently.

Any treatment of the uses of tubes having high amplification factors is of necessity primarily a discussion of their use in resistance-coupled amplifiers. In order to understand their application to this type of amplifier it is necessary to have its underlying theory clearly in mind.

Fig. 1 is a diagram of a two-stage amplifier with resistive-interstage coupling. The operations may be sketched roughly as follows:

When a signal is impressed on the input circuit, consider the phenomena at the instant when the grid potential has reached the highest value occurring during the cycle. In Fig. 2 this condition is represented by the point t_1. At this same instant the plate current reaches a maximum. Now, looking back at Fig. 1, we see that the voltage at the plate of tube No. 1 is equal to the battery voltage minus the IR drop in the resistance R_{p1}. The value of this drop is simply $I_p \times R_{p1}$. Therefore, it is directly proportional to the plate current. Thus, when the plate current is greater, as at t_1, the drop in the coupling resistance, R_{p1}, is greater, and hence the plate voltage on the tube is less. The curve of plate potential in Fig. 2 shows this exactly. Incidentally, it may be noted that the signal has been shifted 180° in phase by going through the first stage.

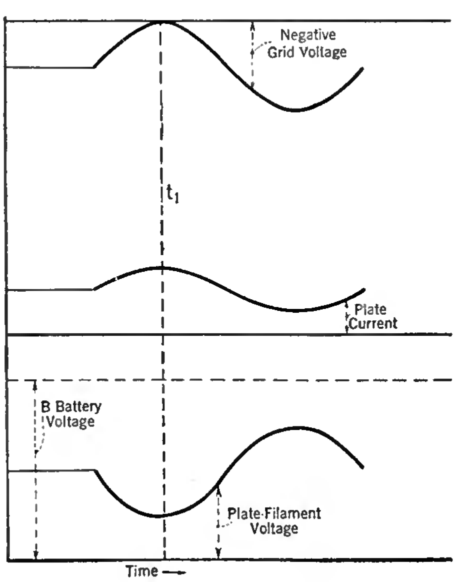


FIG. 2

The alternating component of this plate potential is applied to the grid leak resistance, R_{g2}, of the second tube, while the direct component is kept back by the blocking condenser C_{b2}. The grid of tube No. 2 is so connected that the drop in the grid leak resistance is the alternating component of grid voltage. In this stage the action is exactly like that in the preceding one.

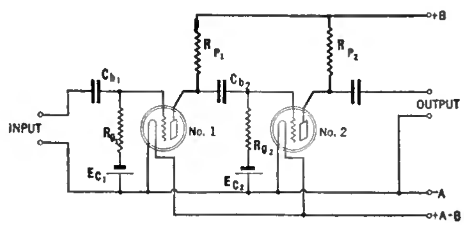


FIG. 1

Now, having a slight familiarity with the circuit and its mode of operation, let us proceed to a more rigorous analysis of the performance. To do this we make use of a fundamental principle of physics which may be stated as follows: With circuit elements whose coefficients are constants, the circuit response to a complex emf. may be determined by evaluating the respective responses to each of the (simple) component emf's. and taking the summation, if desired. In the present case this principle permits us to analyze the performance of the amplifier circuit for the alternating quantities alone, neglecting entirely the direct components.

Fig. 3 is drawn in this way. It may be noted that only the quantities entering into the alternating-current phenomena are shown. The interstage coupling resistor, R_p, is shown connected from the plate back to the filament. In practice it is connected to the positive terminal of the B battery and through the latter to the filament, but here we do not need to show the battery. The representation of a tube by a generator and the series resistance r_p is quite common in analyses of tube output characteristics.

By the use of Kirchoff's Laws for alternating current circuits an expression may be worked out for the relation between e_{g2}, the output voltage of the network, and μe_{g1}, the input voltage. The first voltage corresponds to the alternating voltage on the grid of the second tube while the second is proportional to that on the grid of the first tube. The steps of the mathematics are hardly worth showing in detail. The final expression is that given in Fig. 3. This expression contains a group of terms independent of frequency, and two terms containing the quantity P, where $P = 2\pi \times$ frequency, which are dependent on frequency. The first of these latter is directly proportional to frequency and thus may be expected to interfere with the amplifier performance more at higher frequencies; the second, on the contrary, is important at low frequencies since it is inversely proportional to frequency.

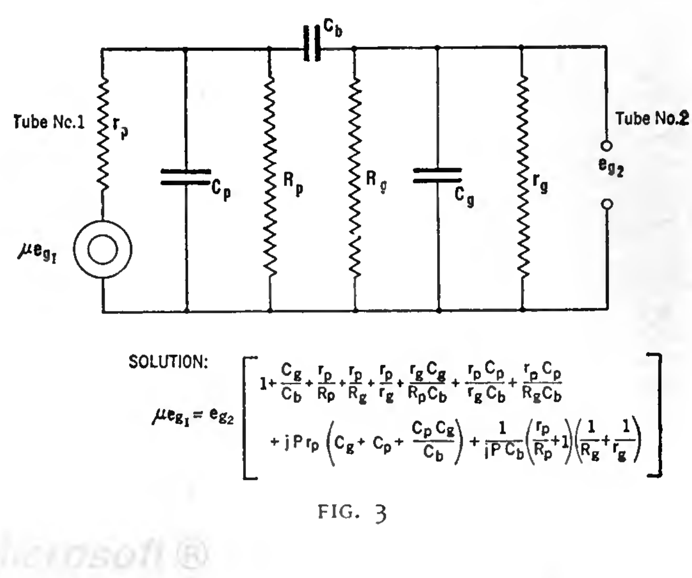
Before investigating the magnitudes of these two frequency effects we must see what the values of the various circuit coefficients are. Certain of them are quite familiar to radio workers, such as the internal plate circuit resistance r_p, the coupling resistance R_p, the grid leak R_g, and the blocking condenser C_b. The quantities C_p, C_g, and r_g have not been in common use, so a word about their magnitudes will hardly be amiss.

The plate-to-ground capacity, C_p, is very nearly the sum of the following:

(1.) Tube inter-electrode plate-filament capacity.
(2.) Tube inter-electrode plate-grid capacity.
(3.) Stray capacities in wiring.

For the Radiotron UX-240 the first two are 1.5 and 8.8 micro-microfarads, respectively.

The quantities r_g and C_g cannot be treated rigorously without going beyond the scope of the present paper. Their magnitudes are de_



SOLUTION:

$$\mu e_{g_1} = e_{g_2}\left[1+\frac{C_g}{C_b}+\frac{r_p}{R_p}+\frac{r_p}{R_g}+\frac{r_p}{r_g}+\frac{r_gC_g}{R_pC_b}+\frac{r_pC_p}{r_gC_b}+\frac{r_pC_p}{R_gC_b} + jPr_p\left(C_g+C_p+\frac{C_pC_g}{C_b}\right)+\frac{1}{jPC_b}\left(\frac{r_p}{R_p}+1\right)\left(\frac{1}{R_g}+\frac{1}{r_g}\right)\right]$$

FIG. 3

pendent on the constants of the plate circuit of the second tube. For our purpose it will be sufficiently accurate to consider r_g infinite as long as the second tube is biased sufficiently. C_g may be expressed as:

$$C_g = C_{gf} + C_{gp} (A_v + 1)$$

The reason for the appearance of the quantity $(A_v + 1)$ where A_v is the voltage amplification actually obtained between grid and plate of the second tube, is explained in the appendix on page 240. In practice C_{gf} is usually 3 to 4 mmfd. and C_{gp} 8 to 10 mmfd. while A_v may be between 2 and 25 or more. Accordingly C_g will vary over the range from 20 to perhaps 300 mmfd. The figures given, by the way, do not include the stray capacities in the wiring. It should further be noted that there is no marked difference in the values of these capacities for low and high amplification tubes; that is, the Radiotron UX-201-A for which $\mu = 8$ and the Radiotron UX-240 for which $\mu = 30$, have substantially the same inter-electrode capacities. The Radiotron UX-171 has nearly the same grid-to-plate capacity as the others, but as it has twice their filament surface its grid-filament capacity is somewhat greater.

The frequency characteristic of each individual stage may be calculated by the relation shown in Fig. 3. The frequency characteristic of the complete amplifier is equal, of course, to the product of the frequency characteristics of the individual circuits. Fig. 4 shows certain of these overall frequency characteristics. It should be noted that the use of higher value coupling resistances increases the amplification, but that these increases are always less in magnitude at the upper end of the frequency characteristic than in other portions of the range. Accordingly, the frequency characteristic becomes poorer as the coupling resistance is increased.

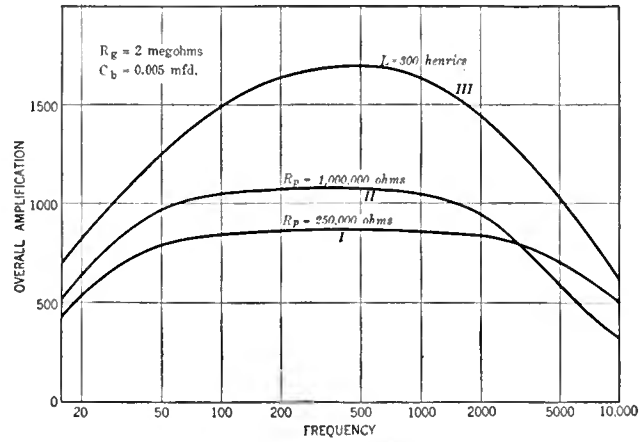


FIG. 4

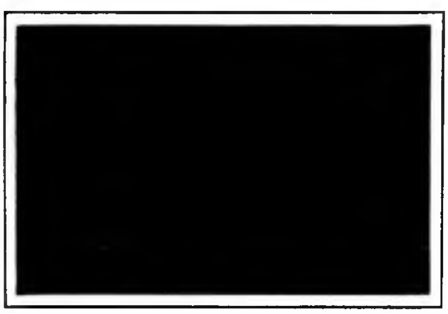


FIG. 6

CHOICE OF AMPLIFICATION FACTOR

THIS is an excellent point in the discussion to take up the question of the choice of the amplification factor. It should be pointed out that this factor is completely under the control of the tube designer so that there is little difficulty in building tubes having values anywhere between 0.5 and 500. Any increase in the amplification factor, however, involves an increase in the plate resistance of the tube, if the filament and plate dimensions and the spacings are kept the same. Fig. 5 shows this variation in plate resistance with amplification for tubes similar to the UX-201-A in plate and filament structures. It may be shown from the mathematical expression in Fig. 3 that any increase in the plate resistance r_p leads to a loss of amplification which will be more pronounced at the high frequencies than elsewhere. Further, as the actual voltage amplification of tube No. 2 is increased, the capacity C_g of Fig. 3 is increased almost directly, as may be seen from the expression already given for it; this capacity increase also tends to make the amplifier "lose" higher frequencies.

