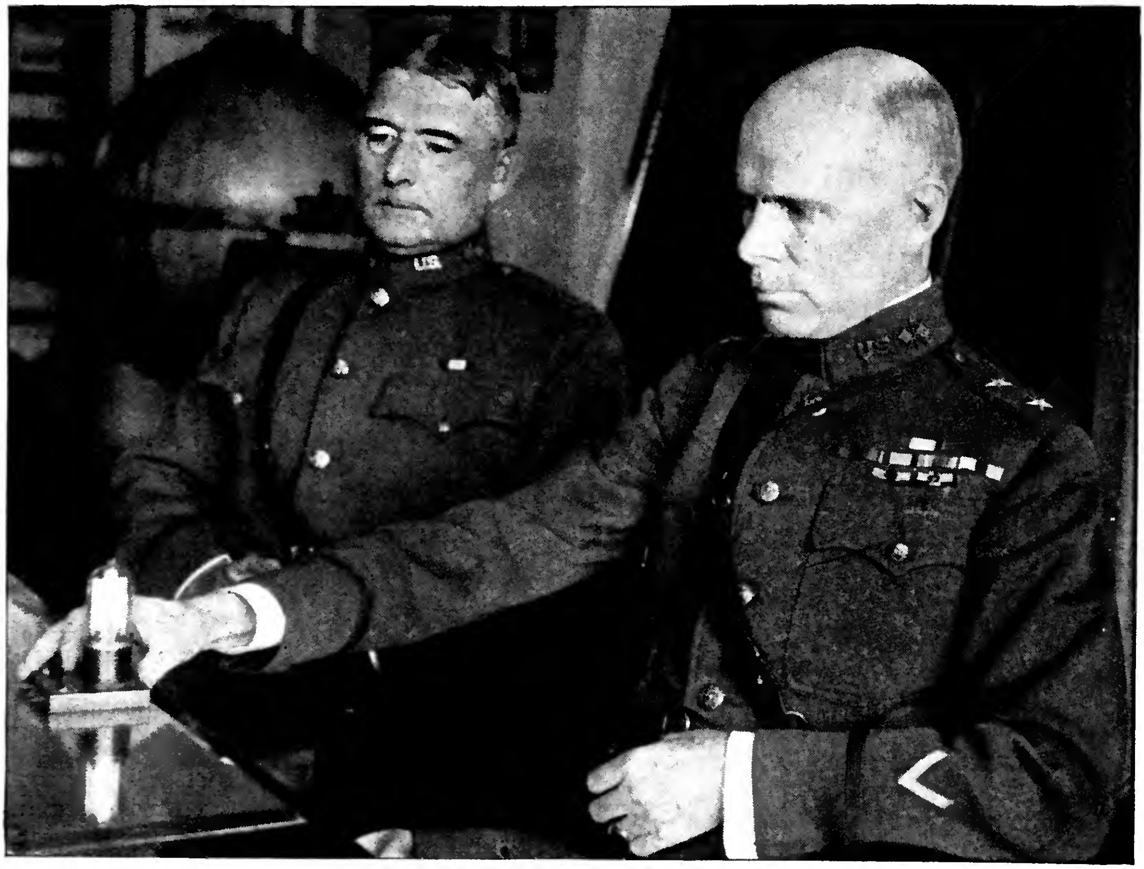


HAIL AND FAREWELL

Major General George O. Squier, right, seated with Col. Charles McK. Saltzman who has recently succeeded him as chief signal officer of the Army. General Squier is returning to private life, after forty years of active service—one of the best known men in radio. "Wired wireless" is attributed to him as well as other developments and technical refinements in radio. Col. Saltzman is well suited to assume charge of the Signal Corps, since he has previously done much in the administration of the Corps

RADIO BROADCAST

Vol. 4 No. 5 March, 1924

Broadcasting Complete American Programs to All England

How KDKA Programs on Only 94 Meters Were Heard in England Even Over Lowly Crystal Sets. What Broadcast Repeating May Mean

By W. W. RODGERS

INTERNATIONAL broadcasting, three months ago only an imaginative theory, is now an actual fact, due to the great progress made in relaying or repeating broadcasts, by means of high frequency waves.

Short waves or high frequency broadcasts—both terms have the same meaning—have opened up a new field in broadcasting. The first test completed at the very start of the New Year open up possibilities that promise extremely rapid developments in 1924.

The first complete international repeating of concerts was accomplished by the Westinghouse Electric and Manufacturing Company coöperating with the Metropolitan-Vickers Electric Company at Manchester, England. There is a kind of unusual justice that KDKA, one of the pioneer broadcasting stations should be the first radio station to transmit concerts to England on a thoroughly accurate basis.

Radio moves so swiftly these days that events tread upon the very heels of one another. The transatlantic tests, sponsored by RADIO BROADCAST, the *Wireless World and Radio Review* (London) and the British Broadcasting Company used the old method of transmitting programs. These had hardly been completed to the satisfaction of the world, when this new scientific feat was accomplished and the latter was so much more satisfactory that there was hardly a comparison between the old method and this new method started by the Westinghouse Company. The old method of transatlantic reception, as all readers of RADIO BROADCAST know, is the same as receiving the concerts in the United States. The station trying to reach England sends out advance notices and then on a prearranged night sends its concert. Those on the other side, know the hour the concert will be broadcasted and listen patiently for the signals. Sometimes on favorable nights, the operator equipped with an extremely sensitive receiver will hear fragments of the concert, but he is never certain to get the signals. The drawback to this method is, of course, the fact that only a small minority of the people living in a country can hear these transatlantic signals because it is only the small minority who own high-priced, very sensitive receiving apparatus. The great mass of the people depend upon the one—or two—tube sets—the English call them "valves"—for the reception of the concerts.

No reception is certain by this method. The listener must be ruled by the god of static, and the good or bad genii of "conditions." It is at best a haphazard arrangement.

But now comes the perfection of the short wave, or high frequency broadcasts. The first announcement of the use of high frequency or very short wavelengths came late last year when Station KFKX, the first radio repeating station in the world, was opened at Hastings, Nebraska. This station is near the exact geographical center of the United States for the purpose of repeating the broadcasts of KDKA, at East Pittsburgh, Pa. It was built to bring the concerts of KDKA to the people of the entire country. The normal range of KDKA was greatly increased because of the repeating station, and the people on the West Coast, who heretofore, had not heard that station, except on very sensitive multi-tube sets, began to pick up Pittsburgh with average receivers.

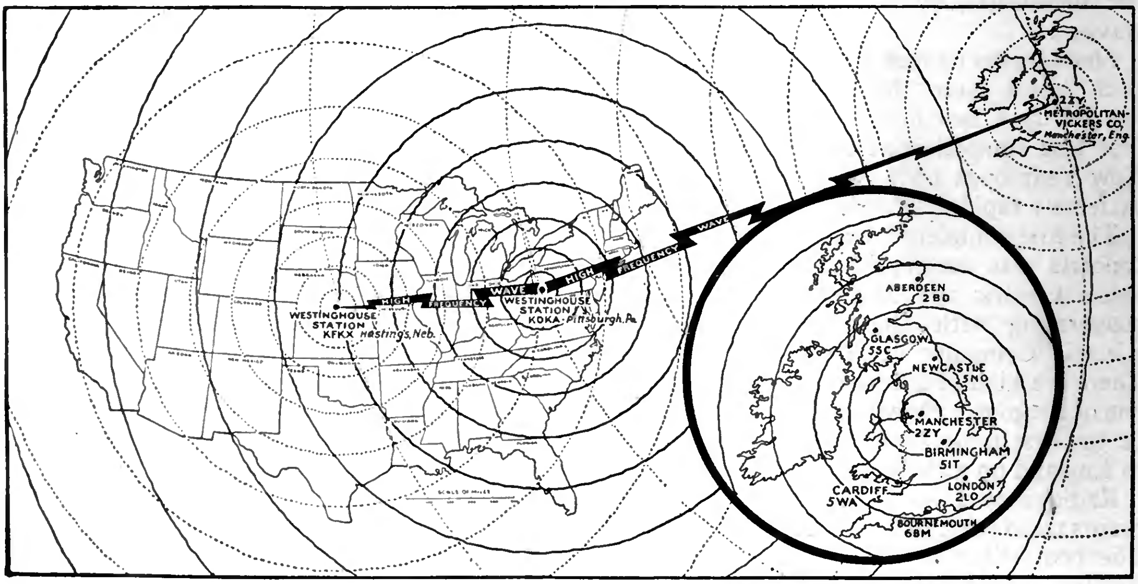
The same principle as used in rebroadcasting from KFKX at Hastings was used in the repeating of concerts in England. The same waves were used as were sent to KFKX, in fact the same transmitter broadcasting its very short waves to the Hastings, Nebraska station simultaneously carried the concert to England for repeating.

All this development in short wave application was accomplished in the last two years' experimenting with these short waves by Frank Conrad, assistant chief engineer of the Westinghouse Company. He had found in his experimenting that the short waves go farther with the same power than do the longer waves and had also made the revolutionary discovery that the short wavelengths were not affected by daylight in nearly the same degree as are the ordinary waves now used in broadcasting. Interference from other stations, of course, at that frequency, did not exist.

Thus, since a medium by means of which broadcasting could be carried on at great distances without interference was at the engineer's command, no barrier opposed international broadcasting. But the proper coöperation from the other side of the Atlantic involved many problems, which though not apparent to the public, took nearly a year to perfect. International broadcasting, brought to a climax with the New Year, really started early in 1922, yet so quietly were the developments made that, at the time of the trans-Atlantic tests last November, few in the broadcast world had even hinted at the possibilities of the repeating station.

HOW THE PLANS WERE QUIETLY MADE

IN THE summer of 1922, Mr. A. P. M. Fleming, manager of the research department of the Metropolitan-Vickers Electrical



HOW KDKA'S 94 METER WAVE TRAVELS

KFKX at Hastings, Nebraska, and the stations of the British Broadcasting Company rebroadcast the short waves with the regular transmitter so that any one with a simple receiver can pick the signals up

Company, visited the engineering department of the Westinghouse Company. During this visit, he talked with Mr. Conrad, Mr. Davis, and others of the officials interested in broadcasting and was told of the short wave tests and how this new medium promised great developments in the radio field. It was in a talk with Mr. Davis that the idea for this international broadcasting was started.

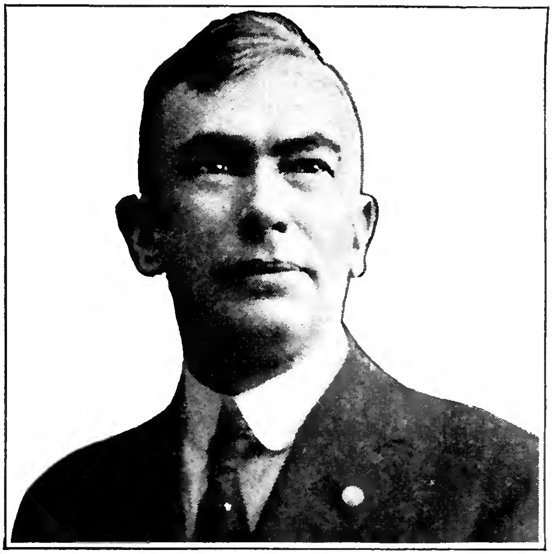
Mr. Fleming told Mr. Davis of the broadcast situation in England at the time and though the possibilities were there, the thought seemed literally and metaphorically a very ethereal subject because while the United States had been very thoroughly "sold" to radio broadcasting, in England the furore was just starting. The public had not caught the enthusiasm. Many of the English newspapers were even severely critical of the future of broadcasting.

Despite the uncertain broadcasting situation in England, the research department of the Metropolitan-Vickers research laboratories were at the time working on the radio problem and had high hopes for radio broadcasting in England. As a matter of fact, scarcely had Mr. Fleming returned when the radio storm broke and swept over England in the same manner it had swept the United States.

During the later months of organization, the British Broadcasting Company was formed, an organization which has a monopoly on broadcasting in England. The company is an association of manufacturers operating broadcasting stations. Those comprising the association of

MR. H. P. DAVIS

Vice-President of the Westinghouse Company, before the microphone at KDKA where he sent New Year greetings to England at 7 P.M. on December 31, 1923. It was just midnight in England



MR. FRANK CONRAD

Assistant chief engineer of the Westinghouse Company, who was largely responsible for the success of the short wave broadcasting

broadcast stations include the following—2LO, London, 363 meters; 6BM, Bournemouth, 385 meters; 5WA, Cardiff, 353 meters; 5SC, Glasgow, 415 meters; 5IT, Birmingham, 423 meters; 5 NO, Newcastle, 400 meters; 2AC, Manchester, 370 meters; and 2BD, Aberdeen, 495 meters. These stations besides operating independently of each other are also linked by land wire so that in the event of an important happening in one section of the country, the stations can be linked together. Simultaneous broadcasting from all eight stations occurred in RADIO BROADCAST'S test of last November.

This was the situation when the "Metro-Vick" Company began testing with East Pittsburgh on short wavelengths. After leaving America, Mr. Fleming had not been forgotten by the Pittsburgh broadcast officials and they were constantly in correspondence with him regarding the progress of developments with the high frequencies. After the success of the short wave tests in the United States, the English Company installed a private high frequency receiver in its plant at Manchester, England to test with the broadcasts of KDKA and particularly with the broadcasts sent to KFKX.

After many weeks' testing and frequent changes in the design of various units in the high frequency receiver, the results showed a stable reception and one that could easily be

"THIS IS 2LO, LONDON"
And Captain E. P. Eckersley, chief engineer of the British Broadcasting Company with a wavemeter and long wavelength pipe testing their radiated wave. 2 LO was one of the stations to rebroadcast KDKA's short wave program

placed on the air in England whenever desirable. So the Metropolitan-Vickers Company sent the program out through "Merrie" England and the European continent for the first time, December 29, 1923. The other seven British broadcasting stations were linked in by land phone with the result that all of them were broadcasting KDKA's concerts, a feat never before accomplished.

Of course, this wasn't the first time KDKA had been heard in England. As a matter of fact, KDKA has been receiving hundreds of letters from all parts of the world, telling of the reception of its concerts on its regular wavelength, but the receivers of these broadcast signals did it with multi-tube sets and then the reception at most was greatly dependent upon weather conditions and was quite haphazard. However, here was an actuality that gave every one in the ordinary broadcast range of the English stations, (which, by the way, are limited by law to an output of three kilowatts and which usually operate much below that figure), an opportunity to listen-in.

Knowing from the cables that passed back and forth between England and the American company that the proper time had come to exchange international greetings, arrangements were made to repeat KDKA's concerts throughout England through the Metropolitan-Vickers pick-up with Mr. H. P. Davis of the Westinghouse Company sending the greetings. Mr. Davis gave his New Year's greeting from the East Pittsburgh Studio of KDKA at seven o'clock, Eastern Standard Time Monday evening, December 31, 1923. Because of the difference in time—five hours—this was exactly midnight in Great Britain and Mr. Davis's speech was the first greeting received in the Old World from the New, for the coming year. Mr. Davis said:

"To the people of Great Britain in this New Year's Eve, I send greetings from America and express to you the wish of every American—that Great Britain and her European neighbors may enjoy a prosperous, peaceful, and progressive New Year.

"That the means of communication have been greatly advanced during the past year is fitly shown by the fact that I am able to speak directly to you, across an intervening ocean. This achievement will ultimately result in making known to you America's daily events and your every day happenings known to us.

"A year ago such an achievement seemed beyond belief. With such advancement in the radio art an established fact, no man dares predict what developments will take place before another New Year.

"It is a wonderful thing for the world—this achievement which enables the peoples of one continent to "listen in" on the activities of the peoples of another continent—for the friendship of nations is founded on closer understanding among the various peoples and in no way can different nations better understand each other and become more closely in touch with each other than by improved means of rapid and accurate communication.

"It is also fitting that Westinghouse Station KDKA, the pioneer broadcasting station of the world, should be the first station to develop a means for the repeating of its programs to you, the peoples of other continents, for it was here, and by this station, from which I am now sending this message, that radio broadcasting was first undertaken. This feat is only another progressive step in the development of this great utility.

"On behalf of the people of America, it is my great privilege, therefore, for the first time in history, by means of the spoken word, to speak directly to you the wish for a happy and prosperous New Year."

The announcer at the time Mr. Davis spoke was an Englishman, chosen because of the fact that his decided English accent would be an added touch to the broadcasting. This announcer was Mr. Sidney Nightingale, who prefaced the speaker's remarks.

An aftermath of Mr. Nightingale's announcing came the next day in a message from his mother, Mrs. J. R. Nightingale of Manchester, England. This lady listened to her son's announcing 3,900 miles away. It is safe to say that a mother, any mother for that matter, after hearing her son's voice coming so far would feel quite proud, but she was particularly proud that her son's voice should be the first that came over from America to be repeated by these British stations.

So, just a year after a speculative talk in the offices of Mr. Davis at East Pittsburgh, the theory of the future had become the established fact and international broadcasting had become a scientific accomplishment.

For this rebroadcasting, KDKA transmits to England on 94 meters (3,200 kilocycles), the same frequency or wavelength at which it transmits to Hastings, Nebraska. The wavelengths of the English stations have been listed earlier in this article and are not important except as being a definite link between the 94 meters of KDKA and the broadcast listener of the Old World.

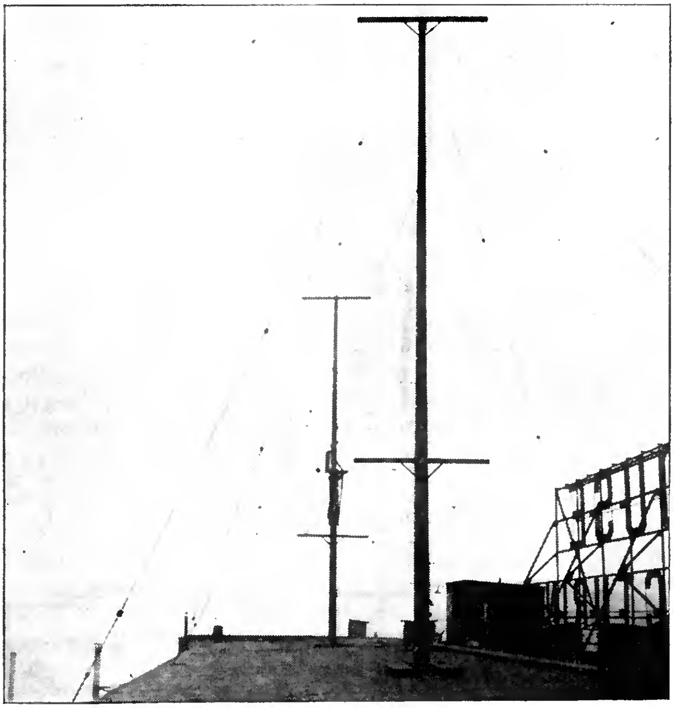
The antenna at East Pittsburgh used for this repeating radio transmission is not more than thirty-five feet long. This is much smaller than the antenna required for ordinary broadcasting. There are only thirty-five feet between flat top and counterpoise. The antenna and counterpoise consist of two small cages.

One of the difficulties of short wave broadcasting is that every precaution must be taken to prevent any outside influences, such as vibration, that would change the frequency. The vibration of the ground or the swinging of the antenna would serve to throw the set off its frequency. To guard against the possibility of swinging, the East Pittsburgh short wave antenna, including the flat top and counterpoise, are stretched between cross arms rigidly attached to the tower instead of the more common swinging spreaders.

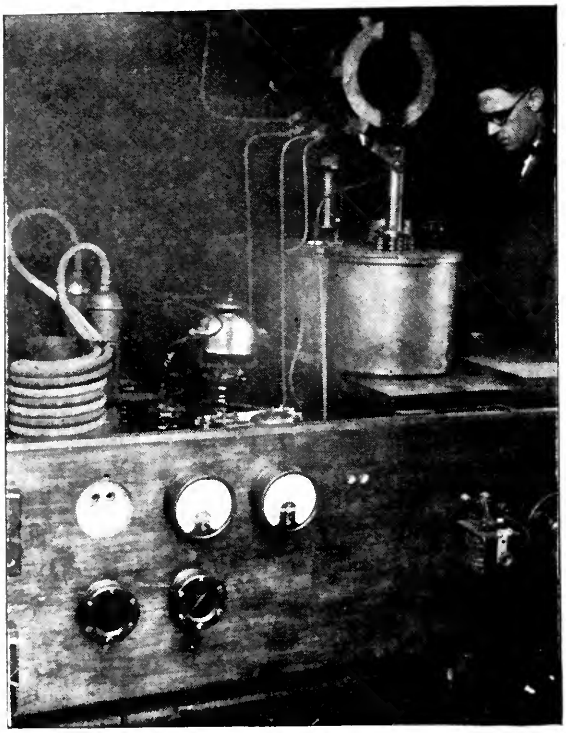
The lead-in from the antenna to the counterpoise consists of copper tubing rigidly mounted on long high voltage porcelain insulators on the poles. The various inductances on the set are wound on rigid forms. Copper tubing is used to make all the connections.

The short wave set at East Pittsburgh is located on the top of a nine-story building and is subjected to the usual jars. But the set is therefore suspended on a system of springs, and vibrations of the building cannot affect the operation of the set.

The transmitting set at East Pittsburgh con-



THIS ANTENNA RADIATES ON 94 METERS
And is only 35 feet long. Note that the spreaders are tightly fixed to the masts, in order to prevent any swinging of the wires and consequent slight variation in the radiated wave. This is the antenna used in sending to England and to KFKX, the "repeater" broadcasting station at Hastings, Nebraska



THE 94 METER TRANSMITTER
In use at KDKA to send programs to Hastings, Nebraska. The transmitter is supported on heavy springs so local jars will not change the wavelength adjustment

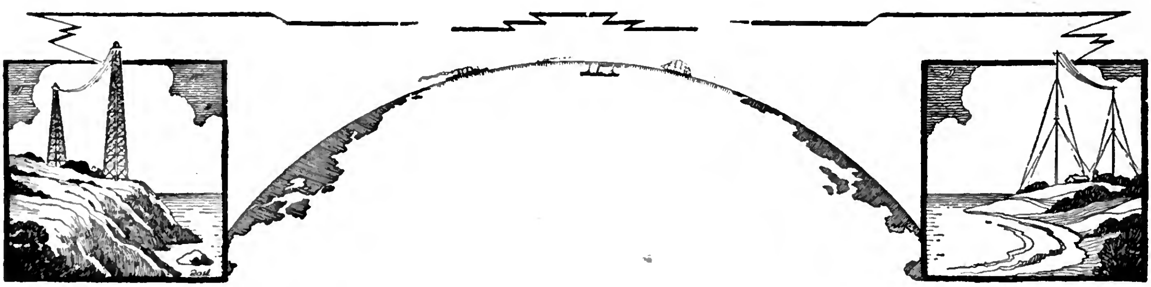
sists of three panels: the rectifier panel, the modulator panel, and the oscillator panel. The rectifier converts the high voltage A. C. current, obtained by stepping up the ordinary plant current supply to high voltage D. C. for the plate circuit. The modulator with its accessories impresses the voice frequency on his high voltage D.C. current before it goes to the oscillator. Finally the oscillator converts the high voltage D.C. currents into radio frequency, in which form it is delivered to the antenna.

Although this article tells, primarily of repeating of concerts in England, that all the while that the very short waves of 3,200 kc. are going across the ocean to be received in Great Britain, similar waves are going out to Hastings, Nebraska, where they are being repeated through Station KFKX. Therefore, when KDKA goes into operation, with the repeating equipment in England and at Hastings, Nebraska, the station is covering nearly half of the world.

Not only is this an enormous scientific and engineering achievement but it is also a great step forward toward better international relations. By means of this amazing means of communication, the human touch is possible over thousands of leagues of ocean and it must prove a thing of inestimable good, bringing as it does whole continents into personal communication, which is bound to result in that better understanding so vitally necessary for any lasting peace.

C. W. Horn, superintendent of radio operations of the Westinghouse Company, a man who is very close to the broadcast situation, sees something significant in the English repeating. According to Mr. Horn it sounds the death knell of those stations who either can't or won't put on the air the best of programs. The pace that is being set is very swift and, Mr. Horn thinks, those who can't maintain it will fall by the wayside.

Significantly, the repeating of these English concerts brings to mind the remarks of Mr. Davis, one year and a half ago, relative to the broadcast situation. At that time he said that the only way to obtain the greatest possible good out of radio was to have a few modern powerful and efficient transmitting sets located in such manner as to serve various districts. Within these districts there would be located repeating stations which would repeat efficiently the concerts broadcasted by the central station. Developments of the last few months seem to indicate that this may be the ultimate in broadcasting and with events moving so swiftly, the new year may give the answer.



The Truth About Trick Circuits

PART IV

Various Circuits and What They Mean

By ZEH BOUCK

NO, THERE are very few things in this world bearing the imprint of originality to such an extent as to justify the descriptive "new"—whether it be vitamins or radio circuits. But there exists a psychological attraction in scientific things called "new", and if the lack of antiquity is made at all convincing, the public will do anything from nauseating itself with yeast cakes, to stretching its spine one half inch a day, or wasting solder and patience on misrepresented radio circuits.

The only systems which have made their appearance since the Great War that embody original principles not found in previous equipment, are the super-regenerative and the super-heterodyne. The reflex dates back to the pioneer days of bulb reception, while the neutrodyne principle is a century old—though credit should certainly be given to Hazeltine, an original and talented experimenter, for adapting it to the conventional radio frequency amplifier. Englund, Round, Fiske, and Weagant experimented with four circuit receivers, in the early days of radio, and discarded them for more efficient circuits, as many over-credulous broadcast enthusiasts are doing today.

The so-called "new circuit" is a most inviting pitfall into which the broadcast enthused public is being willingly led by newspaper radio supplements (who must give their readers what they wish), pseudo-radio engineers and avaricious manufacturers.

THE WHY OF THE "NEW" CIRCUITS

CIRCUITS are dubbed "new" for one or more of several reasons. Occasionally an experimenter, whose radio experience does not antedate the advent of wireless telephone broadcasting, hits upon a receiving arrangement, which he honestly believes to be new; and an equally ignorant manufacturer is often induced to build up some circuit that De Forest and Colpitts played with years ago. RADIO BROADCAST receives one or two of these brain-children each week. The second, and more malignant type of "new" circuits are those consciously camouflaged by manufacturers in order to gain the psychological advantage of the exclusive and "new," or to disguise a single circuit set, against which the radio public has been warned, under an innocuous epithet. The editor of RADIO BROADCAST was recently talking with the head of a radio store, concerning the merits of single circuit regenerative tuners. The radio dealer was quite decisive in his denunciation of such receivers, averring that none were ever sold over his counter.

I am the "New" Circuit

I am the new circuit. I am as numerous as the hours. I am born and reborn whenever there is nothing of real value immediately at the disposal of the "gyp" or the pseudo radio experts who feel the need of having their names appear in print.

I am generally a complication of some discarded radio relic. My new clothes, though expensive, are usually of poor quality. They serve me well in my masquerading and aid in beguiling the inexperienced. My best friends are those who desire an immediate "clean-up" with but little thought to the future. I am valuable in that my faults may be cited as the "horrible examples" after knowledge of my cunning has been gained.

I am the subject of much controversy and usually a breeder of ill-will, suspicion, and doubt.

My biographer, Mr. Bouck, knows me of old and has used me to serve two useful purposes at a single stroke. Under his pen I am disclosed as the prince of "birdies" and the masked Ancient posing as Youth.

I am the "New" Circuit.—THE EDITOR.

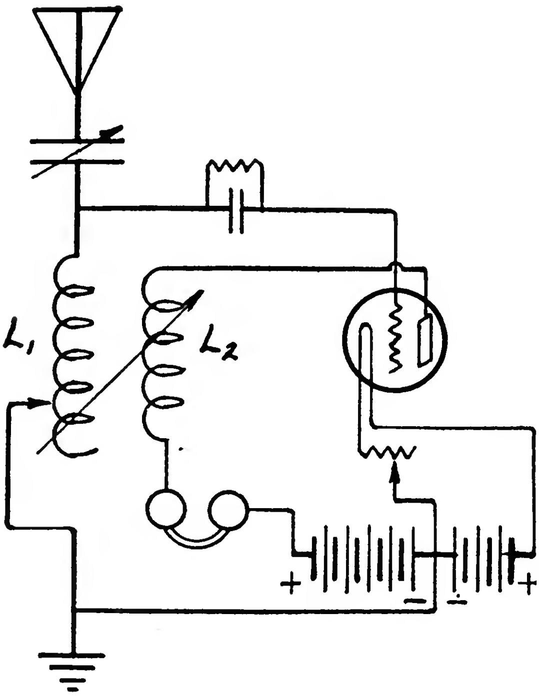


FIG. 1

The single-circuit regenerator. By adding a few jimcracks to this old-timer, it may be made to look much different and becomes sufficiently complicated to attract attention

Rather amazed, your editor pointed to a set featured by the company in question, and which was obviously a single circuit tuner of the type diagramed in Fig. 1.

"What do you call that?" asked Mr. Lynch.

"Oh, why that's a——circuit!" and the dealer named a meaningless trade mark.

That the single circuit regenerator is a guilty creature is shown by its many aliases. The reader may safely assume that any regenerative bulb set sold for less than thirty dollars is a single circuit tuner, and, for the good of radio, he should refrain from buying it. Many of the circuits, however, are so disguised that a casual glance will not disclose the usual malefactor. But such camouflage is superficial, and a critical analysis of the circuit before building or purchasing the set, will disclose the wolf in sheep's clothing—generally a "dyne" or a "plex", or the name of the company selling the set or parts.

The reader who has followed our quasi-theoretical discussions of inductance, capacity, etc., in the last three issues of RADIO BROADCAST, should now be able to grasp the true significance of circuits. He should experience little difficulty in stripping the "new" circuits that our newspapers are forever proclaiming, of their superfluities—little useless variations or additions—and bring to light the underlying circuit, which will probably be as old as the hills. And a critical analysis of a circuit may save him hours of futile labor into which the lure of something apparently new might have intrigued him.

To emphasize in the reader's mind, the essential considerations in circuit analysis, we shall briefly review the salient arguments in the previous articles, and apply the knowledge which we have gained to showing up a few (alas! space permits but very few) typical "gyp" circuits.

HOW TO RECOGNIZE "NEW ANTIQUES"

WE FOUND that inductance, or "L", is a characteristic of a conductor, a circuit, and particularly of a coil of wire, and that through the agency of inductance energy can be transformed (by induction) from one circuit to another. It was also explained how inductance is one of the qualities which determine resonance, or tuning, the other determining quality being capacity. When the opposing reactances of inductance and capacity are balanced, at a certain frequency or wave, the circuit is in resonance with, or tuned to that wave. It was also shown that condensers possess a secondary effect of by-passing—that is, a high frequency current will pass quite

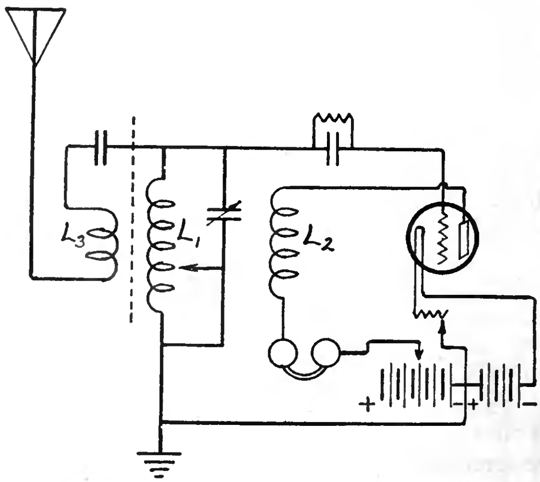


FIG. 2

At a single blow I kill interference for I am partly a wave trap; make tuning sharper because my primary and secondary are loosely coupled; and save you expense as all the parts for me are cheap. And, I nearly forgot, I can make many enemies among my neighbors readily across a condenser which would "open" a direct current or low frequency alternating current circuit.

We shall take, as our starting point, the most common single circuit tuner, that shown in Fig. 1. This receiver is regenerative through a tickler feed-back. Tuning is accomplished by a variable antenna condenser, a tapped inductance, or both. L1 is an auto-transformer, with its winding common to the antenna and grid circuits. Impulses in the plate circuit are regenerated (fed back to the grid circuit) by induction from L2 (the tickler) to L1. This circuit is a very powerful radiator, and *is often used in transmitting systems.*

The circuit shown in Fig. 1, with and without modifications, has many unofficial names, a few of which are: "The Parker Circuit," "The Haynes Circuit," "The Overland Circuit," "The Hardy Circuit" (Fig. 2), "The Flewelling Circuit" (Fig. 3). The "Aeriola Senior," several of the "Radiola," "Radak" "Grebe" series are also of this type, though the manufacturers, of course, make no claim to an exclusive or original circuit.

The derivation of Fig. 2 from Fig. 1 is most obvious. The manufacturer has ostensibly attempted to incorporate a wave-trap (L3), hoping, perhaps, to disguise the single circuit tuner, which nevertheless remains in all its iniquitous glory. The addition of L3 does not reduce the tendency to oscillate at the

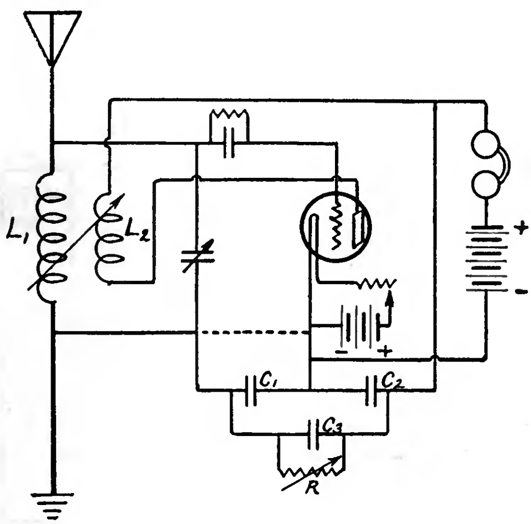


FIG. 3
Much perfectly good printer's ink has been wasted upon me and I have caused my share of whistles and howls, I have helped many a "gyp" dealer unload parts of questionable merit and now I am serving the very useful purpose of gathering dust

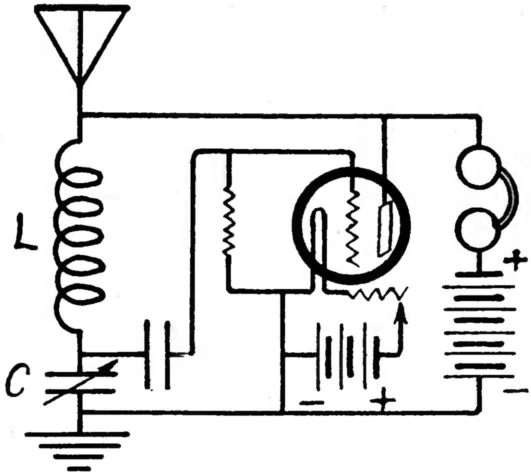


FIG. 4
Before inexperienced experimenters or ruthless gold-diggers, press-agented this "Simplex," alias "Flivver," alias "Carpet of Bagdad," alias "Automatic Regenerative Circuit," it was described by Colpitts as a *transmitting system.* It is a wolf in sheep's clothing

received frequency (unless you are content to reduce signal strength at the same time), nor is it effectual as a wave-trap. Fig. 2 is a typical "New" circuit.

Fig. 3 shows the Flewelling circuit, and again it requires no stretch of the imagination to associate its genesis with Fig. 1. A short scrutiny will show the differences between it and the more elementary single circuit tuner superficial and of doubtful advantage. C1 acts as a by-pass condenser, giving the effect of the straight ground connection to the filament (as per the dotted line) in Fig. 1. C2 is nothing more than a slightly misplaced telephone shunt capacity (although it is often used in this position) bridging the high voltage battery and receivers. C3 and the variable resistance R, do little more than complicate and render the circuit less stable through an undesirable additional regeneration, secured by means of an ultra-audion action. The De Forest ultra-audion oscillating circuit is characterized by a lead running from the lower side of the tuning coil to the plate side of the telephone receivers rather than to the filament battery. As may be guessed, the Flewelling circuit is a powerful and malignant radiator.

NEW CLOTHES FOR AN OLD ACTOR

ANOTHER fundamental circuit which has been dubbed "new" as many times as it has names, which is legion, is the Colpitts *oscillator,* Fig. 4. This *transmitting circuit,* when used for receiving, has many names —"Automatic Regenerative," the "Flivver circuit," the "Carpet of Bagdad," the "Simplex," etc., etc.

This circuit regenerates by means of capacity feed-back through condenser C and the capacity between the antenna and ground. Sometimes L is tapped, or a variometer is used in place of the usual coil—thus giving us another "new" circuit. Occasionally the coil is a fixed inductance, and C is variable. This circuit, with one hundred volts on the plate, is capable of transmitting in excess of fifteen miles: in other words, an inconsiderate operator using this circuit for reception, can spoil a concert for all other listeners within a radius of several miles.

Fig. 5 shows the "Phantom" circuit, which is nothing more than our single circuit set with tuned plate regeneration. Instead of coupling L2 to L1, as in Fig. 1, L2 is made a variable inductance (a variometer or a tapped coil). When the plate circuit is tuned to resonance with the incoming signal, energy for regeneration is fed back, from plate to grid, through the capacity in the tube. When two circuits are in resonance with each other, they are, of course, affected by the slightest variation in one of the circuits, even if coupled by only the small capacity existing between the grid and plate of a vacuum tube.

