Popular Radio

15¢

JULY 1922

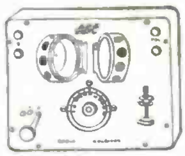
THERE ARE NO ETHER WAVES

A new and revolutionary conception of radiant energy that demolishes present-day theories of electromagnetic wave motion

By Dr. Charles P. Steinmetz

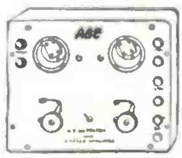
ABC *Standardized Radio* UNITS *Sectional Receiving*

THE three ABC units here shown form the ideal combination for a receiving set. They may be purchased one at a time if desired, enabling you to add to your station at any time without discarding any previous equipment.



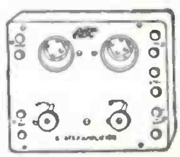
No. 5010
Crystal Detector

This first unit is capable of receiving wireless telephone up to 25 miles. The only accessories needed are the "completion package" and 2,000 Ohm head set, making the total price $40.00



No. 5013
Combination Detector and Amplifier

The first two units make a vacuum tube outfit capable of receiving wireless telephone up to 150 miles. Price $37.50: and for both units complete, except storage battery . . $94.70



No. 5014
Two-Step Amplifier

The third unit will increase the range and signal strength of the two previous units very considerably. Price for this unit alone, $45.00: or for the three units complete, except storage battery, $155.55

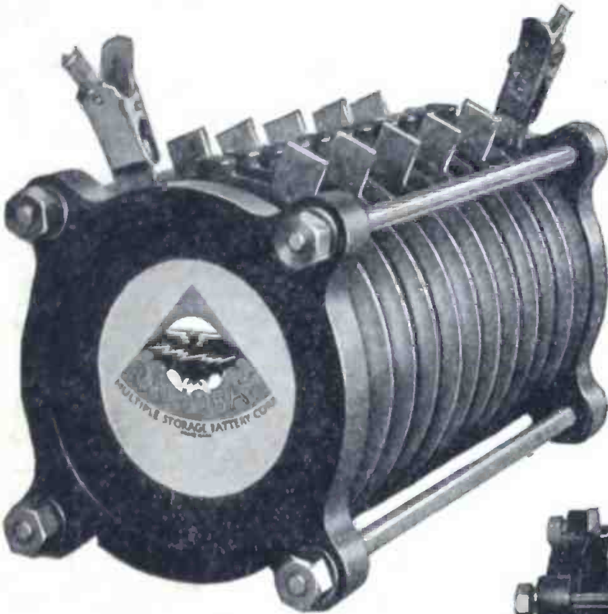
We have a very complete, interesting and educational catalog which you should have. Ask your dealer or write us.

Jewett Manufacturing Corp.

342 Madison Ave., Dept. D7, New York

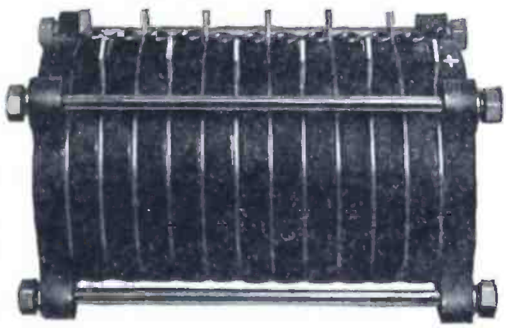
The Multiple Storage Battery Corporation Announces

RADIOBAT "B"



The Most Remarkable "B" Type Radio Battery

Revolutionary in Design and Construction



Radiobat "B" is practically everlasting. It has no glass to break, no wooden case to rot, no separators of any kind. Radiobat "B" is leak-proof, it is free from acid fumes.

Any voltage desired can be obtained simply and easily. Radiobat "B" will give a clearer tone to your Radio.

Also for laboratories and Experimenters interested in high voltage with low amperage.

As Radiobat "B" has just been placed on the market, it is possible that your regular dealer will not be able to supply it. If this is the case, write us today enclosing $12.00, the price of this extraordinary battery.

MULTIPLE STORAGE BATTERY CORP.

350 MADISON AVENUE, NEW YORK

Dealers write at once for our proposition

POPULAR RADIO

VOLUME I | CONTENTS *for* JULY, 1922 | NUMBER 3

(*Cover design by Charles B. Falls*)

DEPARTMENTS

VOLUME I | JULY, 1922 | NUMBER 3

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KENDALL BANNING, *Editor* LAURENCE M. COCKADAY, R.E., *Technical Editor*

GREBE RADIO
"He who has heard but part of the truth
said Chuang Tzu,
"thinks no one equal to himself."
Compare your present outfit with a Grebe!
Doctor Mu.
Licensed under
Armstrong U. S. Patent,
No. 1113149.

A PAGE WITH THE EDITOR

WHEN the Circulation Manager admits that the remarkable newsstand sales of a magazine is overdue partly to the excellence of the product and not solely to his remarkable abilities as a circulation manager, then the Editor may safely conclude that he is dealing with an Honest Man. Read what our Circulation Manager Reports:

"Dealers agree that POPULAR RADIO will lead the field. Its general make up, covers and contents are perfect. The editors certainly are doing a wonderful job, and the attached figures are the very best evidence of it."

The "attached figures" of copies actually sold show a sale of 93 percent in the Boston district! The Editors bow, and extend to the Circulation Manager the ancient Chinese blessing, "We hope you will live a million years and have a thousand children."

* * *

HERE is a letter that warms the cockles of the heart; it comes from Tottenville, New York:

"At a monthly meeting of the Tottenville Radio Club last night, it was decided to adopt POPULAR RADIO as our official club magazine. The members were highly enthused over it and declared it to be the best all-around magazine now on sale."

ROBERT A. FULLER.

* * *

AND here are three typical letters from widely scattered points that indicate that POPULAR RADIO is really accomplishing one of its main objects—to tell the layman about radio in terms that he can clearly understand:

"Your descriptions of the construction and operation of a radio set are the best that I have seen. They are written in plain English and illustrated in a way that a novice can understand."

R. H. INNES, *Dallas, Texas.*

"It is written in plain and very understandable language. All radio fans should take it to understand how to install and work their sets in the most efficient way."

EDMUND R. COLWELL, *Montclair, N. J.*

"I believe that POPULAR RADIO is the best and most helpful book for the money on the market."

A. E. HARP, *San Francisco, Calif.*

* * *

AMONG the leading radio experts who have undertaken to contribute to POPULAR RADIO since our last number went to press are some of the foremost scientists in the world—including Major-General George O. Squier, the father of "wired wireless," Professor J. H. Morecroft of Columbia University, John V. L. Hogan, Dr. Clayton H. Sharp and Minton Cronkhite.

INCIDENTALLY,—as further evidence of the quality of the magazine—just glance over the list of famous artist contributors! The striking cover design on this number was drawn by C. B. Falls, one of the most distinguished poster artists in the world. Next month's cover has been painted by Harry Townsend, one of the eight Official Artists of the A. E. F. Other artist-contributors are Adolph Treidler, Joseph Cummings Chase, Franklin Booth, Henry Reuterdahl (the Official Artist of the U. S. Navy), Gerald Leake, Frederic Stanley, J. Clinton Shepherd, Orson Lowell——and Don Herold and Clare Briggs, the famous cartoonists. National celebrities, every one of them!

* * *

THIS letter from Belington, West Virginia, sounds a timely warning:

"I am enclosing 15 cents for which please send me a copy of your current issue; it was all sold out at the newsstand in our town before I could get one."

FRED SIMPSON.

Do your magazine shopping early! Better order your August number from your newsdealer *now.*

* * *

AND here is a personal letter from one of the most widely-known men in the electrical industry who points out one of the really worthwhile duties of an editor—to render a useful public service:

"POPULAR RADIO is bringing to the radio novice and to the radio amateur in terms that the lay reader can understand, sound and authoritative information concerning the electrical science and the radio art—and in this it is rendering a real and invaluable public service."

GEORGE H. GUY, *New York.*

* * *

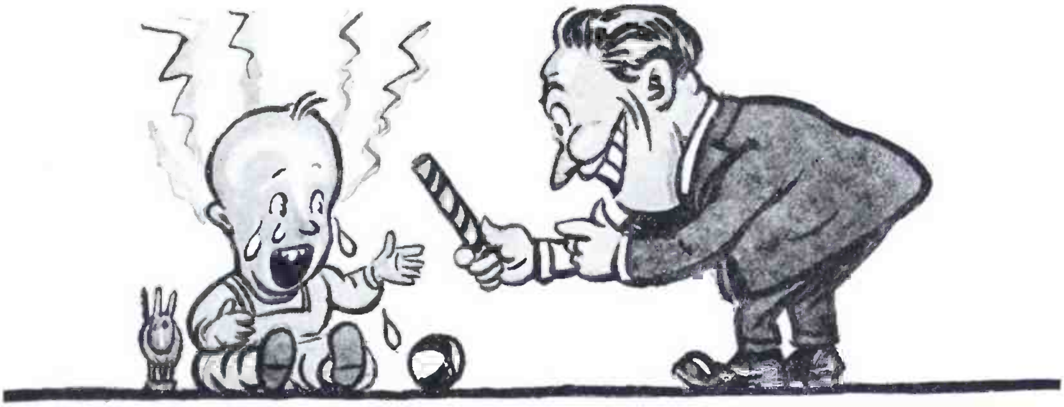
IN the protection of our readers, all radio equipment that is advertised in this magazine has met and must continue to meet the approval of the POPULAR RADIO INSTITUTE. A more extended notice of the Institute and its investigations will appear in the next issue—August.

* * *

THE leading article in the next number will be "Fighting Fire by Radio," illustrated with photographs that show how the Forest Service is saving Uncle Sam countless thousands of dollars—not only in reporting forest fires but also in directing the work of the fire-fighters.

Kendall Banning

Editor, POPULAR RADIO



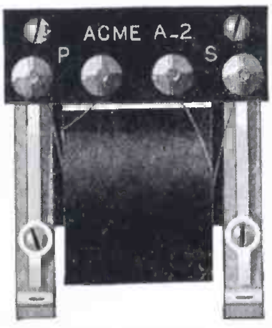
The end of a perfect howl—

THE squawls of a two year old are as music to the ear beside the howling demonstration put up by a fractious radio set. And how a set can howl unless one offers the soothing influence of the proper amplifying transformer.

Most any transformer can amplify sound, but it will also amplify the stray fields which produce howling and distortion. It takes the Acme Amplifying Transformer with its specially constructed iron core and coil to put an end to the howls and yowls. Only when you add the Acme do you get the realistic tone and volume so markedly absent in the ordinary radio receiving set.

The Acme Radio Frequency Transformer greatly increases the range of any receiving set, either vacuum tube or crystal detector type. The Acme Audio Frequency Transformer produces not only volume, but reality of tone. It is indispensable to the satisfactory operation of loud speaking devices. The combination of one or more stages of Acme Radio and Audio Frequency Transformers assures the maximum of range, of volume and of reality in tone.

The Acme Apparatus Company, pioneer radio engineers and manufacturers, have perfected not only Radio and Audio Frequency Transformers as well as other receiver units and sets, but are recognized as the foremost manufacturers of Transmitting Apparatus for amateur purposes. Sold only at the best radio stores. The Acme Apparatus Company, Cambridge, Mass., U. S. A., New York Sales Office: 1270 Broadway.



Type A-2 Acme Amplifying Transformer, price $5 (East of Rocky Mountains)

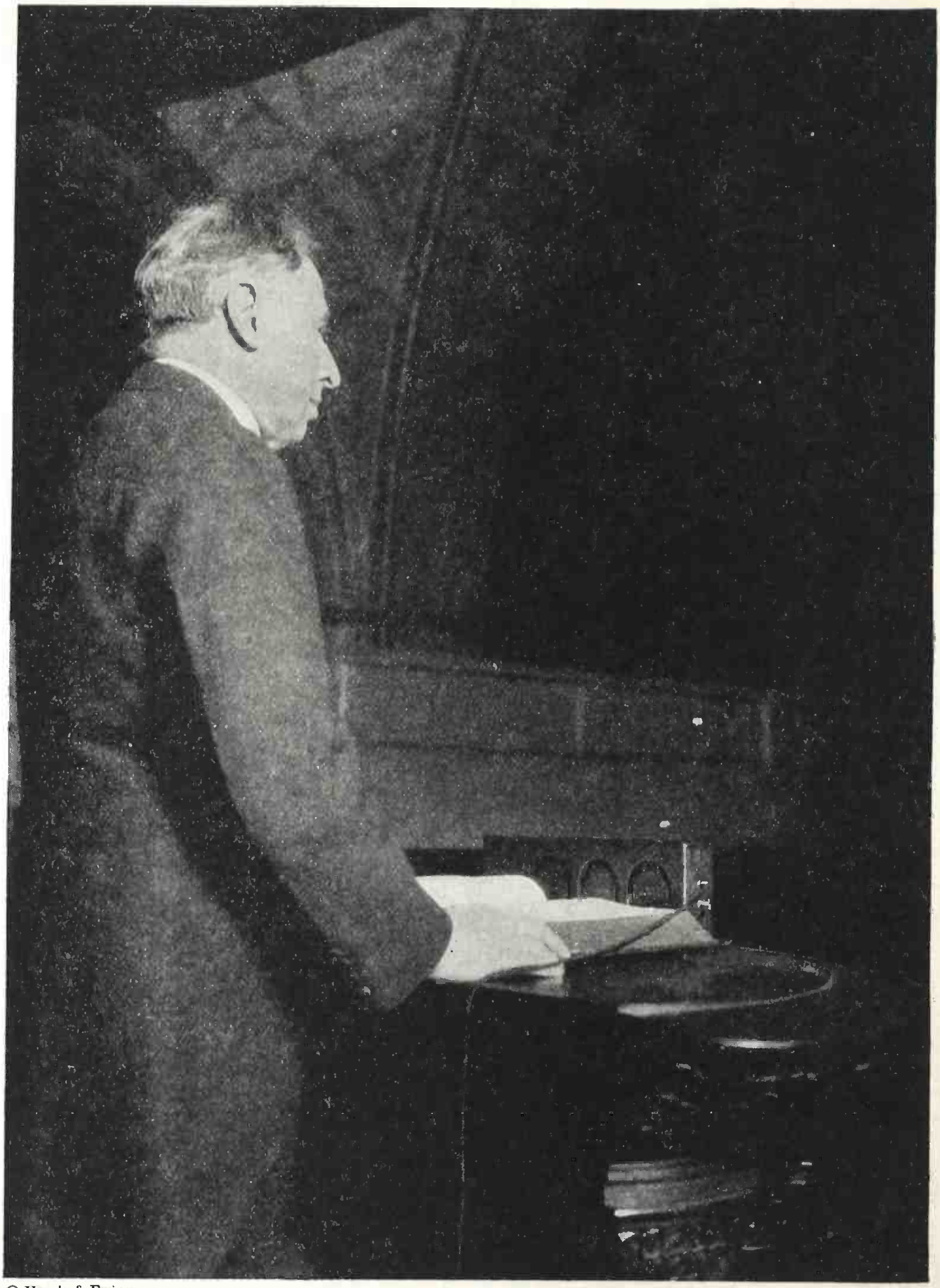
ACME

for amplification

© Underwood & Underwood

IF *one of our amateurs should pick up a radio message sent out to us from some planet circling a sun on the far frontiers of the Milky Way he would know that the sender of the message lived and died more than* 25,000 *years ago and that the message had been on the way all that time, and this, too, coming at the speed of light—* 186,000 *miles a second. For the light by which we see such a star left there* 25,000 *years ago.*

—Hudson Maxim



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A SERMON THAT WAS BROADCASTED OVER AN AREA OF 12,000 SQUARE MILES

By means of the four microphones connected in multiple on the pulpit, the voice of Dr. Charles Wood of Washington, D. C., was converted into electrical current that was transmitted by radio from a station in the church loft over a distance of 350 miles in all directions. Is the radio hurting the church? *Turn to page* 176.

Popular Radio

VOLUME I JULY, 1922 NUMBER 3

Radio: *the* World's Peace-Maker

Is Wireless Destined to Succeed Where Statesmen Have Failed in Bringing the People of the Earth into Understanding with Each Other? So Thinks the Distinguished World-Correspondent—

WILL IRWIN

IT was two summers ago. Teddy, who lives just behind me in the country, had been exceedingly busy these many weeks. I know young Teddy as a mechanical marvel, and having myself been born without dower of a mechanical sense, I admire his activities without investigation. I did notice him dimly, at different times, in the act of nailing wires along the flag-pole, and digging some kind of trench by the back door. Also, I found him at his chum Kilby's making a trade for a worn-out automobile battery.

"Whatever is he up to now?" I asked Kilby.

"Wireless telegraphy," said Kilby.

"Gee, the kid's ambitious," I remarked. As I remember it now, I had heard only recently that you could telephone without wires.

The day of the Carpentier-Dempsey fight arrived, and I was marooned in the country. I was trying to work pending the hour when I should telephone to Boston for news, when Teddy strolled in.

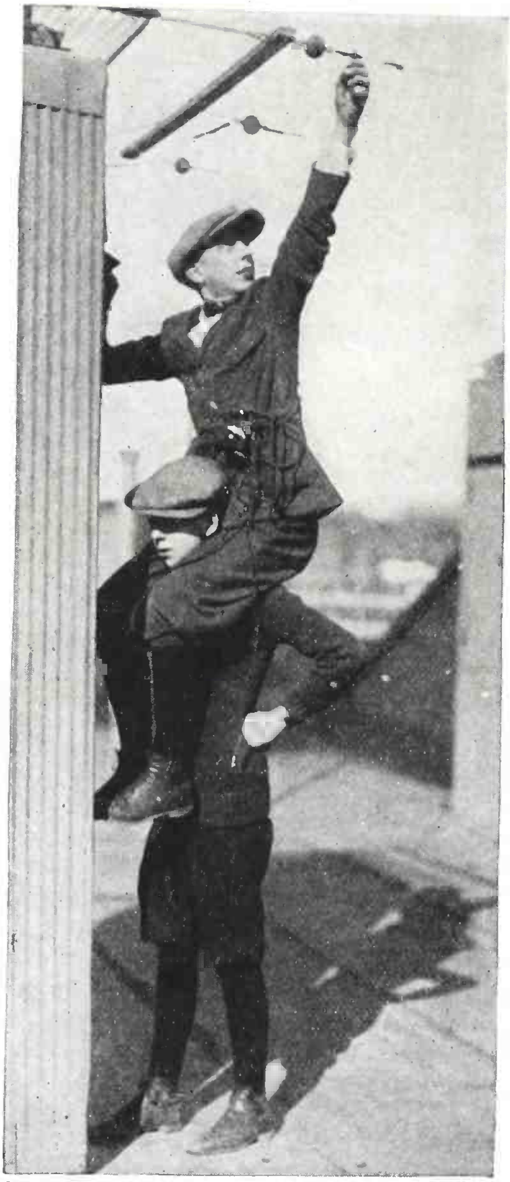
"Want to hear the returns from the fight?" he asked. "Got the old box tuned. They'll be talking from the ringside in ten minutes."

I flew to Teddy's room. He slipped on his headpiece, did some mysterious testing; I slipped on mine. A voice, far clearer and more natural than any I had ever heard over the conventional telephone, was saying:

"Carpentier has just entered the ring!"

When the excitement was over, I expressed to Teddy my fulsome admiration—plucking official dispatches out of the air in that way. Teddy received my compliments modestly. "All the fellows are doing it," he said.

I didn't really believe him. It was only last winter, when the newspapers began to burst out with radio columns, when Hoover held his conference in Washington, when the statisticians announced a million receiving outfits in the East alone, when I found the term "ether hog" embedded in American slang, that I realized how a new force of civilization had been slipped over on my generation. The newer generation is always doing that to the elder, I suppose. Probably along about 1830, middle-aged gentlemen heard with dim interest that people were starting railroads, and noticed next that stage-coaches were beginning to disappear. The



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THE NEW PIONEERS OF PEACE

The average amateur receiving set has a range of about 200 miles. What effect will this have in bringing together the nationalities of crowded Europe?

younger generation is forever remolding the world under our noses; but we have on our reading glasses and cannot see.

I have been speculating of late on this new agency of civilization; I have even tried to make out the slang of the craft in the radio columns. And I am wondering if we have not found this time a thing bigger than we know. A steam-engine turns wheels or lifts burdens. A locomotive draws, an aeroplane carries material things. But this device distributes speech, which is thought made audible, and thought is the basis of everything. Before the war, some expert on transportation calculated that any two given places on the earth's surface were eleven times nearer than they were a century before; hence the necessity for that growth, so marked since the war, from nations to alliances and finally toward some system of general world federation. But here we are in process of bringing all points in the world so close together in this important matter of speech from man to man, that virtually no distance intervenes at all.

I am quite aware—moron though I am in the matter of mechanics—of the mechanical limitations in this stage of development. I know that the million radio enthusiasts on our Atlantic coast are only listeners, not speakers, that the present receiving radius for a set within the means of an ordinary boy is only two hundred miles or so; that we have not solved the problem of unlimited numbers of conversations. However, he who says that all the limitations cannot be conquered rates himself, to my mind, with those who said in 1810 that a locomotive traveling twenty-five miles an hour would kill all its passengers by "air suction" or those who said in 1905 that the aeroplane must always remain a toy and would never fly far. I believe these difficulties will be conquered and then—what a changed world!

To begin with the most important thing: the question before us all is whether we are going to get rid of war or war is going to get rid of us.

Everyone who has struggled with this problem understands that it has a dual nature. We must organize the world in such manner as to have a real international law between nations as we have national law between individuals; and we must back up this law by a real moral sense.