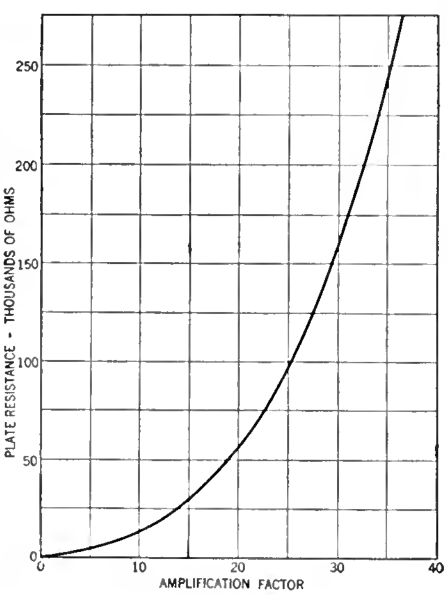


FIG. 5

Accordingly, the choice of the proper amplification factor for a tube for resistance-coupled amplification should be the highest value which is consistent with a satisfactorily flat frequency characteristic. Of course, opinions on frequency characteristics differ, but it is felt that in the design of Radiotron UX-240 the greatest value of amplification factor that should be used in a high-quality receiver has been chosen.

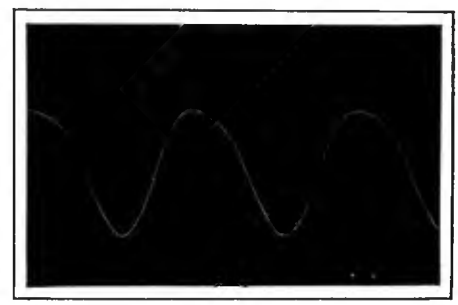


FIG. 7

One of the curves of Fig. 4 shows an experimentally determined overall frequency characteristic when iron-core inductances are used for interstage coupling. The units used have unusually high inductance, but the loss of amplification at low frequencies shows that, even so, impedance coupling was unsatisfactory.

So far we have assumed that the circuit coefficients are constants. Actually this may or may not be a valid assumption in a practical case. The two circuit coefficients which may

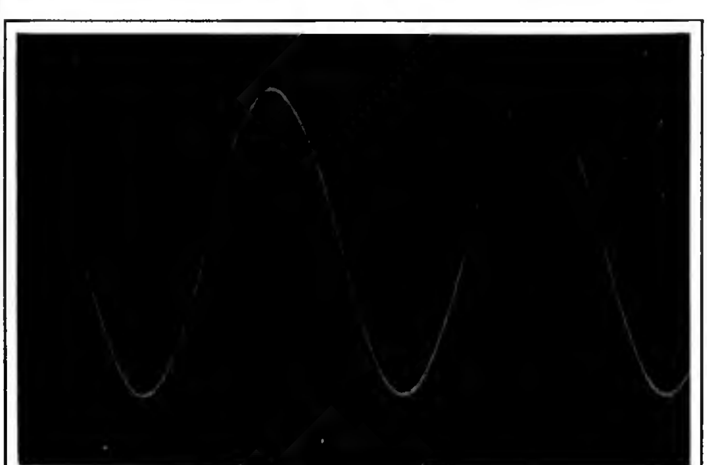


FIG. 8

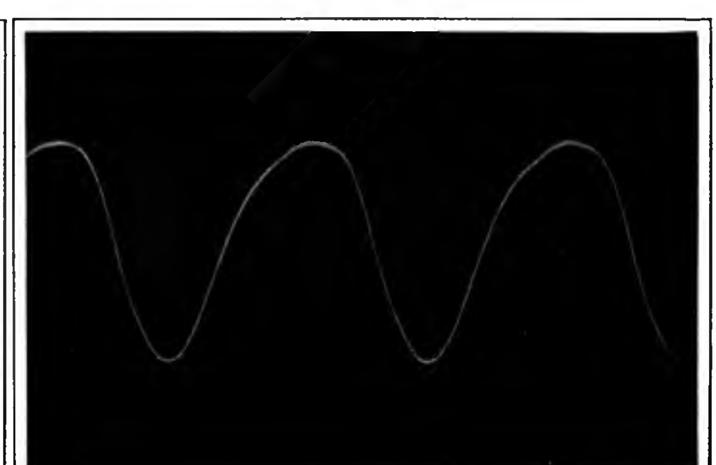


FIG. 9

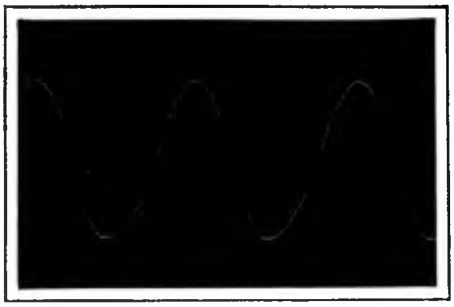


FIG. 10

FIG. 11

FIG. 12

vary appreciably in practice are the plate resistance and the grid resistance.

Variation of the plate resistance becomes a matter of importance if the plate current is permitted to decrease to too low a value at any time during the cycle. The effect of this may be seen by comparing the oscillograms of Figs. 6 and 7. Fig. 6 shows the output of the UX-240 when operating normally, while in Fig. 7 the negative bias on the grid is excessive. The resulting distortion on the lower half of the plate-current wave is quite objectionable.

Variation of the grid resistance is negligible in magnitude when the grid potential is negative. When the grid becomes positive, however, its resistance falls quite rapidly, and it may, under some conditions, introduce appreciable distortion. If the source of the signal voltage has good regulation there is little likelihood of distortion occurring; the oscillogram of Fig. 8 demonstrates this. It shows the output of the UX-240 for the same signal voltage as in Fig. 6 and 7; that is, 1.06 volts effective, this time with no bias at all. The plate current is obviously undistorted. Fig. 9 shows the rather poor results obtained when the regulation of the signal source is unsatisfactory.

If the tube is operating with a blocking condenser and grid leak and receives sufficient signal to make the grid positive, the electrons which flow from the filament to the grid must continue through the leak and back to the filament. In doing so they will develop a voltage drop across the leak which will bias the grid negative; the trouble will thus be largely self-correcting. Fig. 10, which illustrates this point, was made under the same conditions as Fig. 9 except that a blocking condenser of 0.015 mfd. was interposed in the lead from the grid to the signal source and a grid leak of 1 megohm was connected from grid to filament. The improvement in output wave form over that of the preceding oscillogram is quite striking.

Fig. 11 shows the distortion that occurs with no bias and the same signal amplitude as before, when the signal is supplied from another tube through an interstage transformer. Here the grid current cannot bias the tube appreciably as it has a low-resistance return to the filament and hence produces only a negligible IR drop. In the record of Fig. 12 this condition has been corrected by the introduction of a suitable bias.

Perhaps a word about the UX-240, the tube on which our work is based, would not be amiss. In external appearance this tube is identical with the UX-201-A. The filament characteristics and ratings are also identical. Normal operating conditions for the tube are 1.5 to 3 volts grid bias, 135 to 180 volts plate supply voltage, with a 250,000 ohm resistance in series with the plate. Under these conditions the actual voltage amplification will be between 15 and 20, representing better than 50 per cent. utilization of the tube's inherent amplification factor of 30.

Fig. 13 shows the mutual characteristics of the tube and Fig. 14 shows a family of plate characteristics. These are the two forms in which static characteristics are conventionally shown and are reproduced for that reason.

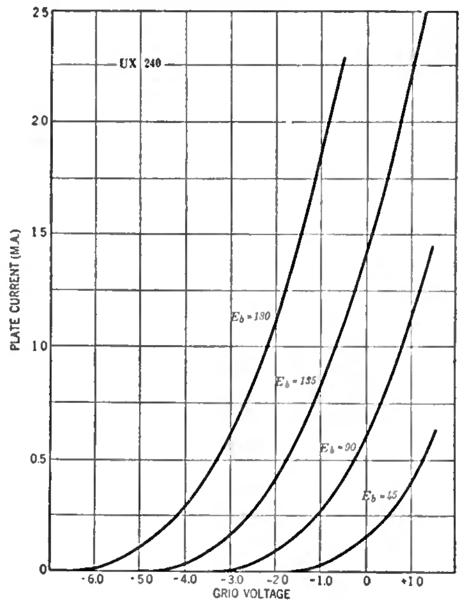


FIG. 13

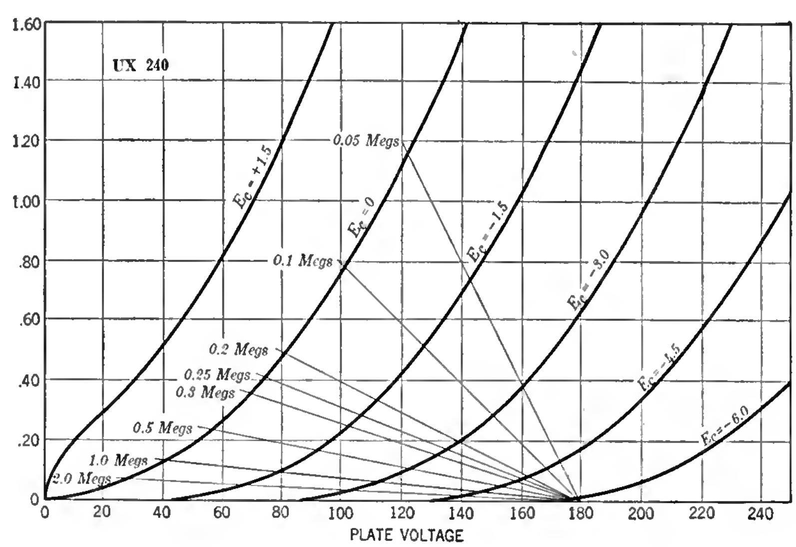


FIG. 14

APPENDIX

The change in grid-to-ground capacity introduced by the plate and plate circuit of the tube may be treated as follows: In the case of a resistance-coupled circuit having substantially unity power factor, so that there is no appreciable phase shift, let us observe what happens when the grid is raised in potential 1 volt. The plate potential falls by an amount A_v volts, where A_v is the actual voltage amplification which the stage is furnishing. Now, across the direct grid-filament capacity we have introduced a net change in potential difference of 1 volt, and accordingly the quantity of electricity which will raise this potential difference 1 volt is added to that already providing the electro-static field between grid and filament. Across the direct grid-plate capacity we have introduced voltage changes of 1 volt at the grid side and of A_v volts at the plate side, the two changes being of the same sign insofar as their effect on the electrostatic phenomena is concerned. As a result, a quantity of electricity sufficient to change the grid-plate capacity to $1 + A_v$ volts must flow on the grid.