This circuit is, needless to say, claimed to be new, and in evidence of the newness, the fact that the set will function with no ground connection is cited. Of course it will —and so will any other tuned plate or tickler regenerative receiver!

Some People Think This

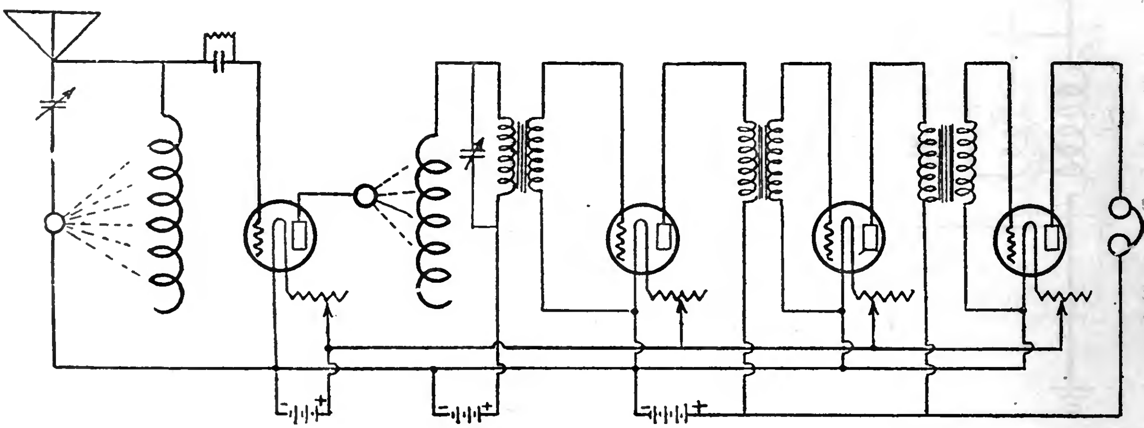
"Radiophone reception has been developed so rapidly of late that the interested public has been literally jumping from one marvel to another. Not since the release of the epoch-making super-regenerative circuit has anything of so great importance been brought to the attention of radio fans as the so-called phantom circuit. . . .

"The phantom, however, is so sensitive that it requires a tiny amount of incoming energy for operation, and only a small piece of wire for a collector. This wire, preferably lamp cord, may be about fifteen feet long. It may be thrown carelessly about the floor, dropped out the window, or concealed beneath the rug or behind the moulding. It may be disposed of in any place that is convenient. . . . "—*The descriptive article about this "phantom circuit."*

THE "GOULASH" CIRCUIT

AT TIMES there is no limit to the extent to which an "experimenter" or manufacturer will go in search of something which he may brand as "new." The Kauffman circuit, Fig. 6, is illustrative of this. Its inventor, perhaps weary in the quest of things new, decided to shake up all of the present day circuits, and, via the newspaper wireless supplements, tendered the public this radio goulash.

The Kauffman circuit embodies all three methods of regeneration we have just discussed. There exists capacity feed-back through antenna and ground and condenser C;



THIS ISN'T WHAT IT SEEMS

They called this a "phantom circuit" in the periodical in which this originally appeared and fiom which this diagram has been photographed. Do you recognize your old friend, the tuned plate circuit? This arrangement will work, but any properly connected, squeaking and howling single circuit regenerator will do about as well under similar conditions. Who was it who said, "It's all right, but it doesn't mean anything"?

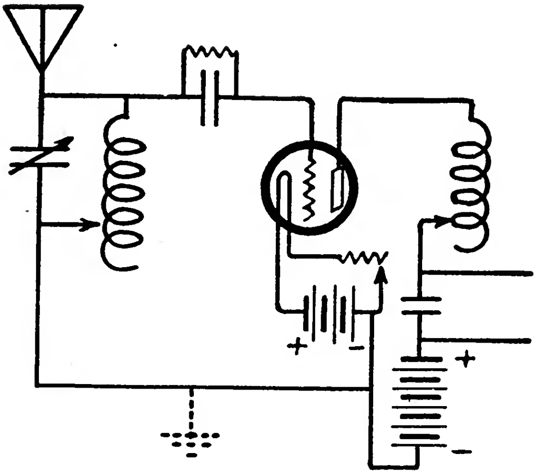


FIG. 5

Behold! No ground connection, but I work just the same. Am I not new? Indeed you are—*not*, old dear, you are Fig. 1 in a new gown and some other fixings

inductive feed-back between L1 and L2; and then tuned plate regeneration effected by means of the tapped coil, L3. Quite naturally, with all this regeneration, it is a very difficult matter to control or stop oscillations. To do this, the inventor was compelled to short-circuit his whole system with the comparatively low resistance R. In efficiency, this is quite on a par with controlling an electric bell by short-circuiting the battery.

One could continue thus almost indefinitely. But the reader is, by now, qualified to use his own discrimination, at least in so far as avoiding the single circuit tuners and their modifications which are generally efficiency detracting additions. The inseparable mechanical characteristic of the single circuit tuner is a coil in the antenna circuit (L), which is also common to either the grid or plate circuit. If a set employing this auto-transformer is regenerative, it should neither be bought nor made for receiving purposes. With all its coils and circuits, the Kauffman arrangement is, as we have shown it, nothing but a single circuit tuner. You can hang coils to anything in a set, from the tip of the bulb to condenser knobs, but it will still be a single circuit tuner, unless the antenna tuning system is given a coil all to itself.

If the reader desires a regenerative set, and one is desirable in the case of a broadcast enthusiast who cares to follow up speech and music with code, the receiver chosen should be one of two types. The variocoupler tuner, with tuned plate regeneration (the coupler-twin-variometer set is a good example of this system) is an excellent short wave set, while the three coil honeycomb (primary, secondary and tickler) is equally efficient on all waves.

But even using one of these two receivers, if the experimenter is operating in a crowded radio district, it will be more considerate of his neighboring enthusiasts, if a non-oscillating receiver, such as an efficient reflex or the neutrodyne, is used on the broadcasting waves.

If you have any doubt concerning a "new" circuit, submit it to Radio Broadcast, and its engineering staff will be glad to tell you the truth about it.

WHILE WE'RE ON THIS SUBJECT

We wish to say a word about the campaign against the squealing receivers. We do not make a practise of blowing Radio Broadcast's horn in our text pages, but in this case, we feel that it is justified.

It is doubtful if any single agency could have brought down the avalanche of objection to the howlers, though several of our misguided contemporaries are attempting to take into their own camps the entire credit for this campaign, though they never criticised the nuisance until the general public began complaining.

Back in 1922, the editorial reprinted on the next page, appeared in Radio Broadcast and it was followed by many others of like nature—so many, in fact, that the magazine lost thousands of dollars worth of advertising for adopting what some manufacturers of squealing receivers called a "short-sighted policy."

One of the principal reasons for the recent transatlantic receiving tests was to demonstrate to all those who listened, American broadcast stations being off the air, just how serious this menace has become. Judging from the space

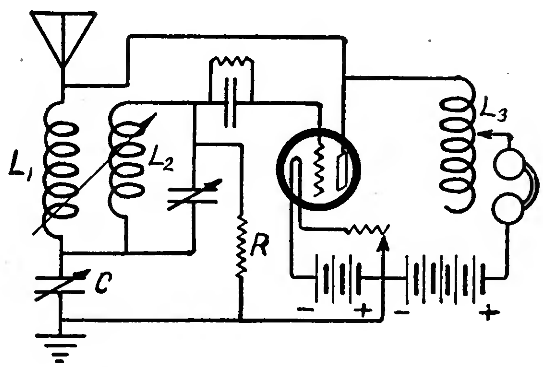


FIG. 6

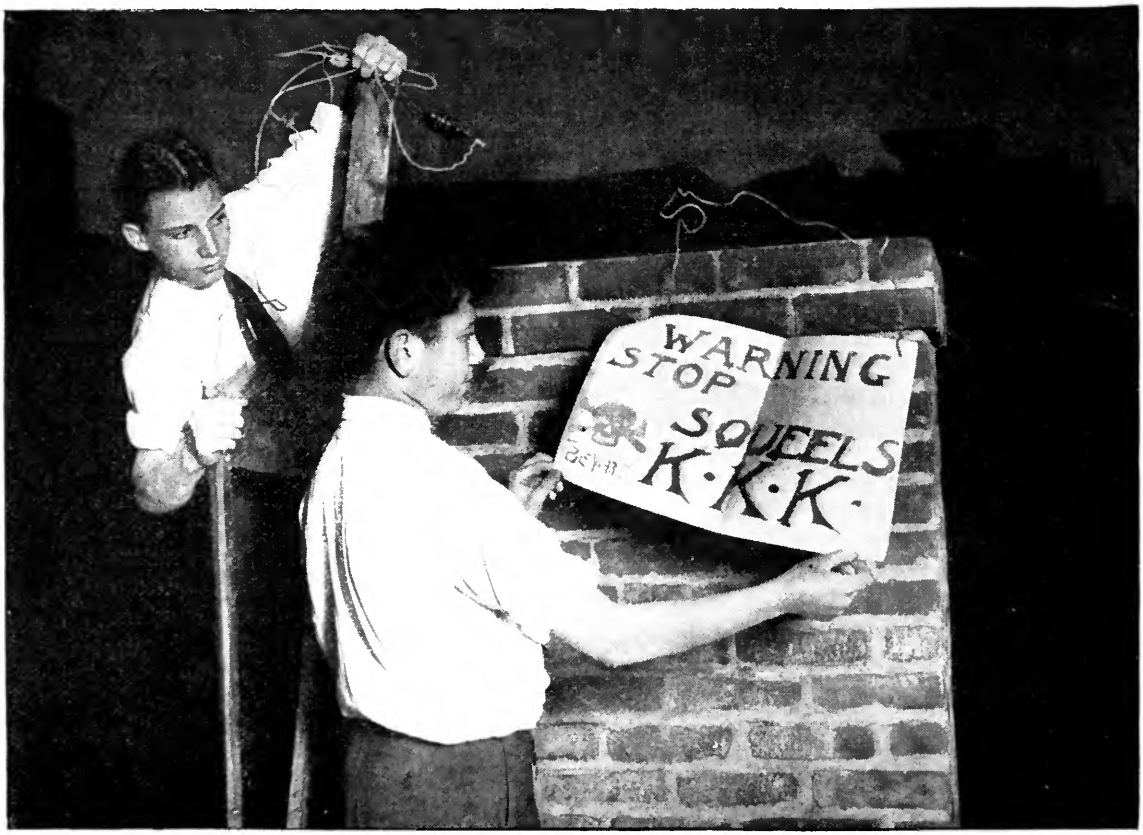
I combine them all and am therefore the best. So does hash, but it is hardly to be preferred to chicken or lobster now being devoted to the discussion, perhaps we were not as short-sighted as it at first seemed. The very cures now being offered for this disease to-day were described in the editorial below—in 1922.—THE EDITOR.

REGENERATIVE RECEIVERS MUST BE CONTROLLED

AS ONE listens nowadays for the evening concert he is continually bothered by whistling noises coming from his receiver, generally, it seems, at a critical point in the program. Just as the singer endeavors to show the radio audience how well her voice can execute a pianissimo passage, a series of peeps (of which fortunately, she is not aware), spoils the whole effect.

These whistling interruptions are due to some regenerative receiving circuit in the neighborhood of the listener, radiating from its antenna continuous-wave power which, combined with the power sent out from the broadcast station, produces a disagreeable beat note in other receiving sets in the vicinity. When a regenerative set is made to oscillate, it really becomes a miniature continuous-wave transmitting station, sending out perhaps one hundredth of a watt of power. It might seem that such a small amount of power could do no harm, but it is to be remembered that the amount of power picked up by an antenna from the distant broadcasting station is only a very small fraction of this. In fact, if the oscillating receiving set is within a mile or so of the listening station being disturbed, the amount of power received from the broadcasting station may be only a small fraction of the amount received from the interfering oscillating receiver.

As more receiving sets are installed, the nuisance from this source continually increases at a much faster rate than does the number of receiving stations. This trouble must be controlled and stopped in some way, either by the good sense of the operators or by requiring that receiving sets shall not be allowed which are capable of oscillating at the frequencies used for broadcasting. If Armstrong's super-regenerative idea is used by an appreciable number of receivers, on elevated antennas, the trouble will be immeasurably worse, and some regulation should be at once put into effect to prohibit the use of these sets except on loop aerials, which radiate comparatively little power. A regenerative, oscillating set may be used without causing this trouble if it is preceded in the receiving circuit by a radio-frequency, non-oscillating amplifier, a scheme not yet used to any great extent.



WHAT WE MAY COME TO

ONE HUNDRED FEET BELOW THE HUDSON

In the New Jersey-New York vehicle tunnel, radio engineers, and members of the tunnel commission received broadcasting from Pittsburgh on the loop and six tube set shown in the photograph. These experimenters were 500 miles by air from Pittsburgh, down 100 feet in the water and behind 30 feet of mud and steel, encasing the tunnel. G. Y. Allen, radio engineer of the Westinghouse Electric Co., is facing the camera, bareheaded, fourth from the right. Radio may be used as a safety communication in future tunnels

The March of Radio

THE FEDERAL TRADE COMMISSION INVESTIGATES THE RADIO CORPORATION

LAST month a report by the Federal Trade Commission dealing with the situation existing in the radio industry was transmitted to Congress. This report was the outcome of an investigation requested by House Resolution 548 of the 67th Congress. This report is so thorough in its gathering of important facts not generally known of the radio field, that it should have the widest publicity. Many items in the daily press, having to do with patent suits, trade agreements, shortage of tubes, etc., can be better understood in the light of this official report of present conditions in the industry. The Federal Trade Commission had no power to determine whether or not a monopoly exists in radio. It could merely collect the facts of the situation.

The report traces the development of the situation which gave rise to the founding of the Radio Corporation. In 1919, two of the officials of the Navy Department, in conference with the General Electric Co. officials, suggested that an American radio company be formed privately, with the idea of having radio channels controlled entirely by American interests. The General Electric Co. was party to the conference not only because of its vast electrical resources but because the Alexanderson alternator, a General Electric product, was just then assuming tremendous importance as the best high powered, transmitting generator available. This original project, instigated by Admiral Bullard and Commander Hooper, of the Navy, did not mature because Secretary Daniels was in favor of Government ownership of radio.

EDWARD W. BOK

Donor of $100,000 for a workable plan for international peace, reading winning plan No. 1469 before the microphone at New York

The General Electric Co. then went ahead on its own initiative and formed the Radio Corporation of America, which at once absorbed the American Marconi Co. Most of the $25,000,000 capital was furnished by General Electric and Westinghouse interests. The United Fruit Co. (one of the other members), had a comparatively small share in the stock allotment. The new Radio Corporation at once started to acquire all the available radio patents which had not been controlled by the companies forming it, until, at the time the Trade Commission report was issued, about 2,000 radio patents were controlled by the Radio Corporation. These 2,000 patents represent the pooling of all those owned by the General Electric Co., the Westinghouse Co., the American Marconi Co., the American Telegraph and Telephone Co., the Western Electric Co., the United Fruit Co., the Wireless Specialty Apparatus Co., the International Radio Co., and the Radio Engineering Co. These companies agreed to a mutual exchange of information relating to radio at the same time the latest interests were pooled which undoubtedly accounts for the almost simultaneous appearance of new developments in entirely different laboratories of companies who are members of this radio combine.

The Radio Corporation is the selling company for all the apparatus controlled by the hundreds of patents which had been accumulated in its archives. The agreement specified that the General Electric Co. and the Westinghouse Co. will manufacture the apparatus and deliver it to the Radio Corporation to sell, the division of the output to be 60 per cent. General Electric, and 40 per cent. Westinghouse manufacture.

Until the expiration of the Fleming patent in 1922, the Radio Corporation had an absolute monopoly in the sale of vacuum tubes. Even the De Forest Company had no legal right to sell "audions" until after the expiration of the Fleming valve patent. There are now seventeen concerns which still retain license privileges granted by Armstrong before his patent had been acquired by the Radio Corporation. These licensed manufacturers are at present being sued by this corporation on the basis that they have no right to manufacture sets which are manifestly intended for use with vacuum tubes. It is contended by the Radio Corporation in this suit that the sale of these sets constitutes an infringement of their tube patents. If this suit is decided in favor of the Corporation the decision "will prevent all competition in the sale of complete sets" in the language of the commission's report.

"The company has secured a virtual monopoly in the field of international communication," says the report, "and it controls all the high power stations with the exception of those owned by the government." In addition it has entered into traffic agreements with the various foreign governments and radio companies so that practically no messages originating in foreign countries can be received in America except through the Radio Corporation.

An interesting outcome of this situation in international radio was the decision of several of the more important daily newspapers and press services to be rid of this control. They decided to build a radio station of their own. But they couldn't do it in the United States—so they went to Canada and erected their station in Nova Scotia. This station is now being operated independently of the Radio Corporation of America, by virtue of an agreement with the British Post Office.

Here are some authoritative figures which show the tremendous growth of the radio industry. In 1921 the Radio Corporation furnished on order 112,500 tubes; in 1922, 1,583,021; and in 1923, at the rate given in the report the sale of tubes will reach 4,000,000. This means that the radio public has invested about $24,000,000 in tubes alone, in a single year.

We do not question these figures. But—isn't it time that more of the "development cost" of the tube was charged off and the price adjusted more in accordance with the actual manufacturing cost?

Broadcasting Over Extremely Long Distances

SINCE broadcasting has come into its own, we are all learning a great deal about sections of the world that were formerly nothing more than names associated with a spot on a map, or, in many instances, not even that familiar to us.

Men in our foreign service and even in the Arctic and Antarctic regions need no longer be without direct and very intimate contact with this great country of ours. A few months

FOLLOWING AN AIR MAIL PLANE BY RADIO

Superintendent D. B. Colyer of the Western Air Mail Division of the Post Office Department is tracing on the map the course of Jack Knight's mail plane from Omaha to North Platte. The pilot reported in to Omaha every fifteen minutes by radio. Mr. J. V. Magee, special assistant to the Postmaster General is leaning over the map

LEADERS IN THE MYTHICAL DX CLUB
Dr. and Mrs. Q. F. Roberts who heard Chicago broadcasting at their home in Apia, Samoa

ago Radio Broadcast published a description of the attempts being made in Samoa to pick up American broadcast programs. Mr. Quincy F. Roberts, American Vice-Consul in Apia, Samoa, who wrote the article for us, sent the following message through station VMG, Samoa, to the Director of Naval Communications at Washington, D. C.

"Please inform Zenith Edgewater Beach Hotel Radio Station that Chicago messages and music to MacMillan, North Pole were received by me at 7.45 Samoa time, December 19th."

When we think of Samoa located some 12 degrees below the Equator, in the Pacific ocean hearing broadcasting intended primarily for Donald MacMillan, up above the Arctic Circle, we may have some slight notion of what a powerful agency broadcasting really is developing into. It is of interest to note that the MacMillan material sent out from station 9XN begins at midnight Central Time. It was picked up in Samoa at 7:45 in the evening or more than four hours earlier. The distance from Chicago to Samoa is about 7,300 miles. Is this not an evidence of the vastness of the area covered by a single broadcasting station? We now have more than 500 of them. Are they serving to the utmost the useful purposes to which they may be put?

PWX Reaching Out Farther

IN A recent number of the Revista Telefonica Internacional appeared a note on the operation of the Cuban station PWX, a note which makes the manager feel justly proud. It was considered notable when PWX was first heard in Canada, then came the thrill of reception on the Pacific coast, then Alaska and later England. And now northern Europe is quite regularly picking her broadcasting. The chief engineer of the Cuban Telephone Co., which operates PWX, has received a letter from the foreign manager of the Federal Telephone and Telegraph Co. saying, "I am pleased to be able to say that I constantly receive reports from various territories, including Mexico, Great Britain, and Holland, from those who pick up your station. In fact it seems to be one of the most prominent ones operating to-day."

What Mr. G. W. Pickard Has Found About Fading

ONLY a short time ago we commented upon the hopeless task that the scientists of the Bureau of Standards had laid out for themselves in trying to get some idea on the why and how of fading, using the data sent in by hundreds of amateurs who had been requested by the Bureau to make observations. It seemed to us at the time, that what was needed in the solution of this problem was not mere observations, but more accurate observations, observations not dependent upon the ear, which is such a poor instrument for judging the intensity of a sound.

Such a paper has just appeared, a most remarkable series of observations by Mr. G. W. Pickard, one of the ablest radio experimenters in the country. By the use of carefully constructed radio frequency amplifiers he has been able to increase the intensity of signals from most of the Eastern stations to such an extent that the signals could be actually read on a sensitive galvanometer. Having properly adjusted his apparatus he and his associates have then taken readings (or have made the signals record themselves automatically) for long periods of time, showing how the signal changed in intensity from day time to night time.

We have known that transmission is better in the winter than in the summer. Austen's results having shown a variation of about three to one, for wavelengths considerably longer than those used for broadcasting. Pickard's results show even a greater difference. He found the average winter signal strengths were five times as great as those for summer.

His results show that for stations within perhaps ten miles of the receiving set there is practically no observable fading effect. Actually, his instruments showed a fluctuation of about 10 per cent. but such a small difference is not detectable by the ear. As the distance between the transmitter and the receiver increases, short period changes in signal strength begin to appear, especially in the night time signals.

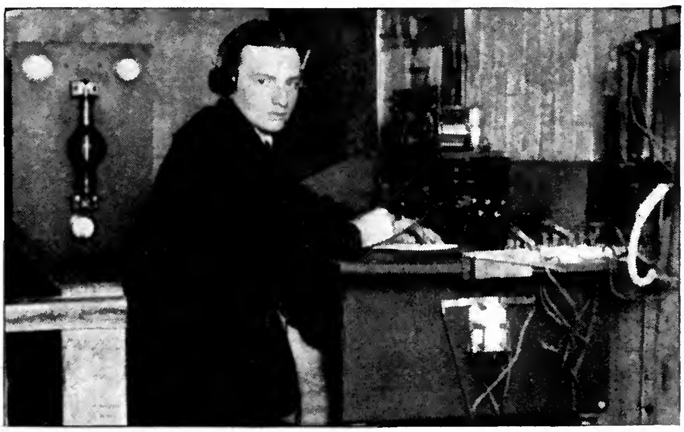
"In day time," says the paper, "although transmission is relatively free from the large amplitude, short period, variations commonly known as "fading," "swinging" or "soaring," there is usually a slow change from hour to hour which in the majority of cases appears as a gradual decrease from morning to night, the morning intensities often being twice those of the afternoon.

"About half an hour after sunset at the receiving station, the weak and relatively constant field from the distant station begins to show marked short-period fluctuations which grow in amplitude from minute to minute until, soon after sunset, they usually assume grotesquely large amplitudes. The principal change from day to night is an increase in field intensity; in general, the lower limit of the night time field is approximately the same as the late afternoon field, although from time to time there will be found a momentary fall to a much lower value than at any time during the day. The upper limit of the night time field is not so definite; it may be ten, a hundred, or even on occasions, thousands of times greater than the day-time intensity, depending upon the distance, and the character of the night.

"The amplitude of the short period variations, that is, those fluctuations ranging in duration from seconds to tens of minutes, is principally controlled by the distance between the transmitter and the receiver, and this is true of both night and day transmission. At eleven kilometers (about seven miles) from a broadcasting station, there is a well defined short period fluctuation in intensity during night time transmission which is practically absent during the day, and which on some evenings shows an amplitude of 10 per cent. or more. As the distance increases the amplitude of the variations increases, becoming readily observable by day at a distance of fifty kilometers, more or less.

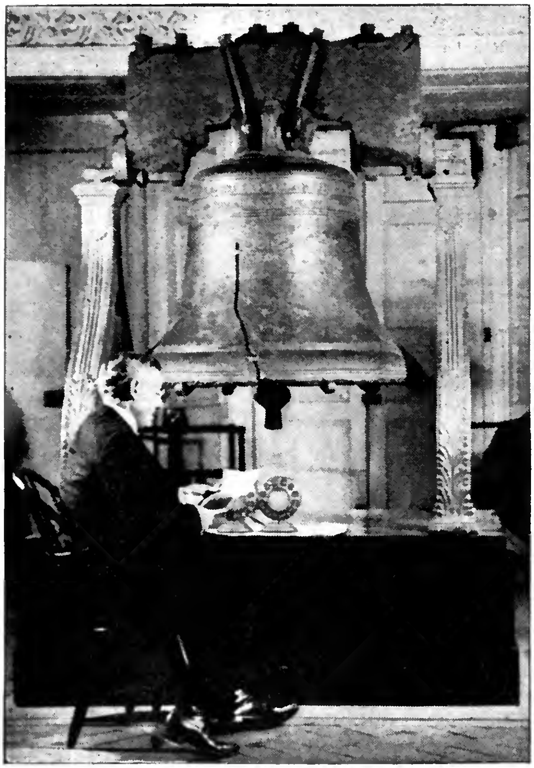
"At first there is no change in the character of the fluctuation other than amplitude, but when the distance of between one and two hundred kilometers is exceeded, the oscillations of periods ranging from seconds to a minute or two become less prominent, and the longer swings of minutes and tens of minutes are accentuated. At an ill-defined distance of perhaps one hundred and fifty kilometers the amplitude of the short period variations appear to be a maximum."

We hope Mr. Pickard will continue to gather data on the transmission of radio signals, because, with his apparatus and skill, much more reliable and valuable results will emanate from the experiments than from those of some other investigator just taking up the problem. As an indication of the apparatus used and skill shown in making these tests, let us point out to those radio listeners in the New England States who occasionally hear a weak signal from the Texas stations, that Mr. Pickard



AMATEUR STATION 6AWT, SAN FRANCISCO

With the owner and operator, Bartholomew Molinari, at the key of his 250-watt tube set. Molinari has exchanged radio messages direct with WNP, the *Bowdoin*, which is now frozen in off Greenland on its slow way to the North Pole



THE OLD LIBERTY BELL AND THE NEW MICROPHONE

Together at Independence Hall, Philadelphia. Harry T. Baxter, Chief of Philadelphia City Property is reading the history of the famous bell, which listeners heard last New Year's Eve

(near Boston) receives these stations strong enough to get a continuous record of their signals on his galvanometer, an instrument by no means as sensitive as a telephone receiver.

The Army's Radio Chief Retires

ON JANUARY first, 1924, Major General George O. Squier, Chief Signal Officer of the United States Army, retired and was succeeded by Col. Charles McK. Saltzman. In Major General Squier, the Signal Corps had one of the ablest scientists in the entire radio field. General Squier has been in active Army service for forty years. During that time, his services have been many, but he is chiefly known for his technical contributions to radio. He is responsible for "wired wireless" or "line radio," as it is often called. He has made successful experiments using trees as antennas and first observed the phenomena as early as 1904.

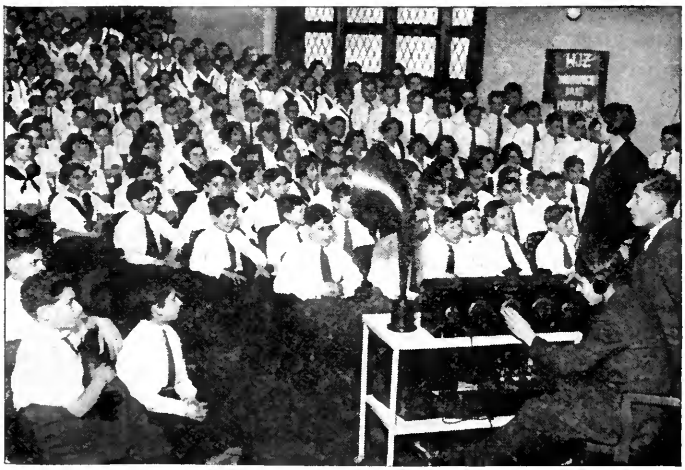
Major-General Squier's developments with "wired wireless" have made modern multiplex telegraphy and telephony possible. Where a wire once carried but a single message, now eighty-five telegraph messages and five telephone conversations can be sent over it simultaneously.

Under Major-General Squier, the Signal Service of the Army has expanded, the standard of operation and maintenance has been kept high, so high that our own Signal Corps has had to acknowledge none as superior.

He is a graduate of West Point, secured his Ph. D. in physics at Johns Hopkins and has done considerable research under Rowland and Preece. His name is frequently linked with Marconi, Fessenden, De Forest, and Armstrong as one of radio's great. With the active duties of army life no longer pressing on him, General Squier may be able to devote his time exclusively to research in his chosen field of radio and electricity. And one may say . . . "Well done, good and faithful servant."

A New Standard for Wavelength Measurements

EVERY intelligent radio listener is interested to know that the frequency of radiation from a given broadcasting station is so constant that its signals may be used as a wave-length standard. But he is



A CLASS IN THE "UNIVERSITY OF THE AIR"

In the junior high school 61, New York City. The assorted students are listening to a special lesson in music being broadcast from the Metropolitan Opera House, New York

THE CHRISTUS OF THE PASSION PLAY BROADCASTS

From his room at the Waldorf-Astoria through WJZ. Anton Lang is almost the only member of the Oberammergau Passion Players who can speak English. Thomas A. Cowan is the announcer and H. V. Higgs is the operator at the speech amplifier panel

perhaps curious to know how this standard measurement is made. The signals of the station are compared with a standard wavemeter, of course.

But how are we to know that this standard wavemeter really stays standard? By comparison with other standard wavemeters, you suggest, just as the mariner used to judge the accuracy of his chronometers. He used three of them and compared one with the other. Of course nowadays the chronometers are tested for accuracy each day by means of the radio time signals sent out from many stations for just that purpose. These signals themselves come from a "standard" clock, however. How do we know that the clock is right? This clock is adjusted by comparison with the time taken for a revolution of the earth, as measured by the passage of certain stars through the meridian. The earth itself is a great clock of such extremely great mass that its rate of rotation may be assumed constant.

What corresponding standard do we have for the radio wavelength? A wavemeter is nothing but a resonant circuit, the resonant frequency of which is determined by the inductance of its coil, and the capacity of its condenser. How do we know whether or not these change? In general, we tell this by the same method the old sailing master used to employ with his chronometers. We compare several coils by very accurate measurement. If their comparative inductances stay the same, we are reasonably sure in saying that each of them is staying constant; for the condensers, we make similar comparisons.

But is there some other method, avoiding entirely the use of coils and condensers? The mariner eventually leaves his chronometers and goes to the earth's rotation for his standard time. The satisfactory use of some substitutes for the usual inductance-capacity standard wavemeter has occurred several times lately. By sending high frequency current through a pair of wires ("wired wireless") and adjusting this frequency to the right value, standing waves can be set up on the wires just as stationary waves can be set up on a stretched rope if its end is shaken up and down with just the right frequency. The length of these standing waves can be very accurately measured by a vacuum tube detector. Then, on the assumption that the waves travel along wires with the same speed as they would if they were as free as are actually radiated radio waves, the frequency of the vacuum tube oscillator which is furnishing the power for the test, is accurately known. A wavemeter may then be accurately calibrated for this one frequency; other points may be calibrated in similar manner after the length of the standing wave has been changed.

Another scheme starts with frequencies which are sufficiently low to be counted. The rate of vibration of an electrically driven tuning fork for example, can be measured to $\frac{1}{100}$ of 1 per cent. if sufficient time and apparatus are available. A vacuum tube may then be excited in some way by the oscillation of this fork. This fork might vibrate a microphone.

If the apparatus is properly arranged, it will generate frequencies not only the same as that of the fork (which is accurately known) but frequencies of every multiple of the original. Thus, if the fork is vibrating 1,000 times per second, the frequencies of current generated by the tube will be 1,000, 2,000, 3,000,—15,000—100,000 etc. Every frequency will be some exact multiple of the fork frequency.

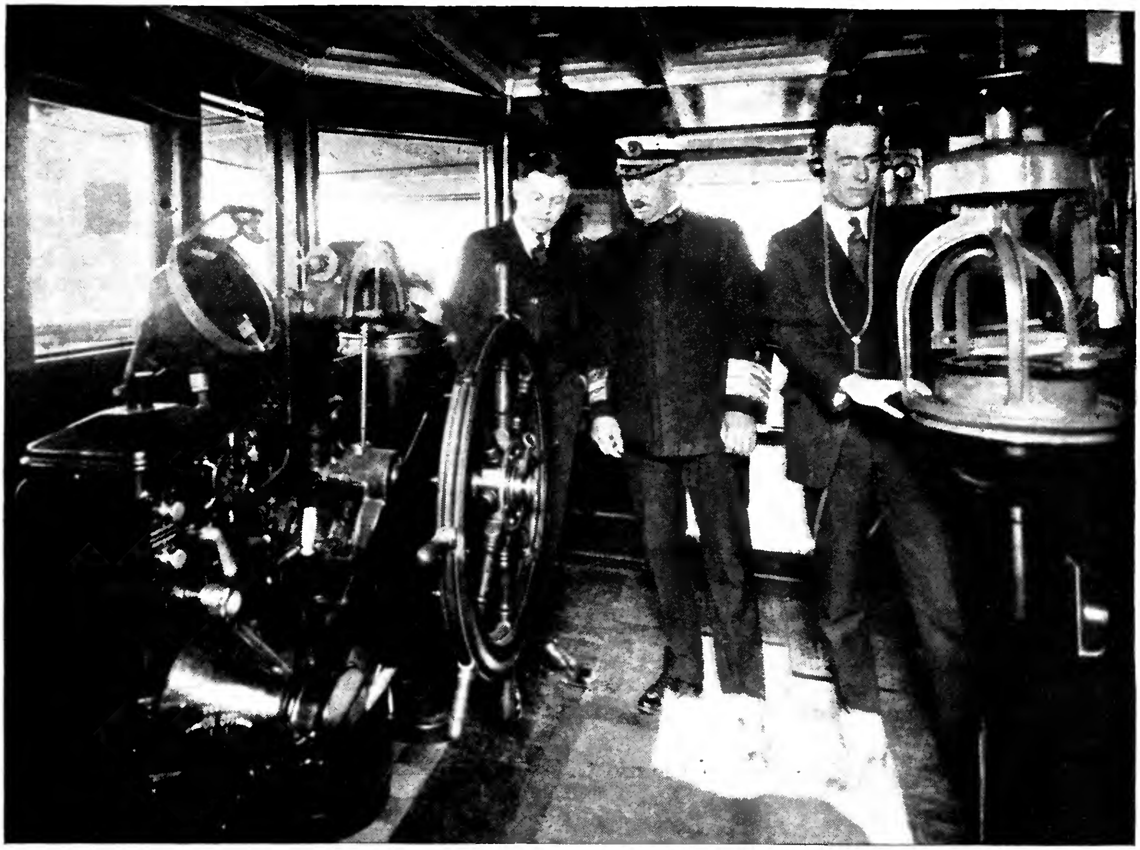
If now some other device, like the fork, were available which would vibrate at some accurately known frequency of about 100,000, then we could use it as we do the fork, for getting many more and higher frequencies, each being a multiple of 100,000, so our wavelength standards would be extended right up into the broadcasting band of frequencies.

GENERAL GUSTAVE FERRIÉ
One of the powers behind radio in France. He is head of French military radio and was instrumental in its rapid development since and during the war

Certain crystals, notably quartz, Rochelle salt, tourmaline, and a few others, have the remarkable property of changing their shape when put into an electric field. The change in dimensions is not sufficiently large to be seen by the unaided eye, but this change nevertheless occurs. For example, if a small piece of Rochelle salt be put between the plates of a condenser which is receiving let us say, a 1,000,000-cycle signal, that little crystal will be changing its shape just that number of times per second.

This effect, which is covered by the term, *piezo-electricity*, has been known for many years, but no important application had so far been made of it. During the war several experimenters at Columbia University, as well as others working in Europe, showed that it was possible to use this phenomenon advantageously in building a submarine detector and much more research was carried out to examine *piezo-electric* effects more closely.

A slab of quartz crystal, properly cut with respect to the axes of the crystal and excited by an electric field of the proper frequency, may be made to grow longer and shorter at this frequency to a remarkable degree. It may be made to vibrate so violently that the slab actually pulls itself into two pieces in spite of the rather high tensile strength of such a crystal. If the slab of quartz is ground smooth, with square edges, it is found that the frequency of the impressed electric field must be within a very small fraction of 1 per cent. of a definite value (this depending on the size of the slab)



"METAL MIKE" AND THE KOLSTER RADIO COMPASS

Aboard the SS. *Maui*, on the San Francisco-Hawaii run. "Metal Mike" is the affectionate nautical term for the Sperry gyroscope steering device. V. Ford Greaves is at the right, operating the Kolster radio compass and position finder. Elmer Sperry, Jr., who was recently drowned in the English Channel, is demonstrating his steering device to Captain Peter Johnson, commodore of the Matson Navigation Co. fleet

to get maximum amplitude of vibration of the slab. Thus with a certain slab about two inches long and half an inch wide, a frequency of the electric field of perhaps 50,000 cycles per second would give a scarcely perceptible vibration, but 50,500 cycles would result in vibrations so violent that the slab would break itself in two.