From a photograph made for POPULAR RADIO

WILL IRWIN LISTENS IN

In the radio he sees something infinitely greater than a mere instrument for entertainment, however. He conceives it as a medium for bringing the scattered peoples of the world into contact and eventually into understanding.

Leagues or associations of nations, tribunals of arbitration, Pacific pacts, will serve but little if peoples keep up those old hatreds and suspicions which result mainly from poor acquaintance—if the average German continues to believe that the average Frenchman is a false, immoral little doll, and the average Frenchman believes that the average German is a wallowing human hog.

I remember an instance which points the moral. Three months after the armistice, I traveled down the Rhine with a commission of French officers. In the party was a young lieutenant, member of a family which owned a famous French printing establishment. He had been brought up in the business; art typography was his hobby. Also, he hated Germans. At Mayence (or Mainz) lived Gutenberg, generally credited with the rediscovery of printing for the western world. In the town museum are kept not only his presses, his types and specimens of his early work, but a library of artistic printing which has been accumulating for four centuries. The lieutenant and I, the only members of the party interested in such things, went A. W. O. L. to visit the museum. We were admitted by the curator, a crop-headed little German with a square set to his shoulders, a red scar across his scalp and a barking voice. Every line and tone and gesture proclaimed that he was an ex-officer of the late Imperial army. The Frenchman saluted formally; the German clicked his heels and bowed stiffly. We moved to the collection in an atmosphere of frigid hate, badly veiled with overdone politeness. And so we plunged into Gutenberg and into exchange of views on printing. When, four hours later, we left the Museum, the Frenchman and German shook hands enthusiastically, and both of us visitors had joined the Gutenberg Soci-

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WILL THE AMATEURS BREAK DOWN INTERNATIONAL BOUNDARIES?

These school boys at Haslemere, England, are doing something more than merely rigging up an antenna on an old wind mill; they are laying the foundations for a radio acquaintance with schoolboys in France and Germany and Italy —and perhaps some day in America.

ety! The bond of common intellectual interest is stronger than the bonds of race.

So, in the next generation the average German of Nuremberg, say, may remember, as war clouds the horizon, that French boy of Tours with whom he used to discuss every night his butterfly collection or his stamps or his troubles with his wireless apparatus. And it will not be possible to make him believe with conviction that every Frenchman is an effeminate little rat. And similarly the Frenchman, remembering Hans, the ether-chum of his youth, will not swallow the idea that every German wallows in blood. That is the boy end of it—wireless telegraphy, glory be, is primarily a boy-activity. And because the thoughts of youth are long thoughts it is also the important end. But men too will be speaking nightly with men of similar tastes. "How can I hate a man I know?" said Charles Lamb.

All this, provided we overcome the language barrier. And there comes another fascinating possibility. All my generation, certain enthusiasts have been inventing and trying to implant a universal language. The Esperantists showed how simple a language could be made. Strip it of grammatical irregularities and idioms, construct its vocabulary so far as possible from those roots common to all the European tongues, and you have a language in which any person of average intelligence ought to become proficient in a few weeks. Indeed, people especially gifted in the language faculty have learned a good speaking knowledge of Esperanto in a week. But none of these projects "took hold;" Esperantism remained the tongue of a few enthusiasts. There was lacking a pressing need—the only thing which urges men on to great changes of habit. The need is here.

Who knows but in the days of my grandson every school of standing will be teaching along with the native tongue a tongue universal? And if that comes about—all it will mean for peace and international understanding—we shall owe it solely to the wireless telephone.

General Electric

There Are No Ether Waves

A New Conception of Radiant Energy That Disposes of Many Present Day Theories

By Dr. Charles P. Steinmetz

THE *author of this article—who is not only a great electrical engineer and the Chief Consulting Engineer of the General Electric Company but also one of the greatest physicists of the world—does not believe in ether waves. Science, he says, has disproved the real existence of any material substance like the ether. In this statement he reflects the most recent scientific conclusions on the subject. Light and radio waves are merely properties of an alternating electromagnetic field of force that extend through space.*

Scientifically this is conclusive. Professional scientists do not need the idea of the ether. They can think better without it. They can think better in terms of an electromagnetic field.

For non-scientific readers this may not be so easy. The idea of a field of force is not easy to grasp. Perhaps it will be necessary for a while, for beginners to retain the understanding of radio effects by the ether hypothesis—to think of light and other radiations as being waves in something, waves like waves in the water.

To science the ether hypothesis is useless. In helping the mind to get a preliminary idea of radio, it may still be of service. Just as it is convenient to keep on thinking of gravitation as a force between two pieces of matter, although the Einstein theory of relativity has shown that gravitation is neither a force nor energy nor a property of matter, but is, apparently, a property of space.—Editor

THE greatest contribution to science of the last ten or fifteen years, in my opinion, is the theory of relativity as worked out by Einstein and his collaborators. It is of vital importance because it revolutionizes our whole conception of nature and space. The theory of relativity concludes that there exists no absolute position or motion, but that these elements are relative.

In other words, if we had only one single body in the universe we could never know whether that body is moving or standing still. If we had two bodies we could never find out whether body A moves and body B stands still, or whether body B moves and body A stands still. Nor could we determine whether they both move. There is no real absolute motion and we can speak of motion as relative only. If we had only one body in other words there would be no reason in speaking of that body as either moving or standing still. The conception of motion comes in only when there is more than one body.

This conclusion is incompatible with the hypothesis of the ether as carrier of light.

If ether fills all space, then there must be absolute position and absolute motion. A body is at rest or is moving relative to the ether, and this would be an absolute motion and would enable us to find out whether the body is standing still in regard to the ether or whether it is moving in regard to the ether, even if no other body existed.

If the theory of relativity is right, therefore, then there can be no such thing as the ether and the ether hypothesis is untenable. It becomes necessary, then, to look into this ether hypothesis to determine how it was evolved and what it means.

The first theory of light which demanded attention was promulgated by Newton. He explained light as a bombardment of minute particles projected at extremely high velocities. If this corpuscular theory of Newton's is right, then two equal beams of light when superimposed, must always combine to a beam of twice the intensity. Experience shows, however, that two equal beams of light, when superimposed, may give a beam of double intensity or they may extinguish each other and give darkness, or they may give anything between these two extremes. This can be explained only by assuming light to be a wave, like an alternating current. Depending on their phase relation the combination of two waves, as two beams of light or two alternating currents, may be anything between the sum and the difference of the two intensities. Thus two alternating currents which are in phase add; if they are out of phase they subtract.

If light is wave motion, there must be something to move, and this hypothetical carrier of the light wave has been called the ether. At this point our troubles begin.

The phenomenon of polarization shows that light is a transverse wave; that is, the ether atoms, or whatever it is that moves in the ether, move at right angles to the light beam, and not in the direction of the beam as is the case with sound waves. In such transverse motion, a vibrating ether atom neither approaches nor recedes from the next ether atom, and the only way in which the vibratory motion of each ether atom can be transmitted to the next one is by forces that act between the ether atoms so as to hold them together in their relative position. That is, transverse waves can exist only in solid bodies. As the velocity of light is extremely high (180,000 miles a second) the forces between the ether atoms, which transmit the vibrations, must be very great.

In other words, the hypothetical ether is a solid with a very high rigidity—infinitely more rigid than the hardest steel.

At the same time the ether must be of extremely great tenuity, since all the cosmic bodies move through it at high velocities without meeting any friction. In the revolution of the earth around the

International

DO WAVEMETERS REALLY MEASURE "ETHER WAVES?"

If, as Dr. Steinmetz maintains, there is no such thing as ether there are obviously no such things as ether waves. Accordingly this machine, instead of recording lengths of ether waves, must be recording some other forms of resonant phenomena which do not rest upon the ether hypothesis.

sun either the ether stands still and the earth moves through the ether at twenty miles a second, or the earth carries a mass of ether with it. In the first case, there should be friction between the mass of the earth and the ether; in the latter case, there would be friction between the ether that is carried along with the earth, and the stationary ether. But in either case, the frictional energy would come from the earth and show astronomically as an increase of the length of the year and increase of the solar distance. And no such evidence of ether friction is observed.

The conception of the ether is one of those hypotheses, which have been made in the attempt to explain some difficulty, but the more it is studied, the more unreasonable and untenable it becomes. It is merely conservatism or lack of courage which has kept science from openly abandoning the ether hypothesis. Belief in an ether is in contradiction to the relativity theory, since this theory shows that there is no absolute position nor motion, but that all positions and motions are relative and equivalent.

Thus the hypothesis of the ether has been finally disproven and abandoned.

There is no such thing as the ether. And light and wireless waves are not wave motions of the ether.

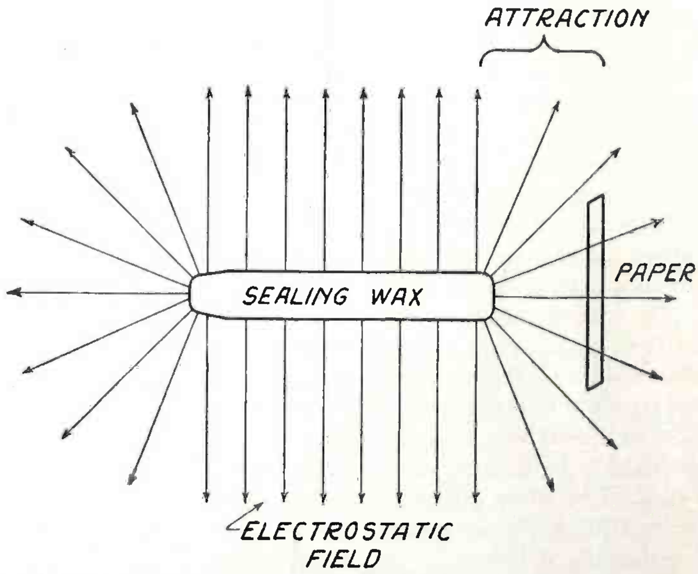
What, then, is the fallacy in the wave theory of light, which has led to the erroneous conception of the ether?

The fact that beams of light can cancel out each other, and can interfere, proves that light is a wave, a periodic phenomenon, just like an alternating current. Thus, the wave theory of light and other radiations stands today just as unshaken as ever. However, when this theory was established the only waves with which people were familiar were the waves in water and sound. Both are wave motions. Waves involving movement of matter. As the only known waves were wave motions, it was natural that the light wave was also considered as a wave motion. This led to the question; what moves in the light wave? And this question led to the hypothesis of the ether, with all its contradictory and illogical attributes. But there is no more reason to assume the light wave to be a wave motion of matter than there is to assume the alternating current wave to be a motion of matter. We know that nothing material is moving in the alternating current, and if the wave theory of light had been propounded after the world had become familiar with electric waves of alternating currents, that is the waves of periodic phenomena (which are not wave motions of matter), the error of considering the light wave as a wave motion would never have been made and the ether theory would never have been propounded.

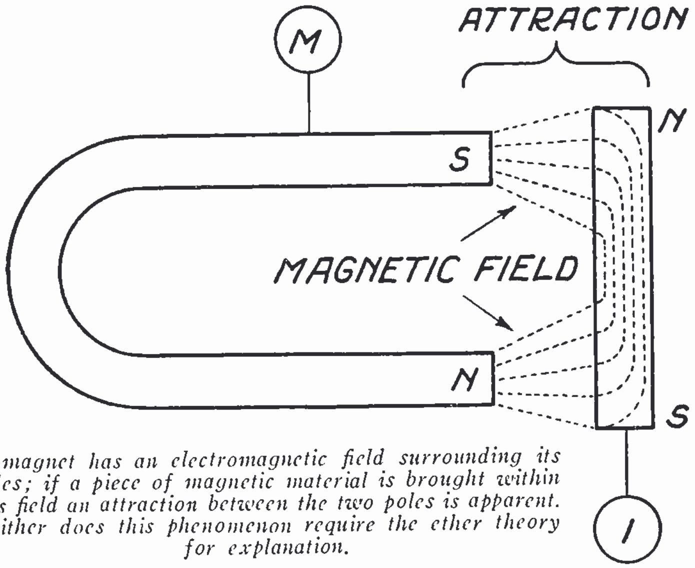
Hence, the logical error, which led to the ether theory, is the assumption that a wave must necessarily be a wave motion. Electrical engineering has dealt with alternating currents and voltage waves; it has calculated their phenomena and applied them industrially, but it has never considered that anything material moves in the alternating current wave and has never felt the need of an ether as the hypothetical carrier of the electric wave. When Maxwell and Hertz proved the identity of the electromagnetic wave and the light wave, the natural conclusion was that the ether is unnecessary also in optics. But curiously enough, we then began to talk about electric waves in the ether and about ether telegraphy. In other words, we dragged the conception of the ether into electrical engineering, where it never had been found necessary before.

But, if the conception of the ether is unnecessary what are we to think of as the mechanism of the light wave and the electromagnetic wave?

Suppose we have a magnet. We say that this magnet surrounds itself by a magnetic field. Faraday has given us a picture representative of the lines of magnetic force. Suppose we bring a piece of iron near this magnet. The iron is attracted or moved. A force is exerted on it. We say that the space surrounding



This diagram illustrates an electrostatic field that is set up around a piece of sealing wax by rubbing it with a bit of cloth, thus attracting such objects as pieces of paper, for example. This phenomenon does not rely upon the ether theory for explanation, states Dr. Steinmetz; it is explained on sounder scientific grounds.



A magnet has an electromagnetic field surrounding its poles; if a piece of magnetic material is brought within this field an attraction between the two poles is apparent. Neither does this phenomenon require the ether theory for explanation.

the magnet is a magnetic field. A field, or field of force, we define as "a condition in space, exerting a force on a body susceptible to this field." Thus a piece of iron being magnetizable—that is, susceptible to a magnetic field—will be acted upon. A field is completely defined and characterized at any point by its intensity and its direction.

To produce a field of force requires energy, and this energy is stored in the space we call the field. Thus we can go further and define the field as "a condition of energy storage in space, exerting a force on a body susceptible to this energy."

The space surrounding a magnet is a magnetic field. There are other kinds of fields of force. For instance, if we electrify a piece of sealing wax by rubbing it, it surrounds itself by a dielectric or electrostatic field, and bodies susceptible to electrostatic forces—as light pieces of paper—are attracted.

So the earth is surrounded by a gravitational field. If a stone falls to the earth, it is due to the stone being in the gravitational field of the earth, and being acted upon by it.

Now suppose that, instead of our permanent magnet with its magnetic field of force, we have a bundle of soft iron wires, surrounded by a coil of insulated copper wire, and that we send a constant direct current through this coil. We then have an electromagnet, and the space surrounding the magnet is a magnetic field. If now we increase the electric current, the magnetic field increases; if we decrease the current, the field decreases; if we reverse the current, the field reverses. If we send an alternating current through the coil the magnetic field alternates, that is, the field becomes a periodic phenomenon or a wave: an alternating magnetic field wave.

Similarly, by connecting an insulated conductor to a source of voltage we produce around it an electrostatic or dielectric field; a constant field, if the voltage is constant, an alternating dielectric field, (that is, a periodic or wave phenomenon), if we use an alternating voltage.

Magnetic and electrostatic fields are usually combined, since where there is a current producing a magnetic field there is also a voltage producing an electrostatic field. Thus the space surrounding a wire that carries an electric current is an electromagnetic field, that is, a combination of a magnetic field and an electrostatic field. If the current and voltage are constant, the electromagnetic field is constant. If the current and voltage alternate, the electromagnetic field alternates; that is, it is a periodic field or an electromagnetic wave.

Maxwell deduced mathematically, and Hertz demonstrated experimentally that the alternating electromagnetic field (the electromagnetic wave), has the same speed of propagation as a light wave. It has been shown that the electromagnetic wave and the polarized light wave are identical in all their properties. Hence light is an electromagnetic wave.

Electrophysics has been successfully developed to its present high state, has dealt with alternating currents, voltages and electromagnetic fields, without ever requiring a medium such as the ether.

The conception of the field of force, or as we should say more correctly the field of energy, thus takes the place of the conception of the ether. The beam of light, the wireless wave, any electromagnetic wave is a periodic alternation of the electromagnetic energy field in space. Differences between light and other waves are merely those due to differences of frequency. Thus the electromagnetic field of the 60-cycle transmission line has a wavelength of

$$\frac{3 \times 10^{10}}{60} \text{ cm} = 5000$$

kilometers. The field is limited to the space between the conductors and their immediate surroundings. This is extremely small compared with the wavelength. Under these conditions, the part of the electromagnetic energy which is radiated into space is extremely small —so small that it can be neglected. In radio communication we use wavelengths of 15,000 to 200 meters and less; that is, frequencies of 20,000 to 1½ million cycles and more. The circuit is arranged to give the electromagnetic field the greatest possible extent, as it is the field which carries the message. Then a large part, even a major part, of the energy of the electromagnetic field is radiated. The frequency of the light wave is much greater still, 600 millions of millions of cycles. The wavelength, 50 microcentimetres, is a very tiny part of the extent of the field. Therefore practically all of the energy of the field is radiated; none is returned to the radiator.

Our lack of familiarity with the conception of an energy field in space, and our familiarity with the conception of matter as the carrier of energy, may lead to the questions: What is the carrier of the energy of the field of space? Would not the ether be needed as a carrier of the field energy, just as on the older theory it was needed as a carrier of the hypothetical wave motion of matter?

These questions are due to a mental error. Familiarity reverses the relation between primary and secondary conceptions.

All that we know of the world is derived from our senses. They are the only real facts; everything else is conclusioned from them. All sense perceptions are due to energy; they are exclusively energy effects. In other words, energy is the only real existing entity. It is the primary conception, a conception which exists for us only because our senses respond to it. All other conceptions are secondary conclusions, derived from the energy perceptions of our senses. Thus space and time and motion and matter are secondary conceptions with which our mind clothes the events of nature.

Obviously, then, by carrying the explanation of light and electromagnetic waves back to the energy field—to energy storage in space—to the electromagnetic field, we have carried it back as far as possible. We have carried it back to the fundamental conceptions of the human mind; the perceptions of the senses.

¶ *In the next issue—August—will appear the article by Dr. E. E. Free, "How the Sun Helps Wireless," which has been held over from this number in order to include some new and valuable material that is being prepared epecially for* POPULAR RADIO.

From a photograph made in 1915 by Samuel Cohen

A RADIO AMATEUR WHO BALKED THE GERMANS SINGLE-HANDED

One of the most valuable services ever rendered by a radio operator in this country was performed by Charles E. Apgar, who made phonograph records of the mysterious code messages sent out by the Telefunken station—and furnished evidence that compelled the Government to take it over.

The Secret Service *of* the Air

How the police are beginning to use radio in running down crooks was told by Fred C. Kelly in the June number of this magazine. In this article the author (who prefers to remain anonymous) describes how the crooks themselves are using wireless—and how they have been caught at their own game.

By ONE OF THEM

A TOURIST, clad in white, perched upon the edge of the dock at Nassau and dangled a fishing line through the glass-clear water. Near at hand—within earshot in fact—a schooner much in need of a coat of paint was moored to the dock among other even more weather-beaten craft. With West Indian disregard for time, black stevedores were loading cases upon the schooner, as they had been doing for days past; likewise for days past the tourist had been fishing at the same spot. But his eyes, shaded by the broad Panama hat, watched every movement on the dock or schooner. And when the final case had been placed aboard the schooner, her crew started to strip the covers from her furled sails.

The tourist rose, strolled up the street and ten minutes later from the big wireless towers a message was speeding through the air. It was an innocent enough message, evidently of no great importance. It read:

"Hendryx, Washington. Helena leaving. Try meet her on arrival. She has considerable baggage."

The secret service of the air was at work. It was doing its bit to stop the influx of contraband liquor from the Bahamas. But even the secret service of the air is not always infallible.

* * *

A few days later, upon a smooth sea, with Martha's Vineyard just out of sight below the horizon, a speedy looking schooner much in need of a coat of paint lay hove-to, rolling gently to the Atlantic swell, a blue triangular flag at her main topmast head.

Presently, in the direction of the land, a tiny white speck appeared which developed into a rushing power boat, her brass work gleaming in the sun and her mahogany cabin glistening with varnish. At the boat's wheel was a uniformed officer and another yachtsman; at the summit of the craft's single mast there streamed a triangle of blue.

Upon the schooner's deck a bull-necked man gazed at the oncoming yacht through his glasses.

"That's him," he remarked and gave an order to a mulatto standing near. A moment later, a tiny ball rose upward to the schooner's trucks and broke out into a square of white bunting. Immediately upon the power boat's mast there appeared a red triangle beneath the blue. Fifteen minutes later, the yacht was motionless fifty yards from the schooner and a rowboat was dancing towards her.

A few nights later a small schooner, much in need of a coat of paint, was headed towards the inner harbor of New York under her rickety gasolene kicker. A police boat fell in behind the slowly chugging little schooner, trailing in her wake until she at last turned up the East River and dropped anchor off a recreation pier under the shadow of Queensboro bridge.

But on that silent run up the harbor the secret service of the air had not been idle. Lurking about the pier, crowded in the shadows, were armed men. The *Helena* would indeed be met at the dock and her baggage well looked after! And there were others there too. Motor cars and trucks were parked near the dock, as if awaiting loads; most of them had their engines running. The waiting officials and police figuratively patted themselves on their backs. There had been no hitch in their plans; the schooner was in the stream; the trucks were awaiting her cargo.

Presently, from the river came a sharp whistle—three short blasts and a long one. From a waiting car came the reply. A moment later, the staccato exhaust of the craft's motor echoed over the river

International

EAVESDROPPING BY RADIO

When the San Francisco police raided a local bucket shop they found this miniature radio apparatus for receiving stock tips transmitted by a confederate in a broker's office that had wire communications with the N. Y. Stock Exchange.