By combining these two terms we find that the effective capacity from grid to ground is:

$$C = C_{gf} + C_{gp}(1 + A_v)$$

It should be noted that a general treatment of this capacity effect is, ipso facto, a study of regeneration due to inter-electrode capacity.

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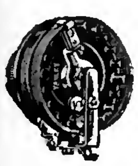

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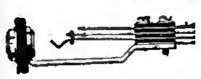

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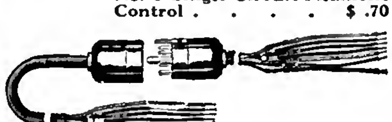

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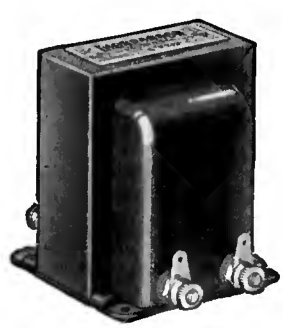

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The *Radio Broadcast* LABORATORY INFORMATION SHEETS

THE RADIO BROADCAST Laboratory Information Sheets are a regular feature of this magazine and have appeared since our June, 1926, issue. They cover a wide range of information of value to the experimenter and to the technical radio man. It is not our purpose always to include new information but to present concise and accurate facts in the most convenient form. The sheets are arranged so that they may be cut from the magazine and preserved for constant reference, and we suggest that each sheet be cut out with a razor blade and pasted on 4" x 6" filing cards, or in a notebook. The cards should be arranged in numerical order. An index appears twice a year dealing with the sheets published during that year. The first index appeared on sheets Nos. 47 and 48, in November, 1926. Last month an index to all sheets appearing since that time was printed.

The June, October, November, and December, 1926, issues are out of print. A complete set of Sheets, Nos. 1 to 88, can be secured from the Circulation Department, Doubleday, Page & Company, Garden City, New York, for $1.00. Some readers have asked what provision is made to rectify possible errors in these Sheets. In the unfortunate event that any such errors do appear, a new Laboratory Sheet with the old number will appear.

The Information Service of RADIO BROADCAST is conducted entirely by mail, the coupon on page 255 being used when application is made for technical information. It is the purpose of these Sheets to supply information of original value which often makes it possible for our readers to solve their own problems. —THE EDITOR.

No. 113 RADIO BROADCAST Laboratory Information Sheet **August, 1927**

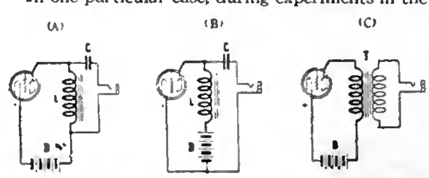
Output Circuits

THREE POSSIBLE CIRCUITS

IN THE sketch on this Sheet are shown three output arrangements that can be used to couple a loud speaker to a power tube in order to prevent the direct current in the plate circuit of the power tube from passing through the windings in the loud speaker and affecting its satisfactory operation. In sketches "A" and "B," the inductance of the choke coil, "L," should be at least 60 henrys and these coils should have a low resistance so as to prevent any great loss in voltage which would occur if the resistance was very high. A good unit should not cause a loss in voltage of more than 15 or 20 volts and this means that its d.c. resistance must not be greater than 750 ohms. The blocking condensers, "C," should have a capacity of from 2 to 4 mfd. The larger size theoretically gives somewhat better reproduction but practically little difference will be noticed with most loud speakers whichever size is used.

The arrangement shown at "A" has the advantage that, if the condenser breaks down, it will not result in any damage to the loud speaker because a breakdown in the condenser will merely cause the loud speaker to be shunted across the output choke "L" whereas, with arrangement "B," a breakdown of the condenser will cause the B battery to be short-circuited through the loud speaker and it is possible that the latter will be burned out. A disadvantage of arrangement "A" is that the a.c. current flowing through the loud speaker must flow through the B supply in order to return to the negative filament, and a comparatively small amount of resistance in the B supply will frequently cause a howl in the amplifier. In the arrangement shown in "B," the a.c. currents in the loud speaker return directly to the negative filament and do not have to traverse the B power unit; consequently, with this latter arrangement, there is less danger of oscillation in the audio amplifier.

In one particular case, during experiments in the



Laboratory, a resistance of 37 ohms in the B power unit, using circuit "A," produced continuous oscillations, whereas a resistance of 600 ohms was necessary in circuit "B" before oscillations were produced.

The arrangement at "C" shows an output transformer which is also a satisfactory method of coupling a loud speaker to a tube. It is essential, however, that the transformer be very carefully designed to prevent magnetic saturation because it must carry comparatively large direct current.

No. 114 RADIO BROADCAST Laboratory Information Sheet **August, 1927**

The Transmission Unit

DEFINITION

ANY electrical system having anything to do with the transmission of electrical energy which is finally to be changed into sound energy should have its performance rated in some manner which bears a relation to the sensitivity of the ear. Two audio amplifiers might give power outputs of 800 milliwatts and 1000 milliwatts, and it appears from these figures as though the second amplifier would be capable of giving a considerable increase in volume over that obtained from the first amplifier, but actually this would not be so; the difference between the two amplifiers could hardly be detected by the ear. Evidently it would be of advantage to express the relation between the power outputs of the two amplifiers by some unit which would indicate their relative value as measured by the ear. The telephone companies have worked out such a unit, known as the transmission unit, abbreviated "TU." It is possible for the ear to just distinguish the difference between two powers that differ in intensity by 1 TU.

The two powers mentioned above, 800 and 1000 milliwatts, are in the ratio of 1.25 to 1. The TU difference between these two powers is equal to ten times the natural logarithm of the ratio of the two powers:

$$\text{TU} = 10 \log_{10} \frac{P_1}{P_2}$$

The ratio in this case is 1.25 and the natural logarithm is 0.097, which, multiplied by ten, gives 0.97 TU. The minimum perceptible change in loudness is 1 TU and therefore the difference between the two amplifiers would not be audible.

The equation given in the preceding paragraph gives the TU when two powers, or their ratio, are known. If instead of powers we deal with voltages, E_1 and E_2, then the formula is:

$$\text{TU} = 20 \log_{10} \frac{E_1}{E_2}$$

When using currents, I_1 and I_2, the equation is:

$$\text{TU} = 20 \log_{10} \frac{I_1}{I_2}$$

The logarithm of the ratio of two voltages differing by 12 per cent., is 0.05, and 20 times this gives 1 TU. Therefore, if two audio transformers differ in amplification by 12 per cent., they will give equally good results because a 1 TU change is not audible to the ear.

The natural logarithm of numbers can be found by using a slide rule or they can be determined from tables of logarithms which are frequently found in the appendix of text books.

No. 115 RADIO BROADCAST Laboratory Information Sheet **August, 1927**

Wave Traps

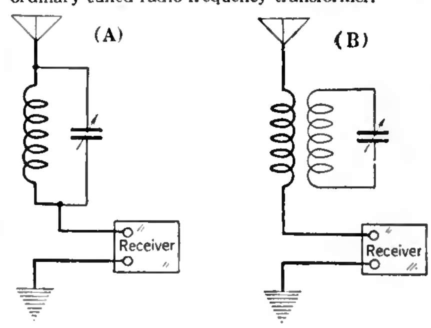
DIFFERENT TYPES

IN MANY cases where difficulty is experienced in eliminating the signals from a nearby powerful broadcasting station it will be found advantageous to use a wave trap in the antenna circuit.

A wave trap is a simple device consisting of a condenser and a coil, the latter with or without a primary, depending upon whether the circuit shown at "A" or "B" is used. In either case the wave trap should be tuned to the frequency of the interfering station. It then offers a very high impedance to the flow of currents of this frequency and in this way reduces their strength.

The circuit shown in "A" will give most complete elimination of undesired signals but has the disadvantage that it will also reduce somewhat the signals from other stations operating on frequencies adjacent to that of the station causing the interference. In cases of severe interference, however, the circuit shown at "A" must be used. The capacity of the variable condenser may be anything from 0.00025 mfd. to 0.001 mfd., and the coil must naturally contain sufficient turns so as to tune the circuit to the frequency of the interfering signals. There is no reason why a standard condenser and coil, designed for reception on the broadcast frequencies, cannot be used and it will then be possible to tune the trap to any frequency in the broadcast band.

The circuit shown at "B" tunes much sharper than the circuit shown at "A" but does not give complete elimination of the undesired signals. This circuit can be used with satisfaction when the interference is not very severe. The coil may be any ordinary tuned radio-frequency transformer.



No. 116 RADIO BROADCAST Laboratory Information Sheet **August, 1927**

Static

POSSIBILITIES OF ELIMINATION

NATURAL electrical disturbances occurring in the atmosphere are known as "static" or "strays" and frequently cause serious interference during the reception of signals. The subject "static" has been broken up into the following divisions by DeGroot in an article in *The Proceedings of the Institute of Radio Engineers.*

(A)—Loud and sudden clicks occurring intermittently. These do not seriously affect reception and apparently originate in nearby or distant lightning discharges.

(B)—A constant hissing noise giving the impression of softly falling rain or the noise of running water. This form usually occurs when there are low-lying clouds in the neighborhood of the receiving antenna.

(C)—A third form produces a constant rattling noise which sounds somewhat like the tumbling down of a brick wall!

These three forms can be considered as forms of natural static. The problem of the elimination of static is a difficult one upon which a great deal of work has been done and many different schemes have been devised, most of these schemes making use of two receiving antennas feeding a common receiver. The static signals present in the two antennas are made to balance out each other whereas the desired signals are not balanced out. In Morecroft's book, *Principles of Radio Communication,* it is suggested that one of the most promising lines for the development of a static eliminator has to do with a vacuum-tube detector which can only produce a limited response and therefore even with very heavy static the response cannot be more than the definite peak response of the tube.

