Popular Radio

MARCH 1923

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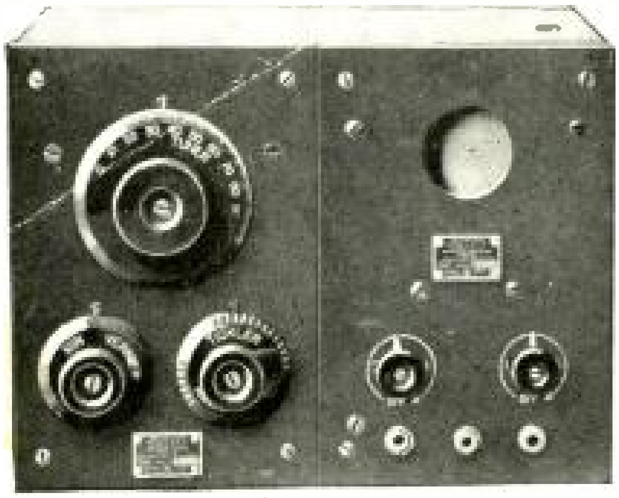

In TRENTON, he hears stations 1500 miles away with Radiola RC

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"Just a line to tell you that Radiola RC has given perfect satisfaction. On Tuesday evening between 11.15 and 11.30 I picked up Chicago and Kansas City."

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This is but one of thousands of letters received in which owners of Radiola RC have commented on its remarkable range. Half the delight of radio lies in this ability to pick up the far stations.

Radiola RC is a compact, highly-sensitive, long-distance receiver that can be used with a loud-speaker to flood a room with music. Thousands of Radiola RCs are in use everywhere.

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The Audiophone Jr. is complete and self-contained—needs no separate battery or other accessories—goes to you ready for use on connecting to your receiving set.

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The Audiophone Jr. can be used with any two or three stage power amplifying outfits. Where two stage amplification does not give the desired volume, the range of the Audiophone will be made ample by the addition of a Bristol One Stage Power Amplifier ....**Price, $25.00**

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THE BRISTOL COMPANY
Waterbury, Conn.

POPULAR RADIO

EDITED *by* KENDALL BANNING

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(*Cover design by William Edgar Fisher*)

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VOLUME III — MARCH, 1923 — NUMBER 3

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E. E. FREE, Ph.D., *Contributing Editor* LAURENCE M. COCKADAY, R.E., *Technical Editor*


"When happiness or calamity is about to come," said Confucius, "it can be known beforehand." Insure complete radio happiness with a Grebe Receiver.
Doctor Mu.
IF YOU buy inferior radio apparatus you must not expect the best results.
Its long record of satisfactory service has won for the Grebe Receiver the unqualified endorsement of all experienced radioists and dealers.
Your copy of "Musings of Doctor Mu" sent free upon request.
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Musings of Doctor Mu

A Page with the Editor

The two foremost radio scientists of New England—Prof. R. A. Fessenden, said to be the "first man to transmit the human voice by radio," and Dr. G. W. Picard, who holds more patents on the crystal detector than any inventor in the world—are now included among the distinguished contributors to Popular Radio. That these two eminent experts should select this magazine as the medium for the important announcements that they will make during this year is both a tribute of which the Editor is not insensible as well as a rare treat to our readers.

* * *

Every radio amateur in the country knows Hiram Percy Maxim and Paul Godley—perhaps the two most popular radio fans in the world and certainly two who are of monumental help and inspiration in the development of amateur radio. It is with peculiar gratification, therefore, that the Editor presents Mr. Maxim's article on page 188 of this issue, and Mr. Godley's article on page 202. The latter (familiarly known among the fans as "Paragon Paul") supplements his article by a personal letter in which he states:

"Popular Radio *is doing a real service. Everyone is always glad to help those who are of service.*"

The Editor may be pardoned if he accepts this commentary as "praise from Sir Hubert"—who, according to legend, was the than-whomest of complimentors.

* * *

The broadcasting of the present series of Philharmonic Orchestra concerts in New York—a project initiated by Popular Radio—is bringing to light some "human interest" touches that are worth more than casual comment. And not the least interesting of them is the fact that Henry Hadley's old mother up in Massachusetts is enabled for the first time to hear this great orchestra play when her son conducts!

* * *

"I built the 2 variometer, 1 variocoupler set described on page 210 of the November Popular Radio," writes Charles J. Adolph of New York, "using 100 feet of braided antenna wire strung in back of the picture moulding. I received all local stations and the following stations; WOC, WGR, WGY, KDKA, WWJ, WQAA, WDAP, WMAM, WHAS, WLW, and WMAF. Using my outside aerial I have reached as far as Fargo, North Dakota."

"If you see it in Popular Radio *it's so!"*

* * *

As evidence of the efforts which the Editor is making to give our readers the best and only the best, it may interest them to know that in order to obtain pictures of Sir Oliver Lodge (for use as illustrations of his series of articles now running in Popular Radio), we commissioned the foremost portrait photographer of England, E. O. Hoppé, to make a special trip of hundreds of miles to Sir Oliver's laboratory in Amesbury. That he was eminently successful in his quest is proved by the example of his work on page 211. The Editor regards it as the best photograph ever made of Sir Oliver.

* * *

One of the most important uses of radio (and the Editor is not so sure but that it may prove to be the most important use of all) lies in the field of education. The possibilities of bringing real education—"the world's greatest scientists and the world's greatest music"—into the Little Red Schoolhouse and into American homes are only beginning to be realized by a small number of universities which are experimenting with "extension courses" that are being broadcast for the benefit of the people of half a State. Popular Radio, which has emphasized the importance of this phase of radio from the beginning, is particularly glad, therefore, to have the National Radio Chamber of Commerce take up the campaign and co-operate with us in establishing radio as an educational force more far-reaching than any the world has ever known.

* * *

Schooldays—so far as this Editor is concerned—were long regarded merely as raw material out of which elderly but forgetful composers made sentimental songs; certainly he never classified them exactly under "Pleasure." It is with particular gratification, therefore, that he finally wheedles his first word of praise from an old teacher, Thomas M. St. John, who once viewed with patient alarm the efforts of the Editor to acquire an elementary knowledge of physics.

"I find that the articles in Popular Radio are written in an offhand, readable manner that appeals to me," he writes from East Windham, N. Y. "I must confess that it is a mighty good magazine—even if you *are* the Editor."

* * *

On March 20 the yearly subscription price of Popular Radio will be $2.00 a year—as already announced.

To help every subscriber to take advantage of the present low rate of $1.50, our Subscription Manager is inserting in this March number an order blank that will enable each subscriber to get the magazine at the low price for just as long a period in advance as he desires. But his subscription must be paid not later than March 20.

Don't forget the date!

Kendall Banning

Editor, Popular Radio

This combination completes any RADIO RECEIVING SET

MAGNAVOX Radio

The Power Amplifier and Reproducer Supreme

THE Magnavox, in amplifying witn extreme sensitiveness every signal supplied to it from the receiver, must necessarily amplify any extraneous sounds which may originate in the receiver or power amplifier itself.

Therefore, the *combination* of Magnavox Reproducer with Magnavox Power Amplifier (as illustrated) is very desirable. By this equipment, in connection with a good receiver, you get the music or speech with true clearness—and in practically any volume required.

To own a good receiving set without Magnavox equipment, is like having your house properly wired and then using only small, feeble candle-power lamps in the sockets!

The Magnavox Co., Oakland, California
New York: 370 Seventh Avenue

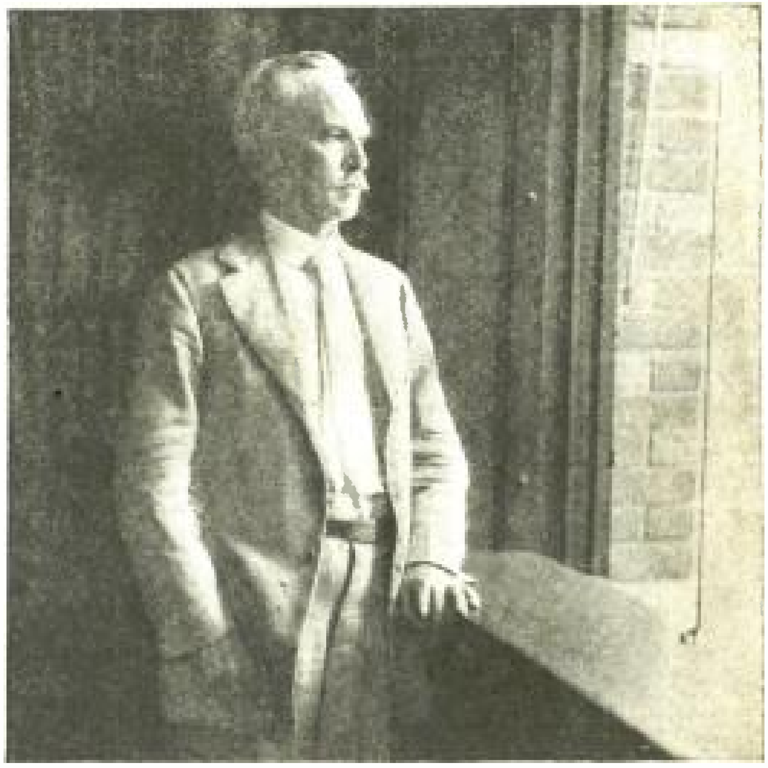
R-2 Magnavox Radio with 18-inch horn: this instrument is intended for those who wish the utmost in amplifying power; for large audiences, dance halls, etc.

R-3 Magnavox Radio with 14-inch horn: the ideal instrument for use in homes, offices, amateur stations, etc.

Model C Magnavox Power Amplifier insures getting the largest possible power input for your Magnavox Radio. 2 and 3 stage.

When you purchase a Magnavox product you possess an instrument of the highest quality and service.

Magnavox products can be had of good dealers everywhere. Write us for copy of new illustrated booklet.



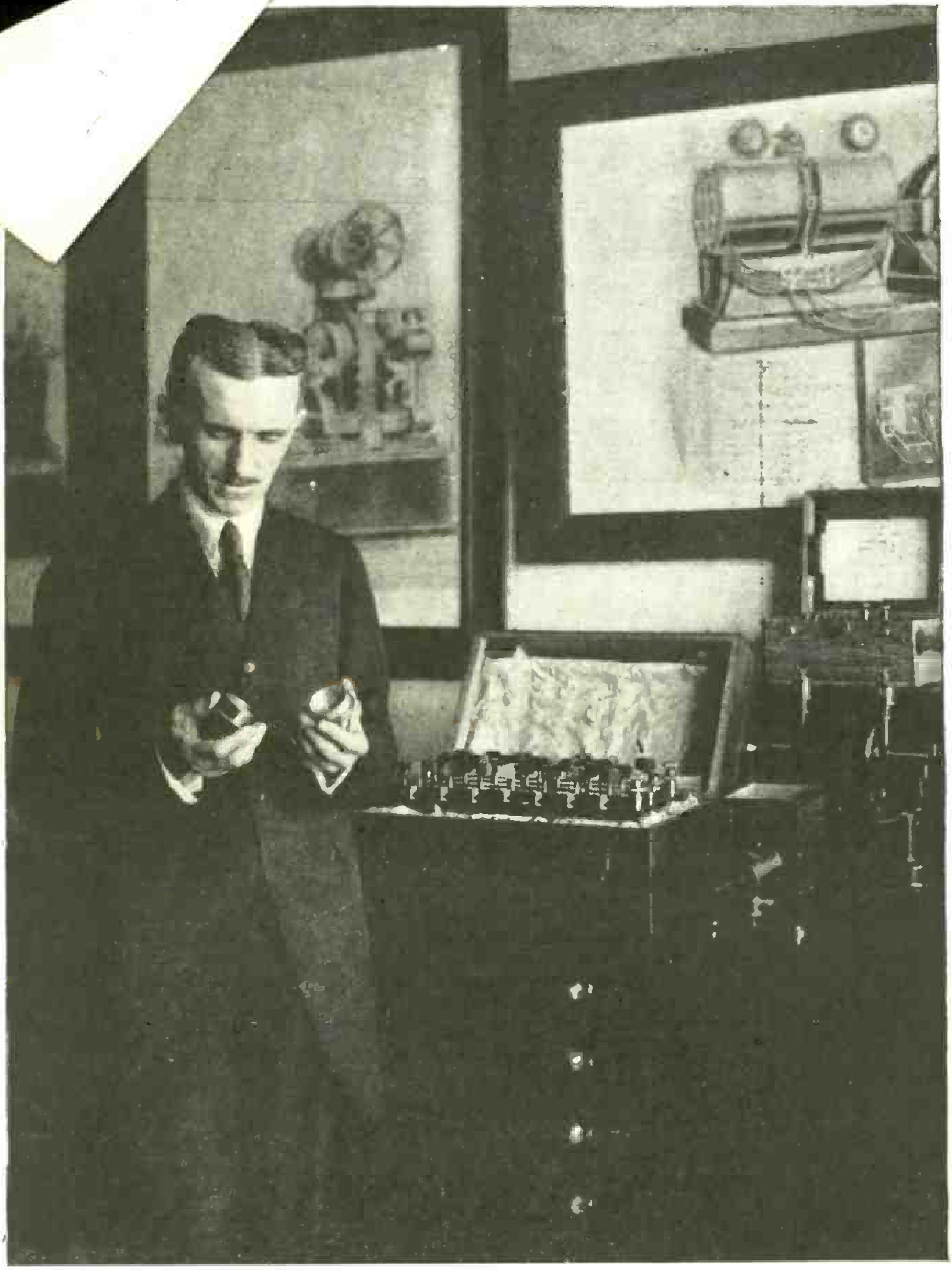
Radio—the Most Far-Reaching of Educational Agencies

TO THE EDITOR OF POPULAR RADIO:

I THINK you are profoundly right in your belief that the vital need now in the interests of radio is a provision for worth-while programs. Your plan for this sounds feasible. If you can bring it to pass you will have initiated an educational service that may conceivably become more far-reaching than any other educational agency, and of inestimable value to the culture of the Nation.

David Kinley

President, University of Illinois



From a photograph made for POPULAR RADIO

"Power Can Be and Will Be Sent by Radio"

Such is the statement of Nikola Tesla—one of the most imaginative geniuses among the great inventors—whose spectacular experiments with high frequency currents twenty-five years ago established him as a world-known figure. He is the inventor of the induction motor and of the coil that bears his name.

Popular Radio

VOLUME III — MARCH, 1923 — NUMBER 3

The Motion Picture Speaks

How the long-cherished dream of inventors to make the "movies" vocal has at last been solved by the radio experts, who are converting sound successively into electric current, light waves, pictures, electric current and back again into sound.

LEE DE FOREST, Ph. D., D. Sc.

TALKING movies are an accomplished fact. Perfect synchronism of speech and action has been attained, and this success is another triumph for that wonder worker of radio, the audion amplifier. The talking movie depends upon the use of the tubes to amplify the minute electric currents with which it is necessary to work and it is no exaggeration to say that the vocalization of the motion picture would never have been accomplished at all were it not for the fact that the motion picture technicians had available to them the perfected inventions of the radio engineer.

The earlier attempts at talking movies, fiascos which we all remember so well, depended upon schemes for connecting together an ordinary phonograph and an ordinary motion picture machine. The phonograph was supposed to repeat a certain sound at the exact instant that the appropriate action took place on the screen. To make the two machines run precisely at the same rate there were complicated arrangements of governors and regulators. In one of the processes, for instance, small holes were punched at intervals in the film. Compressed air escaped through these holes much as it does through the holes in the paper roll of a piano player and this escaping air was supposed to regulate the speed of the phonograph so that it would play its record at a rate exactly equal to the rate of progress of the film.

None of these devices worked very well. Not only were there delicate mechanical or electrical adjustments which frequently got out of order, but there was another difficulty, one which would be entirely unforeseen, probably, by anyone not actually experienced in the motion picture business. This was the disturbance of the record caused by breakages of the film.

Once in a while when you are watching the pictures in a motion picture theatre you will see the picture suddenly disappear, leaving a blank white screen. This means that the film has torn in two. The young man in the projection room does a little fast work and presently the picture goes on again as though nothing had happened. But before that particular film can be used again its torn ends have to be trimmed off so that they are even and then stuck together again with film cement. This makes the film an inch or two shorter than it was before.

So far as the picture is concerned, this shortening makes no great difference. There are sixteen separate snapshots to the foot of film and the loss of one or two of them is not even perceptible when the film is projected. But suppose that the film is one which has been carefully synchronized with a phonograph record. If you leave out an inch or two of film the sound record gets behind the action by just that much. After three or four breaks have been made and fixed you will hear the sound of a fall, for example, a second or two after it has really happened. It will sound like an echo.

It is not possible to avoid occasional breakage of the film and this was the reason why experienced motion picture engineers were always rather sceptical of any scheme for mechanically synchronizing films with phonograph records. What was needed, they thought, was some way of recording the sound record on the film itself so that the sound record and the sight record would be synchronous and inseparable automatically.

This is exactly what the new talking movies are. In my process, for instance, which I call the "Phonofilm process," the record of the sounds is registered in the form of a narrow strip of lighter and darker hairlike lines running crosswise, at the edge of the film, like the rungs of a tiny ladder. This record is produced at the same time that the pictures are taken, by a photographic process. When the film is run off these sounds are reproduced.

The "photographing of sounds" is new only in details. Scientists have been photographing sounds for many years and by half a dozen different processes. The beginning of the story takes us back to 1879 and to Dr. Alexander Graham Bell, the inventor of the telephone.

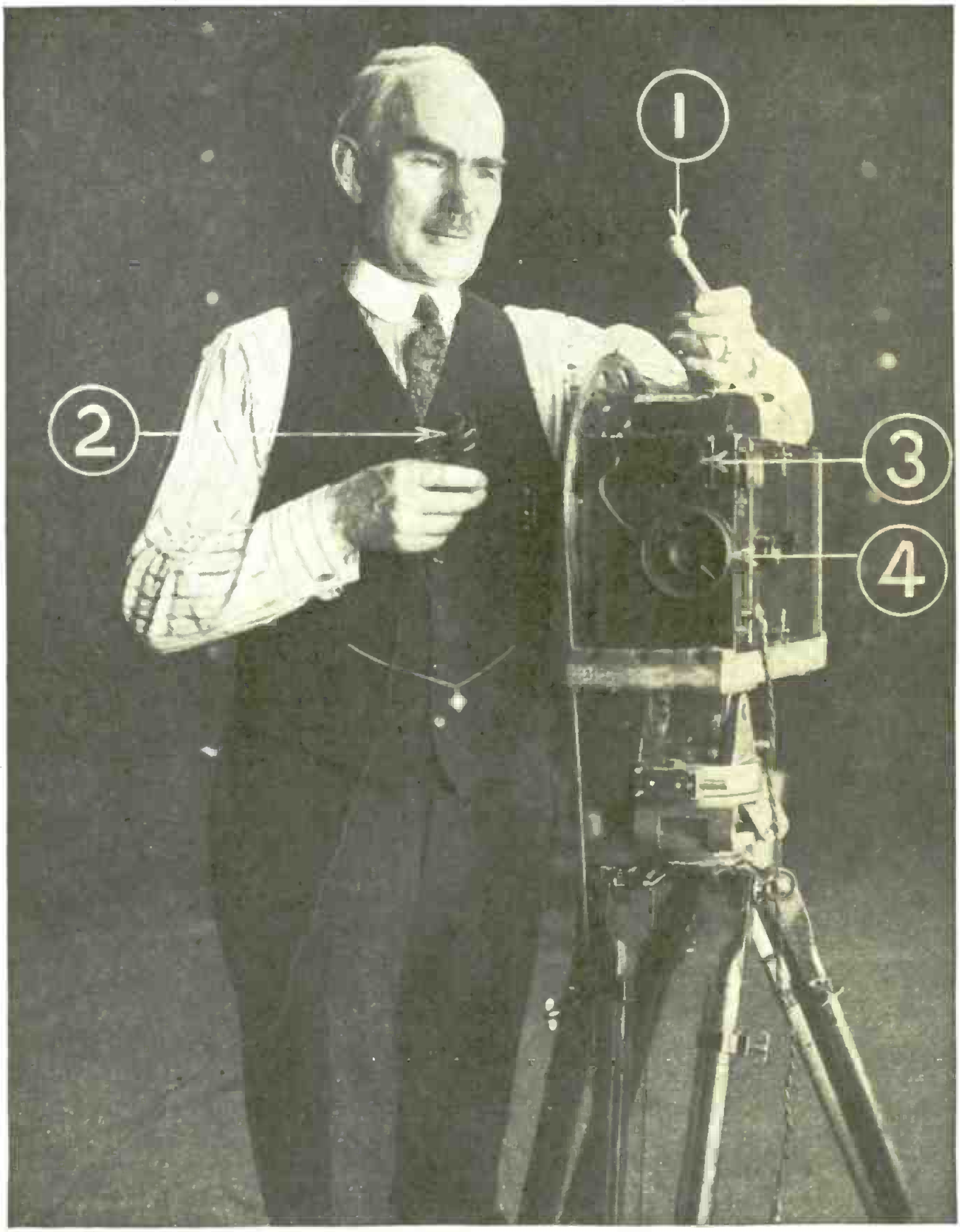
When Dr. Bell was working out the telephone he gave a good deal of attention also to other ways of transmitting speech. Perhaps the telephone might turn out a failure and some different device might have to be substituted. Among other things he tried out a way of talking along a beam of light. One day in 1879 he stood in his garden and actually talked for over two hundred yards along a beam of sunlight reflected from a little mirror which he held in his hand.

The secret was in the mirror. It was made out of very thin glass and it was not perfectly flat. Instead it had a slight spherical curvature as though it had been cut out of the side of a very large globe of glass. The beam of light was reflected from this curved surface.

Back of the mirror was a mouthpiece into which Dr. Bell spoke so that the sound waves of his voice struck against the back of the mirror. These waves made the mirror vibrate just as the diaphragm of a telephone vibrates when you speak into it. And when the mirror vibrated its curvature changed, it became alternately a little flatter and a little more curved. This affected, of course, the amount of light reflected from its front surface. The beam of light fluctuated in strength and these fluctuations were found to correspond exactly to the sound waves, which were beating against the back of the mirror-diaphragm, just as the electric currents in a telephone transmitter correspond to the sound waves which strike against its diaphragm.

Dr. Bell's device was really a telephone in which a mirror took the place of the usual transmitter and a ray of light took the place of the electric current in the wire.

In 1879 there was no particular use for such a device. The motion picture was still a dream. The electric telephone proved to be successful and the light-telephone—Dr. Bell called it a photo-



From a photograph made by Paul Thompson for POPULAR RADIO

The Camera that Records Both Action and Speech

For the benefit of the readers of POPULAR RADIO, *Dr. Lee De Forest is here demonstrating his new and remarkable invention. He is inserting the "photion" (1) into its proper socket. This photion (coined from the words "photograph" and "audion," meaning literally an audion that takes photographs) is the secret of the phonofilm machine. The microphone that receives the voice is shown at (2); the opening (3) leads into the chamber that contains the apparatus that converts sound into light waves. (4) is the regulation shutter equipment used on every motion-picture camera. The records of both motion and sound are thus recorded on the photographic film.*

phone—dropped out of sight. He did not attempt to photograph the sound waves.

But might not such a device have its use in war? The Germans thought so and in 1890 they financed the investigation of one Ernst Walter Rühmer on this same problem.

Rühmer did not use a mirror. He selected a totally different principle, the principle of the electric arc. He used an ordinary old-fashioned arc lamp, in the circuit of which was a microphone. When he spoke into the microphone, the sound waves affected it and it, in turn, affected the brightness of the arc; producing fluctuations which corresponded, as in Dr. Bell's device, to the pulses of the sound. This fluctuating light from the arc Rühmer sent out in a searchlight beam miles across the country to a receiving station where its pulses could be converted back again into audible sound.

During the war the Germans revived and improved this old method of Rühmer's. An apparatus devised by Dr. H. Thirring is said to have been in use at times on the Western front. Many a searchlight beam watched incuriously by our scouts as of no importance may have been carrying light-borne words which our intelligence department would have enjoyed hearing. But Dr. Thirring's work was not known until after the armistice and the possibility that a photophone was being used went unsuspected.

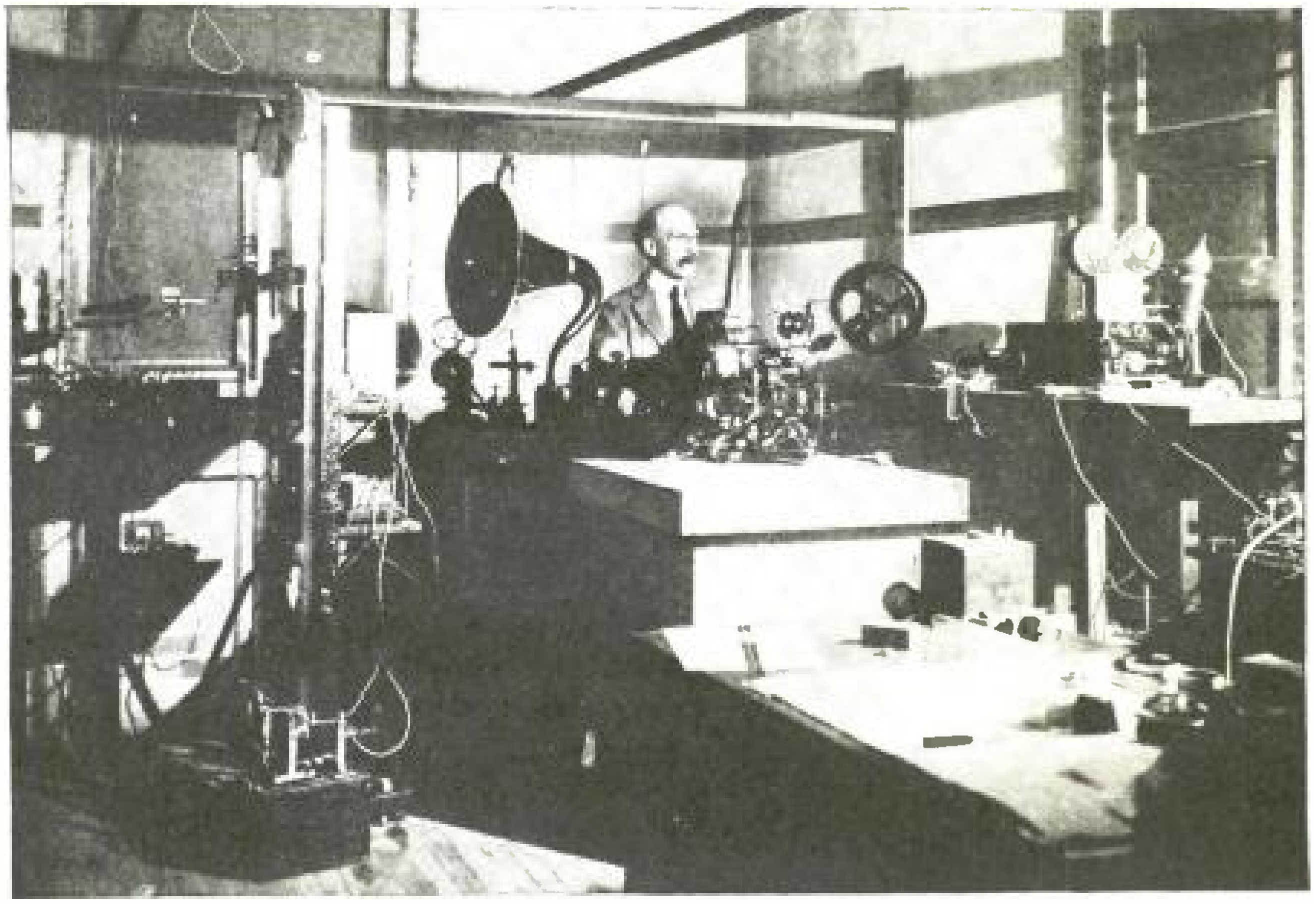
The British Admiralty, however, were working along similar lines, though for a different purpose. They were seeking a method of telephoning between ships at sea. Dr. A. O. Rankine, the distinguished physicist who conducted their investigations, did not use the arc method. He used a vibrating grating attached to a diaphragm, like that used years before by Dr. Bell and was so successful that he was able to talk for a distance of eight miles over a beam of sunlight only six inches in diameter. The familiar heliograph used in all armies and navies to exchange dot-and-dash signals by means of a beam of sunlight became capable of serving as a telephone as well.

None of these things had any immediate application to the movies. Even in 1918 no one seemed to see that these new war inventions contained the answer to the old problem of how to make the movies speak.

The first person to see this connection, or the first, at least, to actually make it effective, was Bergland in Sweden. Early in 1921, he exhibited to a group of scientific men a machine in which sound was recorded by means of a moving spot of light reflected from a tiny mirror. Sound waves were made to vibrate this mirror, and the mirror vibrated just as Dr. Bell's mirror did, but it was arranged so that the vibration took the form of back-and-forth swings instead of changes in curvature. These swings made the little spot of reflected light move back and forth across a moving photographic film, and the result was a wavy line photographed on the film. The waves in this line, the ups and downs of it, were found to correspond exactly to the pulses of the original sound. From this line the sound could be reproduced.

According to the published descriptions of it, Bergland's original machine was merely a sound recorder. It produced a record of sound just as a phonograph does but it recorded this on a strip of photographic film instead of a disk or cylinder of wax. In applying his invention to the making of a talking motion picture Bergland used two films side by side. One film received the picture just as it does in an ordinary motion picture camera. The other film received the wavy line which was the sound record. As the picture was taken the two films were moved forward by the same shaft. In this way, Bergland undertook to obtain exact synchronism between the two films.

But it is reported that he did not.



THE LABORATORY OF A DOCTOR WHO IS A "VOCAL SPECIALIST" ON FILMS

The workroom of Prof. J. T. Tykociner, of the University of Illinois, who has developed a talking motion picture film that uses a special shutter actuated by sound waves instead of the moving mirror or photion on which Dr. De Forest's invention depends.

Motion picture film always shrinks and changes a little as time goes on. Separate pieces of it do not always shrink equally. Then the holes in the margin of it, into which fit the teeth of the sprocket arrangement which moves the film, sometimes wear a little larger, so that the motion of the film is not quite uniform. These difficulties and others like them, it is said, interfered with the perfect agreement of Bergland's two films. It was necessary, or highly desirable, to put the two records actually on the same single strip of film.

Even while Bergland was working in Sweden this last step was being taken by another inventor in England. Only a few weeks after the Bergland tests Mr. Grindell Mathews announced the perfection of a camera which photographed the wavy line of the sound record and the successive pictures of the scenic record actually on the same film. The sound record was made in the same way as in the Bergland camera, by means of a tiny mirror swung back and forth in correspondence with the waves of sound.

This gave to the world for the first time a process in which the sound and the picture could not help being synchronous, since both of them were recorded on the same film strip.

It might seem that not much could be added to this but in developing the phonofilm we have succeeded, I think, in improving in at least two particulars any of the previous processes for a speaking film. The first of these improvements is what we believe to be a better way of photographing the sound. The second is an improvement in a part of the apparatus which I have said nothing about so far, the part which translates the sound photograph back again into real sounds which we can hear.

A STRIP OF TALKING FILM
(Actual Size of Negative)

This negative was made by Dr. De Forest's new phonofilm process. The hairlike lines of the right of the strip of sprocket holes on the left is the record of sound. During projections, a beam of light passes through this record onto a photo-electric cell and converted first into an electric current, amplified by vacuum tube amplifiers and finally reconverted back into sound by means of a loudspeaker.

If you look inside the camera which we use in taking the phonofilm the only unusual thing you will see is a small glass tube about the size of your little finger. When the apparatus is operating, this tube glows with a brilliant violet light. It is the new invention, which we call the "photion." It is the thing which we use to photograph sound.

The tube contains a special mixture of gases which it took me over three years of experiment to perfect. When an electric current is passed through the tube, this gas mixture becomes luminous. It is the gas which produces the violet glow.

Perhaps you have seen lately some of the neon-filled glow lamps which are being used to attract attention in stores and shop windows. A tube of bent glass, often shaped into words or letters, contains a little of this neon gas, about one thousandth of one per cent of which is contained in ordinary air. When a high frequency electric current is sent through this neon-filled tube, the gas glows with a soft reddish light which is pleasant and attractive. The photion works on much this same principle. Of course, the gas in it is not neon and the glow is violet, not red. But it, too, is a gas glow excited by an electric current.

If you watch carefully the glow of a photion in operation you may be able to see that the light is not absolutely constant. It flickers a little. Pulses of greater brightness alternate with brief instants when the glow is a trifle dimmer. This means that the photion is translating sound into light. The rapid flickers and pulses which you see mean that you are literally seeing speech.

The photion tube is excited by a high frequency electric current, modulated by the voice in exactly the same way as in a small radio-telephone transmitter. This part of the apparatus is in fact identical with the radiophone transmitter.

In the electric circuit which operates the photion and which causes it to glow we insert a highly special substitute for the microphone and one or more vacuum tubes as amplifiers. This ground receiver picks up sound waves and converts them into pulses of electricity. The electric pulses, after being amplified sufficiently, control the radiophone which is exciting the glowing photion and affect its light. The flickerings of this light, its rapid brightenings and dimmings, correspond exactly to the waves of sound which enter the microphone.

This shows you how the phonofilm process transforms sounds into light; but how does it photograph them, how do we secure a permanent record of them on the motion picture film?

This is how. The glowing photion is in a little chamber by itself inside the camera and this chamber is light-tight except for one tiny slit only one millimeter long and a fortieth of a millimeter wide. The moving film on which the motion picture is being taken runs past the photion chamber in such a position that the edge of the film passes just under this slit. The light from the photion streams through the slit and is photographed on the film, making the strip of tiny hairlike lines already described; a darker line for each instant when the photion is brighter, a less dense line when the light of the photion is a little more dim.

This little ladder of lighter and darker lines is our photograph of sound, our answer to the problem of recording successfully both the sight and the sound. The width of the sound photographs is always the same. The *intensity* of the light, and that alone, is varied by the sound. This feature distinguishes the phonofilm from all other methods, and permits a more faithful reproduction of every light and shade of sound than is otherwise possible. And by this photion or phonofilm method, it is seen, there is complete absence of any mechanical moving parts, nothing in the entire system up to the final diaphragm of the loudspeaker which can introduce a natural period of vibration of its own, tending to distort the original sound, in record-

From a photograph made by Paul Thompson for POPULAR RADIO

A SCIENTIST WHO UTTERS SPEECH THAT WE CAN SEE

Dr. De Forest—best known to radio fans as "the man who put the grid in the radio bottle," or in more scientific terms, the inventor of the audion or three-element vacuum tube—is here revealed in his laboratory inspecting a motion picture film that records both the movements of his lips while speaking and also the sounds that issue from them. Long before the advent of the vacuum tube, however, Dr. De Forest was experimenting with "wireless" telephony; many old-timers among the radio amateurs of New York recall the thrilling experimental days when his squeaky and distorted voice-tones, transmitted by arc and high-frequency spark telephones, filled the ether with early promises of the marvels that were to come. The square box at the inventor's elbow, with the small circular opening, contains the new type of microphone especially developed for the talking films.

ing or in reproduction. So far as the taking of the movie is concerned, this is the whole of the story.

But how is one to get this back into real sound again? How is the sound record on the film to be reproduced when the motion picture is run off in the theatre?

Consider first what the problem is. The taking of the talking motion picture involved two successive conversions of one kind of vibration into another kind. First the waves of sound were converted into electric waves by the microphone. Next the electric waves were converted into light by the photion. Now we must do these same two things in reverse order. On the finished film is our little ladder of darker and lighter lines. A ray of light can be made to shine through this ladder and the strength of the light that gets through will correspond to the lines on the ladder. As each dark line passes across, the light transmitted will be momentarily dimmer. This gives us, to start with, what we finished with when the movie was taken, namely, a light which flickers in exact correspondence with the waves of sound. The problem is to convert these flickers back again into real sound.

Most of the previous investigators and inventors have made this light-sound conversion by means of the metal selenium, a metal which has the property of changing its electrical resistance when light rays fall on it. But no one was satisfied with selenium. It was too erratic and undependable, too slow in recovery.

Years ago the same Dr. Hertz who discovered the waves now used in radio made another discovery. He discovered that plates of certain metals gave off electrons when they were illuminated. Every radio fan knows that the filament of a vacuum tube gives off electrons when it is hot. Dr. Hertz's metal plates did the same thing, only they did not have to be hot. All that was necessary was that light of some kind should be falling on them. This discovery was the beginning of the photoelectric cell.

In modern forms of the cell, the metal plate which is to give off the electrons is in a vacuum inside a sealed glass bulb. It looks a good deal like a glass egg with two short glass tubes about the size of lead pencils sealed into it, one at each end. The light shines into this egg from one side. On the other side, facing the light, is the plate of the sensitive metal, usually of the rare metal potassium or the still rarer one, rubidium.

When hit by the light the metal gives off electrons and the number given off a second changes with the strength of the light. The more light, the more electrons. You see at once what the pulsating light which shines through the sound record on the film will do. It will cause the electron emission inside the photoelectric cell to pulsate also. More or fewer electrons will be given off in exact correspondence with the sound waves which were originally photographed on the film.

This makes the first of the two conversions which we saw to be necessary, the conversion of the light pulses into electric ones. The next conversion, the one into real sound, is made in the usual fashion by amplifier tubes and a special telephone. The electron current in the photoelectric cell is feeble, but even one tube will amplify it until it will operate a telephone. Four or five tubes will make it strong enough to operate a loudspeaker and fill the largest motion picture theatre.

This gives you the whole process. Suppose we are taking a motion picture in which, let us say, Buster Keaton falls downstairs. For each step there is a bump and the sound wave of each bump makes a little flicker in the glow of the photion. This flicker records itself on the little ladder of lines which is being photographed on the film. Wherever that film goes, whatever is done with it, there is the record of Mr. Keaton's bump side by side with the view showing just how he came to make it.

General Electric

HE PRODUCES SOUND BY MEANS OF A VIBRATING MIRROR

What is in effect a motion picture photograph of the human voice, reproduced in the form of a graph that records vibrations, is the invention of Dr. Charles A. Hoxie. His machine is called the "Pallophotophone," and it not only "photographs" sound but reproduces it with most amazing clarity and power.

Then some day the film is shown in a theatre. The light of the projection machine shines through one of the pictures and shows a visual image of Mr. Keaton's downfall. At the same instant another light shines through the sound record. This light sees, so to speak, the sound image of Mr. Keaton's bump. It carries this image on to the photoelectric cell. The cell instantly transforms it into an electron image of the sound of the bump and hands this on to the audion amplifier. The amplifier strengthens it into a greater sound and hands it on to the loudspeaker which lets out, in its turn, a loud bang and we who sit, watching and listening, hear the misfortunes of Mr. Keaton at the same instant that we see them.

And at *exactly* the same instant! For all these changes and conversions happen with almost inconceivable rapidity, with the speed of electric currents which come close, most of them, to the 186,000 miles a second which is the speed of light.

From the special viewpoint of the


Courtesy of J. E. Williamson

THE FIRST MAN TO TRANSMIT SOUND ON BEAMS OF LIGHT

Back in 1880 Dr. Alexander Graham Bell invented the "photophone," by means of which speech was transmitted 200 yards on a ray of sunlight reflected from a curved mirror. In the picture above the good doctor is revealed as a diving Bell; it was snapped while he was emerging from the Williamson submarine tube in the West Indies, shortly before his death.

radio engineer there is one particularly interesting aspect of these various conversions of vibrations between light and sound and electricity. It is that they constitute a kind of modulation just like the modulation of continuous waves of radio telephony by sound waves.

Light is, of course, an electromagnetic wave just like the radio waves except that its wavelength is very much shorter, or, in other words, its frequency is tremendously higher. Instead of the frequency of about 800,000 a second which characterizes the ordinary broadcasting wave, light has frequencies measurable only in quadrillions a second, wavelengths defined in millionths of a millimeter.

Now in ordinary radio telephony the modulation consists merely in superimposing the low frequency waves of sound, which have from 20 to about 5000 vibrations a second, onto the moderately high frequency waves of the continuous wave radio. The sound wave goes out, one might say, as a passenger on the radio wave. Similarly, in the phonofilm, the function of the photion is to superimpose these same low frequency waves of sound first onto the higher frequency waves of the radio telephone and then onto the still higher frequency waves of light. The passenger is the same but is traveling on a different train, a train of much shorter cars. In ordinary radio modulation we speak of "audio" frequency and "radio" frequency. In these new light conversions we must speak of audio frequency in relation to what we may call "photo" frequency, this being the tremendously high frequency of the waves of light.

And just as there are various ways of producing the modulation of radio frequency by audio frequency, so there are various ways of superimposing sound waves on light. The photion is one of these ways. The mirror methods of Dr. Bell and of Dr. Rankine are others. The arc method of the Germans is still another. And two other methods, two newer ones, have been announced within the past year in the United States.*

And now what does this mean for the movies? Granted that a real talking movie can be produced about which there now seems little doubt, will this cause any serious change in the present methods of producing motion pictures and of presenting motion picture plays?

The motion picture experts do not agree in their answers to these questions. Most of them seem sceptical. They do not expect, they say, any immediate public favor for a talking movie no matter how perfect it is. The reason they give is a psychological one.

The essence of a successful motion picture, they say, is their ability to create an illusion. The images on the screen do not look exactly like the actors. They are just a jumble of black and white masses and lines and dots. Our favorite stars look lifelike to us because we have become used to this. We recognize the lights and shadows of the screen as symbols, much as the multitude of little black lines and dots and curves on this page are recognized by you as symbols of letters and words and thoughts. This page would not be so recognized by a savage who did not know the symbols of our alphabet.

And without illusion of reality which the mind makes for itself out of the symbols on the screen, motion pictures would have, these experts believe, much less interest and emotional appeal.

Now suppose you combine these visual screen symbols with sounds. The sounds are symbols also. They too must create their illusion. Will they reinforce the eye symbols or will they interfere with them? Most likely, say the sceptics, the result will be interference, not reinforcement. It is easy, they think, to create one illusion at a time, either an eye illusion or an ear illusion. It is much less easy to create both at once and to have them fit into each other in the mind. And so, they think, the path of progress for the talking movie is not going to be altogether smooth.

Perhaps not, but this is little likely to deter inventors from following it. We believe that we have already in the Phonofilm a device of great utility in scientific investigations and in the making of speech records side by side with pictorial ones, for instance in making records of important events. Whether the motion picture experts will adopt it for purposes of public entertainment we are content to leave to them—and to the future.

*One of these methods is that of Professor J. T. Tykociner of the University of Illinois. This, too, has been applied to the making of talking movies. In place of the moving mirror or the photion, Professor Tykociner uses a special mercury arc lamp. The light of this lamp, modified in intensity by the vibrations of the sound, falls onto the moving film, where it is photographed to make a strip of shaded lines not unlike the record on the Phonofilm.

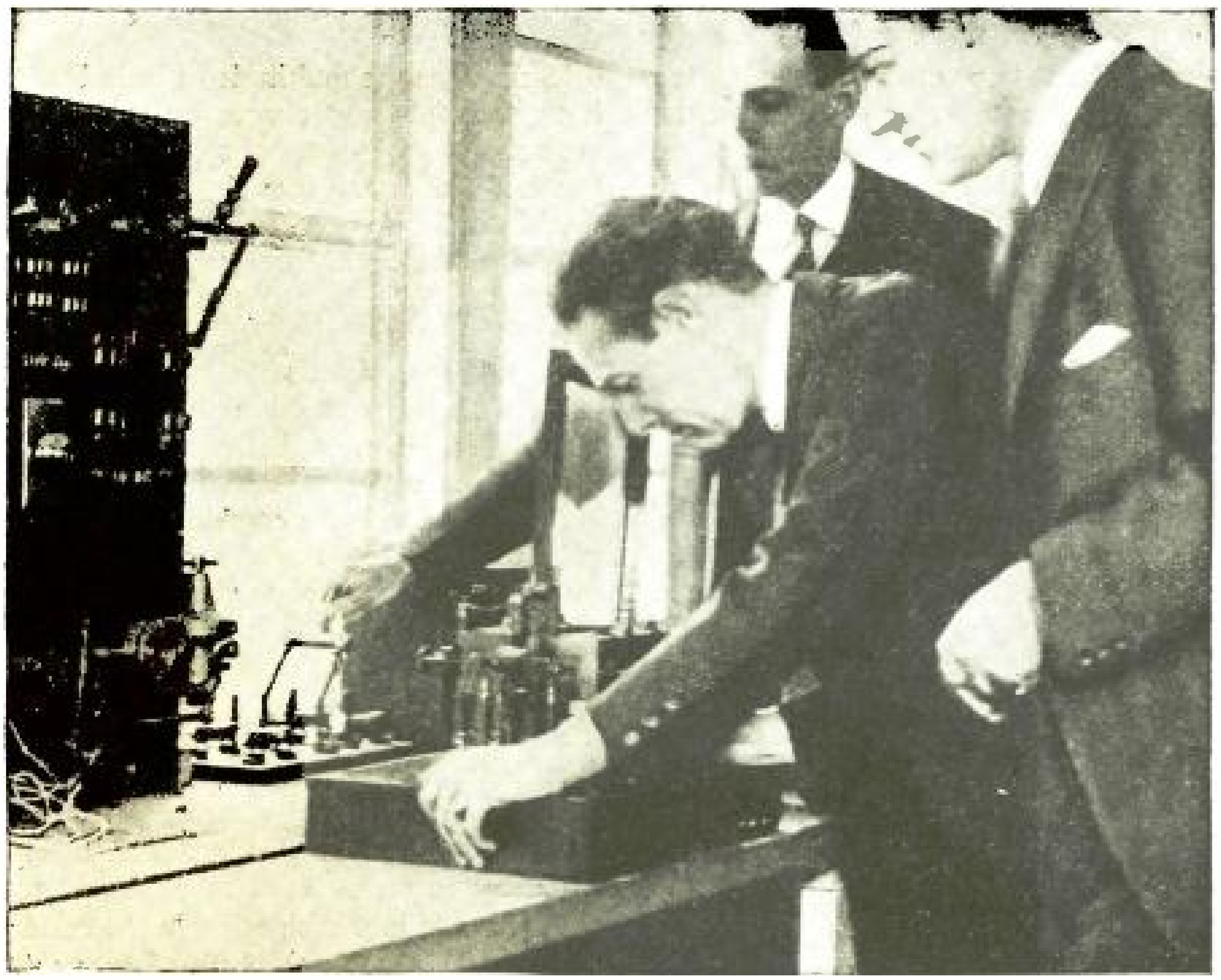
The other new method has been announced by Dr. Charles A. Hoxie of the Research Laboratory of the General Electric Company. His device appears to depend on a moving mirror, which would make it an improved form of the method used by Bergland in Sweden and by Mathews in England.