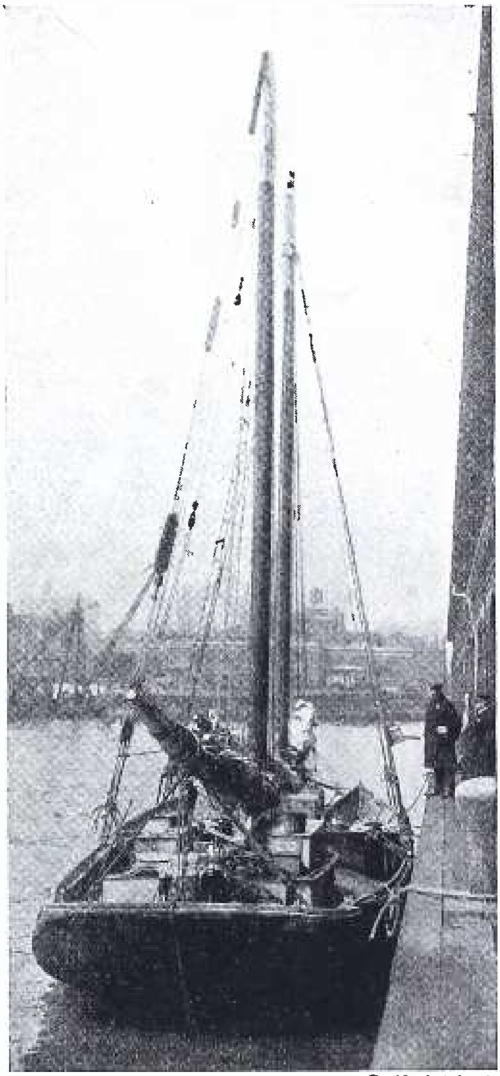
and the schooner came slowly alongside the dock. Scarcely were her hawsers made fast when the hidden men swarmed over her bulwarks like old-time buccaneers boarding a prize. A few seamen exchanged blows with the raiders; a bull-necked man swore a bit, and all was over. An hour later the heavily loaded motor trucks were rumbling through the streets with armed men beside the chauffeurs and a patrol wagon was carrying a bull-necked man with several of his fellows to a police station.

The following morning, however, the bull-necked man and his fellows walked forth from their enforced quarters of the previous night. Disgruntled prohibition officers glared after them as they tumbled over the bulwarks of their schooner, cast off the hawsers and with spluttering motor headed down the river.

Within the cases, boxes and kegs that had been seized there was not a drop of liquor. Nothing but plain sea water and unfermented cane juice!

But in another part of the city a few men, just returned from a cruise in a fast power boat, sat in a luxuriously furnished apartment and joked as they read the accounts of the schooner's seizure. Safe from prying eyes, they had stored enough of the real liquor to keep them supplied with luxuries for many weeks.

On this occasion the secret service of the air had lost, but such are ever the fortunes of war. Constantly, day and night, week after week and month after month, a battle of wits is being waged between officers of the law and law-breakers—and both sides are using the secret service of the air.



Pacific & Atlantic

CAPTURED ON A TIP VIA WIRELESS

Not all schooners seized by the excise officers carry liquor; sometimes the rum-running plan to let the authorities get false tips by radio and run down a decoy vessel that carries no contraband at all!

Few people realize what an important part radio has played in apprehending criminals; few realize what a tremendous part it played in the war; fewer still realize its possibilities and its limitations. And, although it is the easiest of means for transmitting secret messages, at the same time it is the most difficult means for keeping anything secret. A message hurled through space by wireless is everyone's property and the code has never yet been invented which cannot be decoded. Moreover, a law-breaker who hears a code message or even one which savors of a hidden meaning, at once is on the alert. Guilty consciences make keen wits and suspicions are at once aroused. The simplest and apparently the most innocent message may carry a hidden meaning which no one could ever suspect.

During the war, code messages often gave way to apparently plain, everyday messages which readily passed the censors. Now and then some little peculiarity, some chance or coincidence or some "hunch" aroused suspicions; still, thousands of radio and cable messages with concealed meanings passed in and out. Remarkably clever were many of the ways in which this was done, too.

There, for example, was the case of the German messages, a meaningless, musical hum or buzz which puzzled all hearers, which meant absolutely nothing and which caused endless annoyance in 1914 and early in 1915. With the tremendous power of the great Nauen station behind it, the musical note, like the buzzing of a titanic bumblebee, sped through space.

At the same time a somewhat similar phenomenon was observed by radio operators in connection with the large radio transmitting station of the Atlantic Communication Company (generally known as the "Telefunken Company"), located at Sayville, Long Island. In the words of L. R. Krumm, who at the time was Chief Radio Inspector of the Bureau of Navigation in New York, his staff noticed that shortly after the declaration of war in August 1914, "Sayville station was sending and receiving a considerable number of extraneous messages not considered part of the regular traffic, which was supposed to be in plain English." The mystery was brought to the attention of William J. Flynn, Chief of the U. S. Secret Service, but the strange signals and buzzes could not be deciphered. Was the Sayville station sending information to the Germans? The matter looked serious.

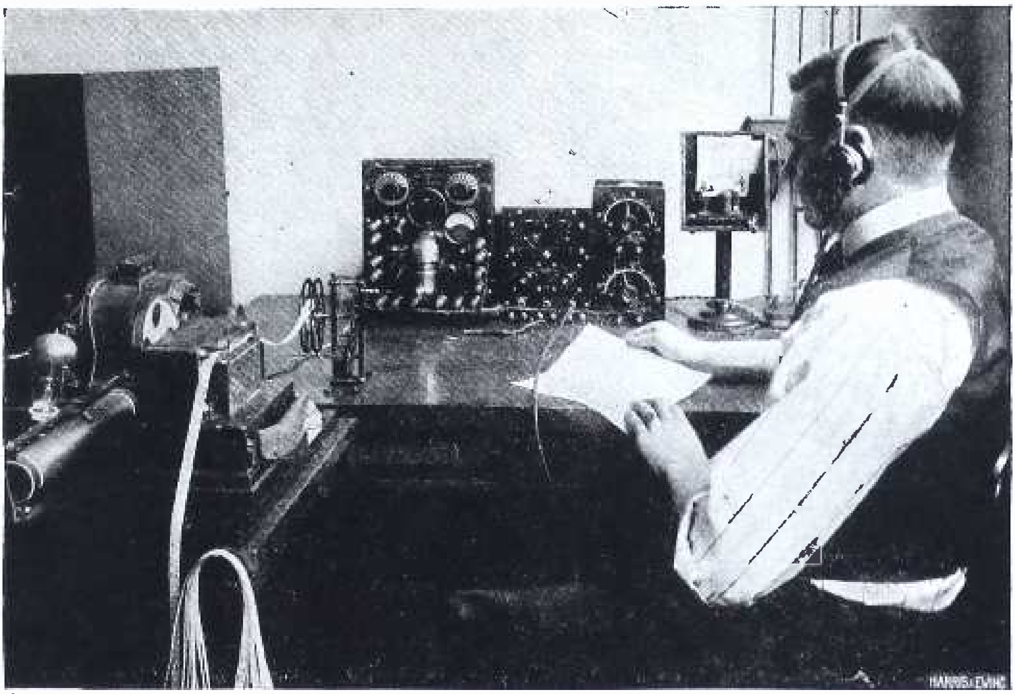
But Uncle Sam's secret service of the air were not the only ones to note the Sayville signals. Over in Westfield, New Jersey, a keen-witted radio amateur, Charles E. Apgar, had also been studying them on his own account. Every night at eleven o'clock he had noted that the Sayville Station had called POZ—which was the great radio station in Nauen, Germany. Upon establishing contact, the Sayville Station proceeded to communicate with an incredible speed—so rapid as to make the messages unintelligible.

Mr. Apgar got an idea. He had been experimenting successfully as far back as 1913 in recording radio signals on wax phonograph records. To do this he had developed an amplifying apparatus of a highly ingenious nature that he called an "ampliphone"—an apparatus that enabled him to read radio messages at a distance of 600 feet from his house. Why not make phonograph records of the Sayville signals and study them at his leisure?

He did so. But no sooner had he gotten started on this self-imposed task, however, when he received a summons from Mr. Krumm, who introduced him to William J. Flynn. The next day Mr. Apgar was pursuing his investigations for the U. S. Secret Service. On June 7, 1915, he picked up his first phonographic record of the Sayville radio signals. For two weeks he labored, during which he piled up scores of wax cylinders. This canned evidence was then delivered to the government authorities.

Perhaps in poring over these transcriptions the motor of the phonograph ran down, and as the wax cylinders revolved more slowly the "buzz" became disintegrated and resolved itself into distinguishable code signals. At any rate, Mr. Apgar's wax records revealed vital information — and the Sayville station was promptly taken over by Uncle Sam. And it was a radio amateur who did it—admittedly one of the most valuable services rendered by an individual during the war.

Both the Germans and the Allies used innumerable methods for transmitting secret messages; many of the most effective of these did not die with the cessation of hostilities. Some of them were adopted by law-breakers as well as by law-abiding persons when they wished to communicate without letting others know what was being said. It would surprise the average person to know how many and how simple are the available means



© Harris & Ewing

IT IS EASY TO SEND SECRET CODE MESSAGES BY RADIO ON TAPE MACHINES

The dot-and-dash system, by which letters and figures are indicated by transmitting apparatus that punctures paper strips, may be readily manipulated to convey undecipherable meanings to those who are not in the secret.

of sending secret messages. Despite popular ideas, codes or cryptograms are neither the most commonly used nor the safest. Of course, any message with a hidden meaning is a code message; the fact that such codes are not recognizable as codes make them the most difficult to detect or to decipher.

Who, for example, would suspect anything out of the ordinary in a radiogram stating that a cargo of sugar had been shipped and that the bills of lading were going forward by hand? And who would guess that another message announcing the birth of a child and stating it had been christened Mercedes would have any hidden meaning? Such messages passed the censors without question yet by a coincidence which, if used in fiction, would be scoffed at as impossible, these innocent-appearing messages led to the apprehension of the most dangerous and long-sought criminals.

Wholly by chance, a quiet man whose secret mission was unknown outside of a scant half dozen officials, happened to be a passenger upon the very ship by which this sugar was supposed to be forwarded. By an even more remote coincidence, he saw the innocent appearing message. Instantly his suspicions were aroused, for he had watched the steamer's cargo going aboard and he knew there was no such shipment. The rest was easy. "Sugar" meant important information; the "bills of lading" meant documents and the message from a fond and proud parent announcing the "arrival of a daughter" was nothing more or less than a tip as to when the bearer of the letters sailed and her name.

That time the secret service of the air scored against the enemy.

While such a method of communication is perhaps the safest and most secretive, it is not a simple nor a satisfactory way to carry on a secret correspondence in cases when messages must be frequently interchanged. Elaborate codes of double meanings must be prearranged and the messages must present a natural appearance with apparent sense to them. To invent messages which appear natural and which are composed of words with double significance is no child's play. For a brief time they may pass unquestioned; but sooner or later some lynx-eyed man may wonder why certain unusual words recur so frequently and an investigation will result—usually with unfortunate results to the conspirators. It is practically impossible to prevent messages by radio from reaching their destination or to prevent secret messages from being received by those for whom they are not intended. Anyone can receive; only a house-to-house daily search could put the lid effectively upon receiving by radio. With indoor and loop aerials the enemy is perfectly safe; he can hear every message that speeds through the ether. During the war, all amateur and private wireless stations were closed. Because the government did not wish its messages to be heard? Not a bit of it. Our officials never for a moment deluded themselves with the idea that they could prevent messages from being heard. But to prevent messages from being sent.

Uncle Sam could censor, hold up, destroy or forbid messages by telegraph, cable or mail—but not by radio. If any radio messages were permitted to go out, all who listened could hear them; there was no censorship, no control possible except by closing all sending stations—and even that was impossible. If a spy or a criminal wanted to send a radio message he could send it and did send it. Not on a large scale to be sure. But there was nothing to prevent him from setting up a station, getting his message or information off and hastily vacating the vicinity. And there was many a warning sent through the ether in just this way. But during time of war it is far easier to control the air than in times of peace.

The means of getting secret radio messages through without detection are almost unlimited; a force of trained men constantly at work would be necessary to keep pace with the schemes put into practice by men, who, if they turned their brains and inventive ability to legitimate channels, would make fortunes. It is said, (although I am not sure that it was ever demonstrated), that the Germans devised a method of sending out radio waves of such incredibly high frequency that no ordinary set could receive them; that even after being reduced by detectors they were still too rapid to produce a vibration in the receiver that was decipherable; only by means of special apparatus designed for their reception could the code be caught.

But the majority of devices for carrying on an aerial secret conversation are far simpler and less spectacular than anything of that sort. Specially designed typewriters, in which the type bars do not carry the letters corresponding to those on the keyboard can be used to produce messages which are almost beyond the possibility of decoding, yet the other party to the scheme, merely by typing off the message on a machine in which the letters are reversed, can translate the hodgepodge of letters into a legible message.

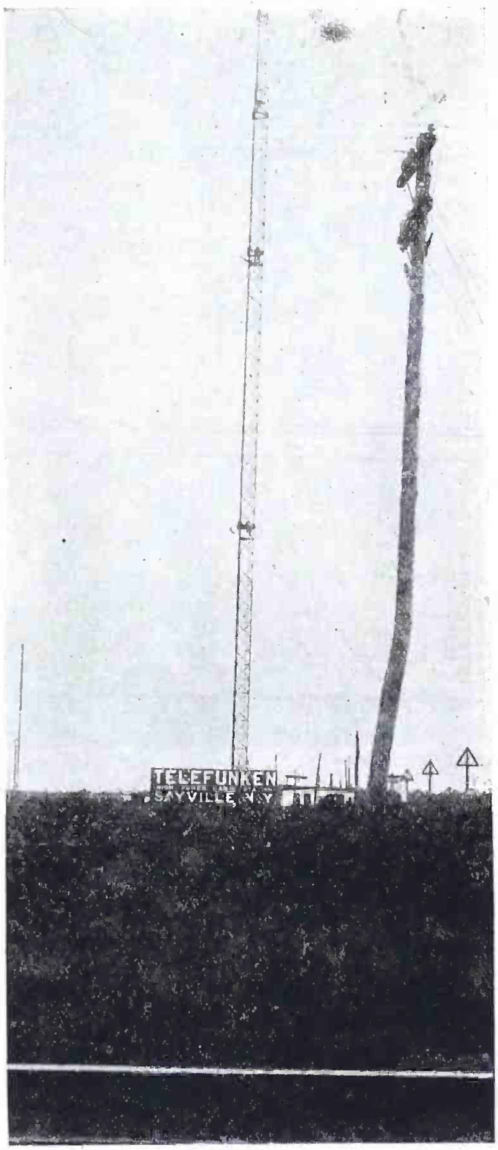
On one occasion while in Europe I received a radio code message which could not be decoded. At least, all the experts in London, including the naval and military intelligence officers, the Admiralty experts and the inventors of innumerable codes, could make nothing of it. Yet it was the simplest code in the world—once you knew the key.

I had left word with a friend to use a certain well known commercial code when communicating with me. The first message I received was not in this code and I could not decipher it. In vain I took it to every office of the published commercial codes; every expert shook his head and declared it was not like anything he had ever seen. Meanwhile my friend was on the high seas out of reach and for many months the message remained a curiosity, one of the few messages which had baffled British and American officials alike.

When I at last returned and met the sender my first question was, "What code did you use with that message?"

He replied that he had used the one I had designated and to prove his statement he produced the book he had used. The book was a maritime edition of the code and the words my friend had used were the combinations of letters representing signal flags to be flown when sending signals corresponding to the commercial code words. In other words, my innocent friend had used a code within a code which could only have been deciphered by running up the corresponding flags and translating the code from them. Here, once more, mere chance had played an important part and I wondered that some one had not stumbled on the idea before.

Another means of using the code is to use a specially prepared and arranged tape-puncturing machine which will produce a special tape for sending. When the dot and dash messages are sent from the big stations the operator does not tap off the dots and dashes on a key, as does the operator in a country railway station. Instead, the message received from the sender is copied on a typewriter-like machine which bears groups of dots corresponding to letters upon its type bars. When a letter is struck, a tape is perforated with dots. Then this perforated tape is run through a sending machine that is provided with metal fingers which make contacts through the perforations in the tape and automatically send the message vibrating through the ether at far greater speed than any human hand and brain could tap it off on a key. On the ordinary tape, two dots, one above and one below a central line, signify a code dot while one dot above and one below but slightly out of line vertically mean a dash.

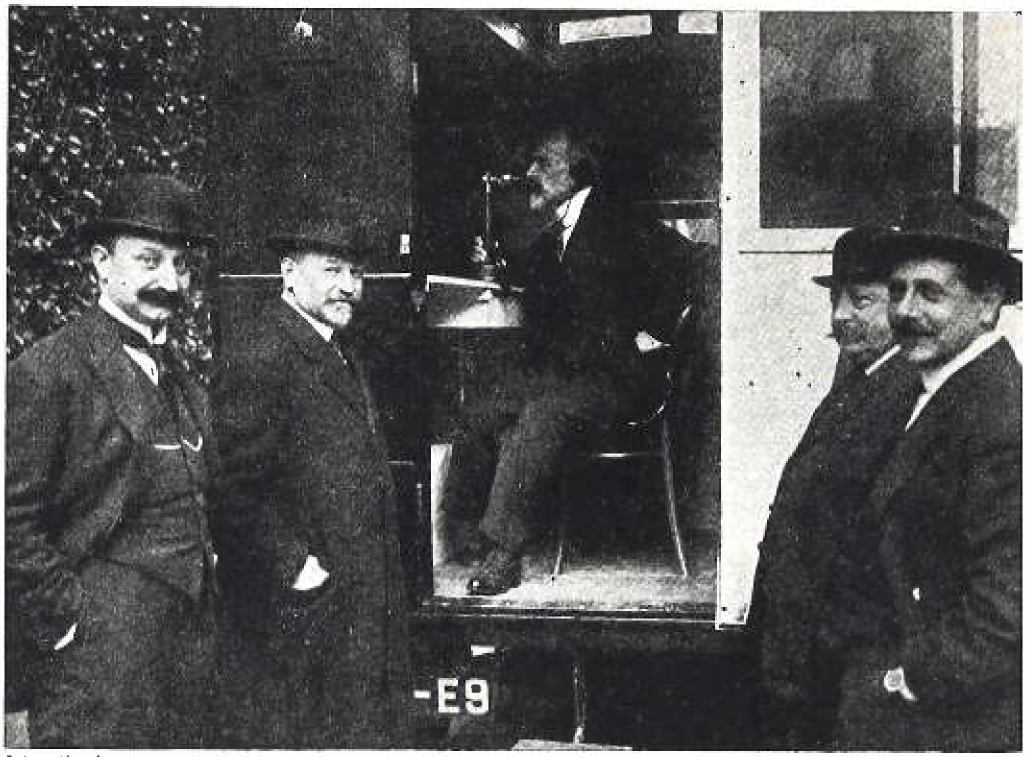


International

CLOSED BY THE "SECRET SERVICE OF THE AIR"

The famous transmitting tower at Sayville that once held mysterious radio communications with Nauen, Germany, every midnight—until its mystery was solved by a peer of Sherlock Holmes.

But there is nothing to prevent a person so disposed from altering this conventional arrangement. Suppose it were prearranged that one dot directly above another meant a dash, that two dots out of line meant a dot and that two dots close together meant two dashes or anything else. Such a tape would produce messages which, when recorded on the receiving machine, would present an ir-



International

THE POLICE OF PARIS USE THE RADIO ON THEIR MOTOR VANS

On May 1st—the day observed by the radical elements—the Prefect of Police of Paris experimented with radio-equipped motor vehicles that enabled the authorities scattered at different points about the city to keep in communication not only with headquarters but also with officers in a police airplane, as an aid in directing the crowds that participated in the May Day demonstrations. The Prefect is the portly gentleman in the derby hat at the right of the picture.

regular or serrated line which at first glance would appear to be an ordinary message, but which would be meaningless to those not in the secret.

Endless variations are possible in this way and have proved one of the greatest puzzles to the secret service of the air. Indeed, the dot and dash codes have always provided a most easy and simple means of secret communication. A prisoner tapping out the dots and dashes in his cell, may readily talk with his fellows and this is a well known and widely practiced means of communication among convicts in prisons.

If a person desires to communicate with another by conversing over a radio 'phone it may be done and is being done in such a way that the most secret matters are spoken of freely. It is only necessary to choose the time, the hour when the big broadcasting stations are sending out their nightly programs, and by using waves of a different length few will hear what is being said. Nearly every one will be tuned to the 360 meter waves and attention will be devoted to the music, songs or baseball returns. Even if some amateur or beginner hears the conversation no heed will be given to it—there are far too many more interesting things in the air for that. Sometimes the very frankness of such conversations is their greatest safeguard. If there is nothing suspicious about two people talking, suspicions will not be aroused, and it is just as easy to have a prearranged code of double meanings for spoken words and sentences, for questions and answers, for casual remarks, for numbers and names as for written words. No one knows or can even guess how much plans for hold-ups, burglaries, rum running and other dark deeds may be transmitted nightly by radio.

Next time you are listening to a broadcasting station, tune your set to shorter waves and see how many people you hear talking. If you have never tried it you will be surprised; while you may not hear a word of interest the chances are that something you hear—if you knew its real import—would be vastly interesting to a small army of guardians of the law. Or again, you may hear a conversation which seems pure jargon, a meaningless hodge-podge of numbers, names and words. In that case you may be sure that a secret message is being given.