Reception is also interfered with to a great extent in many localities by sounds produced by electrical apparatus, in which category can be classed the interference caused by various electrical motors and generators, x-ray apparatus, oil burners, precipitators, electrical transmission lines, etc. Their elimination is best accomplished at the source of the trouble by means of filter circuits such as those described in Laboratory Sheet No. 77, in the March, 1927, RADIO BROADCAST.

At the present time it appears that the best method to overcome natural static is to use a receiver in conjunction with a loop or a very short antenna, because with a loop or short antenna a high signal-to-static ratio can be obtained. Also, to prevent serious interference with broadcast programs, high power at the transmitting station is coming into more common use so that even under fairly bad conditions of static satisfactory reception can still be had.

No. 117 RADIO BROADCAST Laboratory Information Sheet **August, 1927**

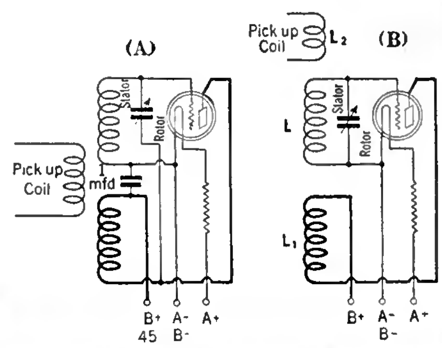
Super-Heterodynes

THE OSCILLATOR

IN A super-heterodyne receiver it is necessary to have one tube acting as an oscillator and functioning to produce radio-frequency energy which, in combination with the incoming signals, will produce a third frequency capable of being amplified by the intermediate frequency amplifier. The amplitude of the locally generated oscillations, in comparison with the incoming signals, has a very definite effect upon the strength of the signal which is finally detected and some care should therefore be taken in adjusting the circuit for most efficient operation, *i.e.*, loudest signals.

In sketch "A" is given the circuit used, probably, in a majority of super-heterodynes. It has the disadvantage that both sides of the variable condenser are at high potential and therefore some hand-capacity effects will be experienced.

In sketch "B" is shown an oscillatory circuit which is not open to the disadvantage of circuit "A" and is capable of giving just as good results in actual practice. In this circuit the rotor plates of the variable condenser connect to the low-potential side of the grid coil instead of across the entire coil. The "low" end of the grid coil connects to the filament and is therefore at ground potential and consequently there is no hand capacity. If a 0.0005-mfd. variable condenser is used, then coil "L" should contain 52 turns of No. 24 wire on a 2¼" tube; for a 0.00035-mfd. condenser the number of turns should be 65. L_1, the plate coil, should consist, in either case, of 60 turns of No. 28 wire wound on the same tube and spaced from the coil "L" by ¼". L_2 is the pick-up coil which should be connected in the circuit of the first detector tube; it should consist of 10 turns of No. 28 wire preferably wound on a tube slightly larger than 2¼" so that it can slide over the other form and the coupling be varied in this way. Either a 201-A or 199 type tube may be used in the oscillator without changing the coil constants.



No. 118 RADIO BROADCAST Laboratory Information Sheet August, 1927

Audio Amplifiers

FREQUENCY AND LOAD CHARACTERISTICS

ANY audio amplifying system has two characteristics, equally important, which determine how well it will function. They are generally known as the frequency characteristic and the load characteristic.

The frequency characteristic indicates the relative amplification of the amplifying system of various frequencies between the limits over which the amplifier is to be operated. The frequency characteristic is generally shown in the form of a curve and, of course, a flat curve indicates equal amplification at all frequencies. Slight rises and depressions in the curve in the order of 10 per cent. can be neglected because they are too slight to be noticeable to the ear.

The load characteristic of an amplifier, while not in such common use, is just as important as the frequency characteristic. The load characteristic will show how the total amplification of the system varies with different input voltages at a constant frequency generally of about 1000 cycles. If the amplifier is a good one the amplification will remain constant over the entire range of input voltages at which the amplifier would normally be worked. If a two-stage amplifier is operated with a 201-A type tube in the output with 90 volts on the plate, it will overload very quickly because a 201-A cannot deliver much power. Consequently, the load characteristic curve of such an amplifier would begin to fall off comparatively quickly, but if a 171 tube with the proper voltages were to be used in place of the 201-A, then the load characteristic would indicate that it was possible to obtain much more power from the amplifier without overloading it.

Both of these characteristics depend upon the type of tubes used and the voltages with which they are supplied, and upon the design of the coupling devices connecting the output of one tube to the input of the next. Frequency and load characteristics can be taken on any part of the complete amplifier but such curves may have very little in common with the characteristics of the complete system. Consequently, although curves on individual units are useful in designing an amplifier, curves on the completed system should always be made to make certain that some factor, such as common coupling in the batteries, is not seriously altering the overall characteristic.

No. 119 RADIO BROADCAST Laboratory Information Sheet August, 1927

Radio-Frequency Choke Coils

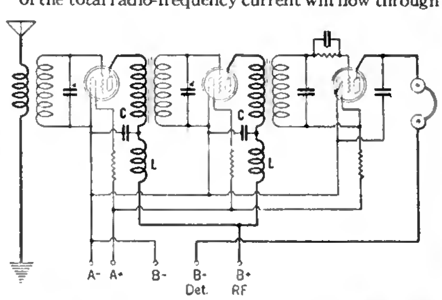
THEIR PLACE IN CIRCUIT

IF A very high-gain radio-frequency amplifier is to be constructed, it is essential that radio-frequency choke coils be used in the amplifier to prevent it from oscillating. Neutralization will prevent the production of oscillations due to feed-back through the tube but will not prevent the production of oscillations due to coupling in the battery leads or in a B socket-power device. To prevent instability due to these effects it is necessary that choke coils, L, and bypass condensers, C, be used in the plate circuits of the radio-frequency tubes, as indicated in the diagram on this Sheet. These choke coils offer a very high impedance to the flow of radio-frequency currents and all these currents therefore flow through the bypass condenser connected between the choke coil and the negative filament, instead of through the plate battery.

What size choke and what size condenser should be used? To keep down the cost they should both be as small as possible whereas their effectiveness becomes greater as their size is made larger.

The plate impedance of a 201-A type tube is about 12,000 ohms and it is essential that the condenser which is incorporated to bypass the r.f. currents does not introduce in the plate circuit any great amount of impedance. A 0.003-mfd. condenser will increase the total circuit impedance from 12,000 to about 12,120 ohms, a negligible amount. This value is correct at 500 kilocycles, the lowest frequency used in broadcasting, and at higher broadcast frequencies the effect of the condenser will be even less.

The choke coil's impedance must be large in comparison with that of the condenser so as to cause practically all the current to flow through the condenser and not through the choke. If the choke coil's impedance is made 1000 times greater than that of the condenser only one-tenth of one per cent. of the total radio-frequency current will flow through



the choke coil and therefore good filtering action will be obtained. If the choke coil's impedance at 500 kilocycles is to be 1000 times greater than the impedance of the condenser then it must be 12,000 ohms. The inductance of a choke coil with an impedance of 12,000 ohms at 500 kilocycles is 38 millihenrys. Most radio-frequency choke coils have an inductance of much more than this.

No. 120 RADIO BROADCAST Laboratory Information Sheet August, 1927

A-Battery Chargers

TRICKLE VERSUS HIGH-RATE CHARGERS

THERE are many different types of A-battery chargers now available; some of them are satisfactory for use as trickle chargers and others only efficient when used to charge the battery at comparatively high rates of charge. The charger employing an electrolytic type of rectifier, for example, is very well adapted for use in trickle charging. It is very efficient, requires little attention, and has long life.

Another very satisfactory type of rectifier for a trickle charger is the so-called dry crystal, which was developed rather recently. A third type of rectifier that can be used for trickle charging is the Tungar but it is not especially efficient as a trickle charger, because of the comparatively large amount of power required to heat its filament.

There are three types of rectifiers that are satisfactory for use in high-rate charging. They are the Tungar, the Vibrator type, and the new cartridge recently developed by Raytheon. All of these chargers are capable of delivering fairly large amounts of rectified current for charging a battery and are fairly efficient when delivering these currents.

There is little to be said regarding the comparative efficiency of the two methods of charging. Trickle charging has the advantage that it requires somewhat less attention than does high-rate charging but it has the disadvantage that it is somewhat difficult to determine just what the best rate of trickle charge should be in order to prevent the battery from being overcharged or undercharged; also slow rates of charge used in trickle chargers are hard on a battery. With a trickle charger, a low-capacity storage battery can be used because it is not called upon to supply any great amount of current for a long period of time.

With high-rate charging, on the other hand, it is usual to charge the battery every one or two weeks and also a fairly large storage battery is necessary in order that it will have sufficient capacity to supply the receiver between charges. It seems to be generally agreed among battery manufacturers, however, that the high charging rate is somewhat better for the battery in that it makes possible longer life. For best results the charging rate should gradually taper off as the battery becomes charged.

Manufacturers' Booklets

A Varied List of Books Pertaining to Radio and Allied Subjects Obtainable Free With the Accompanying Coupon

READERS may obtain any of the booklets listed below by using the coupon printed on page 255 Order by number only.

1. Filament Control—Problems of filament supply, voltage regulation, and effect on various circuits. Radiall Company.

2. Hard Rubber Panels—Characteristics and properties of hard rubber as used in radio, with suggestions on how to "work" it. B. F. Goodrich Rubber Company.

3. Transformers—A booklet giving data on input and output transformers. Pacent Electric Company.

4. Resistance-Coupled Amplifiers—A general discussion of resistance coupling with curves and circuit diagrams. Cole Radio Manufacturing Company.

5. Carborundum in Radio—A book giving pertinent data on the crystal as used for detection, with hook-ups, and a section giving information on the use of resistors. The Carborundum Company.

6. B-Eliminator Construction—Constructional data on how to build. American Electric Company.

7. Transformer and Choke-Coupled Amplification—Circuit diagrams and discussion. All-American Radio Corporation.

8. Resistance Units—A data sheet of resistance units and their application. Ward-Leonard Electric Company.

9. Volume Control—A leaflet showing circuits for distortionless control of volume. Central Radio Laboratories.

10. Variable Resistance—As used in various circuits. Central Radio Laboratories.

11. Resistance Coupling—Resistors and their application to audio amplification, with circuit diagrams. DeJur Products Company.