In all of these methods, the curved mirror of Dr. Bell, the arc of Rühmer and Thirring and Tykociner, the shaking mirrors of Rankine and Bergland and Mathews and Hoxie, and in the photion, the result accomplished is the same. It is the superposition of an audio frequency signal on photo frequency waves of light.—EDITOR.

Seeing by Radio

By WATSON DAVIS

IT is at present possible—as every well-informed amateur knows—to transmit pictures *via* wireless by several more-or-less successful processes. When the art of thus transmitting "still" pictures has been speeded up, the next step obviously will be to transmit motion pictures; perhaps even to transmit scenes direct from life! How this conception may become a reality is something more than hinted at in the remarkable invention of C. Francis Jenkins. An exclusive description of the Jenkins apparatus will shortly appear in POPULAR RADIO, illustrated with special photographs that show its operation together with specimens of the pictures as they are received.



A REAL MAKER OF MODERN "MIRACLES"

While John Hays Hammond, Jr., has been actively engaged in many lines of scientific experimental work at his laboratory near Gloucester, Mass., he is principally known to the public through his stirring demonstrations of radio-controlled vessels, torpedoes and aircraft—a development of radio that promises to have profound effects upon our civilization in both war and peace. He is here shown in the act of directing by radio the movements of an un-manned yacht in the harbor.

A PLAN FOR A PAY-AS-YOU-ENTER

RADIO NET

By JOHN HAYS HAMMOND, JR.

The recent demonstrations, initiated by Popular Radio, of the possibilities of broadcasting events of importance by means of the "pick-up" system, points the way to what appears to be a logical development in radio—so far as general broadcasting on the ether is concerned. Such a method of broadcasting requires the installation of land wires between the auditorium or field where the events are held and a distant radio station. In this article Mr. Hammond proposes a plan for restricting this broadcasting service to subscribers only, by "narrow-casting" (by means of wired wireless) along the telegraph, telephone or electric light wires or along power cables. Mr. Hammond's project is, in effect, a restriction of the "pick-up" system of broadcasting to that section of the public who may pay a toll charge to the telephone, telegraph or power companies or to other public service corporations that may be willing or able to develop a system for undertaking such a venture on a profit-making basis.—Editor.

MY idea of a complete, nation-wide broadcasting system is this:

That the present copper line equipment of the United States, owned by such companies as the telephone and telegraph organizations, should participate in the general problem of broadcasting.

Only at the termini of these lines should there be erected radio broadcasting stations of moderate power to cover the rural districts. Thus, where radio became necessary, it would be used, but the ether would not be used for any unnecessary transmissions. This is an important fact in view of the increasing demand on the single line ether conductor furnished to us in radio transmission.

The distribution of news could, for illustration, be classified thus:

1—General international news.
2—Financial and market news.
3—Congressional and legislative news.
4—News from the various scientific and advisory departments in Washington, such as the Agricultural Department, the Bureau of Standards, the Weather Bureau, and others.
5—Transmission of music.
6—Educational news in the form of lectures.
7—Commercial and advertising news.

The bulk of this news could be initiated from various centers such as New York, Chicago, San Francisco and other important cities. This news would be segregated and carried by voice on the lines by the present carrier multiplex telephone system, and specific frequencies could be allotted to each of the seven classes specified above.

From Washington would originate information concerning the activities of our political representatives. The desks of the various members in the House and Senate could be equipped with transmitters under the control of operators in the galleries of these chambers. The name of the speaker could be

Westinghouse

"THE NEWSPAPER THAT COMES THROUGH YOUR WALLS"

News items, stock quotations, weather reports—these are but a few of the features of our daily papers that are already being broadcast regularly by the large stations. Will "narrow-casting" along telephone, telegraph, electric light and power cables develop such a service for subscribers only?

International

BY MEANS OF THIS HUGE AMPLIFIER AN ENTIRE TOWN HEARD PRESIDENT HARDING SPEAK

The inevitable expansion of radio broadcasting will make it possible for entire communities to listen to the deliberations of Congress—to say nothing of other events of national or international importance. This remarkable apparatus was installed near Cincinnati, Ohio, in order that the President's address at the great centenary celebration could be heard over a radius of a mile.

announced by the operator in the gallery and the particular transmitter opposite the speaker could be switched in momentarily by the operator. His voice could then be carried back to his constituents even in the distant sections of the country. Thus the centers of legislative action could be constantly in personal touch with the people of the country—a situation that would, I believe, have a profound effect upon some of the methods of Congressional debate, and would lead eventually to modifications of congressional procedure.

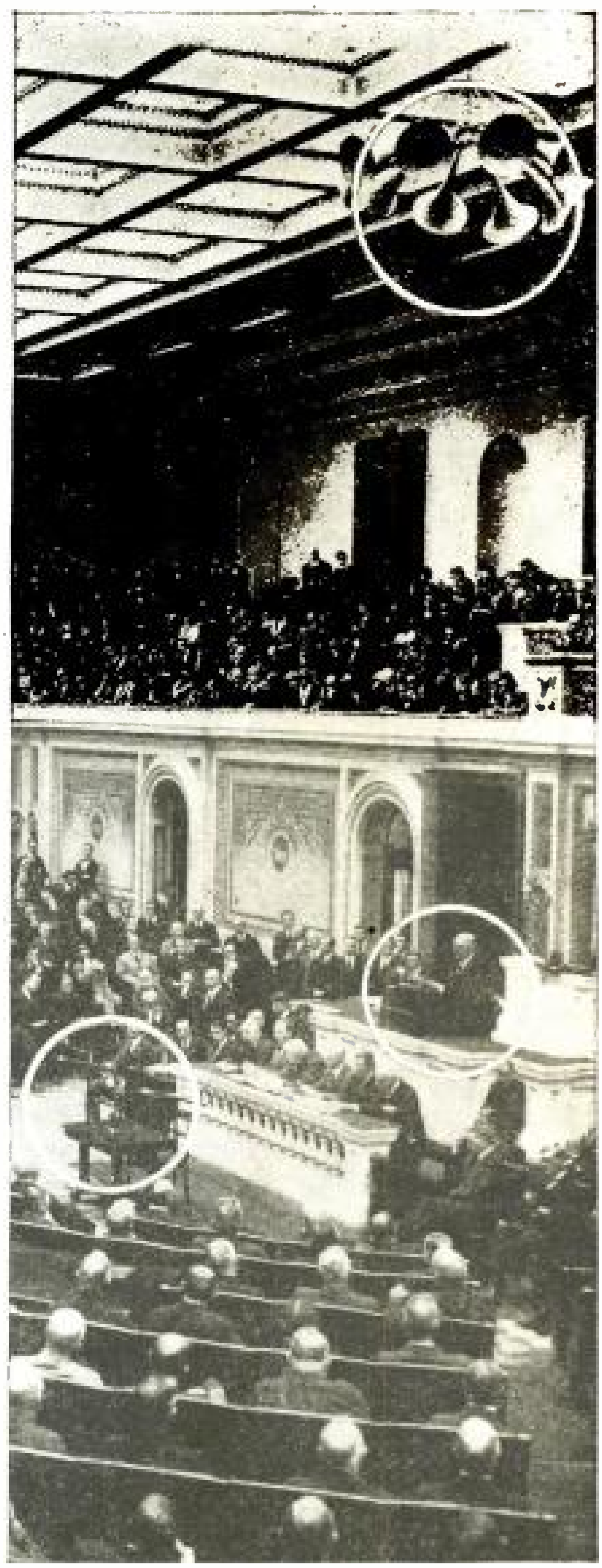
By such an installation of radio equipment at the Capitol it would be possible for the President to address an audience numbering millions of people on occasions when he gives voice to proclamations of nation-wide interest. The political importance of such a system would not leave Washington cold.

Through the great network of the telephone lines news could be switched or concentrated upon, or disseminated to any part of the country. The millions of present telephone subscribers would find their telephone not merely a limited instrument, as it now is so far as intercommunication is concerned, but a source of educational interest and pleasure. They could, for example, by calling up their local central, ascertain what news was being transmitted under the various headings referred to, and the central by switching to any one of these frequencies could obtain for the subscriber whatever news was desired and bill him at the prescribed rates. Urgent calls could be put through promptly; the numbers of other calls could be recorded by the central and given to the subscriber at the conclusion of the news transmission.

Passing on from the telephone subscriber, the news would be transmitted over the lines to terminal points, where it could be converted into radio-telephone transmission. We will imagine for purposes of illustration that one of these points would be some outlying town that has certain local interests. The long distance news transmitted from New York and Washington would come through for broadcasting, but there would also be added at this point another frequency which would carry the local advertising and general local news. This, then, would be broadcast by radio over a range of a few hundred miles covering all the rural districts in this section. It would be possible for people marooned in an Iowa snowstorm to hear a lecture in New York City or the Metropolitan Opera or legislative debate on the floor of Congress, agricultural advice from Washington headquarters or the status of the stock market. The rural subscriber who depends upon the reception of programs by radiophone would be equipped with a foolproof receiver; he would be given a standard form of antenna, some instruction as to the handling of the equipment and the service and attention of certain company engineers who would occasionally have to look over the radio equipment.

The multiplex messages carried over the lines would be easily modified into the multiplex form of radio transmission.

I know that from the technical point



National Photo

A HISTORIC MOMENT IN THE HISTORY OF RADIO

When President Harding appeared before the 67th Congress at the opening of the 4th session, his speech was picked up by microphones, conveyed by wire to the naval radio station at Anacostia (NOF) and broadcast for all to hear who would. The horns attached to the ceiling amplified the President's voice in the auditorium.

From a photograph made by Westinghouse for POPULAR RADIO

THE EAR OF A MILLION LISTENERS

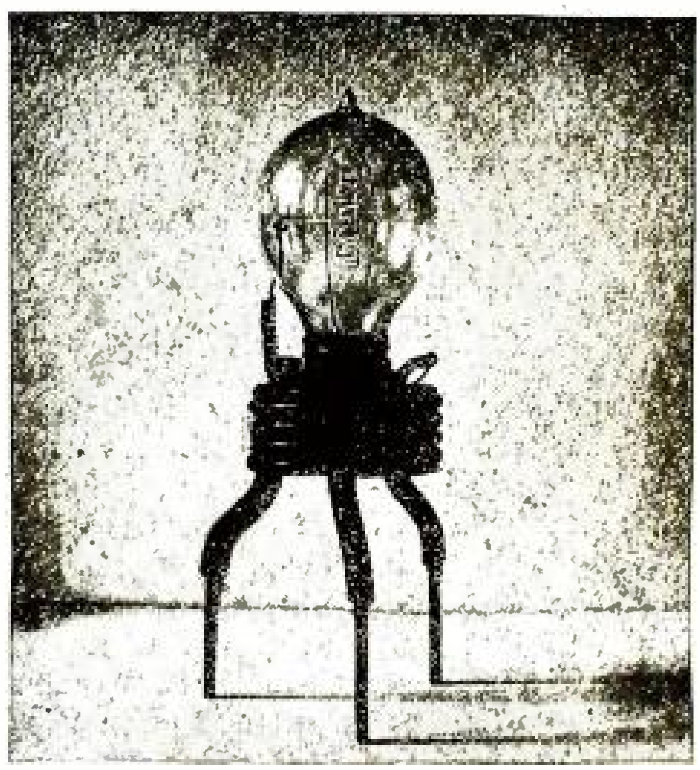
No longer is the audience at grand opera, concerts, lectures and other public gatherings limited to the handful that can crowd into a hall. By means of the "pick-up" system of broadcasting, the people of a half dozen States may listen in. The picture above shows the installation of the microphone at the Century Theatre, New York, when the concerts of the City Symphony Orchestra were broadcast from WJZ—a project initiated by POPULAR RADIO.

of view the plan that I am suggesting is possible of realization. I believe that the monetary return to be derived from this system would make it eminently worth while as a practical project. I think that the present telephone system can be made a more vital factor than it is in the affairs of the nation, and it seems to me that radio is the logical means of infinitely extending the use of the line system for purposes of broadcasting.

There is still a large part of the population of the United States that is severed from direct connection with important centers of industry and progress. Great areas of the country sparsely settled are now to a great extent out of touch. Such a scheme of broadcasting as I propose would, I believe, be a powerful factor in unifying the interest and general sentiment of this great nation, and in national emergencies such a system would give the Government an unprecedented guidance in the trend of public opinion.

The Influence of Radio on Warfare

The rapidly extending use of radio during the closing stages of the World War, not only in establishing lines of communication but also for controlling engines of destruction, indicates a line of development that is destined to have a profound effect upon military and naval science. An important article on this subject is now in course of preparation for POPULAR RADIO by one of the world's foremost military authorities, who is at present engaged in the compilation of data that will establish his work as a real contribution to the literature of radio.



THE ANCESTOR OF THE MODERN AUDION

Here is the original "Fleming valve." It consists of a carbon filament enclosed in a glass vessel with a second wire or electrode inserted between the filament leads.

HOW I PUT THE ELECTRONS TO WORK IN

The RADIO BOTTLE

The Evolution of the Famous "Fleming Valve"—Told by Its Inventor

The wonders of radio are made possible by the vacuum tube—the modern "Aladdin lamp." This article describes how an apparent scratch on a bit of discolored glass led to a discovery from which the present science has grown.

By PROF. JAMES AMBROSE FLEMING, M. A., D. Sc., F. R. S.

AN aeroplane is speeding along at a hundred miles an hour, two miles up in the sky above the English Channel. A slender wire trails out behind the machine. From time to time the pilot glances at the compass on the instrument board.

Suddenly a voice speaks to him, the voice of a man sitting many miles away in his office in the city of London, a voice that has overtaken him.

The pilot listens, turns a switch, and answers. He is detached from earth, hurtling through space, but it is as though he were standing in that city office talking to his director.

This is one of the miracles of today brought to pass by a lamp. Another aeroplane speeds like a blind thing in a fog. The pilot can see nothing. He is quite lost, everything is blotted out, yet he has no fear. A tiny lamp has the aeroplane on an invisible leash, and leads it safely to the aerodrome.

Somewhere on the illimitable ocean is a battleship. An admiral in Whitehall, faced with a sudden emergency, desires to find that ship, speak with the captain, and send the grim ironclad steaming full speed to a secret destination. A few years ago it would have been an impossible task; now, a lamp accomplishes the miracle.

A ship is going down with hundreds of helpless passengers. An agonized signal for help is flung into the heavens—by a lamp. And another lamp, hundreds of miles away, instantly responds and sends a ship to the rescue.

A world-famous prima-donna pours out her soul in song in a little room, and the magic lamp takes her song and carries it from her lips to thousands of homes where people sit and listen to the thrilling cadence of her voice.

It seems almost incredible that these wonders are made possible by a lamp, yet it is true.

The story of how I came to invent the Fleming thermionic valve, which played so important a part in bringing these things to pass, began long ago when Edison was devoting his genius to lighting the homes of the people with electricity. After countless experiments the labors of Edison in the United States and of the late Sir Joseph Swan, aided by Mr. C. H. Stearn, in England, turned a scientific theory into an accomplished fact, and produced the electric incandescent lamp which was destined to work such wonders in the world.

Forty years ago, early in 1882, after the Edison Electric Light Company of London was formed, I was appointed electrical adviser to the company. I was therefore brought into close touch with the many problems of incandescent lamps and I began to study the physical phenomena with all the scientific means at my disposal. Like everyone else, I noticed that the filaments broke easily at the slightest shock, and when the lamps burned out the glass bulbs became discolored.

This discoloration of the glass was generally accepted as a matter of course. It seemed too trifling to notice. But in science it is the trifles that count. The little things of today may develop into the great things of tomorrow.

I wondered why the glass bulb grew dark and I started to investigate the matter. I discovered that in many burned-out lamps there was a line of glass that was not discolored in any way. It was as though someone took a smoked glass, drew a finger quickly down it, and left a perfectly clean line behind.

I found that the lamps with these strange, sharply-defined clean spaces were covered elsewhere with a deposit of carbon or metal, and that the clean line was immediately in the plane of the carbon horseshoe filament and on the side of the loop opposite to the burned-out point of the filament.

It was obvious to me that the unbroken part of the filament acted as a screen to that particular line of clear glass, and that the discharge from the overheated point on the filament bombarded the remainder of the bulb with molecules of carbon or vaporized metal shot out in straight lines.

My experiments at the end of 1882 and early in 1883 proved that I was right.

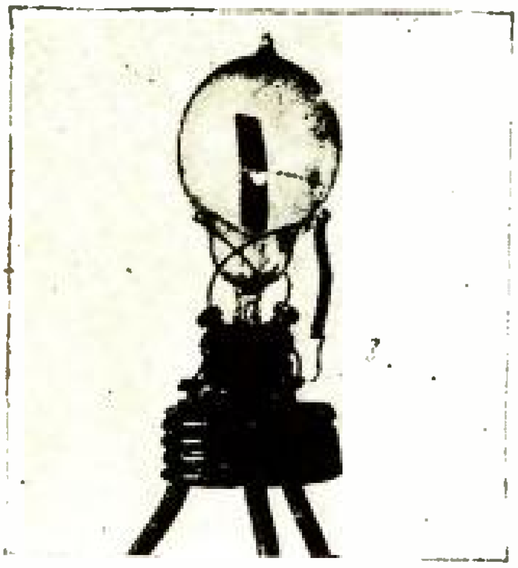
Edison was at work in his laboratory in 1883 when he noticed that if he fitted a tiny metal plate inside the bulb of an electric lamp and connected it outside the bulb with the positive end of the filament, he obtained a slight current. The phenomenon was called "the Edison effect"; but Edison could not explain it, nor did he use it in any way.

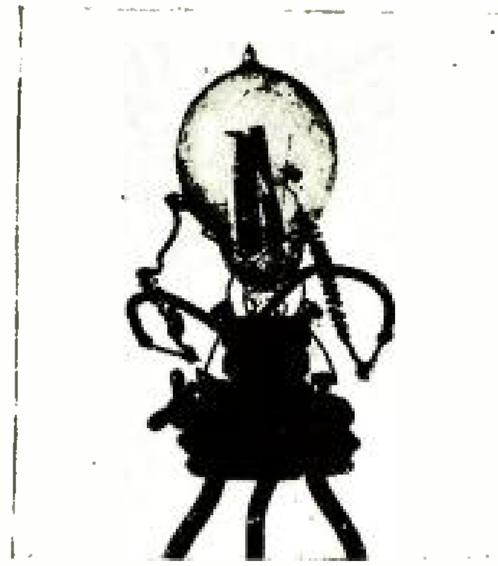
In October, 1884, Sir William Preece obtained from Edison some of these electric lamps with metal plates sealed inside them, and he turned his attention to the investigation of the phenomena of the Edison effect. He decided the Edison effect was connected with the projection of carbon molecules from the filament in straight lines, thus confirming my original discovery. There Sir William Preece let the matter rest, just as Edison had done. He did not satisfactorily explain the phenomenon nor did he seek to apply it in any way. The Edison effect remained just a peculiar property, a mystery of the incandescent lamp.

From a photograph made for POPULAR RADIO by Hoppé, London

HE GAVE THE WORLD THE TWO-ELEMENT TUBE RECTIFIER

While Prof. J. A. Fleming was investigating the phenomena of the disintegration of the filaments in the first Edison electric incandescent lamps he received the first inkling that the filaments in the lamps, while heated, were continuously shooting off particles, which he later found were tiny electric charges. He proved that this was the case by enclosing a plate in with the filament upon which he collected these charges, forming an electric current. Thus was developed the tube rectifier that bears his name.





TWO OF THE EARLY EXPERIMENTS WITH VACUUM TUBES

AT LEFT: *This tube had a filament with a rectangular-shaped plate inserted inside the glass bulb, with leads running through the glass for external connections.*

AT RIGHT: *This tube had a filament and two cylindrical plates, one of which entirely surrounded one leg of the filament. Both of these types of plates are found in modern vacuum tubes.*

Other work claimed my attention for a long time, but I was certain in my own mind that there was still a great deal to discover about this peculiarity of the incandescent lamp, and directly the opportunity occurred I started to investigate the subject once more. In 1888 I had some special lamps made at the Edison and Swan lamp works. Some were strangely shaped, with long glass tubes springing from the sides; others had tubes shaped like the capital "L." The filaments were of carbon, bent round like a horseshoe, and within the bulbs or in the side tubes metal plates were fixed.

With these lamps, I conducted many tests of a highly technical nature, which I fully described in various scientific papers to the Royal Society and Physical Society. I was keenly interested, although the average man would have found little in my laboratory to appeal to him. I fully confirmed Sir William Preece's observations that the molecules discharged from the incandescent filament could not pass round a right-angle bend, and doubly confirmed my original discovery that the molecules traveled in straight lines.

Then I enclosed the negative leg of the carbon filament in a glass tube, and found that the bombardment of electrified particles was completely stopped. By altering the position of the metal plates, I learned that I could vary the intensity of the bombardment. At last I tried placing a metal cylinder completely around the negative leg of the filament without touching it, and the mirror galvanometer that I was using to detect the currents indicated the strongest current of all. It was plain that the metal cylinder enclosing the negative filament caught all the electrified particles that were shot out from the filament.

What I discovered led me to experiment with electric arcs in the open air, and I found that the same phenomenon existed. I published the result of these experiments in a paper in 1889. "On Electrical Discharge Between Electrodes at Different Temperatures in Air and High Vacua."

Thereafter, whenever the opportunity occurred, I continued my experiments with a view to further discoveries. I need not enter into technical details here, but all my researches indicated that the molecules of my original discovery were composed of particles charged with negative electricity. Since the brilliant discoveries of Sir J. J. Thomson in 1897 we have called them "electrons." By surrounding the negative filament with a metal cylinder and bringing the filament to a high state of incandescence, a current of negative electricity was induced to flow from the filament to the plate, but it could not be induced to flow in the opposite direction from the plate to the filament.

I have often been asked to explain why the current could flow one way and not the other, and I think a rough analogy is to liken the glowing filament to a battery of guns always firing shells at a certain target. The shells must travel away from the guns. The impulse is behind them, so they must go forward. It is physically impossible for them to travel toward the guns from which they have been fired. In hitting the target the shells burst and expend their energy, just as the electrons give up their energy, or negative electricity, when they hit the cylinder surrounding the filament.

It is thus easy to understand why the current can flow only one way, that is, from the filament to the cylinder. The electrons are like porters, all hurrying in one direction with a tiny load of negative electricity. As there are no porters traveling in the opposite direction, it is impossible to get any current carried back again.

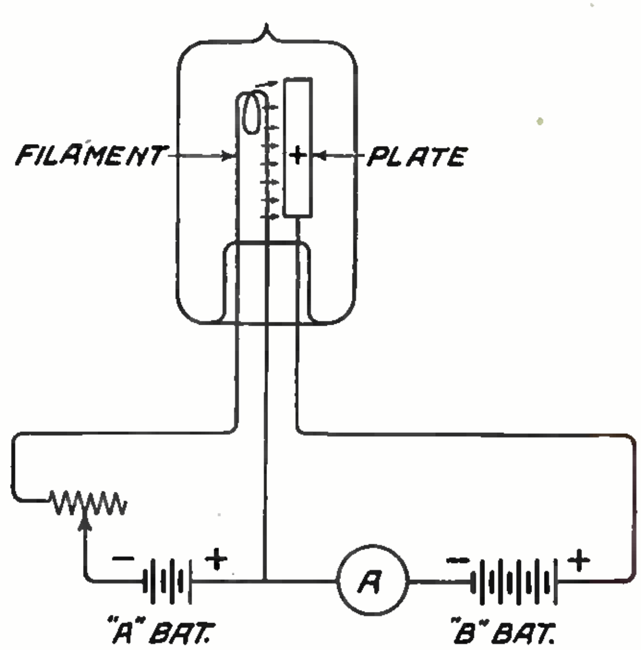
In 1899 I was asked to act as electrical adviser to Marconi's Wireless Telegraph Company and to assist in solving the technical problem of equipping the first transatlantic wireless station at Poldhu with electrical apparatus that would send a wireless impulse across the Atlantic. At that time a wireless signal had not been sent much over 100 miles, so it was a big jump to send a signal 2,000 miles.

We realized that high power would be necessary, and that the old methods of supplying power would be useless. Accordingly, we ordered certain machinery, which was installed in due course, and in November, 1901, Senatore Marconi, with two assistants, went to St. John's, Newfoundland, to see if it was possible to obtain messages from Poldhu.

The weather was bad. High winds enveloped them as they stood on Signal Hill trying to induce their kites and balloons to rise in the air. They had barely coaxed one kite to rise when it broke from its moorings and fell into the sea. They tried again until at last the long-looked-for signal was detected. On December 12 they heard three distinct taps signaling the letter "S" and wireless telegraphy across the Atlantic was an accomplished fact, needing only more perfect instruments to make it commercially possible.

In those early days the coherer was used to detect signals. All wireless students know how it works. The metal filings in the coherer leap together at the touch of an electrical impulse and form a bridge for the current to pass over, and they have to be tapped apart before they can detect another electrical impulse. Senatore Marconi improved on the coherer as a receiver by inventing the magnetic detector. Yet there was room for still further improvement.

Wireless waves from spark sets arrive as a series of impulses, or gushes, and they set up an alternating current in the aerial wire,



HOW THE FLEMING VALVE WORKS

This diagram illustrates the passage of the electrons from the filament to the plate, thus causing a current to flow through the meter deflecting its needle.

General Electric

THE GIANT OFFSPRING OF THE MIDGET FLEMING VALVE

Like the model shown on page 175, this latest product of the electrical laboratory is a two-element vacuum tube. It handles 1,000 kilowatts of oscillating electrical energy, or more than 1,000,000 times as much as its tiny forebear. This great tube, however, uses a filament current of thousands of amperes, whereas its forerunner used less than one. It is possible that some time in the near future similar vacuum tubes will be used for extremely high power purposes, for converting high potential D.C. to A.C. and vice versa.

that is, a current that swings backward and forward. I realized that if this alternating current could be rectified or converted into direct current, it would be possible to use the mirror galvanometer of Kelvin to register oscillations that were possibly too weak for the known receivers to detect. I aimed, like many other men, to stop the current swinging back and to make it always flow forward.

It was a difficult problem. I experimented with many of the rectifiers then in use in my efforts to solve it. One rectifier can be made of plates of aluminum and graphite immersed in a solution of certain salts. The current was able to pass freely from the graphite to the aluminum, but when the current was reversed and attempts made to make it flow from the aluminum to the graphite, a deposit formed on the aluminum, which effectually stopped the current from flowing.

While this acted well enough for certain purposes when the frequency of the currents was low, it was quite useless for wireless purposes. With a low frequency current the electric impulses, coming slowly, gave time for the deposits to form on the aluminum plates. But wireless oscillations, coming at the rate of hundreds of thousands or millions a second, were so rapid that they gave no time to create the deposits.

Finding that these chemical rectifiers were not suitable for use with high frequency currents, I sought something that would operate more rapidly as a rectifier. I was pondering on the difficulties of the problem when my thoughts recurred to my experiments in connection with the Edison effect.

"Why not try the lamps?" I thought.

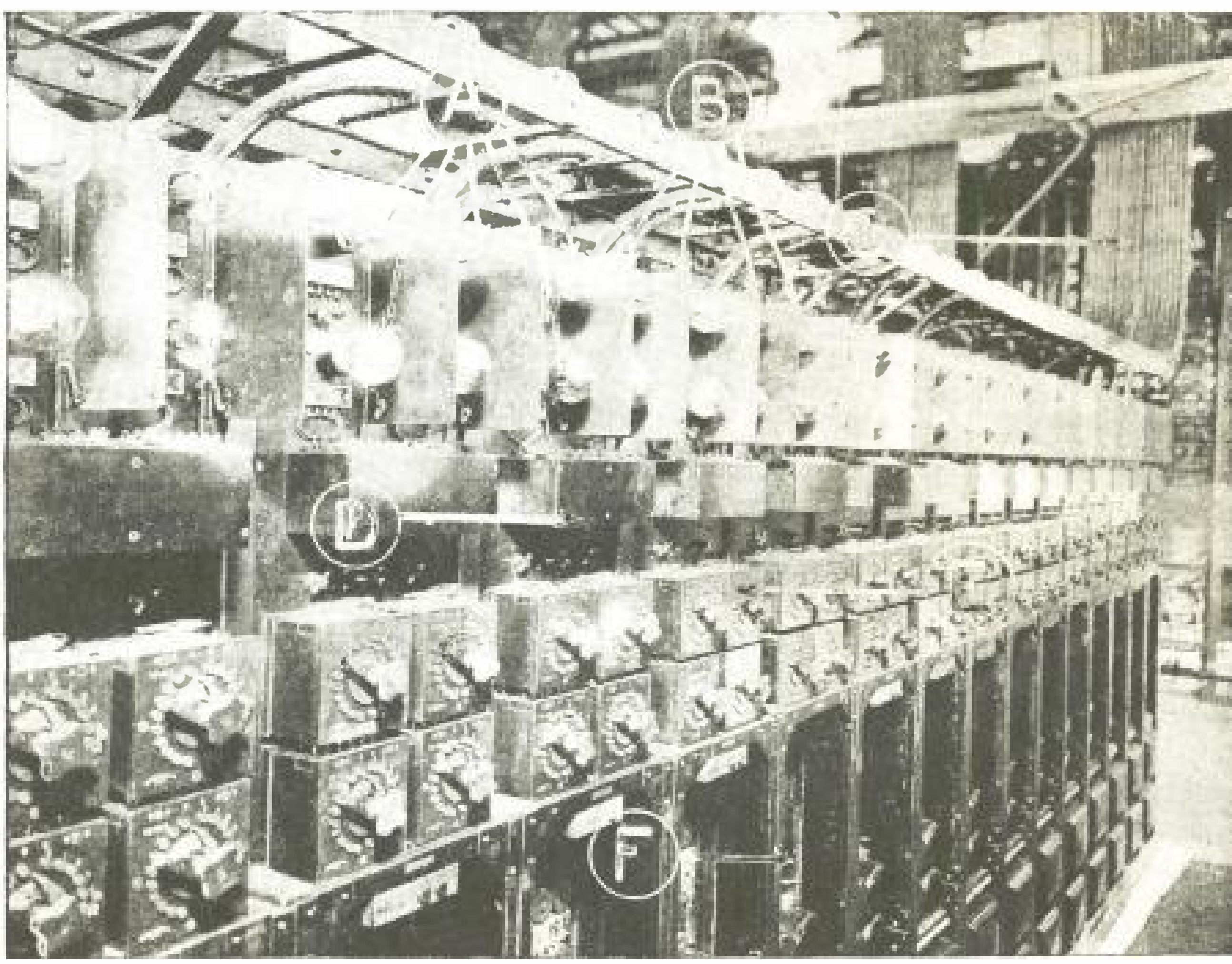
Then and there I determined to see if they would serve the purpose. I went to a cabinet and brought out the same lamps that I had used in my previous investigations. My assistant helped me to construct an oscillatory circuit with two Leyden jars, a wired wooden frame, and an induction coil. We then made another circuit, in which was inserted one of the lamps and a galvanometer, afterward tuning it to the same frequency as the first circuit.

It was about 5 o'clock in the evening when the apparatus was completed. I was, of course, most anxious to try the experiment without further loss of time. We set the two circuits some distance apart in the laboratory, and I started the oscillations in the primary circuit.

To my delight I saw that the needle of the galvanometer indicated a steady direct current passing through, and found that we had in this peculiar kind of electric lamp a solution of the problem of rectifying high frequency wireless currents. The missing link in wireless was found—and it was an electric lamp.

I saw at once that the metal plate should be replaced by a metal cylinder enclosing the whole filament, so as to collect all the electrons projected from it. I accordingly had many carbon filament lamps made with metal cylinders and used them for rectifying the high frequency currents of wireless telegraphy.

This instrument I named an *oscillation valve*. It was at once found to be of value in wireless telegraphy, the mirror galvanometer that I used being replaced by an ordinary telephone, a replacement that could be made with advantage in those days when the spark system of wireless telegraphy was employed. In this form my valve was somewhat extensively used by Marconi's Telegraph Company as a detector of wireless waves. I applied for a patent in Great Britain on November 16, 1904.



A RELAY STATION WHERE TELEPHONE SIGNALS ARE AMPLIFIED

Without these vacuum tubes, A, long-distance telephony would be impossible. B shows the metal shields that prevent interference; C the incoming telephone lines; D the grid batteries; E the amplification controls and F the filter circuits.

In 1907 De Forest added the grid, consisting of a zigzag wire placed between the filament and the plate. Thus was born into the world the valuable thermionic valve, consisting of an incandescent filament enclosed in a highly exhausted glass bulb, the filament being surrounded by a metal cylinder, with a wire grid or cylinder of metal gauze placed between the cylinder and the filament.

It may be truly said that a little thing like a burned-out lamp led up in the course of years, and after countless experiments by many scientists, to the modern miracle of wireless telephony.

Since the date of my experiments in 1904 a countless multitude of eminent scientists have turned their attention to the study of the thermionic valve. In its three-electrode form, that is, with the spiral wire grid in addition to my metal cylinder, it has given us the solution of a long-considered problem—that of making a perfect telephone relay. It has enabled us to transmit speech by ordinary wires thousands of miles overland, as well as making possible the achievement of wireless telephony. It has become the master weapon of the telephonic engineer.

We are even now not nearly at the end of the services it may render to electrical science and to mankind.

A Novel Receiver

WITHOUT BATTERIES

The elimination of batteries from receiving sets has long been the subject of experiment. There have been some sets developed that use a step down transformer for lighting the filaments. but they have been unsatisfactory. Here is a set that uses 60-cycle house-lighting current for both the filaments and the plates of the vacuum tubes. It is interesting to note that the crystal detector has been reverted to in this development.

By LAURENCE M COCKADAY, R. E.

A RADIO receiving set in which the usual batteries are eliminated and connection is made instead to the ordinary lamp socket is now considered practical by the Bureau of Standards of the Department of Commerce.

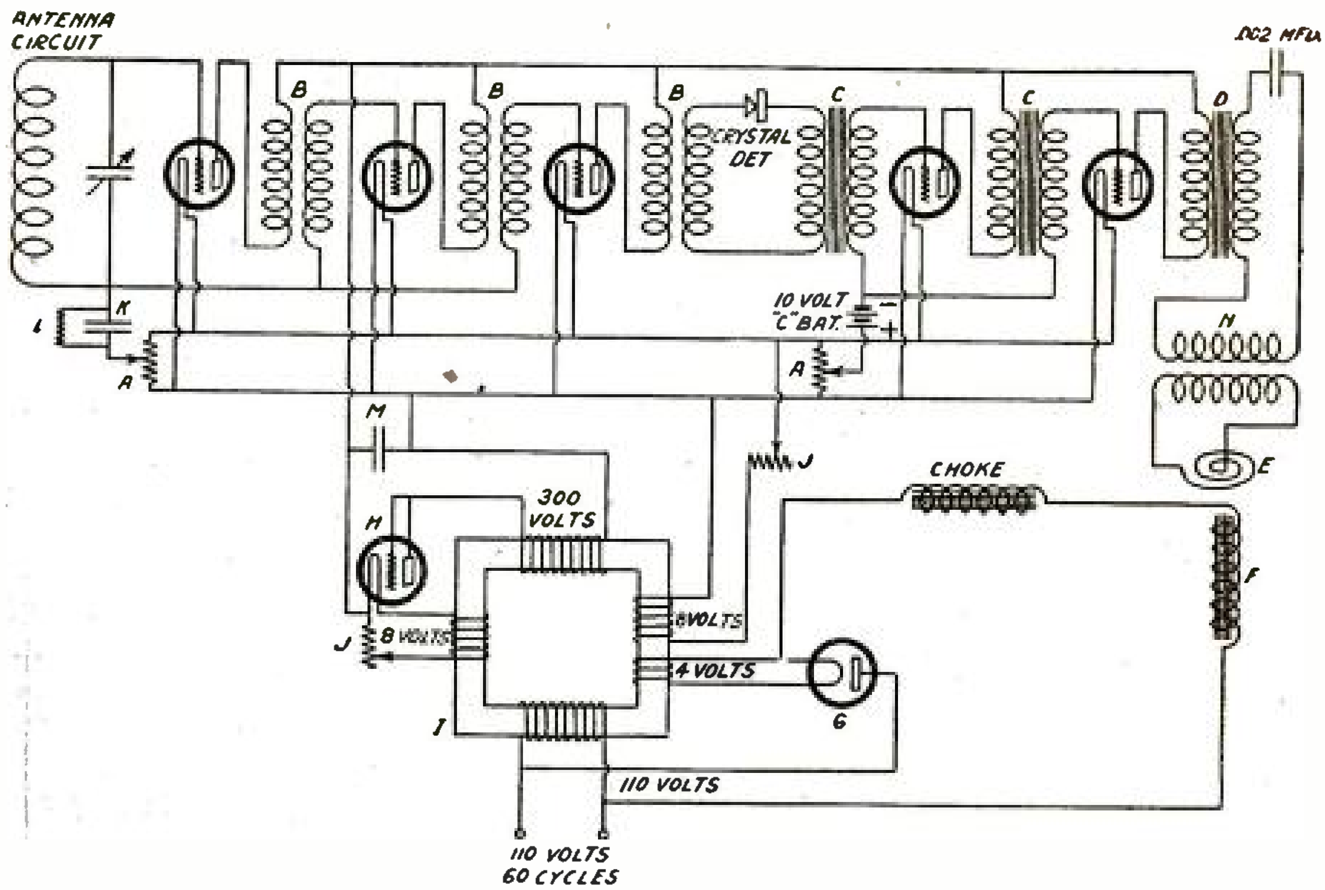
The apparatus is a simple tuner. It may be used with any type of antenna. It eliminates the storage battery which is ordinarily required to light the filaments of the vacuum tubes and which is bulky and heavy and dangerous about the house because of the acid it contains.

In this amplifier both the filament storage battery and the dry battery used in the plate circuit are replaced by a special transformer and an electron-tube rectifier and accessories, the aggregate bulk and weight of which is less than that of the batteries. It uses a small 10-volt dry battery in the grid circuit which is required to deliver only a very small current and should have a life of at least several months.

In order to reduce the hum of the alternating current, there are more adjustments to make than in the ordinary amplifier supplied from batteries.

Of the parts in this amplifier that replace the storage battery in the ordinary amplifier, the special transformer is the only one the cost of which would approach the cost of a storage battery. The cost of the transformer would probably be mainly the labor of assembling it.

This amplifier has three radio frequency stages and two audio frequency stages, and uses a crystal detector. The 60-cycle current when used in an ordinary amplifier circuit introduces a strong 60-cycle note in the telephone



THE·CIRCUIT DIAGRAM FOR THE RECEIVER

The antenna circuit consists of a loop shunted by a variable condenser, and the other parts are designated as follows: A, potentiometers; B, radio frequency amplifying transformers; C, audio frequency amplifying transformers; D, step down transformer; E, moving coil of the loudspeaker; F, field coil of the loudspeaker; G, rectifying vacuum tube; H, vacuum tube used as a high voltage rectifier; I, special 5-winding transformer; J, filament rheostats; K, condenser; L, grid leak; M, large capacity condenser; N, telephone condenser.

receivers and makes reception impossible. This has been practically eliminated by the balancing resistances, grid condensers and special grid leaks of comparatively low resistance, telephone transformer in the output circuit and use of crystal detector instead of electron tube detector.

In the final form of the amplifier, there is only a slight residual hum. The amplification obtained is as good as that obtained with the same amplifier, using direct current. The complete outfit including the loop is compact and portable.

The amplifier as constructed operates most satisfactorily for wavelengths from 200 to 750 meters. This range was determined by the working range of the radio frequency transformers used. By using suitable radio frequency transformers, this range can be extended to receive any radio waves. The circuit diagram of the outfit, including the means of supplying current to a loudspeaking telephone receiver, is given in the accompanying diagram.

A New Method of Tuning on a Super-Sensitive Receiver

Radio amateurs who have constructed the remarkable long-distance set developed by Laurence M. Cockaday and described in detail in the article "How to Build a Real DX Regenerative Receiver" published in POPULAR RADIO for January, 1923, will be glad to learn that Mr. Cockaday has developed a still more efficient apparatus that will be exclusively announced and described—after the present series of tests are completed—in this magazine.

From a photograph made for POPULAR RADIO

A RECEIVING SET THAT USES ELECTRIC LIGHT WIRES AS AN ANTENNA

Merely by screwing the plug into the socket of an electric lamp you may now listen in on broadcast programs. This apparatus is designed to operate by means of wired wireless—or "line radio," as it is more familiarly known.

WHAT REALLY GUIDES RADIO WAVES?

"The Heaviside Layer" answers Sir Oliver Lodge. "The earth" answers Dr. Elihu Thomson. In this article the Chief Signal Officer of the Army summarizes the controversy and points out the bearing that line radio has upon this live problem

BY MAJOR GENERAL GEORGE O. SQUIER, U. S. A.

IN the recent controversy regarding the Heaviside layer,* no note has been taken of the recent results achieved by "wired wireless," which in my opinion has an important and striking bearing on the interesting question now in discussion.

In "wired wireless" or "line radio" we are dealing with electric wave propagation just as we are in space radio. But surely in "wired wireless" there is no question of a Heaviside layer, since the electric lines of force terminate on the wire conductors when a metallic return

*See "Is the Heaviside Layer Valid?" by Dr. Elihu Thomson in POPULAR RADIO for December, 1922, and "What Bends Radio Waves" by Sir Oliver Lodge in January, 1923, in which each of these scientists explains his conception of the solution of this problem.

is used, or on the conductor and the earth when an earth return is used. In either case the conductors, or the conductor and ground, serve as the guides for the electric waves by directing them in their travel.

When electrical impulses travel along a wire, they stick close to it, gliding along it or through it and turning corners when it turns. Is it not logical to think of radio waves as using the earth like a wire and gliding over it? The principal difference is that the wire is essentially a line, one dimensional, while the earth can be considered in this case as a surface, two dimensional. The wire guides the impulses directly to their destination with little loss. while the space radio impulses spread over the surface of the earth in the same way that the waves created by the drop of a pebble spread over the surface of a pond.

The way in which the electric waves are propagated in the two kinds of wireless is strikingly similar. In the case of space radio the surface of the earth acts as the guide of the impulses, whereas in "wired wireless," a special kind of earth, in the form of a copper wire, acts as the guide. If the two antennas, used for sending and receiving a space radio message, were connected by a wire, the line radio condition is obtained and the transfer of the impulses between the two points becomes simpler.

That is essentially what was done when I invented wired wireless or line radio in 1910. The radio waves glided along a wire instead of the earth. It was demonstrated that many simultaneous messages could be sent over a wire just as they could be made to glide over the surface of the earth.