Radio has been a means of enjoyment to thousands; it has spread like wild-fire through the land. But there was never a crook yet—a really dangerous crook—who was not up to the minute in availing himself of the latest inventions as a means to defeat the law. And radio has been and is a boon to law-breakers as well as to peaceful and law abiding citizens. No wonder it is a difficult undertaking the government has set itself to enforce the prohibition laws. With radio linking boats at sea with shore, warnings and any other information may be sent back and forth between the smugglers' craft and confederates ashore and the secret service of the air cannot prevent it.

Not long ago, a certain man was listening at his set, tuning his instrument to pick up any messages which might throw light upon a plot which, he was led to believe, had been largely carried on by radio. Scattered in various places, there were probably fifty more of his kind doing the same thing.

Night after night they had been doing this, one man constantly at the receivers; yet nothing had been heard which they could lay hands upon.

Nothing? Yes, there had been something. Over and over again, a voice had been heard making commonplace remarks; at times mentioning names and numbers. There was nothing suspicious about his voice—but he was apparently talking to himself!

Of course his words were taken down and hours were spent poring over them in attempts to decipher his conversations. But to no avail.

Then, by one of those strange chances, the puzzle was solved. One of the secret listeners-in grew weary of the fellow's one-sided chatter. He breathed a sigh, stretched his cramped limbs and, as he did so, one arm came into contact with a desk telephone near at hand. Instantly, the man was all attention, for where only one voice had been heard before, now there were two! It was no longer a one-sided conversation; a man and a woman were talking!

To the layman the phenomenon would have seemed incomprehensible, but it was simple. The woman, having no sending set, was talking over an ordinary telephone to the man who, listening to her words with ordinary telephone receivers and was talking to her over his radiophone, while she was receiving his words on her receiving set. Only by the chance touch of the listener's arm was the puzzle solved when, through the capacity effect of the human body, the woman's words were made audible over the wireless set. And the joke was on the men with their loop aerials. The mysterious speaker was but a law-abiding citizen; the woman was his fiancée and the mysterious numerals' names and words all referred to plans for the approaching wedding.

Never again would the operators be caught napping if another one-sided conversation came to their ears. They expressed their appreciation of the joke in the form of a wedding gift to the couple who so unconsciously had caused them so many sleepless nights. It was a silver goat bearing the inscription "You got ours." It was accompanied by a card on which was written: *"With the best wishes of the Secret Service of the Air."*

The first church in the world to conduct a service by wireless is the Herron Avenue Presbyterian Church in Pittsburgh, which inaugurated the plan early in 1921.

Is *the* Radio Hurting or Helping the Church?

The Larger Significance of the Introduction of Wireless Apparatus in the Conduct of Religious Services, and Its Effect upon the Church-Goer and upon the Church Itself

By HOMER CROY

SIX or eight farmers were gathered in an old-fashioned "parlor" on a Sunday morning. The room which had been kept in darkened seclusion for so long was now open, and on formal furniture the people sat, all in intent listening attitudes. And yet not one of them was speaking. Abruptly there was a creaking of chairs, a movement, and the sons of toil knelt. After a few moments they arose, once more to resume their stiff, correct positions. After a time they filed out and climbing in their buggies and cars drove away. They had been to "radio church" in the country. The services had been conducted from the center table.

That is one of the new and astonishing developments of the radio telephone. In rural districts church services are now being conducted by its aid. There had been no preacher, no pulpit—nothing but a few wires stretched from the roof of the house to the ridgepole of the barn and the box on the center table. But they had observed the Bible quite as much as if they had knelt in a cathedral, as the Bible says, "For where two or three are gathered together in my name, there am I in the midst of them."

One of the farmers has a receiving set and on Sunday mornings hitches it on to church services and his neighbors who are not so fortunate come in. It is all there; the complete service; the singing, the sermon—all save one thing and that has to do with a basket. Tell it not in Gath, but it may be that some of them gather a little more cheerfully when they know that at the end of the service two or three solemn looking men are not going to pass down the aisle with large and yawning plates in their hands.

In Wellsburg, West Virginia, as an example, church services are given to the farmers without the people leaving home. In this neighborhood is a group which, until last year, had a small country church which it attended, but finally the church was closed. Now one of the farmers has a receiving set and on Sunday mornings turns the party line into the telephone; his neighbors who had once attended church now take down their receivers and without leaving their homes participate in the church services. Thus is it being done in many sections of the country—and one of the surprising things about it is that it is so impressive that the people kneel and pray.

The radio church is growing at an amazing rate. At first the churches were slow to take it up, as it did not seem compatible with their beliefs that religion could be communicated without contact, but now there is a rush for it. The Church of the Covenant in Washington, D. C., has its own broadcasting station—the first church in the United States to attempt such an experiment.

With the first inauguration of broadcasting, clergymen were called in to deliver brief addresses over the radio, to make announcements. This they would do by coming to the sending room of the broadcasting plant and there send out their messages. To the Calvary Episcopal Church of Pittsburgh belongs the honor of being the first church to send out its entire service by radio. Its clergyman had gone to the sending station, made addresses and the choir had gone. So successful were the experiments that the Calvary Church decided to try the experiment of broadcasting its entire service. As a result a microphone was installed in front of the preacher, another in front of the choir and a third in the rear of the church to pick up any stray sounds. The service was heard by all those who cared to listen in and was an instant success. The first time a complete service was sent into the air was January 2nd, 1921. The church itself was seven miles from the sending station, but the service was clear and distinct.

At about this time the Herron Avenue Presbyterian Church of Pittsburgh found itself without a pastor. It appealed to the board for a minister but was unable to be supplied with one. And then an

Westinghouse

THE RADIO CHOIR—THAT IS REPLACING THE OLD CHURCH CHOIR

It is not inconceivable that many of the small and inexperienced village quartettes will eventually be replaced by large aggregations of great singers whose music will be broadcasted to services conducted over wide areas.

Westinghouse

THE CHURCH SERVICE COMES TO GRANDMA

No longer need the shut-in be deprived of the privilege of listening to the country's best preachers. The radio is beginning to bring his voice even into the remote rural districts.

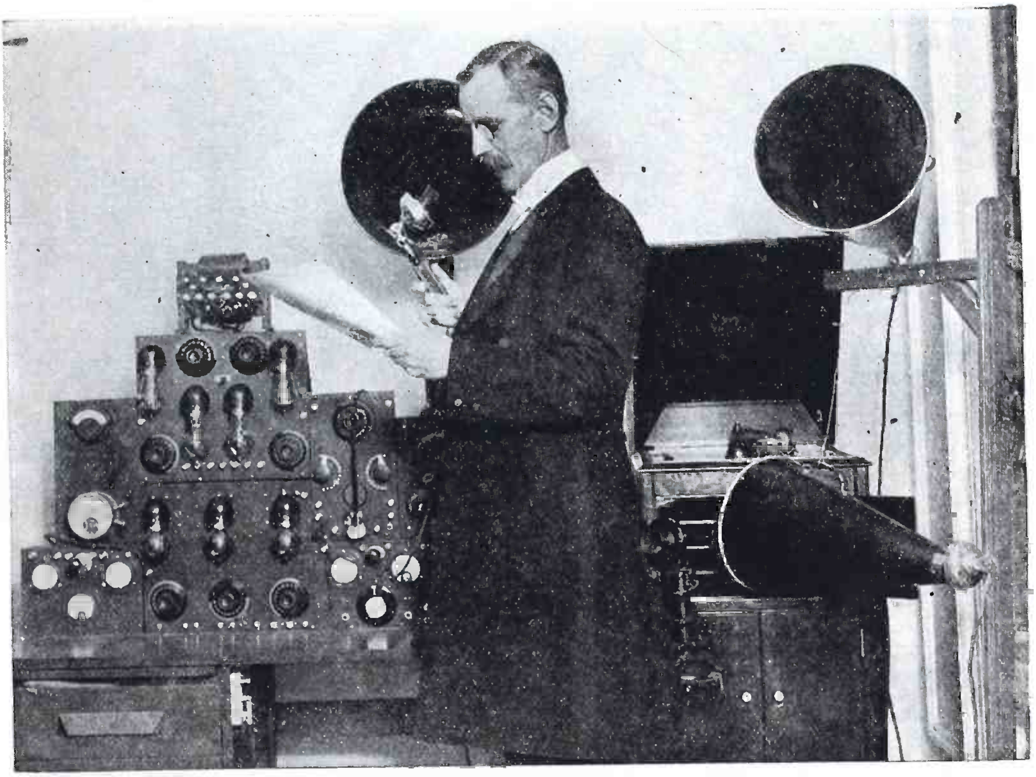
idea came to one of the members of the board of trustees.

"Why can't we hook up to this new thing called the radio telephone and get our service that way?"

No one could answer him because no one knew anything about it; and moreover there was no one they could go to for information, as the experiment had never been tried. They were breaking new land; virgin soil. How could it be done? What about wires? Would people go to church when there wasn't a minister in sight? The idea was top-heavy with questions.

The experiment was tried. An amplifying horn was placed in the pulpit and a loop aerial set up beside it; and then with fears and doubts they awaited Sunday morning. Would the people come? Would they demand a living personality? That was what they had been told. Sunday morning arrived; the people came; the instrument was tuned up—and the service was as clear and distinct as it was to the people in the "parent" church several miles away. Even the coughing of the members of the congregation could be heard! The service moved along until the collection was announced—and two sprightly ushers bounced out into the middle of the aisle. There was nothing lacking except a preacher and a choir.

The service was a success, but the board was afraid that for the first Sunday the church had drawn merely a curiosity audience. But the next Sunday there were just as many people as on the first occasion. The congregation began to grow and soon there were as many people in the audience as when there had



HOW LARGE IS HIS SUNDAY AUDIENCE?

The average church attendance is small; even in the large city churches it is considerably smaller than the average theater audience. But the preacher who talks by radio may reach tens of thousands.

been a pastor in the pulpit. In fact, in some respects the service was better, as the sending church was larger, had a better preacher and a better choir. The "pastorless" church was getting a higher class service than it would if it had to depend on itself.

The practice was taken up by other churches until now it is known in several states.

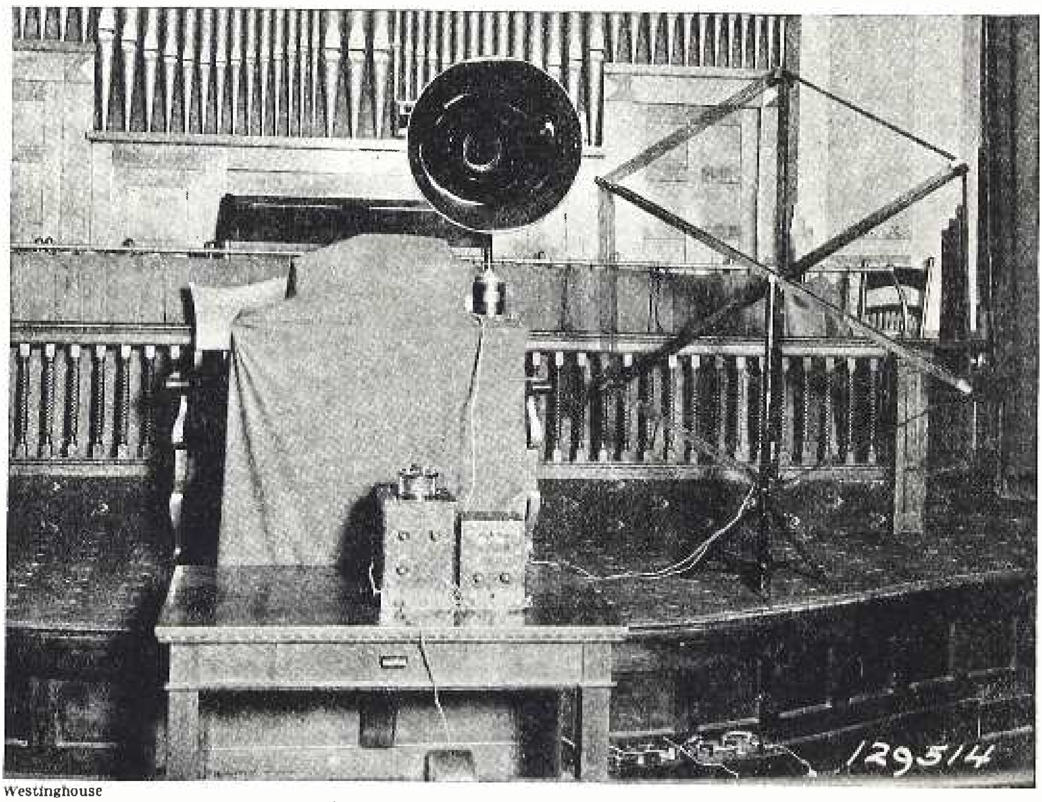
January 2nd, 1921, marks, probably, one of the biggest changes that has ever come into the church. It means the centralizing of the church; the doing away with so many conflicting and needless creeds; so much useless competition and so many petty jealousies which for so long have been a millstone around the neck of the church. Church services will be shortened; much of the verbal underbrush will be cleared out, for sermons that go over the radio will have to say something. They will have to be more than an impressive collection of words. They will have to carry a message and get it over simply and directly.

The radio will mark the disappearance of numbers of small struggling churches and the centralizing of services in a few of the larger ones. Instead of there being thousands of small churches there will be a few large, flourishing ones with exceptional, outstanding pastors. Two or three will suffice for a city the size of Detroit. All those who must stick to one denomination will tune in with the belief that appeals to them most strongly, but ultimately the preacher with the message will be the one that will attract the people. In fact—and be it understood that this is only in the realm of speculation—one exceptional and outstanding preacher may each Sunday have the United States for his congregation. Billy Sunday at his home in Winona Lake, Indiana, may have an audience that extends from New York to San Francisco, and from Canada to Mexico and, for that matter, lap over. He may deliver his sermon from his own home, but it is more probable that he will go to some church where there is a choir and the thrill of a crowd. And no doubt somewhere in the offing will be Homer Rodeheaver with his trombone.

A new audience will be added to the church: cripples, shut-ins, and mothers too tired to go. Cripples who have not been to church in years will have the word of God brought to them. Trained choirs will sing, great pipe organs play and Farmer Jones sitting in his rocking-chair in Boone Stop, Missouri, will hear. The tabernacle of the city is on the way to the cross-roads.

The audience, in the era now opening upon us, will be unlimited. Passengers on liners plowing their way across the ocean will gather in the social hall and listen to sermons delivered on land; people speeding across the continent in trains will participate in the services; passengers in airplanes will listen above the chugging of the machinery, sailors in battleships, and men in submarines will pause for the sermon; men who must work in coal mines on Sundays will hear, and lonely sheep herders will erect their aerials and bow their heads in worship. People in the air, in the water and in the lonely places of the earth will stop to listen. Such an audience is staggering to the imagination, but it is coming.

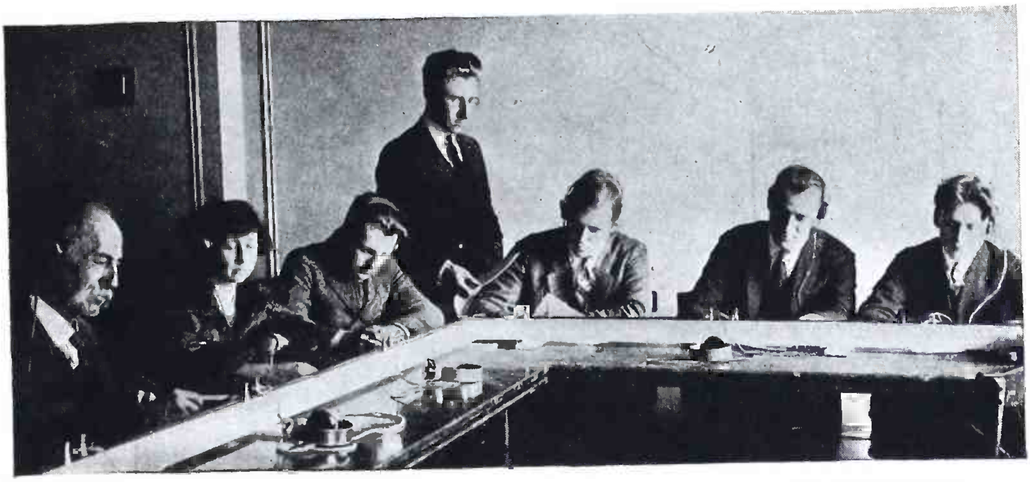
And soon.



Westinghouse

"THEIR PASTOR'S VOICE"——

—but the pastor himself was miles away, preaching by radio not only to his own flock but to other congregations as well. This loud speaker and loop aerial were installed in the Herron Avenue Presbyterian Church in Pittsburgh.



International

CANDIDATES BEING EXAMINED FOR AMATEUR RADIO LICENSES

Licenses are required for transmitting only. To qualify, the candidate must demonstrate his or her capacity to receive and send ten words a minute in the code.

How *to* Learn *the* Code

Sooner or Later Every Owner of a Receiving Set Wants to Enter the Inner Circle of the Ether by Reading the Morse Signals—and the Genuine Radio Fan Learns Them. This Article Is Written by One Who Did—

PAUL McGINNIS

THE student of radio code grows impatient with his perfectly good mind when he tells it again and again that "da de da da" is the letter "Y", and he wonders how any mind can be so stupid. He is too harsh with himself.

Even when the student has progressed more or less steadily, and when he is about fast enough to secure a first grade license, his mind often seems to make no progress for weeks and even months at a time. Some students quit in disgust at such a time, little knowing that success waits just around the corner and that their minds have been working faithfully all the while.

Success does not come by speeding up the progress of copying down the letters as they are sent, but rather by forming new habits of hearing entire words and even phrases without paying specific attention to the individual letters which form them.

The radio code is a foreign language. No one could speak a language fluently if he stopped to spell each word to himself, no matter how fast his mind might work. He must think in phrases, which he has heard so often that his mind forms them almost automatically.

The operator who copies forty words a minute usually strains less than the beginner who copies ten. His mind does not work faster than the mind of the beginner; it merely works with fewer acts.

As the experienced operator sits at his typewriter and copies an important message coming, perhaps, from a statesman or a king, he changes the paper in his machine. He even tells a joke to another operator beside him, and maintains his normal rate of speed although he may have been working eight hours. He is at ease, and has none of the worry of the beginner who strains to catch every letter separately as it comes to him.

But he was once a beginner himself, and he strained his mind before he learned a better way. He first learned the dots and dashes which go to make up letters, and he learned them slowly, thinking them over as he went to sleep perhaps, and wondering when he would ever distinguish between Q and Y.

Some schools prefer that the students learn the letters by sound only and ask them never to look at charts which show the dots and dashes used for each letter. They may be in the right, for the sense of hearing is the one which is most concerned, and the sense which must be developed.

Not all minds are alike, however, in their processes of learning. The mind with the strongest visual memory no doubt makes better progress at the start by looking at a chart; such a mind must listen to the buzzer for the auditory sensation of the letter, and then refer to its visual memory to identify the letter by its arrangement of dots and dashes.

The visual process is a roundabout way, of course, and must soon be discarded for the simpler system of auditory memory. The auditory system of teaching, without the chart, is quite likely the best, although there is no way to prove it.

The beginner with a keen visual memory may often startle his friends with his rapid start, but learning the code is a true art which has no short cut, and sooner or later he slackens his pace, and his friends overtake him.

An ordinary mind can remember six figures when they are spoken, and can usually repeat them, both forward and backward. Some minds, of the keen visual type, can retain as many as ten or more figures "in the mind's eye," and repeat them at leisure. If such a mind exists in a class, and the instructor sends ten letters at a time, the student with the unusual mind can retain the letters and set them down at leisure usually to the astonishment of his classmates, most of whom have been unable to receive more than two or three of the letters.

Such a student will stand well in his class always, but if he is to become a fast operator, he must discard the visual processes and learn to write letters, words, and then phrases as he hears them.

Learning the code is much like solving a puzzle. Little Willie in the fourth grade humiliates his venerable old grandfather by learning the trick of it before grandfather, with all his great store of knowledge, has obtained a good start in finding the solution.