12. Distortion and What Causes It—Hook-ups of resistance-coupled amplifiers with standard circuits. Allen-Bradley Company.

15. B-Eliminator and Power Amplifier—Instructions for assembly and operation using Raytheon tube. General Radio Company.

15a. B-Eliminator and Power Amplifier—Instructions for assembly and operation using an R. C. A. rectifier. General Radio Company.

16. Variable Condensers—A description of the functions and characteristics of variable condensers with curves and specifications for their application to complete receivers. Allen D. Cardwell Manufacturing Company.

17. Bakelite—A description of various uses of bakelite in radio, its manufacture, and its properties. Bakelite Corporation.

19. Power Supply—A discussion on power supply with particular reference to lamp-socket operation. Theory and constructional data for building power supply devices. Acme Apparatus Company.

20. Audio Amplification—A booklet containing data on audio amplification together with hints for the constructor. All American Radio Corporation.

21. High-Frequency Driver and Short-Wave Wavemeter—Constructional data and application. Burgess Battery Company.

46. Audio-Frequency Chokes—A pamphlet showing positions in the circuit where audio-frequency chokes may be used. Samson Electric Company.

47. Radio-Frequency Chokes—Circuit diagrams illustrating the use of chokes to keep out radio-frequency currents from definite points. Samson Electric Company.

48. Transformer and Impedance Data—Tables giving the mechanical and electrical characteristics of transformers and impedances, together with a short description of their use in the circuit. Samson Electric Company.

49. Bypass Condensers—A description of the manufacture of bypass and filter condensers. Leslie F. Muter Company.

50. Audio Manual—Fifty questions which are often asked regarding audio amplification, and their answers. Amertran Sales Company, Incorporated.

51. Short-Wave Receiver—Constructional data on a receiver which, by the substitution of various coils, may be made to tune from a frequency of 16,660 kc. (18 meters) to 1999 kc. (150 meters). Silver-Marshall, Incorporated.

52. Audio Quality—A booklet dealing with audio-frequency amplification of various kinds and the application to well-known circuits. Silver-Marshall, Incorporated.

56. Variable Condensers—A bulletin giving an analysis of various condensers together with their characteristics. General Radio Company.

57. Filter Data—Facts about the filtering of direct current supplied by means of motor-generator outfits used with transmitters. Electric Specialty Company.

59. Resistance Coupling—A booklet giving some general information on the subject of radio and the application of resistors to a circuit. Daven Radio Corporation.

60. Resistors—A pamphlet giving some technical data on resistors which are capable of dissipating considerable energy; also data on the ordinary resistors used in resistance-coupled amplification. The Crescent Radio Supply Company.

62. Radio-Frequency Amplification—Constructional details of a five-tube receiver using a special design of radio-frequency transformer. Camfield Radio Mfg. Company.

63. Five-Tube Receiver—Constructional data on building a receiver. Aero Products, Incorporated.

64. Amplification Without Distortion—Data and curves illustrating the use of various methods of amplification. Acme Apparatus Company.

66. Super-Heterodyne—Constructional details of a seven-tube set. G. C. Evans Company.

70. Improving the Audio Amplifier—Data on the characteristics of audio transformers, with a circuit diagram showing where chokes, resistors, and condensers can be used. American Transformer Company.

72. Plate Supply System—A wiring diagram and layout plan for a plate supply system to be used with a power amplifier. Complete directions for wiring are given. Amertran Sales Company.

80. Five-Tube Receiver—Data are given for the construction of a five-tube tuned radio-frequency receiver. Complete instructions, list of parts, circuit diagram, and template are given. All-American Radio Corporation.

81. Better Tuning—A booklet giving much general information on the subject of radio reception with specific illustrations. Primarily for the non-technical home constructor. Bremer-Tully Manufacturing Company.

82. Six-Tube Receiver—A booklet containing photographs, instructions, and diagrams for building a six-tube shielded receiver. Silver-Marshall, Incorporated.

83. Socket Power Device—A list of parts, diagrams, and templates for the construction and assembly of socket power devices. Jefferson Electric Manufacturing Company.

84. Five-Tube Equamatic—Panel layout, circuit diagrams, and instructions for building a five-tube receiver, together with data on the operation of tuned radio-frequency transformers of special design. Karas Electric Company.

85. Filter—Data on a high-capacity electrolytic condenser used in filter circuits in connection with A socket power supply units, are given in a pamphlet. The Abox Company.

86. Short-Wave Receiver—A booklet containing data on a short-wave receiver as constructed for experimental purposes. The Allen D. Cardwell Manufacturing Corporation.

88. Super-Heterodyne Construction—A booklet giving full instructions, together with a blue print and necessary data, for building an eight-tube receiver. The George W. Walker Company.

89. Short-Wave Transmitter—Data and blue prints are given on the construction of a short-wave transmitter, together with operating instructions, methods of keying, and other pertinent data. Radio Engineering Laboratories.

90. Impedance Amplification—The theory and practice of a special type of dual-impedance audio amplification are given. Aloen Manufacturing Company.

93. B-Socket Power—A booklet giving constructional details of a socket-power device using either the BH or 313 type rectifier. National Company, Incorporated.

94 Power Amplifier—Constructional data and wiring diagrams of a power amplifier combined with a B-supply unit are given. National Company, Incorporated.

100. A, B, and C Socket-Power Supply—A booklet giving data on the construction and operation of a socket-power supply using the new high-current rectifier tube. The Q. R. S. Music Company.

101. Using Chokes—A folder with circuit diagrams of the more popular circuits showing where choke coils may be placed to produce better results. Samson Electric Company

Accessories

22. A Primer of Electricity—Fundamentals of electricity with special reference to the application of dry cells to radio and other uses. Constructional data on buzzers, automatic switches, alarms, etc. National Carbon Company.

23. Automatic Relay Connections—A data sheet showing how a relay may be used to control A and B circuits. Yaxley Manufacturing Company.

25. Electrolytic Rectifier—Technical data on a new type of rectifier with operating curves. Kodel Radio Corporation.

26. Dry Cells for Transmitters—Actual tests given, well illustrated with curves showing exactly what may be expected of this type of B power. Burgess Battery Company.

27. Dry-Cell Battery Capacities for Radio Transmitters—Characteristic curves and data on discharge tests. Burgess Battery Company.

28. B Battery Life—Battery life curves with general curves on tube characteristics. Burgess Battery Company.

29. How to Make Your Set Work Better—A non-technical discussion of general radio subjects with hints on how reception may be bettered by using the right tubes. United Radio and Electric Corporation.

30. Tube Characteristics—A data sheet giving constants of tubes. C. E. Manufacturing Company.

31. Functions of the Loud Speaker—A short, non-technical general article on loud speakers. Amplion Corporation of America.

32. Meters for Radio—A catalogue of meters used in radio, with connecting diagrams. Burton-Rogers Company.

33. Switchboard and Portable Meters—A booklet giving dimensions, specifications, and shunts used with various meters. Burton-Rogers Company.

34. Cost of B Batteries—An interesting discussion of the relative merits of various sources of B supply. Hartford Battery Manufacturing Company.

35. Storage Battery Operation—An illustrated booklet on the care and operation of the storage battery. General Lead Batteries Company.

36. Charging A and B Batteries—Various ways of connecting up batteries for charging purposes. Westinghouse Union Battery Company.

37. Choosing the Right Radio Battery—Advice on what dry cell battery to use; their application to radio, with wiring diagrams. National Carbon Company.

53. Tube Reactivator—Information on the care of vacuum tubes, with notes on how and when they should be reactivated. The Sterling Manufacturing Company.

54. Arresters—Mechanical details and principles of the vacuum type of arrester. National Electric Specialty Company.

55. Capacity Connector—Description of a new device for connecting up the various parts of a receiving set, and at the same time providing bypass condensers between the leads. Kurz-Kasch Company.

(Continued on page 253)

"RADIO BROADCAST'S" DIRECTORY OF MANUFACTURED RECEIVERS

¶ With this issue of Radio Broadcast, we start a comprehensive listing of manufactured receivers. The listing below will appear regularly in this place, corrected to the day we go to press. The Manufactured Set Directory is an additional service to our readers and takes its place with the "Manufacturers' Booklets" section and the "What Kit Shall I Buy?" department, both of which are already very popular. With these three regular features of Radio Broadcast, the reader can survey the entire field and, with little trouble, secure the information he wants.

A coupon will be found on page 255. All readers who desire additional information on the receivers listed below need only insert the proper numbers in the coupon, mail it to the Service Department of Radio Broadcast, and full details will be sent.

Key Letters

Ant.—Antenna
r—Radio frequency stage
d—Detector
a—Audio frequency stage
t—Transformer coupled
res.—Resistance
i—Impedance coupled
o—Oscillator
O—Output device
C—C-battery connections
Ca—Cable connections
Bp—Binding posts
M—Meter (instrument)
Sh.—Shielded
H—Headphone connection included
pp—Push pull

KEY TO ABBREVIATIONS

m—Meters (wavelength)
TRF—Tuned radio frequency
URF—Untuned radio frequency
Super—Super-heterodyne
Ne—Neutrodyne
bal.—Some means of neutralization
gr—Grid resistances
Br—Bridge neutralization
reg.—Regenerative
int.—Intermediate amplifier
r.f.—Radio frequency
rheo.—Rheostat
mod.—Modulator
pot.—Potentiometer
w—Watts
Wt—Weight in lbs.

Tubes

99—60-mA. filament (dry cell)
01A—Storage battery 0.25 amps. filament
12—Power tube (Storage battery)
71—Power tube (Storage battery)
16B—Half-wave rect. tube
AC—Using a.c. (heater type)
Hmu—High Mu tube for resistance-coupled audio
R—A gaseous rectifier tube
20—Power tube (dry cell)
Tun—Tungar rectifier
MV—Multivalve (several elements in one bulb)
10—Power Tube
00A—Special detector
13—Full-wave rectifier tube
2A—Tungar rectifier

Socket-Power Receivers for Use with 110–120 Volts 60-Cycle A.C.