When five telephone and twenty telegraphic messages can be successfully carried commercially on one long-distance toll line by using line radio or wired wireless, which is essentially a gliding wave phenomena, what is the necessity of inventing a hypothetical layer, sixty miles or so up in the air, that reflects the waves successively and sends them zigzagly on their way around the earth? It seems to me that the gliding wave

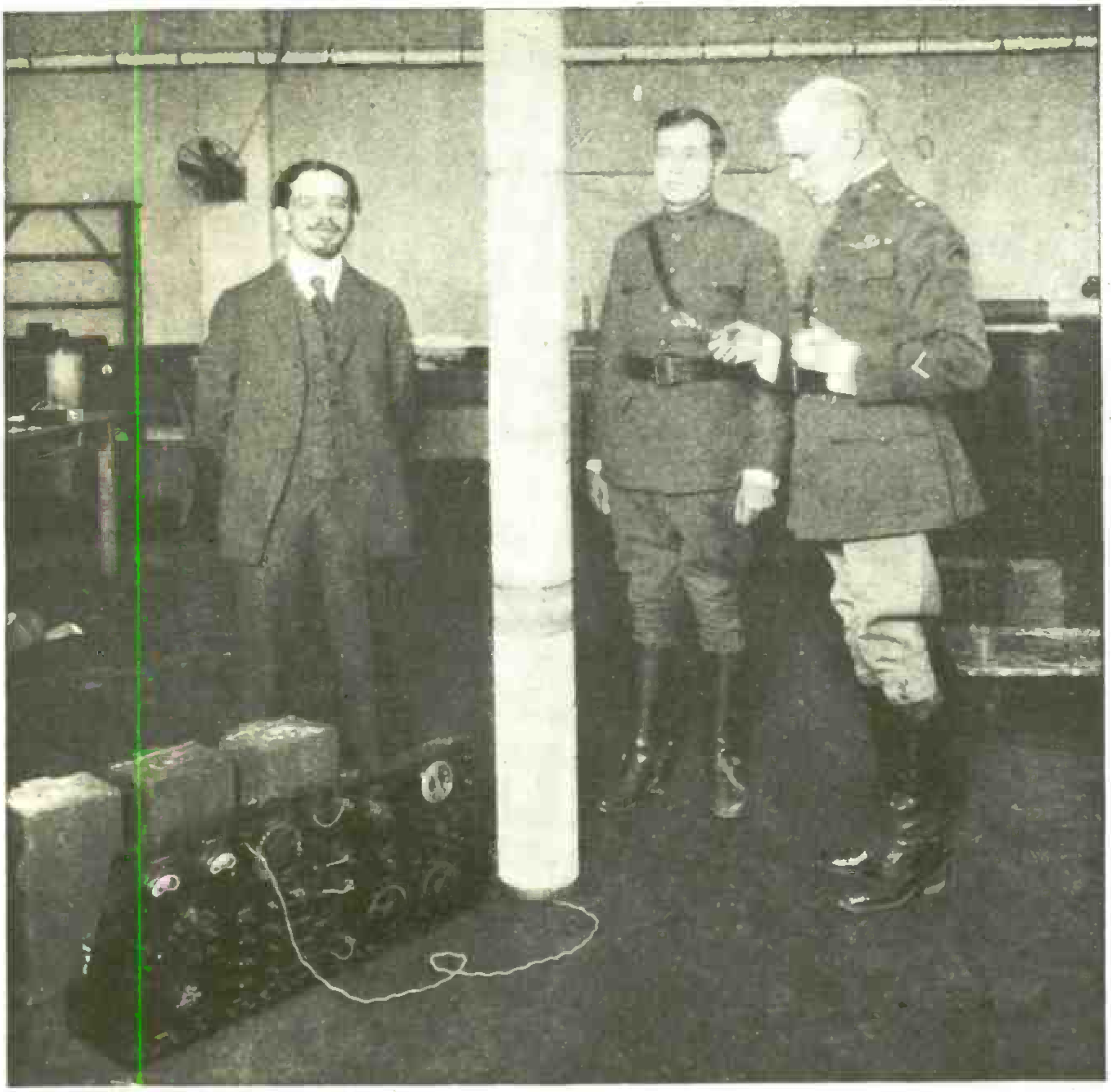
Reprinted from the November POPULAR RADIO

DIAGRAM OF THE HEAVISIDE LAYER THEORY

According to most scientists, radio waves are reflected from and transmitted around the earth by a layer of ionized gas that is suspended about sixty miles high in the atmosphere of the earth. Sir Oliver Lodge is the foremost exponent of this theory.

DIAGRAM OF THE GUIDING WAVE THEORY

On the other hand, a number of eminent scientists (of which Dr. Elihu Thomson is one) maintain that radio waves are attached to and glide over the earth, following its contour in much the same way as do the radio waves in line radio.



U. S. Signal Corps

THE "BIG THREE" IN ARMY RADIO CIRCLES

The civilian at the left is Dr. Louis Cohen, the mathematical expert of the U. S. Signal Corps; in the center is Capt. Guy Hill, inventor and radio expert. At the right is Major General George O. Squier, Chief Signal Officer of the Army and the discoverer and foremost exponent of line radio.

theory is much simpler and more logical.

But I fear that the theory bearing his name has been unjustly attributed to Oliver Heaviside, the great physicist and electrician. In looking through his works, I have been able to discover but one suggestion of an upper layer and this is probably the basis for giving his name to the idea. But I do find that he explains wired wireless with uncanny clearness and that he holds strongly to the gliding theory of radio transmission that wired wireless so clearly proves. Let me quote Heaviside himself. In the Tenth Edition of the Encyclopedia Britannica, issued 1902, Vol. 33, pages 214-215 and reprinted in Electromagnetic Theory, Vol. 3, pages 334-335, we find an article by Heaviside on "Telegraphy." The following is an excerpt from it:

> Comparing the case of the cylindrical wires with the so-called "wireless" case, though there is little difference in theory, there is great difference in practice. Using wires, we can send radiation anywhere we like in small quantities without loss. One wire and earth is enough, but two parallel

wires are preferable, to avoid certain interferences. Were it not for the resistance of the wires, and a litle disturbance and loss in turning corners (for the wires need not be straight), telegraphy with wires would be perfect, by any path to any distance. But in "wireless telegraphy," though no expensive connecting wires are required, which gives a remarkable freedom in certain ways, there is enormous loss, and enormous power is required to send workable signals across the Atlantic, since they are being sent simultaneously everywhere. But for this loss by expansion and by resistance, and possible unsettled interferences, there is no reason to limit the distance. The course of a wave round the earth can be easily followed graphically.

When a wave sent along wires comes to a sharp bend in the circuit, a new wave is generated at the bend. This, combined with the old wave. forms the wave after passing the bend. There is a rapid accommodation of the wave round the wire to the new direction. But if the bending is continuous, instead of abrupt, the accommodation goes on continuously also. The reason is that the electrification cannot leave the wires, so the wave in close proximity must accommodate itself to them. A part of the wave, however, really does go off into space with some loss of energy at a sharp corner by its own natural tendency to keep going, but the wire serves to guide the disturbance round the corner as a whole, by holding on to the tubes of displacement by their ends. This guidance is obviously a most important property of wires.

There is something similar in "wireless" telegraphy. Sea water, though transparent to light, has quite enough conductivity to make it behave as a conductor for Hertzian waves, and the same is true in a more imperfect manner of the earth. Hence the waves accommodate themselves to the surface of the sea in the same way as waves follow wires. The irregularities make confusion, no doubt, but the main waves are pulled round by the curvature of the earth, and do not jump off. There is another consideration. There may possibly be a sufficiently conducting layer in the upper air. If so, the waves will, so to speak. catch on to it more or less. Then the guidance will be by the sea on one side and the upper layer on the other. But obstructions, on land especially, may not be conducting enough to make waves go round them fairly. The waves will go partly through them."

You will note that even the suggestive afterthought in the last paragraph does not involve the idea of reflection of the waves that is included in recent discussions of the so-called Heaviside layer. It is merely the idea of the earth being one conducting medium and the upper layer being another.

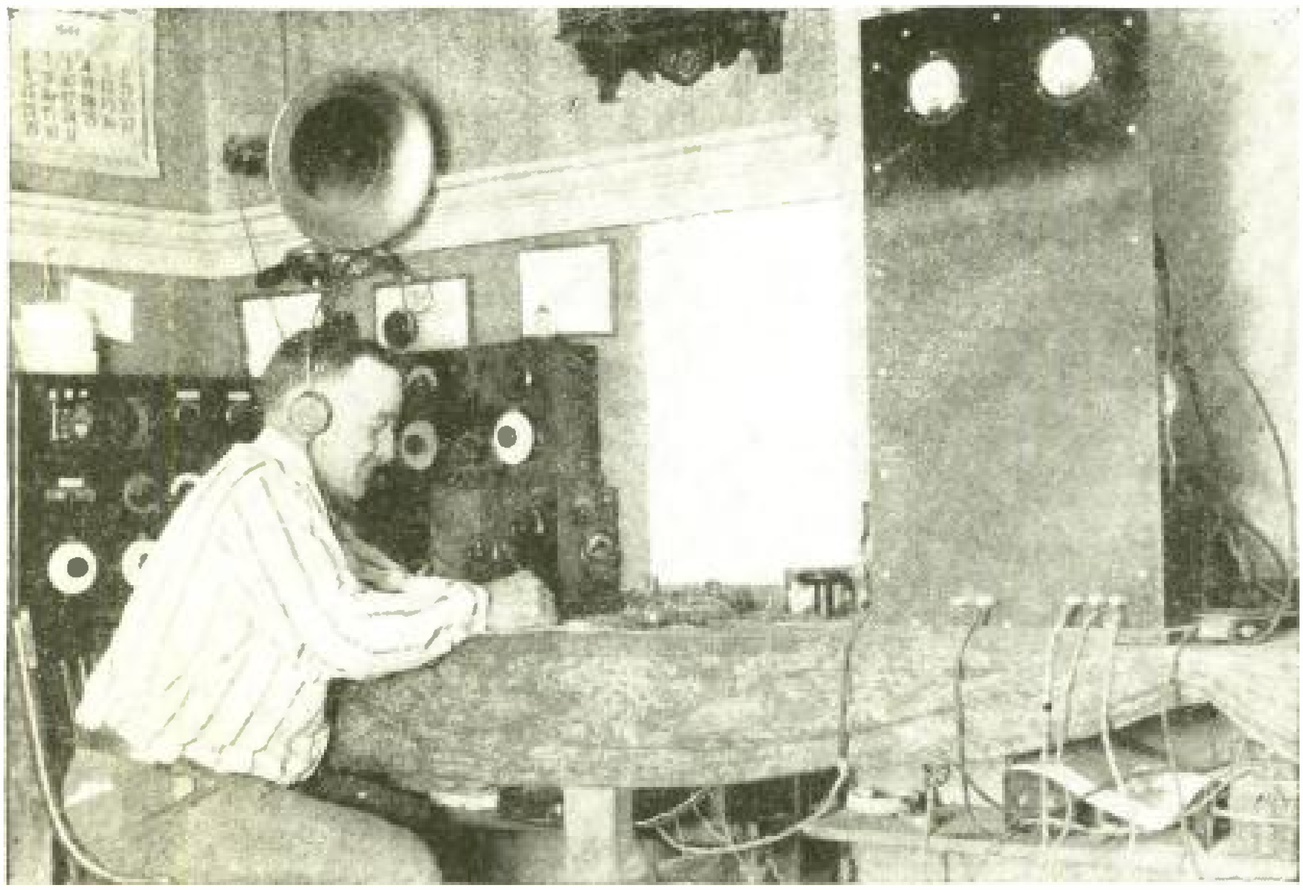
The influence of daylight on radio transmission, which has been one of the main arguments in support of the Heaviside layer theory, it seems to me, is just what one would expect on the gliding wave theory. On the gliding wave theory the conductivity of the surface of the earth is a prime factor, and it is conceivable that this conductivity is profoundly affected by the influence of sunlight, so that this argument, it seems to me, is equally applicable to the two theories.

I may add here that it is believed that many of the outstanding difficulties which are met with in space radio will become more and more understood as we further investigate "line radio."

Radio will advance through the door of wired wireless. Radio over wires is simply a special kind of radio, but it is becoming the laboratory method through which ideas are tried out before they are allowed to clutter up space.

Wireless, guided by wires, immediately and completely eliminates the discouragements of the radio enthusiast—fading, day effects and static. It reduces radio to the reliability of the best D. C. wire circuit. Experiments may thus be conducted day and night, under ideal conditions, without bothering anyone else. I confidently expect that the future advances in radio will be first worked out on wires and not in space. Already radio has benefited greatly by the filters which were originally developed for line radio telephone work. The logical order of progress is from the simpler "conducting wires" to the more complex radiating systems of space radio.

¶ *A new series of articles by one of the foremost authorities on radio phenomena,* Prof. J. H. Morecroft, *of Columbia University, will start in the next number of* Popular Radio.



From a photograph made for POPULAR RADIO

A TYPICAL AMATEUR OF THE INNER CIRCLE KNOWN AS "THE GANG"

The fact that H. L. Gooding, owner and operator of station 6ZZ, happens to live out in Douglas, Arizona, does not mean that he is isolated. For he belongs to that group of about 300 amateurs who communicate with each other nightly from coast to coast as casually as some of us converse with friends at our clubs.

The Radio Amateur

As I Have Found Him

His peculiarities of temperament, method and character as understood (and shared) by the one man in the world who has the most intimate knowledge of him—

HIRAM PERCY MAXIM

IN the year 1906, there lived in a little town in the Mississippi Valley a certain lad, who was at that time twelve years of age. Had you known him, you would have noticed nothing that marked him from other boys. Possibly he may have been a shade more thoughtful, or more interested in scientific things.

One day his eye fell upon an item in the newspaper which he delivered every afternoon. The item described the latest effort of Guglielmo Marconi in wireless telegraphy. This lad was tremendously interested. He read the article again, more slowly. It gave him the most intense pleasure and thrill to imagine all the things that lay between the lines. He read it again, and then again, and it caused him to be late upon his route, the first time in his life.

When he reached his home that afternoon he had searched out a copy of the paper which he could keep for himself. He cut out the item about Marconi and his wireless, and after giving it a final reading he carefully secreted it with certain other precious belongings.

At frequent intervals thereafter this item was brought forth and carefully re-read. It became very dirty and frazzled, and small parts were missing. But they made no difference, for he knew it all by heart.

A great hunger grew within him to know more about wireless. He asked his father about Marconi and wireless telegraphy. The tired and hard-worked parent knew only the bare fact that a man named Marconi was working upon something which was called "wireless." The lad was disappointed. He had hoped that his father might have at least one new fact to give him to think and marvel over.

The lad asked his school teacher. He knew the postmaster, so he asked him. He asked his friend the policeman, and a locomotive engineer who lived next door; and scraped an acquaintance with the telegraph operator at the railroad station. It was all so disappointing. The sole bit of additional information was that "wireless was electrical."

One afternoon, before starting out with his papers, he screwed up his nerve to the necessary pitch to ask the stern-looking elderly lady in the Public Library. She had never heard of Marconi nor wireless, and viewed him with frank suspicion.

Then a wonderful day came. In an ash barrel he found an old copy of *The Scientific American.* His eyes almost

From a photograph made for POPULAR RADIO

ONE OF THE OLD-TIME "SPARK HOUNDS"

Not only did Carl E. Trube of Yonkers, New York, design his own station 2BK, but he built it himself. He is one of the few expert amateurs who uses the spark transmitter instead of the C. W., and his "stonecrusher" became known throughout the land.

popped out of his head, when, looking through the pages, he found an illustrated article on a recently built Marconi station. He retreated with his prize to a quiet spot, and there he read and reread the article, and all but burned out his strong young eyes trying to pull out of the blurred illustration the obscure detail. The article was finally cut out and carefully put away. Every night for weeks, before he climbed into bed, he brought out the dirty bit of paper and read it over again.

This lad was a real wireless amateur, running true to form.

This boy had no notion, even the most remote, what "wireless telegraphy" was. But he was overwhelmingly impressed by it. He had no idea in the world that he was an amateur in the making. Nor had he the remotest thought that there might be others just like him, thirsting for information on the same subject. That there were hundreds of others, young and old, who regarded wireless from exactly the same slant as he regarded it, never crossed his mind. All he knew was that here was the "biggest darned idea for having fun that ever came down the pike."

The lad I am telling of is truly typical of the amateur. I know hundreds of him. I have seen dozens of him grow up from boyhood.

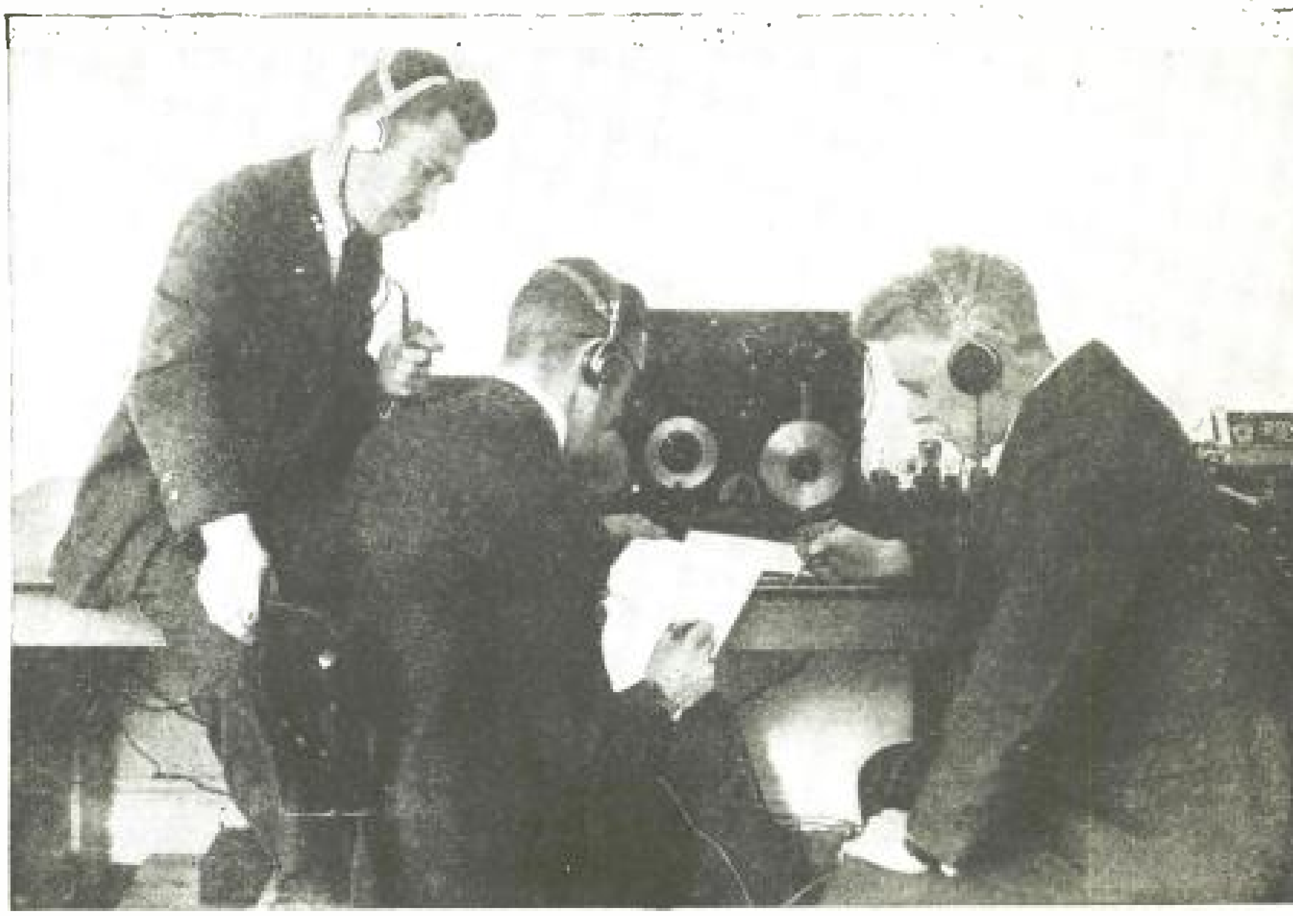
Now for a few words about the general characteristics of this wonderful genus which this lad typifies. He is almost always the son of parents of modest means; almost never is he the son of well-to-do parents. Just why this rule should follow so closely I leave for others to explain. But I can say this: that of all the young fellows whom I have seen take up radio and do something in it, I can recall hardly a single one who has stuck, who has been the son of well-to-do parents. If there is a single one, I hope he will send in his name. I would like to know him.

But let us go back to our story.

Every scrap of information regarding wireless was seized upon and treasured. In the course of events he came to have a fair idea of what a wireless station must look like. But he had never seen one. He dreamed of some day getting hold of enough information to build himself a little amateur station, when he would be able to listen to all the wonderful things that were passing through the air.

Then a great event happened. One day while walking down one of the streets of his little city, what should he see above the top of one of the buildings but an antenna! He could scarcely believe his eyes. A wireless station right here in his own town! There were the wires just as they looked in the pictures. There was, of course, nothing else to do but to trace the lead-in wire down and find where the station was. He could not follow it, but it seemed to enter a saloon. Into the saloon he braved his way. He would have gone through hell-fire and brimstone. The bartender thought he was crazy, as he never had heard of "wireless" and thought the boy was out of his head. The boy saw he was wrong, so he withdrew and searched around behind the saloon. In a tinker's shop he finally located the lead-in wire. It was a place overrun with dust and dirt and old sewing machines, lawn-mowers, and general cast-off household equipment. The proprietor was a well-known character in the town, who was not given credit for being over-bright. The lad asked him if he had a wireless station, and the tinker replied that he had, and pointed to a cleared off space on a bench. Here was mounted a queer assortment of coils and switches, and the telephone receiver from the regular telephone. The tinker person had thought to make use of the regular telephone, and thus save purchasing one especially for the wireless station. A bit of wood held down the hook. When the telephone rang, it was the practice to disconnect the receiver from the wireless station, reconnect it to the regular telephone and answer the call.

The lad glowed as he regarded his first



International

"OLD TIMERS" WHO EMBODY THE SPIRIT OF THE RADIO AMATEUR

No American amateur—and few foreign amateurs, for that matter—needs to be told about Hiram Percy Maxim (at the right), one of the most ardent and most popular of fans and the guiding star of the American Radio Relay League, which is of such inestimable value to the amateur. At his left is Kenneth B. Warner, the secretary of the League, and F. H. Schnell, the traffic manager, who had charge of the recent transatlantic tests.

wireless station. He asked how it worked, and the tinker told him it worked fine, but you couldn't hear anything in it. That seemed strange to the young fellow. Here was a wireless station, yet no wireless messages were coming in on it. He asked questions and it ended by the tinker inviting the boy to try his hand at working the station. In telling me about it, the young fellow said the outfit consisted of a round stick of wood on which had been wound for about a foot, some hundred or so turns of bare copper wire. A slider was arranged to pass over and make contact with these coils and another slider provided the tuning for the telephone circuit. In other words, it was a distinctly home-made, two-slide tuner, such as we used to use in the early days. A bit of galena ore served as a detector; the lump of galena was seated in a wad of tinfoil from a package of chewing tobacco. The antenna consisted of hay-wire, twisted together to make sufficient length to connect between a chimney and a pole fastened to the gable end of the building. The hay-wire was of iron, as is customary with hay-wire.

The lad worked and worked over the little station, while the tinker attended to his daily business. It was vacation time, and so the entire day could be devoted to the job in hand. In telling of it in later years, the boy, now grown up, said that he tried everything that the human brain could think of, but not one single sound could be brought from the outfit. He worked all day long, and when he went home at night it was to study and think and wonder what the trouble might be. Just like every other amateur, he could think of nothing else. It was the one great problem of the hour, that of making this station bring in wireless signals.

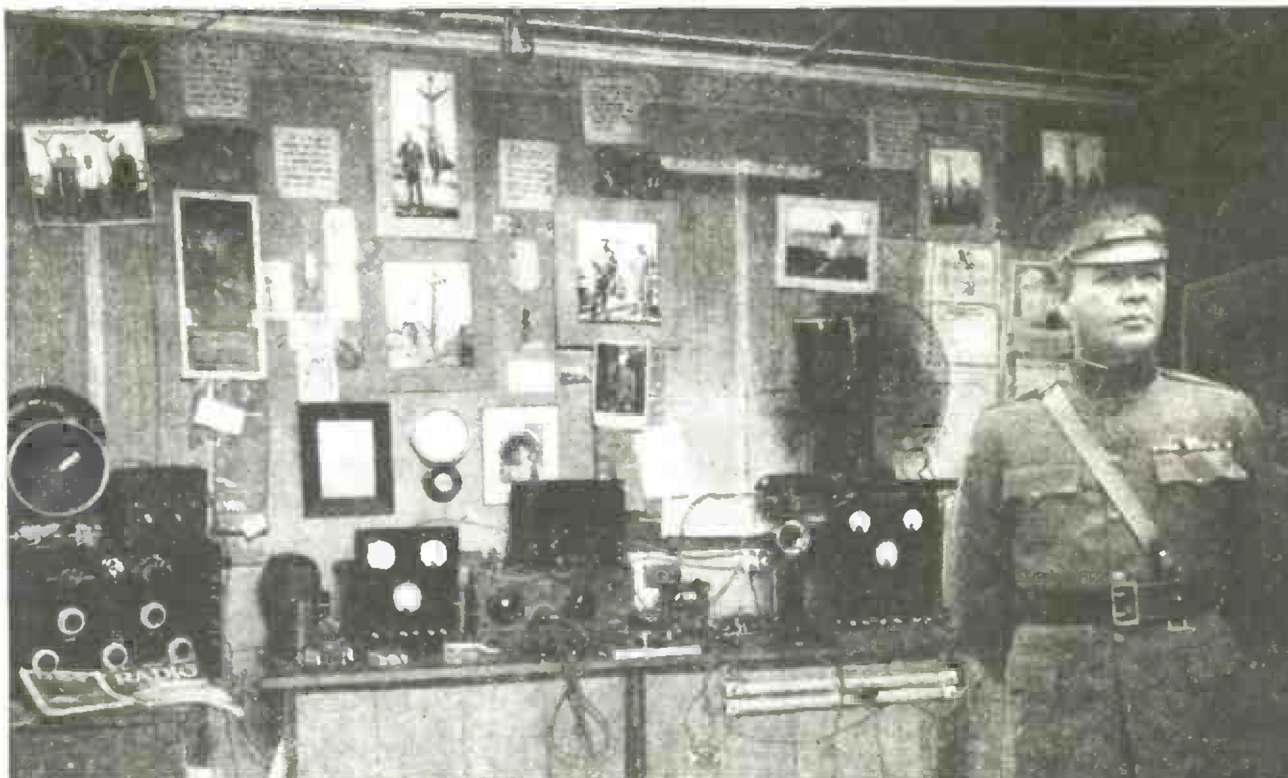
The next day he tried again. After another long session, he said that he resolved to disobey the injunctions of the tinker, which were to leave the piece of galena as it was. He resolved to turn it over and try the other side, in the hope of finding a sensitive spot. While the tinker was away he did this. But the results were the same. The galena was reversed again, and placed in its original position before the tinker returned. The second day was unproductive, and the lad went home thoughtful, but not discouraged. He wondered as he lay in his bed what might be the cause of the failure. Mind you, he was wondering what might be the reason for the non-reception of signals, with iron wire twisted together for an antenna and with a two-slide tuner, a piece of totally unknown galena, and a house telephone receiver, possibly of 100 ohms resistance. We now use 3,000 ohm receivers and carefully soldered copper wire antennae, and very sensitive vacuum tubes with amplifiers.

The lad made up his mind that the haywire was not strictly what a wireless station would use, and that it must be the cause of the trouble. In the morning he broached the subject of copper wire, but found that the cost was a serious matter. But a way was found, just as a way is always found, to finance the copper wire. It was put up, and it certainly looked better and as though it might work. Late in the afternoon all was ready and signals were listened for. But there was nothing. The silence of the grave still persisted. The lad again lay awake that night and thought. He then concluded that it was probably not conventional practice in regular wireless stations to use the house telephone as the receiver. It would be probably better to use regular wireless receivers. He broached this to the tinker in the morning, and again the matter of finances obstructed the path of science. The advertisement in a little magazine of electrical novelties told of a pair of wireless receivers, "Regular Navy Type," which could be obtained for $5.00. This was a huge sum of money and serious thought must be taken before such an investment could be entered upon. But again the project was successfully financed by dint of much promising and of far-advanced future commitments. The phones were ordered. It was a terrible ordeal waiting their arrival. Finally the great day came when the parcel post brought them, and the lad told me that seldom in his life has he beheld such a lovely sight as the spectacle of those bright and shining telephone receivers, with their nickel-plated head-band, lying in their little box.

The test with the new phones was made at once, and great excitement prevailed. But sad to relate, the results were precisely what they had been—dead silence.

The next day he returned to the task, with serious thoughts. He had nothing special to try. He simply returned to the job. He turned his galena over for the hundredth time, and behold—the dots and dashes were in the phones! He had never heard any before, but he recognized them at once. There the precious and wonderful things were, tearing along altogether too fast for him to do more than pick out an "O" and an "M" once in a while. He was transfixed. He dared not move for fear they would stop. He listened for a minute or so, and then deciding the tinker must also hear, he roared for him to come. As the older man hurried over to grasp the phones, the signals stopped. (They always do.) An hour was spent in trying to get them again, but to no avail. The tinker doubted if the boy had really heard them. They were gone and could not be brought back.

The boy continued upon his self-appointed task, and he told me that it was days before he again succeeded in getting a sound out of the phones. But the signals were finally brought in, just as every amateur finally brings them in, and it was



From a photograph made for POPULAR RADIO

THE MOST FAMOUS AMATEUR STATION ON THE COAST

Here is the picturesque interior of the radio shack on Catalina Island, which has worked nearly every section of the country. And here, too, is the equally picturesque operator of 6XAD, in private life Lawrence Mott, soldier, game warden, editor and radio fan.

possible nearly always to hear something going on. What he finally did to overcome his trouble, he says he does not know to this day.

Then another great day came. He never had given a thought to the possibility that there might be others just like himself who were trying to get wireless signals. And so when a strange, rasping, scratchy signal, sent so very slowly that even he could read it, came in, the great thought came to him that it might be another amateur, farther advanced than he, who had built himself a transmitting station as well as a receiving station. The thought was staggering. Yet it must be. Who else but an amateur like myself would be stumbling through the code in this manner? And so he came to wonder as to the building of a transmitter.

Finally, and after fully as long and hard an ordeal as with the receiver, he developed a transmitter which from his house, a distance of a half mile, the tinker could distinctly hear at his shop. The tinker had also built himself one, and an exchange of messages began. It was the most thrilling thing he had ever experienced in his life. He was actually possessed of a wireless telegraph station all his own. It was hard to believe that such a day had actually come. He was at the height of his enjoyment over his possession, and the glory that accompanies mastering a big problem, when one night he heard his self-selected call letters faintly, coming from some station other than that of his friend, the tinker. His heart stopped beating. It was the stranger of the air whom he had heard before. And here he was calling him! How had he learned his call letters? He must have heard them as he signed off when working with the tinker. Could it possibly be that his own signals had reached out and were being heard by somebody a long-way off? Where could the stranger be?

It was breath taking, this hearing his own call coming in faintly, sent by some unknown of the air.

He listened carefully for the stranger's sign-in. He caught it, for it was sent very slowly. He trembled so with excitement when he answered that he could scarcely send. He managed to stumble through the call and the signature, however, and to his profound satisfaction, the stranger came back. He had reached him!

The stranger asked him who and where he was. He told his own name and gave the town where he was located. To the astonishment of my young friend, it was one of the nearby towns, distant some ten miles. The desired information was returned, and each of these young fellows probably enjoyed one of the greatest thrills that will ever come to them in all their lives. They of course looked each other up and a friendship began which will last as long as they live.

My lad grew up and of course took up radio as his life work. He is still an amateur, and if he lives to be eighty he will continue to be one.

In the latter part of 1913 steps were taken to organize the amateurs all over the country into a relay association. It was named very aptly The American Radio Relay League. The writer was one of those who lent a hand in putting it together. It had become a well developed idea by the end of 1914. In 1915 it was a truly national organization, with representatives from all parts of the country and with a creditable relay system in working order. Messages were

From a photograph made for POPULAR RADIO

THIS AMATEUR STATION, 5ZA, HAS BEEN HEARD IN 38 STATES

Out in the wilds of New Mexico Louis Falconi has worked his C. W. transmitter with such persistency and ability that he has become known to "the gang" of real amateurs throughout the whole country.

From a photograph made for POPULAR RADIO

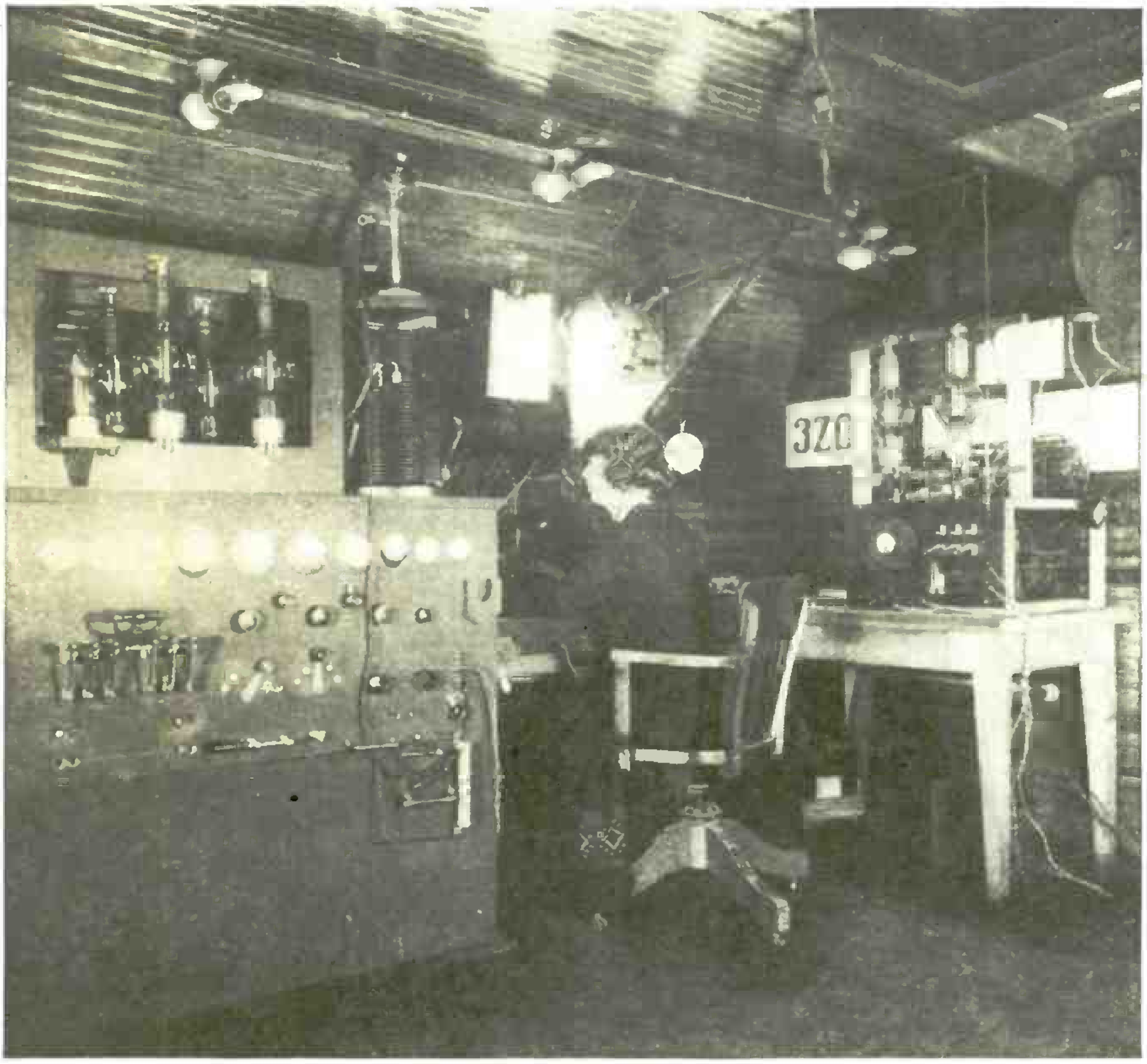
AN AMATEUR WHO BEARS THE TITLE OF "HIGH SPEED KING"

From down in Savannah, Georgia, F. A. Hill (owner and operator of Station 4GL) has been puncturing the ether with the fastest signals ever transmitted by an amateur. He has been known to reel off twenty relay messages without even a pause.

handed on from one station to another, and a fairly large area of the country could be reached. All the snap and vigor of youth was put into the thing, and prodigious effort was made to secure co-operation, better equipment and good operating. By 1916 these young men had become so welded together in a bond of fellowship that they began the publication of their own magazine. They named it *QST*, the international abbreviation for "Attention—All Stations."

In the year 1917 we became involved in the World War. Straightway there came an absolute necessity for hundreds of radio operators. Not only was there a terrible shortage of trained men, but the machinery for training more had not been developed. So one morning the telephone rang in the writer's office, and when it was answered there was a voice which asked if the president of the American Radio Relay League would take the next train for New York and attend an important meeting in connection with radio communication matters. The writer promised. Within the hour he was on his way. Arrived in New York, I found that officers of the Navy desired the assistance of the amateurs. Experienced radio operators must be procured immediately; would the amateurs enlist?

It was a terribly serious situation that faced our country. Operators were required at once, and it would require months to train green men. I gave my word that I would use all the influence I possessed to induce our membership to enlist with the least possible delay. I believed I knew the amateurs, and I did not think they would be found wanting when they realized that their Uncle Sam needed them. I was right. In a few days the League's magazine was sent out with a patriotic appeal to every amateur who



ONE OF THE MOST POWERFUL AMATEUR STATIONS IN SERVICE

Radio fans of the east know station 3ZO and 3XW of Chester, Pennsylvania, owned by the famous Chester Radio Association. Some conception of its equipment may be obtained from this view of its shack. (The woman OP is Miss Bertha Hilton, one of the expert amateurs.) The antenna of this station is shown on page 208 of this issue.

could handle a radio set and who was in good health, to communicate with the nearest recruiting office at once. There was no hesitation. In a few days amateurs began presenting themselves, and in a short time there gathered together hundreds of the best radio men the world ever saw. They were placed in the best positions, in all sorts of ranks from Lieutenant-Commander to enlisted man.

They saved the day for Uncle Sam.

After the war they rebuilt their American Radio Relay League, and put into it the executive and administrative lessons they had learned in the military service. It soon became a greater organization than before. The country was quickly covered with a network of relay lines, and a message traffic many times larger than had been dreamed of began. The handling of these amateur messages was done in the most approved manner. Examples of the most perfect operating that had ever been known could be heard every night in the 200-meter waveband.

Then it became desirable to demonstrate just how efficiently messages could be relayed across the continent, from the Atlantic to the Pacific. Messages were taken in Portland, Maine, addressed to

Portland, Orègon, and from Hartford to Los Angeles, and from New York to New Orleans, and from Chicago to Galveston. The amateurs of the country were asked to be quiet on the nights selected, but to listen in and lend a hand should any of them be required. One of the most thrilling experiences of my own life was listening to the flight of these messages across the continent and hearing them reappear over the western radio horizon as the answers sped back. Repeatedly were messages from my own station in Hartford exchanged with San Francisco and Los Angeles. The quickest was one to the latter city. From the instant the key started the first signal of the message to the time the answer was back and all written out on a telegraph blank was just six and one-half minutes. And this included the time the Los Angeles amateur took to compose his answer, and the Chicago and the Roswell (New Mexico) stations to relay it out and back.

That night the air was as quiet as if no radio stations existed except for those engaged in handling the messages. The organization of the tests and the cooperation of the amateurs of the country was 100 per cent. perfect. At the completion of the tests, when the necessity for quiet no longer existed, it was as though a great swarm of bees had been liberated.

When another year rolled around it was decided to try yet a greater test. An attempt was made to include European countries in the amateur world. Nothing less than transatlantic radio was undertaken. In order to make as certain of the reception on the other side as possible, the most expert reception specialist was selected, and sent to England with what apparatus he believed would be most certain to bring in amateur signals from America. Mr. Paul F. Godley was the amateur selected. After some experimenting he established himself in a field in the little town of Ardrossan, Scotland. When the eventful night for the tests came, the most abominable weather set in, and Mr. Godley and his British checker were obliged to sit all the night through in a wet and cold tent, with the wind howling and everything soaking wet. But he was an American amateur, and notwithstanding the most intense discomfort and actual suffering he actually copied and the checker checked the reception of no less than twenty-six American amateur stations. Some sent actual messages, which were received correctly and completely.

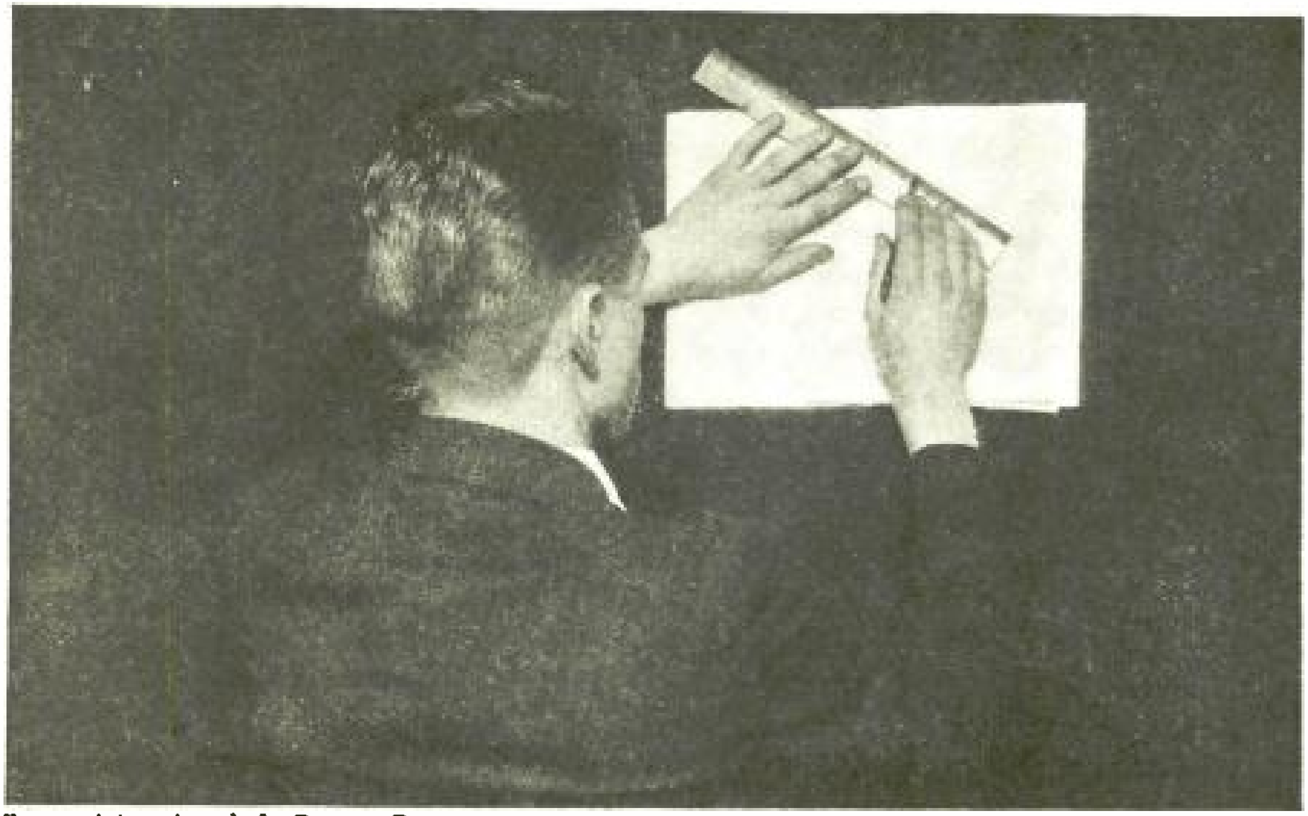
It awakened the British amateurs, as well as the French and the Dutch. The effect was to open transatlantic amateur communication, for English amateurs quickly equipped themselves to receive their American cousins, and the French Government liberated their own amateurs and gave them permission to transmit—a thing which was absolutely prohibited up to this time.

At the present time amateur traffic is moving one way across the Atlantic. Bunches of six messages are transmitted at a time, and the English or French stations receipt for them by cable. It is only a short time before the Europeans will be able to work back to America, and then regular citizen message traffic will move across the Atlantic as it moves across the American continent.

Certainly will this be a far cry from the days when our typical young amateur in the obscure little Mississippi Valley town was struggling to receive signals with a house telephone and some hay-wire on the roof!

How the Transatlantic Tests Were Conducted

The inside story—told by F. H. Schnell, the able traffic manager of the American Radio Relay League—of how 316 Yankee amateurs transmitted signals to Europe will be told in a coming issue of POPULAR RADIO.



From a photograph made for POPULAR RADIO

Lay your ruler across the alignment chart, as described in this article—and read off at a glance the answer to your problems in calculations.

MEASUREMENT CHARTS

FOR DETERMINING THE DIMENSIONS OF YOUR COIL

ARTICLE NO. 2

The inventor of the famous "radio slide rule" is the author of this series of short articles and the originator of the accompanying charts, which are designed not only to save a vast amount of time in the calculations incident to the design of radio apparatus. but also to insure absolute accuracy. These charts appear exclusively in POPULAR RADIO.

By RAOUL J. HOFFMAN, A.M.E.

WHEN the amateur has finally decided what range of wavelengths he desires to cover in his proposed transmitting or receiving set, and when he has determined the correct electrical constants for the coils which will cover this range (by means of the alignment charts given in the first article of this series, published in the February, 1923, number), the next step is to construct the coils that will have these constants.

In other words, if the amateur wants to tune to a wavelength of 400 meters and he has an antenna with a capacity of approximately .0002 mfd., his primary coil should have an inductance of 225 microhenries. The question now is:

"What size of coil will I make that will give me this value of inductance?"

Of course the answer can be figured out mathematically by an engineer, but the average radio fan would find himself in water too deep for him if he should try to do it himself.

However, the simple alignment charts that accompany this article have been prepared so that even the novice will find the answer to his problem in a few seconds. These charts are based on mathematical formulas, but all the reader must know is how to draw a straight line and how to read figures.