Evidently then a piece of this *piezo-electric* quartz might do as a frequency standard. Several workers in this field have recommended the adoption of quartz for this purpose, and a paper showing the feasibility of this was given before the Institute of Radio Engineers some time ago. More recently, a paper by Prof. Pierce of Harvard, gives the results of a very careful investigation of the possibility of such a frequency standard; he examined the effect of temperature, and other variables, on the natural period of oscillation of the quartz, and as a result believes that these little slabs of quartz will give us our most reliable frequency standards. Once calibrated by the tuning fork method outlined above, they will remain permanent for all time. They will not be able to measure directly the frequencies used for broadcasting, but work well up to perhaps 500,000 cycles per second.

It is not at all impossible then that a laboratory will be sending to the Bureau of Standards, in the near future, a half dozen pieces of suitably cut pieces of quartz crystal, for calibration. They would be about the thickness of the lead in a pencil and perhaps $\frac{1}{4}$ inch long. When these have once been accurately calibrated, they need never again be checked; in connection with a vacuum tube oscillator they will serve as the laboratory's absolute standard of frequency.

J. H. M.

How to Increase Your Range

By Using a Simply Made, Simply Operated, and Very Cheap Tuned Radio-Frequency Amplifier that May be Added to Any Receiver

By ARTHUR H. LYNCH

THERE are two very good reasons for the increasing popularity of the tuned radio-frequency amplifier. First it makes for reception over longer distances than are possible without it, and second, it increases the selection power or sharpness of tuning of the receiving system in which it is employed.

Then, too, it usually permits loop operation where an outdoor antenna would be required without it, and there are many advantages to be gained by receiving with a loop. So much has been written on this subject that we may well pass it over with little more than mention.

Another advantage of the amplifiers we are to consider is that in addition to improving reception for *you* they cut out one of the most serious sources of interference for people in your vicinity. By the addition of the radio-frequency amplifier it is possible to have your receiver oscillating without re-radiating into the antenna. This remarkable result is brought about by taking advantage of the vacuum tube as a one-way valve. That is, it will pass current into your receiver but will not let it pass from your receiver back into your antenna. Thus, you may whistle and squawk to your heart's content without bringing the wrath of your neighbors down upon you.

But that is aside from the main issue, which is the improvement of your range and tuning, so let's get down to cases and find out how many ounces of efficiency comes wrapped up in the package of units for building our amplifier. First let us make a list of the necessary parts.

WHAT YOU NEED

1 Panel (Unless there is room on your present panel)

1 Tube Socket

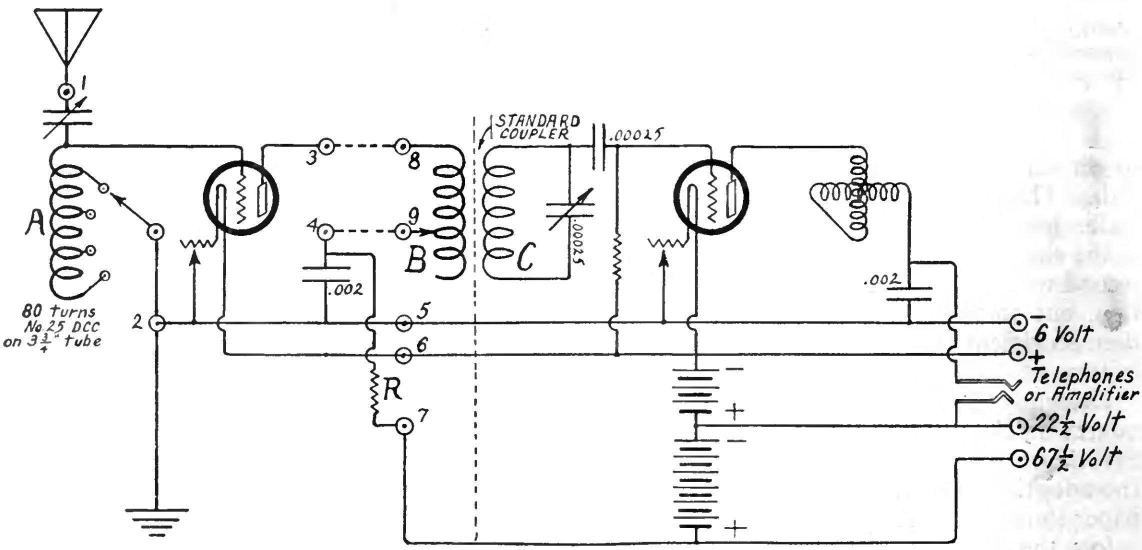


FIG. 1

This is the circuit arrangement for applying the stage of tuned R. F. to a loose coupled regenerative receiver such as the Paragon RA–10, the Zenith, the Grebe CR–3 and the Cutting and Washington. For loop operation it is but necessary to connect the loop between the binding posts 5 and 6, and for use with any of the honeycomb coil sets the antenna and ground posts are connected to the posts 3 and 4. Any single circuit receiver may be employed with the tuned R. F. amplifier by merely connecting the antenna and ground posts together by a piece of wire and placing the output coil on top of or beside the box as shown in Fig. 3

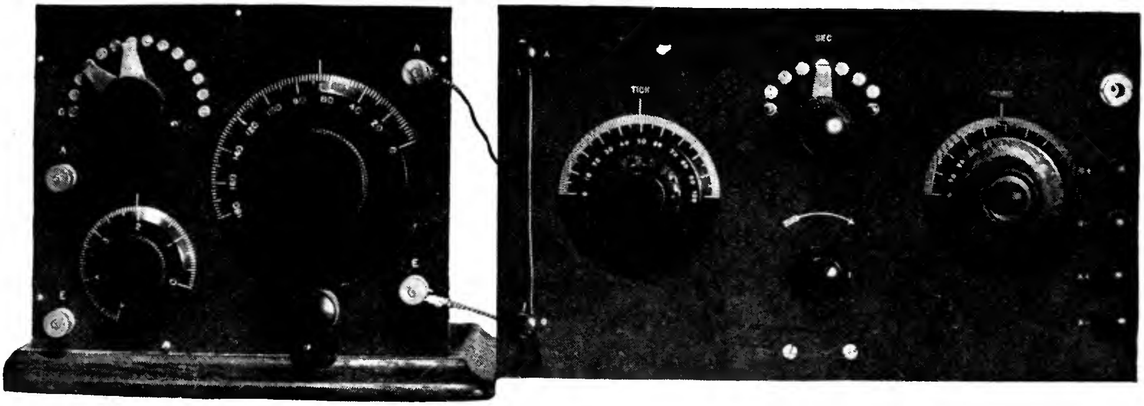


FIG. 2
With a single circuit receiver, the tuned R. F. amplifier is used with an easily made output coil. A piece of bus wire is then connected between the antenna and ground posts as shown here

1 Rheostat (25–30 ohm)
1 Variable Condenser
1 Cardboard or Formica Tube 3¾″ O. D.
1 Baseboard
1 .002 Fixed Condenser
1 330 Ohm Choke (Or any 330 ohm inductive potentiometer)
1 .00035 Variable Condenser.

THE LAYOUT

IN A device of this kind there is a great latitude within which you may work, and the actual placing of the units is a matter of relatively little importance, depending upon just how you wish your amplifier to match up with your other equipment.

If you want a unit for application to any type of receiver, you may follow the layout illustrated in the accompanying illustrations. If, however, there is a certain amount of space into which you desire to crowd the amplifier, you may change the position of any or all of the parts without experiencing any serious trouble.

WITH THE THREE-CIRCUIT RECEIVER

FOR use with any receiver employing a vario-coupler the arrangement shown in Fig. 1 is advisable. Here the primary of the coupler acts as the output coil for the R. F. amplifier and the secondary of the coupler is tuned by the variable condenser across it or the variometer in series with it, as the case may be.

FOR USE WITH OSCILLATING RECEIVERS

AS DESCRIBED in Mr. Bouck's article on page 365 the so-called single-circuit receivers are all of an oscillatory character. It should be understood that the use of a vario-coupler in such circuits does not make them loosely coupled. In fact, the vario-coupler in

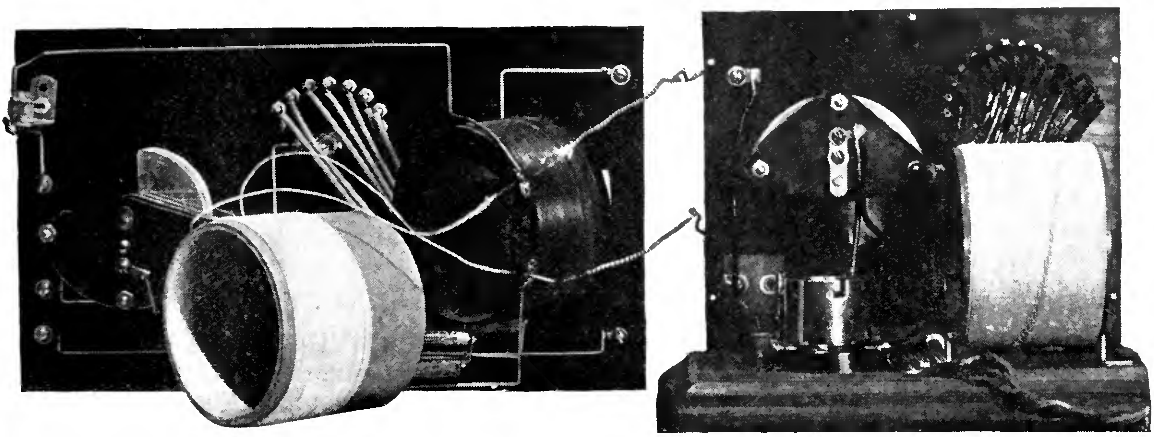


FIG. 3
Even as rudely constructed an output coil as the one above will perform satisfactorily. It need only be placed in inductive relation to what was previously the antenna coil of the single circuit receiver

such circuits is not technically a coupler in the usual sense, and the circuit arrangement illustrated in Fig. 3, should be used. In order to procure the proper coupling between the amplifier and any type of single circuit receiver, an output coil is used to replace the primary of the vario-coupler. (Coil B in Fig. 1).

The output coil is made by winding 45 turns of No. 25 D.C.C. wire on a cylinder having an outside diameter of 3¾ inches. This coil should be equipped with a switch and 3 taps—one at 15 turns, one at 30, and one at 45 turns.

The antenna and ground posts of the single-circuit receiver are then connected by a piece of wire as shown in Fig. 2 and thus a closed circuit, capable of tuning, is formed. It is, in effect, similar to the secondary circuit of Fig. 1 and the output coil acts as the primary.

An amplifier of this type is easy to build and easy to operate, it is worth its weight in gold for increasing the range of your receiver, increasing selectivity, reducing interference from undesired stations, and last, but not least, it prevents your receiver from "blooping" for which your neighbors will forever call you blessed.

What We Think the Public Wants

By E. F. McDONALD, JR.
Zenith-Edgewater Beach Station, WJAZ, Chicago

THERE has always been a considerable division of opinion about what the public really wants in radio broadcasting. Many broadcasters thought most listeners wanted jazz, and others felt that a predominance of classical music would be most pleasing to their listeners, and so on. A survey of the daily radio programs gave proof that the station owners or operators had widely differing notions. They must have arrived at their judgments by some mysterious individual speculation. As for ourselves, we knew no just estimate could be arrived at through the desultory method of making inquiry here and there; nor could we rely much on the daily hundreds of letters from listeners. Constructive suggestions in letters were all too few.

So the idea of a scientific investigation developed among the three Chicago broadcasters. It was decided to put the question up to the entire radio audience. What kind of radio entertainment do you prefer? The three Chicago stations, Westinghouse Electric and Manufacturing Company Station KYW, the Chicago Board of Trade Station WDAP and the Zenith-Edgewater Beach Hotel Broadcasting Station WJAZ joined in the undertaking. Concretely the test took the form of "The Listeners' Vote Contest" and was staged during the recent Chicago Radio Show.

The public displayed interest which quite surprised all of us. It had an opportunity to make its wants known, and did so in no uncertain fashion. For a period of twelve days, at frequent intervals, during each daily broadcasting period, the listening audience was asked their choice of classical, popular, jazz, instrumental, vocal music; of religious, political, educational talks, etc. Active participation on all sides was invited on the ground of influence which the general vote would have, not only on radio programs for the time being, but on the future of radio. That was the major inducement. The three stations also offered another incentive to the listener in many prizes such as complete radio sets and radio parts. A veritable flood of responses deluged the three stations. The personnel gasped at the tons of mail that had to be counted and sorted, tabulated and analyzed in several different ways. Office help was multiplied twenty times and mail order house activity reigned those twelve days where before had been the quiet repose and dignified atmosphere of the musical studio. A careful count places the number of letters received by all three stations at 263,410.

ONE LISTENER OUT OF FIFTY ANSWERED

CONSERVATIVE advertising men of broad experience with whom counsel was taken, agreed that not more than one person in fifty will respond to the most attractive advertisement or prize contest. Accordingly, the listening audience of the three large

Chicago broadcasting stations may be safely estimated at 13,170,500. WJAZ, the Zenith-Edgewater Beach Hotel Broadcasting Station, claims the largest audience—8,534,950. The number of replies received by this station alone was 170,699 of the total of 263,410. In one day this station received 20,152 pieces of mail, representative of an army of listeners upward of a million, scattered in all directions, but yet, considering both intensity of population and degree of distance, pretty well represented every state of the union, the Islands, Canada, Greenland, Central and South America.

A QUARTER OF A MILLION LETTERS

Are in these bulging mail bags and the wire cage. During the twelve days of the "Listener's Vote Contest" recently held in Chicago, stations WJAZ, KYW, and WDAP received letters from every state in the Union, Alaska, Canada, Mexico, Cuba, Bermuda, and Central America, each bringing its suggestion of what the radio programs should be. Miss King and W. J. Hermann, both of Chicago, are shown in the photograph

WHAT THE VOTE SHOWED

AN ANALYSIS of the vote revealed several things which surprised us. Perhaps the most outstanding is the marked taste of our "voters" for classical music. The partisans of classical music exceeded only by six per cent. (of the total voters) those who preferred the popular. More men than women voted. The proportion was 67.4 per cent. men and 32.6 per cent. women. This gives some color of reality to the frequently asked question of the irrepressible cartoonist as to whether the women of the land prefer their husbands at the club until midnight or at home listening to the radio until two.

In none of the announcements of the vote contest was reference made to old songs, yet 5.7 per cent. of the votes specifically asked for them in preference to all else.

Independent deductions can be made from the following tabulation of the vote.

2.7%	desire	Band Music
24.7%	"	Classical music
2.9%	"	Dance music
.3%	"	Dramatic music
1.0%	"	Hawaiian Music
18.4%	"	Jazz
.3%	"	Mexican music
.3%	"	Male solos
5.7%	"	Old-time songs
1.7%	"	Grand opera
.9%	"	Orchestra
.5%	"	Pipe organ
29.0%	"	Popular music
.3%	"	Quartette instrumental
.2%	"	Male quartettes
.8%	"	Mixed quartettes
.5%	"	Religious music
2.1%	"	Sacred Music
.7%	"	Saxophone
.6%	"	Symphony music
2.1%	"	Vocal selections

At WJAZ, we have from the first felt that a well balanced program over-emphasizing no one thing and one which gave particular attention to the best in music, was what the public, or at least our public wanted. And our previous estimate, together with the figures from the test vote shows that desire for the better music is growing stronger. Like a good book, good music unfolds additional beauty and charm in the repetition. The flimsy character of jazz and most of the cabaret type of music we generally acknowledge. All the music in that category serves its purpose, such as it is, and probably will never lose popularity of a sort. But the real substance, what may well be called the meat and potatoes of the musical menu, is that which appeals to the higher intelligence and finer emotions. Thus we reasoned from the very inception of station WJAZ. The recent vote proved we were pretty nearly right. From its first day "on the air," the Crystal Studio of WJAZ was devoted entirely to the best in music, and eventually became known as one of the dependable sources of classical music in the realm of radio. The Oriole Orchestra in the Marine Dining Room which alternates with the Crystal Studio supplies entertainment in lighter vein, and furnishes whatever popular "relief" the program needs.

Greater familiarity with good music is developing partiality for it. The talking machine has been an important factor in music's advance. Popular bands insinuating better music at every opportunity have helped much. And now radio with its all pervasive influence, more than any other agency, is bringing classical music into its own. In former days, when only the well-to-do could afford to hear so-called artistic music, they alone evinced any general desire for it. But now radio gives equal opportunity to people in all walks of life, no matter how lowly, to hear the best music, there is a commensurate growth of general appreciation for it. When Miss Florence Macbeth of the Chicago Civic Opera sang a series of operatic selections on Saturday evening, December 23, more than 5,000 letters of thanks were written to her.

Here is a sample program from our station:

1. *Sobbing Blues*
   Faded Love Letters — Orchestra
2. *My Lovely Celia* (Old English)—Munro.
   The Pretty Creature (Old English)—Storace — Baritone Solos
3. *Souvenir de Moscou*—Wieniawski
   Mazurka—Mlyuarski — Violin Solos
4. *Where 'Ere You Walk*—Handel — Baritone Solo
5. *Berceuse*—Chopin
   Ballade—Chopin — Piano Solos
6. *Silvery Moon*
   Marcheta — Orchestra
7. *Do Not Go My Love*—Hageman
   Minor and Major—Spross — Contralto Solos
8. *Sonata, D Major*—Mozart — Violin Solo
9. *Sunshine of Mine*
   Pekin — Orchestra
10. *My Heart At Thy Sweet Voice* (Samson et Delilah)—Saint-Saens — Contralto Solo
11. *Liebestraum*—Liszt
    Etude—Chopin — Piano Solos
12. *Retreat*—LaForge
    Pirate Song—Gilbert — Baritone Solos
13. *Londonderry Air*—Kreisler
    Rondine—Beethoven-Kreisler — Violin Solos
14. *Susie*
    Wonderland of Dreams — Orchestra

Twenty years ago this program would have been branded as high-brow, and as intended solely for the ears of high society. Now it is every day diet, for the consumption of the radio audience in the lumber camps, on the plains, in the rural districts, in the tenements, and homes, and clubs of the city dwellers, the largest number of whom within the influence of the Chicago broadcasting stations, we think, pay radio allegiance to Station WJAZ. And we are sure our judgment of programs is responsible.

Even before the Listeners' Vote Contest, we had thousands of testimonial letters from all parts of the country, some written in aristocratic hand and on crested stationery; some on the letterhead of the business or professional man; some in pencil on soiled paper in illiterate fashion, but all giving testimony of how the human heart whether in the mansion or in the hovel beats response to good music. Those letters gave lively encouragement to us to continue as we had set out. But it could not be affirmed that these letters were representative of the majority opinion. Our judgment of popular approval, however, was definitely substantiated by the acid test; the Listeners' Vote Contest.

1923 Passes in Review

And in Passing Reminds Us that We Have Done a Business of $150,000,000—That the Vacuum Tube Business Alone Is One Fifth the Value of the Incandescent Lamp Business—That Our Entire Nation Has Heard Three of Its Presidents Speak and Suggests the Question "Who Pays?"

By J. H. MORECROFT

Professor of Electrical Engineering, Columbia University

As we look back over the accomplishments of radio broadcasting during the year just closed we can certainly feel that the rosy predictions ventured at the beginning of 1923 have been well vindicated. It doesn't seem possible for radio to continue to develop at such a rapid pace during the next few years, but then, who can say? There are still many important questions to be solved, such as—Who is going to pay? but the lack of a solution for these problems apparently does not act at all to prevent continued rapid progress.

INCREASE IN IMPORTANCE OF RADIO'S MISSION

As we try to put into their proper perspectives the various features of radio broadcasting which have shown development during the past year those broad questions dealing with the general utility of radio to the people at large loom big in the foreground. Is radio forcing itself upon the people of our country as a necessary part of their every-day life, or has it remained the plaything of enthusiastic youth and a source of income for a few small dealers in radio parts? The answer is, of course, evident. During the past year the people of the United States by the hundreds of thousands, have listened to the voices of three of their presidents, an event which Radio Broadcast spoke of a year ago as one of the great benefits radio was sure to bring to the American people.

HARDING

The deep, resonant voice of the late President Harding was heard by more of his people than had been that of any former president. This may seem like an exaggeration when we think of the way the people used to flock to hear Theodore Roosevelt; always he spoke to crowded houses but even so, the number who heard him remains comparatively small. An audience of five thousand people is a large one; it takes a very powerful voice to be heard by such a group of people, yet when Harding spoke to the few thousands in the auditorium at St. Louis, for example, he had an invisible audience of five hundred thousand, conservatively estimated. This is as many people as Roosevelt could have addressed in possibly two hundred and fifty packed meetings, in the larger cities. In the words of the physicist, the size of the President's audience of to-day is of "a different order of magnitude" than it was three short years ago. It is five hundred times as great.

WILSON

Not only did we hear President Harding plead with his countrymen to see the grave situation of the world with him, eye to eye, but we heard that great exponent of idealism, Woodrow Wilson, pour forth invective on

---

Looking Back Over the Year

Says Professor Morecroft, "In spite of some disappointments, if the next few years give us as much improvement and advance in radio broadcasting as the one just ended has done, it passes our imaginative powers to predict what its status and service may become."

Radio Broadcast now presents this review of radio in 1923 after the accomplishments have had time to be soberly weighed and balanced. It is doubtful that any one person in the radio art is better able to picture for us what has gone on in radio during the past year. His treatment of this vast subject is concise, clear, and very much to the point. It will give you some idea of what has been and what may be done with our infant giant.—The Editor.

THE FIRST PRESIDENTIAL BROADCASTING
The late President Harding at the microphone in St. Louis, June 21, 1923

those responsible for failing to further the close international relations which he endeavored to bring into being. A remarkable example of what radio can do, was that short address of Woodrow Wilson. Due to the excellent engineering preparations of the telephone company's staff, his voice was carried by the ether ripples so faithfully that we could almost imagine he was in the same room with us. Never before (or since, it seems) have we had such a demonstration of radio's ability to conserve the quality of the human voice as it is thrown over hundreds of thousands of square miles of our country.

COOLIDGE

MORE recently we heard our present Chief Executive deliver his message to Congress, in that cool, matter of fact, modest fashion, which so well exemplifies his character. It is incomparably more interesting to hear the message delivered than to read it in the next morning's paper. We now regard it as an established custom that when any thing of great moment is taking place in the national capitol, or anywhere in the country, for that matter, we shall be "let in on it."

LLOYD GEORGE

AND not only have we heard our own leaders but hundreds of thousands had the privilege of listening to one of the world's cleverest statesmen, the one man who was able to hold his high position secure during the entire duration of the World War. Lloyd George might have addressed possibly fifty thousand people in his tour of this continent, without the help of radio; as it was, probably one million Americans heard the persuasive voice and telling arguments of the little Welsh statesman.

All this has been accomplished in an art which, only a dozen years ago, was regarded as so undeveloped that several unscrupulous promoters were seriously in danger of a long term in the Federal penitentiary for trying to sell radio telephone stock; the enthusiastic circulars promised large returns from a field of such dubious possibilities that Uncle Sam regarded the men involved as either criminals or fools. Of course such a company as that which runs WEAF can still vouch for Uncle Sam's judgment being sound when he brought to the bar of justice the promoters who so glibly proved their anticipated profits from the radio telephone game. Most broadcasting stations, as a matter of fact, would be glad to-day to have these same promoters step in and show them how to make money on their stations. Most of them have their accounts on the wrong side of the ledger and there is no one to-day with vision keen enough to point out to us how some of the items may be shifted to the other side. This is one problem which 1923 has seen fit to leave to its successors.

INCREASING THE EFFECTIVE AREA OF BROADCASTING

NOT only have the events which radio has broadcast during the past year been of continually increasing importance, but the distances covered have almost equally been extended. In the deep Colorado canyon, the engineering explorers were able to tap the all-pervading ether and listen to the activities of their fellows in spite of the fact that 2,000 feet of impassable cliff separated them from the earth's surface, and miles upon miles of falls and rapids lay between them and us, whether they proceeded down the river or returned. And from near the North Pole McMillan actually talks to his club members in Chicago and dedicates their new club house for them; at Christmas time he listens to the voices of those of his kin he has left behind. But at the same time another explorer has entirely disappeared, in so far as radio is concerned; although he had radio equipment to keep in touch with home, an impassable barrier of some kind throws back Amundsen's radio waves to the region whence they started. While McMillan seems only a short distance away from us, Amundsen has apparently sunk into such an ether pit that his signals cannot possibly get out.

AID TO EARTHQUAKE SUFFERERS

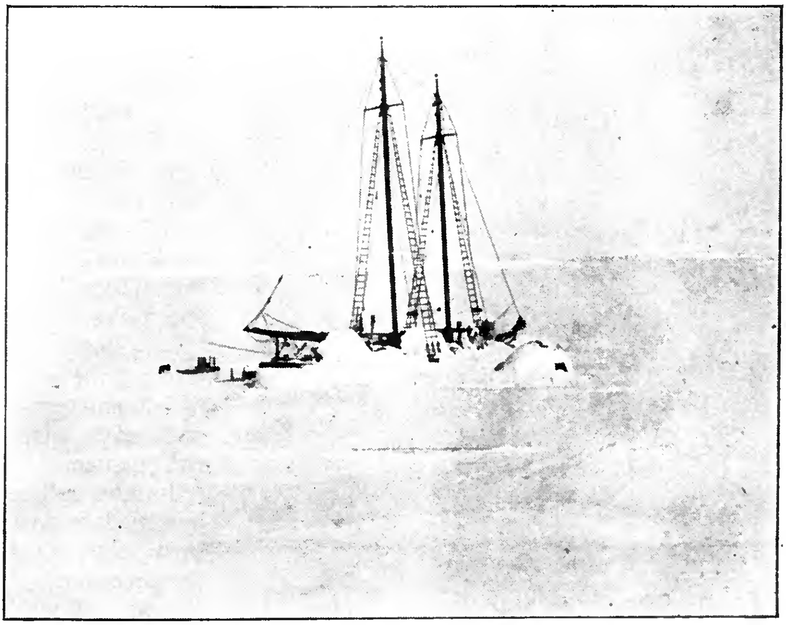
IN JAPAN'S earthquake crisis, radio was the only link by which these people could tell us of their trouble and needs. Cables were twisted and broken by the convulsed bottom of the sea. Only the unbreakable fields of the electrons remained to transfer communication over the thousands of intervening miles. Such prompt aid as we were able to offer must have been seriously delayed had it not been for this radio link which kept us in touch with stricken Japan.

HOLIDAY RUSH TO EUROPE

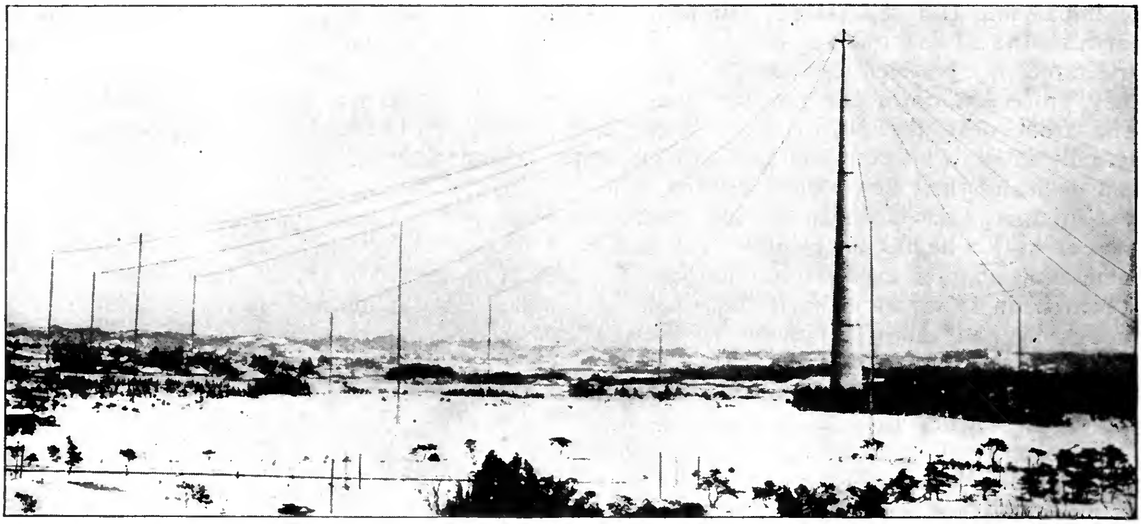
IT IS interesting to note that during the Christmas holidays the messages of good cheer from Americans to their European kin piled into the Radio Corporation's office at such a tremendous rate that even the ether seemed to be taxed to carry its burden. Thousands of those living in our land of plenty were trying to cheer their friends and relatives in Europe (especially those in Germany) during the season that should have been festive for everyone. The messages to Germany accumulated at such a rate that the traffic manager surely would have been overwhelmed had it not been for the flexibility of the radio links. No sooner had the stations transmitting to England, Norway, and Poland been freed of their traffic than they were all put to the task of sending *Fröhliche Weinachten* and *Glücklickes Neu Jahr* to the German receiving operators. Five powerful stations all concentrated their ether missiles on that part of the earth's surface and so the abnormal traffic demands were easily taken care of. Such a rapid shift of channels would probably have been impossible with any other means of communication.

VOICES SPAN OCEAN

OF EVEN greater significance than these feats of the powerful ocean-spanning radio channels is the successful attempt of the broadcasting stations, both professional and amateur, to throw the human voice across the Atlantic. Although the results were not as satisfactory as we had fondly hoped for, still they showed that such communication is possible under good conditions and that as we make the transmitting apparatus more powerful, and our receiving apparatus more free from disturbing influences, talking across the Atlantic will be an everyday occurrence. But a single month after the close of the trans-ocean broadcast tests English listeners heard



THE "BOWDOIN" FROZEN IN FOR THE WINTER
It is in this icy expanse that radio has penetrated to "lift dread monotony"



RADIO STATION JAA WAS THE ONLY LINK JAPAN HAD WITH THE OUTSIDE WORLD
This antenna, strung on 660 foot masts, with 500 kilowatts behind it, saved unnumbered Japanese and foreign lives in the recent great earthquake. Land lines and cables alike failed, while radio carried on

a complete concert from this country and rebroadcast by their own stations.

GOVERNMENTAL ACTIVITIES

DURING the past year radio broadcasting benefited greatly from Government acts which were a long time coming. The reallocation of wavelengths for broadcasting, even though confined to a much narrower band of frequencies than we think broadcasting is entitled to, was a great boon to those who want to hear distant stations, as well as to those who are situated close to several stations. The unbearable condition which existed when but 360 meters and 400 meters were available to the broadcasting stations has vanished, and, with the exception of a very few who live within the shadow of a powerful station, and a somewhat greater number who have yet to learn how to operate their sets selectively, interference has been practically done away with, in so far as it was due to the broadcasting stations themselves. We do occasionally hear a whistle due to the beat note between the carrier waves of two distant stations, but often one of the stations is operating at a frequency appreciably different from that assigned to it by the Government.

THE BUREAU OF STANDARDS' WORK

THE Bureau of Standards has pursued a worthwhile work in trying to change our wavelengths to frequencies, our meters to kilocycles. The advantages of speaking in kilocycles, instead of meters, has been well analyzed in RADIO BROADCAST on previous occasions, and is so evident that even though the radio public is loath to throw over any of its newly acquired radio terms, and replace meters with kilocycles, the change seems sure to come about, even though slowly. Especially to the technically trained radio engineer this change in terms is appreciated to be a forward step in radio nomenclature.

It wasn't long after the radio boom started before the Bureau of Standards was flooded with requests for the calibration of radio apparatus. Now, although this is exactly the kind of work the Bureau is supposed to carry out, the staff was altogether inadequate to satisfy the demands for calibrations, and it could not be sufficiently augmented by trained technicians because of the very meager salaries the Government offers to those entering the lower positions at the Bureau. Naturally most of the work called for was the calibration of wavemeters, for every responsible operator realized at once that he must know accurately the frequency his station was sending out.

Besides calling to its aid several of the University laboratories, in carrying out this calibration work the Bureau decided to follow the precedent established by the French during the war, of sending out, periodically, standard frequency signals; thus instead of the wavemeters being shipped to the Bureau of Standards for wavelength calibration the standard frequency was delivered direct to the customer, and he could do his own calibrating. Circulars were sent out recommending certain reliable methods of utilizing these standard frequencies.

This service is one of the most valuable, if not the most valuable, the Bureau has contributed to the radio art; it is still maintained on regular schedule, as it should be, and is now being further augmented by the Bureau sending out the frequency of those broadcasting stations which are maintaining their specified frequency within a reasonably narrow limit. This "standard frequency service" of the Bureau will do much to improve the situation in broadcasting in so far as it is affected by the beat notes between carrier waves of different stations.

BROADCASTING AID TO THOSE IN TROUBLE

DURING the past year radio has, on innumerable occasions, proved itself a genuine contributor to human safety. How many shipwrecks have occurred during the last twelve months in which radio has well played its assigned rôle? We must reckon by the hundreds, the lives of those shipwrecked passengers and crews who have been speedily picked up by a vessel which, perhaps a hundred miles or more away, was called to the scene of the accident by the appealing SOS call of the stricken ship. This, the greatest of all the services radio is carrying out for us, goes on now as a regular part of our daily life, and we know nowadays that, except under the most severe weather conditions, a wreck at sea does not necessarily mean the loss of a single life.

SERVICE TO THE INDIVIDUAL

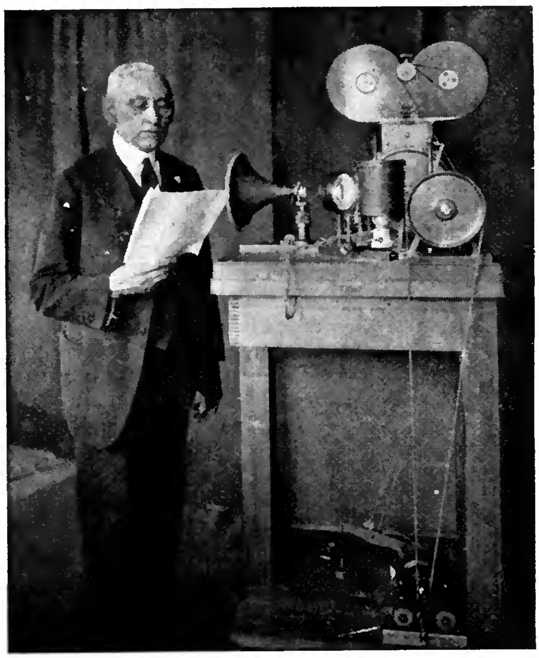
THE number of cases of service rendered to individuals by radio, and to the Government when it is seeking criminals, steadily mounts. The well known radio engineer, E. F. W. Alexanderson, himself, was well repaid for his contributions to radio's progress when his kidnapped son was found through radio broadcast messages. No longer can the criminal escape the law by booking, immediately after his crime, passage on a European-bound steamer. Even before she has passed from sight of our shores a description of the escaping man is being received in the ship's radio room and he is more securely trapped than if he had never left the country.

RADIO COMPASS

IN SPITE of the wonderful radio compass service the Government has adopted, a few months ago, our navy had the most disastrous accident ever put into its records. Six destroyers piled up on the rocky coast of California in spite of the fact that radio compass bearings were available and should have neutralized the risks of navigation which fog and storm had imposed. We have never had evidence however that radio did fail in this accident; it seems more than probable that the man responsible for the disaster depended upon his intuition rather than the certain guide of the compass bearings which were his for the asking. Thousands of ships are now safely navigated in foggy weather by the help of this service. The number of accidents averted by its use are beyond reckoning.

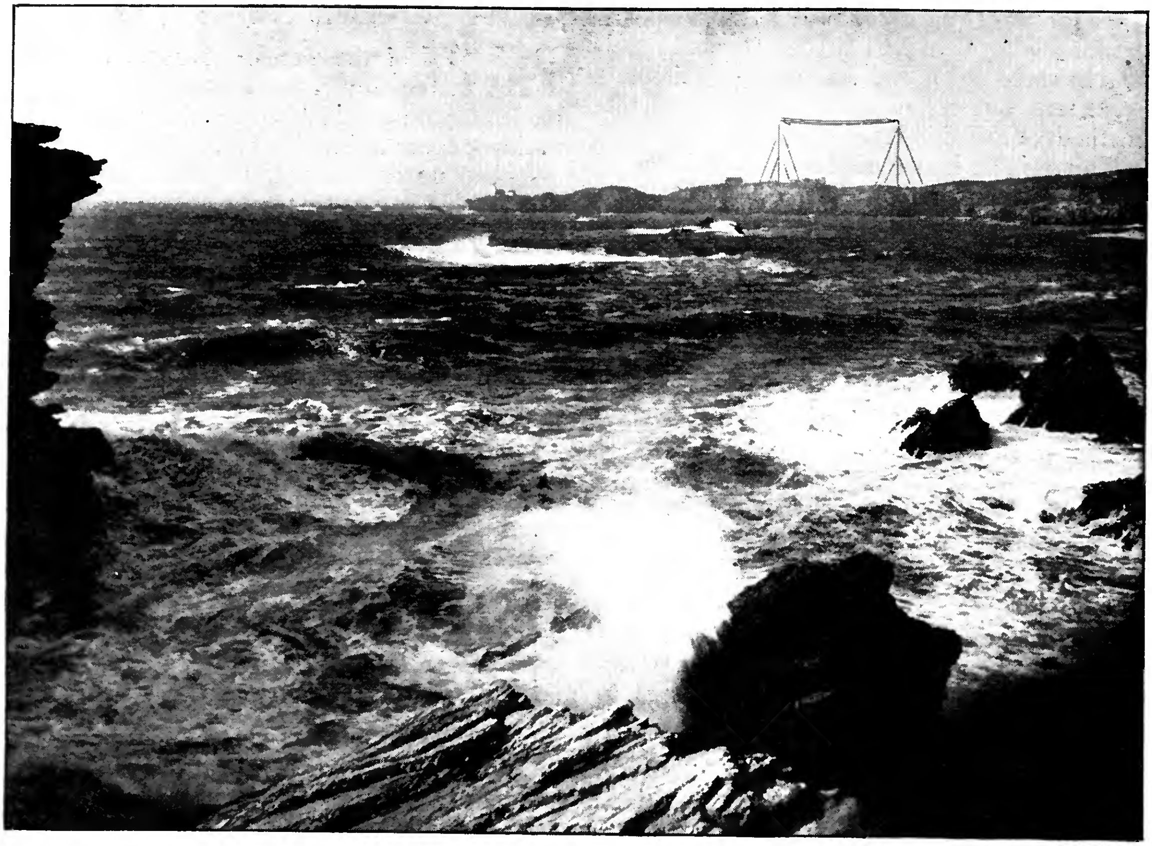
HEALTH OF BODY AND SOIL

THE Government's health service talks, its spread of the news valuable to farmers telling of the weather to be expected and what products he can profitably dispose of in the morrow's market, its continued radio time service to ships at sea, all have an ever increasing importance in our daily lives.