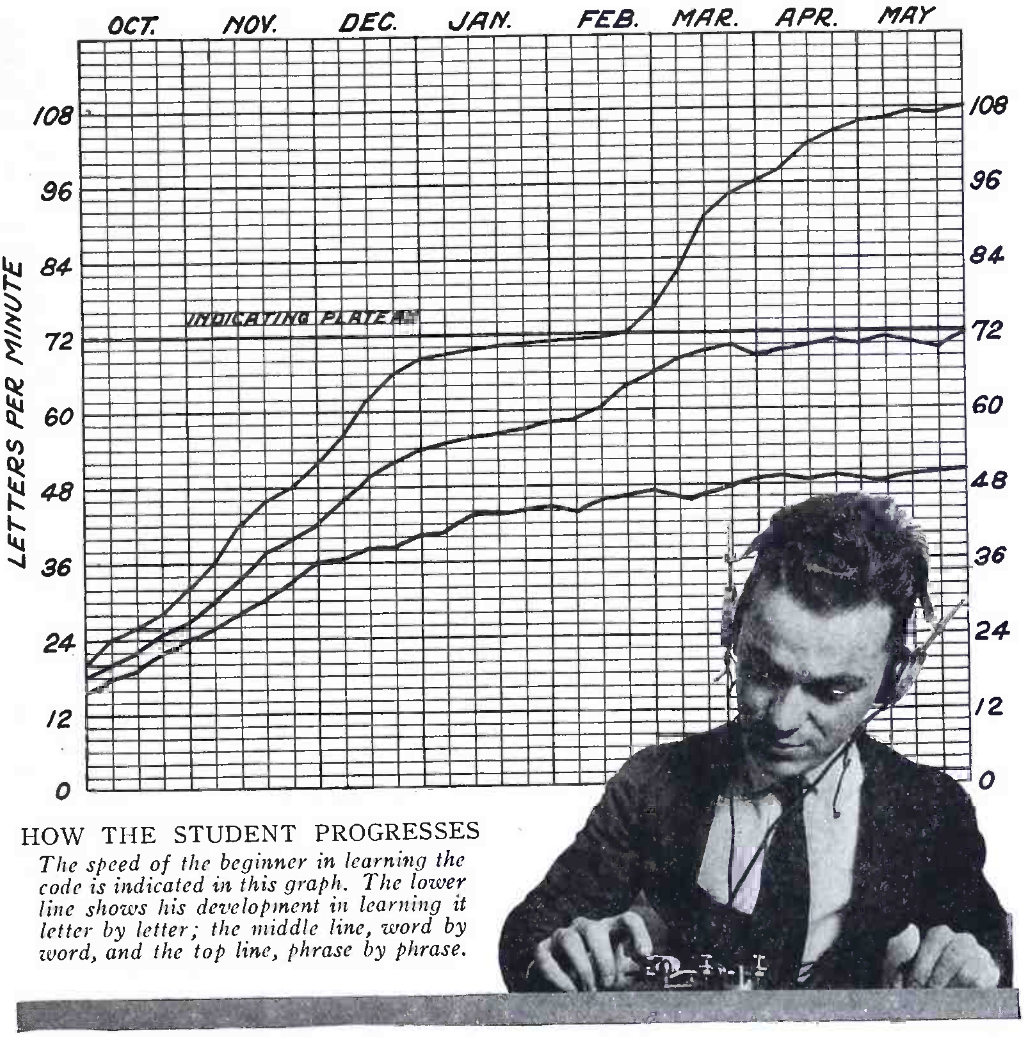
The code, in its democratic way, offers the same lengthy task to the old as well as the young and to the quick as well as the slow.

As the long and short buzzes come to the ear in a complex maze, the mind at first strains and can make nothing out of the confusion. It sounds like "oodle oodle de oodle" to the novice. The student in the classroom is almost as much at sea, even though the signals are much slower.

He is unable to distinguish between the letters at all until suddenly some feature catches his ear and helps to fix the signal in his mind. The single dash for T and the single dot for E are distinguished first as a rule, and other letters fix themselves in the mind much more slowly.

Perhaps the beginner discovers that the signal for Q is like the warning whistle of a train as it approaches a crossing; two long notes, a short one and then another long one. Thus, the similarity helps him to recognize Q when it comes to him slowly, but he must forget the similarity later if he is to become a fast operator. He will not have time to think "train whistle" before his pencil writes Q. He must make his actions more simple and automatically write Q, just as a German says *"rot"* or a Frenchman says *"rouge"* or a Spaniard says *"roto"* when he speaks of the color red.

He must not be discouraged if his pencil stands still when the buzzes of the



HOW THE STUDENT PROGRESSES

The speed of the beginner in learning the code is indicated in this graph. The lower line shows his development in learning it letter by letter; the middle line, word by word, and the top line, phrase by phrase.

letter Q come to him, even though he knows perfectly well, a second later, that the letter was Q. A mother must point many times to a hat or coat and say "red" before her baby finally understands, and the college instructor finds the same difficulty in teaching a foreign language.

If the mind is kept continually open and sensitive to the signals it will after a time eliminate errors and discover short cuts. The beginner who is discouraged needs only to recall his efforts in first learning to put on his collar and tie his necktie. His fingers were slow, and he invented many ways of pushing collar buttons through button holes until he found himself one day doing the trick seemingly without thinking anything about it.

During the process of learning the code, there are dull days, weeks and even months, during which periods the student seems to make no progress at all. Such apparently inactive periods may be caused by discouragement or inattention; perhaps the copying of messages seems too easy. At any rate, there is at least one period in the code student's progress as shown in the accompanying chart, when his mind seems to be at a standstill.

The curves shown on the chart represent the progress of a group of students who were learning telegraphy. The curves show in a general way how a student can expect his mind to act. In the curve marked "receiving" an inactive period or "mental plateau" is shown to occur during the fourth and fifth months of the student's efforts.

The accepted explanation of the plateau is thus set forth by Prof. R. S. Woodworth, of the Department of Psychology at Columbia University:

"The plateau is the figurative indication of a natural slowing down in the progress of the student during a period of study, and is followed ordinarily by signs of renewed impetus caused by the adoption of improved methods."

To progress from the plateau stage it is necessary not to increase the speed of the acts which the mind has already learned to perform, but to learn new habits of hearing words and even phrases in their entirety. Such new habits can come only from continued practice; while the mind seems to have gone stale, it is really getting a fresh start in a new direction as is shown decidedly by the abrupt upward trend of the curve after five or six months.

The plateau may come at the end of three, four or five months, and it may last much longer than a month or two, depending upon the individual's alertness. It is a bugbear to the student who does not understand it, but he should not be discouraged, for it comes to all beginners, regardless of their ability.

The beginner should learn, by all means, to "copy behind," that is, to write down the words several seconds after they are sent. This is the only safe method, for if he tries to keep up with the ticks he is apt to anticipate them and, hearing the first half of a familiar word, write the whole word and thus make mistakes.

Experts can copy from six to ten and even twelve words behind, depending upon their power to remember the words. They find it good practice to keep behind, for the meaning of the sentence may help them to make out a word of which they were not quite certain.

To shift from copying letters to copying words often stumps the student. At first he is sure to miss many of the words and his copy is hopelessly incomplete. He thinks it is better to copy letters, leaving out of uncertain ones and trusting that he will catch enough letters to make out most of the words. He hates to miss an entire word. It seems stupid to him.

He should realize that he is starting all over again, in a sense, and that he is learning *words* and *phrases* instead of *letters*. He must think of letters only when they come to him detached or in coded messages. He will find that such "mixed" messages will be easy enough; he will copy the words readily and will have plenty of time to think of the detached letters and figures.

The word-habit will cause many mistakes at first, but after a time it will not only be simpler but superior in accuracy.

Copying with a typewriter is much faster than with a pencil after the operator has learned the keys. A single movement in pressing a typewriter key takes the place of a series of movements in making a letter with a pencil.

To send with a telegraph key is much easier than to receive at first; that is because the fingers always know just what to do. As the chart indicates, a speed of some twenty words a minute is attained with almost steady progress.

The plateau in learning to send is not marked, although the hand can actually be made to think in words instead of letters and can acquire trains of action. A slight plateau is shown in the curve after about two months of practice. It is at this time that the hand is learning to send words instead of letters, and is busy learning the trains of action which form common words.

Perhaps the most obvious train of action in every day life is demonstrated unconsciously when we dress and undress. Almost everyone at some time has started to take off his shoes only and has suddenly awakened from his absent-mindedness to find that he has removed his hose and perhaps other garments as well.

The victim of such absent-mindedness has formed a train of action in undressing. He has followed this train in the same way for years, and when he once starts his mind on the train by removing his shoes, he continues without conscious effort.

In the same way the muscles of the hand learn to send common words in code. The operator has only to think the word; he does not think the letters. And his hand ticks it out. Common words such as "the", "and", "but", and "in" are learned almost at the outset. Endings of words such as "ing" and "ion" become automatic; after long training the hand acquires an extensive vocabulary of words which it sends in trains.

After three or four months the hand has approximately reached its muscular limit in the speed of sending letters and its progress from that time on comes in sending word trains which are not slowed down by the brain that thinks of each letter.

After a certain point in training is reached, sending is learned much more slowly than receiving because the mind can be trained to work much faster than the fingers; if a typewriter is used the operator can receive much faster than he can send. He can eventually find time to correct the sender's mistakes as he writes the message down.

Most beginners have heard of the "glass arm", but most of them do not take proper care to prevent it.

If the key is operated with the fingers or with the muscles of the hand, the continual strain will sooner or later cause temporary paralysis when the operator attempts to send with a key; this condition is known in the trade as the "glass arm." The operator may be able to write and use his hand in any other way, but when he attempts to send a message with a key, his hand and arm become rigid and will not obey him.

Almost any good operator can show the beginner how to place his fingers lightly on the key and make the movements with his wrist in the proper manner.

Progress at first will be much slower than would be the case if the student used his fingers to form the dots and dashes, but in the end the wrist movement is much the speedier. A tired hand or wrist is a danger signal and shows that the method of sending is wrong. A perfect wrist movement will enable an operator to send for hours, causing him little more fatigue than would come from writing a letter or other mild exercise of the hand and forearm.

RADIO PUTS SPEECH INTO MOTION PICTURE FILM

DURING *the recent brief visit to this country of Dr. Lee de Forest, arrangements were made with him to write for this magazine an article that will describe his latest experimental work with one phase of the de Forest audion tube activity about which but little has been written —its capacity to produce synthetic music from light! This development paves the way for that long-sought phenomenon—the motion picture film that talks.*

International

SIR ARTHUR CONAN DOYLE SAYS:

"I EXPECT *in the next three or four years some definite messages will be received to prove the contentions of the spiritualists. I believe they will come through radio. I think it is along this line that we will get our evidence. They have transmitters in the line of ether and all we have to have is the receiver. We will have the direct communication that Edison hoped for.*"

Are *the* Dead Trying *to* Reach Us by Radio?

The Second of a Series of Articles that Describes the Experiments of Psychic Investigators for Establishing Communication with a Possible Spiritual World through the Medium of Delicate Electrical Instruments

By HEREWARD CARRINGTON, Ph. D.

In the preceding article, published in the June number, Dr. Carrington pointed out the scientific possibility of some form of instrumental communication with a spiritual world, if such a world exists; granting the reality of such a world, communication with it through the medium of highly sensitive radio apparatus might conceivably be established.

The author pointed out that thought appears to be dynamic in its action, and sets up certain definite etheric radiations, which can apparently be detected. Such being the case, it would appear to be a short step to the construction of a possible "detector" delicate enough to register these ether impulses. Dr. Carrington believes we are on the eve of such a discovery, and it is upon this problem that he is now experimenting in the Psychical Laboratory in New York.

—EDITOR

THE all-pervading ether which science has stated surrounds us, penetrates every cell and molecule of our bodies and of our brains. Life must, accordingly, exist in this medium, insofar as we ourselves exist in it; insofar, indeed, as our minds and consciousness also exist in it. Mind is, therefore, in "contact" with it.

But what is ether? No one knows. Haeckel was inclined to believe that it is such a fine gas that a sphere of it the size of our earth would weigh but 250 pounds. Lodge, on the other hand, contends that it is more solid and dense than platinum and gold. Dr. Steinmetz, in this issue of Popular Radio, advances still another conception of it. Lord Kelvin said that no man could believe in the ether who did not also believe that it presented opposite and contrary properties. We can hardly dogmatize, then, as to the nature of this ether.

Is the ether atomic in structure? If so, what exists in its intra-atomic spaces? Another ether? I have already stated that occult science contends that there may be four ethers, one above or within the other. Certainly this theory may be accepted as a possibility. Various solid bodies can occupy the same space, if they are of differing densities. We can, for example fill a glass "full" of marbles; we can then fill in the spaces between the marbles with coarse shot; we can fill the spaces between these coarse shot with fine shot, and the spaces between the fine shot with water. It is conceivable at least, that this process may go on indefinitely; certainly we do not know where it may end. And just as air and ether carry different rates of vibration, as expressed in sound and light, so it seems reasonable to suppose that varying ethers, if they exist at all, may convey differing rates of vibratory activity, which are not detectible in another medium.

If this be true, the difficulty which has been experienced in detecting any form of brain waves or telepathic impulses may be explained. These impulses might exist, but be conveyed in some "mentiferous ether," as already suggested. When we discover that, then we shall immediately be enabled to register the waves which are operative in telepathy.

Already, Dr. E. E. Free, in a recent interview, has asserted his belief in the possibility of detecting such impulses electrically, by means of suitable instruments. He says:

> "There is no physical improbability that in the nerves of, say, the human brain exists some arrangement of tissues or of chemical molecules, competent to act as a wireless detector for such wireless impulses as may be sent out, as the result of nerve impulses originating elsewhere—as within other brains, for instance.
>
> "What would this be but telepathy?
>
> "But one must not become too speculative. Our only facts at present are that nerve energy is electrical, and that all electrical disturbances start wireless waves.
>
> "From these as an abutment we have built into the unknown what might be called a cantilever bridge of speculation . . . It has two essential members in its structure. One, the hypothesis that the wireless waves sent out are really sufficiently distinct and powerful to be detected by possible apparatus; and second, that such a receiving apparatus may exist within the human brain. . . ."

Both of these speculations surely seem rational.

It is not necessary to presume in such cases, that the thought itself is transmitted, any more than it is in wireless telephony. Only vibrations would be sent and received, and these vibrations would be re-translated upon arrival at their destination. Just as the chemical action in a battery remains in the battery, but is represented outside by its "dynamic correlate," known as the current, so in the case of the brain the dynamic correlate of thought, whatever that may be, remains in the brain. But its vibratory expression is transmitted outward into space, as a form of undulatory motion or ether waves.

To sum up my hypothesis, I may state:

In order to obtain a specific action we must employ a specific instrument—a telephone for a telephone, a brain for a brain.

Every living thing is a dynamic focus.

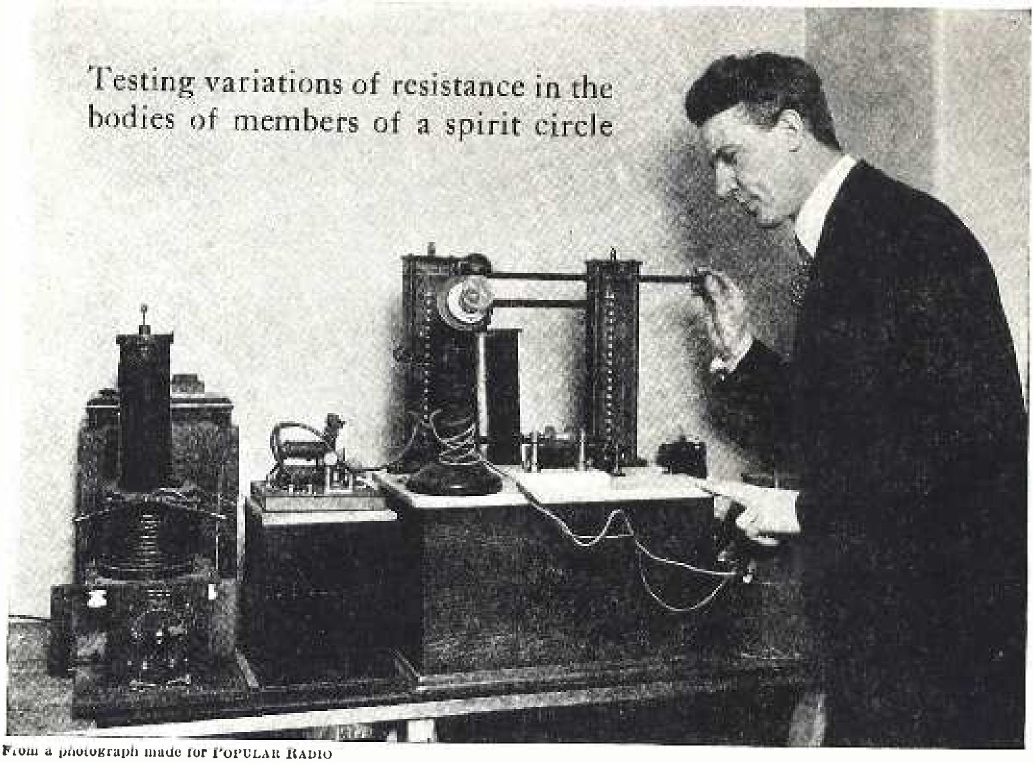
A dynamic focus tends ever to propagate the motion which is proper to it.

Propagated motion becomes transformed according to the medium it traverses; a force may be transmitted or transformed.

In an identical medium there is only transmission; in a different medium there is transformation.

If thought is dynamic in its expression, it may be transmitted and transformed. Then it may be re-transformed in another organism, which supplies the necessary conditions. Thought may be restored.

All this may be conceded so long as we have physical brains. But what of



From a photograph made for POPULAR RADIO

beings who no longer have such organs? What are we to say as to the inhabitants of some spiritual world? If such exist at all, they are certainly devoid of brains as we know them. How then, would any form of instrumental communication with such spiritual beings be possible or even conceivable?

First of all, it is now certain that the body itself does not feel, does not sense. The eyes do not see, the ears do not hear. It is the inner being within which sees, hears and senses. Physiology proves this. It has been contended that in addition to our physical bodies we also possess an etheric double, or "astral body," resembling the physical body in all its detail, and that it is this body which is the seat of the emotions, the feelings and the sensibilities. There is a great deal of actual evidence of the existence of some such invisible body. If certain French investigations are to be credited, it has been seen, felt and photographed; it has moved mechanical instruments; it has caused certain chemical screens (calcium sulphide) to glow with added brilliance when approached by it. Calculations have been made as to its density, structure and weight. According to these researches, we have a fairly good general idea as to its nature.

This invisible, inner body, then, may possibly be the vehicle of thought. It may possess centers whose normal office is to send and receive telepathic messages. One etheric center may thus act upon another etheric center directly, and only indirectly upon the physical brain cells. The action would thus be dynamic, yet psychical; physical in a sense, yet not physical as we conceive it. There is here a sort of physical communication of a spiritual thing. Its activity may take place in some higher ether or be some mode of activity in the ether which we cannot yet register. But that is no proof that such registration is impossible; on the contrary, it is my belief that it is possible, and will one day be registered. It seems, therefore, that it is merely a problem of developing sufficiently-attuned apparatus of the right kind, before we will detect and register these subtle mental vibrations. And these vibrations need not necessarily emanate from a physical brain, as we have seen. We may conceivably receive telepathic impulses from the dead!

The question which presents itself for practical solution, therefore, resolves itself down to this:

What sort of apparatus must we employ; what kind of detectors must we use, in order to register those etheric undulations which may be sent out from discarnate minds? And, having once detected and measured these wavelengths, what device could we construct which would enable us to send out the same sort of subtle etheric waves which, we may assume, would be somehow registered at the other end of the line? For if a definite wavelength can be transmitted, it is natural to suppose, *a priori,* that the same wavelength could be received by some inner mechanism.

The reader must not expect me to furnish him with a detailed list of blue prints, and say, "Construct a piece of apparatus in *this* manner, and you will receive messages and communications at once from the spirit world!" Were this possible, the problem would already have been solved; there would be no doubt concerning it at all. This cannot yet be done. But much can be done by clearing away doubts and misconceptions, by indicating the road which we must travel, and suggesting the kind of apparatus which must be employed, in order to obtain any possible results. Experiments of this character are now being made in the American Psychical Institute and Laboratory, and readers of this magazine may care to undertake experiments of a similar character. If so, I should be glad to hear from them and to receive reports of their investigations.

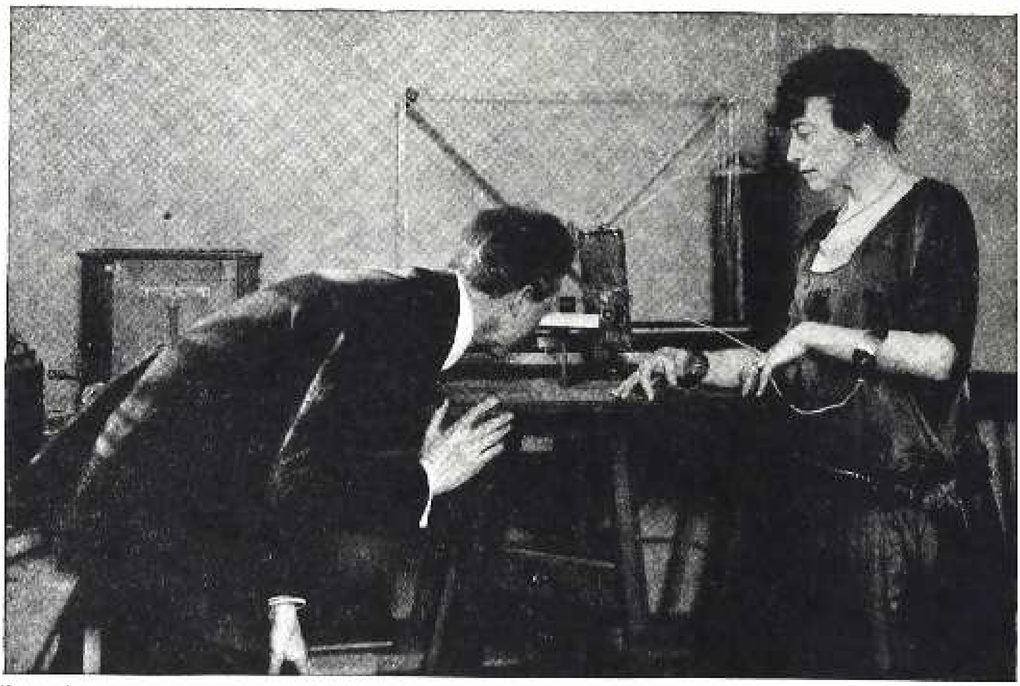
One of the first problems that we must solve, is to discover the nature and length of "brain waves" by experiments in telepathy. The two subjects may be placed in a high-tension electric field, or in a space across which carrier waves of known length and frequency are passing. These carrier waves, as already suggested, would doubtless reinforce and possibly render evident the etheric undulations that are operative in telepathy. If these could then be detected and calibrated, we should have made our first definite forward step toward an understanding of direct mental action, expressed through a certain machine—in this case the human body and brain.