For the benefit of the more experienced amateur who understands something of mathematics, I will show how the alignment charts for inductance and design of a coil were evolved. The reader may skip the following formulas if he desires and take my word for it that they will answer his problem, in the form of charts, whether he reads and understands them or not.

The formula for inductance of a coil follows the equation:

$$L = 4\pi^2 \left(\frac{d}{2}\right)^2 n^2 l K \ldots\ldots 1$$

wherein

L = the inductance required.
d = the diameter of the coil in centimeters.
l = the length of the coil in centimeters.
n = the number of turns per centimeter.
and k = a constant depending on the ratio d/l.

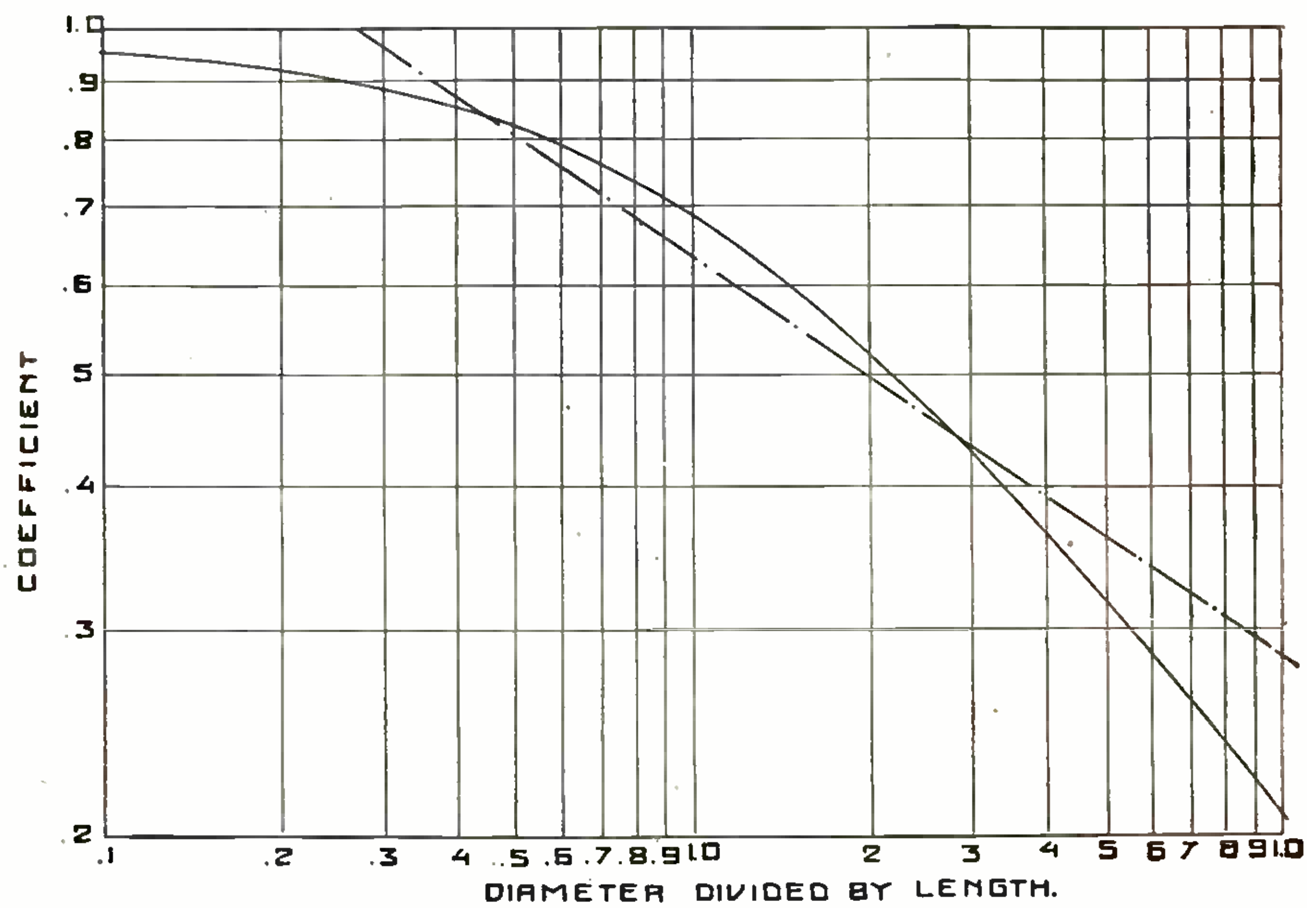
As the correction factor k depends on the relation of the diameter and the length of the coil, we cannot, by means of the above formula, calculate directly the dimensions of a coil assuming the other three variables.

Therefore, in order to make the equation No. 1 available for a simple alignment chart, we will have to eliminate the coefficient k. We plot the correction factor against the ratio d/l on a sheet of logarithmic cross-section paper and substitute a straight line for the curve. By so doing we eliminate this troublesome feature of the formula, with results which will not differ perceptibly from the original values, within the practical limits of a coil design. (See Figure 1.)

The equation for a straight line on logarithmic paper has the form:

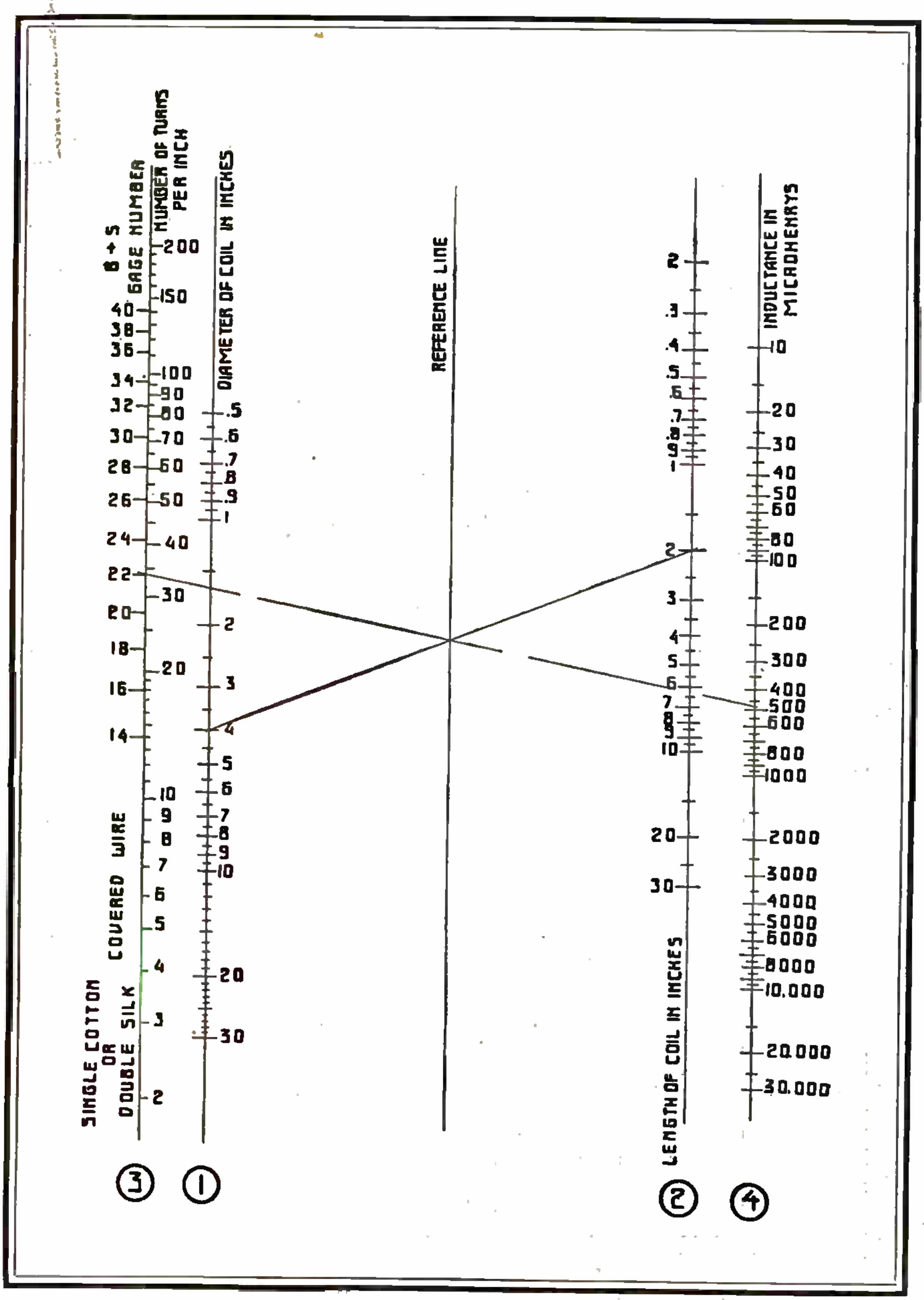
$$y = cx^n \ldots\ldots 2$$

where y and x are variables and c and n are constants.



A STEP IN THE PREPARATION OF THE CHART

FIGURE 1—*In this diagram we have the correction factor k, plotted against the ratio d/l, which is shown in the form of a curve. In order to eliminate the factor k from the formula used in the charts, this curve has been replaced by a straight line with results that do not differ perceptibly from the original values in the original curve.*



USE YOUR RULER ON THIS CHART—

as described in the accompanying text—to learn the exact dimensions of the coil you need. Similar charts for determining constants of radio circuits and calculating capacities of condensers in series appeared in Popular Radio *for February, 1923.*

Substituting for y and x the coefficient and the ratio of d/1 respectively, the following expression is obtained:

$k = c(1/d)^n$ 3

Evaluating we will have:

$k = c(1/d)^{.35}$ 4

then substituting k (in equation No. 1) by the equation No. 4, we will have:

$L = cn^2 l^{1.35} d^{1.65}$ 5

and using the inductance values found in laboratory tested coils and the units in inches we will have:

$L = .0154 n^2 d^{1.35} l^{1.65}$ 6

where
L = the inductance in microhenries.
n = the number of turns per inch.
d = the diameter of the coil in inches.
and l = the length of the coil in inches.

This formula can be used only with the aid of logarithms. For practical use we have converted it into a chart, shown on the page opposite.

Knowing the inductance value we wish to incorporate in a single layer coil, we must decide two factors in the coil design:

First, the diameter of the tube we intend to wind the coil upon.

Second, the size of wire we intend to wind the coil with.

To understand fully and clearly the use of the chart let us consider the following example:

We want to build a coil with an inductance of 480 microhenries. We have some insulating composition tubing 4 inches in diameter that we want to use. We also have a quantity of No. 22 single-cotton-covered wire on hand that will be suitable.

The problem is: "How much wire will we wind on to make a coil with an inductance of 480 microhenries?"

On the chart on page 200, on scale 3, connect, with a ruler, the size of wire (No. 22) with the inductance in microhenries (480) on scale 4. A line so drawn will cross the reference line at a certain spot. Now turn to scale 1. Connect the diameter of the tube (4 inches) with the before mentioned spot on the reference line and carry the line over until it crosses the scale 2. At this point on scale 2 we find the answer; we need a coil 2 inches long.

We now proceed to wind on the tube (4 inches in diameter) two inches of winding, of No. 22 single-cotton-covered wire—knowing beforehand that the inductance of the completed coil will be 480 microhenries.

Try out these charts the next time you build a receiver or a transmitter and learn for yourself how simple the system is. You will then know exactly what size of coils to use for the wavelength range you want to cover.

In radio work there is no one thing that is more fascinating or more satisfying than the knowledge that you *can* predetermine the "constants" of your set.

From a photograph made for POPULAR RADIO

Regeneration Without Radiation

THIS *timely article by John V. L. Hogan (originally scheduled for publication in this number of* POPULAR RADIO*) will appear in the following issue—April. Mr. Hogan's contribution will be supplemented not only with diagrams but with photographs made in his laboratory from actual models constructed for the express purpose of obtaining illustrations for the text.*

From a photograph made for POPULAR RADIO

THE FIRST MAN TO PICK UP AN AMATEUR'S TRANSATLANTIC SIGNAL

When the author of this article sailed for Scotland in December of 1921 for the purpose of picking up radio signals from American amateurs, his mission was regarded about as foolish as the eventful voyage of Columbus. But he picked up over a score of amateurs—some of whom used less electrical power than is used in an ordinary electric light bulb!

"DEAD SPOTS"

What They Are and How to Find Them

By PAUL GODLEY

ONE of the most important symbols which denote the remarkable progress which has been made by the public toward the absorption of all that is to be known about radio lies in the fact that almost anywhere now, no matter what the nature of the gathering, one is apt to hear some two or more radio fans holding forth earnestly concerning the probability that they reside in a "dead spot."

I find myself wondering each time I come within earshot why someone does not come forward and bravely ask:

"What in the name of Heaven is a dead spot?"

To be frank, I frequently want to ask the question myself, for as far as I have been able to find out, there is no one item connected with radio transmission phenomena which has received as little attention from radio engineers or about which there is as little known as the so called "dead spot."

Many years ago, and but a few weeks after I had for the first time seen a commercial radio outfit, I heard someone in a knowing fashion reel off a lengthy and mystifying yarn which had for its setting a spot in mid-Atlantic where no radio signals had ever been heard from any radio station. But this yarn did not startle me half as much as the one offered immediately in return that had to do with another wonderful spot in mid-Atlantic where signals from stations in all parts of the globe *always* came in with great reliability and distinctness!

Radio folks—professionals and amateurs alike—have long talked about "dead spots." Experience has shown that there *are* certain stretches of coastal territory and mountainous areas where it is extremely difficult to effect reliable communication in the conventional manner. But always the term "dead spot" is a relative one only; a "dead spot" being due to the partial absorption of the electromagnetic waves.

A well-known example of this phenomena lies in the inability of ship stations in Long Island Sound to establish satisfactory communication with shore stations on the Atlantic side of the Island, even though the Island is, at its widest part, but forty miles across. Coastwise vessels find great difficulty in communicating with New York City in a satisfactory fashion over distances of but fifty or sixty miles when they are close to the Jersey shore.

An example of this phenomena which deals with transmission on amateur wavelengths may be cited as follows:

A first class amateur transmitter in New York City finds it possible to communicate directly with a like amateur station in Philadelphia, ninety miles distant, during daylight hours. When darkness falls, the signals of the Philadelphia station become unreadable until late in the evening, and are even then unreliable.

Radiophone listeners, too, report "dead spots" in various localities. In Atlantic City during the summer months it is possible to secure fairly good broadcast programs both from New York and Philadelphia during daylight. At night, however, programs from both points are unreliable. Many points on Long Island, forty to seventy miles distant from the New York City stations, frequently find it impossible to record satisfactory broadcast programs.

During the summer of 1920, an effort was made to take advantage of this phenomena in the choice of sites for stations which were to handle the commercial traffic along the Atlantic coast. During the war the Navy department handled all ship-to-shore traffic, inasmuch as all land radio stations had passed into their hands when war was declared. Subsequent to the Armistice this traffic was handed back to commercial companies. Considerable competition then existed between the older and some newly formed companies as to who should handle the bulk of it. There proved to be a sufficient amount of traffic to make its handling profitable. At least four companies who owned and operated stations within the vicinity of New York were each making frantic efforts to get the better of the other. The most serious difficulty encountered was that of interference between the sending stations.

To be specific, one station at Cape May, New Jersey, two in New York City, one at Babylon, L. I., one at Southampton, L. I., one at New London, Conn., and one on Nantucket Island, frequently tried to establish communication with the same ship at the same time, particularly when that ship would report 200 or more messages ready for transmission. Perhaps one of these stations would receive an acknowledgment from the ship operator whose efforts to get the traffic off were frequently rendered futile because of the interference from the competing stations. Loop aerials and receivers of various types were tried with but little relief.

Brown Bros.

HOW "DEAD SPOTS" ARE CREATED

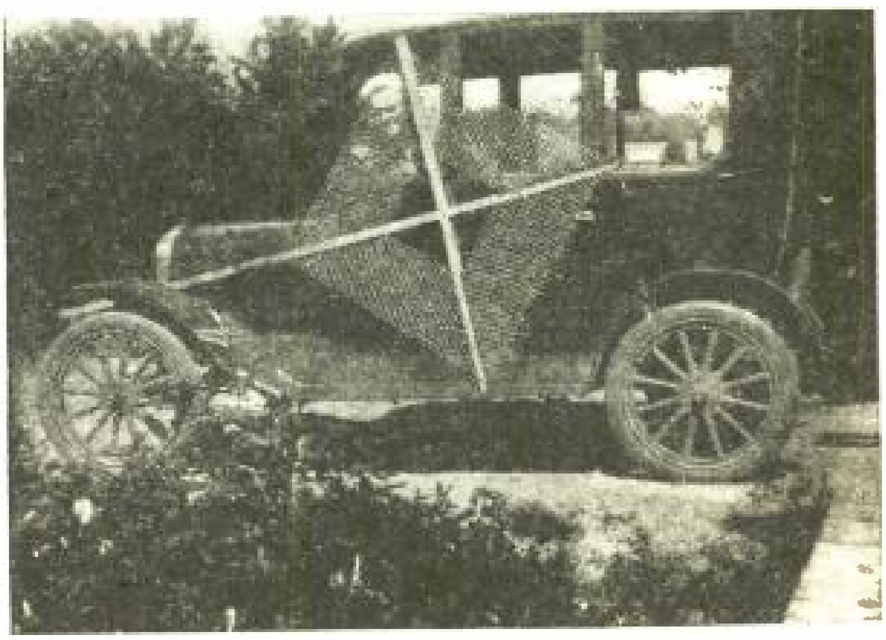
Usually the cause of the trouble is a wall—especially a wall in the form of a building that is largely of metal construction—between your radio receiver and the broadcasting station. Such a structure serves as a shield that deflects the radio waves in much the same way as a ten-foot fence serves as a shield when it intervenes between two men who are conversing. An ordinary crystal or single-tube receiver is usually insufficient to detect the weakened radio waves that do penetrate the shielded areas.

The idea was then hit upon of locating certain points on the North Atlantic coast which would provide comparative freedom from most interfering land stations. The method of locating these "dead spots" proved to be rather ingenious and interesting; to the gratification of those in charge of operations, locations were found where interference from many stations was almost entirely eliminated.

In one of the illustrations which accompany this article (see page 206) is shown a super-heterodyne type of receiver mounted in a Ford sedan. The receiver consisted of a three-element vacuum tube detector, a frequency changer, and a four stage radio frequency amplifier. The car lighting battery was used for all vacuum tubes. However, separate plate potential batteries were used respectively for the detector, the frequency changer (oscillator) and the radio frequency amplier. The circuits of the amplifier were so arranged that the signals could be weakened; that is to say, a certain type of audibility meter was provided. The antenna used consisted of twenty turns of wire on a wooden frame, four feet on a side. The antenna (loop) was so mounted on a rear fender that it could be revolved until pointing toward the transmitting station. Signal strengths obtained with this outfit were equivalent to those which could be obtained on a "T" type antenna, 160 feet high, in conjunction with a single vacuum tube detector and regenerative receiver.

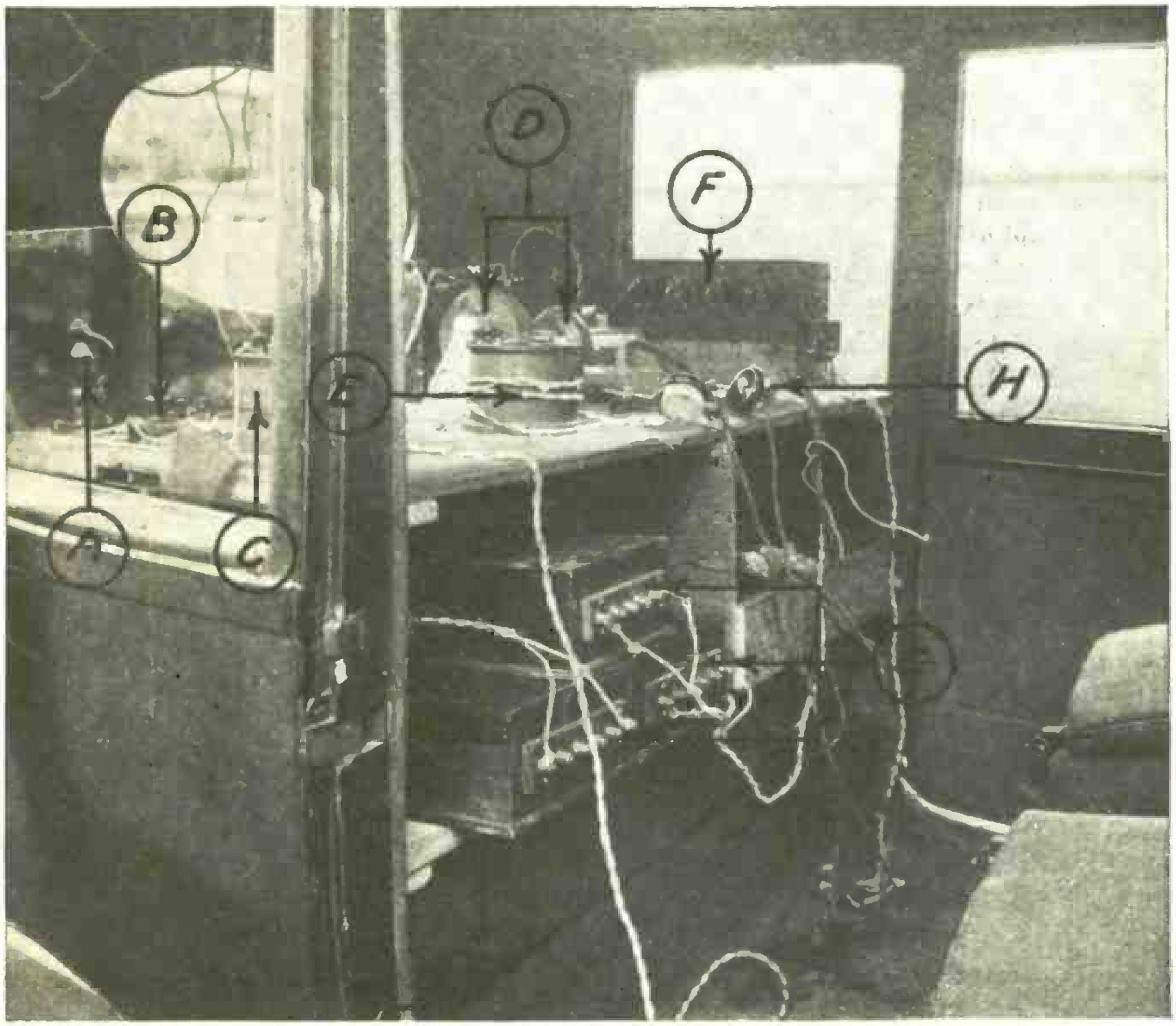
Upon careful study of a topographical map, a point was generally chosen so as to be shielded from the transmitting station by low hills, a rather dense forest, or by a stretch of coast line. Past experience had shown that these usually acted as a shield. At a point near East Moriches, L. I., signals from New York City stations and from New London, Conn., were found to be almost totally inaudible, while signals from the station at Babylon, L. I., were reduced to the point where they would be of no serious trouble. At Smith's Point, some one mile farther toward the Sound, signals from the New York stations, the Babylon station as well as the New London station, were about up to standard. In both positions, signals from out at sea were equally strong. At the Smith's Point location, however, signals from great distances were recorded, as it was possible to read the signals of ships well out at sea and entirely beyond the range of communication of any of the land stations mentioned previously.

As the result of observations in this locality, a receiving station was planned and finally erected. On Cape Cod a point was found near North Truro, Massachusetts, where signals from Boston and Chatham stations were materially reduced. It became necessary at this point, however, to fall back upon large sand dunes for the shielding effect, and an



ON THE TRAIL OF THE "DEAD SPOTS"

The amiable face that peers behind the loop antenna belongs to Paul Godley. The antenna was fitted onto a rear fender during the experiments with radio reception.



THE INTERIOR OF THE RADIO SLEUTH

This extremely sensitive receiving apparatus, which the author installed in a small sedan, includes: A., the vacuum tube used for detection; B, the rheostat for this tube; C, the tuning condenser; D, the honeycomb inductances; E, the heterodyne control; F, the radio frequency amplifier; G, the "B" batteries for the detector, oscillator and amplifier. And, of course, the telephone receivers H.

extremely interesting phenomenon was discovered; a movement of the receiver of only a few hundred feet in either direction caused a marked difference in the strength of signals that came from land stations, while practically no change in signal strength was to be observed in the signals that originated at sea.

Observations taken near the station at New London, Conn., pointed to considerable shielding of this same sort. While signals from New York City stations came in with considerable strength, signals from Long Island and from stations on Cape Cod and near Boston were weak, whereas signals from all vessels in the Atlantic lines came in with what seemed to be doubled strength. It is certain that the exceptionally good work which the station at New London (WLC) has always done is thus accounted for.

It was desirable to locate a third station on the coast of Maine; for this purpose an extended series of observations were taken between Bar Harbor and Eastport. In addition to natural shields or barriers against radio signals from coastal stations, it became necessary in Maine to look, first of all, for a source of power supply. This existed at but few points along the coast. Observations taken at or near Rockland indicated exceptionally good shielding from all transmitters with the exception of the Naval station at Bar Harbor. Ocean-going vessels in the Atlantic lines could be received at this point with great clearness. The Bar Harbor station, however, was a serious drawback and after many experiments along this part of the coast, a point was found near Harrington, Maine, where shielding from both Bar Harbor and Rockland was ideal. Some weakening of signals from ocean-going vessels was to be noticed, however, due, no doubt, to the absorption taking place while the signals were in transit across Nova Scotia.

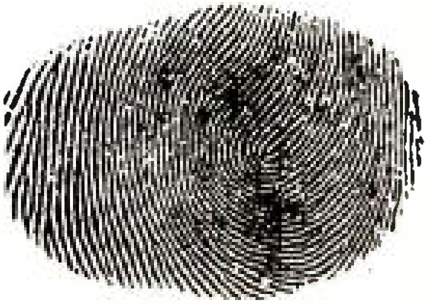
It has long been presumed that hills absorbed or deflected radio signals. Frequently mountains cast decided shadows; so do forests in lesser degree. In the case of the forest, absorption plays the greatest part in the weakening of the signal. Where a chain of mountains exist, the shadowing effects may become quite complex. This is also usually true in the larger cities, due to large steel structures, and is particularly noticeable where communication is being attempted upon the shorter wavelengths. The shorter the wavelength the more pronounced the shadowing effect, for the size of objects such as mountains and groups of trees and tall buildings are of the same order as the dimensions of the radio waves. Where the length of the wave is several thousand meters, few mountain ranges are to be found whose dimensions are sufficient to render them other than relatively small objects in the path of the wave.

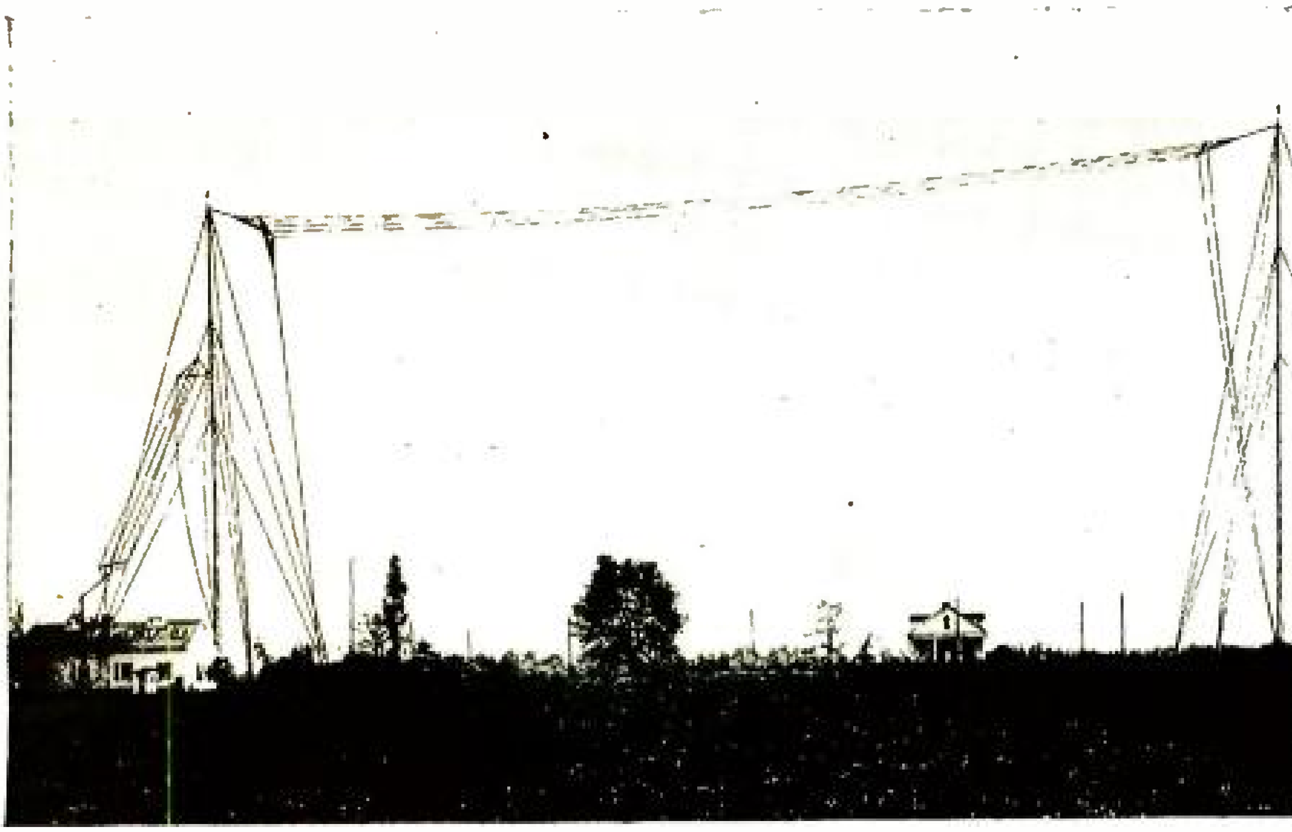
Large bodies also act as reflectors. An instance of this is on record. An attempt was being made to receive a signal from a point directly away from a mountain. The signal from the distant station was considerably weakened by bringing the receiver within approximately one and a half wavelengths of the mountain. It is to be assumed in this case that energy reflected by the mountain back into the receiver, arrived there completely out of time with the oncoming wave. The reflected wave counteracted the incoming wave with the result that signal strength was weakened.

Complete information concerning the effects of various objects upon the transmission of radio energy is not now available. When it is, it should be possible to definitely plot the rise and fall of signal strengths over any particular territory. There is little doubt that the "fading" effects observed by so many broadcast listeners are caused by the reflection of the electric wave from layers of gas many miles above the earth. The assumption is that the energy travels up and through the earth's atmosphere to a layer of ionized gas—that the gas reflects the wave, sending it again earthward—that in its travel the wave has encountered nothing which tends to absorb its energies. Suddenly a vapor cloud or a flaw in the reflecting mirror results in the absorption or loss of the signal. These irregularities occur rapidly at short wavelengths in mountainous or hilly countries —less rapidly over level country and at sea, but, under given conditions, the frequency of the fading intervals is a function of the wavelength.

"DETECTIVE BURNS"—

otherwise known as William J. Burns, Director of the Bureau of Investigation, Department of Justice of the United States Government, will shortly publish in POPULAR RADIO *an authoritative article descriptive of the present and impending use of radio for running down criminals, ranging from the broadcasting of warnings to the broadcasting of portraits and fingerprints.*





Chester Radio Club

AN AMATEUR ANTENNA THAT APPROACHES PERFECTION

This flat-topped, inverted L type meets the specifications given in this article to an exceptional degree. It is owned and operated by station 3ZO, in Chester, Pennsylvania.

HOW TO GET THE GREATEST EFFICIENCY OUT OF YOUR

RADIO CIRCUITS

NO. 1 OF A SERIES OF ARTICLES OF PRACTICAL HELPFULNESS FOR THE EXPERIENCED AMATEUR

That one of the world's greatest physicists should prepare especially for POPULAR RADIO such a series of practical, helpful articles on such specific subjects is a matter of importance to radio amateurs everywhere. These articles constitute a real and important contribution to the literature of radio.

By SIR OLIVER LODGE, F. R. S., D. Sc., LL. D.

THE main essentials of a radio installation are capacity and self-induction, or "inductance" as it is commonly known in America, introduced (in the case of a receiving station) in the form of a collector and a detector, and (in the case of a transmitting station) in the form of a generator and a transmitter.

The transmitter and the collector are one and the same thing—the aerial. The transfer from generator to detector is usually effected by a switch. Capacity and inductance are the essential ingredients of an aerial, and it is on them that the wavelength depends. But it is a question what value the capacity and inductance shall have and how they shall be arranged.

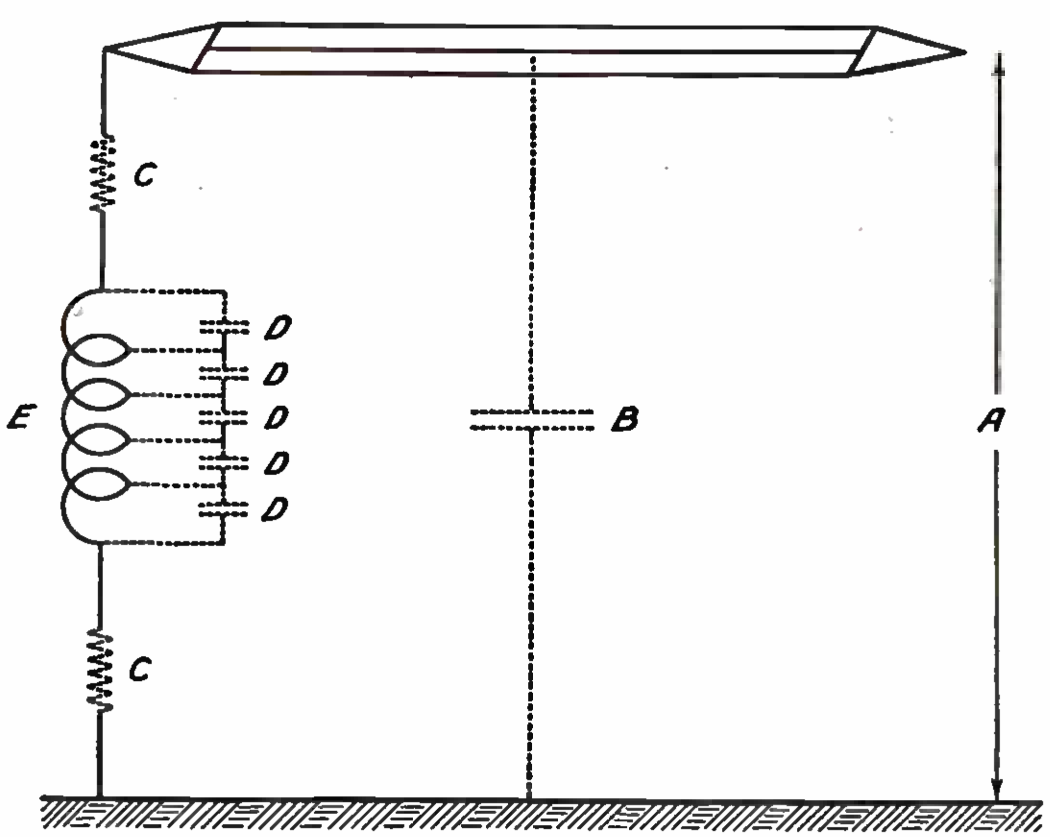
It is obvious that the more open the capacity, the better will it serve as transmitter or collector; hence, whatever capacity is used, it should mainly be in the aerial, in order to attain the highest efficiency. Any defect of capacity in the aerial can be supplemented by a closed adjustable capacity, which of course is very convenient and will always be subordinately required for tuning.

If the aerial could be arranged so as to extend to a great vertical height, its capacity would be as open as possible, and its efficiency as a transmitter or absorber would be correspondingly high; for both the radiating and the absorbing power is proportional to the square of the height. But there are practical limitations to the height that is convenient, so that when the greatest available height is attained any bulk of the aerial beyond that naturally has to be horizontal.

The wavelength, however, depends on the product of capacity and of inductance. So, for any considerable wavelength, if the length representing electric capacity is small, the length representing magnetic induction must be great.

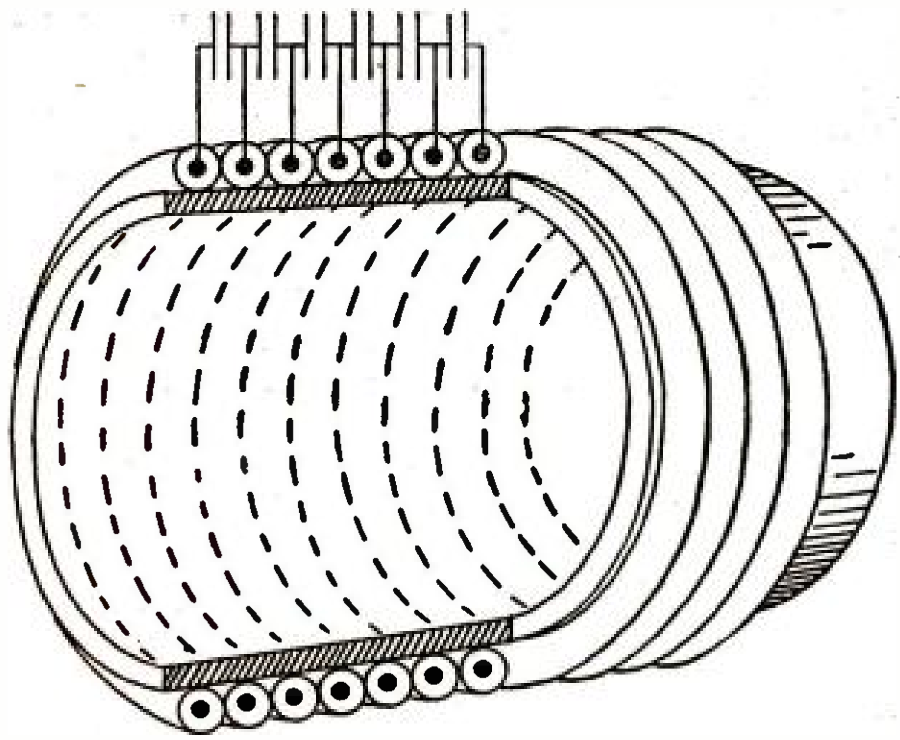
Hence, to get any reasonable wavelength, the capacity of the aerial must be supplemented or reinforced and made effective by a considerable amount of inductance. But whereas the capacity area may with advantage be as extensive as possible, there is no advantage in increasing the mechanical size of the inductance; on the contrary, indeed, there is an advantage in reducing it to a small value, so that quite a minute coil will serve for a great wavelength.

Why should there be this advantage in constricting the inductance coil? Because any capacity which it possesses is useless and to some extent deleterious. There is no gain in mixing up capacity and inductance; they should be kept distinct and separate. The upper part of the aerial, combined with the earth below it, should have all the capacity, and the inductance coil should have as little as possible. Then the wavelength has a chance of being clear and definite. Whatever capacity exists between the turns of the coil has the effect of shunt-



THE THREE QUALIFICATIONS OF YOUR ANTENNA SYSTEM

The height of the antenna above ground, A, should be as great as possible. The upper part of the antenna, combined with the earth below it, should have all the capacity indicated at B. The inductance coil E should be kept as small as possible for a given wavelength, so as to reduce the distributed capacity, D, to a minimum, and the resistance of the circuit, C C, should be kept as low as possible.



HOW DISTRIBUTED CAPACITY CAUSES BROAD TUNING

This diagram illustrates the effect of distributed capacity between the windings of a coil. The insulation between the adjacent turns of wire forms a dielectric and the wire itself forms the plates of a number of little imaginary condensers between the turns of wire. These little condensers have a deleterious effect upon sharp tuning.

ing some of the oscillation and making it useless. The shunted portions would have any number of indefinite frequencies, and would not contribute to the main wavelength.

This has become known to practical men, and, as a result, what is called *basket* winding has been often adopted, in order that the turns of wire may have some intervening space between them and not lie too close together. Of course this has some effect in diminishing inductance, since the magnetic influence of the turns of wire on each other is slightly diminished. But the reduction in capacity is found to more than compensate this disadvantage, and it is easy enough to get sufficient inductance by making the coil bigger.

Only, of course, then more wire has to be used for the coil; and the more wire it contains, the more capacity it has. So it is evidently a question of compromise, and the best result has to be found by practice. Some capacity between the turns is inevitable; and, apart from basket winding, we may consider how best to secure a minimum of it.

First of all, then, thin wire is indicated; from the capacity point of view the thinner the better. The only disadvantage of thin wire is that its resistance is high. But resistance affects only the damping of the vibrations. And the vibrations are usually sufficiently persistent to cause damping to have no great importance, unless it were excessive. Damping by radiation of energy is inevitable, and moreover it is useful. Other damping is of no use, but it is usually small in comparison. Of course the wire must be of the highest conductivity. But, given that, there is a gain in keeping its thickness very small.

If in any case so much wire has to be used that its resistance does become excessive, then instead of making the wire thicker it would be better to have several wires in parallel. The wires should be very thinly insulated from each other, and then stranded or laid together. A strand of this kind forms a perfect conductor for high frequency oscillations, inasmuch as every part of a

From a photograph made for POPULAR RADIO by Hoppé, London

Sir Oliver Lodge Writes Concerning This Noteworthy Series of Articles—

"I am writing a series of articles for POPULAR RADIO *on points concerning which amateurs would probably be glad to get information. . . . I write not for mathematicians, nor yet for beginners, but aim at boiling down the result of mathematics into popular form suitable for amateurs who want to understand the principles of what they are doing, and who are constructing parts of their own apparatus."*

Oliver Lodge

thin wire helps to carry the current, whereas only the outside of a thick wire is effectively conductive for an extremely high frequency of oscillation; so that the effective resistance of a thick wire is considerably greater than it would appear to be when measured in the ordinary way with steady currents and a Wheatstone bridge. Such considerations do not apply to a strand of fine wires, however thinly insulated from each other they are.

It may be asked, "Why insulate the parallel wires from each other at all?" But it is clear that if they are in metallic communication, all along their length, they virtually constitute a thick wire. The ether waves cannot then gain access to more than the combined periphery. The inner wires will be screened by the outer ones, just as the interior of a thick conductor is screened; whereas if there is any insulating material between them, however thin, the waves can, as it were, soak in and utilize the conducting surfaces of all the wires. (In this connection it must be remembered that it is the ether, and not the copper, which really transmits the energy; the function of the insulating material is vital.)

Given then as thin a conductor as suffices for the quantity of electricity to be conveyed, the expression for the capacity of such a wire shows that in order to keep it small the turns of wire in a coil had better not lie close together. They can be separated by an air space, or they might be separated by a thick cotton covering outside the real insulation—a covering as airy and uncompact as it can conveniently be made. Basket winding is one way of getting this result, but a thick cotton covering would be another, and would seem to be more convenient.

However that may be, and however the distance between the wires is secured, it can be allowed for in the calculation, and the best method of obtaining the separation can be left to the instrument makers themselves.

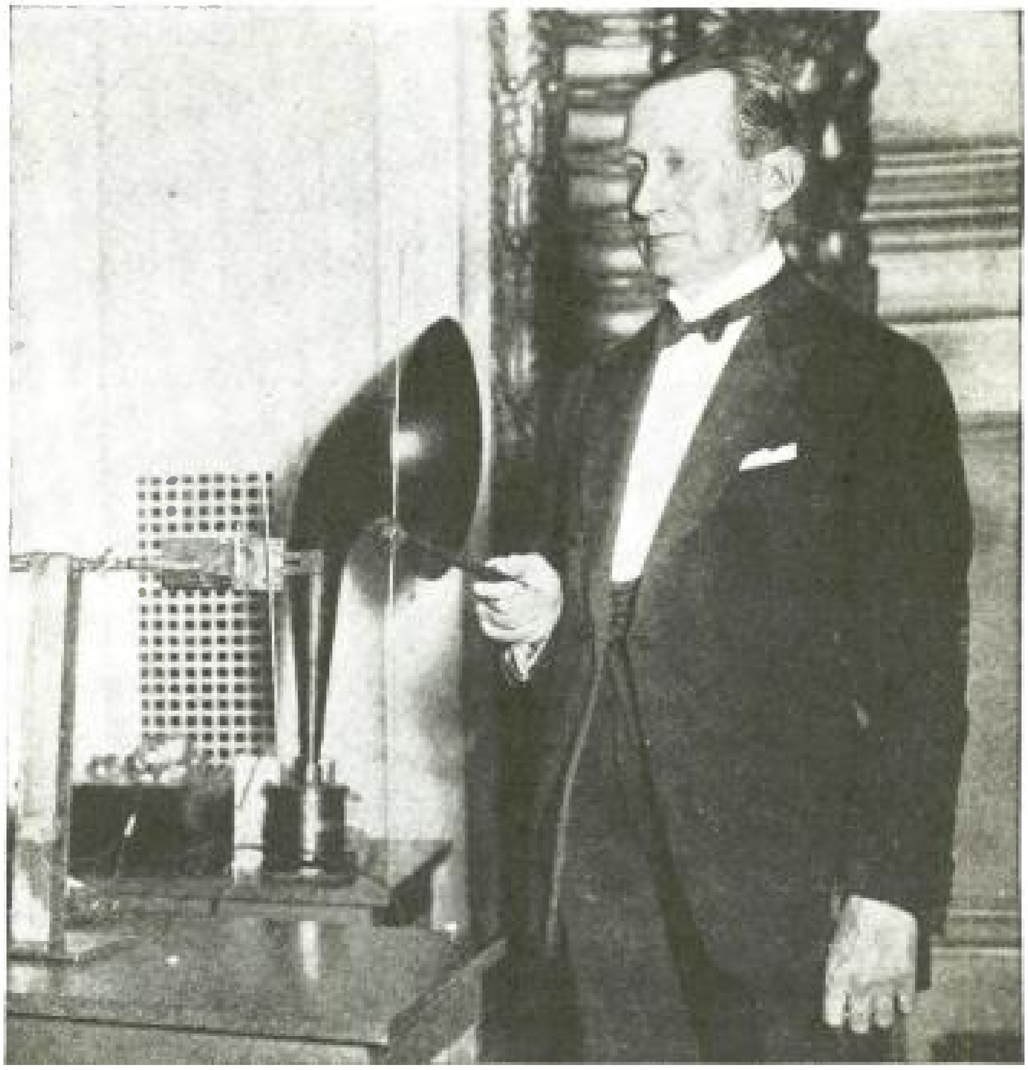
I have not myself, however, found that much separation is really necessary in a receiver. I am inclined to think that its advantage is subordinate and that close winding is quite permissible, as well as certainly more compact, provided certain other considerations are satisfied.