C. A. HOXIE

Recording his own voice on his own invention — the pallophotophone



THE NAVAL RADIO STATION AT PT. ARGUELLO, CAL.
Near which six American destroyers went on the rocks in heavy weather last year. It was from the radio compass station here that the disputed bearings were asked for and received

IN THE RADIO BUSINESS INCREASES

TO THE business man of America, the radio industry is becoming a power to be reckoned with. According to reliable estimates the total sale of radio apparatus last year was one hundred and fifty million dollars. Only three years ago it was practically nothing. The radio public didn't exist; it was instead the phonograph public putting its money into machines and records, but in these same three years phonographs and records have suffered a terrible relapse. Losses and bankruptcy seem to face the talking machine manufacturers although it is not at all evident that this condition of affairs is necessary; it seems that radio and the mechanical reproducers might have prospered side by side, each aiding the other in getting its share of the public's money, but such wasn't the fact. It has frequently been stated therefore that radio has killed the business of mechanical reproducers. Now it is likely that the real reason for the slump in the record market was due to the comparison we couldn't help making between the two methods of getting the voice and music. As even the phonograph manufacturers must admit, the ordinary record is a pretty poor imitation of the human voice; practically all of them give a very disagreeable scratchy noise and even when they don't the enunciation is seldom distinct enough for one to understand the words of a song, for example, unless it is repeated many times. Contrast with this the reception, with a good pair of head phones, using a crystal or non-regenerative receiver, from a well modulated station. Every word is at once understood, the words of a song, and even *patois*, are well reproduced.

Had the phonograph people been willing and able to improve the quality of their product to make it a reasonable competitor with radio, their business would not have been in the difficult straits it is in to-day.

The sale of vacuum tubes alone last year was about $24,000,000, about one fifth as much as the electric lamp business, a business dealing with one of the necessities of life, about forty years old, whereas the triode business is in its third year.

The quality of the apparatus offered to the radio public was a great improvement over that sold the year before. Then, every small machine shop was turning out coils, condensers, rheostats and what not, and most of it was of quite disreputable quality. These fly-by-night concerns have largely disappeared, leaving more reliable manufacturers in the field, to the great improvement of the product. The company which furnishes most of the laboratory apparatus for radio experiments has improved its products. Practically all of it shows skill and care in design and workmanship.

DEVELOPMENTS IN THE THREE ELECTRODE TUBE

UNDOUBTEDLY the one great improvement which the past year furnished to the radio art had to do with the triode, the really essential part of any transmitter or receiver used in radio communication. The improvement with which most of us are familiar, naturally has to do with the small low powered receiving triode. Instead of requiring a storage battery of considerable capacity to operate our tubes, dry cells now serve. The amount of current required to heat the filament has been decreased to exactly one twentieth of what it was with the older tungsten filament triodes. And this great improvement, it should be pointed out, is really the contribution of pure science. Who would have thought that a layer of thorium only one molecule deep at its thickest part could so easily liberate the caged-up electrons which are needed to make the tube function? A dull-red, thoriated filament, heated with only one sixteenth of an ampere looses practically the same number of electrons as did the old white-hot tungsten filament requiring one and a quarter ampere at twice the voltage used for the new filament. These little dry cell triodes

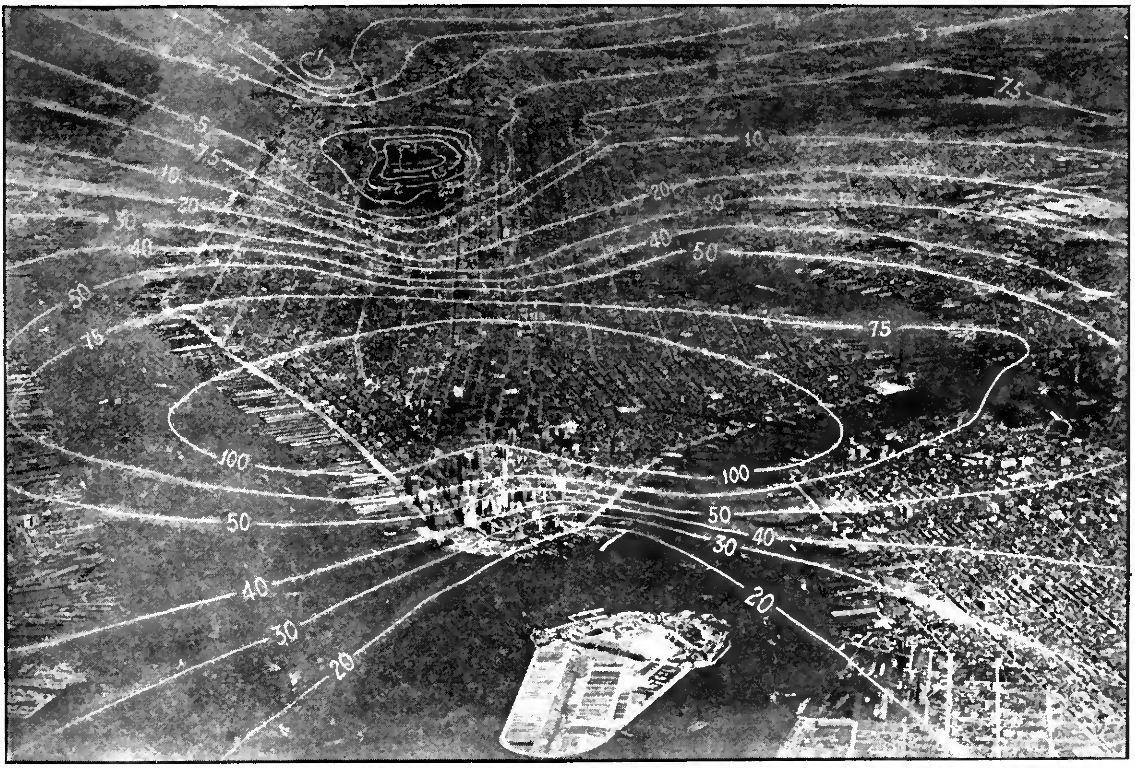


Photo by Fairchild Aerial Camera Corp.

WHAT AN ETHER MAP LOOKS LIKE

The white lines show how the signal intensity, or field strength of WEAF, New York varies. In several sections of the city this station's signals are extremely weak. WEAF is located almost in the heart of the great canyons of the down town high building district. These tall steel buildings seem to cast radio shadows. This aerial-ether-radio map shows the field strength of the station is reduced one fifth at the tip of Manhattan, hardly ten blocks away are the greatest boon of the year, in the opinion of the millions of radio enthusiasts.

And not only in the small receiving tubes was remarkable advance made. Some experimenter with more ingenuity and common sense than the rest of us got the idea that the reason ordinary metal could not be sealed airtight into glass was because the glass pulled away from the metal as it cooled down, thus leaving a fine crack through which air could penetrate. And such being the fact why not make the metal sufficiently flexible at the place it joined the glass that when the cooling glass tried to pull away the comparatively weak metal would follow it? With this very simple analysis of the problem furnished, it was really solved. It is now possible to get airtight seals between big copper tubes and correspondingly large glass tubes, by making the copper very thin where it is to be stuck to the glass.

This simple and ingenious solution of a problem which has vexed physicists for years opened the way at once to the construction of very high powered transmitting tubes, the upper limit of which had previously been fixed by the safe heating of the plate, which was inside the tube just as it is in the ordinary receiving tube. But with the new construction, the plate could just as well be on the outside of the triode, so why not use a metal tube with the filament and grid inside, the metal tube itself being the plate? Such was done, and the plate can now be cooled by partly immersing the triode in running water, a very efficient cooling scheme. Thus at one fell swoop the possible output of high frequency power from the largest tubes was changed from one to one hundred, or even one thousand, kilowatts. A few of these water cooled triodes can replace, and indeed have replaced, one of the huge Alexanderson alternators used for transoceanic traffic.

TRANSMISSION OF POWER BY RADIO

MUCH has been said, not only last year, but in previous years, about the transmission of large amounts of power by radio and it is a most fruitful field for conjecture. Some thought that airplanes could be held in a powerful radio ray, from which it might extract the energy it requires to sustain itself. Again, it has been thought that radio rays might be used, so powerful that by concentrating one on the work of an enemy the undesired object would at once be consumed. No real advance has been made in this problem, and none is likely, in spite of the late Doctor Steinmetz's predictions to the contrary. Last month Doctor Whitney, director of the General Electric research laboratory, where we might expect such things to be done if they were possible, showed how it was possible to light a small incandescent bulb by radio power. The lamp which was lighted was connected to a coil about two feet from a powerfully oscillating triode of large power output. This looks like the wireless transmission of power, and in fact, it is of course just that, but it wasn't the outcome of progress in the problem of power by radio at all. Every electrical engineer knows of many instances in which electrical energy is transferred from one circuit to another without connecting wires. The lighting transformers mounted on the poles of the electric company, in every suburban community, are just as good illustrations of the same thing Doctor Whitney showed. We ordinarily say that the energy gets from one circuit to the other by mutual induction, a phenomenon well known by Joseph Henry and Michael Faraday nearly a century ago, but they didn't ascribe it to the transmission of power by radio; neither should we.

NEW TYPES OF RECEIVING SETS

NEW receiving sets have been seeking the approbation of the radio public during the year just passed. With the coming of the low power receiving triode, many listeners decided that the much desired superheterodyne receiver was within their reach. It seems certain that this type of receiver will be adopted by many of those who must travel great radio distances, who constantly seek stations farther and farther away. This type of receiver has been used in making practically all the long distance receiving records.

The difficulty of making a stable high frequency amplifier has long been recognized; due to the internal capacity of the triode, between the grid and the plate oscillations are almost sure to be set up when the amplifier is properly adjusted to amplify an incoming signal. An oscillating amplifier is useless; it will not amplify at all. So when Professor Hazeltine pointed out the way to neutralize the tendency of the high frequency amplifier to oscillate, a great step forward was made in this branch of radio. It now appears that the Radio Corporation had, in its files, a patent which, they allege, covers the same idea, but it seems also that the engineers of the Corporation didn't appreciate the value of the idea. Credit for showing the value of this neutralization of the triode capacity, by employing a circuit properly designed to do it, rightly belongs to Hazeltine. This type of set is now on the market under the name he has chosen for it, the neutrodyne. This new set has been much in favor because it requires no fussy adjustment of rheostats or regeneration to make it perform at its best. A simple chart of condenser settings, once obtained for all the stations within the range of the set, enables one to tune in on them at any time and get them if they are sending; no hair-splitting adjustment is necessary before the operator feels that the set is doing all it can to bring in the desired signal.

HAROLD W. BEVERAGE

Whose work on the "wave antenna" for reception has won him the Liebmann Memorial Prize

SINGLE CIRCUIT REGENERATIVE SET STILL HERE

THE now doubtfully famous single circuit regenerative set is still satisfying many and disgusting more. In the hands of one who knows how to use the set, it undoubtedly yields much satisfaction and does not necessarily annoy one's neighbors. After the Christmas holidays, however, when every new fan was making his Christmas present oscillate as violently as possible, "to increase the receiving range" we well realized the reasons for classifying it as radio's greatest nuisance. In the vicinity of the large cities, evenings were filled with such a collection of hums and whistles that a large and active swarm of bees would have been put to shame.

This type of receiver is surely due to be discarded, in spite of its efficiency and simplicity. Whereas it is conceivable that every one owning such a set will in time become sufficiently familiar with its behaviour to realize its shortcomings and not make it oscillate any more than absolutely necessary, it is still easier to conceive a whistle-less ether if these sets are done away with.

A two-circuit regenerative receiver (if regeneration is advisable at all) gives only a small fraction of the interference that its single circuit brother does, and with a little practice can be made to perform about as well in so far as distance is concerned, and much better as regards the selectivity of the set. In spite of the great impetus this single-circuit receiver, due to Mr. Frank Conrad, gave to radio broadcasting as a result of its great sensitiveness and ease of adjustment, it is time to dispense with its services. This is only a natural development and it should be done away with for the same reasons that steam engines are being supplanted in electric power houses by the more efficient steam turbine. The steam engine was a wonderful device and its originators cannot be given too much praise, but due to changing conditions, it is being supplanted by other apparatus which is more economical of coal. We need a set which is more economical of the ether than is the single circuit regenerator, and the past year has given us several to choose from.

PROGRESS IN KNOWLEDGE OF TRANSMISSION PHENOMENA

GREAT contributions have been made to our knowledge of how radio waves are propagated. Last year we had a hazy idea that stations did not transmit as well in some directions as in others, that there were apparently dead spots in the region surrounding a station, that the strength of a given signal did increase and decrease in an irregular manner, but all these ideas were merely qualitative only, and open to challenge.

The past year saw great advance made in the art of measuring radio signals. Trained experimenters have actually plotted curves showing accurately the strength of signal to be expected in different directions from a given station and have developed the measuring scheme to such a state that a proposed location for a new station is now thoroughly mapped (electrically) to test its suitability. These electrical surveyors have already saved prospective station managers much chagrin and money.

Only last month Mr. G. W. Pickard gave a most interesting paper on the phenomenon of fading, as noted on page 374 of this issue. We now know exactly to what extent a signal waxes and wanes from minute to minute, and even though we have no way of preventing this, the information Mr. Pickard has given us is most welcome and valuable.

RADIO IN TRAIN CONTROLS

IN ANOTHER field, radio has made no progress where one might think it well adapted to function, and that is in automatic train control systems. One would think that radio would lend itself admirably to the automatic prevention of collisions, yet such application of radio is still to be made. While Government commissions are ordering railroads to put in automatic train stop devices of any kind that will work, the field seems to be occupied with cumbersome electromagnetic brakes and air pressure systems. A stalled train could use a vacuum tube transmitter to act on sensitive relays of approaching trains with ever increasing certainty as the distance between them decreased. The signal received on the approaching train would rapidly increase in intensity as the imminence of collision increased so that the scheme seems to have just the right characteristics. But the year just passed didn't show results of these conjectures that were of importance.

USE OF SHORT WAVES FOR RE-TRANSMISSION

THE inauguration of double wave transmission at KDKA, the pioneer of broadcasting stations, marks a real step in the progress of broadcasting. Here they send out regular programs on the specified frequency of 920 kilocycles, and also transmit it on 3,200 kc. This radiation is picked up at KFKX, Hastings, Nebraska and used for modulating this station, thus making the high frequency radio wave connect the two stations just as the telephone company now operates several stations from the same microphone by wire connection. It was thought that there would be less fading and less interference if this very high frequency wave was used as the connecting channel, but it seems that a much greater advantage in using the high frequency link lies in the possibility of directing and focussing the beam of radio waves. Marconi and Franklin have shown that by using a reflector at both sending and receiving stations such directive and focussing action is possible and that the received signal is increased hundreds of times over what it would be with the usual non-directive radiation. This kind of radio link between stations, where a comparatively narrow beam of waves is originated at the focus of one mirror and gathered at the focus of another, is a very likely development in the near future.

THE NATIONAL ASSOCIATION OF BROADCASTERS

THE stand taken by the Society of Authors, Composers, and Publishers in demanding royalties where none were available, as well as the desire to answer the question—Who is going to pay? gave rise to the National Association of Broadcasters, as we have mentioned before in RADIO BROADCAST. This group of enthusiastic station managers has apparently succeeded in their scheme to popularize new music by broadcasting it for the authors themselves instead of letting some society, which would take most of the profits, handle the "plugging" of the new song or dance piece. The scheme of course takes time to get under way, but the prospects for its success seem excellent at this time, only a few months after the inception of the idea.

EDUCATIONAL RADIO

EDUCATIONAL radio, of real cultural value, has been tried in a small way, and those responsible for the venture feel justified in proceeding with more ambitious plans for the coming year. People will apparently pay for radio material when no coercion at all is exercised; the fact that they are being given something worth while makes them willing to pay for it, even though they might get it almost as well without paying a cent. This is a very interesting phase of the psychology of the radio audience which hasn't been at all utilized as yet.

INVENTORS HONORED BY THEIR FELLOWS

DURING the past year two of radio's deserving workers have been publicly rewarded for their contributions to our art. For conceiving and putting into operation the wave antenna H. W. Beverage, one of the younger engineers of the Radio Corporation, was given a prize of five hundred dollars cash, by the Institute of Radio Engineers, and Dr. Lee De Forest, the inventor of the audion, was granted the Institute Medal of Honor. These two men had quite evidently well deserved the honor their fellow engineers were so glad to bestow upon them.

THE PALLOPHOTOPHONE

THE pallophotophone, developed by Mr. C. A. Hoxie of the General Electric Co., is one of the most striking illustrations of the application of the results of pure science to a directly useful purpose. This device photographs the voice on a moving picture film and so can be reproduced simultaneously with the projection of the picture, giving the voice as it would be heard in a real drama. Of course it doesn't have to be used with a moving picture. Solely as a recorder of the voice or other sound this device of Hoxie is a valuable contribution to our technical progress.

By it, the sound waves are made to impinge on a very small mirror, causing it to vibrate back and forth with a motion which truthfully corresponds with the sound wave actuating it. A beam of light reflected from this little mirror is thrown on to the edge of a moving film and as it vibrates gives a serrated shadow on the edge of the film after this is developed and fixed. The serrations correspond to the frequency and intensity of the sound waves which were acting on the mirror. Pioneer work on this device was done by Prof. Miller of Case School of Applied Science and the late Prof. Webster of Clark University.

In using this queer looking bit of film to reproduce the original sound, a beam of light is sent through the moving film and then falls on a sensitive photoelectric cell. This is where the application of pure science is more apparently evident. Physicists have known for years that light waves falling on a fresh surface of certain metals (such as sodium) were able to actually pull some electrons out from the surface and so make possible the flow of current (flow of electrons) from the light-affected surface to another electrode in the tube. The number of electrons thus pulled out of the photoelectrically active metal depends upon the intensity of the light ray, hence so does the current flowing across the tube, or cell, as it is called. This effect has been principally used by scientists to help them learn more of the structure of matter, but Hoxie uses it in a different way. The flickering beam of light emerging from his film (flickering because of the serrated shadow across it) falls on the photoelectric cell, causes a weak current which pulsates in a manner corresponding to the original voice and this current, properly amplified, gives back the original sound and gives it back with remarkable faithfulness. In demonstrating his pallophotophone before a large meeting of engineers the inventor, concealed from the audience, spoke directly into the amplifier once and then gave the same speech from the pallophotophone; the audience couldn't tell which was the man and which was the film. This device is one of the year's important contributions and illustrates beautifully the value to every one of the truth-seeking labors of the pure scientist, the man who is interested not in inventions and patents, but in searching out Nature's truths.

REDUCTION IN NUMBER OF BROADCASTING STATIONS

THE year has seen the number of broadcasting stations somewhat decrease, not that new licenses haven't been granted but that a greater number of stations have been abandoned. This is as it should be; we shall not get the best out of broadcasting until but a few very powerful stations are in operation, stations which radiate kilowatts instead of watts and stations which can afford to get the best talent available. (We have heard some frightful singing during the past year). Fewer and better stations should be the slogan for improvement at the transmitting ends of the radio channels.

THE PATENT SITUATION

THE patent situation in radio seems, to the unbiased observer, somewhat disquieting; gradually but surely a most stringent monopoly is being obtained in this field by the Radio Corporation. This possible monopoly, of course, doesn't as directly affect the radio listener as it does the small manufacturer, whose factory doors are closed by patent decisions in favor of his gigantic rival. In fact monopoly in itself isn't necessarily detrimental to the progress of radio any more than it is in the art of illumination, for example; in this field the General Electric Company controls about 99 per cent. of the incandescent lamp output of America yet we can't say that the art of illumination hasn't made progress. Of course we don't know whether it might not have made much more rapid progress if others had been in competition.

The effect of a monopoly on the public's interests depends entirely on the vision and fair mindedness of those responsible for directing the affairs of the monopolistic corporation, so that the Radio Corporation, in spite of the strong position it seems to be acquiring in the radio field, does not at once merit our condemnation. We hope its management will show the same "public be served" ("at a reasonable price," we add) spirit which most public service companies are now so anxiously putting forward.

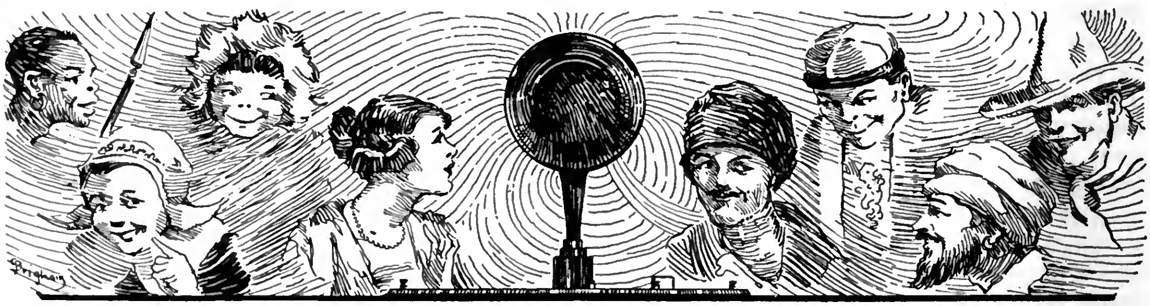
SOME PROGRESS IN RADIO PHOTOGRAPHY

SPASMODICALLY we hear of the wonderful success of the transmission of pictures by radio. If we could believe the inventors' statements, the problem has been solved several times during the past year. But if it actually had, we should undoubtedly have had ample notification. Could radio solve the problem of rapid and accurate reproduction of pictures, it would confer to the press of the country a boon not surpassed by the linotype or rotary press. There are many newspapers at the present time supporting laboratory work aimed at the solution of this problem so we must believe that as yet it is in the experimental and undeveloped stage.

PRIVACY IN RADIO COMMUNICATION

IN SO far as we know there has been no real progress made in securing privacy in radio communication. Directive radiation, synchronously tuned mechanisms at the transmitting and receiving ends of the channel, elimination of the carrier frequency and one side band, all tend to get secrecy for a time, but none of them approaches the secrecy obtainable with ordinary wire connection. Full secrecy may come some day, but the past year contributed little to the solution of the question.

When we look back over the year's accomplishments, it is certain that, in spite of some disappointments, if the next few years give us as much improvement and advance in radio broadcasting as the one just ended has done, it passes imaginative power to predict what its status and service may become.



Why No Receiver Can Eliminate Spark Interference

Presented Before the Radio Club of America as Part of the Report of the Committee on Interference

By L. A. HAZELTINE
Professor of Electrical Engineering, Stevens Institute of Technology

WE ARE accustomed to thinking of a radio wave as having a single wavelength, or a single frequency. Such a wave would be produced by an unmodulated antenna current, as represented in Fig. 1a. The current here chosen for an example passes through a complete cycle in one millionth of a second, so its frequency is one million cycles per second, as represented by the single line in Fig. 1b; this frequency corresponds to a wavelength of 300 meters.

For signalling purposes, however, the radiating current must be modulated. In telephony, the modulation is by the voice; in continuous-wave telegraphy, it is by the sending key; while in other systems of telegraphy it is by some tone source in addition to the key.

Why It Can't Be Done

Interference from spark stations is a subject that becomes of increasing importance with the sale of every broadcast receiver. Why the issue has been side-stepped so thoroughly is a matter of great conjecture. Some of the blame may be laid at several doors, but rather than place the blame, we find the Radio Club of America attempting to seek a solution.

At a recent meeting of the Club, Professor Hazeltine was asked to explain why even the most selective receiver would not eliminate this interference, even though it was receiving broadcasting on a frequency considerably above or below the code station. His most interesting and instructive analysis answers this question thoroughly.

We trust it may act as a stimulus to hasten some action whereby broadcasting and ship to shore radio service will be allotted waves sufficiently different to overcome this serious situation.—The Editor.

HOW MODULATION OCCURS IN CONTINUOUS WAVES

THE simplest modulation would be that produced by a pure musical tone impressed on a telephone transmitter which controlled the radiating current. This current would then vary as represented in Fig. 2a, where the frequency of modulation is represented as 1,000 cycles per second. (In this figure and those that follow, it is not possible to represent all time intervals to the same scale, as the radio frequency and the modulation frequency differ so greatly.) The effect of the modulation is equivalent to the introduction of two new currents having different frequencies called "side frequencies." The side frequencies are respectively the sum and the difference of the original "carrier" frequency and the modulation frequency, and in the example chosen are therefore 999,000 and 1,001,000 cycles per second. The intensity of the radiation at the side frequencies is usually considerably less than the radiation at the carrier frequency, as represented by the three lines in Fig. 2b.

If the modulation is produced by a musical note which is not a pure tone, as for example the note of a violin, it will have a fundamental frequency and harmonics, which are multiple frequencies such as 1,000 cycles per second for the fundamental and 2,000, 3,000, etc. for the harmonics. In this case two side frequencies are radiated for each harmonic, as 998,000 and 1,002,000 for the second harmonic.

In the voice, or in musical instruments played for a considerable interval of time, musical tones will appear having all frequencies between certain ill-defined limits. Tones whose pitch or frequency is above about 5,000 cycles per second are not appreciable, and this

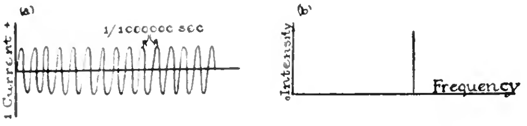


FIG. 1
Pure, unmodulated continuous wave

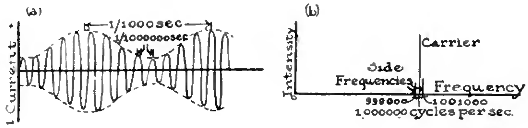


FIG. 2
Continuous wave modulated by pure tone

figure may be taken as a safe upper limit. Hence a 300-meter broadcasting station will radiate waves having frequencies confined between 995,000 and 1,005,000 cycles per second, these extreme values having little importance. Fig. 3a represents such a voice-modulated current; and Fig. 3b represents the relative intensities of the component waves, which consist of the "carrier" and the two "side bands." Broadcast stations whose carrier frequencies differ by 10,000 cycles per second evidently have no overlap in their frequency bands and can be distinguished by sufficiently selective receivers, provided that their signal intensities are not too different.

HOW A "SPARK STATION" RADIATES ITS WAVE

A SPARK telegraph station, on the other hand, produces a radiating current in a succession of groups, each of which is of short duration, compared with the interval between groups, as represented in Fig. 4a. This is essentially equivalent to modulating a continuous wave by a variation in intensity which rises very rapidly to a maximum, then falls rapidly, and is sensibly zero for a large portion of the group cycle, as represented by the dotted envelope in Fig. 4a. Such a modulation curve is very rich in high harmonics. If the rate of building up of the oscillating current is very high and the decrement is at the legal limit of 0. 2, a wave which nominally has the frequency of one million cycles per second will actually consist of waves of almost uniform intensity ranging from about 970,000 to 1,030,000 cycles per second, and of waves of rather slowly decreasing intensity extending down to very low frequencies and up to a few million cycles per second, as represented in Fig. 4b. Such a wide band of frequencies will overlap a great many broadcasting bands and is the cause of the great amount of interference from spark stations.

HOW THE RECEIVER RESPONDS TO VARIOUS WAVES

SO MUCH for the transmitted waves. Now let us see how the receiver responds. Selectivity is accomplished by *tuning* the receiver to a certain frequency. But the receiver will respond not only to that frequency but also to neighboring frequencies. The relation between response and frequency with a fixed tuning adjustment is represented by a "resonance curve," of which examples are given in Figs. 5 and 6. (As with the preceding figures, it has not been possible to draw these to scale.) For broadcast reception without sensible distortion of the music or speech, it is necessary that the resonance curve embrace a band of frequencies corresponding to that usefully radiated, as represented in Fig. 3b. On the other hand, the wider the band embraced, the greater will be the tendency to pick up interfering signals and atmospheric disturbances ("static"). For pure continuous-wave telegraph reception a very narrow band is best.

WHAT MAKES RECEIVERS SELECTIVE

THE shape of a resonance curve and the effective width of the frequency band are controlled in two ways: first, by the ratio of the resistance to the reactance in each tuned circuit; and secondly, by the number of successive tuned circuits.

The effect of changing the resistance of a tuned circuit is illustrated in Fig. 5. The middle curve represents conditions when the resistance of the coil and the condenser are kept low by proper design and construction,

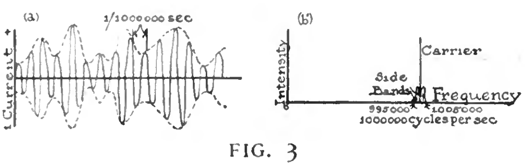


FIG. 3
Continuous wave modulated by voice

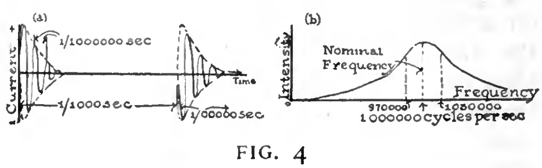


FIG. 4
"Spark" or damped wave

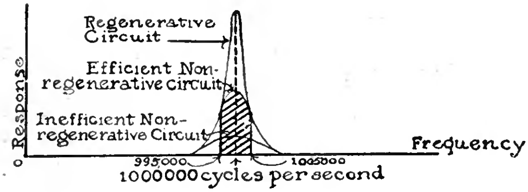


FIG. 5
Receiver selectivity with different resistances

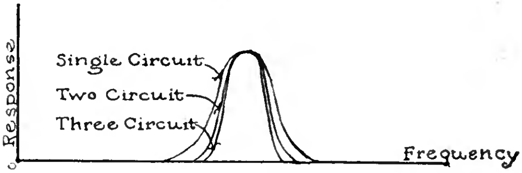


FIG. 6
Receiver selectivity with different numbers of successive tuned circuits

and gives a width of frequency band which covers the broadcast side bands satisfactorily. The moderate dropping off of the curve at the extreme frequencies is not important. The upper curve represents conditions in this tuned circuit when the effect of resistance has been artificially reduced by regeneration, and shows that distortion will thereby result. Here, the components of low audio frequencies (corresponding to radio frequencies very close to 1,000,000) are being amplified much more than those near the limiting frequency. The lower curve represents conditions when the coil and condenser have improperly high resistances. This arrangement gives a lower response to the broadcast music or speech, but the same response to interference as the other curves. It is a fortunate circumstance that for the allotted broadcasting frequencies it is feasible to design coils and condensers so as to nicely cover the frequency bands without the necessity of regeneration; for the use of regeneration is almost certain to be carried too far, resulting in distortion and finally in beat notes or "whistles" when the oscillating state is reached.

SELECTIVE TYPES OF RECEIVERS

THE effect of changing the number of successive tuned circuits is illustrated in Fig. 6. The single-circuit receiver gives a curve which drops off rather slowly outside the useful frequency band, and so is particularly subject to interference. The curves for the two-circuit receiver and particularly for the three-circuit receiver (which are drawn with the same maximum point, for convenience) drop off much more rapidly outside the useful frequency band, though they do not differ greatly inside. This applies to receivers in which the successive tuned circuits are very loosely coupled, or not reactively coupled at all as in the neutrodyne. When the coupling is close, there is little gain in selectivity over the single-circuit receiver. It should also be noted that "three-circuit" here refers to three successive tuned circuits preceding the detector and not to a receiver having two such tuned circuits, plus a tuned plate circuit for regeneration.

ONE EXAMPLE OF INTERFERENCE EXPERIENCE

INTERFERENCE from a radio telephone broadcasting station is illustrated by the curves of Fig. 7, and is due to the fact that the response curve of the receiver overlaps the frequency band of the interfering station. This will occur only when the station is very powerful and near-by, or when its frequency is very near that being received, or when the receiver has little selectivity. To minimize this effect, the receiver should be made as selective as possible by employing more successively tuned circuits. In addition, it is frequently helpful to reduce the size of the receiving antenna or the amount of amplification.

Interference from a spark telegraph station is of a different sort and is illustrated by the curves of Fig. 8. It is not usually due to the nominal frequency of the station, but rather to those side frequencies which come within the response band of the receiver. It will be

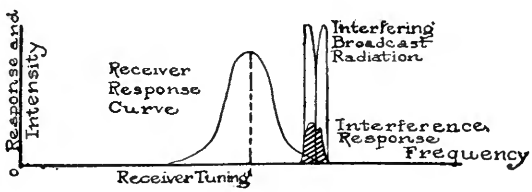


FIG. 7
Interference from telephone broadcasting station

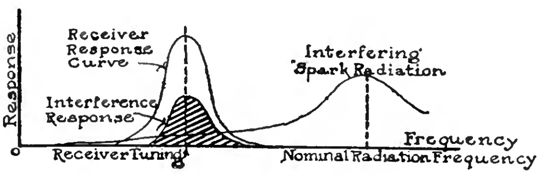


FIG. 8
Interference from spark telegraph station

reduced by narrowing the response band of the receiver as far as distortionless broadcast reception will permit; but this would be done anyhow in a properly designed receiver.

WHY SPARK STATIONS CAN'T HELP INTERFERING

EVEN if one uses more successively tuned circuits, it won't avail, *because the interfering frequency is the same as the frequency being received.* Obviously we cannot select between two waves which have exactly the same frequency.

Those who have used neutrodyne receivers, which ordinarily employ three successively tuned circuits, have observed that a strong spark station can be tuned in almost anywhere on the dials, provided only that the three dials are set for the same frequency. When the dials are set for different frequencies, usually the spark stations (and also atmospherics) are no longer heard. This is a direct proof that the interference is not caused by the nominal frequency of a spark station, but rather by a portion of its side band.

It cannot be too strongly emphasized that the *interference from spark stations is scientifically impossible to eliminate at the receiving end.* It is also impossible to eliminate at the transmitting end unless the rates of building up and dying out of the spark oscillation can be slowed down so as to correspond with the rates of amplitude variation in modulated continuous waves. Such a result, however, has never been attained by any form of spark oscillator. The solution of the problem of interference from telegraph transmitting stations must therefore be the substitution of continuous-wave transmitters for spark transmitters. The pure continuous wave is by far the most preferable, as the modulation is at a low rate, corresponding to the keying. Modulated continuous waves, however, are not likely to be objectionable if the modulation is not abrupt.

Sound: A Matter of Personal Opinion

By R. H. MARRIOTT

Radio Engineer, Puget Sound Navy Yard, Washington. Past President of the Institute of Radio Engineers

BEFORE the advent of radio broadcasting, different people selected the sound producers they thought they would like, for example, by patronizing certain types of theatres or buying certain types of phonograph records. Probably there were a million such audiences with from one to a thousand persons in an audience. But in radio broadcasting the broadcasters do the selecting of the sound producers and probably two hundred audiences containing from fifty to a million persons in an audience, do the listening.

One common idea seems to be that sound is something definite, mathematically exact. People think an expert can combine a number of long and short and big and little sound waves before an audience and that every one in the audience will hear the same sound. That idea is wrong. An expert can produce one set of sound waves, but the audience will hear as many different sounds as there are different people in the audience. Each person may hear a sound, but that sound will be different from what a different person hears. That is one reason why different people choose different types of music.

EVERYONE DOES NOT HEAR THE SAME SOUND THE SAME

IF YOU have a regenerative radio receiver, you can probably perform some interesting experiments in sound. Tune in some amateur who is sending with a tube transmitter, and vary the pitch of the whistle while different people are listening. You will probably find, especially if you have a vernier condenser, that no two of the listeners will lose the signal at the same high note. And when each one listens alone and adjusts for himself you may find that no two of them leave the dial on the same setting if they are asked to pick the note that sounds best to them. Those experiments are best made on weak signals. By using louder signals you can probably find that certain notes or certain degrees of loudness are painful to certain people and not to others.

The greatest differences in hearing will probably be found when comparing high notes. And the quality of sound, particularly from the violin, is said to be due largely to high notes or harmonics. And if a listener does not hear those high notes there is no sound from them so far as that listener is concerned.