Then we should devise a suitable detector, capable of registering these ether waves with accuracy and facility. Once the detector had been perfected, the next step would be the perfection of a sending apparatus, emitting the same form of wavelengths at the same frequency.

Experiments should also be tried in obtaining possible direct pressures and registrations by subtle forces. The mere exercise of an energy in itself would prove little; but if it manifested signs of intelligence, then we should have something of value and significance.

Doctors Matla and Zaalberg van Zelst, of The Hague, Holland, claim that they have already received direct communications in this manner, when no medium at all was present. Their apparatus was elaborate; the principle of it was as follows: The letters of the alphabet were painted on a flat disk, which slowly revolved. One letter at a time appeared in an opening that was cut in a card that covered this disk. Lower down, was the "key" of the instrument; it consisted of a flat plate, very delicately balanced; the slightest pressure on it would complete an electric circuit. When this key was pressed by some invisible being or force, at that moment the letter "M" (say) appeared in the opening above and this letter was automatically printed on a sort of ticker-tape.

In this way the messages were spelled out; long messages, it is claimed, were recorded and were published in a book entitled "The Mystery of Death," pub-



From a photograph made for Popular Radio

MEASURING THE PSYCHO-GALVANIC REFLEXES OF A MEDIUM

Our body is in effect an electric battery; its power varies with our mental activity and our emotions. By means of a galvanometer the current impulses may be measured to 1-millionth of an ampere. Dr. Carrington believes that thought impulses from a spiritual world may some day be recorded on some such highly sensitive instrument.

lished first in Dutch and later in French.

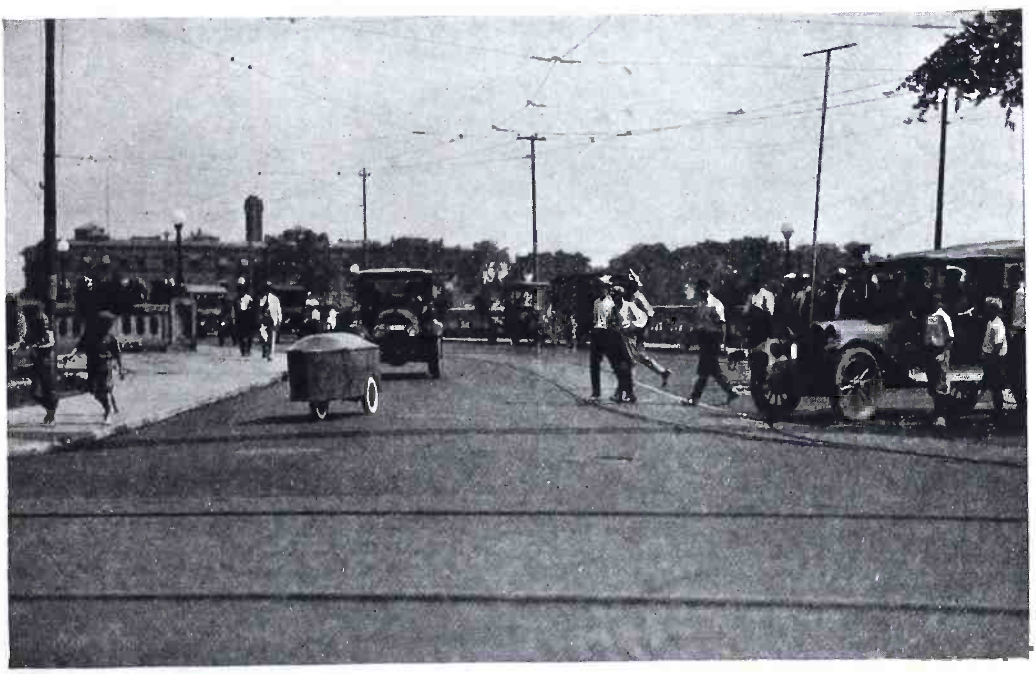
It is possible, however, that messages of this character cannot be received unless some other factor be present, and that factor is life. Vital force, vital energy, life—whatever that may be—seems to be a necessary factor in nearly all these manifestations, and it is possible that we cannot obtain them without its presence, directly or indirectly. This life force seems to be utilized, in some mysterious way, and rapidly expended in the production of many of these phenomena; but the close relationship between life and electricity should not be lost sight of in this connection. Is there not a bridge between the two—a bridge which can be discovered, uniting and connecting them? And across this bridge may not action and interaction take place, of a nature hitherto unsuspected? It seems rational to suppose so. We stand here upon the border line of life and matter, in that mysterious realm that connects soul and body, and it is here that discoveries of the greatest significance will assuredly be made in the near future.

We already have, in our Psychical Laboratory, instruments that detect the differences between various bodily radiations and devices which record the energy-changes of members of a circle. Radiations from the body, and especially from the finger-tips, appear to be proved. Yet if this be true, we have here cases of nerve-energy, or life-force, that exists outside the body, in space, that acts and reacts upon other forces and energies. If this "externalization" of life force be a fact, it opens up the possibility of conducting and even collecting it, and applying it like any other energy. If it could be "caught," as it were, we should then have this vital intermediary between the material and spiritual worlds, and be enabled to utilize it for communication.

All sorts of fascinating possibilities come to the mind. If life, leaving the body at death, could be registered in some manner, might not experiments be conducted with this in view? We know that there is all the difference in the world between a living and a dead man; yet no physical change may be detectable. Something has, nevertheless, left the living man and that something is his life. If life could be somehow registered or "caught," at the moment of death, we should have here immediate proof of its persistence after the destruction of the physical body. Whether or not this life force contained a mind, consciousness and personality of its own would be another question—a question capable of solution, however, by proper methods of careful, scientific, psychical investigation.

Thus it would appear that a possible method of communication with some spiritual world—granting that it exists—may some day be established by means of highly sensitive radio apparatus that may record impulses too delicate to register on machines that have so far been devised. Such an idea is not as fantastic as might appear at first thought. Without departing essentially from recognized scientific facts or accepted psychical phenomena, I have shown that some such method of communication might be established in the future, when our methods of research have been more fully perfected. When our young experimentalists, especially in radio, begin working in this direction we may hope for startling results.

¶ This article will shortly be followed by an article written by Harry Houdini, president of the Society of American Magicians, who will describe how the fakers among the spiritualists have been using radio for years in staging tricks at their seances.



A RADIO-CONTROLLED MOTOR CAR ON A CITY STREET

Among the more spectacular achievements with radio, few have a wider interest than the guidance of cars, boats or airplanes from a distance. How this is done will be told in "How Machines Are Controlled by Radio," by Dr. Henry Smith Williams—in the August Popular Radio.

From a photograph made for POPULAR RADIO

THIS HOME-MADE SET COSTS FROM $15.00 to $22.00 FOR MATERIALS

Fastening the secondary coil to the sliding support. This sliding coil makes it possible to tune out interference on this set.

How *to* Make and Operate a Two-Circuit Receiving Set

Further evidence of the purpose of the Government authorities to encourage radio amateurs is furnished by these specifications, which have been carefully worked out by the Bureau of Standards, and issued as a sequel to the specifications of the crystal receiving set which were published in the May issue of this magazine.

By WATSON DAVIS

UNCLE SAM is telling the radio fan how to make his own receiving equipment that will enable him to snatch his share of the music, lectures, code and other wireless activity in the ether. The Bureau of Standards, Department of Commerce, cooperating with the Bureau of Markets, Department of Agriculture, has compiled these simple instructions for the amateur.

At a total cost of from about $15 to about $22, depending upon the quality of the telephone receivers and the condenser purchased, he can make an efficient radio receiver right at home that can distinguish between messages from different transmitting stations sent on wavelengths nearly the same. The outfit will enable anyone to hear radio code messages or music and voice sent from medium-power transmitting stations within an area about the size of a large city, and from high-power stations within fifty miles, provided the waves used by the sending stations have wave frequencies between 500 and 1500 kilocycles a second—that is, wavelengths between 600 and 200 meters. This equipment will not receive undamped (continuous) waves.

This set is superior to a single-circuit outfit as it is more selective, that is, it can be tuned sharper. Those who have constructed the Bureau of Standards single-circuit $11 radio receiver according to instructions published in the May issue of this magazine can utilize all the parts of that set in making the better outfit described here.

The instructions tell how to make all the parts of a receiving station except the antenna, lightning switch and necessary ground connections. How to make and erect an antenna and make necessary connections to the receiving set was explained in the previous article.

Parts of the Set

The two-circuit receiving set consists essentially of a coupler, a variable condenser, a crystal detector, and accessories.

The assembled receiving set is shown in Figure 1, and Figure 2 shows how to wire the set.

The coupler, shown in left half of Figure 1, is composed of a fixed section made up of the coil tube P, the upright J, the contact panel K, and the base B, and a movable section composed of coil tube S, the supporting contact panel M and the base L.

The Movable or Secondary Coil

The coil tube S, (Figure 1), is a piece of cardboard tubing 3⅝ inches in diameter and 4 inches long. A round cardboard table-salt box which can be obtained at a grocery store is about 3⅝ inches in diameter and can be used for this purpose. One of the cardboard ends or caps should be securely glued to the box. This tube is wound with No. 24 (or No. 26) double cotton covered copper wire.

To wind the wire punch two holes in the tube ⅜ inch from the open end, as shown at R, Figure 2. Weave the end of the wire through these holes so that it is firmly anchored and has one end extending about 10 inches inside the tube. Punch a hole F about ⅝ inch from the other end (which has the cardboard cover secured to it) in line with the holes punched at R. Draw the free end of the wire through the inside of the tube and thread it out through the hole at F. Now wind on 10 turns of wire and take off a 6-inch twisted tap made by twisting a 6-inch loop of wire together at such a place that it will be slightly staggered from the first connection. Hold the turns tight and punch a hole B directly underneath this tap. Insert the end of the tap in the hole and pull it through the inside of the tube so that the turns are held in place. The hole for this tap should be slightly staggered from the first two holes which were punched. Punch another hole L ⅝ inch from the other end of the tube and in line with the hole B. Thread the twisted tap out through this hole and pull it tight. Wind on 10 more turns and bring out another twisted tap, then 10 more turns and another tap; 15 turns and another tap; 15 more turns and another tap. Finally, wind on 20 more turns and bring out the free end of the wire in the same manner as the taps were brought out. The tube now has 80 turns of wire wound on it and there are 5 twisted taps and two single wires projecting through the row of holes at the closed end of the tube. The position of the wires inside the coil tube is shown by the dotted lines.

The Base and Support for Coil

The contact panel M, Figure 1, which supports the coil tube is a piece of dry wood or Bakelite 5½ inches high, 4 inches wide and ½ inch thick. The end of the switch arm should be wide enough so that it will not drop between the contact points, but not so wide that it cannot be set to touch only a single contact. Having located the hole for the switch-arm bolt, the switch arm should be placed in position and the knob rotated in such a manner that the end of the contact arm will describe an arc upon which the contact points are to be placed. The holes for the contacts should next be drilled, the spacing depending upon the kind of contacts which are to be used.

The movable base L is a square piece of dry wood 4 inches long, 4 inches wide and about ¾ inch thick. Care should be taken to have the edges of this block cut square with respect to the sides.

Now screw panel M to the movable base L, as shown in Figure 1. Care should be taken to have the edges of the blocks M and L evenly lined up so that the two edges of the block L, Figure 1, which slide along the inside edges of the strips H and I will be smooth continuous surfaces.

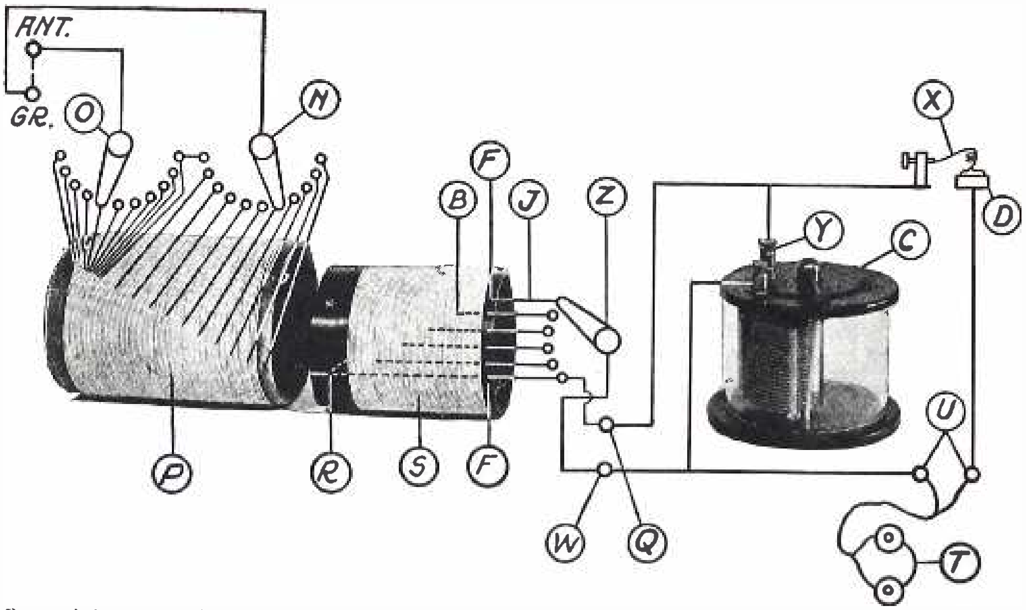
The Parts Needed and the Approximate Cost

You will have to buy these parts of the set, or find them around the house:

6 ounces No. 24 double cotton covered copper wire	$ .80
2 round cardboard boxes	
3 switch knobs and blades, complete	1.50
24 switch contacts and nuts	1.00
3 binding posts; set-screw type	.45
4 binding posts; any type	.60
1 crystal; tested	.25
3 wood screws; brass, ¾ inch long	.03
2 wood screws for fastening the panel to the base	.02
Wood for panels (from a packing box)	
2 pounds paraffine	.30
Lamp cord; 2 to 3 cents a foot	
Telephone Receivers	4.00 to 8.00
1 battery clip for crystal	.10
Miscellaneous Screws	.30
1 variable condenser; 0.0004 to 0.0005 microfarads (400 to 500 micromicrofarads)	3.00 to 6.00

The Fixed or Primary Coil

The cardboard tubing or coil tube P is 4⅛ inches in diameter by 4 inches long. About 2 ounces of No. 24 (or No. 26) double cotton-covered copper wire is used for winding the coil. Punch two holes in the tube about ½ inch from one end. Weave the wire through these holes in such a way that the end of the



From a design made for POPULAR RADIO

FIGURE 1

What the electrical parts of the receiving set are, combined with a diagram that illustrates the system of wiring.

wire will be firmly anchored, leaving about 12 inches of the wire free for connecting. Start with the remainder of the wire to wind turns in a single layer about the tube, tight and close together. After one complete turn has been wound on the tube hold it tight and take off a tap. This tap is made by twisting a 6-inch loop of the wire together at such a place that it will be slightly staggered from the first connection. Proceed in this manner until 10 twisted taps have been taken off, one at every turn. After these first 10 turns have been wound on the tube, take off a 6-inch twisted tap for every succeeding 10 turns until 10 taps are taken off or 100 additional turns have been wound on the tube. After winding the last turn of wire anchor the end by weaving it through two holes punched in the tube as at the start, leaving about 12 inches of wire free for connecting. It is to be understood that each of the 21 taps is slightly staggered to the right from the one just above, so that the taps will not be bunched along one line on the cardboard tube. (See Figure 2.) It might be advisable, after winding the tuning coil, to dip the tuner in hot paraffine. Glue a cardboard cover to the end of the tube where the single turn taps are taken off.

The Panel

Panel K should be made from a board 7½ inches long by 4½ inches wide and about ½ inch thick. The position of the contacts can best be determined by inserting the switch arms in their respective holes and turning the knobs so that the ends of the switch arms will describe arcs. The position of the several holes for the binding posts, switch arms and switch contacts may first be laid out and drilled. The "antenna" and "ground" binding posts may be ordinary 8/32 brass bolts about 1½ inches long with three nuts and two washers. The first nut binds the bolt to the panel, the second nut holds one of the short pieces of stiff wire, while the third nut holds the antenna or ground wire as the case may be. The switch arm with knob may be purchased in the assembled form or it may be constructed from a ⅜-inch slice cut from a broom handle and a bolt of sufficient length equipped with four nuts and two washers, together with a strip of thin brass. The end of the switch arm should be wide enough so that it will not drop between the contact points, but not so wide that it cannot be set to touch only a single contact. The switch contacts may be of the regular type furnished for this purpose or they may be 6/32 brass bolts with one nut and one washer each.

The fixed base B is a piece of dry wood 5½ inches wide, 19 inches long and between ¾ and ⅞ inch thick. The support J for the fixed coil tube is 5½ inches wide (the width of the base), 6 inches long and about ½ inch thick. This board should be screwed to one end of the base so that it is held securely in a vertical position. It will then project about 5 inches above the base B.

A strip of wood I, 11 inches long, 5/16 inch wide and about ¼ inch thick is now fastened to the base by cigar-box nails or small brads so that it is even with the rear edge, as shown in Figure 1. The upright panel M having been fastened to the movable base L, as previously explained, is placed in position as shown. The next step is to locate the strip H in such a position that the block L will slide easily back and forth the entire length of the fixed base B. Having found this position this strip is secured in the same manner as the strip I. It is, of course, understood that neither the movable coil tube S nor the switch contacts and binding posts have, up to the present time, been mounted on the upright panel M. The wooden parts for the loose-coupler are now finished and should be covered with paraffine.

It might be advisable after winding the coil tubes P and S to dip them in hot paraffine. This will help to exclude moisture. Have the paraffine-heated until it just begins to smoke so that when the coils are removed they will have only a very thin coating of paraffine.

The Variable Condenser

The variable air condenser C should have a maximum capacity of between 0.0004 and 0.0005 microfarads (400 to 500 micromicrofarads.) The type pictured in Figure 1 is inclosed in a round glass case, but the "unmounted" type may also be used. The variable condenser is mounted on the base B, Figure 1. After the holes for the detector binding post, and also the holes for the telephone binding posts U have been drilled, the board should be coated with paraffine.

The Crystal Detector

The galena crystal D may be mounted as pictured in Figures 1 and 2. The holder for the crystal is a metallic pinch-clip such as the ordinary battery test clip or paper clip. This clip should be bent into a convenient shape so that it may be fastened to the base.

The wire X which makes contact with the crystal is a piece of fine wire (about No. 30) which is wound into the form of a spring and attached to a heavy piece of copper wire (about No. 14). This heavy wire is bent twice at right angles, passes through the binding post, and has a wood knob or cork fixed to its end as shown. It is desirable to have the fine wire of springy material such as German silver, but copper wire may be used if necessary.

The importance of securing a tested galena crystal can not be emphasized too strongly, and it should be understood that good results can not be obtained by using an insensitive crystal.

Assembling the Coupler

The movable portion of the coupler should be assembled first. As shown in Figure 1, the fittings making up this part of the set are the movable base L, the coil tube support M and the coil tube S. Insert in M the 6 switch contacts (machine screws), the switch arm, and the binding posts, in the proper holes which have been drilled. Adjust the switch arm until it presses firmly on the contact points (bolt heads) and fasten the bare end of a No. 24 copper wire between the nuts on the end of the switch-arm bolt 2, Figure 2, which projects through the panel M. Wind this wire into the form of a spiral of two or three turns like a clock-spring, leaving a few inches of the wire for connection. Insert two small screws V, Figure 1, in the panel M so that the switch arms will not drop off the row of contact points when the knob is turned too far.

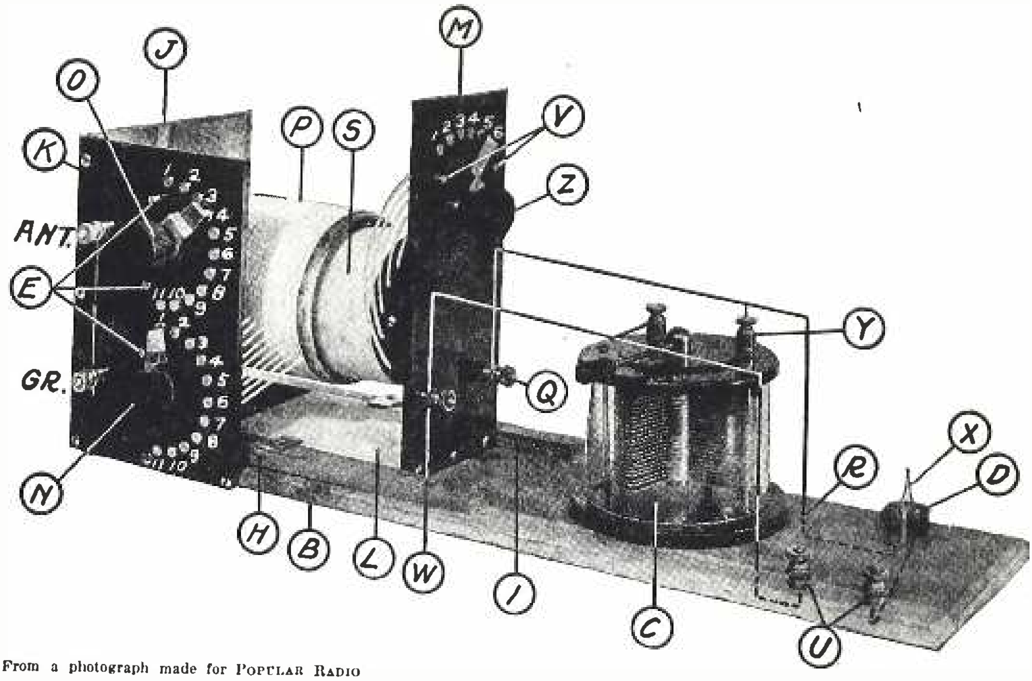
The coil tube S is now ready to be fastened in position on the panel M. Cut a 1-inch hole in the cardboard end of the coil tube and place it with the closed end next to the panel M in such a position that it will be just below the row of nuts and washers (switch contacts) and in the center of the panel M with respect to the sides. Fasten it to the panel with short wood screws. The switch-arm bolt with the spiral wire connected to it should project through the hole cut in the end of the coil tube. Thread the end of this wire through a hole punched near the end of the coil tube next to the panel and connect this wire to the back of the binding post, W, Figures 1 and 2. The wire F, Figure 2, is now connected to the back of the binding post Q. There now remain 5 twisted taps and 1 wire to be connected to the 6 switch contacts. The taps should be cut off about 1½ inches from the coil tube and the insulation removed from the pairs of wires thus formed. Each pair of wires should be twisted together, as shown at J, Figure 2. The connections are now made by clamping the 5 taps and also the end of the single wire between the nuts and washers on the contact bolts. The connections are clearly shown in the diagram.