The main consideration is to use as little wire as possible in the inductance part of an aerial; or, in other words, to wind the coil so as to get the maximum inductance out of a given length of wire. This will have a double advantage; it will keep down the resistance, and also it will keep down the capacity—both of which must obviously depend on the length of wire used.

So far as I know, insufficient attention has hitherto been paid to this important consideration, and I doubt if coils are often wound so as to obtain the maximum inductance. I regard this as important, and propose to take it fully into consideration in the articles of this series.

Among the Subjects to Be Covered in This Series Are—

The predetermination of the inductance of coils;
The design of coils for specific purposes:
The relation between capacity and inductance in a circuit;
The qualifications of antennae;
The arrangements of circuits and apparatus for different wavelength ranges.



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THE MAGIC WAND OF THE MODERN MAGICIAN

With such marvelous accuracy may a beam of radio be directed by means of the "projector" which Senator Marconi is demonstrating, that it will actuate relays, one at a time, ring bells and operate receiving sets located at various points in a room as the beam is revolved.

HOW I SEND SIGNALS ALONG

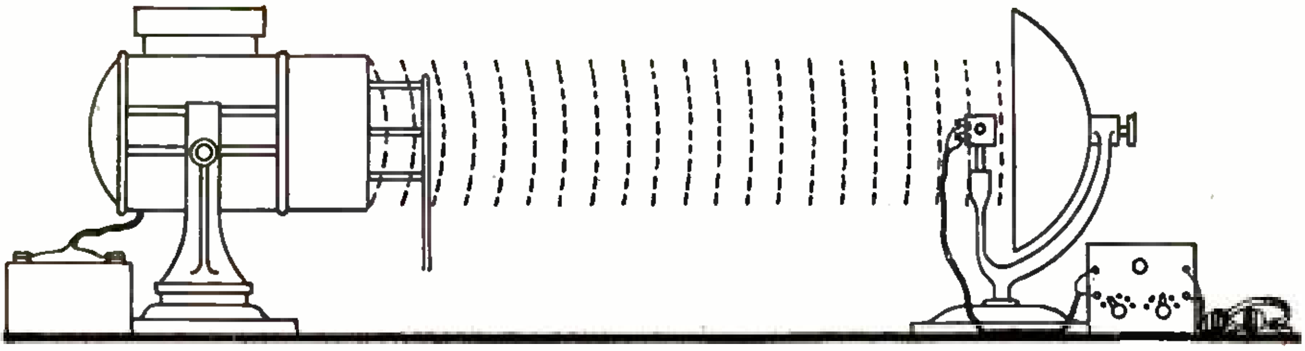
INVISIBLE BEAMS

How the New Short Wave That Can Be Aimed in a Definite Direction is Opening Up a New and Remarkable Assortment of Wave Bands

By SENATOR GUGLIELMO MARCONI, D.Sc., LL.D.

TWENTY years ago I got the simple letter "S" transmitted for the first time across the ocean from England to Newfoundland without the aid of cables or conductors. Those first feeble signals which I received proved once and for all that electric waves could be transmitted and received across the ocean and that long distance radio telegraphy—about which so many doubts were then entertained—was really going to become an established fact.

Radio has already done much for the safety of life at sea, and for commercial and military communication. From now on it is destined to bring new (and until



A new system of communicating along a beam of light. A light wave is directed in a narrow path from a searchlight and picked up by a reflector which concentrates the waves on a light-sensitive cell which records the signals.

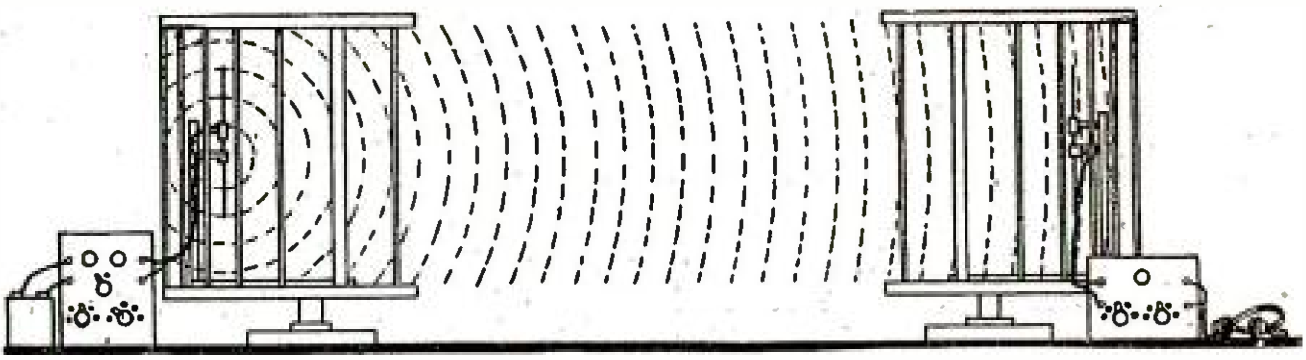
recently even unforeseen) opportunities for recreation and instruction into the lives of millions of human beings. New designs and new uses of vacuum tubes are likely to work quite as many new wonders in the future as they have in the past.

Great possibilities lie in the development of these tubes, especially in their connection with short wave transmission, a somewhat neglected branch of the art. Yet radio waves only a few inches long have many advantages over the waves now used, which range in length up to twelve miles. Such short waves can be more easily moulded to carry the human voice, and receiving sets tuned to them would be less disturbed by static and interference. Indeed, much of my time is now devoted to experiments with the short wave, particularly for use in the secret transmission of messages. So free from interference is this short wave field that I am reminded of my earliest experiments, when the entire field was practically clear and the vast territory of radio was unexplored.

As early as 1899 I showed how it was possible, by means of short waves and reflectors, to project the rays in a beam in one direction only, instead of allowing them to spread all around, in such a way that they could not affect any receiver which happened to be out of the angle of propagation of the beam. I also made tests in transmitting a beam of reflected waves across country over Salisbury Plain in England and pointed out the possible utility of such a system if applied to lighthouses and lightships, so as to enable vessels in foggy weather to locate dangerous points around the coasts. At that time I also showed that a reflected beam of waves could be projected across the lecture room to actuate a receiver and ring a bell only when the aperture of the sending reflector was directed toward the receiver.

Again in 1916 I took up the investigation of the subject with the idea of utilizing very short waves combined with reflectors for certain war purposes; in this work I was assisted by Mr. C. S. Franklin. We used waves only two and three meters long. With these waves disturbances caused by static are almost non-existent; the only interference experienced came from the ignition apparatus of automobiles and motor boats. These machines apparently emit electric waves from 0 to about 40 meters in length; perhaps the day will come when they will be required to have their ignition system screened or to carry licenses for transmitting! During these experiments I observed that one of the short wave receivers acts as an excellent device for testing, even from a distance, whether or not one's ignition system is working right. Some motorists would have a shock if they realized how often their magnetos and spark plugs are working in a deplorably irregular manner.

The transmitting reflector used to concentrate the waves into a ray or beam, in these experiments, was arranged so



¶ *Another new system for projecting a beam. Both the light and the radio beams are dependent on the same phenomena of electromagnetic wave motion. This system uses a radio beam which is invisible.*

that it could be revolved and the effects were studied at a distance with receiving apparatus.

Mr. Franklin has calculated the polar curve of radiation into space in the horizontal plane, which should be obtained from reflectors of various shapes, by assuming that the waves leave the reflector as plane waves of uniform intensity, with a width equal to the aperture of the reflector. The calculated curves agree well with the observed results. Reflectors with apertures up to 3½ meters wavelength were tested and the measured polar curves agreed with the calculated values.

At first the range of the signals was only six miles. Later, on a 15 meter wave generated by an electron tube at the Carnavon station, we transmitted over a distance of seventy-eight miles to one of the mail boats on the Irish coast. The important fact noticed was that there was no rapid diminution of the strength of the signals after the ship had passed the horizon line from Carnarvon. It was easily proved later that clear speech could be exchanged at all times between Hendon (London) and Birmingham, a distance of ninety-seven miles, by using reflectors at both ends.

For these tests, the power supplied to the tubes employed was usually 700 watts. The aerial was rather longer than half a wavelength and had a radiation resistance which was exceedingly high. The efficiency of the input to the tubes to aerial power was between 50 and 60 per cent and about 300 watts could be actually radiated into space. Speech heard with this arrangement is usually strong enough to be just audible with a shunt of from ¼ to ½ ohm across a 60 ohm telephone.

When both reflectors are disconnected and out of use, speech is only just audible with no shunt. Average measurements indicate that the value of the energy received when both reflectors are used and the waves concentrated in a beam, is about 200 times that of the energy received without any reflectors. It would seem that here is one possible solution to secret radio communication, the use of directed beams of magnetic waves.

During the continuous wave tests at Carnarvon, it was found that simultaneous transmission and reception was possible on the same aerial. This system is now being used successfully for duplexing, as it avoids all switching from transmitting to receiving.

Besides giving directional working and economizing power, reflectors are showing another unexpected advantage, an advantage which is probably common to all sharply directional systems. It has been noted that practically no distortion of speech takes place, such as is often noticed with non-directional transmitters and receivers, even when using short waves.

The results between Hendon and Birmingham easily constitute a record for radiotelephony in respect to the ratio of distance and wavelength, as Birmingham is 10,400 wavelengths from Hendon.

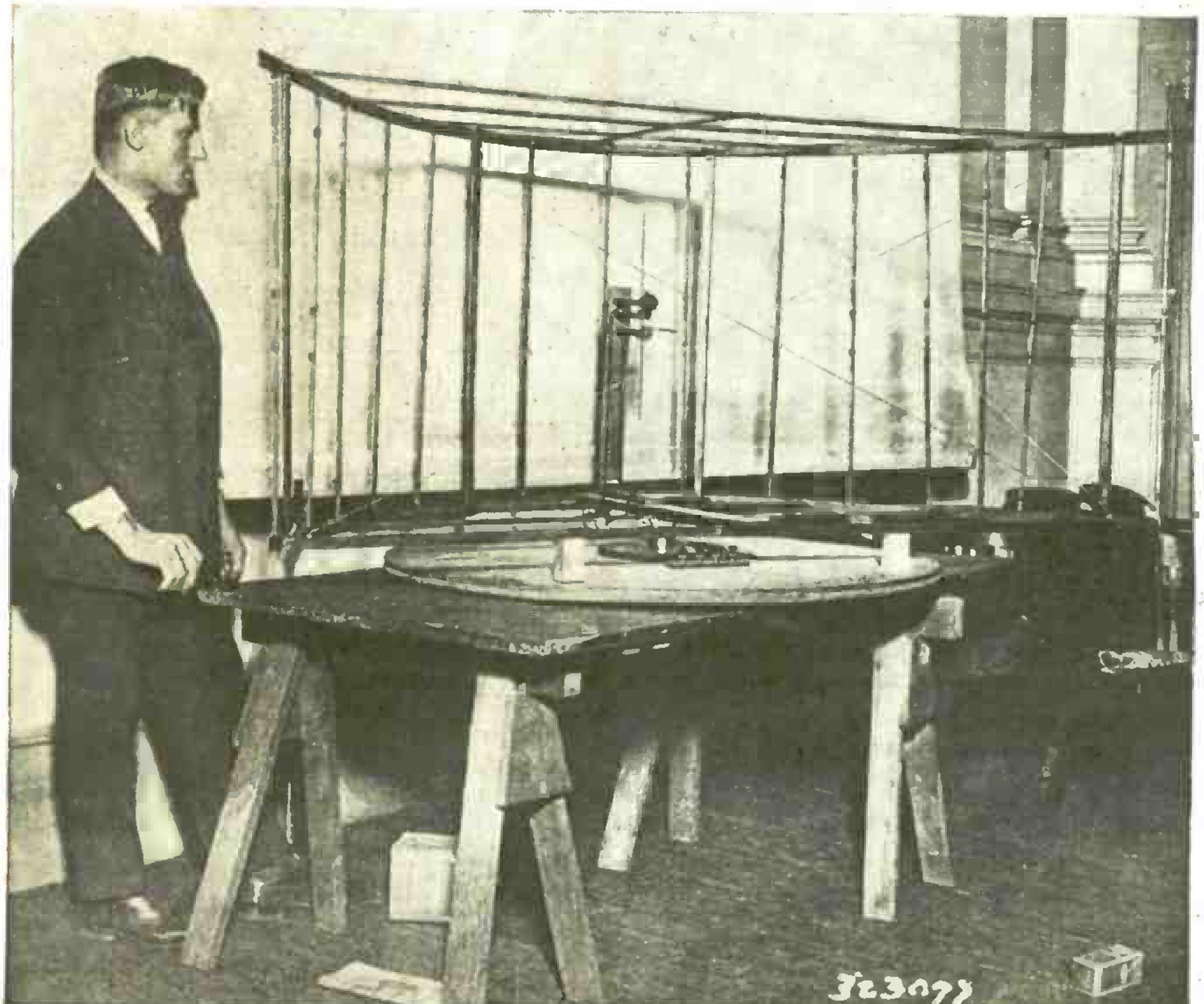
We consider that these results represent only what could be obtained from a first attempt, and not what could now be done by utilizing the experience gained.

A new wireless beacon has recently been developed at Inchkeith Island in the Firth of Forth, near Edinburgh. By means of a revolving directive beam of radiated energy which it produces, ships at sea can ascertain the position of the lighthouse in thick weather. With a 4 meter wave generated by a spark transmitter and a beam reflector, signals have been sent which were readily distinguishable on a ship seven miles away fitted with a single tube receiver. The reflector made a complete revolution every two minutes, and a distinct signal was sent at every half point of the compass. This enabled the ship to determine the bearing of the lighthouse accurately within a quarter point of the compass, or within 2.8 degrees.

With the revolving beam the exact periods of maximum reception are not easy to judge by ear, but the times of starting and vanishing are easy to determine, as the rate of rise and fall of the signals is extremely rapid.

By means of a clockwork arrangement a distinctive letter is sent out every two points and short signs mark intermediate points and half points. This is done by contact segments arranged on the base of the revolving reflector.

These short directional waves resem-



A WORKING MODEL OF THE MARCONI REFLECTOR

This is the apparatus for concentrating the radio rays in one single beam. The small vertical object at the center of the reflector is the oscillator. The length of the waves propagated by this miniature antenna system is only about one or two meters.

bling a beam of light decrease in strength so gradually when traveling over water that the distance of the transmitting station may readily be estimated.

Still another help to navigation may be found in the reflected beam wave. Hertz showed that electric waves can be completely reflected by sounding bodies. In some of my tests, I have noted the effects of reflection and deflection of these waves by metallic objects miles away.

It seems to me that it should be possible to design apparatus by means of which a ship could radiate or project a divergent beam of these invisible rays in much the same manner as a searchlight, in any desired direction so that if they should meet another ship they would be reflected back to a receiver screened from the transmitter. This would reveal the presence and bearing of nearby ships in fog and heavy weather, even though such ships were not provided with radio equipment.

"SECRET MESSAGES CAN BE SENT BY RADIO"

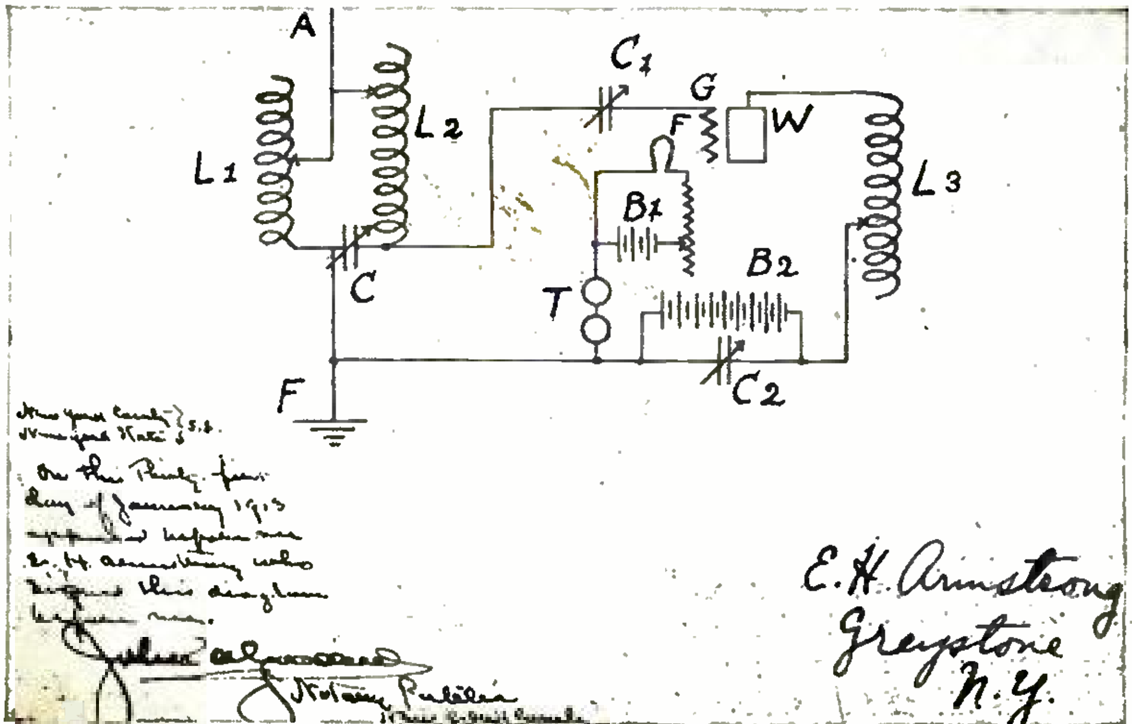
So states Senator Marconi, whose recent experiments with short waves (some of them only a few inches in length) that can be focused like a beam of light is opening up a line of development in radio communications that has heretofore been regarded as closed. This picture of the Senator was snapped by Paul Godley during a visit to the Marconi yacht, "Elettra," which is practically a floating radio laboratory.

From a photograph by Paul Godley

"Stations I Have Heard"

In the next number of POPULAR RADIO—April—will start a new department that will tell, in brief paragraphs, of some of the exceptionally good results obtained by amateurs and novices from their receiving sets and how they get them.

If you are getting exceptionally good results from *your* set—tell POPULAR RADIO how you do it!



A SKETCH THAT MADE A FORTUNE

When young Armstrong wisely brought it to a notary public to be attested, he established a priority claim to his invention of the feedback circuit—a claim that was upheld by the courts.

A Hook-Up for $500,000

In this article Dr. Henry Smith Williams, *himself a distinguished scientist, tells how a radio amateur hit upon an idea for a "feedback" circuit and stuck to it till he proved that "there was a fortune in it—"*

EDWIN H. ARMSTRONG

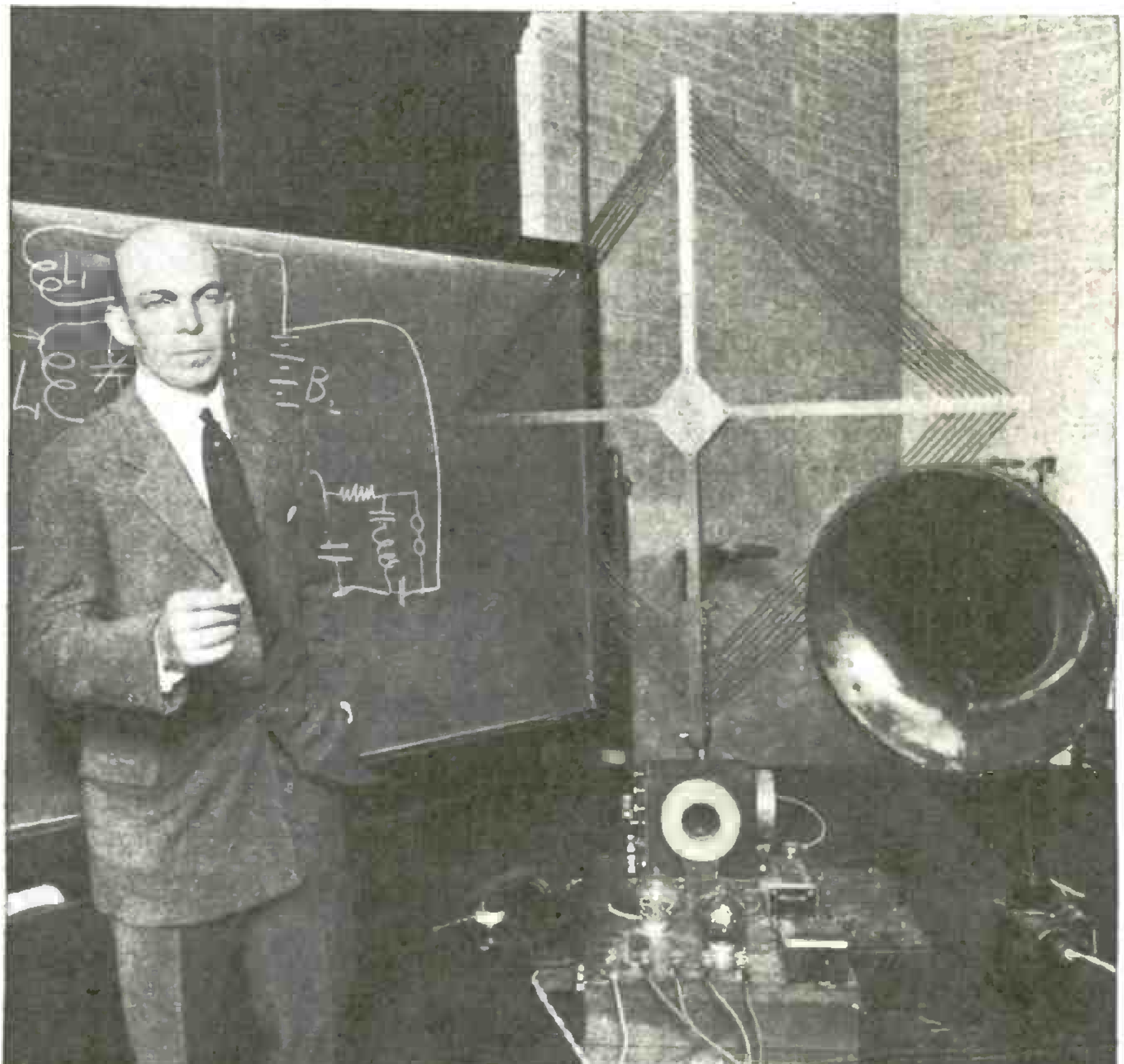
RADIO, as young America has tackled it, is the most wonderful game that the youth of any generation has ever played. As informative as it is fascinating, it comes near to nullifying the age-old edict that there can be no royal road to learning. For the young enthusiasts who are playing this game are at the same time becoming trained mechanicians and thoughtful students of electrical phenomena; in due course they will open up new fields of radio practice that are at present unknown.

The prophecy that within ten years there will be a radio receiving telephone in every home that now has a phonograph, and in most homes that now have telephones, seems not in the least hazardous. Scarcely more so is the prophecy that within fifteen or twenty years it will be almost as customary to carry a little radio receiving telephone apparatus in your pocket as it is now to carry a watch. If these prophecies, and others in kind, become realities, it will be largely because many thousands of American youths learned to play the radio game almost in childhood, and in so doing were given the opportunity to demonstrate the possession of inventive talents that otherwise might never have been suspected.

One might be disposed to say that radio is essentially a boy's game at which men who remain perennially young may play. It gives full opportunity for use of the imagination and for the manifestation of inventive ingenuity, and youth is essentially the time when imagination has free play. Only the young—including a few rare mortals who never grow old—have the imagination and the temerity to attempt the impossible; to believe in miracles—and to achieve them.

The proof of this, were proof needed, may be found in the history of radio development. Young Heinrich Rudolf Hertz, called the father of radio, found the first definite clues; young Guglielmo Marconi—at the age of twenty—made the first convincing demonstrations; young Lee De Forest perfected the magic tube that is the heart and soul of the modern radio apparatus; and young Edwin H. Armstrong performed the final feat of jugglery that permitted the necromantic bulb to reveal its ultimate miracles. There appear to be no old men in the story.

Everyone knows something of the achievements of the first three of the



Brown Bros.

"FEEDBACK" ARMSTRONG DEMONSTRATES HIS LATEST TRIUMPH

Radio engineers and scientists have realized the limitations of the regenerative circuit, although still recognizing its superiority to other known single-tube circuits. But Armstrong has recently come forward with the super-regenerative circuit (pictured above)—the first circuit to overcome these limitations.

pioneer workers in radio just named. Here I wish to refer to the remarkable work of the fourth member of the *coterie*—partly because of the news interest associated with the fact that the long series of litigations that have grown out of his discovery has just been terminated; but chiefly because it seems fitting that every user of a radio receiving telephone should know the story of the youth who played the radio game so well as to make possible its application for the foundation of the art of broadcasting.

Only a short time ago, in the year 1906, Armstrong was a sturdy boy of about fifteen, at the home of his parents, in Yonkers, New York, enthusiastically engaged in the then new radio art.

The boy's interest had been aroused by reading reports of Marconi's early work. He set to work to construct a wireless apparatus of his own. For about a year he worked unsuccessfully, but at last he began to receive messages. Then a neighbor, an electrical engineer, Mr. Charles I. Underhill, gave him a vacuum tube, which the donor himself did not know how to operate. Young Armstrong soon found out the secret, however, and presently he went on to experiment with the new type of electron tube, the audion, which Lee De Forest had introduced in 1907. The earlier tube had been of the type called the Fleming valve. It was after he had gained full mastery of the use of the audion tube, as then understood, that young Armstrong, a college student at Columbia, was led in the course of experiments with the current from the local plate battery (the "B" battery as it is now called), to attempt to augment the incoming, message-bearing current from the aerial by "feeding-back" a portion of the local current into the grid-filament circuit.

The thing worked out better than he could possibly have anticipated and presently he was aware that he had made an important discovery. What he had done, as the sequel showed, was to invent the apparatus afterward called a "tickler coil," establishing the now famous "regenerative" circuit.

The young inventor could not secure financial backing to have his device patented at the moment; but he made a diagram (what is technically called a "hook-up") of the apparatus as he had modified it, and went before a notary in January, 1913, to have his signature on the sheet showing this diagram officially authenticated. It was a fortunate thing for him that he did so, because this simple document was the most important witness in the long series of litigations which resulted in the final verdict by the United States District Court of Appeals in which the "Feedback Armstrong's" claim to rank as the discoverer, with ownership of the important patent rights appertaining thereto, was given final legal recognition.

On another occasion, we will examine in detail the technical aspects of this remarkable discovery. Let it suffice here to cite the comment of Professor Michael I. Pupin, in whose laboratory at Columbia University young Armstrong worked, to the effect that the invention of the feedback, in itself of vast importance, led the young inventor also to make another most important step in radio telegraphy—the construction of the vacuum-tube oscillator. Professor Pupin declared that one large electrical corporation is now engaged in experimentation with powerful vacuum-tube oscillators with an output of upward of fifty kilowatts. "Such tubes have practically unlimited possibilities in communication," said Professor Pupin, "while their application in other industries will in the near future result in some revolutionary changes of vast importance."

Note, then, this further comment, as pertinent to our present theme:

"In this case, as in (practically) the case of every other important invention," said Professor Pupin, "it is the student who produces the original idea and not the research laboratories of the big cor-

Brown Bros.

"THE MAN WHO MADE LONG-DISTANCE TELEPHONY POSSIBLE"

This term has been applied to Michael I. Pupin, professor of electro-mechanics at Columbia University, in whose laboratory Edwin H. Armstrong studied. Like his famous pupil, he also received a vast fortune for an invention known as "the Pupin coil."

porations. The latter do some wonderful and important work, especially in refinement and development of inventions, but the conditions of efficiency under which they work hamper their originality.

"You can't get a man like Armstrong to punch a clock. In fact, I know he was fired for refusing to punch a clock—but I took him in at Columbia."

The narrator who reports the conversation goes on to say that Armstrong himself, who was present, laughed and declared that he had just "one more thing to put over," and that then he meant to retire for the time being and go over to Europe for a rest. He would not say what the nature of the "one more thing" might be; but perhaps an inkling as to its character may be gained from another interview with the now famous inventor. In this interview, Armstrong makes the prophecy that the radiophone receiver will be as common in the not distant future as the victrola now is.

"Not every home will have a radiophone, of course," he said, "but I can predict that every home having a phonograph will be equipped with radio."

This equipment, it is further prophesied, will consist of none of the outside and unsightly wires, switchboards, and batteries now seen at every radio station. The whole radiophone receiver, horn and all, will be no larger than the now ordinary music box, and the current to operate it will be supplied by electric cords, connected with the nearest wall plug. Instead of the aerial wires that are now used the radiophone receiver will have a small coil of wire or a metal rod five or six feet long, something no more conspicuous than the ordinary curtain rod. Outside wires will be unnecessary.

Armstrong himself has this sort of equipment in his home at Yonkers even now. He has set up there a small receiver that employs no outside wires and which picks up music and other signals from the broadcasting station at Newark with such strength that they may be heard half a mile away.

There is nothing remarkable about this, from the standpoint of the inventor himself, except the fact that this receiving apparatus has no outdoor aerial. As long ago as 1915 the young experimenter could describe the results with his then newly discovered "feedback" apparatus in these words, addressed to Mr. Underhill, the engineer who had supplied him with the vacuum-tube:

"During the past four months I have worked up a number of improvements on the audion detector and I believe that I have a receptor which is from two to three times as sensitive as any other, and this is a conservative estimate. With this receptor I can hear every navy station on the Atlantic Coast from Cape Elizabeth, Maine, to Colon, Panama, including Guantanamo, Cuba, with the telephone receiver lying on the table. The Florida stations are so loud that they can be heard all over the room, and on good nights, Key West can be heard down on the floor below."

In writing thus, the young inventor was giving an account of results attained with a method which he has since made available for all the world. In the words of a writer in the New York *Tribune*, "no transatlantic telephone conversation can be carried on without the Armstrong principle, nor can any of the big radiophone broadcasting stations now sending music nightly through the ether operate without using the Armstrong patent. Even the modern multiplex forms of wire telegraphy and telephony (wired wireless) must use the Armstrong method."

That is what has come from the efforts of the boy who started out to play at the radio game when his companions were chiefly concerned about baseball and other outdoor sports. When the man who has done these things chooses to enter the field of prophecy the entire radio world must listen, and few will be disposed to question that his prediction as to a compact radio telephone receiving apparatus, without aerial or other cumbersome accessories, will presently be realized.

Popular Radio's Chance to Render Service

Popular Radio can perform an important public service by helping to solve the problems of radio broadcasting. . . .

It is obvious that the only power which can establish adequate "rules of the road" is the Federal Government. Eventually we should have a national system, the cost of which would be maintained by taxing all stations according to their sensitivity. Before this can be secured, however, it will probably be necessary for private initiative to organize a system of high-calibre stations for broadcasting throughout the country, with an extensive system of membership and membership dues for receiving stations.

—J. W. MacCracken,
President, Lafayette College

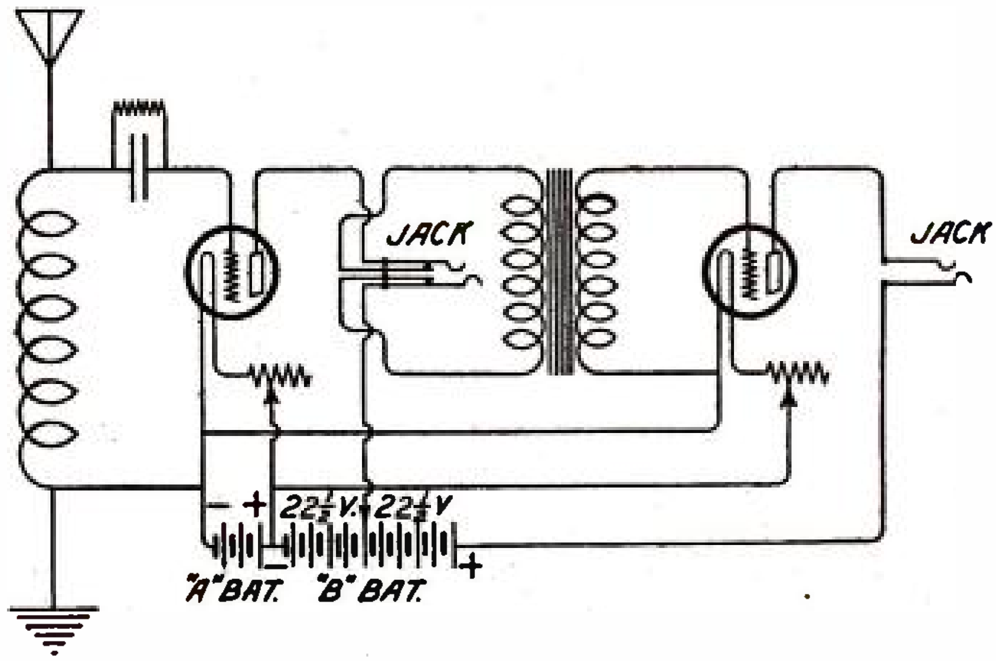


FIGURE 1

This is a circuit for adding one stage of audio frequency amplification to a straight audion detector circuit employing a tuning coil for tuning.

How to Make a One or Two-Step AUDIO FREQUENCY AMPLIFIER

The Eighth of a Series of Practical "How to Make" Articles for the Radio Amateur

By A. HYATT VERRILL

WHILE many radio enthusiasts make their own sets, which are fairly successful, many seem to think that they must purchase amplifiers ready-made. In reality, however, there is nothing mysterious, complicated or difficult about making an amplifier of one or two stages. In fact, a one-step amplifier is just as simple and easy to make as an ordinary tube set.

In making an amplifier the instruments cannot, of course, be made at home—the rheostats, audio frequency transformers and tubes are not devices which an amateur can construct. But there are, in addition, the wire binding posts, plugs and similar accessories, and the person who constructs his own amplifier has ample opportunity for exhibiting his skill and workmanship, both in the wiring work and in mounting the instruments on a panel or in a cabinet. There are, moreover, certain rules which must be borne constantly in mind when constructing an amplifier, or otherwise the device will not work efficiently.

In the first place, all connections *must* be tight and soldered; there should be no loose connections, no loose binding posts and no careless, sloppy work. Connections and joints which might pass unnoticed in a receiving set with just one vacuum tube will result in howls, squeals and other noises in an amplifier, for it must be remembered that sounds due to any loose connection or fault are magnified just as much by an amplifier as are the signals that should be heard. And the more steps there are the more these faulty sounds are magnified; hence the more carefully the instruments must be made.

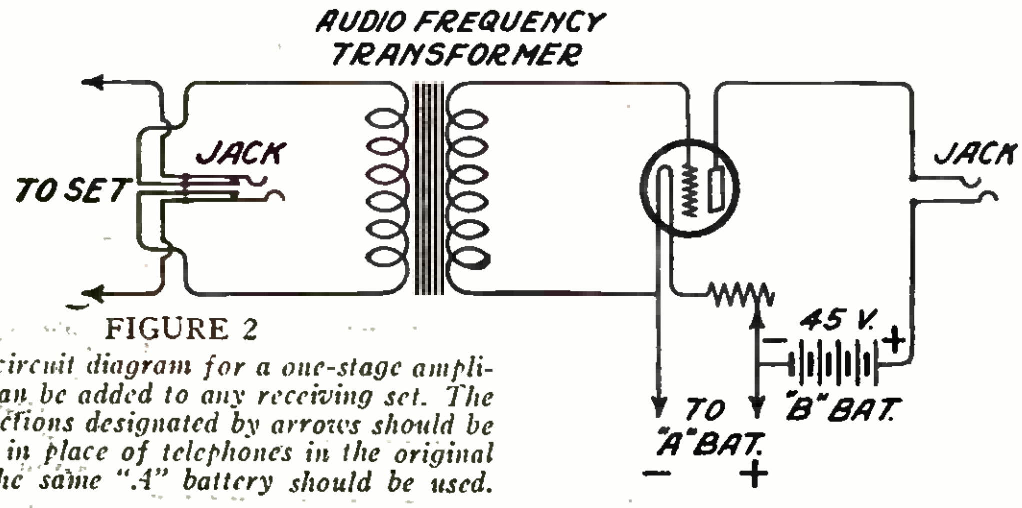


FIGURE 2

This is a circuit diagram for a one-stage amplifier that can be added to any receiving set. The two connections designated by arrows should be connected in place of telephones in the original set, and the same "A" battery should be used.

In the second place, if more than one stage of amplification is used, the iron cores of each successive transformer must be placed at *right angles* to the one preceding it. This is important in order to separate the magnetic fields.

In the third place, all wires should be kept as short as possible. They should not be run parallel if it can possibly be avoided, and where two wires cross they should be kept well separated.

The simplest amplifier to build is a one-step such as is shown in Figure 2. Although it is best to build it as a separate unit with a telephone jack attached to the wires which are led to the detector set, the amplifier may, if desired, be built on a single panel with the set, Figure 1. By using a jack as shown, the set can then be used either with one tube or with the amplifier using additional tubes. By merely inserting the telephone plug in the first jack, the contact with the amplifying transformer is broken and the detector tube alone is used, whereas, by removing the plug and inserting it in the second jack an additional vacuum tube is used as an amplifier. If a second stage of amplification is desired, it may be built exactly like the first and connected as shown in Figure 3. The amplifier may be arranged so that either the receiving set alone can be used or one or both stages of amplification, by merely inserting the phone plugs in the correct jack. When the amplifier is used in connection with the detector set, either the same *A* battery or separate batteries may be used; this is the case also with *B* batteries.

In using the amplifier, bulbs or tubes made for the purpose must be used; amplifying bulbs are practical for use as detector bulbs, but detector bulbs do *not* give as good results for amplifying. It should also be borne in mind that the only adjustment required in the amplifier is

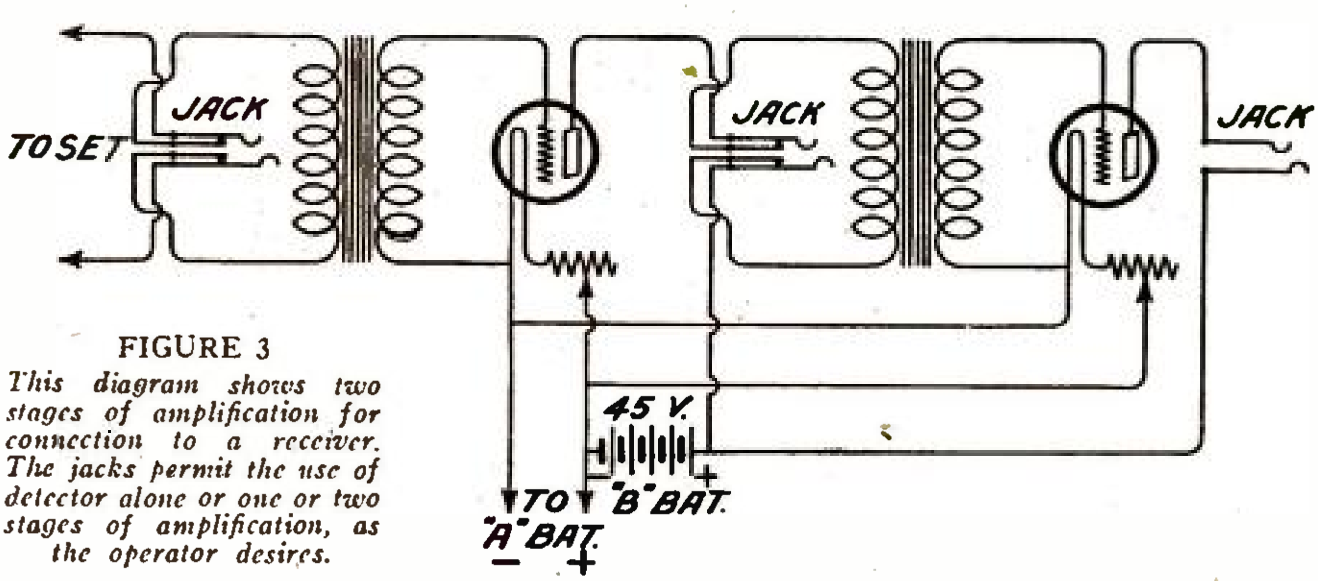


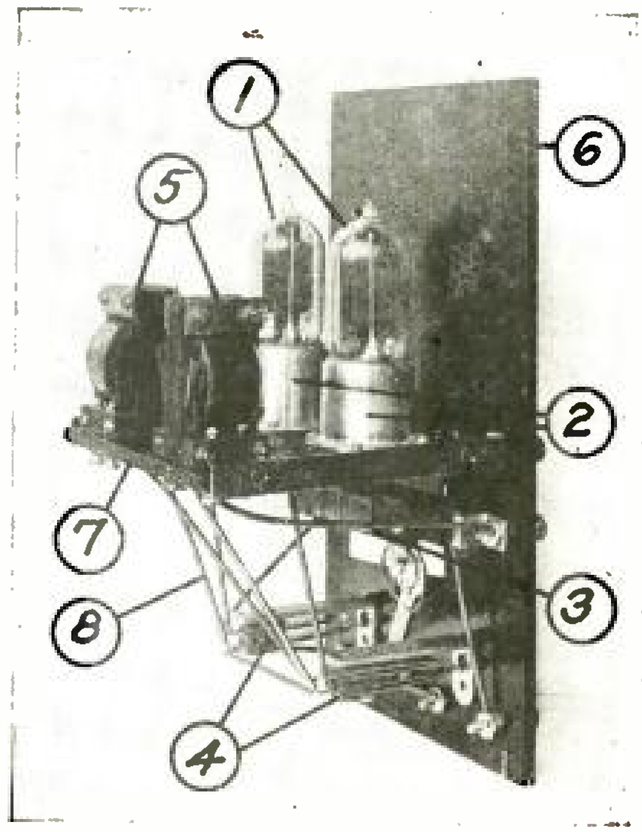
FIGURE 3

This diagram shows two stages of amplification for connection to a receiver. The jacks permit the use of detector alone or one or two stages of amplification, as the operator desires.

the rheostat, and that while amplifiers may be constructed with a single rheostat control for several tubes, far better results are obtained by having a separate control for each filament. Bulbs often vary in quality and, as a variation in the filament adjustment will result in a variation in sound volume, care should be exercised in keeping the filaments adjusted to the right degree of brilliancy.

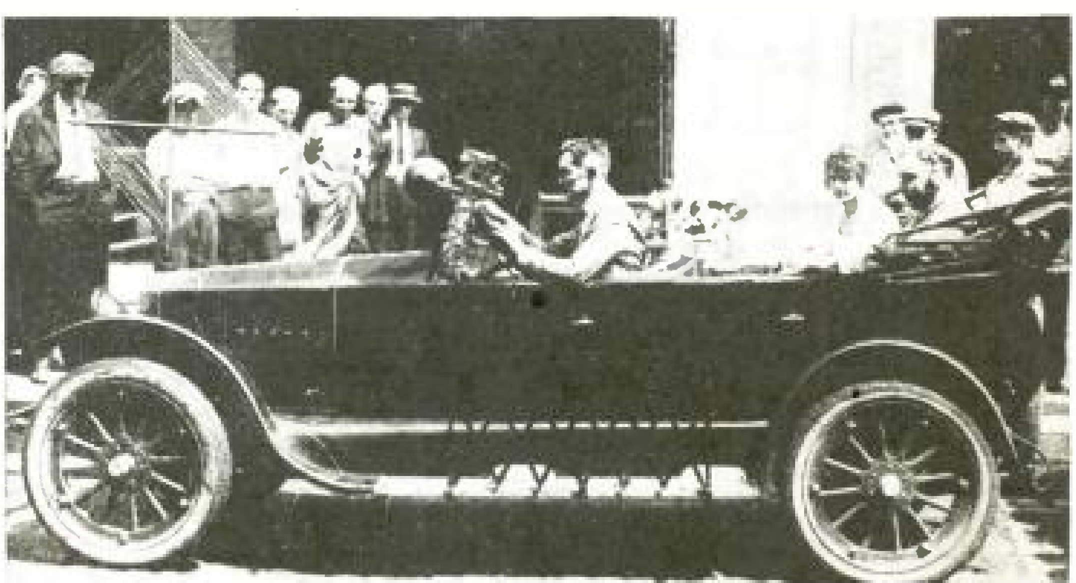
As a last word of advice, it should be remembered that each step of amplification magnifies greatly the received energy; therefore it can readily be understood how important it is that no undesirable sounds or noises, due to loose connections, come in. Of course, the amateur builder may make his set up on a board or in a cabinet as it suits his taste, but as long as the precautions outlined in this article are observed and the wiring diagrams followed in connecting up the set, good results will be obtained.