By experimenting with the whistle from the radio receiver it may be found that some people soon learn to hear notes that they failed to hear at first. When head sets were first used in the early days to receive radio signals people said they could not hear plainly audible spark signals in the head sets. In 1902 it was difficult to get telegraph operators to operate wireless stations. Many wire telegraph operators said they did not hear the buzzing sounds. After they heard them, nearly all would say they could not learn to read long and short buzzes, although they were expert at reading the long and short intervals between the closing and opening of a sounder. The trouble was that these men never had heard such signals before and therefore their mental machinery was not regulated to hear them or to translate them or even to try to translate them. People may not hear sounds until after they are convinced that other people are hearing them or liking them.

Decisions as to what are good and bad sounds vary in so many ways. They vary with time and vary from the ridiculous to the sublime. When I was a boy, the boys and girls sang, "After The Ball." Now the boys and girls sing, "Yes, We Have No Bananas." Not long ago somebody put a rifle bullet through an automatic phonograph that was playing the latter song at the entrance to a Seattle music store. And recently, when I stopped for a day and night in an Indian Reservation, I did not hear a tom-tom or an Indian song, but I did visit a radio broadcasting station that was playing up-to-date popular music and classical music.

A dictionary says sound is "the sensation produced through the organs of hearing." Or in other words, sound is "a mental impression." From the foregoing and the variety of remarks different people make about the same piece of music, leads to the conclusion that sound is largely a matter of personal opinion.

Considering those things causes one to sympathize with the listeners and the broadcasters and the makers and dispensers of radio equipment.

PITY THE BROADCASTER

PITY the broadcaster, for how is he going to guess what his hearers want? He has but one personal opinion which is different from every other personal opinion that he broadcasts to. Evidently almost any broadcast will please somebody and no one broadcast will please everybody.

What the broadcaster needs is the opinions of everybody else. And he has to forget his own opinion, even though he has a high opinion of his own opinion.

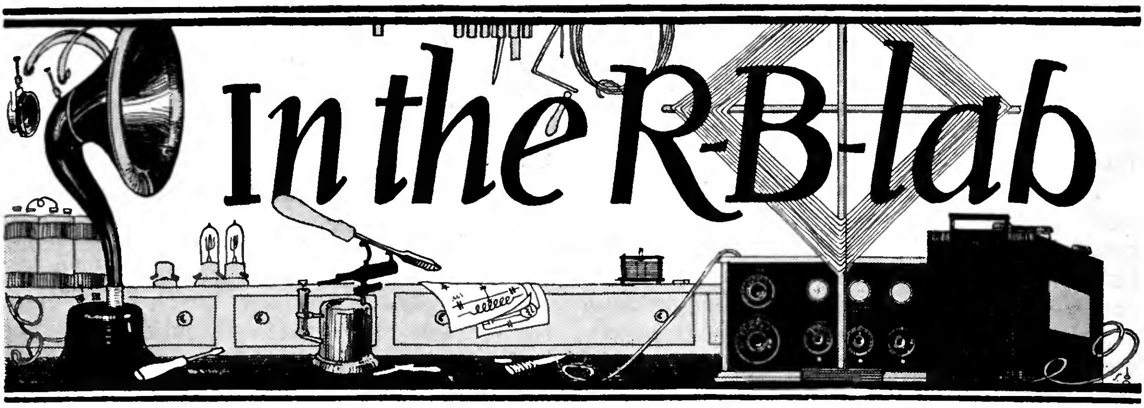
In spite of more than one hundred million different personal opinions, we manage to elect one president. And with many different personal opinions in one state or city we manage to elect one governor or one mayor. By the election process, many antagonistic personal opinions are molded into one more or less universal opinion or agreement.

ADD YOUR PREFERENCE VOTE

EVERYBODY can agree that the broadcaster wants to broadcast what the listener wants to hear. And we can agree that the broadcaster cannot know what the listener likes and dislikes if the listener does not tell him directly or indirectly. But indirect methods are slow. The direct method is to write letters to the broadcaster. If we tell him face to face or over the telephone he may forget it. And he isn't a mind reader. Plain, clear, direct communication is his specialty.

If the listeners vote for the kind of broadcasts they want by writing to the broadcasters, they probably will, in time, elect international sounds including international speech and international music, which can bring about international understanding.

Radio broadcasting is not for communication from one person to one other person or for the communion of a clan; it is for the communion of the human race.



The "lab" department has been inaugurated by RADIO BROADCAST in order that its readers may benefit from the many experiments which are necessarily carried on by the makers of this magazine in their endeavor to publish only "fact articles" backed by their personal observations.

ADDING R. F. TO A STANDARD THREE CIRCUIT SET

(Data by Russell Sheehy, Who Won His Receiver During Our Last Year's "How Far Have You Heard" Contest)

AS A general rule, the addition of radio frequency amplification to a standard regenerative set is not to be advised. These additions complicate the circuit and tuning to such an extent that commercial radio frequency amplifiers, built and sold as auxiliary equipment to standard receivers, have been rarely successful and have never acquired the popularity of circuits and sets especially designed for R. F. amplification. Mr. Russell Sheehy, however, has built a set which, according to the claims of its designer and our own observations, eliminates most of the draw-backs associated with apparatus of this type.

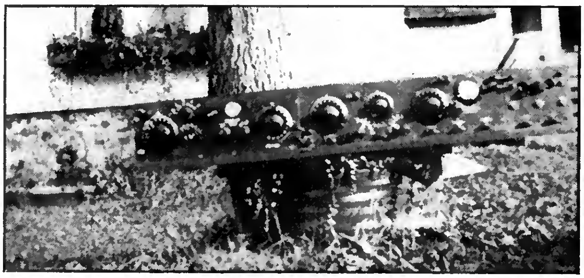


FIG. 1
Front view of the radio amplifier plus a Grebe CR8

The circuit as shown in Fig. 3 is the result of several months of experimentation on the part of Mr. Sheehy, and the various refinements, such as condensers C2 and C4, and the two potentiometers, are perhaps directly responsible for the excellent results, combined with stability, which Mr. Sheehy is experiencing. These additions, incidentally, are complicated only at first sight. They are stabilizing elements, having little effect on wavelength variation, and once set they need seldom be re-adjusted.

The three stage radio frequency amplifier, as indicated diagramatically, may be added to any three-coil honeycomb receiver, or to a vario-coupler, twin variometer set, such as the Grebe CR 8 with which Mr. Sheehy conducted his experiments. In the case of the honeycomb receiver, P and S indicate respectively the primary and secondary coils; and with the variometer regenerator, the primary and secondary of the vario-coupler. When this addition of R. F. is effected in conjunction with the Grebe receiver, such as the CR's 3 and 8, the connection between the lower side of the secondary and the ground must be broken.

Figs. 1 and 2 show the combination built by Mr. Sheehy. The necessary parts for this addition are given below, the letters in parenthesis indicating the symbols by which the respective parts are represented on the diagram.

THE PARTS

ONE tapped coil, 80 turns of No. 22 wire, wound on a 4-inch tube, tapped at turns number 20, 35, 50, 65 and 80 (L).

One switch arm with five points for coil L.

Three sockets.

Two Acme R.F. transformers, an R2 (T1) and an R3 (T2).

(Two vario-transformers could also be used to good advantage here, thus permitting each stage of R.F. to be tuned).

Two variable condensers, .0005 mfd. (C1) and .001 mfd. (C4).

Two Dubilier Micadons .0005 mfd. (C2 and C3).

Two 400-ohm potentiometers (R and R).

Three rheostats (of proper resistance for tubes used).

Two dials for variable condensers.

Eight binding posts.

One 7 x 18 inch panel.

These parts can be bought on the average market at a price in the neighborhood of twenty-five dollars.

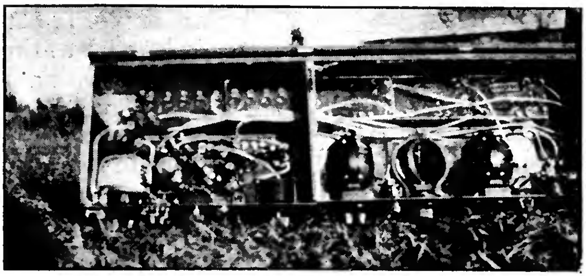


FIG. 2
Behind the scenes of the three step radio frequency amplifier

As indicated in Fig. 3, Mr. Sheehy has used for R.F. amplifying, in the sockets from left to right, a 201A, UV199, and UV199. Satisfactory results, however, should be secured by using the same tubes throughout—UV199s, 201A's, etc. The R. B. Laboratory has found the old UV201's remarkably stable in amplifiers of this type—more so than the UV201A. The difference, however, does not justify the high current consumption when battery charging presents any sort of a problem.

In the preliminary tuning of this circuit, it is suggested that the experimenter place his usual tuning dials, those in the detector circuit, at such positions as would ordinarily tune in a station known to be transmitting at that time. Adjustments should then be made on condenser C1 and the tapped coil L until this station is heard. It will be comparatively easy to pursue more elusive stations from this point. It might be mentioned, as a local station is likely to be the subject of the preliminary

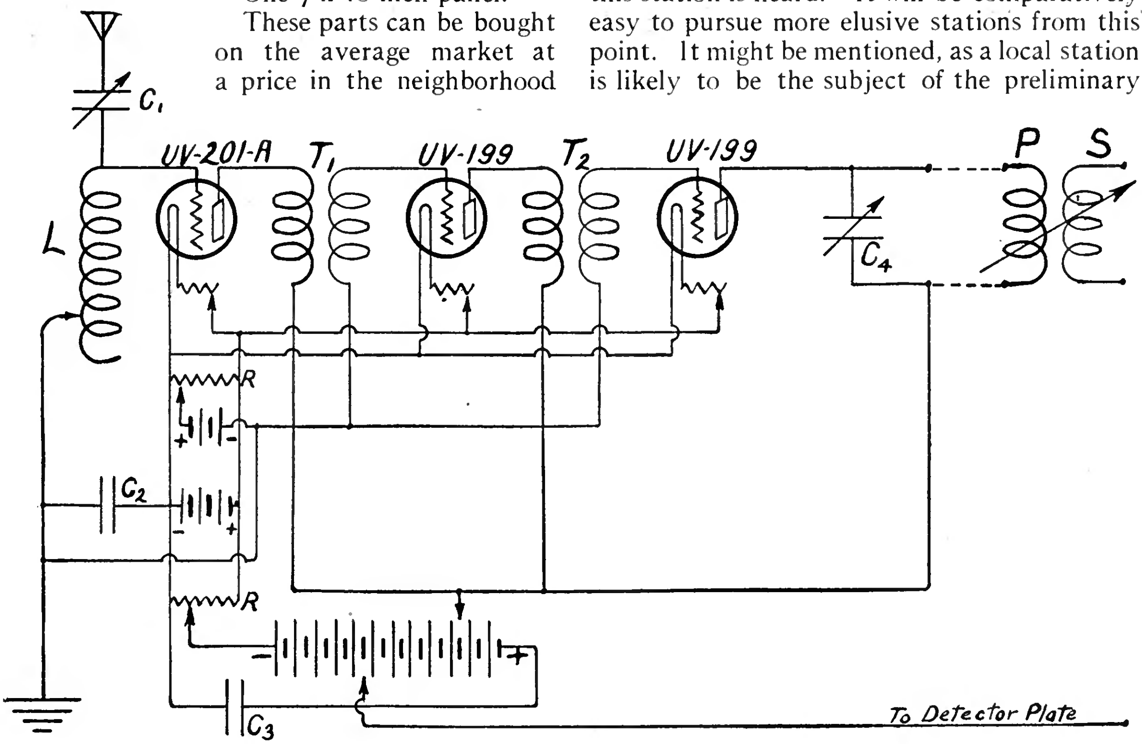


FIG. 3
The circuit for the three stage radio frequency amplifier that can be added to any inductively coupled receiver

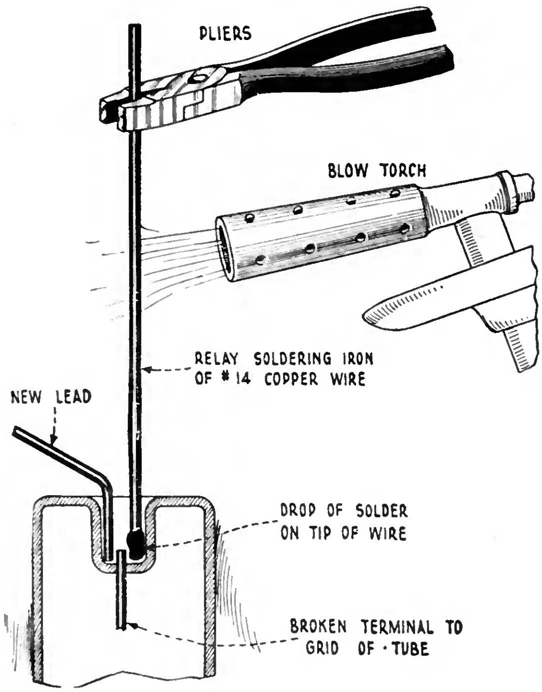


FIG. 4
A handy way of doing delicate soldering

tuning, that little or no amplification will be obtained on signals from near by stations.

The experimenter may, of course, eliminate one stage of R.F., merely adding two stages to his present regenerative equipment. Less than two stages of transformer coupled radio frequency, however, will not be very effective.

A "RELAY" SOLDERING IRON FOR FINE WORK

By H. A. HIGHSTONE

SOME time ago we were confronted with the problem of soldering a lead to the grid terminal of an old Audiotron vacuum tube, the wire having broken off close to the glass. The Audiotron is cylindrical and the wires enter the glass at each end at the bottom of a depression which is but one quarter of an inch in diameter and a full half inch deep. From this you will comprehend that the task appeared to be almost impossible without resorting to the use of jeweler's tools. A happy inspiration however, saved the tube from the junk heap and the same method will doubtless solve a great many knotty problems which arise in the construction of home-made receiving equipment—especially when it is designed with an eye toward compactness.

A piece of No. 14 bare copper wire about six inches in length was tinned on one end (that is, it was covered with a liberal coating of solder) and a drop of solder left on the tip. The small piece of wire protruding from the glass having been previously scraped bright, a piece of No. 24 wire, also brightened, was placed next to it within the depression. The remaining portion of this last was wrapped around the outside of the tube to hold the end in position against the terminal. A very small amount of non-corrosive soldering paste was applied. Next, grasping the No. 14 wire with a pair of pliers, the tinned end was inserted in the opening and held to the two wires to be soldered. A flame from a small blow torch was then played upon the central portion of this improvised soldering iron (Fig. 4). The heat travelled along the wire and almost instantly fused the drop of solder at its tinned tip, firmly fastening the broken terminal to its new lead.

While this idea will probably find but little use for work on the fast disappearing Audiotron, it can doubtless be employed to great advantage in other parts of the receiving set, where the normal-sized soldering iron is too bulky.

THE SINGLE CIRCUIT SET AND THE SODION TUBE

THE radio world is at last becoming aware of the selfish evils of regenerative receivers, particularly single circuit ones, which set up powerful outward radiations and often make reception from near by stations impossible. And, unfortunately, the single circuit set was the most practical receiver in the pioneer days of broadcasting. Because of its simplicity, it has worked its insidious way into the majority of radio homes. Realizing the evils attending the indiscriminate use of such receivers, RADIO BROADCAST has been campaigning for efficient substitutes and recently offered the radio public its "Knockout" one tube reflex. Non-oscillating, efficient reception is also achieved in the Sodion tube, which, for this reason, has been dubbed the "Golden rule tube."

By the use of this tube, the most malignant of the single circuits, that utilizing a variocoupler whose secondary functions as a tickler, may be converted into an equally efficient and a far more considerate receiver. The revised circuit is shown in Fig. 5. In Fig. 6 we have indicated the original regenerating set. The primary circuit survives unaltered, while the tickler coil is returned to its normal functioning as the secondary.

Due to electrical characteristics of the Sodion tube, notably its low input impedence, the output of the tuning circuit should consist of relatively few turns of wire as compared with the usual high inductance secondary common to the conventional audion detecting circuit. Therefore, instead of loading the secondary circuit with the usual variometer, a high capacity variable condenser C2 is shunted across the coil. C2 should preferably have a maximum capacity between .0015 mfd. and .002 mfd. If more convenient, a lower capacity variable condenser such as a 43-plate type may be shunted with a .0005 mfd. fixed capacity.

The Sodion tube is best lighted from a four and a half volt battery through a ten ohm rheostat; it consumes slightly less than one quarter of an ampere.

The potentiometer, R may be of standard design, having a resistance between 200 and 300 ohms. A single twenty-two and a half volt B battery is about right for the best detection.

The terminals of the Sodion tube are as follows: C is the collector, which is analogous to the grid, F the filament, and P the plate

LEAVES FROM AN OLD TIMER'S NOTEBOOK

DRILLING large round holes: The obvious solution to the cutting of large round holes in panel materials, for ammeters, tube peeps, etc., is the drilling of circular series of small holes, and cutting out the disk. This last operation however, presents somewhat of a problem in itself, it being often difficult to join the holes without splitting the panel.

Try this: First drill the circle of holes, close, but not uncomfortably close together, with a

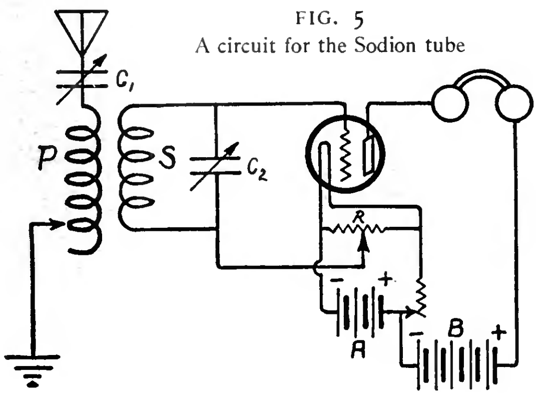


FIG. 5
A circuit for the Sodion tube

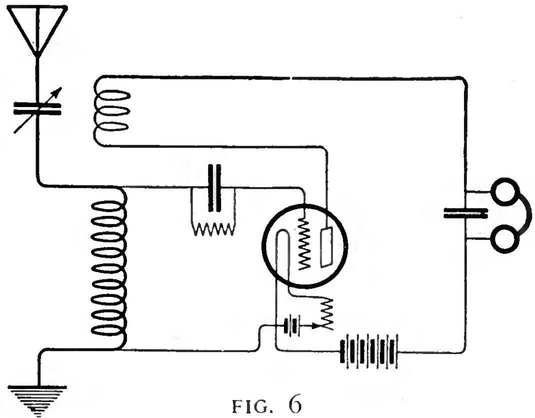


FIG. 6
A so-called single circuit receiver employing a tickler or feed-back coil for regeneration. Note that in Fig. 5 S has been moved over to its rightful place as secondary. This circuit can easily be changed, then, to operate with a Sodion tube

No. 27 drill (passing a No. 6 screw). Then drill out with a larger drill, say No 19 (passing a No. 8 screw). If the spacing of the smaller holes has been rightly judged, the second drilling will widen them sufficiently to cut the disk out cleanly.

BUILDING YOUR OWN LABORATORY

RADIO BROADCAST'S suggestion for March is a pair of tinner's snips, such as illustrated in Fig. 7. The very highest grade should be bought (this holds for all tools) and a medium size tool, about nine inches, will cost between two and three dollars.

They are indispensable for any heavy shearing work, such as the cutting and trim-

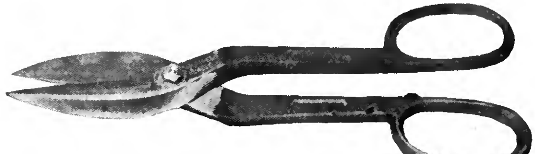


FIG. 7
Tinners' snips for this months addition to the budding laboratory

ming of metal sheeting for panel shielding and the cutting of sheet iron into strips for transformer core construction. The uses to which these snips may be put are many, like that of most good tools, and will suggest themselves to the prudent possessor from time to time.

If you already have a pair of snips—good. Conserve your financial resources until next month when we plan to suggest a rather expensive purchase.

Taking Ohms Out of an Antenna

A Description of Some of the Experiments Being Conducted by the Radio Frequency Laboratories to Improve Reception

By Dr. L. M. HULL

TO MANY an enthusiast in the alluring art of radio reception the antenna is a casual and frequently inconvenient appendage to the main body of his equipment; he feels that in a perfectly evolved mechanism it should be cast off altogether, like the tadpole's tail. This view may be justified, but the process of evolution in radio is still far from perfect. With most receiving equipment which is now commercially available, the antenna still assumes strategic importance in our endeavors to capture itinerant harmonies from Havana, Los Angeles, or 2LO. It is true that the enterprising vendor of radio contrivances may even now guarantee to give us "one thousand miles of clear reception for eighteen dollars" without specifying where, how, or what kind of an antenna is required to accomplish this marvel. But he cannot do this and retain any lingering atavistic sentiment for the eighth commandment. For the receiving antenna, comprising a ground connection and a more or less aerial portion, always serves as the most important collector of electrical energy from passing radio waves, whereby our receiver is given voice in direct proportion to the care and honesty with which this collector is built.

WHY WE NEGLECT OUR ANTENNAS

THIS simple fact, so apparent in the days when Marconi first irritated the ether with raucous sparks, has been somewhat obscured in later years by the tremendous increase in the extent and efficiency of our amplifying apparatus. Large solenoids ("loops"), water pipes, and even the tuning coils in our receivers are affected in minute quantities by passing electrical disturbances, which may be made perceptible by sufficient amplification. When our receiver yields beautiful results with a small loop or a wire laid carelessly about the picture moulding we are apt to lose sight of the fact that it would certainly outdo itself on the same incoming signals if fed by an outside antenna intelligently conceived and located. The tendency toward simple but inefficient collecting structures is natural; we prefer to slight that portion of our equipment which is invariably large and occasionally unsightly if we can compensate for this neglect by buying things in convenient little boxes. But the time is not yet here for forgetting utterly the factors which tend to produce an electrically efficient collector of radio energy. For this reason some general interest may properly be attached to the details of a special low-resistance antenna system which this Laboratory has had occasion to construct for purposes of experiment and comparison.

WHEREIN ANTENNAS DIFFER

MEASUREMENTS of signal intensity and practical tests of receiving apparatus have hitherto been made at this Laboratory with a 4-wire flat-top aerial, 75 feet long and 40 feet high, and a counterpoise of rather limited extent. A photograph of this aerial is shown in Fig. 1. It is directly over a steel-framed building for most of its length, and runs between a wooden mast and a tree. The lead-in is brought through the roof of the building in a composition insulator. This antenna system is believed to correspond in electrical efficiency to the average radio amateur's antenna and for purposes of comparison it was desirable to construct an aerial system which would approach the ideal design in small antennas as closely as can be done on dry land. A photograph of the completed structure which approximates this ideal is shown in Fig. 2. Before describing the details of this special antenna system let us consider briefly the factors which distinguish a good antenna from one which is electrically bad.

A simple antenna system operated, as is commonly done in radio broadcast reception, at wavelengths considerably above its fundamental, can with fair accuracy be regarded as a two-plate condenser; the aerial portion constitutes one plate, which is connected by a "down-lead" through the tuning apparatus to the second plate which is the earth. There are two prime factors which determine the efficiency of such a structure as a collector of energy from incoming waves. The first is its electrical resistance and the second is its effective height. The second factor, the effective height, was of relatively little importance in the experiments for which this antenna was constructed, because there is no definite maximum of performance which can be attained by varying the effective height, other things being constant. This effective height is the distance between two mythical points called the centers of capacity of the system and in general varies directly as the actual distance of the top of the aerial above ground. The sky is literally the limit to the effective height, and in the special antenna in question the height was fixed at a point considerably above all near by structures, but calculated to keep the antenna resistance low, with the available materials.

Any practical antenna shares the common failing of all condensers; it possesses not only electrical capacity but electrical resistance. This resistance is the first and usually the most important of the factors which determine the electrical efficiency. The antenna capacity offers no obstruction to the flow of currents induced in the antenna by incoming waves because it is balanced by a suitable inductance inserted in the down-lead. The adjustment of this inductance to compensate the capacity of the system constitutes the familiar process of tuning the antenna to resonance with the wave of the desired signal. But the resistance of this two-plate condenser remains in the receiving circuit after the antenna is tuned to resonance and opposes the ultimate limit on the amount of oscillating current which an incoming wave train can set up in the antenna, and hence upon the ultimate volume of sound in the received signal.

It should be remarked, in passing, that the oft-repeated saying that it is possible *entirely*

FIG. I

Although Dr. Hull tells us that we may consider the antenna in this photograph as an average one, we can hardly agree. Inspection discloses it to be considerably better than the average. It is as poor as one who is as familiar with the good things in radio as is Dr. Hull could tolerate

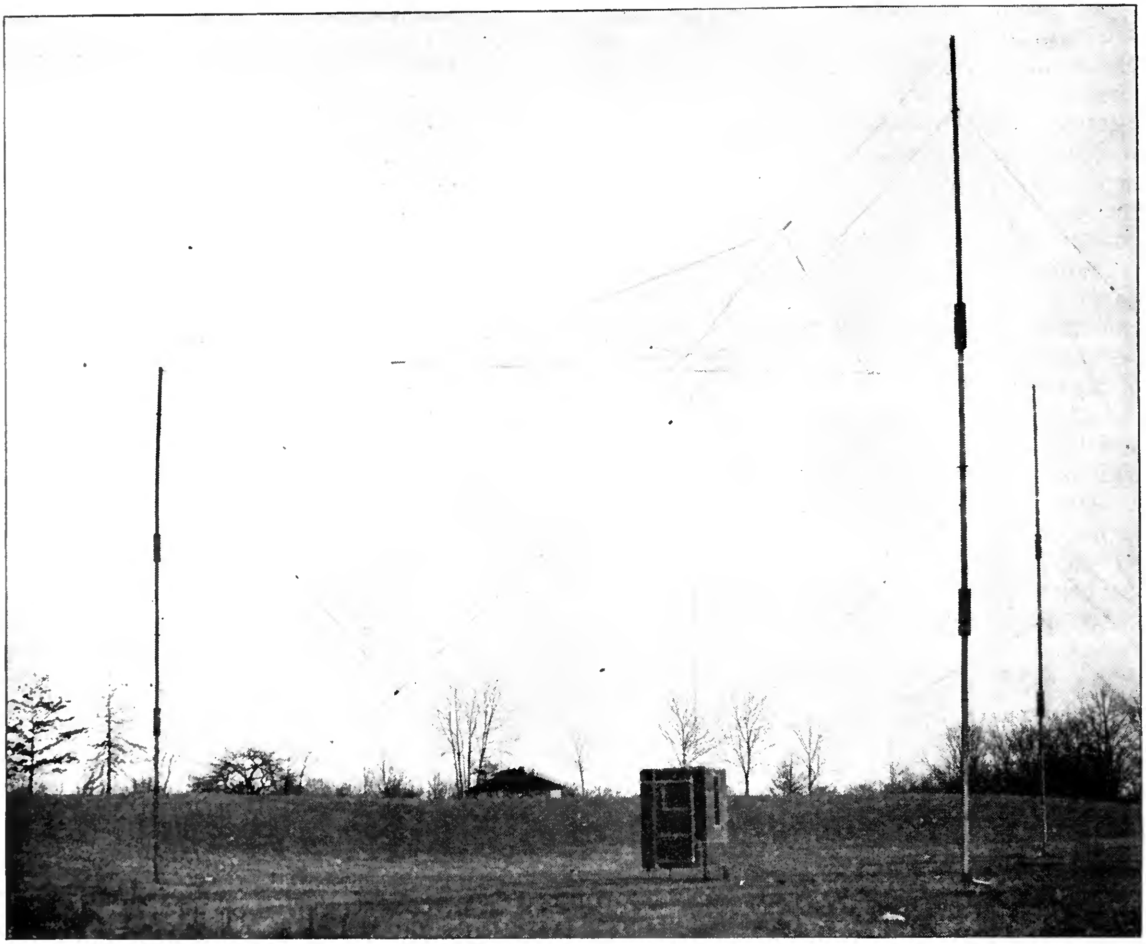


FIG. 2

This shows Dr. Hull's attempt to produce an ideal antenna. There are 3 masts 60 feet high supporting a phosphor bronze equilateral triangle 50 feet on a side crossed by 3 medians. A counterpoise of 6 wires 50 feet in length, each soldered to the copper shell of the receiving station pass out radially and act as the ground. There are two circular connectors around the counterpoise having 30 and 50 foot radii, respectively. The counterpoise is two feet above ground. The lead-in is a single phosphor bronze cable. *All the joints are* well soldered

to offset the effective resistance of an antenna by the use of regeneration in a detector or amplifier tube is fallacious. It is true that the received current in a high-resistance antenna can be increased by regeneration to an immensely greater multiple of its original value than the current in a similar low-resistance antenna with respect to its original value. But the "original value" in the low-resistance antenna is inevitably so much larger than that in the antenna of higher resistance that the net result is always a larger current in the former system, from the same incoming wave. There is a definite functional relation between the maximum received current which it is possible to obtain by regeneration (without local sustained oscillations) and the resistance of the receiving circuit; this relation is practically the same for all types of regenerative circuits. It is of such nature that this maximum of current increases continuously with decreasing resistance. In all non-regenerative receivers, of course, the received current at resonance increases in exact inverse proportion to the circuit resistance.

LOW RESISTANCE MEANS BETTER RECEPTION

ALL this can be summarized in the following simple statement; the lower the resistance of the antenna the greater the signal intensity obtainable in any receiving set from a given incoming wave. The differences are not always large; they may be imperceptible with a double-circuit tuner having a low-resistance secondary. But they always exist, and the antenna characteristic which is of greatest importance in connection with investigations of radio receivers is the antenna resistance.

This resistance of the condenser which comprises the aerial and ground arises from three main causes; loss by re-radiation, conduction losses in the wires of aerial and in the ground, and losses in any dielectric other than air in the electric field between the condenser plates. The first factor is fixed by the height of the antenna and is then irreducible. The second can easily be made negligible in the down-lead and in the elevated portion; in the ground, however, it is a different matter. Volumes have been written on the reduction of ground resistance. Most soil, if not too dry or rocky, is a fair conductor of electricity. Its conductivity increases rapidly with the moisture content. It is a general principle that concentrations of current in such a conductor tend to raise the effective resistance of the whole mass; the problem is therfore how to make connection from the tuning apparatus to the ground without producing points where such concentration can occur. The third factor, losses in imperfect dielectrics in the field, is the most difficult to combat and it frequently supplies most of the effective resistance of an antenna. A vast majority of dielectrics come under the clasification "imperfect." Building materials, including window glass, stones, trees, and—alas—most synthetic or "composition" insulators, all dissipate electrical energy at a surprising rate when placed in the high frequency field under or near an antenna. This is

FIG. 3
Dr. Hull is operating a tube transmitter which is putting 2 amperes into the loop. One of his assistants is inside the copper-clad receiving station trying to pick up energy from the transmitter. This is done to test the effectiveness of copper-shielding

FIG. 4
This is the shielded receiving house in the process of construction. Nearly 300 pounds of copper sheeting .03 inch thick were used before the shielding was completed

the reason why a total resistance of 13 ohms at 400 meters wavelength is considered low for an antenna built, as many of them must be, directly over a building. The resistance of many a receiving antenna is much more than this figure.

OVERCOMING THE LOSSES

IN THE special antenna shown at Fig. 2 the aerial portion consists of an equilateral triangle 50 feet on a side, crossed by three medians, the whole being formed of stranded phosphor bronze wire soldered at all intersections. This is suspended 55 feet above the ground from wire cables carried by three wooden masts. The insulators between the cables and the antenna wires are of glazed porcelain, 12 inches long, the dielectric losses in porcelain being very low compared with all other insulators having a comparable tensile strength. The down-lead consists of a single phosphor bronze cable. There is no conductive connection with the ground; the aerial is "coupled" to the ground through a counterpoise consisting of six wires, 50 feet long, passing out radially from the central point where the building is placed which houses the operator and all instruments. This counterpoise has two circular connectors around it, of 30 and 50 feet radius, and is suspended at the six outside points by 15-foot cables supported by iron stakes. The counterpoise is two feet above the ground and is insulated from its supports by 6-inch porcelain insulators. A more uniform distribution of currents is secured in this way than could be possible with any but the most extensive conductive grounding system.

THOROUGH SHIELDING IS USED

THE instrument house deserves special attention in that the materials of which it is built are completely shielded from the field of the antenna. It is cubical in shape and is covered on all six sides by copper sheeting 0.03 inch thick; the windows are covered with heavy copper screen, and the copper-clad door is provided with flaps so that when it is closed its covering is in electrical contact at all points with the rest of the shield. All joints and seams are soldered fast, so that the copper shell forms a high-grade electrical shield for the walls and the interior. The effectiveness of this shield in preventing external fields in reaching the interior with its accompanying dielectric losses has been tested by placing a loop transmitter carrying a current of 2 amperes at different wavelengths just outside the structure, and exploring the interior for electrical leakage with a coil connected to a sensitive receiver. With the door closed the electrical leakage into the interior is inappreciable. Fig. 3 is a close-up view of the transmitting loop used in these tests, with an operator doing his best to send electric waves through the copper-clad walls of the building.

Fig. 4 shows this shielded house in the process of construction. Nearly 300 pounds of copper were sealed over the exterior before it could be made proof against penetration by electric fields from the outside.

The shielded house is insulated from the ground by 4-inch glazed porcelain insulators mounted on iron pipes which protrude 18 inches above the ground. The counterpoise wires partly shown in Fig. 3, are all anchored to the walls and make electrical contact with the copper shell. This shell is thus an integral part of the counterpoise. The down-lead from the antenna is supported by a porcelain insulator and is brought through a small circular opening in the copper screen over one window. Through the same opening a connector from the counterpoise is brought in to the interior, parallel to the antenna lead-in. When measurements are made, this opening is allowed to gape, so that no dielectric but pure air lies in the relatively intense field between the antenna down-lead and the counterpoise up to the point of connection with an instrument inside. This precaution is particularly important since the highest difference of potential in the whole antenna system exists between these two conductors, and a solid dielectric interposed here exerts more influence upon the total effective resistance of the aerial than at any other point between aerial and counterpoise.

THE SYSTEM AS A WHOLE

REGARDED as a whole we see that this antenna system consists of a flat elevated conductor and a second flat conductor directly over the ground, with a highly conducting cube of copper in its center. No electric fields can penetrate this copper cube, so we are at liberty to place any arbitrary dielectrics such as wooden frameworks, instruments, and a more or less conductive man in its interior without affecting the constants of the antenna. (This heterogeneous but useful combination of materials is shown in Fig. 5, which is a view of the interior of the house). The only solid dielectric in the main field between aerial and counterpoise is furnished by the porcelain insulators at the edges. The only solid dielectric in the field of the large series capacity existing between counterpoise and ground is the porcelain of the insulators upon which the shielded house rests. The bulk of these dielectrics is of course

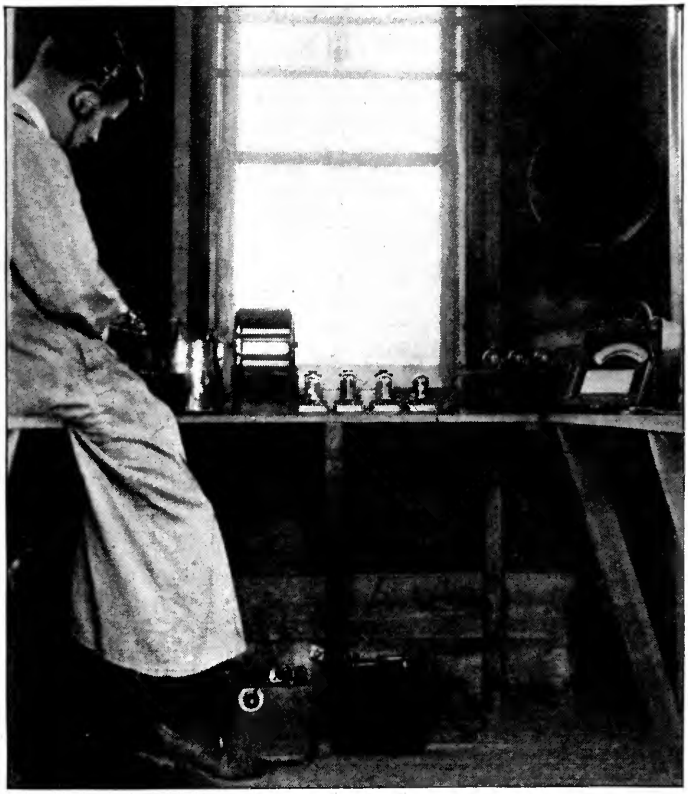


FIG. 5
Inside the ideal receiving station Dr. Hull uses three stages of tuned R. F., a tube detector and a two-stage power amplifier and loud speaker. He can make very accurate measurements of all kinds in this unique laboratory

very small compared with the whole volume of the electric field. The masts themselves are in the very edge of the electric field, but are separated as far from the aerial proper as is consistent with mechanical strength. Experience has shown that dry wood, painted, is no worse than metal towers from the standpoint of energy absorption.