No. Model	Price	Accessories Included	Cabinet Size	No. Dials	Vol. Cont.	No. Tubes	Type Tubes	Cur. Req. Watts	Circuit	Remarks
401. Amrad AC9	142	power unit	27 x 9 x $11\frac{3}{4}$	2	res. on 1st a	3r, d, 2at (6)	5–99, 1–12. 2–16B	50w	TRF Ne.	Series fil. power unit separate. A, B, and C, supplied
402. Amrad AC5	125	power unit	27 x 9 x $11\frac{3}{4}$	2	res. on 1st a	2r, d, 2at (5)	4–99, 1–12. 2–16B	50w	TRF Ne.	Same as above
403. Argus 250B	250	none	$35\frac{1}{8}$ x $14\frac{5}{8}$ x $10\frac{3}{4}$	2	res. on 1st a	3r, d, 2at (6)	5–99, 1–10. 2–16B	100w	TRF gr	2TRF stages, and 1 untuned stage. Series fil. O. Self contained power unit
404. Argus 375B	375	none	console	2	res. on 1st a	3r, d, 2a. (6)	5–99, 1–10. 2–16B	100w	TRF gr	See above
405. Argus 125B	125	none		2	fil. rheo.	3r, d, 2at (6)	5–99, 1–12. 2–16B	60w	TRF gr	See above
406. Cleartone 110	175 to 375	5 a.c. tubes 1 Rectifier	various sizes	1-2	res.	2r, d, 2at (5)	5–AC. 1–Rectifier	40w	TRF	Built in plate supply. A. C. tubes
407. Colonial 25	250	none	34 x 38 x 18	1-3	ant. sw. and a pot.	2r, d, 2ares., 1at (6)	2–01A, 3–99, 1–10. 2–16B	100w	TRF bal.	Built in A, B, and C power unit
408. Day-Fan De Luxe	350	complete less tubes	30 x 40 x 20	1	pot. across r.f. tubes	3r, d, 2at (6)	6–01A	300w	TRF	Motor Generator supplies d.c. for plate and fil. O
409. Daycraft 5	170	complete less tubes	34 x 36 x 14	1	pot. in plate of r.f. and a	3r, d, 2at (5)	5–AC	135w	TRF	Reflexed. AC tubes. Built in plate rect.
410. Larcoflex 73	215	none	30 x 42 x 20	1	res. in r.f. plate	4r, d, 2at (7)	6–01A, 1–71		TRF	Sh.
411. Herbert Lectro 120	120	none	32 x 10 x 12	3	rheo in pri. of a.c. trans.	2r, d, 2at (5)	4–99, 1–71. 1–R	45w	TRF	Series fil.
412. Herbert Lectro 200	200	none	20 x 12 x 12	1	rheo. in pri. of a.c. trans	2r, d, 1at, pp. (6)	4–99, 2–71. 1–R	60w	TRF	Series fil. Sh. O. Push-pull.
413. Marti Table 414. Marti Console 415. Marti Console	235 275 325	6–AC tubes and rectifier. Loud speaker with No. 415	7 x 21 panel	2	res. in r.f. plate	2r, d, 3ares. (6)	6–AC. 1–16B	38w	TRF	AC tubes. Built-in plate supply
416. Nassau Power		none	28 x 45 x 18	2	res. in r.f. plate	2r, d, 3a (6)	5–99, 1–10. 1–16B		TRF Br.	Series fil. M, O.
417. R.C.A. 28	540	all tubes 104 Speaker	$26\frac{1}{2}$ x 63 x 17	1	pot.	2d, o, 2at, 3i (8)	7–99, 1–10. 2–16B, 1–874, 1–876		Super	Model 28 may also be obtained without power units. Loop antenna.
418. Receptrad Super-power A. C. Console	390	power unit loud speaker	28 x 50 x 21	2	r.f. res.	(5)	5–01A. 2–2A	90w	Multi-flex	Loop or outside antenna
419. Superpower AC Cabinet	180	power unit	27 x 10 x 9	2	r.f. res.	(5)	5–01A. 2–2A	90w	Multi-flex, Reg.	See above
420. Simplex B	250	complete	34 x 36 x 14	1	res. in r.f. plate	(6)	6–AC		TRF	H
421. Soverign 238	325	7–AC tubes	37 x 52 x 15	2	res. on 2nd. a	(7)	7–AC	45w	TRF bal.	Uses AC tubes run by small trans. Gas rect. for plate
422. Supervox, Jr.	275	complete	28 x 30 x 16	1	ant. coup. and res. in r.f. plate	1r, d, 2at (4)	3–AC, 1–71. 1–16B	40w	TRF	AC tubes, 71 on a.c. O. Sh. d
423. Supervox, Sr.	450	complete	28 x 30 x 16	2	ant. coup. and res. in r.f. plate	2r, d, 2at (5)	4–AC, 1–10. 1–16B	60w	TRF	Sh. O.
469. Freed-Eisemann NR 11	225	NR-411 power unit	$19\frac{3}{4}$ x 10 x $10\frac{1}{2}$	1	pot.	3r, d, 2at (6)	5–01A, 1–71. 1–R	150w	TRF Ne.	Sh. O.

STANDARD RECEIVERS

No.	Model	Price	Accessories Included	Cabinet Size	No. Dials	Vol. Cont.	No. Tubes	Type Tubes	Plate Cur. mA	Circuit	Ant. Length Ft.	Remarks
428.	AMERICAN C6 TABLE CONSOLE	30 65	none Spkr.	20 x 8½ x 10 36 x 40 x 17	3	pot.	2r, d, 2at (5)	5–01A	15	TRF semi-bal.	125	Partially Sh. C, Ca.
429.	KING COLE VII	80–160	none	varies	2	r. f. pri. shunt	3r, d, lai, la res., lat (7)	7–01A	15–45	TRF	10–100	Steel Sh. O on some consoles. C, Ca, and Bp.
430.	KING COLE VIII	100–300	none	varies	1	r. f. pri. shunt	4r, d, lai, la res., lat (8)	8–01A	20–50	TRF	10–100	See above
434.	DAY-FAN 6 DAYCRAFT 6 DAY-FAN JR.	110 145 —	none Spkr. —	— 32 x 30 x 34 15 x 7 x 7	1	fil.	3r, d, 2at (6)	5–01A, 1–12 or 71	12–15	TRF	50–120	Ca, C, Sh, O
435.	DAY-FAN 7		none		1	fil.	3r, d, la res, 2at (7)	6–01A, 1–12 or 71	15	TRF	50–120	Ca, C, Sh, O .
436.	FEDERAL	250–1000	Loop	varies	1	rheo.	2r, d, 2at (5)	4–01A, 1–12 or 71	20.7	TRF bal.	Loop	Ca, C, Sh. Made in 6 models.
437.	FERGUSON 10A	150	none	21½ x 12 x 15	1	rheo. 2r.f.	3r, d, 3a (7)	6–01A, 1–12 or 71	18–25	TRF	100	C; Ca, Sh.
438.	FERGUSON 14	235	Loop	24 x 12 x 16	2	rheo. 3r.f.	6r, d, 3a (10)	9–01A, 1–12 or 71	30–35	TRF	Loop	C, Ca, Sh. Special bal.
439.	FERGUSON 12	85 145	none Spkr.	22½ x 10 x 12	1	rheo. 2 r.f.	2r, d, lat, 2a res., (6)	5–01A, 1–12 or 71	18–25	TRF	100	Ca, C. Partly Sh.
440.	FREED-EISEMANN NR8 NR9 NR66	90 100 125	none none none	19¾ x 10 x 10½ 19¾ x 10 x 10½ 20 x 10 x 12	2 1 1	rheo. r.f.	3r, d, 2at (6)	5–01A, 1–71	30	TRF Ne.	100	Ca. NR8 and 9 chassis type Sh. NR66 individual stage Sh.
441.	FREED-EISEMANN NR77	175	none	23 x 10½ x 13	1	rheo. r.f.	4r, d, 2at (7)	6–01A, 1–71	35	TRF Ne.	Ant. or loop	Ca, C, Sh.
442.	FREED-EISEMANN 800 850		none none	31 x 15½ x 13½ 36 x 65½ x 17½	1	rheo. r.f.	4r, d, 2at (8)	6–01A, 1–71 or 2–01A	35	TRF Ne.	Ant or loop	Ca, C, Sh. Output stage 2 tubes par. or 1 power tube. O
443.	GREBE CR18 (Short-Wave)	100	Set coils	6 x 7½ x 7	2	rheo.	d, lat (2)	2–01A	8	3 cir. reg.	100	Wavelength range 8–210 m.
444.	GREBE MUI	155–320	none	22½ x 9½ x 13	1–2–3	rheo. r.f.	2r, d, 2at (5)	4–01A, 1–12 or 71	30	TRF bal.	125	Bp, C, binocular coils. dials op. singly or together
445.	HARMONIC R	75	none	26 x 9 x 9	3	rheo. r.f.	1r, d, 2at (4)	4–01A		TRF reg. d	100	H, C, Bp.
446.	HARMONIC S	100	none	26 x 9 x 9	3	rheo. r.f.	1r, d, 3a res. (5)	5–01A		TRF reg. d	100	H, C, Bp.
447.	LEUTZ TRANS-OCEANIC	150	none	27 x 8½ x 13 1/16	1–5	special	4r, d, lat, 3a res. (9)	5–01A, 1–00A, 2–1Hmu, 1–71 or 10	20–40	TRF gr	Ant. or Loop	Range 35–3600 m M. Sh. C. Bp. O
448.	LEUTZ SILVER GHOST		none	72 x 12 x 20	1–5	special	4r, d, lat, 3a res. (9)	See above	20–40	TRF gr	Ant. or loop	See above
449.	NORBERT MIDGET	12	1–MV	12 x 8 x 9	2	rheo.	d, 2at, (1)	1–MV	3	TRF	75–150	C, Bp.
450.	NORBERT 2	40.50	1–MV 1–01A	20 x 7 x 5½	2	special	1r, d, 2at (2)	1–MV 1–01A	8	TRF	50–100	C, Bp
451.	NORCO 66 CONSOLE	130 250	none Speaker	18½ x 8½ x 13¾	1–3	mod. a.f.	2r, d, 3ai (6)	5–01A 1–71	20	TRF	70–90	Sh, C, Ca, O. Drum control
452.	ORIOLE 90	85	none	25½ x 11½ x 12½	2	rheo. r.f.	2r, d, 2at (5)	5–01A	13	Trinum	50–100	Ca, C
470.	ORIOLE	185	none	25½ x 11½ x 12½	1	rheo. r. f.	(8)	8–01A	25	Trinum	50–100	Ca, C, Sh
453.	PARAGON		none	20 x 46 x 17	1	res. r.f. plate	(6)	5–01A, 1–71	40	TRF	100	Double imp. Audio C. Ca, Sh
454.	PARAMOUNT V VI	65 75	none none	26 x 7 —			(5) (6)	5–01A 6–01A		TRF	100	Bp, C.
455.	PREMIER 6-IN-LINE	60–150	none	25 x 45 x 16	1–2	rheo. r.f.	3r, d, 2at (6)	4–01A, 1–00A, 1–12	16–18	TRF	100 loop	Ca, C.
456.	RADIOLA 20	115	5 tubes	19½ x 11¾ x 16	2	reg.	2r, d, 2at (5)	4–99, 1–20		TRF reg.d	75–150	C, H.
457.	RADIOLA 25	165	6 tubes	28 x 37 x 19	1	pot.	o, 2d, 3int. 2at (6)	5–99, 1–20		Super	Loop	Reflexed, C, H.
458.	RADIOLA 28	260	8 tubes	26½ x 63 x 17	1	pot.	o, 2d, 3int, 2at (8)	7–99, 1–20		Super	Loop	C, H.
459.	STROMBERG CARLSON No. 501 502	180 290	none none	25½ x 13 x 14 28⅞ x 50 7/8 x 16¾	2	rheo. r.f.	2r, d, 2at (5)	3–01A, 1–00A, 1–71	25–35	TRF Ne.	60–100	Ca, C, Sh, O, M, H.
460.	STROMBERG CARLSON No. 601 602	225 330	none none	27 x 16¾ x 14 3/16 28¾ x 51½ x 19½	2	rheo. r.f.	3r,d, 2at (6)	4–01A, 1–00A, 1–71	30–40	TRF Ne.	20–60	Ca, C, Sh, O, M, H.
461.	SUN	80	none	23 x 10 x 10	2	res. r.f. plate	2r, d, 2at (5)	5–01A		TRF	100	Bp.
462.	CUSTOM BUILT 7	275	com.	7 x 21 panel	2	special	(7)	5–01A, 1–00A, 1–71	40	TRF	100	Bp. C, O. Built in A and B power