The accompanying photograph will probably suggest one solution to the amateur who is undecided as to the form in which to make the set.



HOW TO MOUNT THE SET

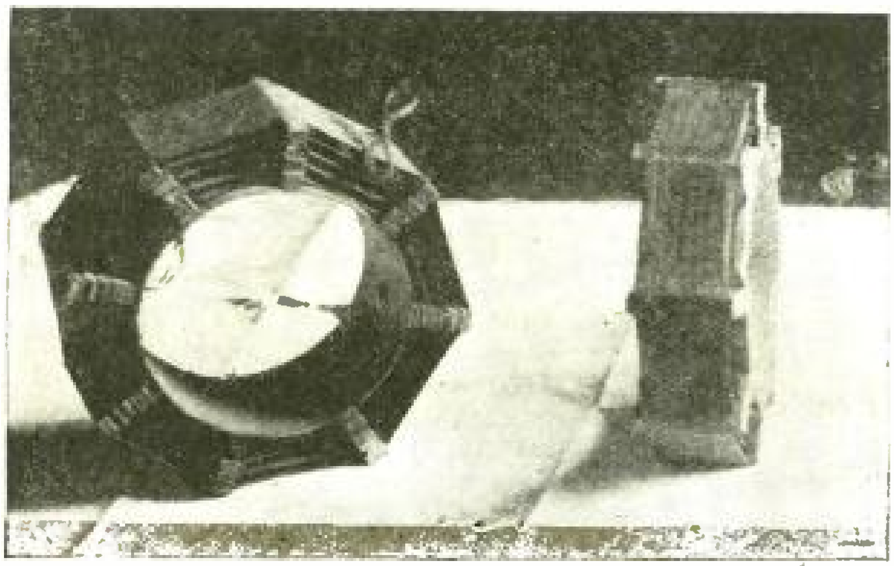
The parts are: 1, amplifying vacuum tubes; 2, tube sockets; 3, filament rheostats; 4, jacks; 5, amplifying transformers; 6, front panel; 7, shelf for mounting the instruments. The diagram for wiring this set is shown in Figure 5.



International

LONG-DISTANCE RECEIVING ON A MOTOR CAR

A Chicago radio fan, Paul D. Coats, has equipped his touring car with an Armstrong regenerative receiver and has placed his loop antenna out of the way on the radiator cap. While motoring about the streets of Chicago on his way to and from business he hears stations all over the country, some of them as far distant as Newark, N. J.



THIS OCTAGONAL COIL RECEIVES BOTH HIGH AND LOW WAVELENGTH SIGNALS

This type of inductance is simple to make, and makes possible the reception of high wavelength signals without using the more cumbersome simple layer coils.

A Home-Made Multi-Layer Coil

BY FREDERICK J. RUMFORD

A MULTI-LAYER coil which is much more efficient than the ordinary layer-wound coil and which is a rival of the honeycomb coil can be made easily at home and with little cost. Such a coil serves well in a regenerative set and can be used to advantage in other hook-ups where inductance is required.

The most practical size is wound on a form of cardboard or formica, preferably the latter, 3¼ inches in diameter and 1¼ inches in length.

Use No. 24 D. S. C. magnet wire and wind the first layer upon the form itself. The second layer is separated from the first by a gap of ¼ inch, made by eight blocks of cardboard ¼ inch square and 1¼ inches long, spaced evenly around the form. In winding the second layer, cross the wire back to where the first layer was started and continue the operation until six layers have been wound.

When the coil is wound, emerse it in parrafine kept at 100 degrees Centigrade until it ceases to bubble, then hang it up to dry. For a wavelength up to 360 meters the coil will require between 35 and 50 turns of wire. Coils for higher wavelengths require more turns. A coil is shown in the accompanying photograph.

With three such coils an efficient regenerative receiver can be made with but little cost. Place bands of fibre around the coils and attach them to blocks mounted upon hinges so that they will swing like honeycomb coils and make the coupling variable.

When one of these coils is placed in a circuit with 'phones, crystal detector and a variable condenser, as shown in Figure 1, it forms an efficient wavemeter. The coil can be calibrated with a standard wavemeter and a curve chart made to show the different wavelengths.

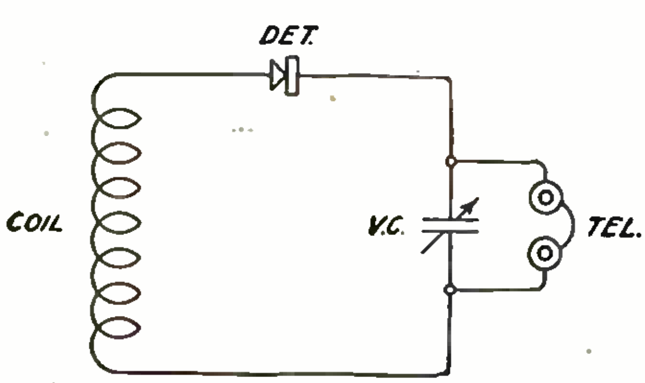
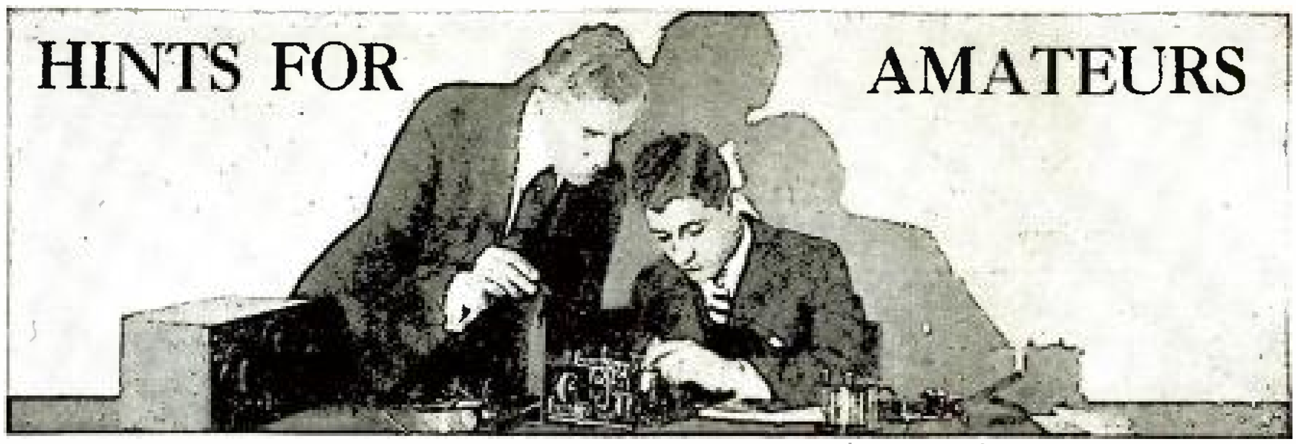


FIGURE 1

A circuit that employs a multiple-layer coil as a wavemeter inductance.

HINTS FOR AMATEURS



It is sometimes necessary for the amateur to bore holes in the edges of insulating panels in order to mount or attach them to another panel. The inexperienced fan often finds that it is almost impossible to do this well, as the panel splits when hte drill is applied to the edge.

The panel splits because the insulating materials are (most of them) built up of layers of impregnated sheets of paper, which are pressed together in a hydraulic press into a solid mass. If the amateur will put the panel in a clamp as shown in the diagram (Figure 1) so that the layers cannot separate while drilling, he will find that it is just as easy to drill into the edge as into the face of the panel.

* * *

In designing radio apparatus, for either sending or receiving, do not place high frequency instruments within the field of low frequency instruments or parts. If you do, they will interfere with each other. For example:

If an audio frequency amplifying transformer were to be mounted close up to a variocoupler or any other radio frequency tuning apparatus, it would seriously interfere with the tuning of the set. This is because the iron core in the amplifying transformer has a much greater "reluctance" than the air core of the tuner, and the iron thus being within the field of the tuner produces an effect similar to the addition of resistance in the coils of the tuner. The effect of reluctance in a magnetic circuit is somewhat similar to what resistance is in an electric circuit.

The radio frequency apparatus in a circuit should be separated from the audio or low frequency apparatus in the circuit and all wires of circuits of different frequencies should be kept well apart to prevent inter-action and inter-reaction between them.

* * *

Do not let the telephone cord droop off the table and come into contact with the top of the storage battery, as there is always more or less strong acid on the top of the battery which will eat away the cloth covering on the telephone cords and allow the wires in them to short-circuit and thus make a lot of crashing, crackling sounds in the telephones.

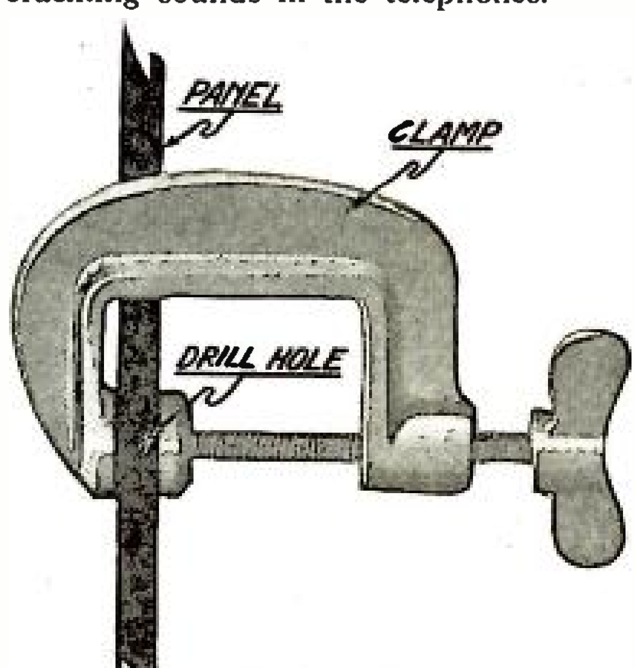
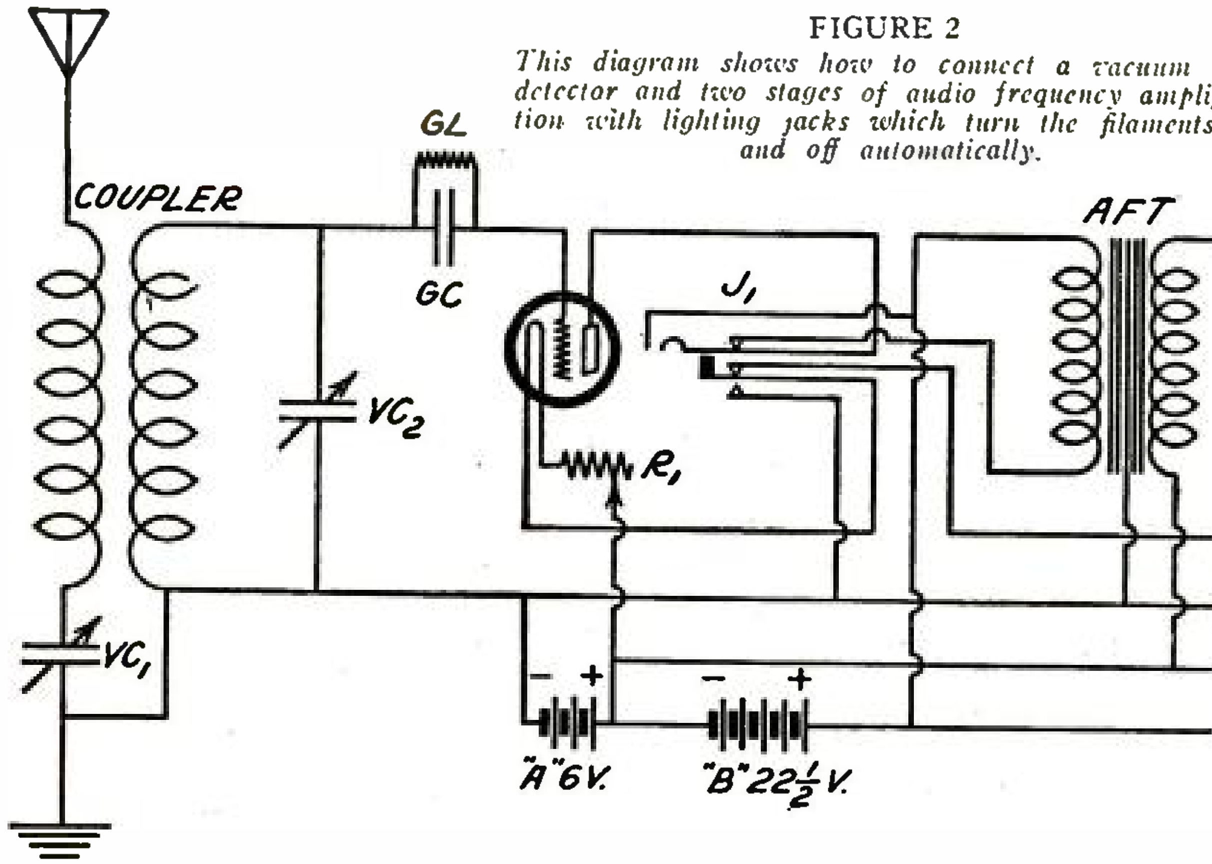


FIGURE 1

Use a small clamp such as this to prevent "splitting" when drilling in the edge of a panel.

FIGURE 2

This diagram shows how to connect a vacuum tube detector and two stages of audio frequency amplification with lighting jacks which turn the filaments on and off automatically.



IN BUILDING a home-made audio frequency amplifier, the amateur often experiences trouble from a phenomenon generally known as "howling." This is a peculiar effect produced by reaction between the successive stages of amplification, which results in loud whistling noises and squawks which drown out the signals. It may be prevented or eliminated by the observance of the following precautions:

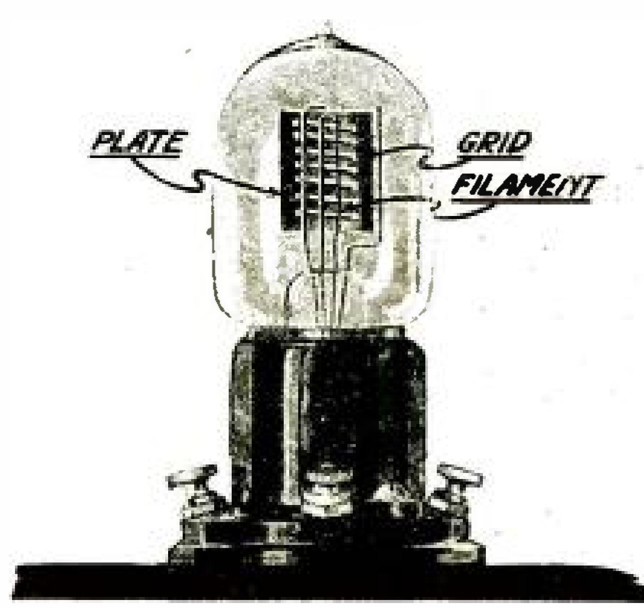
1—Place all the amplifying transformers in such positions that the iron cores upon which they are wound will be at right angles.

2—Ground all the iron cores of these transformers. See diagram on this page (Figure 2).

3—Try reversing the primary wires running to the transformers, listening in after each change until the correct connection is found and the amplifier functions without extraneous noises.

* * *

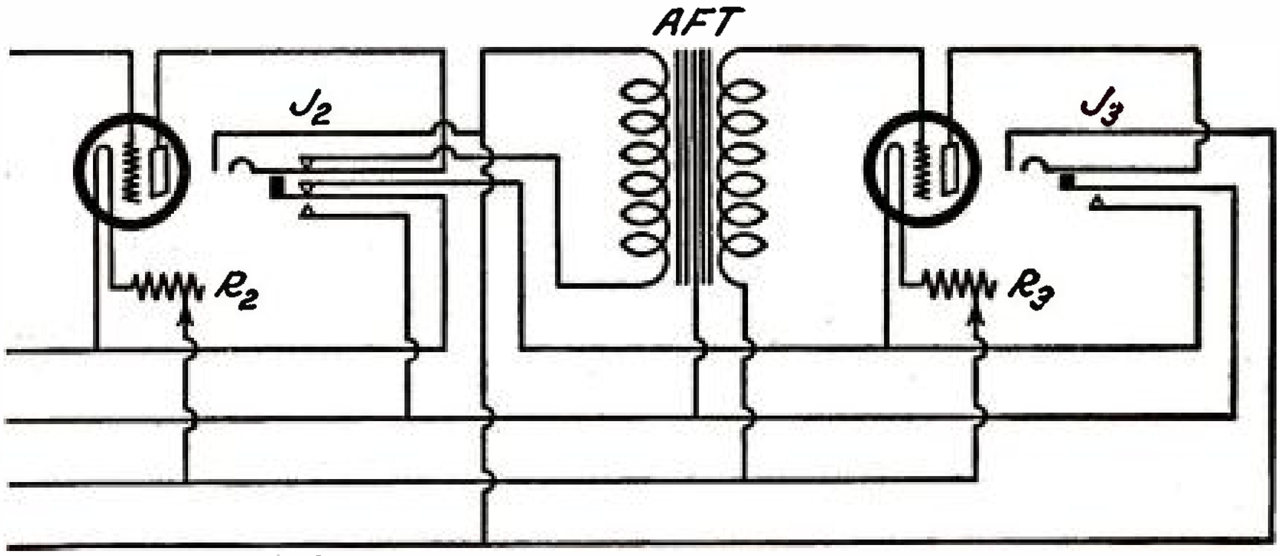
VACUUM tubes should always be mounted vertically. This is because the filament wires in most American tubes are supported vertically in the tubes. Tubes mounted horizontally, sticking out from the face of the panel, have their filaments strung horizontally, and they will sag and may finally lean down far enough to touch the grid, when the tube will become inoperable.



THE RIGHT WAY TO MOUNT A TUBE

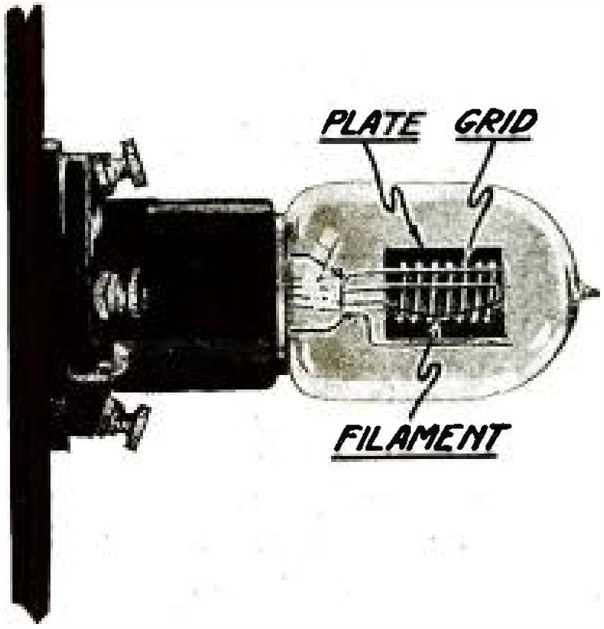
Tubes mounted in this position maintain the filament in a vertical position and eliminate the possibility of sagging.

Most experienced amateurs realize the advantages of using automatic-filament-lighting-jacks. These jacks are used to "cut in or out" the number of vacuum tubes used in a receiving set. When they are used with a detector and two stage amplifier, three jacks are necessary, one for the detector, the second for the first stage and the third for the second stage. The jacks for the detector and for the first stage are called "double-circuit jacks," and the one for the second stage is known as a "single-circuit jack."



The automatic jack has this one great advantage over the ordinary jack; it takes care of the complicated switching of the plate and filament circuits in a single action. When the telephone plug is inserted into the detector jack the filament of the detector tube automatically lights up; when it is inserted in the first-stage jack the two tubes light up; when it is inserted in the second-stage jack the three tubes light up; but when the plug is extracted all the tubes go out. The automatic jack in no way interferes with the proper action of the filament control rheostats.

Many amateurs and beginners who consider using this new type of jack are deterred by a glance at the terminals, which are six in number. The average amateur doubts that he would ever be able to find out where all the connections go. This will be easy if the diagram as shown (Figure 2) is followed. The jacks are designated as J1, J2 and J3.



THE WRONG WAY TO MOUNT A TUBE

Tubes mounted in this position are liable to cause the filament to sag and touch the grid, in which case the tube will cease to function.

* * *

Do not let your storage batteries run down dead, as this misuse will soon cause deterioration and the battery will be no good. When your battery shows signs of dropping, take it to the garage and get it recharged. Better yet, obtain a charging device and keep it always charged yourself by turning on the charger after you have used the set. The charging device will quickly pay for itself, as the battery lasts longer and you will save the money paid to the garage for charging.

WHAT READERS ASK

This department is conducted for the benefit of our readers who want expert help in unravelling the innumerable kinks that puzzle the amateur who installs and operates his own radio apparatus. If the mechanism of your equipment bothers you—if you believe that you are not getting the best results from it—ask THE TECHNICAL EDITOR.

THE flood of inquiries that has poured in upon the Technical Editor has not only furnished evidence of the need of this department: it has also necessitated a system of handling the correspondence that will insure the selection of and answer to only those questions that are of the widest application and that are, consequently, of the greatest value to the greatest number of our readers. Our correspondents are, accordingly, asked to cooperate with us by observing the following requests:

1. Confine each letter of inquiry to one specific subject.
2. Enclose a stamped and self-addressed envelope with your inquiry.
3. Do *not* ask how far your radio set should receive. To answer this inquiry properly involves a far more intimate knowledge of conditions than it is possible to incorporate in your letter.

In justice to our regular subscribers, the Technical Editor is compelled to restrict this special service to those whose names appear on our *subscription list*. A nominal fee of 50 cents is charged to non-subscribers to cover the costs of this service, and this sum must be enclosed with the letter of inquiry.

QUESTION: Would it be possible for me to use a hard amplifier tube for a short-distance C.W. transmitter? If so, what voltage "B" battery should I use on the plate of the tube? If you say that this will work I shall try it with the split-filament circuit.

J. B. DEVLIN

ANSWER: This will work. If you use with this circuit any one of the 1 watt hard amplifier tubes now on the market with a plate potential of 100 to 150 volts, you should be able to transmit at least 5 miles with an average antenna.

* * *

QUESTION: I want to build my own variable condenser of 43 plates, with a capacity of .001 mfd. Please give me a formula for calculating the sizes of the plates and the spacing I should use to get this capacity. I had in mind the idea of making the plates of zinc.

C. SANDERS

ANSWER: Here is the formula for calculating the capacity of a condenser:

$$C = \frac{\text{Area in sq. Cms.} \times (n-1) \text{ plates} \times k}{4 \times 3.1416 \times t \times 900{,}000}$$

Where C = capacity of the condenser in microfarads;
k = (1) for air dielectric
(6) for mica dielectric
and t = thickness of insulation in centimeters.

We suggest that you do not use zinc plates for the condenser, as they will bend and cause the condenser to short circuit. An aluminum sheet of a thickness of 1/32 inch will be satisfactory.

* * *

QUESTION: I am using a single circuit receiver with a WD-11 1½ volt tube working on a dry cell. Will I have to use a storage battery and larger tubes for an amplifier to add to this set or can I use two more WD-11's as amplifiers?

WILLIAM MACKENZIE

ANSWER: You may use the same type of tubes for your amplifier that you are using for your detector. It would be advisable, however, to connect two more dry cells in shunt to the one you are now using. *Do not connect them in series!*

QUESTION: Will it be possible for me to use spiderweb coils with a single circuit regenerative hook-up? If so, will you please give me the best hook-up and the proper number of turns to wind on the coils for wavelengths up to 600 meters?

G. K. HAIST

ANSWER: These coils will work satisfactorily with the circuit shown in the diagram in Figure 1. The primary coil should be wound with 40 turns of wire, with a tap at every tenth turn. This coil should be mounted stationary. The tickler coil should be wound with 60 turns and should be mounted on a hinge so that its position in relation to the primary coil may be varied by swinging, as a door swings on a hinge.

The other parts you will need for this hook-up are:

1 variable condenser, .001 mfd.
1 four-point switch
1 grid condenser, .0005 mfd.
1 grid leak, 1 or 2 megohms
1 telephone condenser, .001 mfd.
1 vacuum tube and socket
1 pair telephone receivers, 3000 ohms
1 filament rheostat, 6 ohms
"A" and "B" batteries

* * *

QUESTION: I want an authoritative opinion upon this puzzling question: A friend, who has a small crystal receiving set, is getting regularly the broadcasting programs from WJZ, KDKA, and also from Ohio stations. They come in clearly, as I have reason to know, as I have listened in with him repeatedly. There are a number of very sensitive, highly developed bulb receivers in his near vicinity, and I tell him that he is getting his long distance signals from the aerials of these stations which are re-radiating. To me it is clear that his location near the bulb sets is the explanation while he claims that it is his fine aerial, which is 100 feet long and 40 feet high. We want to know if what he claims is possible with a crystal set. The set has a wooden panel, variometer, variable condenser, a crystal detector and a buzzer test with a dry battery.

DR. CARL E. MEYER

ANSWER: We believe that your friend is receiving long-distance telephone stations direct. If he were hearing them through re-radiation from other nearby sensitive receiving sets, the reradiating set would have to be in a state of oscillation and it is not probable that this would be the case because the re-radiating station would then *not* be receiving the music clearly but accompanied by a distorting whistle. In the early days of amateur radio when the crystal detector was supreme (the vacuum tube not being in existence) distances up to 2000 miles were bridged by the "crystal."

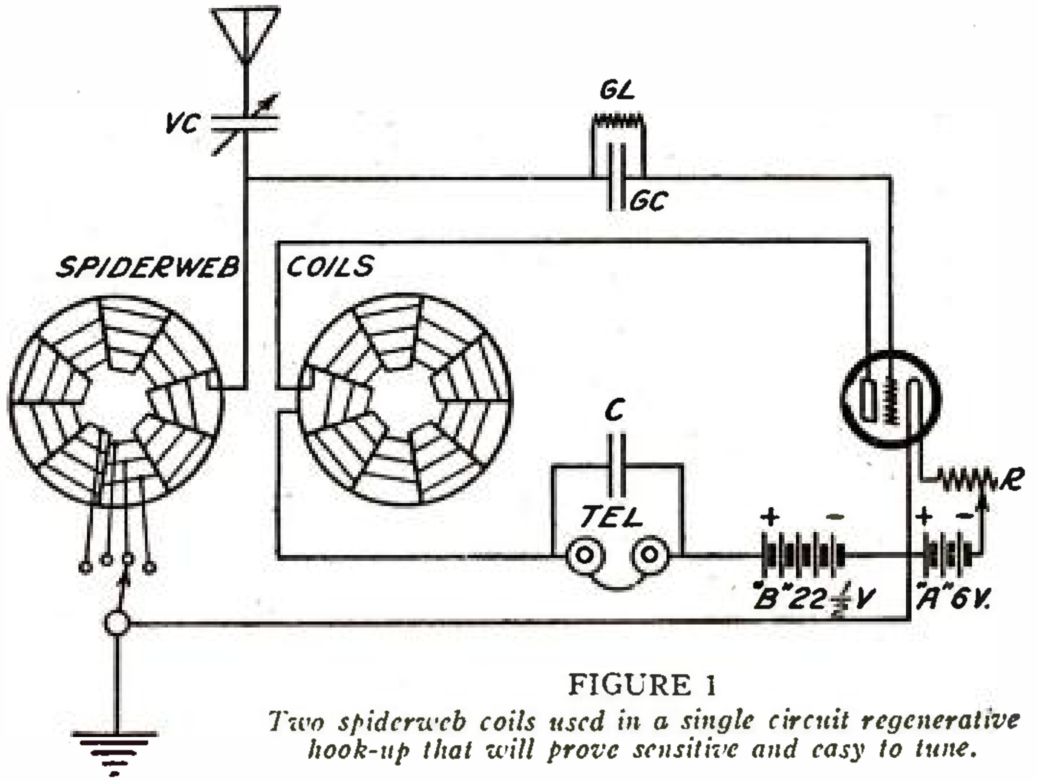
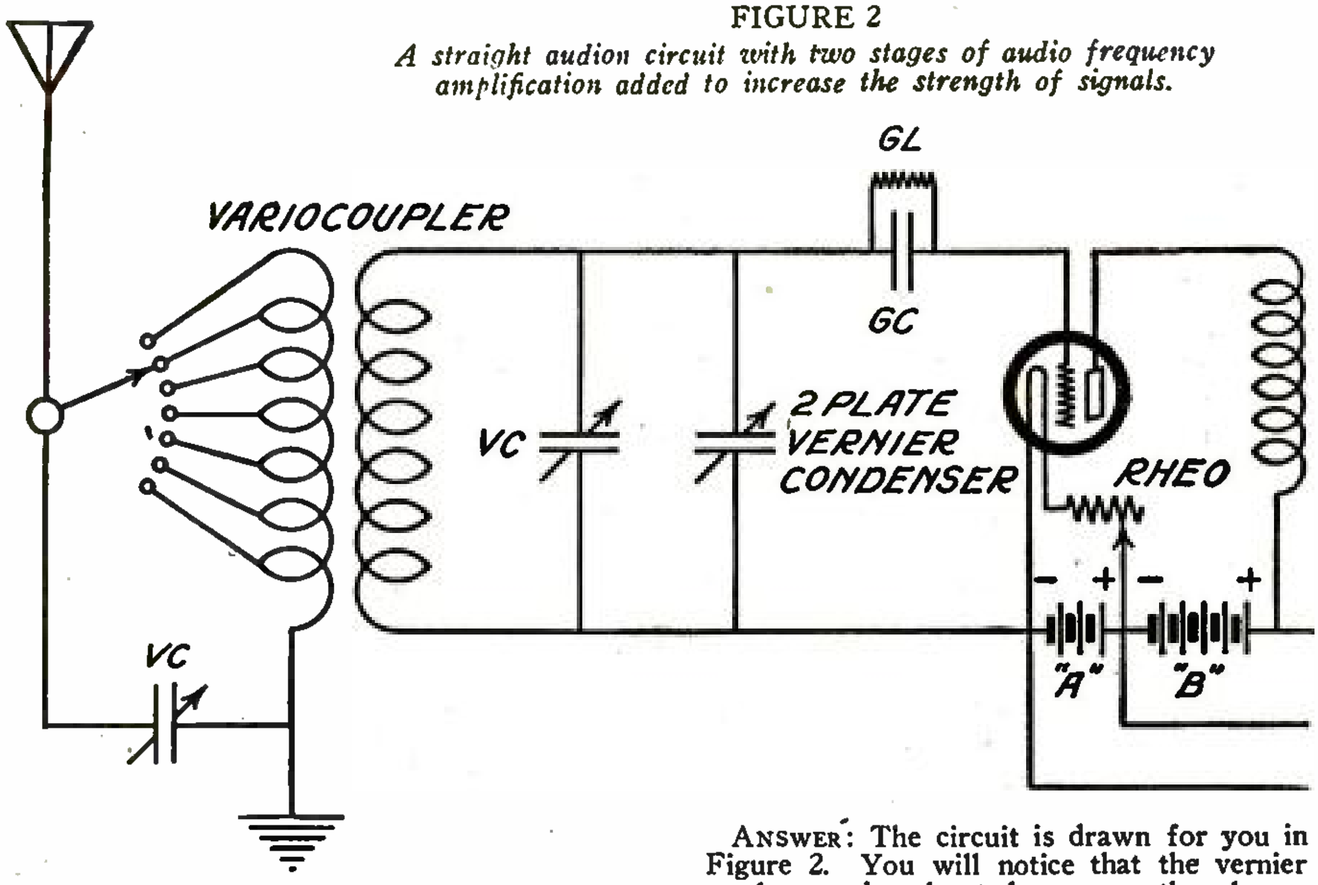


FIGURE 1

Two spiderweb coils used in a single circuit regenerative hook-up that will prove sensitive and easy to tune.

FIGURE 2

A straight audion circuit with two stages of audio frequency amplification added to increase the strength of signals.



QUESTION: I would like to obtain the diagram of a circuit which will give the best results with the following parts:

1—Horne variocoupler
2—variable condensers, .00055 mfd.
1—2-plate vernier condenser
2—amplifier transformers, type A-700
1—detector tube
2—amplifier tubes
3—rheostats
1—grid condenser
"B" batteries

MURRAY K. KITTREDGE

ANSWER: The circuit is drawn for you in Figure 2. You will notice that the vernier condenser is shunted across the larger secondary condenser to help tune the secondary circuit where finer tuning is necessary.

* * *

QUESTION: I have the following parts for a radio receiving set:

1 variocoupler
1 variable condenser
1 grid condenser and leak
1 detector vacuum tube
1 variometer
1 rheostat
"A" and "B" batteries

I would like to make a regenerative set with these instruments. Will you

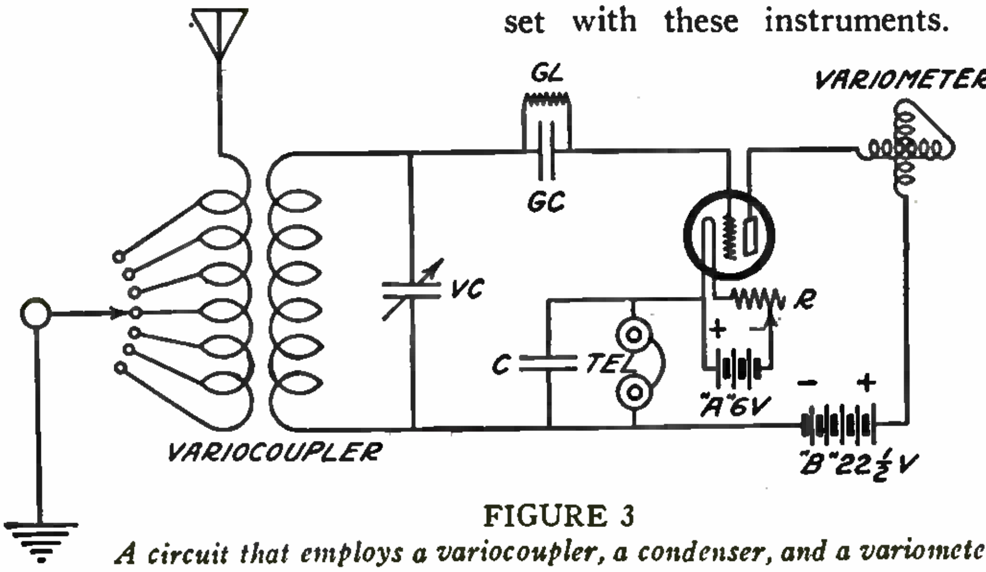
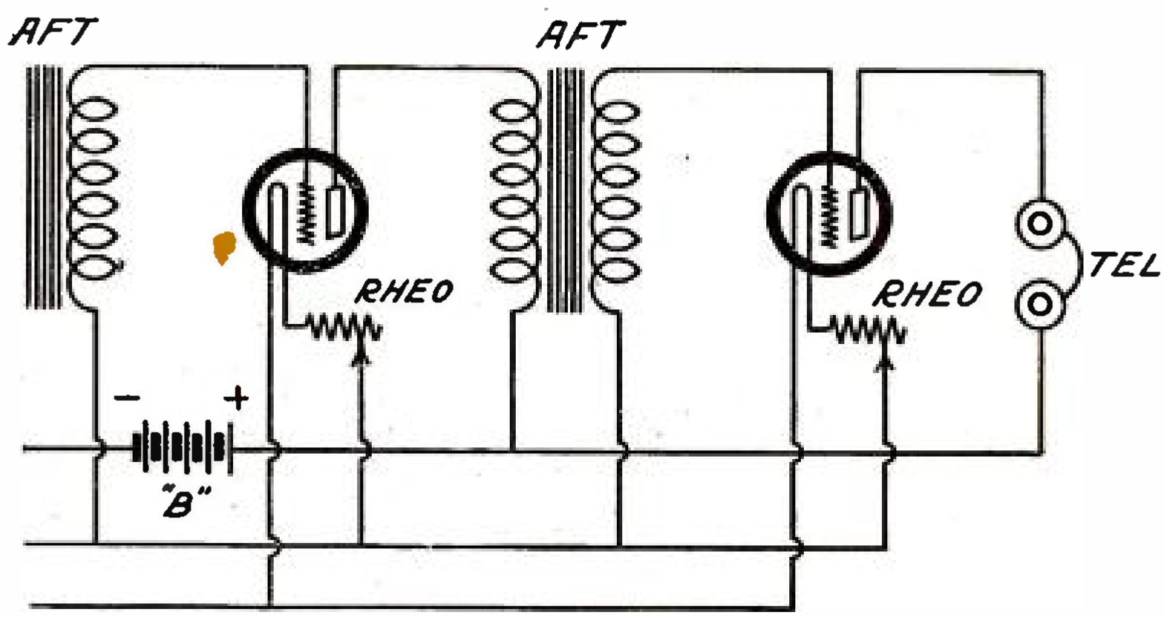


FIGURE 3

A circuit that employs a variocoupler, a condenser, and a variometer.

kindly make me a diagram that will enable me to use them?

E. DEVEREAU



ANSWER: The hook-up shown in Figure 3 will help you. It is sometimes necessary to put a fixed condenser across the telephones in order to get the set to oscillate. This condenser is shown in the diagram as C. The primary circuit is tuned by means of the taps on the variocoupler. The secondary circuit is tuned by the variable condenser, and the regeneration is controlled by means of the variometer. This circuit will tune much sharper than the ordinary single circuit tuner and will be just as simple to construct at home with the ordinary household tools.

QUESTION: Please tell me how to add one stage of amplification to the circuit on page 192 in Mr. Hogan's article in the November issue. I would like to use jacks in each stage.

F. V. KRISTELLER

ANSWER: Consult the hook-up given in Figure 4. This circuit will bring in the distant signals, and will be found simple to tune.

All tuning is done with the taps on the primary coil and with the variable condenser. The regeneration is controlled by rotating the secondary coil, which serves as a tickler. It is advisable when tuning this set not to allow the set to oscillate or it will reradiate and cause interference.

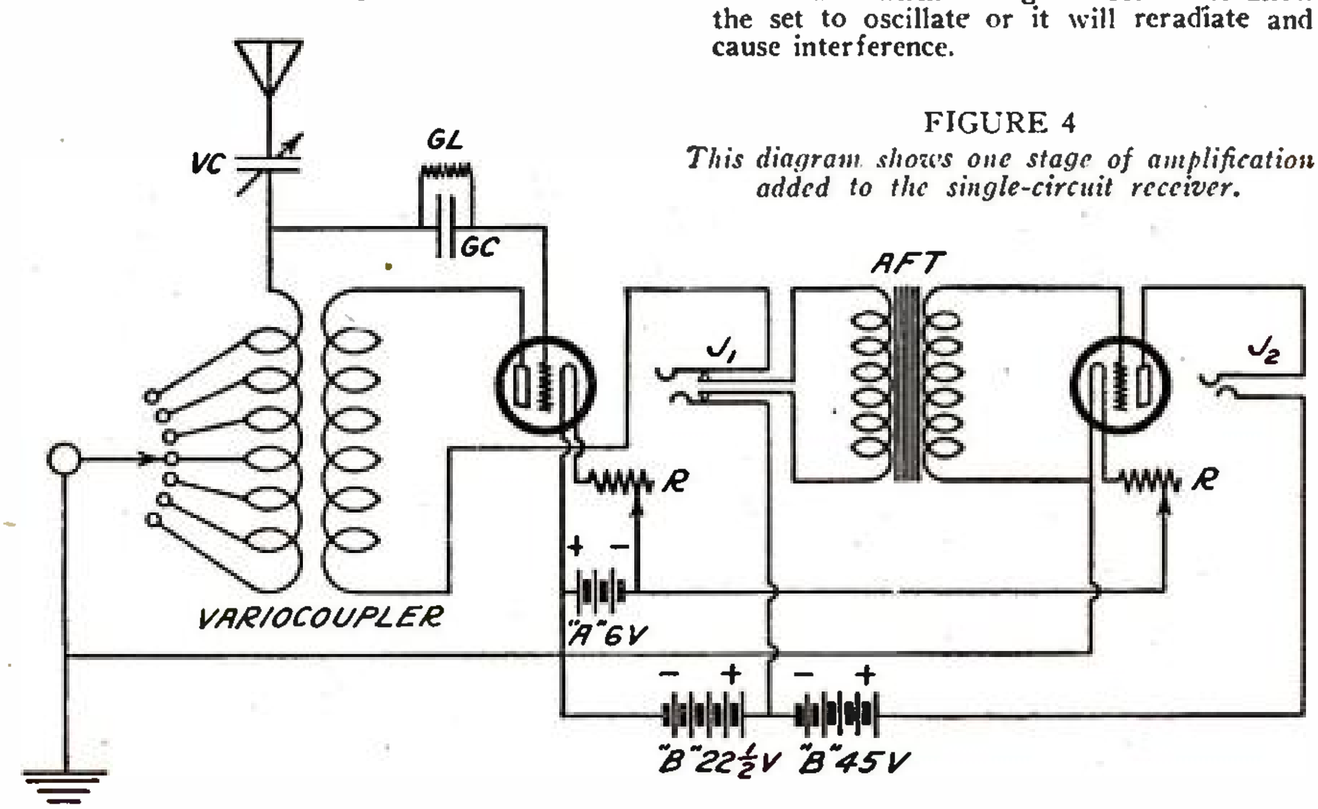
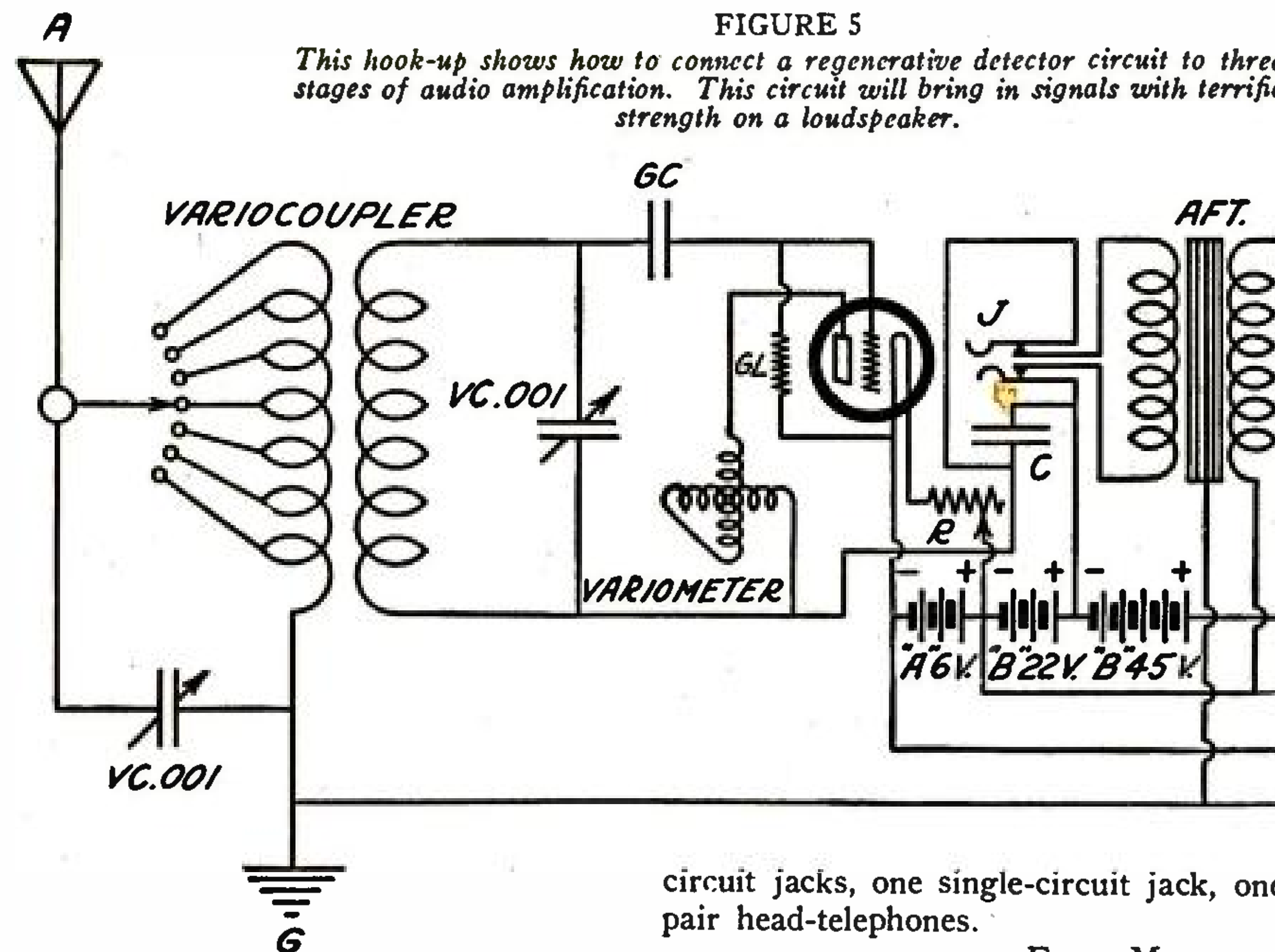


FIGURE 4

This diagram shows one stage of amplification added to the single-circuit receiver.