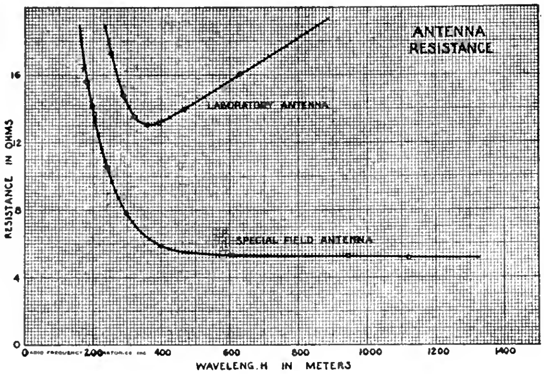


FIG. 6

Here is concrete evidence of the effect of using every effort to reduce antenna resistance to a minimum

The conductor resistance of the system, although small, could probably be reduced by a few tenths of an ohm by the use of a cage down-lead, which will be installed ultimately. The contribution of ground resistance to the total resistance is reduced by the use of the counterpoise instead of a direct ground connection. It is problematical whether a more extensive ground connection would produce less concentration of ground currents and hence lower the total resistance. An investigation of this point is being carried out at the present time.

The cumulative effect of all these structural refinements in producing a low effective resistance for the whole antenna system is shown graphically in Fig. 6. Here the upper curve, marked "Laboratory Antenna" is an experimental plot of the resistance of the "average" antenna which is pictured in Fig. 1. The resistance was measured at wavelengths between 200 and 800 meters. The rise in resistance at the short-wave end of the curve is due to radiation and is observed in all antennas at wavelengths approaching the fundamental or natural wavelength of the system. The rise in resistance above 400 meters is due almost wholly to absorption of energy by the building and other poor dielectrics under and near this antenna. The lower curve shows the resistance of the special antenna system as measured over a somewhat greater range of wavelengths by instruments entirely enclosed in the shielded operating shack. All components of the resistance except the radiation resistance are conspicuously lower than the corresponding components for the other antenna. The minimum resistance is five ohms, corresponding to a minimum resistance of thirteen ohms in the other antenna. The important point, however, is that there is no increase whatever in the resistance at the longer wavelengths, indicating that in this particular operating range the effects of dielectrics in the antenna field have been reduced to insignificance. To the best of our knowledge the only short-wave simple tuned antennas (contrasted with multiple-tuned systems) in actual operation at the present time which show a lower resistance than this system are installed on board ships or in locations where a direct grounding system in salt water is possible. Criticisms or exceptions to this statement would be welcomed by the writer in the interest of further development.

The radiation resistance at 400 meters of the antenna under discussion is 3 ohms, which means that the actual conductor and ground losses are represented by only 2.5 ohms at this wavelength.

Shooting Trouble in the Super

A Series of Concrete Remedies for Almost Any Ill a Super-Heterodyne May Develop During Construction or Operation

By A. J. HAYNES

Vice-Pres. Haynes-Griffin Radio Service Inc.

Since Mr. Haynes's article, describing a "Simplified Super-Heterodyne," appeared in the January issue of this magazine, both he and we have been literally swamped with mail in regard to this set, and, while attempts have been made to answer each of these letters personally (as far as possible) it has been impossible to do full justice to any of them. All of these letters may be divided into two distinct classes—they either contain praise for the circuit, expressing the writer's great satisfaction; or trouble inquiries from people who have not been able to obtain the expected results. Only a very few who have had trouble with one circuit have expressed doubt as to the merits of the set, and this, undoubtedly, can be attributed in a large measure to the confidence which the radio public has in the editorial policy of Radio Broadcast.

We believe that, during the last few months, Mr. Haynes has come in contact with almost every conceivable trouble that could be encountered in the super-heterodyne, and the following discourse on the adjustment of this receiver and the most common troubles encountered should be of assistance to any one building such a set. We can promise the radio enthusiast that, if this set is properly constructed and adjusted, it will be some time before he will wish to seek further for the ultimate receiving set; for quality of tone, selectivity, and distance the "super" reigns supreme.—The Editor.

WIRING

DESPITE the many photographs and diagrams accompanying my article on the "Simplified Super-Heterodyne," published in Radio Broadcast for January, there have been many people who found difficulty in wiring the set properly. This was due in a large measure to their inability to combine the lay-out, as given, with the wiring diagram. For this reason, this article is accompanied by a diagrammatic view of the individual pieces of the apparatus used in this set, with their actual connections. This should entirely eliminate trouble of the foregoing nature.

It is advisable that no more spaghetti be used than is absolutely necessary; and, while *all* leads should be kept as short and direct as possible, this is particularly true in connection with the grid and plate leads from the radio frequency transformers.

TESTING THE SET

THE INTERMEDIATE FREQUENCY AMPLIFIER

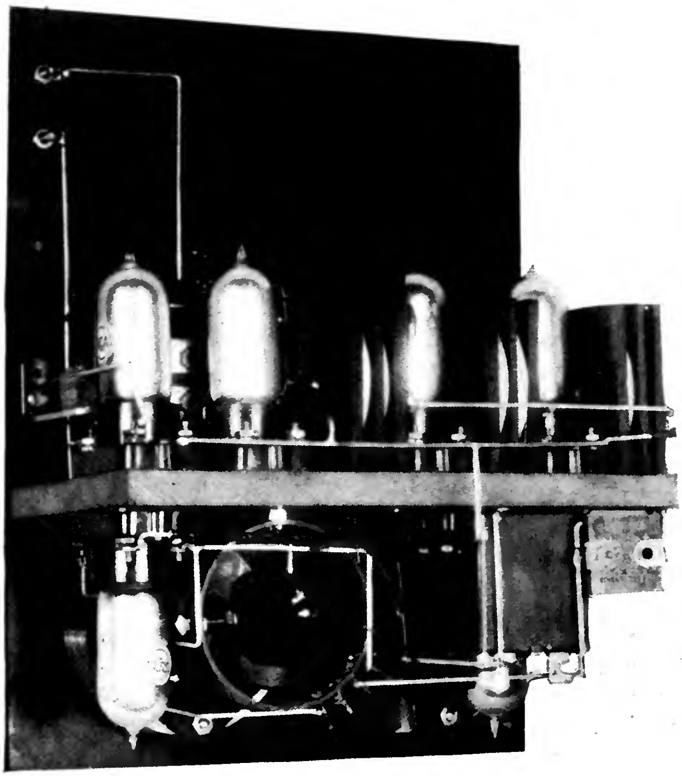
NOW, let us suppose that we have the complete super-heterodyne assembled and wired and, supposedly, ready for operation. Let us start by testing the intermediate frequency amplifier. Snap on the filament switch and turn the filament rheostat on until the tubes assume approximately their normal brilliancy. In the case of 201-A tubes, when a 6-ohm rheostat is used, this will be practically all the way around on the rheostat; but, if a low resistance power rheostat is used, it should be approximately three quarters on. Next, note the polarity of the potentiometer connections, and move the arm on the potentiometer completely over to that side which is connected to the positive A battery line. Plug the receivers into the detector jack and proceed as follows:

Move the potentiometer arm gradually around toward the negative end. At approximately half way around, the amplifier should go into oscillation with a slight "hiss" or "click." If a grating sound is heard in the phones as the potentiometer is varied, the potentiometer winding should be cleaned with a piece of fine sand-paper. The normal operation point of the amplifier is at the position just before the amplifier goes into oscillation, which is found by having the potentiometer arm just on the positive side of the click. If no "click" is heard and the wiring checks out O. K., look for trouble first in the potentiometer itself, making sure that there is an electrical connection between all three posts of the potentiometer, regardless of where the arm is placed. This may be tested with a pair of phones and battery in series, after disconnecting the potentiometer. If the trouble does not lie here, test out the transformers by the same method. When phones and battery are connected across either the primary or secondary windings, a distinct sharp click should be heard—both when this connection is made and when broken.

Assuming that the amplifier is satisfactory, move the potentiometer arm just beyond the point of oscillation, toward the negative side. Now, the entire amplifier is oscillating, and, whenever the grid connection of any of the three radio frequency transformers is touched there should be a distinct thud as the finger touches and leaves the post.

THE OSCILLATOR

LEAVING the amplifier oscillating, test out the oscillator in the following manner: Place the rotor of the oscillation coupler almost all the way in; that is, so that the windings of the stator and rotor are nearly parallel. Now, vary the oscillator condenser (at left of panel) slowly over the entire scale. If the oscillator is working properly—that is if it is oscillating—a succession of whistles or heterodyne notes should be heard in the phones as this condenser is varied. If this is not the case and the oscillator wiring checks out correctly, the trouble can usually be found in the coupler itself. On the stator of this coupler there are two windings—one in the plate and one in the grid circuit. This means that there are four leads that are brought from this stator. If one of these leads, where it leaves the tube, has rubbed against the preceding turn of wire so as to short-circuit with it, it will prevent the oscillator from functioning. If this is the case, it will be well to remove one turn of wire from this end of this particular coil, bringing it back through the coil, as previously. In fact, there is sufficient leeway left in the coupler to remove one turn from each end of each of the two coils, if necessary, without reducing the wavelength range to any extent. *This is the most common cause of trouble I have yet found.* If, after convincing yourself that the coupler wiring is satisfactory, and it still does not oscillate, try varying the B battery potentials; also check up the B battery voltage and try turning the tube filaments a bit higher, to make sure that they are at the proper operating point. With so many tubes controlled from a single rheostat, there will be no danger in burning out the filaments or injuring the tubes—even if they are turned all the way on for a short time.



THIS IS THE REAR VIEW
Of the portable "super" built by Mr. Silver. It is an electrical masterpiece but is not recommended for general construction

Now, supposing you have both the oscillator and intermediate wave amplifier operating properly, turn back the potentiometer arm toward the positive side until the amplifier stops oscillating, and the set should be ready to receive signals.

OTHER SOURCES OF TROUBLE

THERE are several troubles that are sometimes encountered, even after the amplifier and oscillator are performing properly. The most common of these is defective tubes. A bad tube should be suspected above all else, as it is the easiest test to make and occurs quite often. I do not mean by this that the tube is necessarily worthless; but its characteristics may be so different from the other tubes used in the circuit that it will not operate satisfactorily with them. And, again, a tube which might operate quite satisfactorily as an audio frequency amplifier or detector, might not work properly as an oscillator. Therefore, do not neglect to change tubes when hunting trouble in either the amplifier or the oscillator; and also, after the set is operating, change the tubes around until the best possible combination is found. One or two spare tubes are very valuable assets for this purpose.

A not infrequent source of trouble is found in the grid condensers and leaks, as either of these is liable to be defective or open-circuited, and occasionally, in the case of the condensers, short-circuited. As to the matter of grid leaks, there are so few reliable ones available on the market to-day that it is hard to give definite instructions regarding them. However, I recommend that good fixed leaks be used, and, as a general rule, it will be found that a value of about one megohm is satisfactory for both detector tubes—although sometimes for weak signals a higher value of leak may be used to good advantage. Do not omit the by-pass condenser from the plate to the negative filament on the last detector tube—otherwise, the set will be unstable and hand capacity will be noticeable. If the set is operating properly, there should be absolutely no body capacity whatever, even with an entire absence of shielding.

If the set does not tune sharply, or a poor volume is obtained, it can usually be traced to the .0005 fixed condenser, across the input transformer primary. These small fixed condensers are bound to vary somewhat in capacity, and a *small* variation in the capacity here will have no effect on the operation of the set; but occasionally a condenser is obtained which is *so far off* as to seriously affect the operation of the circuit.

This can be checked absolutely by placing a .001 variable condenser temporarily across the first transformer input, and tuning the condenser until maximum volume is obtained. Then, replace the variable with the fixed condenser and note if there is a difference in volume or tuning qualities of the set. Many questions have arisen in regard to the two 0.5 mfd. by-pass condensers, specified for use across the B battery and potentiometer. As a matter of fact, any capacity of .005 or greater may be used, but I would strongly recommend that these condensers should be either 0.5 or larger.

We Have Been Accused

By some of our more experimentally inclined readers of having failed to give them the necessary details for the building of various components of some of the circuits we have described.

"Since Radio Broadcast has been of such tremendous service in bringing the super-heterodyne from behind the door and removing the bugaboos heretofore associated with it," says one reader, "we are surprised to find that mention is made of transformers built by certain manufacturers and no directions given for making them ourselves."

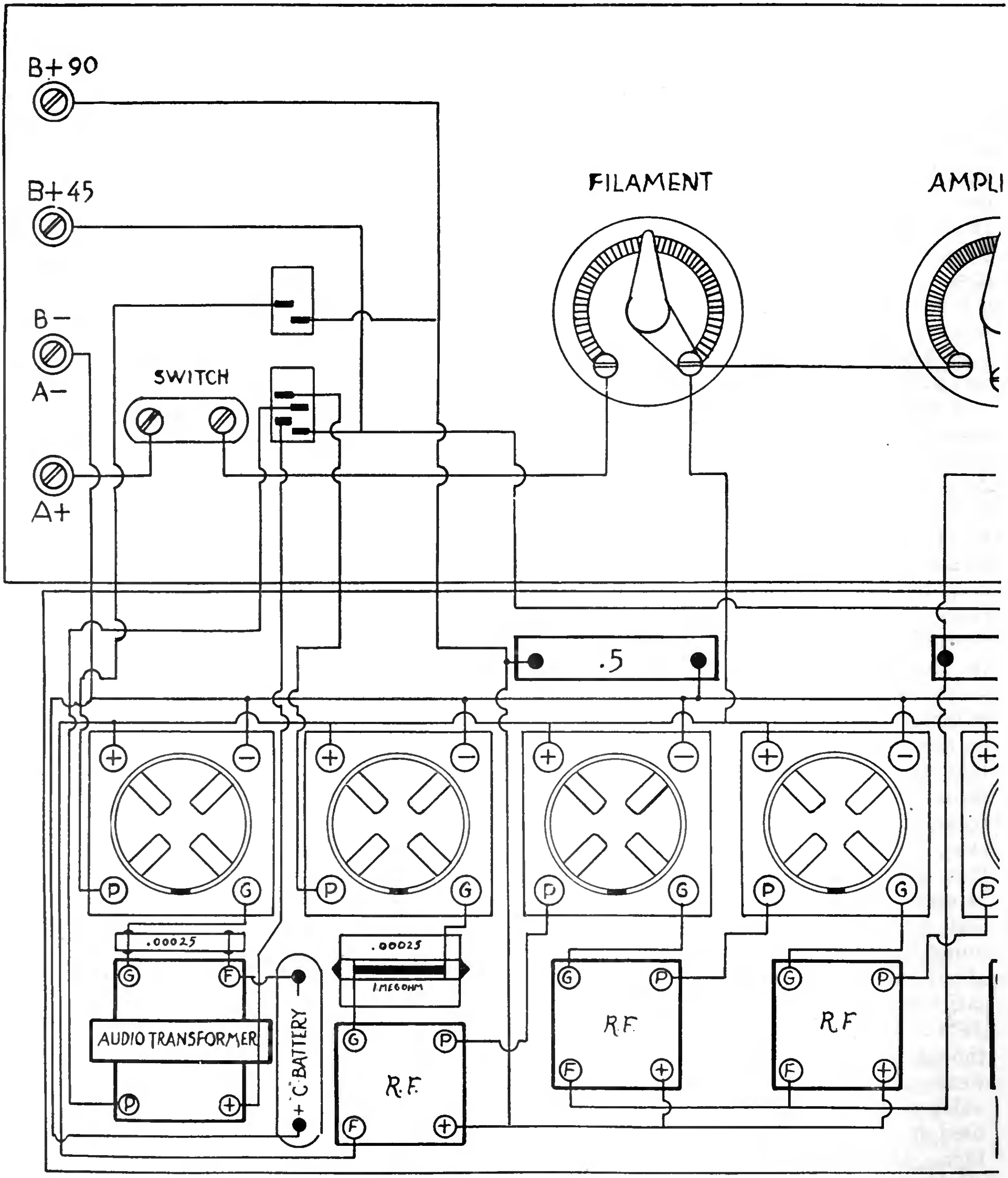
Our answer is this: We believe most of our readers would rather buy certain parts than attempt their actual construction. We must be guided by the desires of the majority. It is sometimes necessary to experiment for months, in an effort to produce a satisfactory substitute for the parts described. We cannot keep the majority from deriving the benefit of a circuit until we can secure the required information for the minority. We will not publish information of this nature until we know it is correct—*and frequently the fault is that we have anticipated the need by a few months* and the reader fails to look over issues of preceding months.

For instance, in the case of the letter referred to, our correspondent mentioned an article prepared for us by Mr. George Eltz, appearing in our November, 1923, number. He failed to observe that Paul Godley had told how to build a resistance coupled super-heterodyne in our February, 1923, number and the very substitutes he desired had been completely described in an article entitled "A Practical Super-Heterodyne with 199's" by Walter Van B. Roberts in Radio Broadcast for August, 1923.

We are doing our best to give you the best, and most of the reader's time and vexation can be saved by an occasional perusal of past issues.—The Editor.

TUNING THE SET

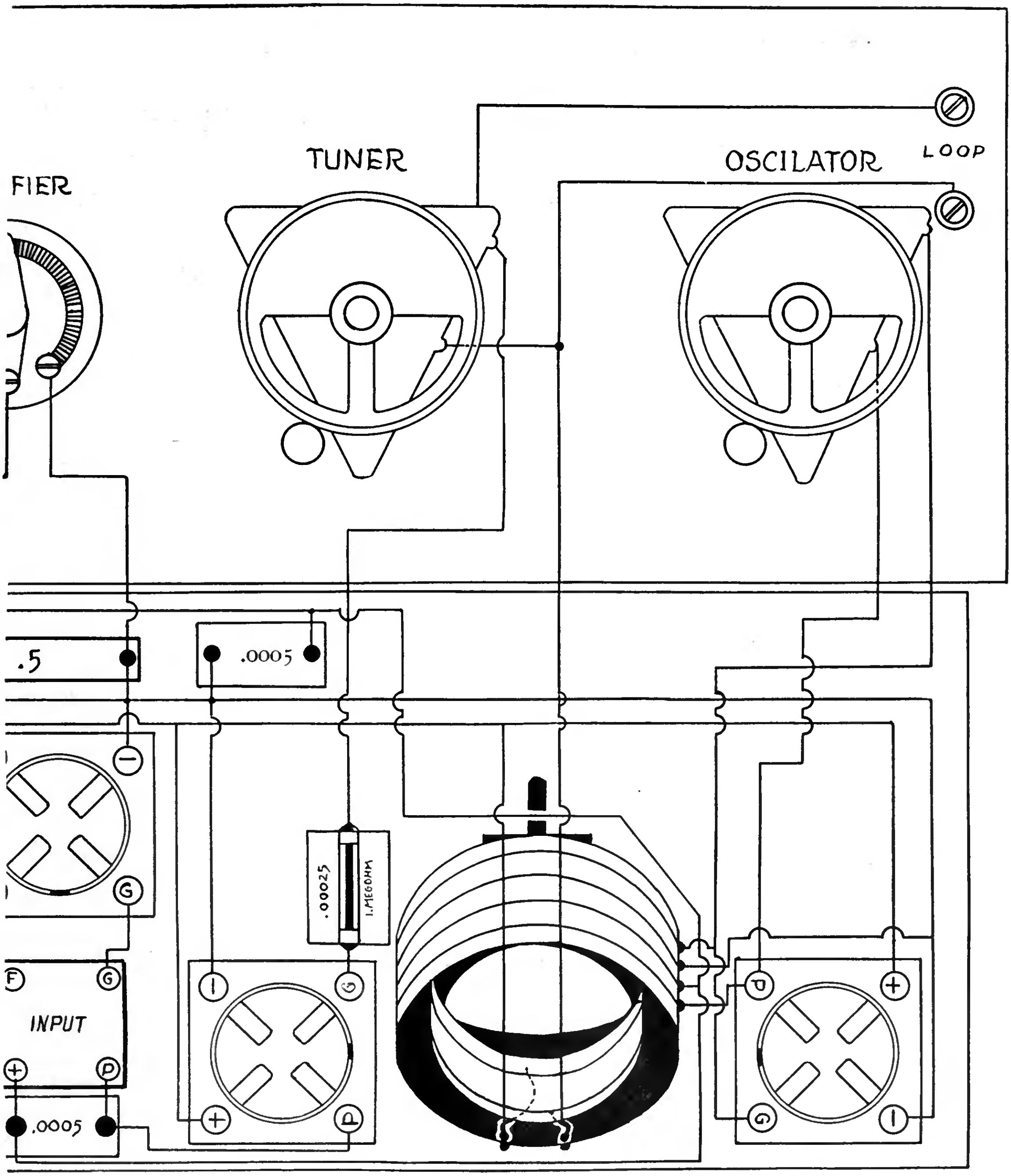
In tuning this receiver, there are practically only two controls that need be used, although there are two secondary adjustments that are available. The two principal controls, in order of their importance are—the oscillator condenser on the left end of the panel, and the loop tuning condenser next to it. It will be found that the oscillator tuning condenser will



THIS IS THE—
Of the seven tube super-heterodyne described—
be followed in detail and will reduce to a—

be much the sharper of the two in adjustment, although with a good loop its tuning condenser should tune fairly sharply. These two condensers must be varied more or less in unison, the general tuning practice being slowly to increase the oscillator control, or left-hand condenser, while the other condenser, which tunes the loop, is increased with it, or continuously moved backward and forward over a small arc as the readings are gradually increased.

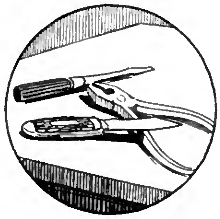
When the circuits controlled by the two condensers are in resonance, regardless of



—DETAILED LAYOUT
—in Radio Broadcast for January. It may
—minimum the trouble encountered in assembly

whether or not they happen to be tuned to a signal, a certain amount of noise can usually be heard, particularly if there is any inductive interference in the neighborhood or if any static is present. It will be noted that, on a low wavelength station, when both condensers are tuned to a station on the lower part of their dial settings, if the oscillator dial alone is increased to the upper part of its scale without moving the tuning dial, this station can be brought in again. This is due to the fact that the signal can be heterodyned with either the sum or the difference of the local and incoming frequencies. However, this is more valuable than objectionable, due to the fact that the radio frequency transformers are designed for a comparatively high frequency, and these two points are so far apart that, by the time the upper point is reached on the oscillator condenser, the tuning condenser is so far from the fundamental wave of the station that, unless the signals are extremely powerful, they cannot get through. Just this, together with the fact that the higher the frequency range the sharper the tuning may be without a loss of quality, is the reason for employing this high intermediate amplifier frequency.

The secondary controls which were mentioned—or we might call them auxiliary controls—are the loop and potentiometer. The loop may be swung in different directions to receive with maximum efficiency from various stations, and this in itself is a great aid in eliminating interference, particularly that of spark stations. There is also the potentiometer adjustment, which controls the volume of the received signal. The further the potentiometer arm is moved toward the *positive* side, the *less* amplification is obtained, and *vice versa,* up to the point where the amplifier breaks into oscillation.



It will be noted that, after all other adjustments have been made, if the filament rheostat is touched, its controls will appear to be very critical. This is due to the fact that it reacts on the potentiometer control and that for every different filament adjustment a different potentiometer adjustment must be made if it is desired to maintain maximum amplification. On the other hand, the proper filament adjustment should be found and left for all time, and all adjusting done with the potentiometer. This filament adjustment should be as low as possible without sacrificing any amplification or quality. Do not lower the filament to the point where the set becomes unstable and the amplifier control becomes "sticky," as we call it; that is, goes in and out of oscillation with a thud at different points on the potentiometer adjustment.

The potentiometer adjustment should not be materially affected by the tuning controls; that is, it may be adjusted for any degree of amplification and left without further adjustment, while the two condensers cover the entire wavelength range.

SIMPLICITY OF CONTROL

THERE is one statement I made in the last article which has caused quite a bit of comment. It was that I considered such a super-heterodyne as this easier to tune than a single circuit regenerative receiver, and I still maintain this to be the case. The reason is that this set has only two variable controls outside of the loop and potentiometer, which once adjusted may be left, and these two controls may be *calibrated absolutely and always remain the same,* providing the same tubes and loop are used. In fact, it is only necessary to calibrate one of the dials, and this should be the oscillator dial settings, in which case the set may be used with any loop; and, after adjusting the oscillator to the desired station according to the chart, it is only necessary to vary the loop condenser until the desired station is heard. In fact, as the oscillator consists of a fixed inductance and variable condenser (after the oscillator rotor is once adjusted) this circuit may be calibrated directly as a wavemeter, and a curve made on a sheet of graph paper with the wavelengths plotted against the oscillator dial settings. This particular set of dial readings and curve was made with one of these sets, using a General Radio .0005 geared vernier condenser, and, while these particular settings will vary somewhat with various condensers and oscillator couplers—even of the same type—they may be taken as approximations; and, if the oscillator dial is so set on its shaft as to correspond on any given station with the dial setting of this station on the accompanying chart, the remaining settings will be found to be very nearly correct.

In regard to the oscillator coupler rotor, this should be adjusted permanently before making any dial setting records. To do this, tune in a fairly weak signal and adjust the tuning condensers and potentiometer for maximum audibility. Now, make a small change in the position of the rotor. The effect of this change of position will be to throw the oscillator somewhat out of adjustment. Readjust the oscillator condenser and the potentiometer for maximum audibility again and continue this process with successive rotor settings until the setting for best signal strength is obtained. *Then leave the rotor alone.*

THE PORTABLE SUPER

THE small portable set, mentioned in the previous article which appeared in the January issue of RADIO BROADCAST, has caused so much comment and I have received so many requests for further information on it, that I am giving, herewith, another photograph showing the back of panel of this set. However, as stated in the previous article, all of the equipment used was specially built for this set, and, except for such standard parts as rheostats, sockets, condensers, etc., the entire set was constructed from raw materials—that is, wire, hard rubber sheet, and machine screws. This, of course, is quite an undertaking and should not be attempted by any one who has not acquired a considerable amount of experience with this work.

A CORRECTION

THE diagram given here varies in one respect from the original schematic diagram which appeared in the previous article. This is in regard to the oscillator coupler grid return which should connect, as shown here, to the common *negative* battery line. Due to an error, this was connected to the positive A battery lead in the previous diagram, and, while thus connected it will not in any way impair the operation of the set, it will cause a somewhat unnecessary consumption of B battery current.

USING AN OUTSIDE ANTENNA

I HAVE received numerous requests for instructions for utilizing a straight antenna with this, or any other loop set. There are several ways of doing this, any one of which will work quite satisfactorily. Personally, I prefer to use the loop at all times and, if atmospheric conditions permit of the use of outside antenna, to couple this loosely to the loop by tuning it separately, this may be done by placing a DL-50 coil and .001 variable condenser in series with the antenna and ground; that is, the antenna should be attached to one end of the coil, the other end of the coil being connected to the fixed plates of the variable condenser, and the *movable variable condenser plates connected to the ground. Neither the antenna nor the ground is connected to the set proper.* Then, by placing the honeycomb coil on the table beside the loop, or even by running the antenna lead-in past the loop within a few inches, sufficient coupling will be attained, when the antenna circuit is brought into resonance by tuuing the variable condenser. However, I do not recommend that this apparatus be incorporated in the same cabinet with the set itself.

Another way of doing this is to run an extra single turn of wire around the loop, connecting the ends of this turn to the antenna and ground respectively, in which case no extra tuning apparatus is necessary. Again, a considerable increase in signal strength may be obtained by merely connecting the antenna to one of the loop terminals without the use of the ground, although this method is not advisable in congested localities where interference prevails. If it is desired, a small separate unit may be built consisting of a standard variocoupler, the secondary being connected in place of the loop to the two input posts at the left of the panel, and the primary being brought out to a series of taps, connected to the antenna and ground in the usual manner.

It will be found, however, in most cases, that an antenna is not necessary unless one wishes to do extremely long-distance work, or very loud signals from long-distance stations are desired; although there are some locations such as a large steel building, etc., where an antenna must be used for consistent long-distance reception.

THE COMPARATIVE MERITS OF THE SUPER-HETERODYNE

THERE is one question that still seems to be unanswered in the minds of many radio enthusiasts, and this has been caused somewhat by recent extravagant claims made for certain circuits. In my opinion—and I feel sure that I am far from being alone in this respect—there is to-day no circuit within the limits of practical use which will give greater sensitiveness, or sharper tuning without sacrificing quality than the super-heterodyne.

For giving us this remarkable circuit, the radio world owes a debt to Major Armstrong, the real extent of which we are only beginning to appreciate.

How Far Have You Heard?

Announcing Radio Broadcast's Second Prize Distance Contest

THIS year our contest is to be in two sections—one for home-made and the other for ready-made receivers.

Each year the automobile has its speed trials, which largely determine the desirability of certain designs and prove the inferiority of others. The Editors of Radio Broadcast believe that a similar race for radio receivers is not only interesting but serves the very useful purpose of proving the over-all effectiveness of one type of receiving equipment over others.

These are about the best radio receiving months of the year and it is possible to pick up stations over great distances. Consistent performance, during an entire month should result in many contestants piling up a very great score. Now is the time to prove the real worth of your receiver.

THE PRIZES

TWO sets of prizes are offered. For the ready made sets some of the best sets which can be obtained will be given. For those winners who own home made sets, complete sets of parts for excellent receivers will be awarded as follows:

Ready Made Sets

FIRST PRIZE	Mu-Rad, Type MA-15
SECOND PRIZE	Neutrodyne, Fada 160
THIRD PRIZE	Sonochorde Loud Speaker, Type C

Home Made Sets

FIRST PRIZE	Complete set of parts for the Haynes super-heterodyne, described in January Radio Broadcast
SECOND PRIZE	Complete set of parts for a "Knock-Out 3-tube Set," described in February Radio Broacast
THIRD PRIZE	Complete set of parts for "Knock-Out 3-tube Reflex Set" with the Sodion tube.

NO "BLOOPERS" ALLOWED

NO REPORTS from owners of oscillating receivers will be considered, because attempts to receive over long distances with such outfits cause a great deal of annoyance to other receivers in the neighborhood and threaten to deal the entire radio broadcasting industry a severe blow. Some of the reasons for this decision are outlined in the article beginning on page 365, which, by the way will tell you whether or not *your* receiver is in the *pest* class.

TESTS TO LAST A MONTH

THE test period will begin at midnight February 19th and last until midnight March 20th. During this time it is but necessary for you to log your reception as follows:

Date	*Time*	*Call letters*	*DX*	*Remark*

It is merely necessary to list the call letters *but hearing only the call letters is not sufficient.* The reception from any station listed should be clear for a period long enough to hear a complete musical selection, the call letters, and location of the station. If this cannot be done—do not list the station. The report of possible winners will be checked with the broadcasting station managers and an *optimistic guess* may lose the contest for you. Play the game!

Under remarks you should include the type of entertainment received during the time your log indicates and a note about the volume, quality and interference.

In listing your time be sure to mention whether it is Eastern, Central, Mountain, or Pacific.

Under DX, give the distance from your receiving location to the broadcasting station listed. This distance may be measured on any standard map, but a very simple method of measuring is found in the Radio Scalometer and the map.

ADDING THE DX

AT MIDNIGHT of the last night add up the mileage indicated on your log and make the following notation at the top of your first sheet:

Stations Heard	Total Distance	Greatest Single Jump	Shortest Distance
38	51,348 miles	3,200 miles	200 miles

RULES

FOR THE HOME-MADE SETS

To win a prize you must send us in addition to your log:

(a) A photo of yourself

(b) One or more photos of your receiver

(c) Complete diagram and working plans for building and operating your set

(d) Complete list of the accessories used, including number and types of tubes, size and kind of A and B batteries.

FOR THE READY-MADES

Same as above except that (c) should merely include the manufacturer's name and type of set you are using.

Put name at top of each log sheet and on back of each photo or diagram sent in.

Leave four-inch space at top of first page of description. Use typewriter and double spacing. Keep a carbon copy for yourself. Mail report not later than midnight, March 23rd. Reports carrying a later post-mark will not be considered.

Write your description of set while tests are on so that it can be mailed as soon as the contest is closed.

SAMPLE LOG SHEET

Stations Heard	38	John Doe
Total Distance	51,348 miles	335 West End Ave.
Best Single Jump	3,200 miles	Chicago, Ill.
Shortest Distance	200 miles	

Date	*Time*		*Station*	*DX*	*Remarks*
Feb. 20	12:05 A. M.	(c)	KDKA	680 miles	Test program to England —loud—interference from "bloopers."
	12:35 A.M.		——	——	——
				Total 51,348	

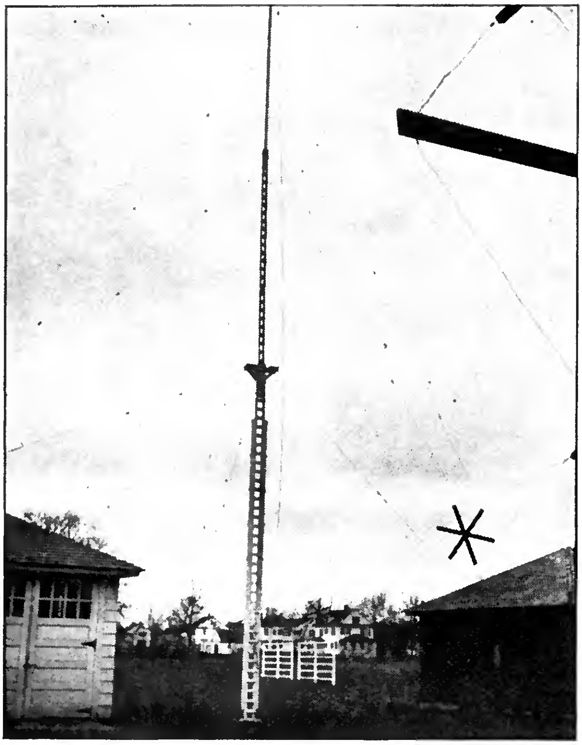
The Amateur and the B. C. L. Get Together

ON MARCH 3rd to 7th, an opportunity will be given for the broadcast listener and the telegraph amateur to meet on common ground and to discuss common radio problems at the Second Amateur Radio District show and convention. This will be held at the Hotel Pennsylvania, New York City.

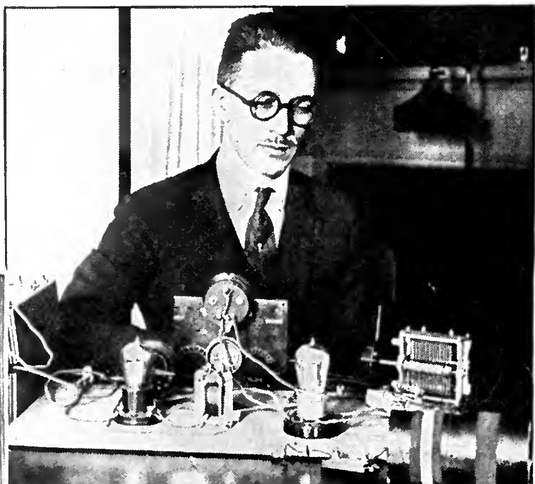
The amateur is not such a fearful soul after all, and the broadcast listener is more amenable to reason than is often thought. The amateurs are planning a program of lectures and meetings which should be instructive to broadcast listeners and certainly to amateur operators.

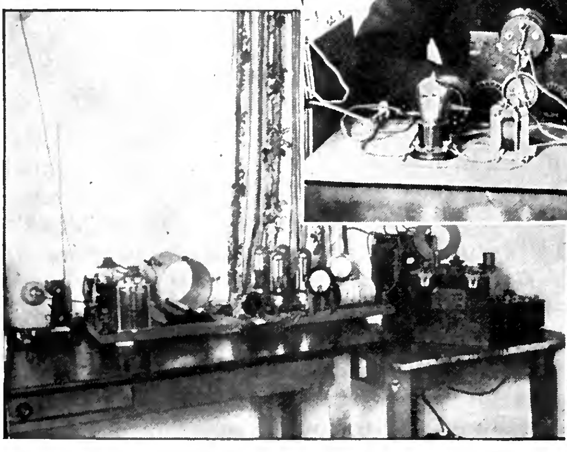
Amateur radio clubs and district associations in other sections of the country can learn of the plans being made for this convention and radio show by writing the president of the amateurs in the second district care RADIO BROADCAST.