We are now ready to assemble and wire the fixed portion of the coupler, composed of the Base B, coil support J, panel K and coil tube P.

Screw the panel to the base and to the support J and insert the binding posts, switch arms and bolts, and contact bolts in the proper holes. The switch arms should now be adjusted so that they make firm contact on the heads of the bolts. Now insert 4 small screws, E, Figure 1, in the front of the panel so that the switch arms will not drop off the row of contact points when the knobs are turned too far. Insert a wire between the nuts on the end of the lower switch-arm bolt N where it projects through the back of the panel K, Figure 1. Wind the wire into a spiral of 1 or 2 turns like a clock-spring and connect the end to the upper binding post which is marked "Antenna." These connections will be understood by referring to the upper left-hand corner of Figure 2.

In the same manner connect another wire from the upper switch-arm bolt to the lower binding post which is marked "Ground." See Figure 2. The connecting wires should be insulated except where a connection is needed and should not touch each other. Two short pieces of wire are now fastened to the binding posts in the front of the panel, as previously explained.

The coil tube P should now be laid on the base in about the same position as it is shown in Figure 1. The 19 twisted taps and also the 2 single wires from the ends of the winding are now to be connected to the back of the 22 contacts on the panel K. Scrape the cotton insulation from the loop ends of the nineteen twisted taps as well as from the ends of the two single wire taps coming from the first and last turns. Fasten the bare ends of these wires to the proper switch contacts. Be careful not to cut or break any of the looped taps. The connecting wires may be fastened to the switch contacts by binding them between the washer



From a photograph made for POPULAR RADIO

FIGURE 2

How the parts of the set are assembled. This set will receive satisfactorily within an area of any large city, from medium-power stations and from high-power stations within 50 miles.

and the nut. The order of connecting the taps may be understood by referring to Figure 2.

Carefully raise the coil tube P against the support J to such a position that when the coil tube S of the movable section of the tuner is pushed in the coil tube P, the space between the two tubes will be equal all around. Mark this position of the coil tube P on J, and fasten it to J with short wood screws.

Wiring the Condenser and Crystal Detector

The mounting of the condenser C and the crystal detector D on the base R is clearly shown in Figure 1. A wire is run from the binding post Y on the variable condenser C, through a small hole in the base R, and is then connected to the under side of the detector binding post. Another wire is now run from the clip which holds the galena crystal, through a small hole in the base, and is then connected to the under side of the right-hand binding post U. The left-hand binding post U is next connected to the binding post on the variable condenser which has no wire attached to it, by running a wire under the base and up through a small hole. The wiring will be understood by referring to the right-hand portion of Figure 2. The wires may be the same size as were used for winding the coil tubes and should be insulated. Two pieces of wire should now be connected from the binding posts W and Q, Figures 1 and 2, to binding posts on the variable condenser. The telephone receivers T are now connected to the binding posts U and the receiving set is complete except for connecting to the antenna and ground.

Connect the antenna lead and ground wire to the binding post marked "Antenna" and "Ground."

Directions for Operating

Push the coil tube S (secondary) about half way into the coil tube P (primary) and set the switch Z on contact point 4. The primary switch O may be left in any position. The wire which rests on the crystal detector must be placed lightly at different points on the crystal until the transmitting station is heard when the set is adjusted as described below. During this operation the primary switch N should be set on contact point 5.

Having adjusted the crystal detector to a sensitive point, the next thing is to adjust the switches on the coil tube P (primary), the switch on the coil tube S (secondary) and also the variable condenser C, so that the apparatus will be in "resonance" with the transmitting station. Set the primary switch N on contact point 1, and while keeping it in this position move the other primary switch O over all of its contacts stopping a moment at each one. Care should be taken to see that the ends of the switch arms are not allowed to rest so that they will touch more than one contact point at a time. If no signals are heard, set the switch arm N on contact point 2 and again move the switch arm O over all of its contacts. Proceed in this manner until the transmitting station is heard. This is called "tuning" the primary circuit.

The tuning of the secondary circuit is the next operation. Set the secondary switch Z on contact point 1 and turn the knob of the variable condenser C so that the pointer moves over the entire scale. If now signals are heard, set the switch on contact point 2 and again turn the knob of the variable condenser so that the pointer moves over the entire scale. Proceed in this manner until the signals are loudest, being careful to see that the ends of the switch arms touch only one contact point at a time. Next slide the coil tube S (secondary) in and out of the coil tube P (primary) until the signals are made as loud as possible. This operation is called changing the "coupling." When the coupling which gives the loudest signal has been secured, it may be necessary to readjust slightly the position of the switch arm O, the position of the movable coil tube S and the "setting" of the variable condenser C.

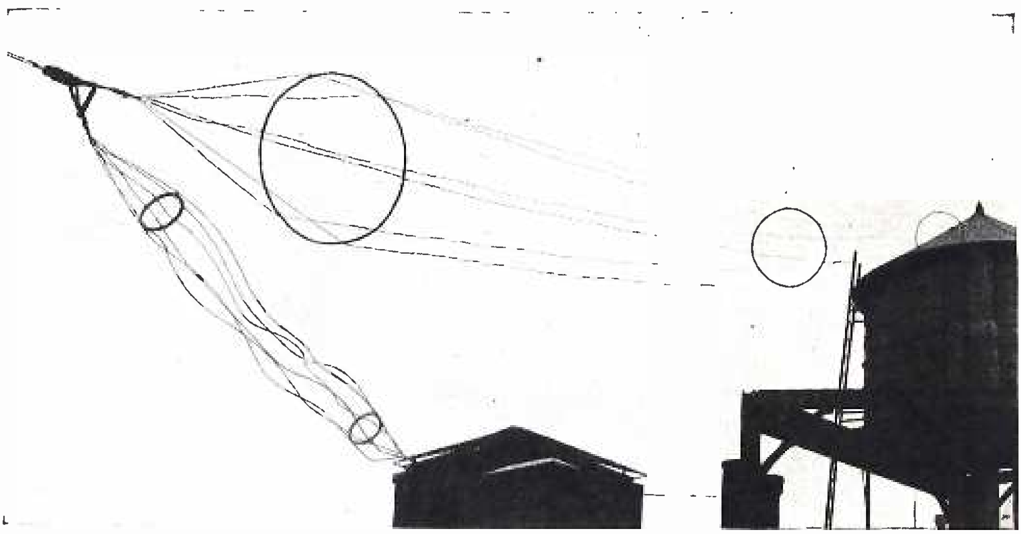
The receiving set is now in resonance with the transmitting station. It is possible to change the position of one or more of the switch arms, the position of the movable coil tube and the setting of the variable condenser in such a manner that the set will still be in resonance with the same transmitting station. In other words, there are different combinations of adjustments which will tune the set so that it will respond to signals from the same transmitting station. The best adjustment is that which reduces the signals from undesired stations to a minimum and still permits the desired transmitting station to be heard. This is accomplished by decreasing the coupling (drawing coil tube S farther out of coil tube P) and again tuning with the switch arm O and the variable condenser C. This may also weaken the signals from the desired transmitting station, but it will weaken the signals from the undesired stations to a greater extent, provided that the transmitting station which it is desired to hear has a wave frequency which is not exactly the same as that of the other stations. This feature of the radio receiver is called "selectivity."

¶ *"Fighting Fire by Radio"—where and how the Forest Service has been using wireless successfully and saved Uncle Sam millions of dollars—will appear in the next issue of* POPULAR RADIO.

© Harris E. Ewing

WHERE YOUR RADIO CALL LETTERS ARE ASSIGNED

This is the inner sanctum of Uncle Sam's radio office—officially designated as the "Radio Service, Department of Commerce"—and the official at the extreme right is Mr. W. D. Terrill, the man who decides what call letters shall be. How the system works, and what your call letters signify will be described in the next issue of POPULAR RADIO.



From a photograph made for POPULAR RADIO

The carefully designed and skilfully made cage antenna on the roof of an apartment building.

An Amateur Who Hears Europe

Have You Ever Heard Station 2BEA Transmit? Here Is a Description of Its Radio Equipment

By RICHARD LORD

WHILE walking up West End Avenue, New York, my eye was attracted by a carefully designed and skilfully made cage antenna, located on a tall apartment building. It was obviously the work of an experienced amateur. I noted that the lead-in continued as a diminutive cage to the window insulator. One look at this shipshape piece of work convinced me that it would be worthy examination, so I got into touch with the owner.

The owner was Mr. William Schweitzer, operating station 2BEA, an amateur of experience with a sound knowledge of the principles of radio.

The first C.W. transmitter which Mr. Schweitzer had operated consisted of four 5-watt tubes. With this small power output he did extraordinary work. On one occasion he was copied in Jefferson City, Missouri, a distance of 1,200 miles, by daylight.

Recently the 5-watt tubes have been replaced by a home-made set that employs two 50-watt tubes to generate the continuous waves. The plate potential is supplied from the secondary of a step-up transformer rectified by means of two Kenotron tubes. The actual voltage supply to the plates is approximately 1250. The circuit used is a Colpitts, employing capacity coupling between the plate and grid circuits.

The evening I called the static was unusually heavy for an early March evening, but a good deal of traffic was handled southwards. Savannah, Georgia, was raised on the first call and messages were put through without repeats.

The relay receiver is a Grebe CR4 with a vacuum tube detector and two stage audio frequency amplifier.

In addition to the relay equipment, Mr. Schweitzer has an excellent long wave apparatus for trans-Atlantic and trans-Pacific reception. The long wave tuner is a conventional honeycomb unit with the primary and secondary inductances shunted by a pair of very fine Kloster design condensers. A special long single wire antenna is used for long wave reception. The incoming energy is first amplified by three stages of radio frequency amplification. The radio frequency amplifier was especially constructed by Roget, of Paris; it employs three French valves and is resistance coupled. This device is remarkably silent in operation and very compact.

The magnified current is then supplied to the receiving tuner. The output in turn is passed through three stages of audio frequency amplification. The three stage audio amplifier is also built by Roget, and employs French tubes. Of course, one will readily believe that this equipment brings in signals of extraordinary strength. Ample energy is received from any of the stations generally copied on this side to operate the Morse relay recording device, which is a part of the station's equipment.

The radio station is located in a little building on the roof. In order to be able to hear the signals in the apartment, ten stories below, Mr. Schweitzer uses a Magnavox, which is supplied through a wire line running to the station. A step-down transformer is used to couple the output of the receiving set with the Magnavox. The music from the Newark broadcasting stations can be heard more than a block from the apartment when the Magnavox is on the windowsill.

Although there is much expensive equipment in the station, the remarkable results obtained are not dependent upon this equipment; they are due to the skill and careful workmanship which are displayed in the assembling and construction of the units. The 100-watt C.W. transmitter has been constructed in its entirety by Mr. Schweitzer.

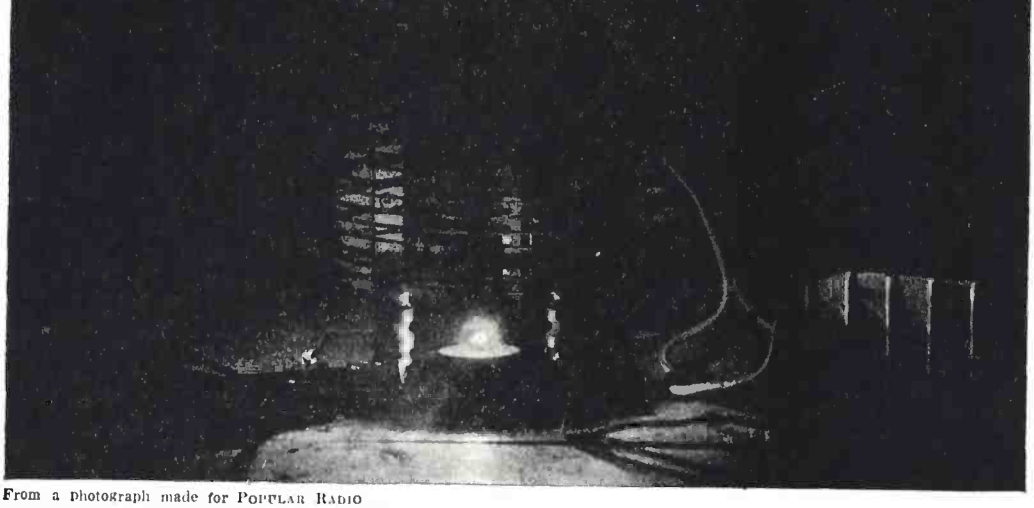
From a photograph made for POPULAR RADIO

Good results from your radio set may be obtained not alone from good apparatus but from proper installation and maintenance—as William Schweitzer has demonstrated with his station 2BEA, a part of which he built himself.

How High Frequency Currents Are Generated

SIMPLE "HOW" ARTICLES FOR THE BEGINNER—NO. 3

By LAURENCE M. COCKADAY



From a photograph made for POPULAR RADIO

This picture shows a spark jumping the gap. The large coil (in the rear) and the enclosed condenser (at the right) comprise an oscillating circuit.

IN the two preceding articles we have learned how electricity is generated and what it is; we have acquired a general idea of what a radio wave is and how it is sent out through space. We have been told that the radio wave is set up in the vicinity of a transmitting antenna only when a current of extremely high frequency is caused, by some means or other, to flow back and forth, or oscillate through an antenna circuit. This radio wave has a definite wavelength for every given frequency of current that is caused to flow in the antenna circuit.

In this third article of this series we will delve into the seemingly mysterious methods employed for producing these high frequency currents and also into the methods of controlling the frequency of these currents whereby a transmitting station may "tune" itself to a wavelength alloted to its use by the government. The case that we will now study is the generation of high frequency currents by the spark discharge method.

—EDITOR

MANY of us who have walked past the radio cabin on a steamer have heard the crashing, sparking sounds that issue from the radio transmitter. Some of us have seen the sets in operation. Most of us have perhaps turned away with the thought: "Well, radio certainly is a wonderful thing, and it must have taken some brain to work out the idea, but it's beyond me."

This, however, is not so. Anybody can understand the mechanics of radio if given the right instruction.

In the last article we became slightly familiar with two electrical instruments—the inductance or coil, and the condenser. We learned that these two pieces of apparatus were storehouses of energy. The coil we found had the ability to store up electromagnetic energy. This meant that the coil produced an electromagnetic field around itself that was similar to the field set up around a steel permanent magnet. The condenser on the other hand, by having all the electrons drawn off one plate and crowded on the other plate, became "charged." This caused one plate to be positive, and the other to be negative. The plate which contained all the electrons was the plate that was charged negatively. These two charges caused the "dielectric" or insulation between the two metal plates to be placed in a stressed or strained condition; in other words, an electrostatic field was set up in the insulation.

We will now connect up these two instruments with a spark gap and show how they, in combination, will cause wave trains of high frequency currents to be generated and how they also can be varied in size so that the frequency of the oscillations can be controlled at will, thus controlling the wavelength emitted from the transmitting set of which they form a part.

If we connect a wire to one plate of a condenser, which is made for high voltages, and which is diagrammatically shown at C in Figure A, and also connect the other end of this wire to one electrode of a spark gap SG, and connect the other plate of the condenser C to another wire which is attached to one end of a coil L, and further connect the other end of the coil to another wire which is in turn connected to the remaining electrode of the spark gap SG, we have connected up a regular oscillating circuit such as used by spark radio telegraph stations for generating the oscillations necessary for the production of the Hertzian or radio waves.

Now we will continue and make the circuit oscillate for our inspection in a very slow manner so that we may comprehend the workings clearly. Of course this will be unnatural, but it will serve to show us the functioning of the circuit in much the same way as motion pictures are slowed down so that the observer may see each individual action.

We will first place a charge on the condenser C; a positive charge on the upper plate and a negative charge on the lower plate, Figure A. As we have already learned, a condenser when charged, contains a store of energy which is in the form of electrostatic electricity, or stationary electricity.

When a condenser is charged in this manner it tries to discharge and thus neutralize the charges on the plates. This discharge cannot take place unless the condenser has some external, electrically conducting path through which the electric current may run. This conducting path may be a wire attached from the positive plate to the negative plate. Inspection of Figure A shows that we have these conditions fulfilled except for one point—the air gap between the electrodes of the spark gap. Therefore, if we wish the electric charges on the condenser to discharge through the circuit we must place a high enough voltage on the plates so that the resistance of the air between the electrodes will be overcome and a spark allowed to jump across the gap. Then we have a complete conducting circuit from the upper plate to the lower plate of the condenser and a cur-

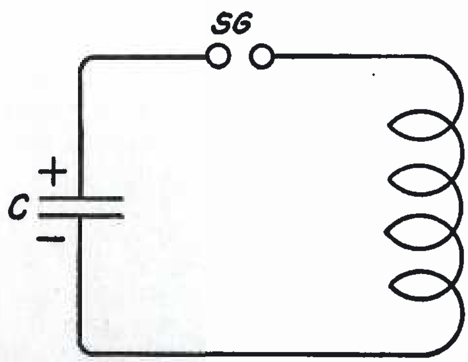


FIGURE A

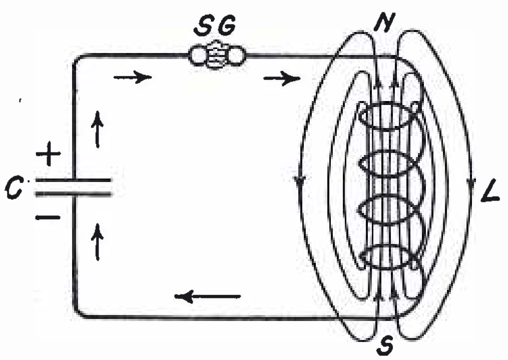


FIGURE B

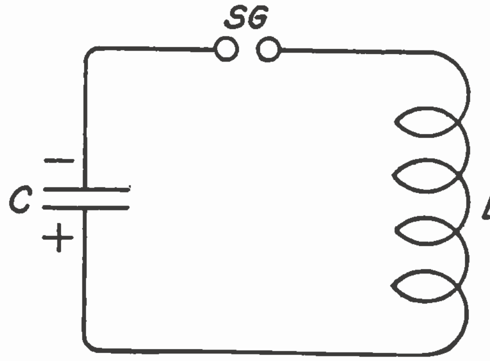


FIGURE C

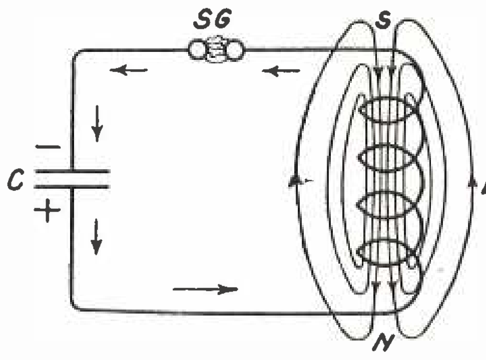


FIGURE D

rent of electricity is caused to flow around through the circuit as indicated by the arrows and the spark shown jumping the gap in Figure B. This current is instantaneous and is shown as a positive impulse making up one half a cycle in Figure E.

We have learned that when a current is allowed to flow through a coil, a magnetic field is set up around the coil, which causes it to become an electromagnet with one end of a north polarity and the other end south, as shown at L in Figure B.

When the current has flowed through the circuit, the charges that were on the condenser C have become neutralized and therefore the current ceases. When this happens the magnetic field that has been set up around the coil L collapses; that is, the magnetic rings fall back on the surfaces of the wires and a peculiar effect is noticed; a voltage is induced in the coil which is positive in the direction that the current was running.

This means that the condenser C receives a reverse charge immediately after the current from the initial charge has ceased to flow.

This second charge places a positive potential on the bottom plate of the condenser and a negative charge on the top plate, (See Figure C). This charge is not as strong as the first charge, however, because there is some energy lost due to the fact that the current must overcome the resistance of the wire and that of the air through which the spark must be forced.

When this second charge on the condenser reaches a high enough value to again break down the spark gap, a spark occurs across the gap and a second current flows through the circuit, in the opposite direction to the first current (See Figure D). This current forms a negative impulse which is shown in the diagram, Figure E, as the second impulse of the first cycle. Again the coil sets up a magnetic field around itself, only this time the top of the coil is of a south polarity and the bottom of the coil is north.

When this field collapses at the cessation of the second current the coil induces the third charge on the condenser which is in the same direction as the original charge.

The same cycle of events then takes place and the current oscillates back and forth through the circuit one way and then the other, but the successive oscillations become weaker and weaker until they die out (See Figure E).

Remember, however, that in our study of these oscillations we have considered them as slow oscillations; in reality they take place in the twinkling of an eye—much faster in fact. One of these series of current wave trains, as they are called, would look to the human eye, like one single crackling spark across the gap. The modern radio transmitter uses frequencies up to 2,500,000 cycles a second, which means 5,000,000 reversing impulses a second, jumping the gap. Little wonder that they look like one single spark!