FIGURE 5

This hook-up shows how to connect a regenerative detector circuit to three stages of audio amplification. This circuit will bring in signals with terrific strength on a loudspeaker.



QUESTION: Please show me how to connect up the following instruments in a regenerative circuit with three stages of audio frequency amplification, with jacks for each stage: One variocoupler, two variable condensers, one grid condenser, one grid leak, one variometer, three amplifying transformers, four rheostats, four vacuum tubes (hard), three double-circuit jacks, one single-circuit jack, one pair head-telephones.

FRED. MILLER

ANSWER: In Figure 5 you will find a diagram that employs the instruments you have on hand. A grid condenser of .0003 to .0005 mfd. capacity should be used with a grid leak of one or two megohms.

* * *

QUESTION: Kindly give me a diagram of the simplest hook-up that can be used with a straight audion circuit, employing a variocoupler.

LESTER ADAMS

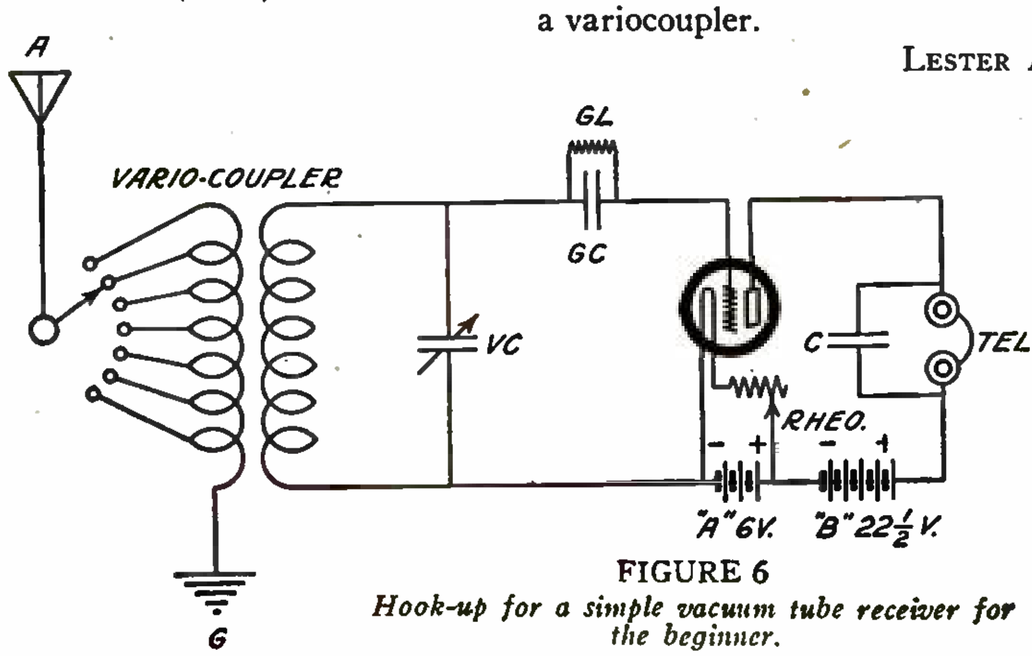
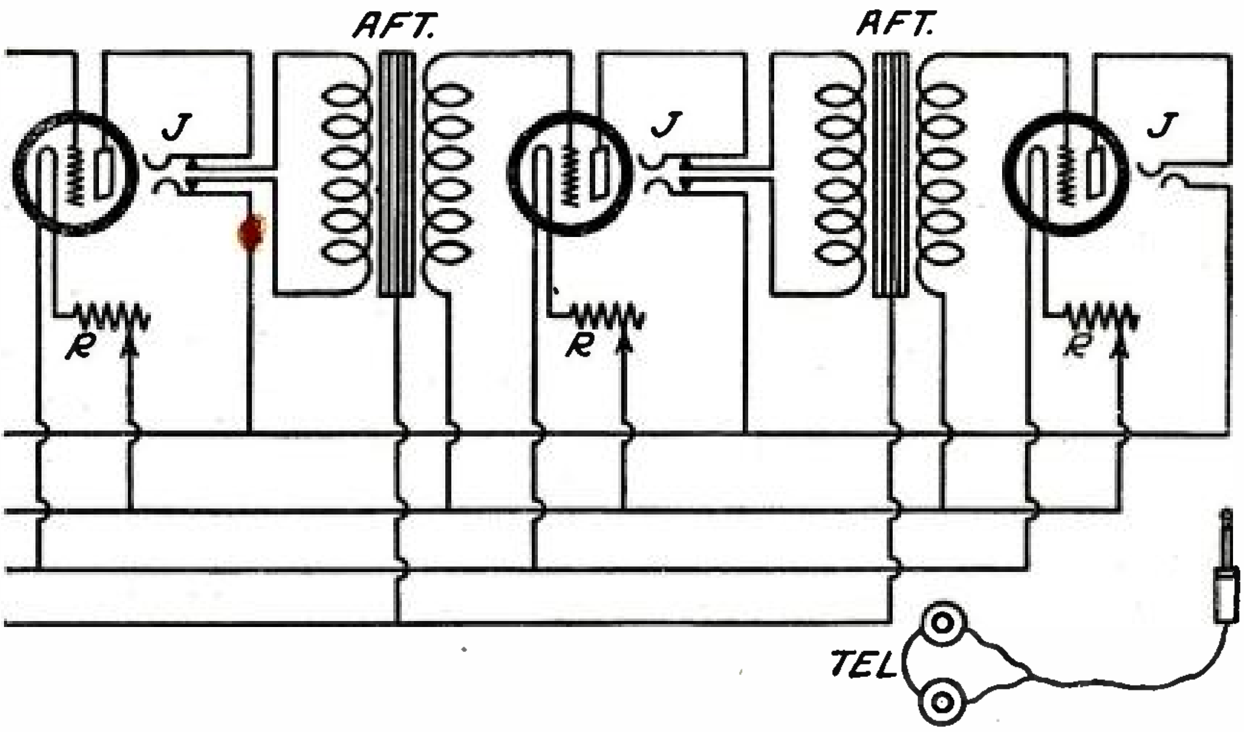


FIGURE 6

Hook-up for a simple vacuum tube receiver for the beginner.

ANSWER: This hook-up is shown in Figure 6. All tuning is accomplished by means of the tapped primary of the variocoupler and the variable condenser VC. The parts desig-



nated as GL and GC are, respectively, a grid leak and a grid condenser. The condenser C is a telephone condenser. This circuit while not regenerative will bring in musical programs clearly and with no difficulty of adjustment. By adding a variometer in the plate circuit it can be made regenerative.

QUESTION: I have a circuit like that shown in Figure 4, page 212, of the November issue of POPULAR RADIO, and I would like to add one stage of audio frequency amplification to it. Will you please draw me a diagram showing how to connect it up?

L. F. SELF

ANSWER: The diagram in Figure 7 gives you the hook-up you require. You will need the following additional apparatus:

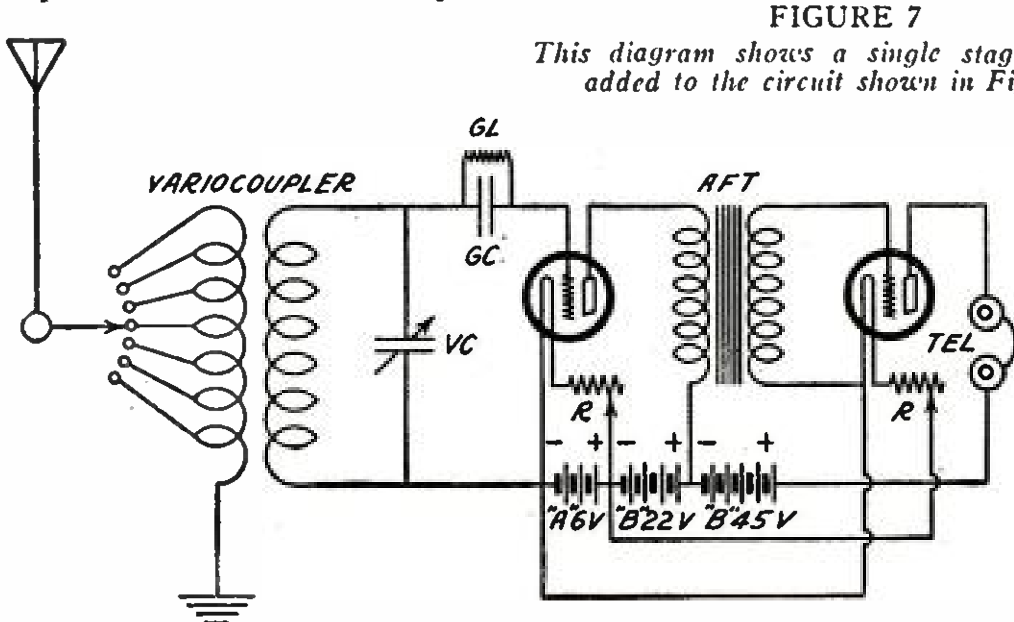
1 audio frequency transformer
1 vacuum tube amplifier and socket
1 filament rheostat
2 "B" batteries, each 22½ volts

You will find that this addition to your set will greatly increase the volume of the received signals.

However, if you add a second stage of audio frequency amplification you will obtain a signal of still greater volume.

FIGURE 7

This diagram shows a single stage amplifier added to the circuit shown in Figure 6.



ITEMS *of general interest that you ought to know; bits of useful information that every radio fan ought to know.*

A French Amateur Is Picked Up by an American Amateur

THE first American amateur to pick up a radio signal from a French amateur is Gene E. Witham, of New York. On the night of December 26, 1922, he heard station 8AB, operated by Leon Deloy of Nice, France. The American, who is a sixteen-year-old schoolboy used a single-tube detector instrument only.

* * *

$5000 for Broadcasting Copyrighted Songs

THE American Society of Composers, Authors and Publishers has decided to charge fees ranging from $250 to $5,000 to radio stations that broadcast songs and musical selections. The fee will be fixed by the Society, according to the broadcasting station's location.

* * *

Ocean Liners Establish a Radio Letter Service

INAUGURATION of an "ocean letter service" aboard Shipping Board vessels, providing facilities whereby messages from a ship bound in one direction can be transmitted by radio to a ship bound in the opposite direction, and mailed by the receiving ship upon arrival in port, was announced recently by the board officials.

* * *

A Plan to Standardize Radio Sets

YOU will be able to buy a standardized, rated and tested radio set if the conference called in New York by the Bureau of Standards is successful. Representatives from technical organizations and manufacturers interested in radio will discuss methods of standardizing radio receivers in a manner similar to fire extinguishers, automobile tires and other products.

* * *

The First American Amateur to Span the Pacific

THE first signals from an American amateur radio station have crossed the Pacific. A radio operator on board a ship only 120 miles off the coast of China has reported to the American Radio Relay League that he picked up the signals of a member of that organization.

This achievement reinforces the successful trans-Atlantic radio test.

A New Long-Distance Broadcast Record

A NEW long-distance broadcasting record was hung up not long ago by station KDKA of East Pittsburgh, Pa., when one of its concerts was picked up by E. G. Osterhouldt, radio operator on the steamship *J. A. Moffett*, 5,000 miles away, off the coast of Peru.

* * *

A Mail Plane Is Saved by Amateurs

LOST in a fog over Lake Michigan, and with his gas almost exhausted, the pilot of a government mail airplane recently sent out a Q S T (general call) to ask any radio station who heard to telephone the Mayfair landing field and send up rockets. Shortly after, rockets were piercing the fog bank and the lost aeronaut made a safe landing. Six different amateurs had caught the message.

* * *

For the Student Who Forgets to Write Home

FROM Princeton comes the report that the radio club organized among the students has undertaken to transmit to any part of the country, without charge, messages from the undergraduates of the university—an undertaking that is made possible by the cooperation of radio amateurs in relaying messages that they pick out of the ether nightly.

* * *

The Shortest Wave Ever Produced

Radio waves only one-fiftieth inch in length, identical to the longest of heat waves, have been produced at the Nela Research Laboratories in Cleveland, Ohio, by the aid of instruments more sensitive than heretofore available. This phenomena was created by Dr. Ernest Fox Nichols and Dr. J. D. Tear.

The achievement marks the joining of the electric wave and heat wave spectra. In this latest proof of the identical character of light, heat and electric waves, these physicists were successful in using two different types of electric wave receivers to detect and remeasure the long heat waves, about one-third of a millimeter, that were obtained by Rubens and Von Baeyer in 1911 from a quartz mercury arc.

Ordinary radio transmission is by electric waves from 200 meters to 15,000 meters (aboht ten miles) in length. The half-millimeter (or one-fiftieth of an inch) wave produced by Drs. Nichols and Tear are the shortest ever produced.

* * *

Applause Travels 3,000 Miles by Radio

The destiny of radio as an angel of international peace was given a remarkable demonstration a few weeks ago when the singing of hymns by a chorus in America was picked up by a schoolteacher, J. E. Samuels, in Wales; later in the same (Sunday) evening he picked up other parts of a program, including numbers on the City Symphony concert at the Century Theatre in New York, which was broadcast from station WJZ in collaboration with Popular Radio. Mr. Samuels reported that he clearly heard the applause that followed the numbers on the program.

* * *

What Amateur Can Beat This Record?

Communicating with thirty-one stations and being heard by ninety-two stations at distances over 100 miles away in a single night is the record of amateur radio station 1CCZ, owned by Edward C. Crossett and operated by W. A. Remy, located at Wianno, Mass. Stations as far away as the Pacific Coast, the Gulf and distant parts of Canada were worked, and every one of the nine radio districts of the country were reached. This is believed to be a record for one night's work.

* * *

The World's Champion Crystal Receiver

A few weeks ago Joel Owen, a farmer who lives near Huntsville, Missouri, read the Bureau of Standards' specifications for building a small crystal receiving set—the set that was described in detail in the May, 1922, issue of Popular Radio. He built the set as described at a cost of $14, and surprised himself as much as the radio experts by picking up signals from Schenectady, New York—about a thousand miles away! So far as is known, this is the world's record in broadcast reception for a crystal set, which usually has a range of fifteen or twenty miles only.

* * *

Carols from Christmas Trees

Song birds in human guise figuratively perched among the branches of the huge Christmas tree erected in Madison Square park, New York, during the holiday week festival. These song birds were selected from among the prominent concert singers, and they actually did their bursting into song from station WJZ. Receiving sets installed in the tree created the impression upon the uninitiated that the singers were actually hidden among the boughs.

* * *

Two Amateurs Send Radio Messages Over 7,000 Miles

All records for amateur radio long-distance tests are believed to have been broken when a letter was received December 18, 1922, by the American Radio Relay League from the radio operator of a steamship in the Pacific, announcing that he had received two radio messages, both from amateurs approximately 7,000 miles away.

The league stated that the two messages were sent by William D. Reynolds of Denver and A. C. Hemrick of Aberdeen, Wash.

* * *

Imported Yankee Accent from a Cigar Box

Receiving sets made within cigar boxes are of unfailing interest to amateurs. One of the most remarkable reports of the capacities of these miniature receivers comes from Paris; it states that J. L. Luntley, an amateur who lives in the suburbs of Colombes, in the Department of the Seine, picked up on the night of December 25th, 1922, the voice of an American who was talking in Iowa, U. S. A., and that the Yankee accent was distinguishable!

* * *

The Speed of Radio

Some slight conception of the speed at which radio waves travel (183,500 miles a second) may be derived from the fact that it would take five hours and forty-one minutes for the sound of a cannon to travel, say, from Detroit to Hawaii—assuming that such a great noise could be made. By radio the music of a concert broadcast by WWJ, Detroit *News*, not only could, but recently did reach A. F. Costa, the postmaster at Wailuku, Hawaii, in about one-fiftieth of a second. Wailuku is approximately 4,400 miles from Detroit.

Underwood & Underwood

LISTENING IN ON THE *GALENA PERFECTOS*

The education of the radio fan is not really completed until he has built at least one miniature receiving set—preferably in a cigar box. The crystal set shown above was entered in a contest by Ben Davis, of New York.

Amateurs Locate Snowbound Trains

WHEN a tremendous snowstorm swept Wyoming and Colorado early this winter and destroyed wire communication, trains No. 29 and No. 30 of the C. & S. Railroad got stalled somewhere out in the drifts. The dispatcher at Casper could not get Denver; in the emergency he turned to the radio amateurs for help. Through the good work of 7ZO at Casper, 9ANG at Kansas City and AD7 at Fork Crook, Omaha, the dispatcher at Denver was finally reached; the missing trains were then located and help was sent to them.

* * *

316 *American Amateurs Are Heard in Europe*

A YEAR ago only thirty-three American amateur stations succeeded in getting across the Atlantic in the test conducted by the American Radio Relay League. Final reports of the recent test show that 316 American stations were heard in Great Britain, France and Switzerland—only six less than the total number of amateur stations that qualified for the final tests.

* * *

Radio Waves Penetrate 125 Feet of Rock

RADIO messages were received recently through 125 feet of soil, shale, sandstone and slate by Bureau of Mines officials in the experimental mine operated by the Government near Pittsburgh. The new use of radio is expected to effect a revolution in the methods of rescuing entombed miners.

"We are trying," said James W. Paul of the Bureau, "to find out if communication can be established with miners who are a mile or more under ground, through the covering of rock, usually at least several hundred feet thick. Fire and other accidents easily put a telephone line out of service, but if radio communication can be maintained we will always have a way of reaching men quickly."

© Kadel & Herbert

A FIRST-AID RADIOPHONE

This portable inductive radio set, designed for rescue work in mines, caissons and submarines, requires no ground or aerial, and the entire electrical power is furnished by small dry batteries. The inventor, Bernaye Johnson, reports that he has taken his apparatus 200 feet down into a coal mine and was heard clearly on the surface of the earth.

* * *

The First Amateur Signal to Come from England?

WHAT are believed to be the first radio signals from English amateurs to be picked up by American amateurs have been reported by A. B. Tyril, of Riverhead, New York, and F. Kral, of Washington, D. C. The signal, 2 F2, was transmitted by the Manchester Wireless Society of Manchester, England, on the night of December 22, 1922. The reception of the signals by the two Americans was promptly reported to the American Radio Relay League of Hartford, Conn. It is possible that this is the first recorded instance of an amateur signal to reach this country from across the Atlantic.

* * *

What Radio Is Doing to the Small Church

FROM its very earliest days POPULAR RADIO has been pointing out how the introduction of radio into the home is destined to have a profound effect upon the church organizations. That effect is now being felt. Authorities of the Episcopal, Methodist and Presbyterian churches are reporting that many of the churches in the small cities and towns are facing ruin, as their former parishioners are now staying at home and are listening to the better sermons and the better music that is being broadcast from the large centers. The result is that the former churchgoers are gradually withdrawing their financial support from the local church.

One Presbyterian church in Trenton recently complained that its people preferred Episcopal service by radio to Presbyterian service in the church; thus sectarian troubles are added to the financial distress of the harassed pastors!

* * *

Running Down Criminals by Radio

BROADCASTING information about fugitives, even to the extent of eventually broadcasting their portraits and fingerprints, may become an established feature of our police system if Attorney General Daugherty's plans are carried into effect for the creation of a National Bureau of Identification and Information. William J. Burns, Chief of the Bureau of Investigation, foresees the development of the idea on a world-wide scale.

Help your neighbor. If you have discovered any little Kink that helps to eliminate trouble in your radio apparatus, or if while experimenting with the connections of your set you should run across some interesting phenomenon, or if you should discover some new hook-up that gives better results—send it to the "Listening In" page.

The Pending Radio Legislation in Washington

As this issue of Popular Radio goes to press, the fate of Congressman White's Radio Bill (H.R. 11964) is still pending—with prospects for its passage during the present session of Congress. It was unanimously reported out by the House Committee and was scheduled for early action. If the bill is acted upon favorably in the House, Senator Kellogg will attempt to secure the co-operation of his colleagues in putting this much-needed legislation through before he retires on March 4th.

The bill is of special interest to radio amateurs because of the proposed changes in the wavelengths assigned to them. It strikes from the existing law the words "200 meters," and provides that "the wavelengths for amateurs shall not be less than 150 meters nor more than 275 meters." This change, which was desired by the amateurs, has the approval of the conference and of the committee. The amateur is the only user of radio to whom a definite assignment of wavelengths is made in the law itself; other wavelengths are allocated by the Secretary of Commerce. The committee apparently recognizes the value of the service which the amateur is rendering in the development of the radio art and in the training of skilful operators, and feels justified in continuing this special recognition, which is given to them.

While little opposition to this bill is anticipated, nevertheless much helpful legislation has been lost in the past because of lack of public interest and insistence.

If the radio operators and fans want the White Bill passed this session, they must indicate their desires to their representatives in Congress.

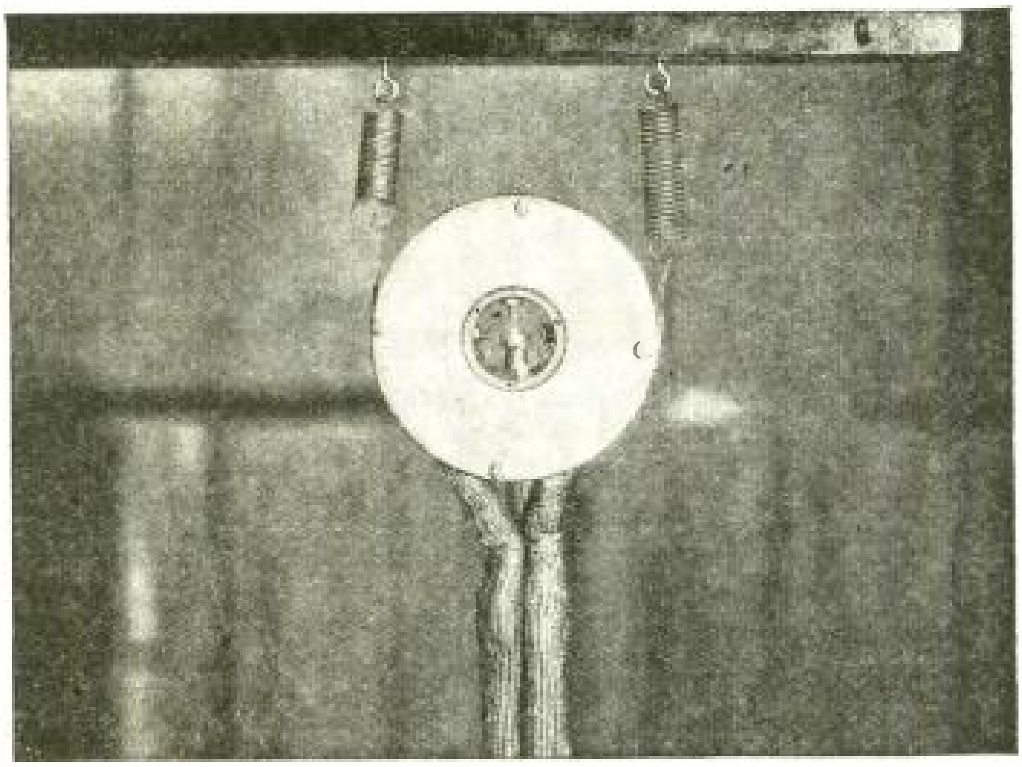
If you have not yet acted upon this suggestion, do so today. Send your Congressman and your Senator at Washington this message:

"I favor the radio bill H.R. 11964."

If the bill is not passed this session, new measures will have to be introduced in the next session of Congress, which does not organize until this coming December.

It may be gratifying to the readers of Popular Radio to learn that their active support of this magazine's efforts to get action on this bill and their response to its appeal to write to their representatives in Washington (as urged in the January number) has brought gratifying results, and that Popular Radio's bound volume of letters from the foremost radio scientists, manufacturers and dealers, which Paul Godley brought to the Capitol, was a prominent and important feature of the hearings.

A further report of the progress of this bill will be furnished by Paul Godley in the next issue of this magazine.



Westinghouse

A MICROPHONE BUILT ON AN ENTIRELY NEW SCIENTIFIC PRINCIPLE

This unique device literally "catches sound with an electric spark." A high voltage glow discharge takes place continuously between the upper electrode (in the inner circle) and the lower shielded electrode. The bright portion of the discharge is covered by a cylindrical shield and only the dark portion, known as the "Faraday space," is exposed to the sound waves to be recorded. As these waves pass through this space they control the amount of current flowing in the discharge, and thus modulate the current in perfect conformation with these waves.

The Remarkable New "Glow Discharge" Transmitter

WHAT is regarded by radio experts as the most efficient transmitter thus far developed is announced for the first time in POPULAR RADIO by courtesy of the Westinghouse company, in whose research laboratory in Pittsburgh, Dr. Phillip Thomas, the inventor, has been conducting his experiments. The effect of this new transmitter upon broadcasting and the significance of its departure from the scientific principles on which transmitters have heretofore been based is described briefly in the following report of the Technical Editor; a more extended notice of the device will appear in a later issue:

Even in the best microphones heretofore developed some of the richness and color of the musical tones has been lost. The trouble has lain in the diaphragm—a little disc of metal which is supposed to vibrate when sounds are impressed against its surface. It is practically impossible to construct a diaphragm which will respond to extremely low tones and high tones at the same time; every vibrating object has a natural period of vibration and responds to impulses of this frequency to the exclusion of vibrations which differ to any extent from it.

Dr. Thomas has rejected the diaphragm as a pick-up device on account of this inherent incapacity to reproduce intricate sound values. After many months of research he has evolved a new device, known as "the glow discharge" transmitter. This new device has no natural period and reproduces tones running from a frequency of 60 to 6000 with absolute truthfulness. Any combination of these frequencies, such as employed in musical instruments, are recorded with naturalness and purity.

During continuous tests at KDKA Pittsburgh, the new transmitter has demonstrated its worth and capacity. The principle of the transmitter is that of the impression of the sound waves on a high-potential low-current discharge between two electrodes, which changes the resistance of the arc column and so controls the electric modulator current.

The development of this device is a forward step in obtaining better broadcasting, as the music transmitted by a station using the device will be true to life and colorful.

LAURENCE M. COCKADAY

NEW PRICES ON
"WORKRITE"

WORKRITE SUPER 180° VARIOCOUPLER

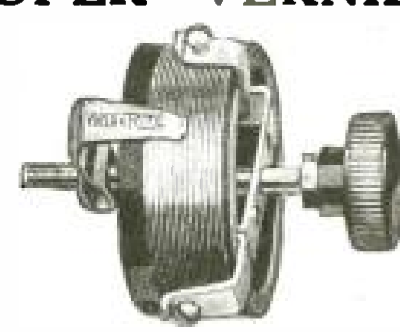
Prices on the WorkRite Super 180° Variocoupler and the WorkRite Super Variometer have been reduced from $6.00 last spring to $3.50 now. That is a big reduction and it has brought us in so many orders that we are rushed to fill them. You want WorkRite Radio Parts on your set. In order to get prompt delivery we suggest that you send in your order at once.

Remember that these instruments are of the high WorkRite Quality. Compare the prices with those on unknown inferior instruments and then you will not hesitate to order your WorkRite parts right away.

WorkRite Super 180° Variocoupler, each,
WorkRite Super Variometer, each, $3.50

WORKRITE SUPER VERNIER RHEOSTAT

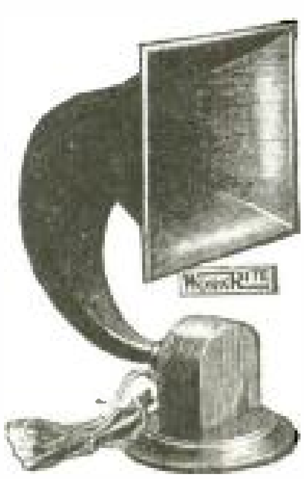
Here is a Real Rheostat! Indispensable on the detector tube when working long distance concerts. For quick adjustment the knob is pushed in and out, causing the contact arm to slide across the resistance wire. For fine adjustment the knob is turned around and the contact arm feeds along the wire.



Patent Applied For

Our special resistance wire is non-corrosive and does not change in resistance through change in temperature. POSITIVELY NEVER GETS HOT. The WorkRite Super Vernier Rheostat is really remarkable in its performance and no detector tube should be without one. To appreciate it you should try one.
Price **$1.50**

WORKRITE CONCERTOLAS



CONCERTOLA JR.

These Loud Speakers are becoming more popular every day. And no wonder when you consider that they have no metal except in the phone units and therefore do away with that "tin-panny" tone entirely.

Both the Concertola Senior and Junior are mahogany finish and will harmonize with the furnishings of your home.

THREE-DAY TRIAL! If after you have tried the Concertola on your set you find that it does not mork satisfactorily return it and we will refund your money.

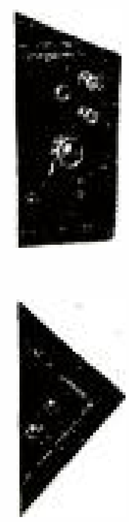
These instruments are intended for use on vacuum tube sets having two stage amplification.

WorkRite Concertola Jr. with Cord and Phone Unit, $12.00
WorkRite Concertola Jr. with Cord and Phone Unit, $24.00

WORKRITE RADIO PARTS WORKRITE

THE WORKRITE MANUFACTURING CO.

5547 Euclid Ave. (Branch Offices, 2204 Michigan Ave., Chicago) Cleveland, Ohio



Manufacturers use *and* like

FORMICA

The radio engineers of the leading radio manufacturers all over the United States have approved Formica in the most sincere and convincing way—by adopting it and using it in their production of radio equipment.

No other insulating material for panels, tubes, and other parts can show a list of makers of high-grade radio equipment using their material that is comparable to that printed on the page opposite. It is practically a directory of independent radio manufacturers in the United States.

This overwhelming preference for Formica among the men who, among all others, know most intimately the qualities and characteristics of radio insulation means only one thing.

IT MEANS THAT FOR YEARS FORMICA HAS MAINTAINED A QUALITY AND UNIFORMITY THAT IS NOT TO BE HAD ELSEWHERE.

These men like the handsome Formica finish. They like the way it works with ordinary tools. They like its high dielectric strength and the wonderful uniformity of the product. They like the fact that it improves with age instead of deteriorating.

The trained engineers and purchasing agents of these manufacturers can scarcely be mistaken in their judgment of materials. The amateur is perfectly safe in following their lead.

DEALERS: Formica advertising and sales support is the most aggressive and effective in the industry. The Formica Insulation Company treats you right.

THE FORMICA INSULATION COMPANY
4641 SPRING GROVE AVENUE, CINCINNATI, O.

FORMICA

Made from Anhydrous Redmanol Resins

SHEETS TUBES RODS

ATWATER KENT

Receiving Sets and Parts

Complete Receiving Set—Coupled Circuit Tuner, Detector, and 2-stage Amplifier
A similar set is furnished without the Amplifier Unit

formers, rheostats, etc., every unit of which is made with the same particular care that characterizes all ATWATER KENT products.

The Detector and Amplifier units are complete including all necessary grid leak condensers, 'phone condensers, transformers and rheostats.

Hear an ATWATER KENT set at your dealer's.

Type L Transformer

Condensite Dial

Standard Audion Socket

1½-Volt Tube Socket

Table Rheostat

ATWATER KENT MANUFACTURING COMPANY

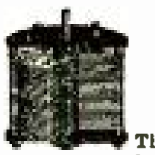
4933 STENTON AVE. *Radio Dept.* PHILADELPHIA, PA.

BUILD YOUR OWN RADIO OUTFIT

HIGH QUALITY GOODS AT LOW PRICES

FAST SERVICE—THE PRICES QUOTED DELIVER THE GOODS TO YOUR DOOR

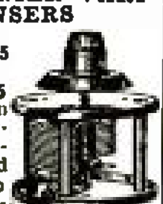
BARAWIK SPECIAL PANEL MOUNTING VARIABLE CONDENSERS



H812—43 plate .001 Mfd. $2.29
H813—21 plate .0005 Mfd. 1.80
H814—11 plate .00025 Mfd. 1.32
H815—3 plate Vernier 1.05

These are especially high grade condensers and we guarantee them to be mechanically and electrically perfect. Genuine bakelite end plates of high dielectric and great mechanical strength. Sturdy aluminum alloy plates perfectly spaced to insure smooth, even reliable capacity. Our low prices save you money. These condensers are of the very best make and are not to be compared with any inferior cheap condensers offered. We guarantee them to please you or your money back.

COMBINATION VERNIER VARIABLE CONDENSERS



H824—23 plate .0005 Mfd. Price $3.25
H826—43 plate .001 Mfd. Price $3.95

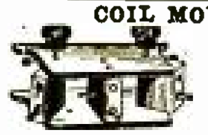
The latest improvement in condensers consists of regular variable condenser controlled by large knob and dial. Separate small knob mounted above dial controls a three-plate vernier condenser. This arrangement permits of very fine tuning. High-grade design and construction. Finely finished. Suitable for panel mounting.

INDUCTANCE "HONEY COMB" COILS

Carefully made — fine looking coils. Highest efficiency. Low distributed capacity effect, low resistance—high self inductance. Very firm enamel impregnation. Range given is in meters when varied with .001 variable condenser. Mounted coils have standard plug mountings.

Turns	Range	Art. No.	Not Mntd.	Art. No.	Price Mntd
25	120- 250	H301	$0.39	H320	$0.97
35	175- 450	H302	.42	H322	1.00
50	240- 720	H303	.49	H323	1.07
75	390- 910	H304	.54	H324	1.12
100	500- 1450	H305	.58	H325	1.16
150	600- 2000	H306	.63	H326	1.21
200	900- 2500	H307	.72	H327	1.30
250	1200- 3500	H308	.78	H328	1.36
300	1500- 4500	H309	.82	H329	1.40
400	2000- 5000	H310	.97	H330	1.55
500	2800- 6100	H311	1.12	H331	1.70
600	4000-10000	H312	1.27	H332	1.85
750	5000-12000	H313	1.43	H333	2.00
1000	7900-15000	H314	1.70	H334	2.38
1250	9750-19500	H315	1.92	H335	2.60
1500	14500-26500	H316	2.18	H336	2.76

COIL MOUNTINGS



H340 Three coil mounting $3.59
H341 Two coil mounting $2.69

High grade fine looking mountings. Polished black composition. Center receptacle stationary, two outer ones adjusted by knobs. Takes any standard mounted coil.

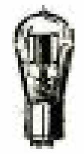
GALENA DETECTOR

Easy fine adjustment Crystal mounted in cup Moulded base and Knob Brass parts polished nickel finish. H732 Each.............85c

This Guarantee Protects You

Examine the goods we ship you. They must suit you in every respect. If you are not satisfied with your purchase return the goods at once and we will refund the price you paid.

VACUUM TUBES



Standard Brands—Cunningham Radiotron. Every one guaranteed new and perfect. We will ship brand in stock unless you specify otherwise.

H105 Detector. Each....$4.45
H110 Amplifier. Each.... 5.95
H115 5 Watt Transmitter 7.70

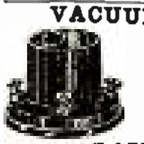
MYERS TUBES

H113 High-Mu Audion. Has 5 time amplification of ordinary tubes. Oscillate anywhere from 2 to 300 volts on plate. Each $5.00
H116 Receptacle for above. Each... 1.00
H117 Adapter to adapt Myers tubes for use in any standard socket. Each...$1.05

MYERS CHOKE COIL

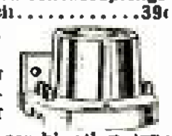
H119 Each $3.50

VACUUM TUBE SOCKETS

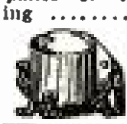


Our Special Socket. A wonderful value. Moulded entirely of bakelite. Four binding post connections. Right angled contact springs. H140 Each...........39c

PORCELAIN BASE AND TUBE

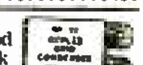


H144 Crosley for either panel or table mounting 36c



High Grade combination type for panel or table mounting. Metal tube. Highly insulated base. H146 Each...............45c

GRID CONDENSER



H162 Mounting holes spaced to fit lugs of above leak Cap. .00025 MF.........14c
H163 Same as 162 but higher grade. Enclosed in metal case......39c

VARIABLE GRID LEAK

Pencil mark type. Resistance may be varied exactly as needed. H160 Each..........18c

VARIOMETER

H410—Completely assembled, price $2.69

Perfect in design and construction. Accurate wood forms. Correct inductive ratios. Solid baked windings. positive contacts Highest efficiency.

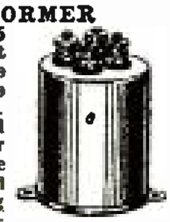
H411—Not assembled but all parts complete, except wire, including winding form $1.48

VARIO-COUPLER

With this loose coupler and two variometers, together with the necessary other parts, a highly efficient tuning set can be made. Easily mounted on panel. Primary winding on formica tube. Inductively coupled for 180 to 600 meters. Multiple taps permit fine tuning.

H415 Price, completely assembled $2.45
H416 Not assembled, but all parts complete. Price, except wire $1.18
H417 Rotor ball only. Each........29c

RADIO FREQUENCY AMPLIFYING TRANSFORMER



H995 Each.........$2.95

This transformer will get the long distance stations loud and clear. Permits of easy sharp tuning. Helps cut out static and interference. Makes your set sensitive enough to use a loop aerial. Enclosed in metal case affording perfect shielding. Suitable for panel or base mounting. Because of its special design can be mounted in any V. T. socket. Works with any make of tube. Wave ranges 150 to 550 meters. Wiring diagrams included.

OUR SPECIAL AUDIO FREQUENCY AMPLIFYING TRANSFORMERS

As high as three stages can be used without howling, due to proper impedance ratio, minimum distributed capacity, low core losses and proper insulation. Mounted style has bakelite panel with binding post connections. Unmounted has core and coils assembled with two holes in core for fastening to apparatus.

H234 10 to 1 Mounted. Each......$3.48
H235 10 to 1 Unmounted. Each.... 2.95
H236 3 to 1 Mounted. Each...... 3.40
H237 3 to 1 Unmounted. Each.... 2.85

FILAMENT CONTROL RHEOSTATS

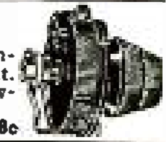
Crosley—Wound on vulcanized fiber. Adjustable to any panel. Complete with knob. H130 Each..............54c

Best grade. High heat resisting base. Diam. 2⅛ in. cap. 1½ amp. Resist. 6 ohms. 1¼ in. Knob with pointer. H132 Each..............48c

POTENTIOMETER

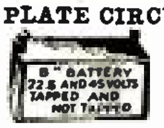
Same style as above rheostat. Gives fine "B" battery adjustment. Resistance 140 ohms. H133 Each 98c

VERNIER RHEOSTAT



Gives exceedingly fine control of a battery current. A necessity for best receiving results. H135 Each............78c

PLATE CIRCUIT "B" BATTERIES



You can make real savings on these batteries. Don't pay more. We guarantee them to equal any on the market regardless of price. Absolutely uniform. Extra long life.

H180 Signal Corps type, small size. 15 cells. 22½ volts. Each, 95c.
H182 Large Navy size, 6½x4x3. 15 cells. 22½ volts. Each....................$1.75
H184 Variable Large Navy size, 5 taps, giving range from 16½ to 22½ volts in 1½ volt steps. Each..............$1.80
H186 Double Navy size 6½x4x6. 30 cells. 45 volts. Suitable for amplifier circuits and power tube use. Two or more of these units in series may be used in C. W. and radiophone circuits. Each..$3.40
H188 Combination Tapped 45 volts, 30 cells, 6½x4x6 battery. Tapped to give 45, 22½, 21, 19½, 18, and 16½ volts. Handles both detector and amplifier tubes. Each $3.55

THE BARAWIK CO. 102 S. CANAL STREET **CHICAGO, ILL.**

USE BARAWIK STANDARD PARTS

YOU SAVE MONEY WHEN YOU BUY FROM US

FAST SERVICE—THE PRICES QUOTED DELIVER THE GOODS TO YOUR DOOR

SOLID BARE COPPER WIRE

Solid bare copper wire for aerials, leads or wiring instruments.

Solid Bare Copper Wire, size 14
H240—100 ft. coil 45c
H242—500 ft. coil $2.15

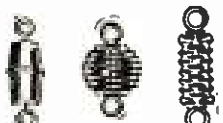
Solid Bare Copper Wire, size 12
H244—100 ft. coil 61c
H245—500 ft. coil $2.75

STRANDED ANTENNA WIRE

Cabled of fine copper strands. Very flexible. High tensile strength. Best for antennas.

H248—100 ft. coil 65c
H249—500 ft. coil $2.95

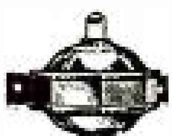
ANTENNA INSULATORS



H260 H262 H264-6

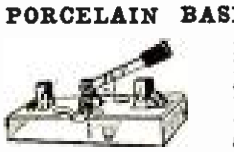
H260 Size 1x3¼. Two for.......17c
H262 Size 2⅛x3¼. Two for.......58c
H264 Size 1½x4. Two for.......80c
H266 Size 1½x10½. Two for $1.35

OUTDOOR LIGHTNING ARRESTER



H980 Price........$1.68
Protect your instruments with this lightning arrester. You cannot afford not to. Weather-proof porcelain case. Air gap type. Permanent. Durable. The most practical quality arrester obtainable. Underwriters approved.

PORCELAIN BASE SWITCHES



Fine white porcelain bases. Copper contacts and blades. Can be used as antenna switches.

H385 Single Pole Single Throw. Each 20c
H387 Single Pole Double Throw. Each 32c
H384 Double Pole Double Throw. Each 50c

SWITCH LEVERS

Moulded composition knob. Exposed metal parts polished, nickel finish. Fitted with panel bushing, spring and two set nuts. A high grade switch.
H380—1" Radius
H381—1¼" Radius } Each
H382—1½" Radius 19c

SWITCH LEVER STOP

Brass, polished nickel finish.
H386—Dozen 18c. Hundred $1.05

ONE-PIECE DIAL AND KNOB

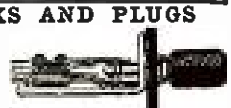
Moulded in one piece of polished black composition with clean plain engraved scale and numerals in contrasting white enamel. Ribbed knob to fit the hand. An attractive neat pattern.

H900 2¼" Diam. for 3-16" shaft. Ea..19c
H901 2¼" Diam for ¼" shaft. Ea....19c
H904 3" Diam for 3-16" shaft. Ea.....25c
H905 3" Diam for ¼" shaft. Ea.....25c
H906 4" Diam. for 3-16" shaft. Ea.....42c
H907 4" Diam for ¼" shaft. Ea......42c

GUARANTEED QUALITY GOODS

at money saving prices. You can build the parts purchased from us into your set and feel confident of the best results. If what you want is not shown here write us for prices—we have every part for your set ready for quick shipment and the prices are right.

RADIO JACKS AND PLUGS



Finest grade jacks. Improved design. Best materials Phosphor bronze springs. Silvercon-tact points. Nickel finish. Mount on panels ⅛ to ⅜ in. thick.

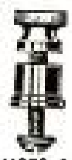
Jacks only:
H390 Open circuit. Each.....43c
H391 Closed circuit. Each....49c
H392 Two circuit. Each......60c
H393 Single-cir. fila. control..69c
H394 Two cir. fila. control....85c

H395 Plug. Large space with set screws for attaching cord. Each...........54c

COMPETITOR JACK AND PLUG

Well made, durable, smooth working. Interchangeable with any standard jacks and Plugs. Solder connections. Nickel finished metal parts. Fiber barrel on Plug.
H387 Open Circuit Jack. Each......27c
H388 Two Circuit Jack. Each......35c
H389 Standard Plug. Each........35c

BINDING POSTS



H370-2

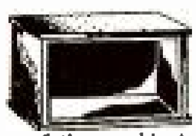
H376-8

Brass, polished nickel finish. Washer and 6-32", screw extending ⅝"....
H370 Large size—barrel and knob ¾" long, dozen 85c
H372 Smaller size—barrel and knob 9-16" long, dozen 70c
H374 Large size with composition knob, dozen 60c
H376 Large size with hole for phone tip or wire, dozen......................20c
H378 Small size with hole for phone tip or wire, dozen.........................38c

STORAGE BATTERY

A very high grade battery made especially for radio service. Guaranteed. Properly cared for will give years of service for filament lighting.
H194 6-v., 40 amp. size. Each..$10.00
H196 6-v., 80 amp. size. Each....$12.50

CABINETS



Fine-looking cabinets solidly built. Made of genuine solid mahogany in elegant hand rubbed finish. You will be proud of your set mounted in one of these cabinets. Hinged tops. Front rabbeted to take panels. Panels not included. Prices are transportation paid.