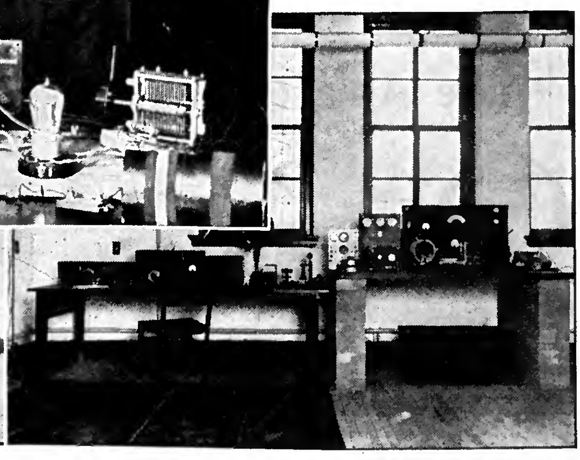
Hams Across



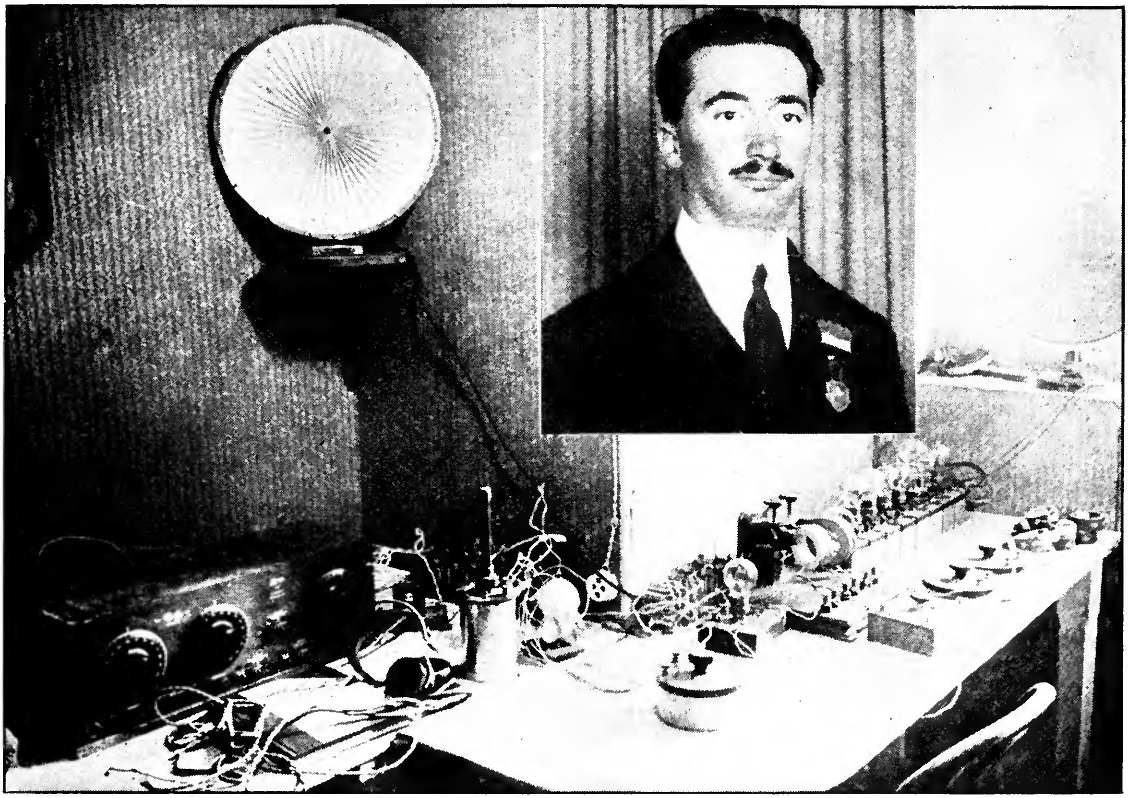
These amateur radio stations in France and America established two-way communication on 100 meters for the first time in radio history during the last months of 1923. TOP: The neat antenna and counterpoise of 1MO, operated at Hartford, Conn., by F. H. Schnell, traffic manager of the American Radio Relay League. CENTER: Mr. Schnell and his 110 meter receiver. LOWER LEFT: The 110 meter transmitter at 1MO. RIGHT: Receiving and broadcasting station at Haverford College, where signals from Leon Deloy's amateur station at Nice, France were brought in on a loud speaker





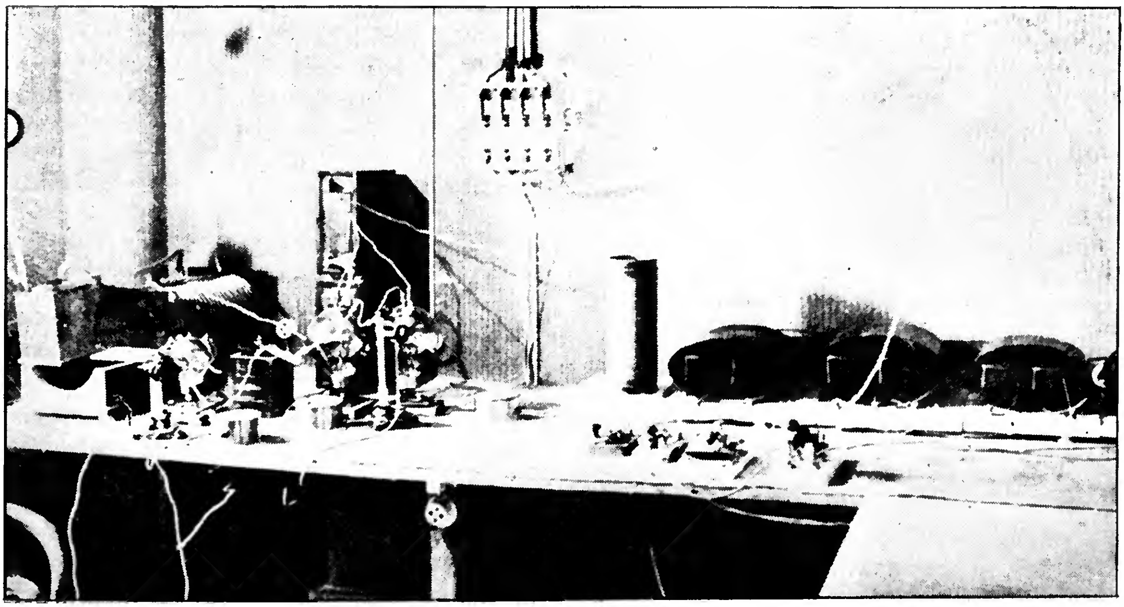


The Sea



M. LÉON DELOY, OF NICE, FRANCE

Who was the first French amateur radio telegrapher to attain two way communication with American amateurs. UPPER PHOTOGRAPH: M. Deloy and his receiving apparatus. LOWER PHOTOGRAPH: The efficient tube transmitter at French 8AB, Nice



Is the Broadcast Listener at Fault?

By CARL DREHER

IN MY article last month, dealing with the telegraph amateur, I called attention to the fact that as an art or industry becomes more complex and diversified, restrictions necessarily multiply, and that it is the part of wisdom to modify one's attitude accordingly. And, as it is fair to treat a man according to his pretensions, my argument was addressed to the amateurs as good technicians, in short as an engineering-minded group. With this in mind, I tried to give my view of the conflict between the amateur and the broadcast listener against a historical and political background.

Before going on I should like to restate my belief that the interests of the telegraph amateur and the broadcast listener will never be merged. They will remain separate groups, following their separate aims and desires. Amateur radio will recruit a certain number of adherents from the ranks of the broadcast listeners, but the percentage will be small compared to the number of BCL's who will never learn the code or finger a telegraph key or own a transmitting set. For this we should be thankful, for if everyone wanted to transmit, the mechanism of radio, creaking a little even under present conditions, would certainly break down entirely. There is no more reason to believe that improvements in the art will enable ten thousand people to talk where one talks to-day, than to expect that if that number of individuals crowded into a hall, all could speak at once without confusion. The cost of transmitting sets, the special and by no means widespread appeal of this form of adventure, the difficulty of learning the code, and many other factors, will keep the two classes segregated substantially as they are now. Why, indeed, should a man who wants to hear the opera be invited to become a brass-pounder?

INTELLIGENCE, WHERE ART THOU?

IF THE principal trouble with the amateurs is that they do not know where they get off, the main difficulty with the broadcast fans is that they do not know, as a class, how to get on the car, and expect miracles from the conductor once they have been hoisted aboard. It is nowhere written, to be sure, that one must have technical qualifications in order to be a good citizen. It is reasonable, however, to expect the exercise of intelligence, which consists, fundamentally, in seeking the easiest means of getting what one wants, without bothering other people, and availing oneself of all the facilities at hand. But many of the broadcast listeners do just the opposite of this.

For example, the larger broadcasting stations receive inquiries every day from people who want to know what station they heard the preceding night playing "Down on the Swanee River," or some such rare musical selection. They usually know the approximate wavelength, and sometimes a portion of the call letters. On being told that all the radio periodicals publish, each month, a list of broadcasting stations with call letters, wavelengths, and other data, not to speak of the programs printed in the daily papers, and that on the basis of this data their own conjecture will be as good as any one else's, they not infrequently express great surprise that they have to play their own guessing game. In fact, a good many people, probably otherwise sensible, display a sort of infantile helplessness when it comes to radio. Not long ago I read a series of inquiries addressed to a broadcasting station, asking, among other things, how many feet correspond to a meter.

It would seem that any person interested in radio, who wishes to be reasonably well informed regarding what he tackles, should read at least one radio periodical—preferably a monthly, since the monthly magazines are much less given to featuring transitory circuits and news than the newspaper radio supplements. Radio conditions alter rapidly and many problems remain to be solved; one cannot get an intelligent view of the field without spending a small amount of time reading one of the magazines every month. This reacts directly on each reader and largely determines what he will get out of his radio experience. Yet it is doubtful whether the radio publications number more readers, in proportion to the total number of people interested, than sporting magazines and other papers in comparatively stabilized fields. Tennis playing or duck shooting have not altered so much in the past decade that a man could not keep up with the crowd merely through his activities in the field, but radio, in its present state, is in a different position. A man reading a well established radio magazine regularly would not be apt to write such an inquiry as the one below, which was addressed to a broadcasting station:

"Will you kindly send me any information you have as to the right way to 'tune in.'

"I have a one-tube set and get the stations quite clear but I get interference."

In the course of a few months he would no doubt have read such a description. He would know how to tune his set with a minimum of trouble for his neighbors and a maximum of satisfaction for himself. And that brings up the somewhat hackneyed, but urgent as ever, question of oscillating receivers.

"THE DESTRUCTION THAT WASTETH AT NOONDAY" AND "AT EVENTIDE"

I AM listening to Dvorak's New World Symphony, using slight regeneration. One of the neighboring B.C.L.'s comes along, his receiver oscillating merrily. He makes a few preliminary flourishes, passing rapidly through the wavelength of the broadcasting station with agonizing squeals; finally he locates on zero beats. He is not satisfied with the result, so with his receiver still oscillating full blast, he detunes somewhat and holds a 2000-cycle note for several minutes. When I am almost used to this, he changes his mind and recommences adjustments, filling the room with howling crescendos and diminuendos; and this clamor lasts for the next five minutes, when, happily, my neighbor decides to go to the movies and shuts off his receiver-transmitter for the night. But I am never safe against him.

It is doubtful, in this case, if there is any other remedy than education of the public. Transmitters may be regulated by law, their number being within reason. Receiving sets are so common that the enforcement of a law against oscillating sets is enough to daunt any legislator. Of course the commercial manufacture of receivers capable of oscillating could be forbidden, but the problem would remain of dealing with the make-your-own group (which would correspond to the home-brew gentry, and would no doubt be quite as numerous).

The problem is fundamentally an economic one. Regeneration is the cheapest form of radio-frequency amplification. It may be carried on in the same tube that is used for rectification. The amplification realized is roughly equal to one step of radio frequency. The price of a vacuum tube is an important consideration to most people, and naturally, when they can get the equivalent of a two-tube set from one tube, they do not hesitate to use the invention which makes this possible, even though they complicate the interference problem in so doing. Means are of course known whereby re-radiation can be prevented. One method is to forbid the use of regeneration. Another is to use a coupling tube, or one-way repeater, between the aerial and the regenerating tube, to act as a valve, preventing the local oscillations from getting out into the air. But this wastes a tube. The most simple scheme is for everyone to use regeneration only to a limited extent. But that requires the general exercise of discretion and considerable respect for the rights of others. Till we get to that point, the wailing of the damned will be mingled with every symphony.

CHARITY, CHARITY FOR THE AMATEUR

FINALLY, every fair-minded person must deprecate the setting up of scapegoats, and there is no denying that many of the broadcast listeners are trying to make scapegoats of the amateurs. Amateurs are blamed for the interference of leaky high-tension transmission lines, X-ray machines, commercial stations, and any other noise that happens to interfere with a broadcast listener. The amateurs, knowing themselves in many cases to be unjustly accused, develop the feeling that they are being persecuted, and become bitter-enders and irreconcilables. Thus, into a situation which requires clear thinking and scientific adjustment, the psychology of conflict is injected, and belligerency takes the place of reasoning. A prominent amateur writes to a current radio periodical, "I believe I speak for every amateur in America when I say that I hope the amateur may see the day when he can tramp on the grave of the nighthawk broadcaster, and kick his tombstone into perdition beyond recall." Simultaneously a broadcast listener declaims in another place, "If that is the station that is broadcasting code . . . my suggestion would be that instead of hiring a lawyer the matter be placed in the hands of a vigilance committee for action." These excited metaphors, and the familiar demand for a "vigilant" committee, will not solve the problem.

The amateur and the broadcast listener are parties to a situation that is by no means simple, and which must be considered from several angles. Their interests are, I believe, fundamentally opposed, and it is idle to deny that a conflict of increasing proportions is in progress between them. But I also believe that an amicable compromise is possible, and will eventually be arranged. The prerequisites to this are, first, readiness on the part of the amateurs in the cities to surrender some portion of their present freedom; and secondly, willingness to learn what it is all about on the part of the broadcast listeners. The spirit of toleration and good will, the desire to understand the other man's motives, and an objective view of the technical problems involved, are badly needed in radio at the present time.

What Makes the Wheels Go 'Round

ONE SYLLABLE ELECTRICAL THEORY. I

Removing the Terrors From the Common Elementary Electrical Theory—The Basis of Radio

By WALTER van B. ROBERTS, B.S, E.E., A.M.

1. ELECTRONS

JUST as sand comes in tiny grains, electricity comes in almost unimaginably small units called electrons. These can be assumed to be round, and about a tenth of a trillionth of a centimeter in diameter. They are all exactly alike and the weight, even of billions of trillions of them, is entirely negligible. In some fashion not yet completely understood, they manage to flow through solid metal wires fairly easily, although insulating substances such as glass, rubber, porcelain, dry wood, etc., even air very effectively block their passage.

2. FREE ELECTRON THEORY OF CONDUCTION

A WIRE, not connected to anything, may be supposed to contain about ten billion trillion electrons per cubic centimeter that are free to travel. There may be a great many more in the wire, but we are mostly interested in the "free electrons" because they are the ones that start moving when an "electromotive force" is applied to the wire by connecting its ends to the poles of a battery or dynamo.

3. ELECTRIC CHARGE

THE actual total number of electrons normally present in a gram of any substance is about six hundred billion trillion. If more than this normal quota are present the substace is said to be *negatively* charged. (It is very unfortunate that in the days before much was known about electricity the term *negative charge* was arbitrarily picked to designate what we now know to be an excess of electrons. A great many words will have to be wasted trying to keep clear of confusion resulting from this unlucky choice of terms.) If less than the normal number are present the substance is said to be *positively* charged.

4. ELECTRIC POTENTIAL

IF A tank of compressed air is connected by a pipe to another tank containing air at a different pressure, air will flow from the tank where the pressure is higher to the one where the pressure is lower, no matter what the relative sizes of the tanks. This analogy should make clear the term "electrical potential" which corresponds exactly to the air pressure. For if two bodies are connected by a wire, electrons will flow, from the one having the greater electron pressure, to the other. But due to the unfortunate convention that electrons are negative electricity, a large electron pressure is called a large *negative* potential, while less than the normal number of electrons causes a positive potential. Except for this reversal of the terms "positive" and "negative" in the electrical case, the analogy can be made complete by introducing the term "negative pressure" or vacuum for the amount below normal atmospheric pressure in the analogy. See Fig. 1.

What You Can Learn From This Series

There is a growing desire on the part of our readers to have a more definite understanding of what goes on in a receiving set when the dials and knobs are turned. Many have rather fantastic ideas about radio in general and radio receivers in particular. It is a very difficult matter to find an author who really knows this subject and is gifted with the happy faculty of telling what he knows in language within the understanding of other than scientific minds. Mr. Roberts is such an author. His articles on super-regeneration and the super-heterodyne have won him many friends among our more technically and experimentally inclined readers.

In the series of articles, of which this is the first, he has covered the entire field of radio in a most interesting, intelligent, and capable manner. He understands his subject well enough to cut the corners without leaving the reader to take any of the facts for granted, merely because they are given as facts. Mr. Roberts has proof for everything, and very interesting proof at that.—The Editor.

5. ELECTRIC CURRENTS

FIG. 2 shows how a continuous flow may be obtained. A fan maintains the air at a higher pressure at A than at B so that a current of air flows from A to B through the pipe. In the electrical case a dynamo or battery is the electrical pump. It is conventional to pretend that an electric current is the flow of positive electricity, and the direction of the current is the direction of this flow. This explains the well known rule that current flows from the positive pole of a battery through the external circuit back to the negative pole. Actually of course it is the electrons that are moving, and in the opposite direction. The strength of the current, which is called the number of amperes of current, is the number of units of electricity that pass a given point in the wire per second,

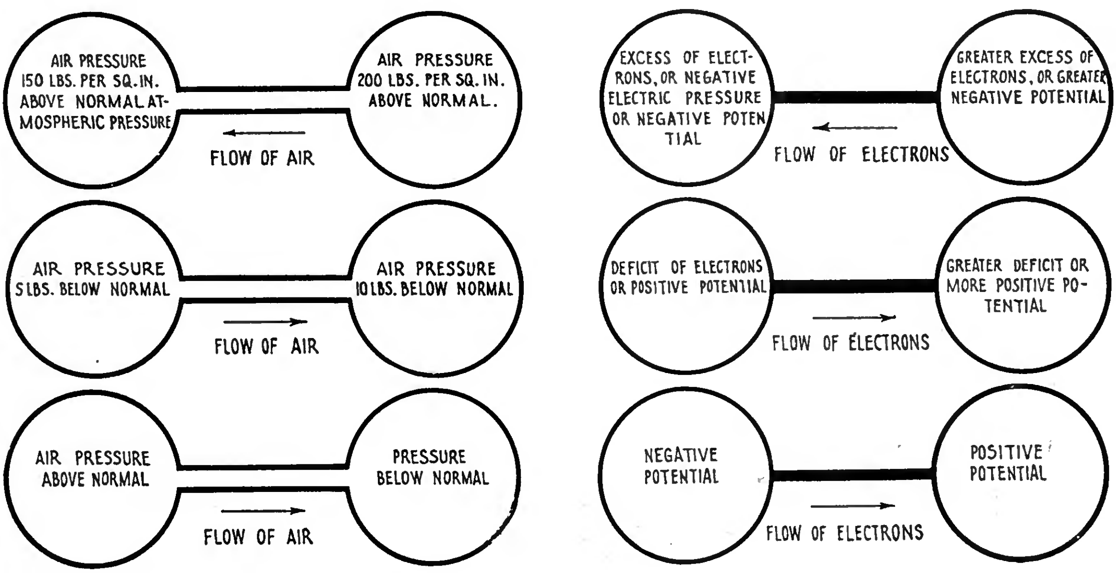


FIG. 1
How electrical pressure is like air pressure

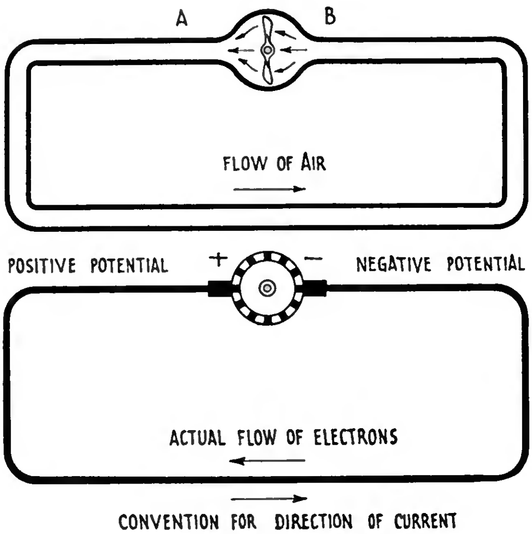


FIG. 2
Showing graphically how a continuous flow of current is maintained

just as the amount of flow of water is the number of gallons passing a given point in a pipe per second. It would be very reasonable to measure an electric current by simply stating the number of electrons that pass a given point per second, but it would be very awkward because even with so small a current as one ampere flowing more electrons go by per second than there are grains of sand visible on all the sea shores of the world.

6. SPEED OF ELECTRICITY IN WIRES

CONTRARY to general belief, electricity flows very slowly through wires. There are so many electrons free to move that a large current results from their very slow motion, just as a large current of water is caused by a very slow motion of the water in a wide, deep river. It is thought that the average rate of drift of electrons along a copper wire one centimeter in diameter carrying one ampere of current is about the same as the speed of the minute hand of a clock. What does travel with terrific speed when a current is started, is an electric "wave"—a thing ahead of which there is no current, and behind which the electricity has begun to flow. When a freight engine starts a long train the engine starts first, then the first car is yanked into motion, the latter in turn starts the second car and so on. Likewise, if we connect a battery to the ends of a wire many miles long, within a fraction of a second the electrons even in the most distant parts of the wire will be on the move.

7. ALTERNATING CURRENTS

WE HAVE been speaking of direct currents, or currents where the electricity flows steadily along without stopping. If, however, the electricity does not on the average move along the wire at all but merely goes back and forth, the current is called alternating. We often say that an alternating current flows "through" a wire: it would obviously be more exact to say that an alternating current flows *in* the wire. A direct and an alternating current can be considered to flow in the same wire at the same time, in which case the resulting motion of the electricity would give somewhat the effect of a man walking two steps forward and then one step back. The frequency is the number of times per second that the electricity vibrates from one end of its path to the other and back again. This round trip is called a cycle, hence the frequency of an alternating current is expressed as so many cycles per second. Sixty cycles per second is usual for house lighting, fifteen to twenty-five cycles for electric railway power, thirty to five thousand for current representing the human voice, and currents of frequencies above about ten thousand are classed as radio frequency currents. Currents of five hundred kilocycles to a thousand kilocycles (500,000 to 1,000,000 cycles) flowing in the antennæ of broadcasting stations are the immediate cause of the radio waves. An interesting point to note about these high frequency currents is that the electricity must barely quiver, for, moving with a speed comparable to that of the hand of a clock, and reversing its motion a million or so times per second, the path traveled would be ultra microscopic.

Either direct or alternating current will heat a wire. If an alternating current heats a certain wire exactly the same amount as three amperes direct current would do, then the "effective value" of the alternating current is likewise three amperes. The effective value is also sometimes called the heating value and the root mean square value.

8. CONDENSERS

FIG. 3 shows a condenser and a hydraulic analogy for it. The crank and piston arrangement, when rotating, produces an alternating current of the water filling the system.

The diaphragm prevents any direct current, but by bending back and forth allows alternating motion of the water. The greater the area of the diaphragm, and the thinner it is and the more flexible the material it is made of, the easier it will be to turn the crank. In the electrical case, corresponding to the diaphragm we have a sheet of some insulating substance separating two sheets of metal. This prevents direct current but allows alternating current. The greater the area of the metal sheets, the closer they are together, and the greater the "dielectric constant" of the substance between them, the less powerful need be the source of alternating current to produce a given current. (To save space, condensers usually have one plate cut up into small pieces and connected together, interleaving with the pieces of the other plate, as shown in Fig. 3.) Returning to the hydraulic case, if the connecting rod is hitched to point No. 2 instead of No. 1, only half the force will be required to turn the crank as the diaphragm will only be stretched half as much. Also the current will be only half as great. But if, then, the crank be turned twice as fast, the speed of the water will be doubled so that the current is the same as before. This establishes a relation that holds good in the electrical case, namely, that if the frequency be doubled, or trebled, etc., the electromotive force required to produce the same current will be only one half, or one third, etc., as great. The "capacity" of condensers used in radio circuits is usually expressed in microfarads, and if air is used as the insulating substance between the plates, the capacity in microfarads, is approximately equal to the area of one of the plates (measured in square centimeters) divided by 11,300,000 times the distance between the plates (measured in centimeters). If other insulating material is used, multiply by its dielectric constant. The dielectric constant of mica, for example, is about 6.

9. INDUCTANCE

INERTIA or mass is the mechanical analogy of electrical self inductance, but in this case the mechanical analogy does not give anything like the complete picture of the electrical phenomenon that it does for the condenser. If a certain length of wire, say a thousand feet, has its ends connected to a source of alternating electromotive force, such as the house lighting circuit, we might expect that the same current would be produced in the wire whether it were coiled up or lying around strung out all over the floor. Yet as a matter of fact, if the wire is wound into a compact coil very little current will flow, while if uncoiled so much current might flow as to blow out a fuse. The mere coiling up of the wire produced the same effect as if the electricity in the wire became very heavy and hence difficult to make oscillate back and forth rapidly. There is no exact mechanical equivalent for this experiment, but the balance wheel of a watch has somewhat similar properties: if its weight be concentrated at the rim it will be more difficult for the spring to make it oscillate and hence the watch will run slower. The electromotive force required to produce an alternating current of given strength in a coil of wire, or inductance, is greater the greater the frequency of the current. If the frequency is doubled or trebled etc. the e.m.f. required will be doubled, trebled etc., or exactly the opposite to what was found to be true for a condenser.

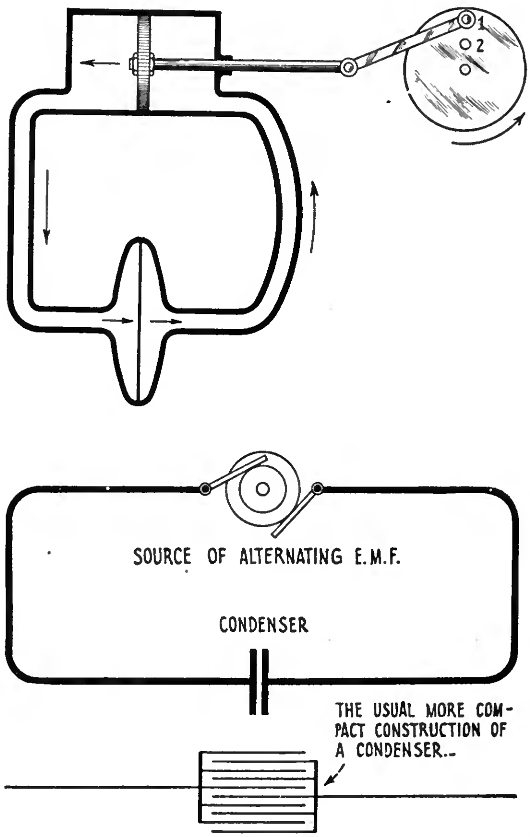


FIG. 3
A water-analogy to the action of a condenser

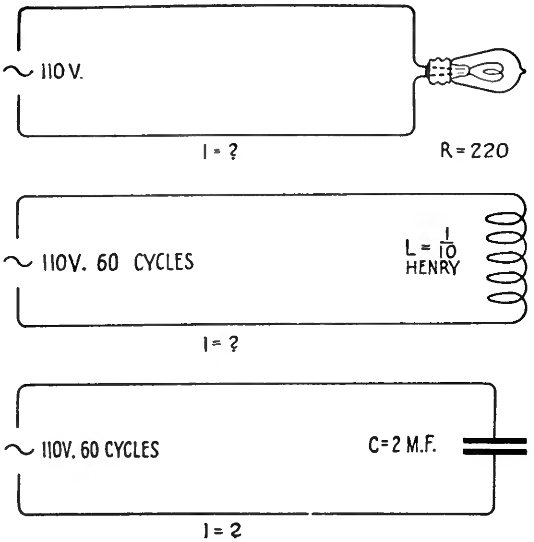


FIG. 4
A simple circuit in which we apply Ohm's law

10. THE VOLT AND OHM

WHAT we call a source of electromotive force is any machine (such as a dynamo, battery, or transformer) that will maintain a difference of potential between the two terminals of a circuit. The amount of e.m.f. or potential difference is measured in volts.

If a source of E volts (either direct or alternating) produces I amperes of current in a certain wire, the number of ohms resistance in the wire is $\frac{E}{I}$, the number of volts required per ampere produced. This is Ohm's law and is usually written $\frac{E}{I} = R$. If any two of the quantities are known, this equation gives the third. For example, if an electric light bulb has a resistance of 220 ohms and it is connected to a 110 volt source of e.m.f. what current will flow? Substituting in the equation the values given we have $\frac{110}{I} = 220\omega$ hence $I = \frac{1}{2}$ ampere. (See Fig. 4) The resistance of a wire is equal to a constant whose value depends upon the metal used, multiplied by the length of the wire, and divided by the area of cross section.† Next to silver, copper enjoys the lowest value of this constant, and hence is the best conductor.

† Except that at very high frequencies, current tends to flow more and more nearly along the surface of conductors. Hence the resistance is somewhat the same as if the wire were hollow like a pipe. This phenomenon is called "skin effect." At frequencies sufficiently high for pronounced skin effect, the amount of surface of the conductor is more important than area of cross section.

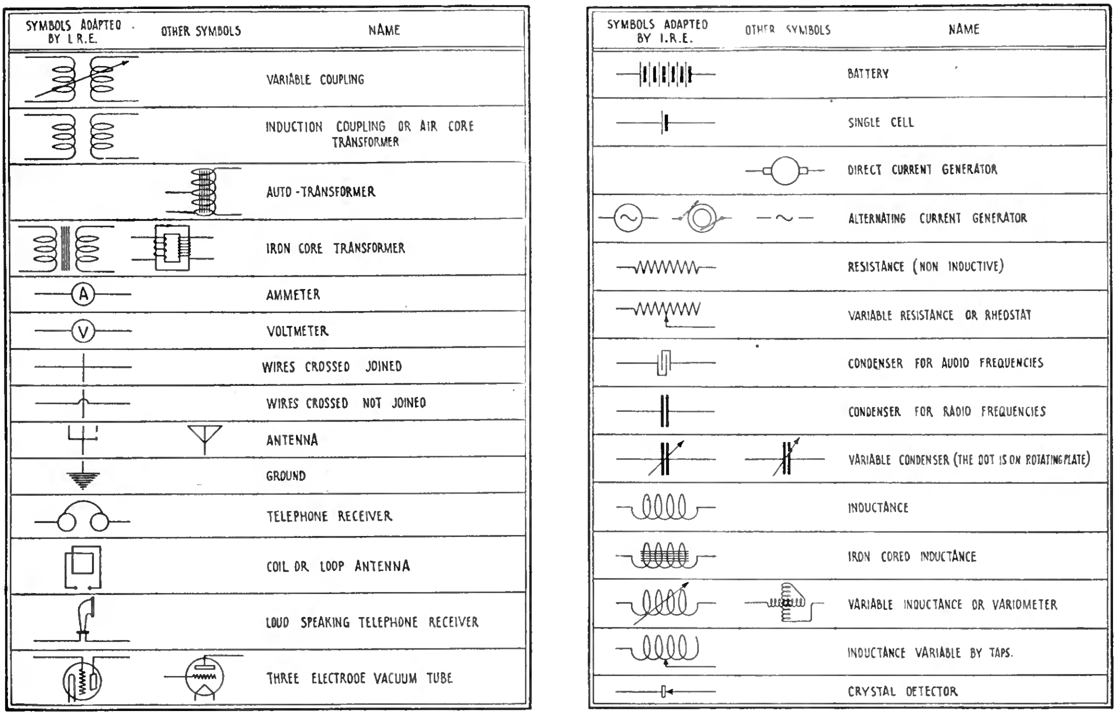
11. INDUCTIVE REACTANCE

IF A source of E volts *alternating* produces I amperes in a certain coil of wire (the wire being supposed so thick that its resistance is negligible) then the quantity $\frac{E}{I}$ is the number of ohms of "inductive reactance" possessed by the coil at the frequency used. Unlike resistance, the amount of inductive reactance depends upon the frequency as mentioned in the paragraph describing inductance. The number of ohms of inductive reactance possessed by a coil at a frequency f is $2\pi fL$ where L is a constant that depends upon the size and shape of the coil and the number of turns of wire on it. This constant is measured in henrys, and is called the coefficient of self inductance of the coil. An illustrative problem is to calculate the current in a coil whose coefficient of self induction is one tenth of a henry and which is connected to the house lighting current supply (110 volts and a frequency of 60 cycles). We start by calculating that at 60 cycles the inductive reactance is $2\pi \times 60 \times \frac{1}{10}$ or 37.7 ohms. Then putting the known values in the formula $\frac{E}{I} =$ ohms we have $\frac{110}{I} = 37.7$ whence $I = 2.92$ amperes. (See Fig. 4.)

12. CONDENSIVE REACTANCE

IF A source of *alternating* e.m.f. of E volts produces I amperes when connected to a certain condenser, then the quantity $\frac{E}{I}$ is the number of ohms of "condensive reactance" possessed by the condenser at the frequency used. The amount of condensive reactance depends upon frequency in a different way from inductive reactance. The number of ohms of condensive reactance at a frequency f is $\frac{1}{2\pi fC}$ where C is a constant called the capacity, and must be measured in farads in order to use in this formula. Illustrative problem: what current will flow if a condenser of 2 microfarads capacity is connected to the house lighting circuit? First, the capacity is $\frac{2}{1,000,000}$ farads, hence the reactance at 60 cycles is $\frac{1}{2\pi \times 60 \times \frac{2}{1,000,000}}$ or 1,325 ohms. Then $\frac{110}{I} = 1,325$ so $I = .083$ amperes. (See Fig. 4.)

The total resistance when two resistances are connected in series is simply the sum of the two resistances. Likewise, if two condensers are connected in series the condensive reactance of the combination is the sum of the separate condensive reactances of the two. And if two coils are connected in series the inductive reactance of the combination is the sum of the



COMMON SYMBOLS USED IN RADIO CIRCUITS

inductive reactances of the coils. (Here however the coils must be far enough apart, or set at such an angle with each other, that currents in one coil have no effect on current in the other)

SERIES COMBINATION OF DIFFERENT KINDS OF REACTANCE

WHEN we try to figure the effect of connecting dissimilar things together we have to use a new and more difficult set of rules. The first of these is, if an inductive reactance is connected in series with a condensive reactance, the reactance of the combination is the number of ohms of inductive reactance *minus* the number of ohms of condensive reactance. Thus a coil and condenser in series work against each other, and if the proper relative values are chosen, will exactly cancel each other so that the combination has zero reactance at the frequency in use. (See Fig. 5)

13. IMPEDANCE

BUT when a resistance is connected in series with a reactance what is the total number of ohms? It is not simply the sum, or the difference, but lies somewhere between the two. It is $\sqrt{R^2+X^2}$ where X is the number of ohms reactance. This quantity which has both resistance and reactance in its make up is called an impedance. If a source of alternating e.m.f. of E volts produces I amperes when connected to a pair of terminals leading into a box which is sealed up so that we have no idea what is inside, what is the quantity $\frac{E}{I}$? we can't call it resistance unless we know that the box contains only resistances—we can't call it condensive reactance unless the box contains only condensers—we can't call it inductive reactance unless the box contains only coils of negligibly small resistance. Impedance is what we call it *whatever* is in the box. Thus resistance and the two kinds of reactance are merely special cases of the more general term impedance. It is impossible to say how impedance varies with frequency unless we know all about the arrangement of resistances, capacities, and inductances that make up the particular impedance under consideration.

For most purposes we want everything either one thing or the other. That is, we want our condensers as free as possible from resistance, we want our inductances to have as little resistance and distributed capacity as possible, and our resistances to be non inductive and to have the least possible distributed capacity.

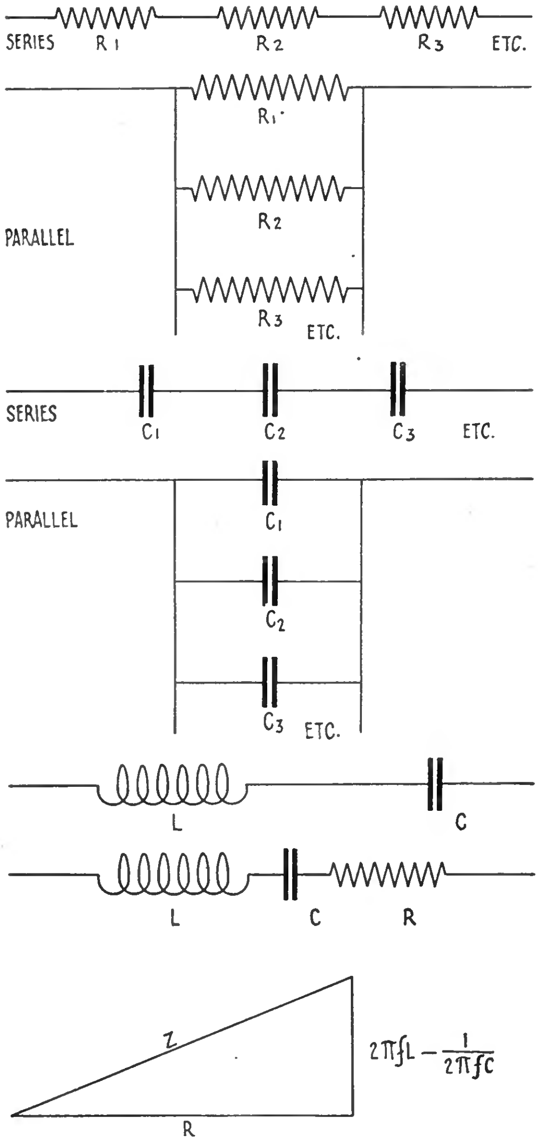


FIG. 5
Simple connections of resistances and capacities

Important Formulæ for Simple Combinations of Resistances and Reactances

Total resistance, $R = R_1 + R_2 + R_3 \ldots$

Effective resistance given by $\frac{1}{R} + \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \ldots$

Total *reactance*, $\frac{1}{2\pi f C} = \frac{1}{2\pi f C_1} + \frac{1}{2\pi f C_2} + \frac{1}{2\pi f C_3} + \ldots$

Effective capacity, C is given by $\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} \ldots$

Total capacity, $C = C_1 + C_2 + C_3 \ldots$

Effective reactance, $\frac{1}{2\pi f C} = \frac{1}{2\pi f (C_1 + C_2 + C_3 + \text{etc.})}$

Total reactance $= 2\pi f = \frac{1}{2\pi f C}$ {If this comes out a negative number, the total reactance is condensive, i. e., the combination acts as a condenser at frequency f}

The total reactance, if any two of the three quantities f, L. and C are given, may be made zero by proper choice of the third. Thus if L = 1 milhenry, C .001 mfd; then the reactance will be zero for $f = \frac{1000000}{2\pi}$

The impedance of this combination, Z, = $\sqrt{R^2 + (2\pi f L - \frac{1}{2\pi f C})^2}$ and may be obtained graphically by laying out a right triangle. The length of the sides are proportional to the resistance and reactance, and the hypothenuse to the impedance.