(Continued on page 252)

No. Model	Price	Accessories Included	Cabinet Size	No. Dials	Vol. Cont.	No. Tubes	Type Tubes	Cur. mA.	Circuit.	Ant. Length Ft.	Remarks
463. CUSTOM BUILT 9	375	com.	7 x 21 panel	2	Mod.	(9)	8–01A, 1–71	40		Loop	See No. 462
464. WRIGHT VII	160	none	25 x 15 x 17½	2	res. r.f. plate	3r, d, 3ai (7)	6–99, 1–20	17¼	TRF	80	Ca, C, O. Na-Ald Amp.
471. VOLTONE XX	50	none	20½ x 8 x 12	2	rheo.	1r, d, 3a res. (5)	1–01A, 1–00A, 2–HMu, 1–71	18	TRF	100	Ca, C, O, Reg
472. VOLTONE VIII	140	none	26½ x 8 x 12	3	rheo.	2r, d, 3a res. (6)	4–01A, 1–00A, 1–71	20	TRF	100	Ca, C, O, Reg
473. PRMCO 105	45	none	18 x 7 panel	3	rheo. r. f.	2r, d, 2at, la res. (6)	6–01A		TRF	100	Ca.
474. PRMCO 110	80	none	18 x 7 panel	1	rheo. r.f.	2r, d, 2at, la res. (6)	6–01A		TRF	100	Ca, C. Drum tuning cont.
475. PENN-C 5	150	none	24 x 10 x 15	3	pot.	(5)	5–01A	15		75	Bp, C, Console
476. PENN-C 6	95–165	none	24 x 10 x 15	1	pot.	(6)	5–01A, 1–00A	15		75	Bp, C.
477. DAVEN BASS NOTE	150	none	23½ x 12 x 16	2	pot.	2r, d, 3a res. (6)	2–01A, 3–HMu, 1–Power	17	TRF	50–100	Ca, C.
478. ZIMPHONIC TABLE CONSOLE	90 125	none none	— 20 x 40 x 15	1	res.	2rd, d 3a (6)	4–01A, 1–00A, 1–12		TRF	100	H, Ca, C, Sh, reg.
479. ZIMPHONIC TABLE CONSOLE	140 175	none none	— 20 x 40 x 15	1	rheo.	3r, d, 3a (7)	5–01A, 1–00A, 1–12	24	TRF	75	H, Ca, C, Sh, reg.
480. PFANSTIEHL CABINET 30 CONSOLE 302	99.50 165	none Spkr.	17¾ x 8½ panel	1	res. plate r.f.	3r, d, 2at (6)	5–01A, 1–12 or 1–71	26–32	TRF	Ant.	Ca, C, Sh.
481. PFANSTIEHL CABINET 32 CONSOLE 322	135 225	none Spkr.	17¾ x 8½ panel	1	res. plate r.f.	3r, d, 3a (7)	6–01A, 1–12 or 1–71	23–32	TRF	Ant.	Ca, C, O, Sh.
482. STEWART-WARNER TABLE 705 CONSOLE 710	Tentative 115 265	none Spkr.	26⅛ x 11¼ x 13 13/16 29¾ x 42 x 17⅛	2	res. plate r.f.	3r, d, 2at (6)	6–01A	10–25	TRF. bal.	80	Ca, C, Sh.
483. STEWART-WARNER TABLE 525 CONSOLE 520	Tentative 75 117.50	none Spkr.	19¾ x 10 x 11⅞ 22⅛ x 40 x 14 11/16	2	res. plate r.f.	3r, d, 2at (6)	6–01A	24	TRF	80	Ca, C.

68. CHEMICAL RECTIFIER—Details of assembly, with wiring diagrams, showing how to use a chemical rectifier for charging batteries. CLEVELAND ENGINEERING LABORATORIES COMPANY.

69. VACUUM TUBES—A booklet giving the characteristics of the various tube types with a short description of where they may be used in the circuit. RADIO CORPORATION OF AMERICA.

77. TUBES—A booklet for the beginner who is interested in vacuum tubes. A non-technical consideration of the various elements in the tube as well as their position in the receiver. CLEARTRON VACUUM TUBE COMPANY.

87. TUBE TESTER—A complete description of how to build and how to operate a tube tester. BURTON-ROGERS COMPANY.

91. VACUUM TUBES—A booklet giving the characteristics and uses of various types of tubes. This booklet may be obtained in English, Spanish, or Portuguese. DEFOREST RADIO COMPANY.

92. RESISTORS FOR A. C. OPERATED RECEIVERS—A booklet giving circuit suggestions for building a. c. operated receivers, together with a diagram of the circuit used with the new 400-millampere rectifier tube. CARTER RADIO COMPANY.

97. HIGH-RESISTANCE VOLTMETERS—A folder giving information on how to use a high-resistance voltmeter, special consideration being given the voltage measurement of socket-power devices. WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY.

MISCELLANEOUS

38. LOG SHEET—A list of broadcasting stations with columns for marking down dial settings. U. S. L. RADIO, INCORPORATED.

41. BABY RADIO TRANSMITTER OF 9XH-9EK—Description and circuit diagrams of dry-cell operated transmitter. BURGESS BATTERY COMPANY.

42. ARCTIC RADIO EQUIPMENT—Description and circuit details of short-wave receiver and transmitter used in Arctic exploration. BURGESS BATTERY COMPANY.

43. SHORT-WAVE RECEIVER OF 9XH-9EK—Complete directions for assembly and operation of the receiver. BURGESS BATTERY COMPANY.

44. ALUMINUM FOR RADIO—A booklet containing much radio information with hook-ups of basic circuits, with inductance-capacity tables and other pertinent data. ALUMINUM COMPANY OF AMERICA.

45. SHIELDING—A discussion of the application of shielding in radio circuits with special data on aluminum shields. ALUMINUM COMPANY OF AMERICA.

58. HOW TO SELECT A RECEIVER—A commonsense booklet describing what a radio set is, and what you should expect from it, in language that any one can understand. DAY-FAN ELECTRIC COMPANY.

67. WEATHER FOR RADIO—A very interesting booklet on the relationship between weather and radio reception, with maps and data on forecasting the probable results. TAYLOR INSTRUMENT COMPANIES.

73. RADIO SIMPLIFIED—A non-technical booklet giving pertinent data on various radio subjects. Of especial interest to the beginner and set owner. CROSLEY RADIO CORPORATION.

74. THE EXPERIMENTER—A monthly publication which gives technical facts, valuable tables, and pertinent information on various radio subjects. Interesting to the experimenter and to the technical radio man. GENERAL RADIO COMPANY.

75. FOR THE LISTENER—General suggestions for the selecting, and the care of radio receivers. VALLEY ELECTRIC COMPANY.

76. RADIO INSTRUMENTS—A description of various meters used in radio and electrical circuits together with a short discussion of their uses. JEWELL ELECTRICAL INSTRUMENT COMPANY.

78. ELECTRICAL TROUBLES—A pamphlet describing the use of electrical testing instruments in automotive work combined with a description of the cadmium test for storage batteries. Of interest to the owner of storage batteries. BURTON ROGERS COMPANY.

95. RESISTANCE DATA—Successive bulletins regarding the use of resistors in various parts of the radio circuit. INTERNATIONAL RESISTANCE COMPANY.

96. VACUUM TUBE TESTING—A booklet giving pertinent data on how to test vacuum tubes with special reference to a tube testing unit. JEWELL ELECTRICAL INSTRUMENT COMPANY.

98. COPPER SHIELDING—A booklet giving information on the use of shielding in radio receivers, with notes and diagrams showing how it may be applied practically. Of special interest to the home constructor. THE COPPER AND BRASS RESEARCH ASSOCIATION.

99. RADIO CONVENIENCE OUTLETS—A folder giving diagrams and specifications for installing loud speakers in various locations at some distance from the receiving set. YAXLEY MANUFACTURING COMPANY.

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THE list of kits herewith is printed as an extension of the scope of the Service Department of Radio Broadcast. *It is our purpose to list here the technical data about kits on which information is available. In some cases, the kit can be purchased from your dealer complete; in others, the descriptive booklet is supplied for a small charge and the parts can be purchased as the buyer likes. The Service Department will not undertake to handle cash remittances for parts, but when the coupon on page 255 is filled out, all the information requested will be forwarded.*

201. SC Four-Tube Receiver—Single control. One stage of tuned radio frequency, regenerative detector, and two stages of transformer-coupled audio amplification. Regeneration control is accomplished by means of a variable resistor across the tickler coil. Standard parts; cost approximately $58.85.