Panel Size	Inside Dimensions High	Wide	Deep	Art. No.	Price Each
6x7"	5½"	6½"	7"	H420	$2.48
6x10½"	5½"	10"	7"	H422	2.75
6x14"	5½"	13½"	7"	H424	3.30
7x14"	6½"	13½"	7"	H423	3.60
7x18"	6½"	17½"	7"	H426	3.90
7x21"	5½"	20½"	7"	H425	4.20
9x14"	8½"	13½"	10"	H428	3.70
12x14"	11½"	13½"	10"	H430	4.40
12x21"	11½"	20½"	10"	H432	5.25

SOLID GENUINE CONDENSITE CELERON PANELS

Notice our very low prices in this fine quality grade 10 genuine solid sheet Condensite Celeron (a product with mechanical, chemical and electrical properties like formica and bakelite). Machines well with out chipping. Won't warp. Waterproof. Highest mechanical and di-electric strength. Attractive natural polished. Black finish which can be sanded and oiled for extra fine work.

Panel Size Inches	⅛" thick Art. No.	Price	3-16" thick Art. No.	Price	¼" thick Art. No.	Price
6x7	H450	$0.50	H460	$0.75	H470	$0.98
6x10½	H451	.75	H461	1.18	H470	1.47
6x14	H452	1.05	H462	1.55	H472	2.05
7x14	H458	1.20	H468	2.60	H478	2.40
7x18	H453	1.55	H463	2.30	H473	3.10
7x21	H457	1.78	H467	2.65	H477	3.60
9x14	H454	1.60	H464	2.30	H474	3.10
12x14	H455	2.10	H465	3.10	H475	4.15
12x21	H456	3.15	H466	4.65	H476	6.20

BATTERY CHARGING RECTIFIER

Charge your battery at home over night for a few cents. Simply connect to any 110 volt 60 cycle light socket, turn on current and rectifier does the rest automatically. Will work for years without attention. Simple connections. Gives a tapering charge which batteries should have. You can make it pay a profit charging your friends' auto batteries. Long connecting cords with pair of battery clips. Prices are Transportation Paid.
H201 For 6 volt battery..........$13.95

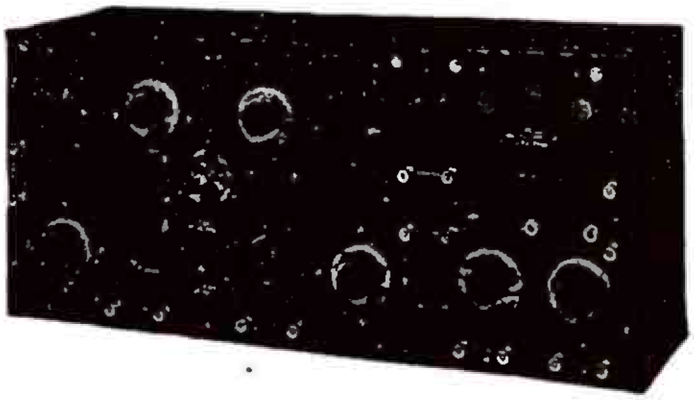
BARAWIK QUALITY HEADSETS

These headsets have proven on rigid tests to be one of the very best on the market. The tone quality is excellent with an unusual volume. Skilled workmen make them from only the best selected materials. The receiver cases are brass in fine polished nickel finish. Polished black ear pieces. Fabric covered head band comfortably and quickly fitted to the head. Supplied with 5-foot cord. These sets were designed to sell for much higher prices, and at our price are a wonderful bargain. We guarantee that you will be pleased with them and agree that they are the best value by far yet offered. If they don't suit you we will cheerfully return your money.
H770—2000 ohm.....$4.00

OTHER STANDARD BRAND HEADSETS

H751 Murdock 56, 2000 ohm $4.45
H752 Murdock 56, 3000 ohm 4.95
H764 Frost, 2000 ohm............ 4.20
H766 Frost, 3000 ohm 4.95
H756 Red Head, 3000 ohm 5.85
H758 Western Electric, 2200 ohm .. 9.50
H754 Baldwin Type C with universal jack plug $12.00
H755 Baldwin Type C unit......... 5.50
H768 Brandes, 2000 ohm 7.15
H789 Holzer-Cabot, 2200 ohm 7.20

THE BARAWIK CO. 102 S. CANAL STREET CHICAGO, ILL.



KENNEDY
Broadcast Receivers

THE PUBLIC is becoming educated to the fact that there are various grades of radio sets, just as there are various grades of phonographs, automobiles and other merchandise.

If you are a discriminating buyer; if you take "pride in ownership," in possessing things better than ordinary—having in your home things of which you can be justly proud, you will be interested in Kennedy Equipment.

If you could view the Kennedy Receivers through the eyes of the Engineer or Scientist, you would understand why it is possible to *eliminate interference* and obtain *long-distance reception* so readily with them.

Kennedy Equipment is made in various types, ranging in price from \$90.00 to \$370.00. May we send you full particulars?

THE COLIN B. KENNEDY COMPANY

SAINT LOUIS SAN FRANCISCO

KENNEDY

—And they're all talking at once these nights! If you want what you want when you want it, you might as well stop struggling with single-circuit receivers.

Under present conditions, with several hundred powerful broadcasting stations all operating on one narrow wave band, the single-circuit receiver is utterly inadequate to give you satisfactory results.

The Paragon three-circuit receiver gives you the station you want when you want it—*and no other.* You can tune in accurately on any station and get a clear, complete program without interruption or disturbance.

Ask some experienced amateur what he knows about

PARAGON

Reg. U. S. Pat. Off.

RADIO PRODUCTS

The amateur will tell you that the Paragon three-circuit receiver, because of its great superior selectivity and sensitivity, can pick and choose between broadcasting stations of about the same signal strength with less than one per cent differential.

This means that with a Paragon receiver you get what you want when you want it—complete messages and clear music from the station you tune in on, without interruption and jamming. Until you have listened in with a Paragon three-circuit receiver, you cannot guess the real pleasure and fascination of radio.

Also Manufacturers of PARAGON	
Radio Telephone Transmitters	Amplifier Transformers
V. T. Control Units	Control Dials
Rheostats	Amplifiers
Potentiometers	Receivers
V. T. Sockets	Switches
Detectors	Variometers

Long before broadcasting popularized radio with the general public, Paragon equipment was the choice of the experienced amateur. He will tell you today that if you want quality and satisfaction, Paragon Radio Products are the best and safest buy on the market.

An illustrated Catalog of Paragon Radio Products Is Yours For the Asking

DEALERS—The Adams-Morgan Company has an interesting proposition to make to reputable radio dealers who believe in quality merchandise. Details on request.

ADAMS-MORGAN COMPANY
20 Alvin Ave., Upper Montclair, N. J.

Type RD-5 Regenerative Receiver and Detector—$75.00
Type A-2 Two-Stage Amplifier—$50.00
(Licensed under Armstrong Patents.)

PACENT AUDIOFORMERS

Ideal for 1½ Volt Tubes, as well as others

No. 25A—PACENT AUDIOFORMER
Price
$4.00

No. 25—PACENT AUDIOFORMER
equipped with binding posts
Price
$5.00

Compact, convenient for mounting, especially designed for radiophone reception — amplifies all audiofrequencies, without distortion (not a "one frequency" transformer).

Don't Improvise "PACENTIZE"

Send for Bulletins P-3

PACENT ELECTRIC COMPANY
INCORPORATED
Executive Offices: 22 Park Place, New York, N. Y.
BRANCH OFFICES:
Philadelphia, Minneapolis, Chicago, Washington, D. C., San Francisco, St. Louis

Canadian and British Licensees: Colonial Radio, Ltd., Hamilton, Canada

How to build the Reinhartz Receiver

is told, complete with illustrations and diagrams, in the latest addition to our FREE looseleaf, handbook catalog.

Write for your copy today—ask for "Chi-Rad" Handbook, Edition RRpr.

Amateurs find the Reinhartz hookup by far the simplest yet designed. In efficiency it rivals the Armstrong and other well-known circuits.

Parts necessary for building your Reinhartz receiver are also listed and described in the "Chi-Rad" handbook—your order, no matter how small, will be dealt with the usual "Chi-Rad" assurance of satisfaction.

Chicago Radio Apparatus Co.
415 South Dearborn Street
Chicago

RADIO "**BOWENG**" RADIO

(Patent Applied For)

LATEST WONDERFUL INVENTION NEW INTERIOR ANTENNA

With this device your receiving set will function perfectly without ground wires as one does in airplane service

Why Spend Money

For outside antennas, or have the unsightly, so-called loop antenna in your home,

When you can—save expense and have more enjoyment with this small device?

Unsurpassed for collecting the etheric waves, and the sharp tuning eliminates interference to a wonderful extent.

EVERY RADIO FAN IN AMERICA SHOULD HAVE ONE

Postpaid with full instructions on receipt of money-order for only $2.50. Fully guaranteed. Order one today.

Dealers Write for Special Price List

INTERIOR ANTENNA COMPANY
P. O. Box 262 MALONE, N. Y.

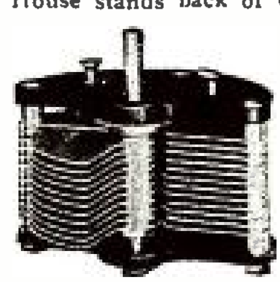
For Clear-Tone, Long-Distance Radio Reception

USE ONLY "UNITED"

CONDENSERS AND TRANSFORMERS

Products of an $800,000.00 plant, equipped with the highest type of precision machinery, manned by expert mechanics, and backed by a seasoned staff of radio engineers.

The guarantee of this old established Electrical House stands back of our products.



"UNITED" VARIABLE CONDENSERS

Cannot short-circuit, because hard aluminum plates are held mechanically in true and permanent alignment. Ends are Bakelite; trimmings brass, nickel plated.

Prices, without dial or knob

43 plate	$4.50	5 plate	$2.75
23 plate	4.00	3 plate	2.25
11 plate	3.50		postpaid

"UNITED" AUDIO-FREQUENCY AMPLIFYING TRANSFORMERS

A fine example of precision-workmanship; completely shielded, in shell of original design. Amplifies detected signals, bringing them to phone or loudspeaker, clear, strong, pure-toned. **Price, Postpaid, $4.50**

Try your dealer first, before ordering by mail. Send name and address of dealer with order. Circular free.

UNITED MFG. & DISTRIBUTING CO.
536 LAKE SHORE DRIVE CHICAGO, ILL.

Do You Want a *Real* Headset?

The Dictograph is the Best Headset in the World at *any* Price

This is the same supreme Dictograph Headset that has always sold for $12—same in quality, same in guarantee, same in everything but the price—$8 complete. Made by the makers of the world standard Dictograph products—the marvelous "Acousticon" for the Deaf, the famous Detective Dictograph, the Dictograph System of Interior Telephones and the Dictograph Radio Loud Speaker for the Home.

Read a few of the many letters received from Dictograph Headset users

U. S. Marine Hospital No. 43 Ellis Island, N. Y.

"The undersigned has for the past sixteen years been an amateur, commercial, and government operator, and has used every known make of radio receiver on the market today. On April 21st one of your Type R-1 3000 ohm receivers was purchased and it can be safely said without dispute that they are absolutely the best radio receivers on the market today, bar none."

C. H. West, U.S.P.H.S.

Havana, Cuba:

"In my long-distance receiving set have four pairs of phones, a 4000 ohm French make, two pairs of — — and a pair of your Dictograph 3000 ohms and I assure you that none of the others afford me the service I get from the Dictograph. The Dictograph gives me a truer, clearer tone than all the others combined. I use them in extremely long-distance work (phone). I hear Chicago, Schenectady, Iowa, and Frisco."

David E. Masnata

La Porte, Ind.

"I have been experimenting with Radio for the past year; in my experience have tried out 14 different headsets, including the — which I purchased for $16.50. I at last have found the ideal phone where tone quality excels, and harshness is eliminated, and I cannot express myself in words as to the wonderful results I have obtained."

J. T. Bachman

Madison, South Dakota

"We are using a Dictograph Headset, also Dictograph Loud Speaker. Both are O.K. In fact, I would not trade my headset for any other I have ever listened through."

Dan D. Coutts

The Standard of the World

Type R-1, 3,000 ohms, for all types of crystal and vacuum tube receiving sets. Complete with 5-foot cord. If your dealer is sold out, order direct from us. Immediate delivery.

Stop into your dealer's today and listen in with this supreme Headset. Note the difference. Insist on Dictograph Products. Every instrument fully guaranteed.

Dealer: Order through your jobber or write direct for names of authorized distributors of the best and fastest-selling Headset on the market today.

THE DICTOGRAPH PRODUCTS CORPORATION

Suite 1315 **220 West 42nd Street** **New York City**

(Branches in All Principal Cities)

Warren Radio Loop, cut away to show construction

What You Can Do With the—

Warren Radio Loop

SELECT your stations, just by turning the loop in the direction of the station desired.

MAKE any set portable. This compact aerial can be packed right with the set.

TUNE on ranges from 175 to 18,000 meters, according to type loop.

MANY other advantages described in Bulletin I 102.

If your dealer is out of Warren Radio Loops, send us your order, with his name.

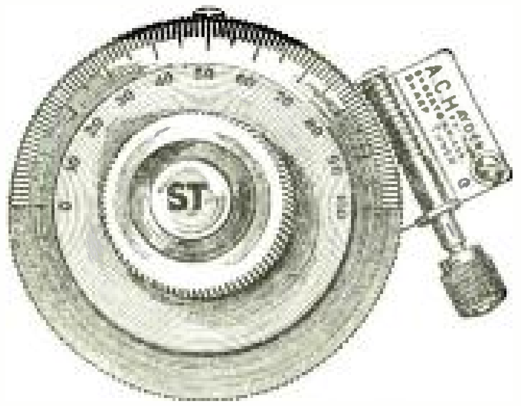
A type for every purpose

Sold by dealers who sell the best

Type-A-737 (300-700 meters) 6 inches square—non-directional.....$10
Type-A-7236 (175-1000 meters) 6 inches square—non-directional...$12
Type-B-2527 (300-700 meters) 18 inches square—directional........$20
Type-BL-2520 (200-18,000 meters) with honeycomb coil. 18 inches square—directional.....................................$25

V-DE-CO RADIO MFG. CO. Dept. F. **Asbury Park, N. J.**

Use ACH SHARP TUNER DIALS



YOUR CHOICE OF

Rough tuning with dial, or one thousandth of an inch in either direction with the Sharp Tuner Knob. Both controlled by center Knob ST. Eliminates a Vernier condenser.

Can be installed on any set, making difficult tuning easy.

GUARANTEE

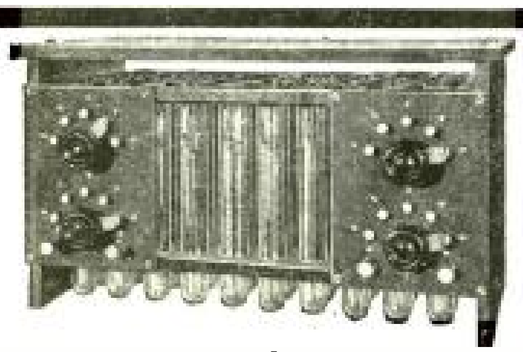
If purchased direct and you find the ACH Dial does not warrant your own personal award of merit, return it and we will refund your money. What better guarantee can we give?

Price of ACH 3-inch Dial Complete $2.50

A. C. Hayden Radio & Research Co.

BROCKTON, MASS., U. S. A.

Mail Orders sent prepaid in U. S. A.



KICO Radio Storage "B" Batteries for EFFICIENT Receiving

1. KICO "B" batteries allow single cell variations by means of switches mounted on panels. (The first in the market with this feature.)
2. Alkaline type.
3. Rechargeable from your 110-volt A. C. line in connection with the rectifier supplied.
4. One charge lasts from three to six months in the detector plate circuit.
5. Neat, efficient and compact.
6. Unlimited life.
7. Your money back if unsatisfied within a 90-day trial.

	(Plain)	(With Panels)
16 cell 22 volt	$6.50	......
24 cell 32 volt	8.00	$12.00
36 cell 48 volt	10.00	14.00
50 cell 68 volt	12.00	17.00
78 cell 100 volt	16.00	21.00
108 cell 145 volt	21.00	26.00

"A" and "B" Battery Literature gladly furnished

KIMLEY ELECTRIC COMPANY

1357 FILLMORE AVENUE BUFFALO, N. Y.

PRICES SMASHED

Each sale has created new friends and customers, with the result that we now announce drastic reductions in our quality lines. All goods prepaid. Send card for complete list. You'll be surprised. You'll tell your friends. A sample saving follows—

Complete Regenerative Vacuum Tube Set

(Knocked down. Approx. range 1000 miles.)

	Our price	Others
Panel 7" x 12"—Bakelite—drilled	$1.75	$2.50
Cabinet of 3 ply wood to fit above panel	1.50	2.50
Two 3" dials @ 35c each	.70	1.40
16 switch points with nut @ 1c each	.16	.48
4 switch stops with nut @ 1c each	.04	.12
8 nickel plated binding posts @ 3c each	.24	.48
2 switch levers @ 25c each	.50	.90
1 filament rheostat. Highest grade	.65	1.10
1 vario-coupler with 7 multiple, 7 single taps	2.25	4.00
1 23 plate variable condenser. Built right	1.95	3.50
1 tube socket—High grade	.45	.85
1 grid condenser and leak	.10	.25
1 phone condenser	.10	.25
1 support for tube socket	.15	.25
10 feet of spaghetti tubing @ 5c per foot	.50	.84
15 feet copper connecting wire	.30	.45
Blueprints showing details to assemble outfit	.10	.25
	$11.44	$20.12

Other articles taken at random from our list are:

Detector tubes—Cunningham—New. NOT rebuilt	$4.25	$5.00
Crystal detector—Enclosed type	.60	1.00
Transformer—Audio frequency	2.95	4.50
Loose coupler—Knocked down with wound coils	3.75	
Variometer—Hardwood stators 4¾" square. Assembled Workrite type	2.45	4.00
Frost Fones ....2000 ohms	3.95	5.00
Kelloggs ....2400 ohms	8.75	12.00
Western Electric ....2200 ohms	9.25	12.00
Two stage amplifier—Knocked down. Cabinet and drilled panel	12.95	23.50
Blueprints giving detail of two stage amplifier	.10	.25

Send for full list today or order from above. Goods sold subject to return for rebate or exchange. YOU SIMPLY MUST BE PLEASED.

RADIO PARTS MANUFACTURING CO.

Dept. "P" 2150 Montclair Detroit, Mich.

IMPORTANCE of AMPLIFICATION

The simplicity of audio frequency amplification still makes it the most practical and popular type. It is adapted to all types of receiving sets and is free from tuning adjustments. With the proper choice of amplifying instruments, audio frequency amplification is accomplished with a minimum of distortion.

TYPE 231-A
AMPLIFYING TRANSFORMER

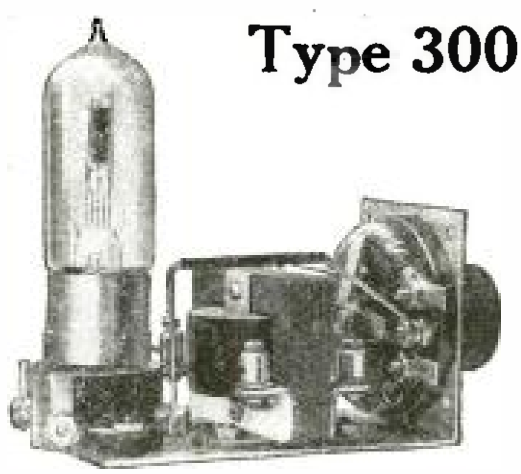
The amplifying transformer is the most important of these instruments. The General Radio Co. was the first company to have available a closed core audio frequency amplifying transformer. This was before the United States entered the war. Many of these transformers were supplied to the army and navy during the war, and with the return of amateur radio after the war thousands have been supplied for use in this country and abroad.

Our latest type is the 231-A. This transformer is designed to give the maximum of amplification possible without distortion. It is the result of careful engineering design. It is particularly adapted to the WD-11 and UV-201 tubes. The electrical constants of the windings are as follows:

	Primary	Secondary
Direct current resistance, ohms	1,100	5,500
A. C. Resistance at 1000 cycles, ohms	11,000	130,000
Reactance at 1000 cycles, ohms	66,000	700,000

PRICE, COMPLETELY MOUNTED $5.00

Type 300-A Amplifier Unit



For those who desire a compact amplifier unit, we recommend the type 300. This unit consisting of our Type 231-A Amplifying Transformer, Type 255 Filament Rheostat, and Type 282 Tube Socket mounted on a nickel finished brass plate, is all ready for the external connections. It may be used as a table unit or mounted behind a panel, in which case only the rheostat knob projects. Connections are properly made so as to keep the unit from howling.

PRICE $7.50

For those who desire to use the UV-201 tubes, this unit may be supplied with a standard base socket—our Type 156.

TYPE 300-B AMPLIFIER UNIT, PRICE $8.00

Send for NEW FREE RADIO BULLETIN 913-U and learn about these instruments

GENERAL RADIO COMPANY

MASSACHUSETTS AVENUE AND WINDSOR STREET

CAMBRIDGE 39 **MASSACHUSETTS**

Do not confuse the products of the GENERAL RADIO CO. with those of other concerns using the words "General Radio." The General Radio Co. has been manufacturing radio and scientific instruments for many years. It has no affiliation with any other company.

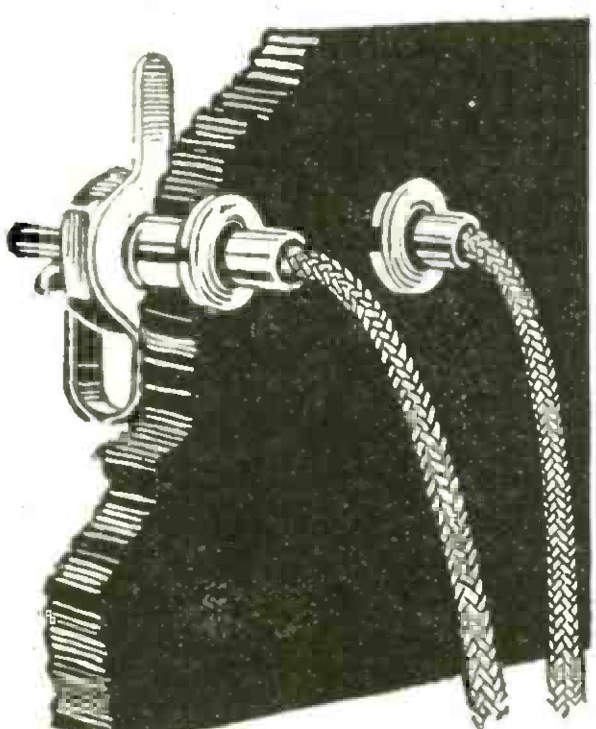
Standardize on General Radio Equipment Throughout

Read Why You Should Use

UNION-RADIO PHONE TIP JACKS

(Pat. Applied For)

25c A PAIR



Here's the Radio device that you have been waiting for. These Phone Tip Jacks assure quick connection and a positive contact. They replace unsatisfactory binding posts. Soldering lug incorporated but use optional.

Accommodate any standard round phone tip and several sizes of bare wire. Great for W D 11 connections and coil mountings. Save buying expensive telephone plugs and jacks. They live up to the Union Radio Standard of Quality. Guaranteed to satisfy. Only 25c a pair.

FOR ASSURED RESULTS

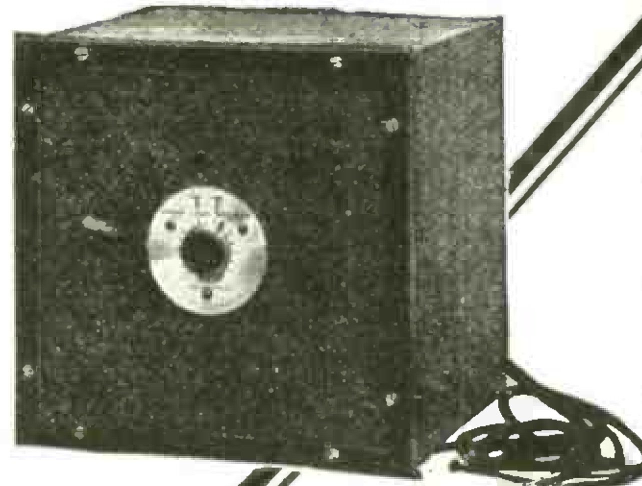
you should "try out" Union Radio Tip Jacks, Variable Condensers, Rheostats, Vacuum Tube Sockets, Condensite Dials, Complete Receiving Sets and Two Step Amplifiers.

Union Radio Apparatus and Accessories are sold by most good dealers. If you can't obtain them from your local store mail your order to us. Write for a copy of our Catalogue A Radio Apparatus.

Wholesalers and Retailers:

Write for our liberal proposition. Dealers' Catalogue A and Price List, also samples sent on request.

UNION-RADIO-CORPORATION
200-MT. PLEASANT-AVENUE,-NEWARK-N.J.
NEW-YORK-OFFICE—116-WEST-32nd-STREET.



DON'T CONFUSE

IT WITH ORDINARY LOUD SPEAKERS

THE TIMMONS TALKER is possessed of most unusual tonal qualities—it provides adjustable amplification, too, which is decidedly advantageous when it is desired to soften the volume of tone for living room or increase the volume for larger audiences.

THIS arrangement further allows you to get maximum efficiency from any set.

THERE is no unsightly horn with ordinary head-phone attachment, but a beautiful, solid mahogany cabinet which is an adornment.

NO separate batteries required, no complicated mechanism. For sale by most worthwhile dealers.

DEALERS

T IMMONS T ALKER

We have a most attractive proposition that will appeal to both dealer and jobber.

We will be glad to ship any dealer or jobber (with privilege of return) an instrument C. O. D. for inspection.

J. S. TIMMONS

337 E. Tulpehocken St.
PHILADELPHIA, Pa.

faultless!

Bakelite-Dilecto (xx grade) is 100% perfect for radio panels. Insist on it!

Better than plain fibre because it resists water, solvents and acids.

Better than hard rubber because it resists heat, high-voltage ozone and fumes, and is more durable.

bakelite-dilecto!

(A Laminated Phenolic Condensation Product)

Better than wood because it is tougher and harder, does not swell, warp or crack, and is non-inflammable.

Your electrical dealer will get it machined for you.

THE CONTINENTAL FIBRE CO.
FACTORY: NEWARK, DELAWARE

Dealer Service from:

New York .... 233 Broadway
Pittsburgh .... 301 Fifth Ave.
Chicago .... 332 S. Michigan Ave.
San Francisco .... 75 Fremont St.
Los Angeles 411 S. Main St.
Seattle, 91 Connecticut Ave.

XX

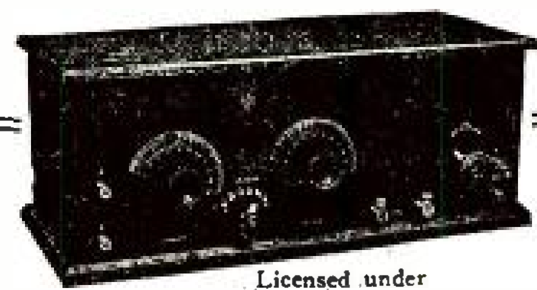
Have we received your order for the 1923 Ace Radio Broadcast Receiver?

If not, you still have an opportunity to get immediate delivery if you place your order NOW!

Let us send you our booklet, "Radio in your home."

Address Dept. XM

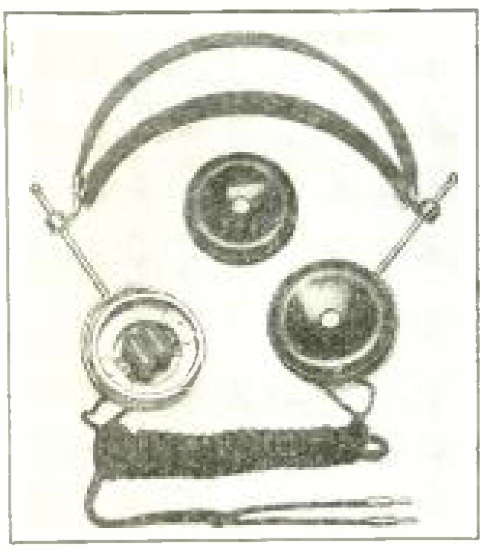
THE PRECISION EQUIPMENT CO.
POWEL CROSLEY, Jr. *President*
2437 Gilbert Avenue Cincinnati, Ohio



Licensed under Armstrong U. S. Patent No. 1,113,149

RADIO

HEADPHONES



SENT ON APPROVAL

$8 LIST PRICE $8

2,200 OHMS LOUD AND
LIGHT WEIGHT CLEAR

Dealers May Send $3.20 for Sample

MONEY BACK GUARANTEE

FRENCH MFG. CO., Seymour, Conn.

Sell

all your spare time

You can market the hours you are free and get cash for them. You will be well paid for the few afternoons or evenings each week it takes you to tell your friends about POPULAR RADIO. No experience is necessary. The work is pleasant and profitable. Let us tell you all about it. You will be under no obligations to us if you *clip this coupon and mail it today*

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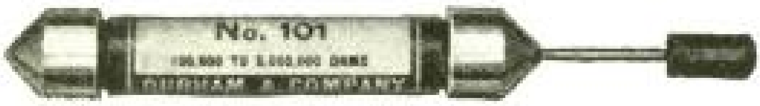
The Plunger Ends All Grid Leak Troubles



ACTUAL SIZE

No more shopping around for grid leaks, hoping you'll get the right one for *your* set. Here's a new patented High Resistance that does the trick for *any* set. For the movable plunger permits quick, easy adjustment and to any range, and once set, your grid leak problem is settled for good.

This new invention—the Durham Variable High Resistance—is now the talk in radio circles. There is no other grid leak that can begin to give the same perfect service. Thoroughly tested and highly approved by leading Radio experts. Ask your dealer for it. If he hasn't it, send 75 cents for each one wanted, and we will supply you direct. Full description on request.

Durham Variable High Resistance

Fits standard clip base. Durham base 40c extra. When ordering give range desired. No. 100 is variable from 1,000 to 100,000 ohms; No. 101 from 100,000 ohms to 5 megohms.

DURHAM & COMPANY
Radio Engineers
1936 Market Street, Philadelphia

ELECTRICAL ENGINEERING IN ONE YEAR

men with training are in demand. For more than a quarter of a century, this school has been training men of ambition and limited time, for the electrical industries. Condensed course in Electrical enables graduates to secure good positions and promotions. Theoretical and Practical Electricity, Mathematics, Steam and Gas Engines, Mechanical Drawing. Students construct dynamos, install wiring and test electrical machinery. Course with diploma, complete

Thoroughly equipped fireproof dormitories, dining hall, laboratories, shops. Over 3000 men trained.

Write for catalog. 30th year opened Sept. 27th, 1922.

BLISS ELECTRICAL SCHOOL
126 TAKOMA AVENUE, WASHINGTON, D. C.

If Making Your Own Radio

This New Handy Time Saver Disc of screw threads and tap drill sizes will automatically give the correct size of drill to be used when using any kind of a tap. The tap drill sizes for U. S. Standard screws; S. A. E. Standard; tap drill sizes for all pipe taps also tap drill and body drill sizes for machine screws used on radio work together with a complete table of decimal equivalents by sixty-fourths of an inch.

Printed on the very best pressed fibre size 3¼ inches with printed instructions. Two for 25 cents postpaid. Stamps accepted.

HAN—DISC COMPANY—3101 Lyndale S., Minneapolis, Minn.

DUCK Radio Pioneer Announces Startling Reductions

Leading Line Since 1909 At Prices to You Less Than Dealers' Cost

FREE Illustrated pamphlet comprising sixty-two Duck radio instruments and sets with reductions averaging 30% mailed on request. Send postal today. Any old-time radio amateur will tell you who we are and our reputation. Only a few years ago almost one-third of the radio instruments sold at retail, exclusive of sales in only a half dozen large cities, were sold by Duck.

A Few of the Many Duck Products at Sensational Prices:

Rheostat, 70c; Bakelite moulded positive contact, 70c; Bakelite Moulded Dial, 55c; superselective moulded variometer, $4.65, worth $8.00; radio frequency potentiometer, $1.15; solid mahogany form variometer, $3.60; 43-plate panel-type variable condenser, pigtail connection, $3.15; detector panel, $5.25; receiving set, mahogany cabinet, detector and two stages of audio frequency, $59.50; radio frequency receiving set with one-step radio and detector, $29.75.

SEND 25c in coin or money order for our big 256-page combined radio catalog and text book. For radio information and hook-ups it is worth many times the retainer asked.

THE WILLIAM B. DUCK COMPANY, 227-229 Superior St., Toledo, Ohio

The Ideal Battery
for Low Voltage Tubes

The Storage Battery Magno is ideal for low voltage tubes. It is the most economical battery made—costing much less than dry cells to operate.

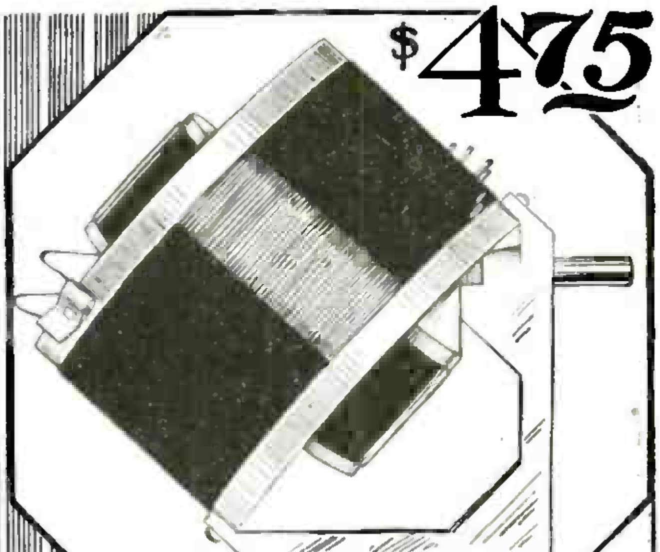
The Magno is recharged by unscrewing cover in inserting "spare" electrode. "Spares" are exchangeable at your dealers or direct from our factory. Each spare will give many times more hours of service than will a dry cell. Keep a spare charge on hand and your concert will never be interrupted. Learn more about this remarkable storage battery.

Write today for descriptive folder. Dealers write for lists.

Magno Storage Battery Corp.
Aeolian Bldg., New York City

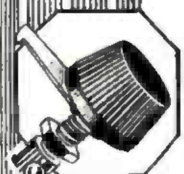
STORAGE BATTERY
MAGNO

$4.75



Vario-Coupler

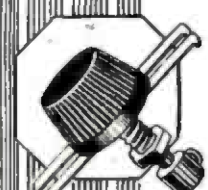
The fastest selling vario-coupler on the market. Technically O. K. and the price is right.



40¢

Inductance Switch

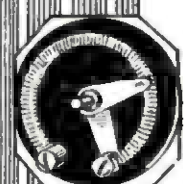
A mighty fine switch. The knob matches Fada Rheostat knob.



55¢

Series-Parallel Switch

Changes quickly from circuit to circuit. The handiest switch for experimenters.



$1.20

Power Rheostat

Will control three or four radio frequency amplifier tubes.

Send 10c for Fada Handbook. Plumb full of radio facts.

F. A. D. ANDREA
1581 D Jerome Ave. N. Y. C.

FADA
RADIO PARTS

A Bigger, *Better* "Popular Radio" for Our Friends and Subscribers

—yet it will come to you without extra cost if you act at once!

TO our big family of POPULAR RADIO readers the addition of 22 more pages of reading matter in the February issue was mighty welcome news.

For several months past, a great store of timely and interesting articles had been piling up on the Editor's desk. There wasn't sufficient space to run them all—practical hints for the radio amateur; helpful suggestions on how to get the most out of *all types of sets;* understandable articles by distinguished scientists written exclusively for POPULAR RADIO; questions answered; hook-ups that work; thrilling stories and personal experiences filled with romance and adventure—just the kind of "live stuff" that has made this magazine so popular with our half a million enthusiastic readers.

So there was only one thing to do. We increased the thickness of the magazine! Now there will be no space limitations to prevent getting these articles quickly to our readers. "Month by month POPULAR RADIO is growing bigger and bigger."

The Same POPULAR RADIO *—only more of it!*

You'll be tickled with POPULAR RADIO these coming months. The same helpful, practical, interesting articles will continue. There will be more of them. New departments will be added. Don't take a chance on missing any of these bigger, better issues. Become a regular subscriber and get the magazine each month at your home.

Although the price of POPULAR RADIO has already been advanced to 20 cents on the newsstands, you can get a full year's subscription, 12 issues, for only $1.50. But this offer is open for a short time only. Act at once!

Save from 90c to $9.00 Mail the coupon today.

Effective March 20th, the subscription price of POPULAR RADIO becomes $2.00 a year. But if you act at once you may subscribe for as long a term as you wish (up to 10 years) at the old rate of only $1.50 a year. In this way you save from 90 cents, on a one-year subscription, to $9.00 on a ten-year subscription!

To present subscribers this same liberal offer is made. You may extend your present subscription to a period up to 10 years at the old price, thus saving from 90 cents to $9.00 and insuring that you receive, every month, the best radio magazine value there is!

Do not delay filling out the attached coupon and mailing it today. Only those subscriptions which come to us postmarked prior to midnight, March 20th, can be accepted at this low rate. A subscription to POPULAR RADIO, besides keeping you in touch with all the rapid developments in this fascinating field, will save you many times its cost in the construction and improvement of a set of your own, and will safeguard you against many an hour wasted in costly experiment.

Get only the best results by becoming a regular subscriber to POPULAR RADIO. Fill out and mail the coupon *now.*

This Coupon Saves You 90c to $9.00

POPULAR RADIO, INC.
Dept. 3, 9 East 40th Street, New York City

Please enter (renew, or extend) my subscription to POPULAR RADIO at the old rate of only $1.50 per year for the term of years checked in the square below. I enclose my remittance (check, money order or registered mail), and do not want to miss a single issue.

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- ☐ 10 years for only $15—saves $9.00 over the newsstand price
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"Rasco Has It" "Build Your Own!"

Partial List of Goods Listed In "Rasco" Catalog No. 8

Detectors
Navy Knobs
Switch Handles
Pointers
Lock Nuts
Cord Tips
Copper Ribbon
Switches
Crystal Cups
Sliders
Litz Wire
Rotors
Panel Scales
Switch Levers
Condenser Plates
Carbon Balls
Audio-Frequency Transformers
Radio Frequency Transformers
Radio Panels
Name Plates
Crystals
Bornite
Silicon
Radiocite
Condensers
Ground Clamps
Plugs
Contact Arms
Aerial Connectors
Bus Bar Wire
Enameled Wire
Transformer Coils
Copper Strip
Flexible Cord
Knobs
Panel Knobs
Key Knobs
Binding Posts
Lock Posts
Machine Screws
Switch Stops
Telegraph Key Knobs
Hard Rubber Binding Posts
Nickel-plated Switch Points
Zinc Spark Gap Ends
Panel Switches
Mounted Crystals
Tin Foil
Rheostat Windings
Spring Clips
Antenna Connectors
Spacing Washers
Carbon Grains
Blow Torches
Minerals
Copper Pyrites
Soft Metal (Hugonium)
Threaded Brass Rod
Cord Tip Jacks
Vacuum Tube Sockets
Mica Diaphragms
Radio Cement
Choke Coils
Magnet Wire
Brass Rod
Grid Leak Condensers
Phone Cords
Metal Dials
Universal Panel Bearing
Binding Post Name Plates
Spaghetti-Insulating Tubing
Handles
Switch Knobs
Potentiometer Windings
Instrument Posts
Hexagon Nuts
Spring Binding Posts
Switch Studs
Cap Nuts
Lubricated Switches
Panel Switch Levers
Mica
Vario-Coupler Rotors
Transformer Stampings
Dials
Phones
Brass Lugs
Copper Lugs
Battery Switches
Aerial Insulators
Composition Dials
Separable Cord Tips
Phone Condensers
Honeycomb Coils
Silk Wire
Resistances
Vacuum Tube Fuses
Rheostat Windings
Galena
Zincite
Plugs
Dial Verniers
Lock Washers
Jacks
Copper Braid
Brass Washers
Mineral Sets
Solderall
Carbon Buttons
Diaphragms
Selenium
Switch Blades

300 Illustrations

This catalog contains over three hundred illustrations. On account of its very great cost, it cannot be distributed free of charge.

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This business was originated with the sole purpose to cater to the amateur who has small orders. ALL OF OUR ORDERS ARE SMALL and that is why your small order will never be side-tracked by us. A trial order will make you a life customer. "We can only stick you once." Try us with a 50c order. ALL GOODS PREPAID.

Radio Specialty Co.

DEALERS Get Our Special Proposition

96A PARK PLACE, NEW YORK CITY FACTORIES Brooklyn, N.Y.—Elkridge, Md.

THE Radio Specialty Company, "RASCO" for short, is probably the most unique radio parts supply house in the United States, if not in the world today. This Company makes a specialty of SMALL ORDERS. No order can be too small to get immediate and prompt attention, for the simple reason that most of our orders are small.

The reputation of this Company was built solely on service. Ask any of your acquaintances what they think of "RASCO" goods, "RASCO" service, "RASCO" promptness! Thousands of unsolicited testimonials on file prove that we serve the public best!

Many houses claim that their orders are shipped within twenty-four hours. A year's record in our Order Department actually shows that over 99% of our orders leave within twelve hours after receipt. We invite you to try "RASCO" service on a 50c order. **MAKE US PROVE WHAT WE SAY.**

Sixty-eight per cent of all of our customers come back for more goods after they have tried our service once. The reason is very simple, as we specialize in very small orders. We could not stay in business if we had to look for new customers continually.

"RASCO" SERVICE IS WHAT COUNTS!

"Rasco" Catalog No. 8

The new "RASCO" catalog, No. 8, will prove a revelation to the man who "builds his own." In this catalog are listed more parts and more items than you have previously thought possible to obtain.

The new "RASCO" catalog contains over 500 different radio items, and has been greatly enlarged over the preceding one. **IT NOW CONTAINS 68 PAGES INSTEAD OF 40.**

Price Reductions

Many items have been reduced to give our customers the benefit of the lower prices that enlarged production makes possible.

Factories in Brooklyn, N.Y., and Elkridge, Md.

These two factories, where our screw machine work, our stamping and our composition work is turned out, make it possible for us to offer the very lowest prices in the country.

75 Vacuum Tube Hook-Ups!

These hook-ups of ALL important vacuum tube connections are given in clear diagrams with complete explanations. This is the one and only catalog containing such a wealth of information on all Vacuum Tube sets, giving all the correct values of all the elements, so that any amateur can readily hook up a set with the instructions furnished.

All Armstrong Circuits: These important circuits are explained clearly, all values having been given, leaving out nothing that could puzzle you. Just to name a few of the Vacuum Tube circuits: The V.T. as a detector and one-step amplifier; regenerative circuit; DeForest ultraudion; V.T. to receive undamped and spark signals; Armstrong circuits; one-step radio frequency amplifier and detector; three-stage audio-frequency amplifier; short wave regenerative circuits; V.T. radio telephone; 4-stage radio frequency amplifiers; radio and audio-frequency amplifier, inductively coupled amplifier; Armstrong superautodyne; radio frequency amplifier and crystal detector; combination V.T. detector one-stage amplifier; two-stage radio frequency amplifier and detector with feedback coupling (regenerative); regenerative receiver, using single spider web coil; Armstrong super-regenerative circuit; two-stage radio frequency amplifier coupled to a two-circuit tuner, using two-slide tuner regenerative receiver; two-stage audio-frequency amplifier, using crystal or V.T.; one-stage radio frequency detector, two stages audio-frequency with feed-back coupling to first tube; power amplifier with loud speaker; regenerative receiver and one-stage amplifier for DX work; one-stage radio frequency detector with feed-back coupling; very sensitive circuit with two stages of radio frequency and regenerative detector; one to ten mile radiophone transmitter; three stages radio frequency, two stages audio-frequency, loop reception; crystal detector with rectification; one tube super-regenerative receiver; short wave regenerative receiver with two variocouplers, capacity-coupled tuner; trap circuit to eliminate interference; selective circuit to eliminate intereference.

If you were to buy a hook containing all of these 75 Hook-ups you would have to spend from $3 to $7.00 to secure the same information.

Announcing the

New

Cunningham

Amplifier Tube

Type C-301-A **List Price, $9.00**

The most efficient vacuum tube ever placed on the market for amateur and experimental use. The engineers of the General Electric research laboratories have at last succeeded in perfecting a tube that every owner of a radio set has been waiting for.

Filament potential	5 volts
Filament current	.25 amp.
Plate potential	20 to 100 volts
Plate impedence	16,000 ohms
Amplification constant	6.5

Greater Power Amplification

Only ¼ Amp. Filament Current

THIS new and improved Cunningham C-301-A Amplifier is a high vacuum tube designed for use as an amplifier and detector, containing a new Tungsten Filament, the characteristics of which are long life, low power consumption, low operating temperature and greater power amplification than any previous amplifier tube. The tube has a standard four prong base, and the glass bulb has the same dimensions as the C-300 and the C-301.

The greatly reduced filament current permits the use of four of these tubes without exhausting the A battery any faster than when using one of the previous type of amplifier tubes.

Complete instructions for the care and efficient operation of this new Amplifier Tube are packed with every tube.

Insert a C-301-A in your amplifier set to-day. Note the improved quality and increased audibility.

The Cunningham Technical Bureau is at your service. Address your problems to Dept. B.

E. T. Cunningham

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