14. RESONANCE

REFERRING to Fig. 5, if L and C are chosen so that at the frequency f their reactances exactly cancel each other (that is, $2\pi f L = \frac{1}{2\pi f C}$) then the only thing left to limit the amount of current that will flow is the resistance of the wire out of which the inductance is made. If care is used to make this resistance as small as possible, the current obtained will be enormous compared to what it would be if only the condenser, or only the coil, were present, or if they had different relative values, or if the frequency were different. All the peculiar effects that occur on account of a condensive reactance in a circuit becoming equal to an inductive reactance are classed as "resonance" phenomena. In the case just described a noticeable current would result from the application of a voltage so small that it would not cause enough current to detect at all if the circuit had not been "tuned" to the resonance condition. There are many mechanical analogies for this condition of resonance. The usual one is soldiers going over a bridge. If the effect of the mass of the bridge just cancels the effect of its stiffness or springyness for the frequency with which their feet come down, violent swaying will result. Another example is the response of a piano string to a note of its own natural frequency sung at it. This response of a tuned system almost exclusively to impulses of its own natural frequency is the basis of all methods of tuning radio receivers to pick up signals of one frequency, and practically no others.

15. MUTUAL INDUCTANCE

MECHANICAL analogies for mutual inductance are so far fetched as to be more difficult to understand than the real thing. The basic fact of mutual induction, and one that is best taken as an experimental fact and let go at that, is that if alternating current flows in a coil of wire, then an alternating e.m.f. of the same frequency will be discovered to exist in a near-by coil. If the ends of the near-by coil are connected to an ammeter it will be seen that current flows. If the ends of the coil are connected to a voltmeter, it will indicate the number of volts e.m.f. that are "induced" in the coil by the existance of current in the first mentioned, or primary, coil. With a given primary coil and a given current flowing in it, the number of volts induced in the secondary depends upon a number of things. The induced voltage will be greater in direct proportion to the frequency, and to the number of turns of wire in the secondary coil. It will be less if the two coils are far apart, and can be made zero by turning the coils at right angles to each other or into any of a number of different relative positions. The maximum voltage will be induced when they are as close together as possible, and then even this maximum can usually be greatly increased by inserting a core of iron through both coils.

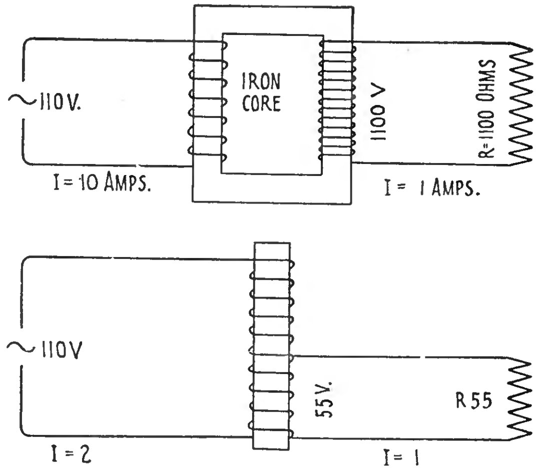


FIG. 6

A simplified drawing of a closed core transformer and (below) an auto transformer

16. TRANSFORMERS

THE ordinary commercial iron cored transformer is simply two coils of wire wound on the same iron core. So long as the secondary of such a transformer is open circuited, or connected to something of impedance so high that not much current flows, we have the very simple relation that the voltage delivered by the secondary bears the same relation to the voltage applied to the primary as the number of turns in the secondary bears to the number of turns in the primary. A ten to one step up transformer would be one whose secondary had ten times as many turns as the primary.

A transformer corresponds to gears in mechanics. If by an arrangement of gears or levers we increase a mechanical force ten times, we know instinctively that we must expect the part of the arrangement that is exerting the "stepped up" force to move ten times as slowly as the part where the original force is being applied. If we choose to gain in force we lose correspondingly in speed or else we could get "something for nothing." The electrical transformer is not a source of power. It merely changes the power put into it at one voltage into the same power (less a small percentage loss) at a different voltage. Hence

ELECTRICAL PREFIXES

PREFIX	MEANING	EXAMPLES
meg	million	1 megohm = 1 million ohms
micro	millionth	1 microampere = 1 millionth of an ampere
kilo	thousand	1 kilocycle = 1 thousandcycles 1 kilowatt = 1 thousand watts
milli	thousandth	1 milliampere or mil-amp = 1 thousandth of an ampere

CONVENTIONAL USE OF LETTERS TO REPRESENT VARIOUS QUANTITIES

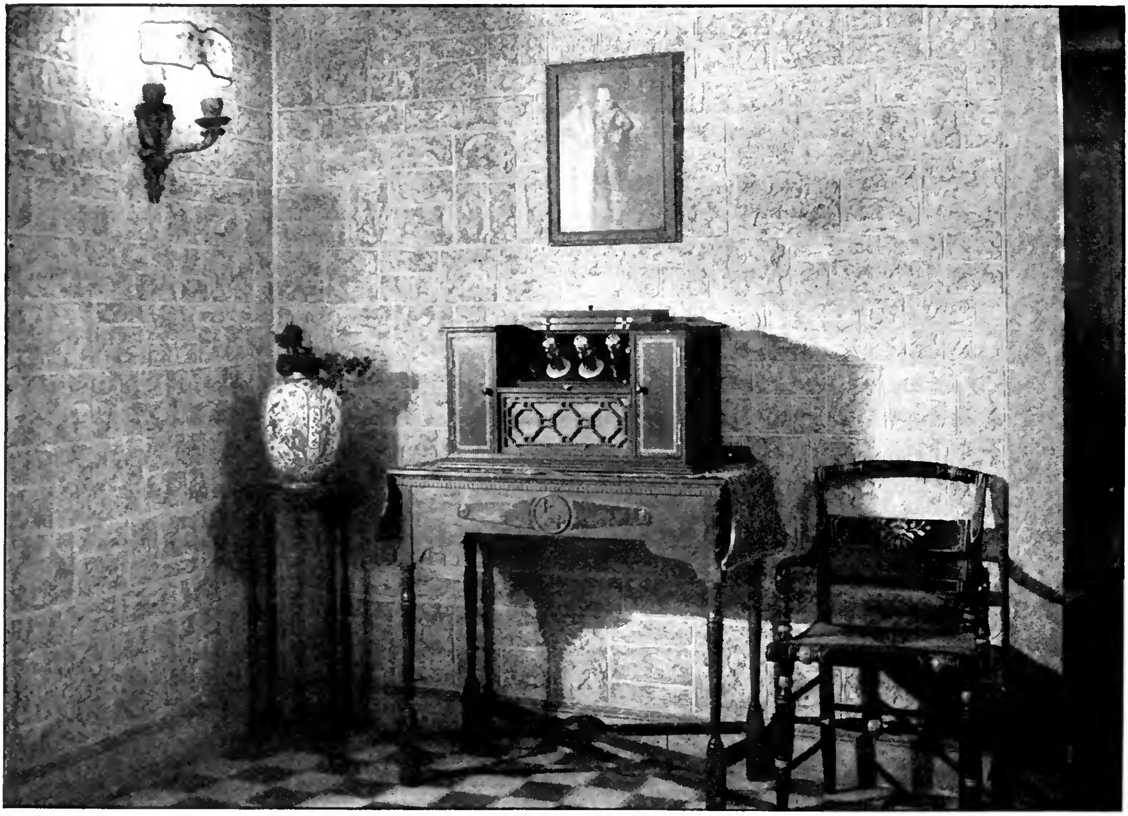
R	Resistance, measured in ohms
X	Reactance, measured in ohms
Z	Impedance measured in ohms
L	Coefficient of self-induction, measured in henrys
C	Capacity, measured in farads
f	Frequency, measured in cycles per second
p or w	Periodicity, $(= 2\eta f)$, measured in radians per second
E or V	Voltage or potential difference, measured in volts
I or i	Current, measured in amperes

just as the speed went down in the mechanical case, so the current is less in the high tension or high voltage side of the transformer. The ratio of currents is exactly the opposite to the ratio of voltages. An auto transformer is no different except that the winding having the fewest turns is merely a part of the other winding. Thus only one coil is required. (See Fig. 6).

It was stated previously that any current in a resistance heats the resistance just as a rope sliding through a pipe would heat the pipe on account of friction. If a current of I amperes flows in a resistance of R ohms, electrical energy is dissipated at the rate of I^2R watts. If an electric toaster has a resistance of 22 ohms and is connected to a 110 volt circuit, then by Ohm's law we know that 5 amperes will flow. Hence I^2R or $5^2 \times 22$ or 550 watts is the rate at which electrical energy is being turned into heat.

17. POWER

IF A battery of E volts causes a current of I amperes, then the battery is working at the rate of EI watts. This power may be all dissipated in resistances in the form of heat, or may be driving a motor, but whatever happens to it, the battery is delivering EI watts. In the case of an alternating current generator of E volts producing a current of I amperes the power delivered by the generator is EI times a constant called the power factor which depends upon what the generator is sending the current through. This constant is never greater than unity and will be less if there is anything in the circuit that does not absorb power, such as a condenser or an inductance.



A BEAUTIFUL RECEIVER IN A BEAUTIFUL ROOM

It is a three-tube set with a loud speaker, built-in beneath the tuning panel. The A and B batteries are enclosed in the panels at either side. This set is made by the Colin B. Kennedy Company

Supplemental List of Broadcasting Stations in the United States

LICENSED FROM DECEMBER 15 TO JANUARY 18, INCLUSIVE

CALL SIGNAL	STATION	FREQUENCY (Kilocycles)	WAVE-LENGTH	POWER WATTS
KFAE	Pullman, Wash.	908.6	330	500
KFMS	Duluth, Minn.	1090	275	100
KFMT	Minneapolis, Minn.	1300	231	5
KFMU	San Marcos, Texas.	1250	240	20
KFMY	Long Beach, Calif.	1310	229	20
KFMZ	Roswell, N. M.	1200	250	500
KFNC	Los Angeles, Calif.	1080	278	500
KFNG	Coldwater, Miss.	1180	254	10
KLX	Oakland, Cal.	589	509	500
WABW	Wooster, Ohio	1280	234	20
WABX	near Mt. Clemens, Mich.	1110	270	150
WABY	Philadelphia, Pa.	1240	242	50
WABZ	New Orleans, La.	1140	263	50
WBBE	Syracuse, N. Y.	1220	246	10
WBBF	Atlanta, Ga.	1110	270	500
WBBG	Mattapoisett, Mass.	1250	240	100
WBBH	Port Huron, Mich.	1220	246	50
WBBI	Indianapolis, Ind.	1280	234	20
WCBC	Ann Arbor, Mich.	1070	280	200
WFAT	Sioux Falls, S. Dak.	1160	258	50
WFMW	Houghton, Mich.	266	1130	50
WFMX	Northfield, Minn.	283	1060	500
WGV	New Orleans, La.	1240	242	100
WJAG	Norfolk, Nebraska	1060	283	250

LIST OF BROADCASTING STATIONS DELETED NOVEMBER 1 TO JANUARY 1

CALL	STATION
KDYS	Great Falls, Mont.
KDZK	Reno, Nevada
KDZT	Seattle, Wash.
KFAP	Butte, Mont.
KFCL	San Antonio, Calif.
KFDB	San Francisco, Cal.
KFDP	Des Moines, Iowa.
KFEP	Denver, Colorado
KFFA	San Diego, Calif.
KFFP	Moberly, Mo.
KFGP	Cheney, Kansas
KFHQ	Los Gatos, Cal.
KFHU	Mayville, N. D.
KFIV	Pittsburgh, Kansas
KFJA	Grand Island, Neb.
KFJH	Selma, Cal.
KFJJ	Carrollton, Mo.
KFJU	Kearney, Neb.
KLN	Monterey, Cal.
KNJ	Roswell, N. Mex.
KQI	Berkeley, Cal.
WAAH	St. Paul, Minn.
WABF	Mt. Vernon, Ill.
WBBC	Sterling, Ill.
WBU	Chicago, Ill.
WCBB	Greenville, Ohio
WCR	Minneapolis, Minn.
WDAD	Lindsborg, Kans.
WDAI	Syracuse, New York
WDAL	Jacksonville, Fla.
WDBF	Youngstown, Ohio
WDM	Washington, D. C.
WDT	New York, N. Y.
WEAB	Fort Dodge, Iowa
WEAG	Edgewood, R. I.
WFAT	Sioux Falls, S. Dak.
WGAR	Fort Smith, Ark.
WGAU	Wooster, Ohio
WHAC	Waterloo, Iowa.
WHAI	Davenport, Iowa
WHAL	Lansing, Mich.
WHAQ	Washington, D. C.
WHD	Morgantown, W. Va.
WIAH	Newton, Iowa
WIAT	Tarkio, Mo.
WKAS	Springfield, Mo.
WKAX	Bridgeport, Conn.
WKC	Baltimore, Md.
WLAC	Raleigh, N. C.
WMH	Cincinnati, Ohio
WNAM	Evansville, Ind.
WOAA	Ardmore, Okla.
WOAK	Frankfort, Ky.
WOAQ	Portsmouth Va.
WOAZ	Stamford, Texas
WPAD	Chicago, Ill.
WPAR	Beloit, Kansas
WQAR	Springfield, Mo.
WQAZ	Greensboro, N. C.
WRAP	Winter Park, Fla.
WRAU	Amarillo, Texas
WSAK	Middleport, Ohio
WSAP	New York, N. Y.
WTAP	Carthage, Ill.
WWAX	Laredo, Texas
WWB	Canton, Ohio
WWZ	New York, N. Y.

The Grid

QUESTIONS AND ANSWERS

The Grid is a Question and Answer Department maintained especially for the radio amateurs. Full answers will be given wherever possible. In answering questions, those of a like nature will be grouped together and answered by one article. Every effort will be made to keep the answers simple and direct, yet fully self-explanatory. Questions should be addressed to Editor, "The Grid," RADIO BROADCAST, Garden City, N. Y.

ABOUT YOUR GRID LETTERS

Judging from the rapidly increasing demands made upon this section, it is performing a valuable service—but it is getting to be a very serious problem.

As a general rule replies to letters addressed to the GRID require the drawing of a diagram or two and a considerable amount of research. Similar service, if purchased elsewhere, would cost a very tidy sum. We are pleased to offer this service to our readers without charge but feel that it is up to our readers to coöperate with us to the extent of sending, with their requests for information, a self-addressed, stamped envelope. Unless our request is complied with the GRID will be unable to consider these inquiries.—THE EDITOR.

ADDING R. F. TO ANY RECEIVER

The Grid has received many requests concerning the adaptability of radio frequency amplification to the particular circuits used by the inquirers. The questions may be summed up in the following order:

1. Can R. F. be added to any existing circuit?

2. If it is possible, how should it be added to the variocoupler twin-variometer regenerative receiver? . . . to the three coil honey comb set?

3. How should it be added to the single circuit tuner?

4. Can additional stages be combined with sets already equipped with radio frequency amplification?

1. In general. There is no reason why radio frequency amplification cannot be added to any existing circuit. As usual, it is merely a matter of a principle of theory and easily mastered fundamental that can be applied to the majority of circuits with which our broadcast enthusiasts are confronted.

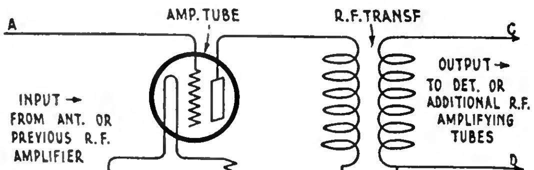


FIG. 1

What you need for an R. F. amplifier to use with any tube set except a single circuit regenerative outfit

The most easily understood system of R. F. amplification (as well as the most fully developed practically) is that employing the intervalve transformer coupling. THE GRID suggests that those readers for whom this article is written confine themselves to this form of R. F. intensification.

The amplifying unit in this case then consists of a single tube, the output of which flows through the primary of an R. F. transformer. Fig. 1 shows such a unit. *To R. F. amplify any circuit whatever, it is only necessary to include one (or more) of these units between the source that it is desired to amplify and the detecting circuit.* In the majority of radio circuits, the unit, or units, will be placed between the antenna circuit and the detecting tube. Some means, either a tuning coil or a variocoupler, must be employed for transferring energy from the antenna to the first R. F. circuit. The former and more simple method is shown in Fig. 2, while Fig. 3 indicates the conventional detecting circuit. Fig. 2, 1, and 3, connected together in the order given, would result in a complete receiver comprising detector and one stage of radio frequency amplification.

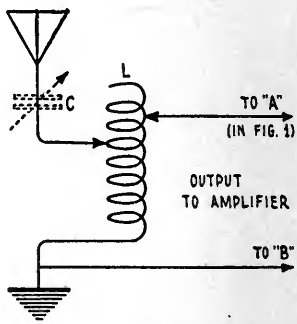


FIG. 2

The simplest means of coupling an antenna to the R. F. transformer unit. "L" may be a two-slide tuning coil or a winding of 105 turns of No. 22 DCC wire, tapped every seven turns, wound on a $3\frac{1}{2}''$ tube. If the tapped coil is used, a shunt condenser of .001 mf. is needed

In Fig. 2, L may be a double-slide tuning coil, or a coil wound with one hundred and five turns of about number

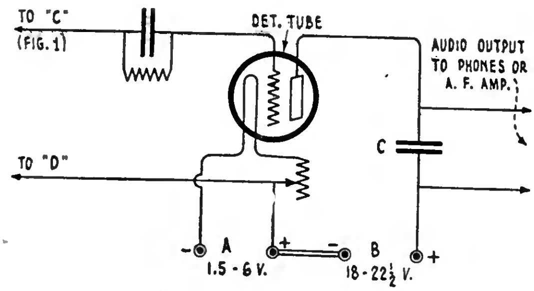


FIG. 3

The detecting circuit. By connecting leads shown in Figs. 2, 1, and 3 (in that order) you have a complete receiver—detector and one stage of R. F.

22 insulated wire on a three or three and a half inch tube. If this latter coil is used, it should be tapped every seven turns, and the antenna tuning condenser, C, of from .005 mfd. to .001 mfd. is desirable.

In Fig. 1, any standard R. F. transformer, such as advertised in Radio Broadcast may be used. R is a grid biasing potentiometer, generally of about four hundred ohms. The selection of the amplifying tube rests with the builder, but the Grid suggests either the UV-199 or the UV-201-A. The A and B batteries will of course vary with the tubes selected, and the reader is advised to use the voltages specified by the manufacturer of the tube he obtains.

The same A and B batteries may be used in Fig. 1 and 3 In Fig. 3. an adjustable tap, in the neighborhood of 22.5 volts, is taken from the common B battery. As explained in the preceding paragraph, the potentiometer R in Fig. 1, is employed to correct the grid bias on the amplifying tube or tubes. The resulting grid potential, favorable to R. F. amplification, however, may not be conducive to the most efficient detection, and the return from the grid of the detecting tube generally runs to the plus side of the A battery. For this reason, in making the indicated connections between Figs. 1 and 3, the wire marked X, running from the secondary of the R. F. transformer to the arm of the potentiometer is broken, and the lead made directly to the plus side of the A battery as in Fig. 3. If the output lead of Fig. 1 runs to an additional stage of R. F., the connection, of course, is left as originally suggested in Fig. 1.

It is not practical to add more than three of these amplifying units to a receiver, and two stages of R. F. amplification generally gives very satisfactory results. One step is seldom sufficient.

2. The addition of R. F. to honeycomb and variometer regenerative receivers has been covered very completely in the Lab Department of this issue of Radio Broadcast. However, there is another method by which transformer-coupled radio frequency amplification can be combined with the variocoupler twin-variometer set, which utilizes the original antenna tuning equipment, rather than the extra tuning coil suggested by Mr. Sheehy. We refer to the arrangement shown in Fig. 4. The shaded portion of the diagram shows the parts carried over from the straight regenerative circuit. The unshaded lines indicate the required additions to effect two stages of radio frequency amplification. The various parts called for are identical with those designated in our previous paragraphs. The set, as shown in Fig. 4, employs a first stage of tuned amplification, with regeneration achieved by means of the variometer in the plate circuit of the detector.

3. There is no practical way of adding R. F. to the tickler regenerative single circuit tuner, without radically altering its form. The experimenter may either add an additional primary coil, transforming the circuit into the standard three coil tickler feed-back arrangement, to which amplification may be added according to the directions given in this month's Lab Department, or utilize the variocoupler as shown in Fig. 4.

It will, of course, be necessary to procure at least one variometer for tuning the secondary, and still another if regeneration is desired.

The Colpitts oscillator (the single circuit tuner employing a single antenna coil with a feed-back condenser, known by various names such as "The Flivver Circuit," the

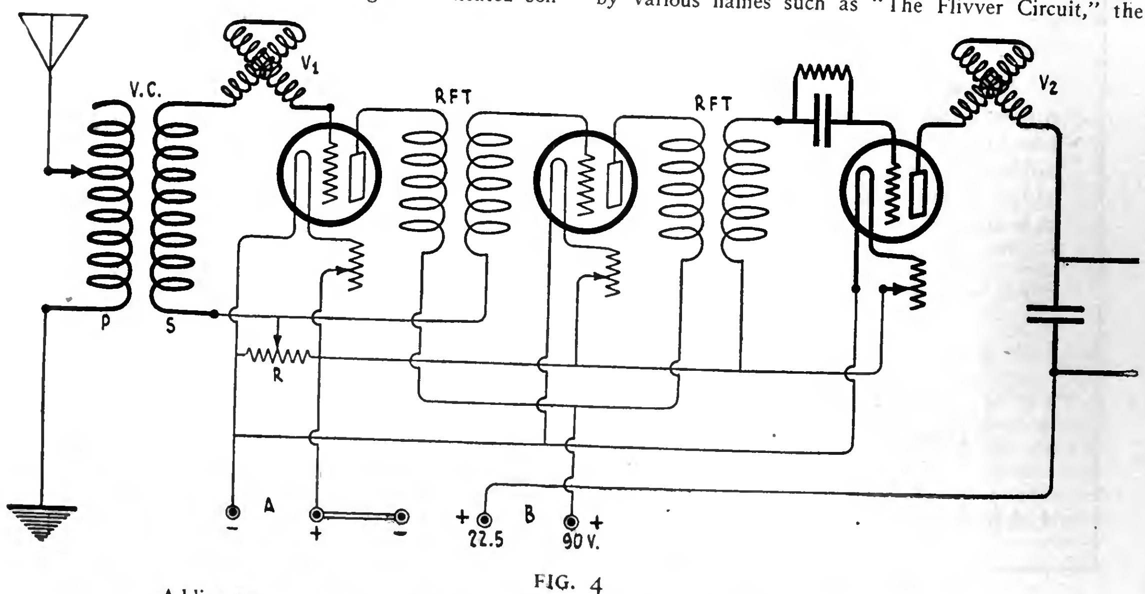
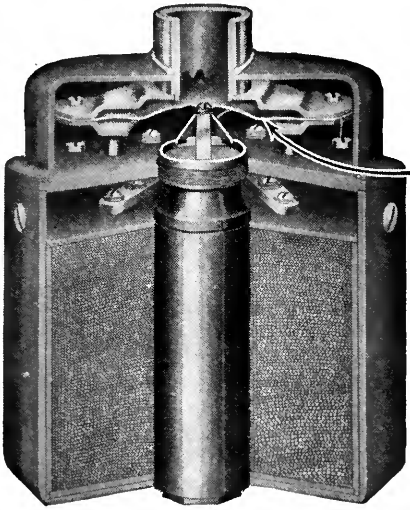
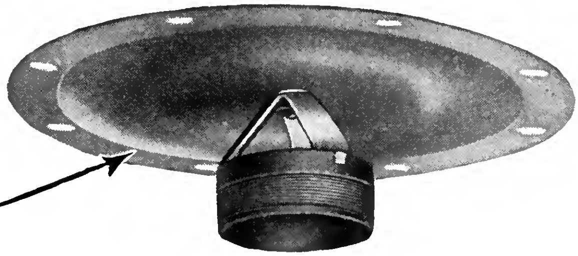


FIG. 4

Adding two stages of R. F. to a twin-variometer, variocoupler receiver. The shaded part of the diagram shows the original circuit and the lighter lines, the added R. F. unit





THE illustration at left shows the interior construction of the Magnavox *electro-dynamic* Radio Reproducer, a type representing the greatest advance ever made in radio reproducing equipment.

The diaphragm (shown above) is of special interest, as explained in the body of this advertisement.

MAGNAVOX–

The true Radio Reproducer

THE basis of the operation of a Magnavox Reproducer is its diaphragm, the importance of which can be seen from the fact that it is required to render an almost human service in recreating every tone and quality of instrumental music as well as speech.

This diaphragm (as illustrated above) has been designed and constructed in accordance with entirely new principles. Its shape, size and special character make it capable of responding to the widest range of tones.

But even this highly efficient diaphragm might be handicapped by operating restrictions—every diaphragm must have a vibrating force applied to it, and the inherent ability of any diaphragm will be injured if it is affected by mechanical operation or other foreign influences.

The use of the electro-dynamic principle of operation (found only in Magnavox Reproducers) removes all objectionable influences. This principle, utilizing the famous "movable coil" permits the Magnavox diaphragm to respond in perfect unison to the original tone.

There is a Magnavox for every receiving set: Type R for storage battery sets, and M1 for dry battery sets.

A1-R—$59.00

This instrument (Magnavox Combination Set) consists of Magnavox electro-dynamic Reproducer combined with a Magnavox Power Amplifier in one unit.

THE MAGNAVOX COMPANY
Oakland, California

New York Office: 370 SEVENTH AVENUE
PERKINS ELECTRIC LIMITED, Canadian Distributors
Toronto, Montreal, Winnipeg

★

3R

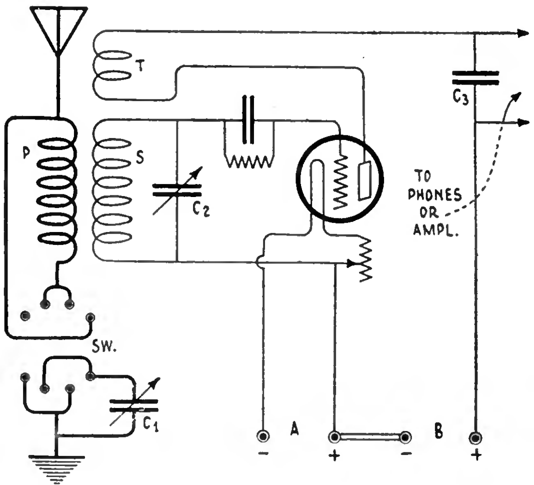


FIG. 5
The three-circuit regenerative receiver with honeycomb coils. The GRID recommends this as a standby set while experimenting with other circuits

"Automatic Regenerative" etc.) may also be made over into an R. F. set, and how to do this has been explained in THE GRID of the February RADIO BROADCAST.

4. As a rule, it is not advisable to add radio frequency amplification to a set already equipped with it. However, where the transformer coupled system has been used, the reader may, as an experiment, add another such stage as outlined in our opening paragraphs.

A STANDBY SET

I have a standard three-circuit regenerative receiver, which is giving me excellent results. However, I have heard and read a great deal about the super-heterodyne receiver, and I desire to build one. Do you advise me to break up my present set, utilizing the parts as suggested by Mr. Eltz in his second "super" article?

O. Y., Philadelphia, Pa.

NO, THE GRID suggests that you keep your present set intact, using it as a standby, while you experiment with the super-heterodyne, or any other circuit which your fancy prompts. And, moreover, we suggest that such of our readers whose chief radio delight is experimenting, and who divide their electric light bills between the upkeep of electric soldering iron and storage battery, supply themselves with such a standby set, preferably a three-coil honeycomb receiver, this type of set being the least likely to permit a sudden change of circuit.

The editor of THE GRID has experimented with many circuits, but there has never been a time when through the failure of some particularly outlandish circuit, or for the sake of comparison, a three-circuit regenerative receiver could not be thrown in by the turn of a switch.

The honeycomb set is, perhaps, even more trustworthy, for it responds to every wavelength on which wireless is transmitted—excepting those in the neighborhood of one hundred meters. Fig. 5 shows the circuit for this set. The three honeycomb coils, which plug into the standard three coil mounting, are P, S and T (primary, secondary and tickler). SW is a series parallel switch, for throwing the primary condenser in those two positions, as well as shorting it on the middle position. C1 and C2 are 23-plate condensers, with or without vernier adjustment. C3 is the usual telephone shunt capacity.

B BATTERY TROUBLE

I have a set which, three months ago, worked perfectly. However, it has recently developed unpleasant scratching noises, and the second stage of the amplifier howls. Do you think I need new B batteries?

A. O. T., New York City

WHEN trouble of this nature develops after the B battery has seen considerable service, it should always be the first consideration as the possible source of the difficulty, *particularly if the "unpleasant scratching noise" is audible on detector and on each step when tested separately.* Worn out B batteries often cause such sounds. Howling can frequently be traced to weak B batteries.

However, if testing shows that the difficulty is confined only to one tube, the trouble is obviously more local. The experimenter may then test for broken transformer windings, dirty prongs on tubes or sockets, poor rheostat connections, etc.

A good 45-volt battery should give a fairly hot spark on a momentary short-circuit.

OSCILLATION OF AN R. F. AMPLIFIER

Is there any way of stabilizing a radio frequency amplifier, other than by biasing the grids and neutrodyning? My amplifier oscillates very readily, and I have esperienced little success using the two methods mentioned above.

R. O. C., Hartford, Conn.

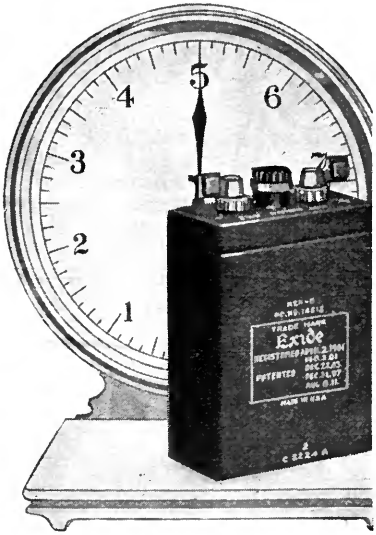
THE neutrodyne is, of course, the most efficient method of stabilizing these circuits. It is, in effect, the ounce of prevention, as it neutralizes the capacity which is responsible for the regeneration and oscillation. Other systems are comparable to the pound of cure.

You might try including a resistance of about 3,000 ohms in the plate circuit of the bothersome tubes, i. e., place the resistances between the plates and the primaries of the transformers. Ballantine has found this method quite effective in stabilizing the circuit without reduction or distortion of signals.

The resistance should be non-inductive—that is, it should not act as a loading coil in the plate circuit. The best type of resistance would be in the form of a carbon rod of the correct ohmage. The experimenter might also wind the resistance on a small wooden bobbin, using 250 feet of No. 38 insulated German Silver wire. This wire, before winding, should be bent over in the middle, giving the effect of two strands, 125 feet long, connected at one end. The common end is fastened to the bobbin, and the coil wound with the two wires. This manner of winding will give the desired non-inductive effect.

RADIO BROADCAST will be pleased to hear from its readers who experiment with this method of stabilization.

To get best results with low-voltage tubes

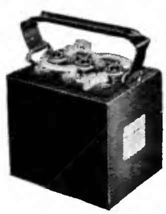


This 2-volt A Exide Storage Battery weighs only five pounds

FOR perfect clearness you must use a storage battery with uniform current. This is particularly true if you are a fan for long distance. When signals are weak the steadiness of a dependable A storage battery is indispensable to good receiving.

There are two tiny but sturdy Exide A Batteries designed specially for WD-11 and UV-199 vacuum tubes, and they give fine service with any low-voltage tubes.

You can carry one of these little batteries in the palm of your hand, yet they are powerful enough for long-distance receiving and have the true Exide ruggedness built into them.



A battery for 6-volt tubes

Three sizes of A batteries

The 2-volt battery has a single cell and weighs five pounds. It will heat the filament of a WD11 or other quarter-ampere tube for approximately 96 hours. The 4-volt battery has two cells, weighs six pounds and will light the filament of a UV-199 tube for 200 hours.

A battery with a pedigree

The Exide A Battery for 6-volt tubes is made in four sizes, of 25, 50, 100 and 150 ampere-hour capacities. These batteries have extra-heavy plates, assuring constant voltage and uniform current over a long period of discharge.

A good storage battery does not just happen. It is the result of long experience. The skill acquired and the resources developed in making batteries for every purpose since the beginning of the storage battery industry thirty-five years ago are built into the Exide Batteries made specially for your radio.

Wherever batteries *must* be reliable—such as on submarines, in the telephone system, in firing the guns of our battleships, in the central power stations of our great cities—there you will find Exides doing their unfailing duty. A majority of all government and commercial radio plants are equipped with Exide Batteries.

Exide Radio Batteries are sold by radio dealers and Exide Service Stations everywhere. Ask the dealer, or write direct to us, for booklets describing the complete line of Exide Radio Batteries.

★ **Exide**

RADIO BATTERIES

THE ELECTRIC STORAGE BATTERY COMPANY, PHILADELPHIA

Manufactured in Canada by Exide Batteries of Canada, Limited, 133-157 Dufferin Street, Toronto

★ Tested and approved by RADIO BROADCAST ★

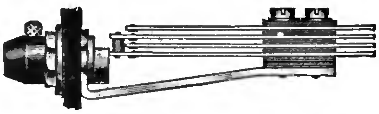
New Equipment

BRANDES TABLE-TALKER

Another loud speaker. Neat in appearance and very satisfactory in operation. C. Brandes, Inc., 237 Lafayette St., New York City. Price $10

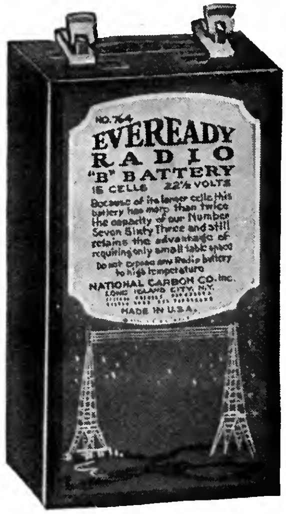
AMSCO COMPENSATING CONDENSER

A very efficient means of neutralizing the tube capacity in R. F. amplifiers, also eliminates the necessity for a potentiometer. Amsco Products, Inc., Broome & Lafayette Sts., New York City



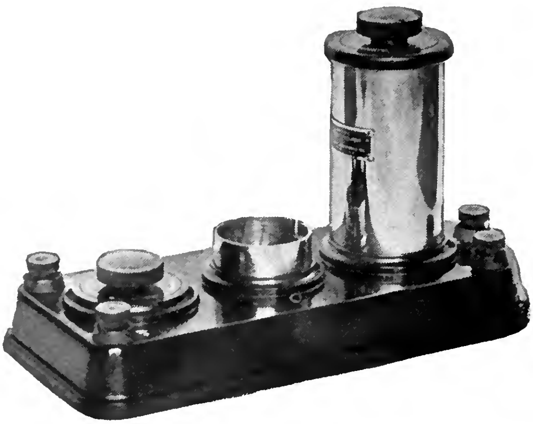
CARTER JACK SWITCH

One of the many types made to serve various purposes. The switch illustrated closes two contacts and may be used to cut in a second headset, also for adding a second cell in parallel. Carter Radio Co., 209 S. State St., Chicago, Ill.



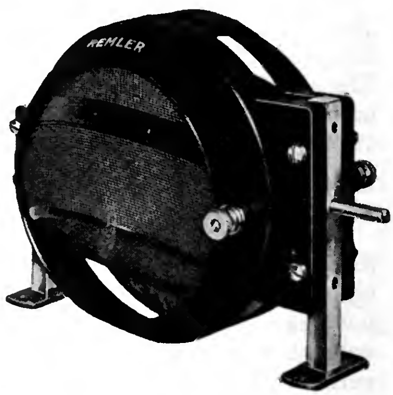
EVEREADY "SKYSCRAPER" B BATTERY

A new development in B batteries which allows larger capacity for the small space it requires. National Carbon Company, Inc., Long Island City, New York. Price $2.25



RADIO FREQUENCY AMPLIFIER UNIT

The Model 5 Ballantine R. F. Amplifier Unit. A very compact and efficient unit comprising the variotransformer, tube socket and rheostat wired to make a complete stage of R. F. amplification. Boonton Rubber Mfg. Co., Boonton, New Jersey. Price $15



REMLER VARIOMETER

Made by the Remler Radio Mfg. Co. It has a fairly wide wavelength range, is ruggedly built, and may be used for either panel or table mounting. Price $7.50