202. SC-II Five-Tube Receiver—Two stages of tuned radio frequency, detector, and two stages of transformer-coupled audio. Two tuning controls. Volume control consists of potentiometer grid bias on r.f. tubes. Standard parts cost approximately $60.35.

203. "HI-Q" Kit—A five-tube tuned radio-frequency set having two radio stages, a detector, and two transformer-coupled audio stages. A special method of coupling in the r.f. stages tends to make the amplification more nearly equal over the entire band. Price $63.05 without cabinet.

204. R. G. S. Kit—A four-tube inverse reflex circuit, having the equivalent of two tuned radio-frequency stages, detector, and three audio stages. Two controls. Price $69.70 without cabinet.

205. Pierce Airo Kit—A six-tube single-dial receiver; two stages of radio-frequency amplification, detector, and three stages of resistance-coupled audio. Volume control accomplished by variation of filament brilliancy of r.f. tubes or by adjusting compensating condensers. Complete chassis assembled but not wired costs $42.50.

206. H & H-T. R. F. Assembly—A five-tube set; three tuning dials, two steps of radio frequency, detector, and 2 transformer-coupled audio stages. Complete except for baseboard, panel, screws, wires, and accessories. Price $35.00.

207. Premier Five-Tube Ensemble—Two stages of tuned radio frequency, detector, and two steps of transformer-coupled audio. Three dials. Parts assembled but not wired. Price complete, except for cabinet, $35.00.

208. "Quadraformer VI"—A six-tube set with two tuning controls. Two stages of tuned radio frequency using specially designed shielded coils, a detector, one stage of transformer-coupled audio, and two stages of resistance-coupled audio. Gain control by means of tapped primaries on the r.f. transformers. Essential kit consists of three shielded double-range "Quadraformer" coils, a selectivity control, and an "Ampitrol," price $17.50. Complete parts $70.15.

209. Gen-Ral Five-Tube Set—Two stages of tuned radio frequency, detector, and two transformer-coupled audio stages. Volume is controlled by a resistor in the plate circuit of the r.f. tubes. Uses a special r.f. coil ("Duo-Former") with figure eight winding. Parts mounted but not wired, price $37.50.

210. Bremer-Tully Power-Six—A six-tube, dual-control set: three stages of neutralized tuned radio frequency, detector, and two transformer-coupled audio stages. Resistances in the grid circuit together with a phase shifting arrangement are used to prevent oscillation. Volume control accomplished by variation of B potential on r.f. tube. Essential kit consists of four r.f. transformers, two dual condensers, three small condensers, three choke coils, one 500,000-ohm resistor, three 1500-ohm resistors, and a set of color charts and diagrams. Price $41.50.

211. Bruno Drum Control Receivers—How to apply a drum tuning unit to such circuits as the three-tube regenerative receiver, four-tube Browning-Drake, five-tube Diamond-of-the-Air, and the "Grand" 6.

212. Infradyne Amplifier—A three-tube intermediate-frequency amplifier for the super-heterodyne and other special receivers, tuned to 3490 kc. (86 meters). Price $25.00.

213. Radio Broadcast "Lab" Receiver—A four-tube dual-control receiver with one stage of Rice neutralized tuned-radio frequency, regenerative detector (capacity controlled), and two stages of transformer-coupled audio. Approximate price, $78.15.

214. LC-27—A five-tube set with two stages of tuned-radio frequency, a detector, and two stages of transformer-coupled audio. Special coils and special means of neutralizing are employed. Output device. Price $85.20 without cabinet.

215. Loftin-White—A five-tube set with two stages of radio frequency, especially designed to give equal amplification at all frequencies, a detector, and two stages of transformer-coupled audio. Two controls. Output device. Price $85.10.

216. K.H.-27—A six-tube receiver with two stages of neutralized tuned radio frequency, a detector, three stages of choke-coupled audio, and an output device. Two controls. Price $86.00 without cabinet.

217. Aero Short-Wave Kit—Three plug-in coils designed to operate with a regenerative detector circuit and having a frequency range of from 19,990 to 2306 kc. (15 to 130 meters). Coils and plug only, price $12.50.

218. Diamond-of-the-Air—A five-tube set having one stage of tuned-radio frequency, a regenerative detector, one stage of transformer-coupled audio, and two stages of resistance-coupled audio. Volume control through regeneration. Two tuning dials.

219. Norden-Hauck Super 10—Ten tubes; five stages of tuned radio frequency, detector, and four stages of choke- and transformer-coupled audio frequency. Two controls. Price $291.40.

WHAT KIT SHALL I BUY (*Continued*)

220. BROWNING-DRAKE—Five tubes; one stage tuned radio frequency (Rice neutralization), regenerative detector (tickler control), three stages of audio (special combination of resistance- and impedance-coupled audio). Two controls.

221. LR4 ULTRADYNE—Nine-tube super-heterodyne; one stage of tuned radio frequency, one modulator, one oscillator, three intermediate-frequency stages, detector, and two transformer-coupled audio stages.

222. GREIFF MULTIPLEX—Four tubes (equivalent to six tubes); one stage of tuned radio frequency, one stage of transformer-coupled radio frequency, crystal detector, two stages of transformer-coupled audio, and one stage of impedance-coupled audio. Two controls. Price complete parts, $50.00.

223. PHONOGRAPH AMPLIFIER—A five-tube amplifier device having an oscillator, a detector, one stage of transformer-coupled audio, and two stages of impedance-coupled audio. The phonograph signal is made to modulate the oscillator in much the same manner as an incoming signal from an antenna

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A KEY TO RECENT RADIO ARTICLES

By E. G. SHALKHAUSER

THIS is the twenty-first installment of references to articles which have appeared recently in various radio periodicals. Each separate reference should be cut out and pasted on 4" x 6" cards for filing, or pasted in a scrap book either alphabetically or numerically. An outline of the Dewey Decimal System (employed here) appeared last in the January RADIO BROADCAST.

R344.4. SHORT-WAVE GENERATORS. TRANSMITTER, *Short-Wave.*
QST. May, 1927. Pp. 9–14.
"A Complete Inexpensive Transmitter," H. P. Westman.
A short-wave transmitter operating with two UX-171 tubes in a back-to-back Hartley circuit with straight a.c. on the plates, is outlined. Complete construction data, and detailed operating instructions relative to the principle employed in using the full a.c. wave, are given for the benefit of the beginner, who may desire to get into the transmitting game.

R333. THREE-ELECTRODE ELECTRON TUBES. *Vacuum Tubes, UX-852.*
QST. May, 1927. Pp. 20–23.
"The UX-852 Transmitting Tube," R. S. Kruse.
Complete tube data relative to the new UX-852 75-watt transmitting tube are presented. These include the oscillating characteristics, filament curves, amplification factor, plate impedance, mutual conductance, and several static grid and plate voltage and current curves.

R281. 71. QUARTZ. QUARTZ, *Grinding of.*
QST. May, 1927 .Pp. 24–26.
"A Method of Grinding Quartz Plates," P. Mueller.
A method whereby quartz crystals may be ground to parallelism is outlined. The method consists of mounting nine crystal slabs to one plate and grinding; by frequent transpositions, true crystal surfaces are obtained.

R084. MAPS AND CHARTS. CHART, *Tube Characteristic.*
QST. May, 1927, Pp. 48–49.
"A Tube Characteristic Chart."
A chart showing the characteristics of plate resistance, amplification constant, and mutual conductance of vacuum tubes, at a glance, has been devised, and is shown. To illustrate the principle, an example is worked out.

R114. STRAYS. STATIC
Popular Radio. May, 1927. Pp. 427–430.
"Static's New Job as a Life-Saver," Com. S. C. Hooper.
The detection, recording, and the analysis of static signals is said to be of material benefit in locating and studying storm areas, especially at sea, where the observations, here referred to, have been made. Experiences while aboard the U.S.S. *Kittery* are related.

R582. TRANSMISSION OF PHOTOGRAPHS. TELEVISION, *Baird System.*
Popular Radio. May, 1927. Pp. 447-ff.
"Television and 'Black Light'," John L. Baird.
The experiments carried on by John L. Baird with his television apparatus are enumerated by the inventor himself. Starting with simple apparatus and making use of many new developments in science, his system now employs rays of light in the infra-red spectrum. Although only in the first stages of development, experiments with the so-called "black light" give promise of great strides being made in the perfection of television, as stated.

R343. ELECTRON-TUBE RECEIVING SETS. RECEIVER, *Short-Wave.*
RADIO BROADCAST. May, 1927. Pp. 24–25.
"A Balanced Short-Wave Receiver," F. C. Jones.
A non-radiating short-wave receiver, covering the range from 9994 to 5996 kilocycles (30 to 50 meters), is described. A bridge circuit is utilized to prevent the set from radiating. Antenna and ground are connected across the zero potential points of the bridge. Two tubes are found necessary in the described arrangement, the constants of which are discussed in detail.

R343. 7. ALTERNATING-CURRENT SUPPLY. A.C. FOR FILAMENTS.
RADIO BROADCAST. May, 1927. Pp. 33–35.
"Filament Lighting from the A. C. Mains," R. F. Beers.
The advantages of series rather than parallel arrangement of filaments are stated as: (1) Total current to be filtered is only that taken by one tube, and (2) higher voltages are available for filtering. Circuit diagrams are shown and explained.

R251. AMMETERS. AMMETERS. *Volume Indicators.*
RADIO BROADCAST. May, 1927. Pp. 38–39.
"Technical Operation of Broadcasting Stations: No. 15. Volume Indicators," Carl Dreher.
Practical circuit diagram and operating data concerning "volume indicators" as used in broadcasting stations, are given. Use is made of either a d.c. or an a.c. milliammeter connected into the plate circuit of a vacuum tube or coupled to it.

R382. INDUCTORS. INDUCTORS.
RADIO BROADCAST. May, 1927. Pp. 40–42.
"Some Facts About Coil Design," R. Gunn.
The oscillating circuit, consisting of inductance, resistance, and capacity, is found to be a form of voltage amplifier, its amplification being equal to the generated voltage divided by the applied voltage. This factor is spoken of as the "gain." The "gain" depends primarily on the coil rather than the condenser, the latter having comparatively lower losses. The following points are considered of importance: (1). The gain of the coil should not exceed the limit of 25n for good quality reproduction; (2). the exterior field of the coil should be as near zero as possible; (3). the distributed capacity should be very low; (4) the coil should be mechanically strong.