We now have a general idea of how this simple little circuit, composed of these simple instruments, can perform this miracle of electrical speed and motion without any mechanical moving parts. Now we shall see how we can control the frequency of these generated impulses, by varying either the size of the coil or the size of the condenser.

We may liken the condenser to a pitcher of water. We know that if we have a small pitcher, a certain sized stream of water will require a certain length of time to fill the pitcher. If we use a larger size of pitcher, and hold it under the same stream of water, it will take a greater length of time to fill it. It will also take a longer time to empty the larger pitcher than it will take to empty the small one.

We can also liken the coil to a coiled tube that we can pour the pitcher of water into. A certain length of time will be needed for the water to wind around through the convolutions of the coiled tube and finally find its way out of the bottom. If we make the tube twice as long, it will take twice as long for the water to run through.

Now apply this idea to the electrical circuit. If we use a larger condenser C, it will take longer for it to charge and discharge, making the currents that oscillate through the circuit to last longer. If they last longer, there cannot be as many each second. Therefore if we increase the capacity of the condenser we get fewer impulses a second, thus decreasing the frequency of the oscillations and increasing the wavelength that is emitted from the antenna to which this circuit is coupled.

Or we may get the same result by increasing the number of turns of wire in the coil, and the current will take longer to run through it, so to speak; again we have less impulses a second or a higher wavelength. Increasing either the capacity of the condenser or the inductance of the coil, increases the wavelength. This latter method is generally used for transmitting stations, as it does not vary the power of the set to such a great extent while changing the wavelength, as varying the size of the condenser varies the power greatly that the circuit uses. A given size of condenser will hold a given charge, and if it is varied in size the charge varies in size also.

The coils are generally made with a large number of turns of heavy wire on them and a sliding contact slides over the surface of the wire and picks out the desired number of turns to be left in the circuit to obtain a frequency that corresponds to the desired wavelength.

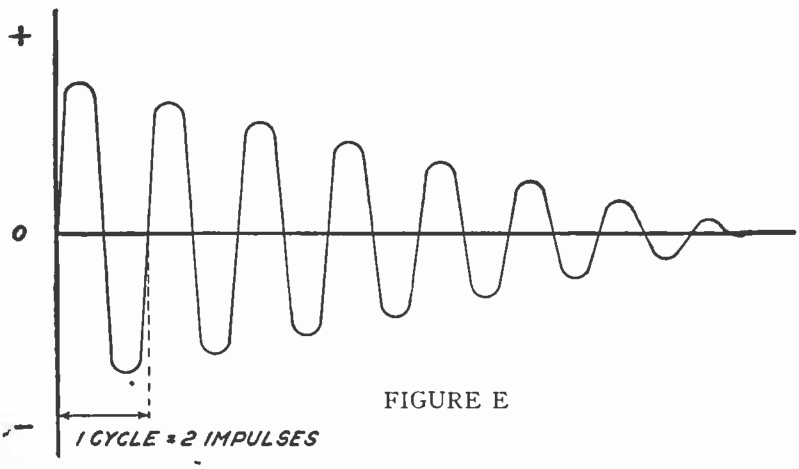


FIGURE E

In this way radio transmitting stations are tuned to the wavelength that they are required to send out on by governmental regulation.

So we find that the whole scheme is, after all, simple. The only feature that made it seem mysterious was the fact that we had no way of telling just what took place when the sparks "jumped the gap," until we analyzed the whole process.

In a future article we will show how these impulses are transferred to the transmitting antenna; then we will see that the coil plays a double role in the radio circuit.

Pointers for Preventing Interference

By C. A. BRIGGS

AMATEURS who operate radio sets for receiving music should tune and stop their bulbs from oscillating as quickly as possible, or they may interfere with their neighbor's entertainment.

When the bulb of a receiving set is oscillating it generates a high frequency alternating current. In this condition it constitutes a small transmitting station which may send out waves sufficiently strong to be picked up by other receiving apparatus in the vicinity. Indeed, communication may sometimes be carried on over short distances by utilizing this very fact.

While listening in on music, lectures and other broadcasted entertainment the amateur sometimes hears a smooth, whistling note that changes its pitch. As many as three such interferences have been heard at one time at a station. These sounds may be caused by nearby listening stations which are picking up the telephone wave and adjusting it in. Telephone waves are best picked up by starting the detector bulb to oscillating and then hunting about over different wavelengths until the whistle or squeal of the radio wave so familiar to radio operators is found. The different adjustments are then arranged to bring the response to the point of maximum efficiency; the final setting is generally such that the receiving tube is just on the point of, but not quite, oscillating.

Sometimes the telephone waves are received while the tube is kept oscillating; in that case the sounds may be loud but somewhat distorted and broken up.

For receiving code signals on continuous wave transmission it is necessary to have the receiving set oscillating, as the whistling note is the signal received. In such cases interference by other receiving sets may not be so serious. The quality of the sound is not important and the effect of the interference of receiving stations will not break up the dots and dashes of the code but merely add a continuous note to the intermittent notes that come from the distant station. An operator may sometimes stop his own tube from oscillating yet receive the incoming code signals with the aid of his neighbor's oscillating tube. This method, however, is not recommended as the other operator is sure to change his adjustments and lose the signal at a critical time.

The type of set known as the "single tuner circuits" are generally credited with being the worst offenders for producing interference. In these sets what constitutes the primary and secondary circuits of more complicated apparatus are in a sense combined, and the closer union of the tube circuit with the aerial is said to cause the set to radiate much more strongly than is otherwise the case.

It is well, therefore, for everybody who operates a radio receiving set to keep these tips in mind, and when he picks up telephone waves to make the necessary adjustments and stop the bulb from oscillating as promptly as he can.

The "Soup-Plate"

A Novel Type of Transmitter that Reverses the Principle of the Loud Speaker

By FREDERICK SIEMENS

THE problem of getting a large volume of sound converted into electricity for use in modulating the high-power transmitting stations that are now being used for radio broadcasting has become of increasing importance during the last year.

Several systems have been worked out to attain this result, but most of them have this serious disadvantage: while they produce a large amount of voice-controlled electricity, at the same time they distort the voice wave that is impressed upon them. Thus the reproduction is not as clear or as faithful as it should be.

One particular method that gives a very good quality of speech and relies upon the electromagnetic principle for its action is illustrated by the accompanying picture. The speaker or singer throws his voice into the "soup-plate" transmitter, as it has been nicknamed, which consists of a large paper diaphragm that vibrates in accordance with the voice wave that impinges upon it. The center of this diaphragm is attached to a moving coil which is placed in the magnetic field of a powerful electromagnet. When the diaphragm vibrates, the coil moves back and forth with it; this motion causes it to change its position in the magnetic field of the electromagnet. These motions of the coil back and forth, which conform with the voice waves, cause electric currents to flow in the coil which also are controlled by the voice waves. In this way the voice wave is changed from a sound wave into an electrical wave without depending on the old style transmitter which distorts so much and which uses carbon grains which are pressed tightly together or loosely as the voice causes them to vibrate.

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Arthur Stringer, the well-known poet, recites his Irish poems by radio, from the broadcasting station at Fort Wood

The voice currents produced by the new method are remarkably true in following the complex voice vibrations as used by everybody in ordinary speech, and are remarkably effective in the reproduction of music. The current obtained from this instrument is magnified or amplified by means of vacuum tube amplifiers, somewhat similar to those used by the amateur, except that the tubes used are larger and are known as power amplifiers.

The cylindrical object that is shown, supported from the rim of the cone-shaped diaphragm by the three radial supports, contains the electromagnet and the moving coil.

The principle of the new transmitter is just exactly the reverse of the loud-speaker used for receiving. In the latter the electrical energy is converted into sound and in the transmitter the sound is converted into electrical energy. The same apparatus can be used for both purposes with slight modifications.

George Grantham Bain

An amateur who sings a copyrighted song by radio for the entertainment of fellow fans expects no financial returns from his efforts. But the use of such music by professional artists engaged by business houses is raising some knotty problems.

DOES BROADCASTING A SONG CONSTITUTE

"A Public Performance *for* Profit?"

If so "Who Will Pay the Piper"?—and How?—Ask the Music Publishers, Authors and Composers

By E. C. MILLS

DOES the singing of a song over the radio—more particularly the singing of a song of which the words and music are copyrighted—constitute a "public performance"? And if it does, is that performance "for profit"? And if it is for profit, who makes that profit and can the owner of the copyright collect payment for such a public performance?

These are only some of the questions that the amazing development of the radio and the extension of broadcasting programs have raised so suddenly that the song-writers and publishers have scarcely had time to determine just how their legal rights as well as their pocket books are being affected. According to the opinion recently rendered by Nathan Burkan of the American Society of Composers, Authors and Publishers, the singing of a copyrighted song by radio does in effect constitute a public performance for profit, and the owners of the copyright are entitled to revenue therefrom. Just how royalties may be collected, however, has not yet been determined.

A copyright on a song (or on any musical composition) vests in its proprietor three distinct rights:

(1) The right to print and multiply printings of the work;

(2) The right to control the mechan-

ical reproduction thereof (such as phonograph records and player-piano rolls), and

(3) The right to publicly perform or license the public performance (for profit) of the copyrighted work.

All of these rights are exclusive.

These rights are based upon the Copyright Act of 1909; it and the preceding Acts granting Copyright having been enacted pursuant to a clause in the original Constitution of the United States which provides that Congress should have the power, for the encouragement of the arts and sciences, to enact such legislation. The broadcasting by radio of concerts, for the entertainment of thousands (and soon, apparently millions) of owners of receiving apparatus, is, in the opinion of the authors, composers and publishers, a public performance for profit.

It is true that the listeners-in on these concerts do not pay to the broadcasting stations any fee for the service; nor does it seem immediately practicable to arrange any basis upon which broadcasting stations might charge a fee to the owners of receiving apparatus.

If broadcasting is to be continued however, it is obvious that it must pay commercial profits to those who operate the stations. Under the present conditions these profits must flow from the sale of receiving sets. If broadcasting does not pay as a commercial enterprise, it will be discontinued. As an alternative, it may be supported by the municipal, state or Federal governments.

If broadcasting pays as a commercial venture of a private concern, and the broadcasting of copyrighted musical compositions constitutes a part of its service, then obviously the music that is being used for purposes of profit and those who create such music are entitled to share in such profits.

Radio has developed in such an amazing and spectacular manner that it promises to become the greatest factor the world has ever known for the dissemination of information and education of the whole people. The position of musical copyright proprietors, including authors, composers and publishers, is now and will be in the future to lend their support to any cause or purpose which promises so much for mankind's benefit, and they therefore do not oppose radio, nor would they handicap or hamper its logical development.

HOW CAN THE RADIO PROFIT THE COMPOSER?

"The widespread use of music in broadcasting," states the author (who is the chairman of the Executive Board of the Music Publishers' Protective Association), "is materially decreasing the earnings of authors and publishers." What can they do about it?

On the other hand, the widespread use of music in broadcasting is bound to affect the earnings of the authors and publishers, it is even now decreasing them materially and promises to do so to a much greater extent. Fair and just recognition of the music writers of the country will make it necessary that they be reimbursed in some way by the radio which at present is reducing their earnings.

A basis for the charging of royalties upon such copyrighted music as is used in these broadcasted concerts has not yet been worked out. The copyright owners have felt that they should not place any obstacle in the way of the development of this art which promises so much. But in due course a plan for charging the broadcasting stations for the use of the product from which they derive their profit will presumably be worked out.

If the contention of the music publishers that the broadcasting of copyright music in the prevalent manner is a "public performance for profit" is correct, then a technical infringement of copyright is committed every time such a composition is broadcasted without a license from the copyright proprietor. The publishers are in communication with the various broadcasting station proprietors, and have every reason to believe that their position in the matter is one of entire fairness, and that they will frankly recognize the rights of copyright proprietors in this matter and work out a plan of compensation on a fair basis.

Photo by A. M. Vinje

A UNIVERSITY PROFESSOR LECTURES TO THE WHOLE MIDDLE WEST

On the principle that the citizens of the State of Wisconsin who support the University of Wisconsin are entitled to such privileges as the institution can extend to them, the officers of the university are carrying on "certain forms of extra-mural teaching" by means of radio broadcasting. This picture shows Prof. Alfred B. Haake delivering a talk on economics. Some of the lectures have been heard as far west as the Rockies and as far east as New England.

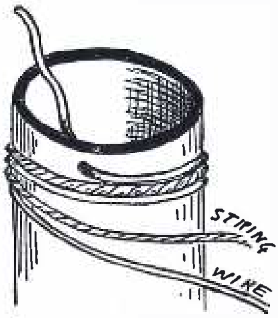


FIGURE 1

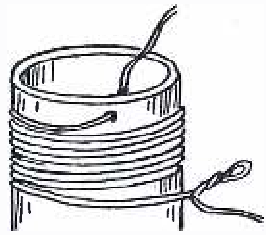


FIGURE 2

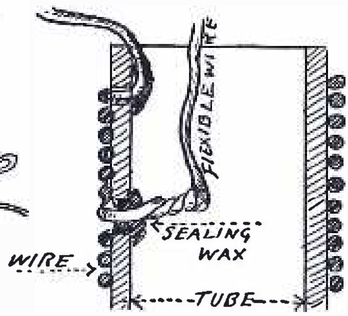


FIGURE 3

Illustrated with pen-and-ink sketches by the author from a home-made apparatus which he built himself

How *to* Make a Loose Coupler Coil

Another of the Practical and Popular "How to Make" Series of Articles for the Radio Novice

By A. HYATT VERRILL

ALTHOUGH vario-couplers, variometers and other instruments have largely taken the place of the older and simpler loose-coupled tuning coils, especially in the more expensive and ready-made sets, still, a well-made, loose-coupled coil is a useful device and will give excellent results. Moreover, it is far easier to make a loose-coupler than other forms of vario-coupler tuners; any one with the least mechanical ability and a little patience may build an efficient coil of this sort at a small cost.

No expensive or special tools are required with the exception of some twist drills, either used in a geared breast drill or a bit-brace, and the only materials needed are some formica or other composition tubes, some half-inch wood, wire, a few binding posts, a multiple point switch, half a dozen ⅛-inch by 1-inch brass machine screws with nuts and washers to fit, a piece of ¼-inch round brass rod about 18 inches long, a piece of ¼-inch square brass rod a little more than a foot in length, a small strip of spring brass and a piece of square brass tubing ¼-inch inside and 2 inches long. Formica or other composition tubes are suggested; while pasteboard tubes or wooden cylinders may be used as the foundations for coils, they are not advisable. They do well for experimental work or rigging up a temporary set, but even if shellacked or soaked in paraffine they will still absorb moisture, and this detracts from the efficiency of the coil. In our climate, where the air is damp and humid in summer and the houses that are heated by artificial means are dry in winter, wood and cardboard will swell, shrink or warp and eventually ruin the coil. Accordingly, if you intend to make a good coil, get tubes that will serve you well and will endure; good work is worthy of good foundations.

The exact size of the coils is not important as long as the diameter of the smaller one is a trifle less than the diameter of the outside coil, so that it may be slipped within and yet leave at least ⅛-inch all around. If the larger tube is between 2½ and 3½ inches in diameter and from 6 to 8 inches long, it will do very well and the smaller tube should be the same length.

The first step is to wind the larger or primary coil. This may be done either with double cotton covered, enameled or bare copper wire about No. 24 in size. Make a small hole about three-fourths of an inch from each end of the tube; thread about 6 inches of the wire through this and fasten the wire on the inner side of the tube with a drop of sealing wax. Then wind the wire on smoothly and evenly. If you are using insulated wire, merely wind on the turns side by side, but if you are using bare wire wind it on with a cotton string or twine between each turn of wire, as shown in Figure 1.

When you reach the hole at the opposite end of the tube, run the wire through, fasten it inside the tube with sealing wax and snip it off close.

When you wind a tube, you will find it far easier for two to work than to do it alone. One can then hold the coil as the wire is wound on while the other can unroll the wire and keep it free from kinks. If you buy a reel or spool of wire this may be hung up on a nail or peg and may be reeled off easily without fear of kinking. Also, if you have a lathe you will find it very easy to attach the tube to the lathe and by revolving the tube wind the wire on easily and smoothly. To fasten the tube in the lathe, slip it over a cylindrical piece of wood, fasten it lightly by small screws through holes close to the ends of the tube and place the chucks against the wooden cylinder.

To wind the smaller or secondary coil is not a simple, for this must be tapped at intervals of every twenty turns. Start the wire in the same way as on the large coil and wind on twenty turns. Then, make a small loop or twist in the wire as shown in Figure 2. Scrape off the insulation and attach a piece of flexible insulated copper wire about a foot long. Make a good connection (keep the wires bright and twist them firmly together), and then, just where the tap comes on the tube, bore a hole, run the flexible wire through, pulling the loop in by gently pulling on the end of the flexible wire at the end of the tube and drop a bit of sealing wax upon the wire where it enters the hole (Figure 3). The only care needed in doing this is to have the hole large enough to allow the tap to pass through freely, to be careful and not kink the wire on the outside of the coil and to hold the wire wound on the coil in place while making the tap and pulling it through the hole. You may have a bit of trouble with the first tap, but if anything goes wrong you can unwind the first twenty turns and start over again without much trouble—and it is a good plan to become adept and to make a neat job of this first tap before continuing to the next.

After the first tap is made the others will be easier, for by carefully measuring the distance from the first turn of wire on the tube to the hole for the tap you can measure off the spaces on the tube for the other taps and make the holes ahead of time. After the first tap is successfully made, continue winding for the next twenty turns, make a second tap the same way and so on to the end of the coil, where the wire should be run through a hole, fastened on the inside of the coil with sealing wax and left with about a foot of loose wire free.

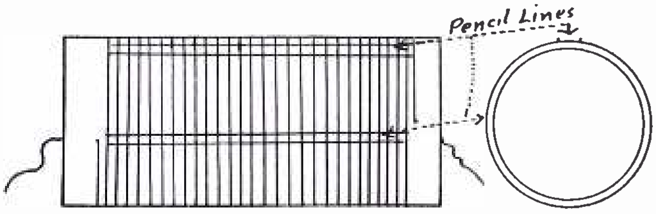


FIGURE 4

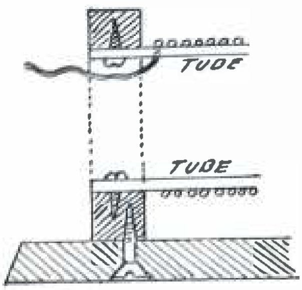
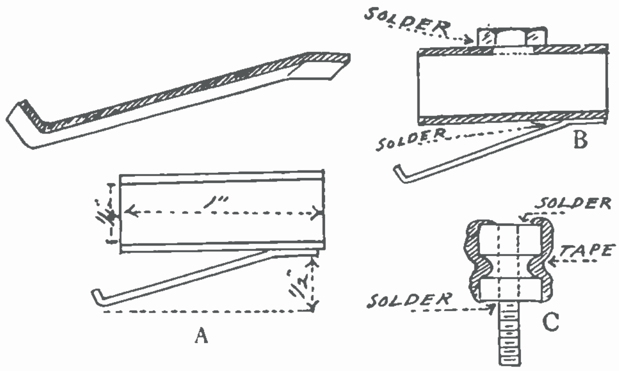


FIGURE 5



FIGURES 6, 6A, 6B AND 6C

The next step is to mount the coils. Use either Bakelite, fibre or well-seasoned white wood for this. If you have a jig-saw or a small keyhole saw, you can readily do everything yourself, but if not you can get some nearby carpenter or cabinet maker to cut the pieces for you. Assuming the large coil is 3 inches in diameter and 7 inches long, you will require a rectangular piece 5 by 15 inches for the base or panel; two pieces 4 by 4 inches for the primary or large coil support; two pieces 3 by 3 inches for the supports for the secondary or smaller coil and two circular pieces or discs just the right size to fit snugly into the smaller tube.

The two pieces 4 by 4 inches to support the primary coil should have circles or holes cut in each; the circles should be just large enough to admit the bare ends of the large coil. Have all these pieces of wood smoothed and sandpapered, bevel the edges of the square and rectangular pieces and give them a coat of stain and let them dry. Then sandpaper again, give another coat of stain and when dry give two coats of valspar varnish or shellac. While the stain or varnish is drying you can go on with the other parts of the loose-coupler. Along the large coil (if wound with insulated wire) mark two lines ¼-inch apart as shown in Figure 4, using a ruler to get them straight. Be sure that they are true and parallel with the axis of the coil. At 90 degrees from these, or at one side if the first lines are uppermost, draw two more lines parallel with the first. Then, with a red-hot iron, burn off the insulation along these two marks between the pencil marks, ¼-inch apart. If the wire is cotton covered you may overcome any tendency of the cotton to

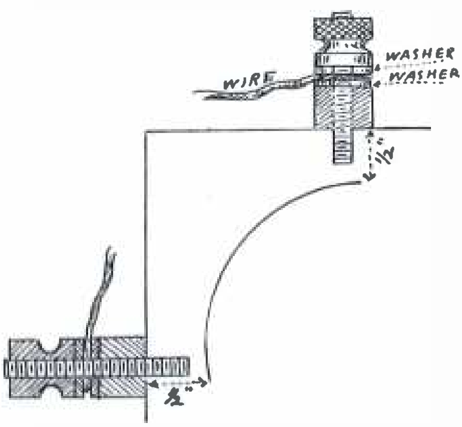


FIGURE 7

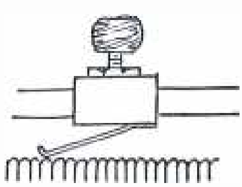


FIGURE 7A

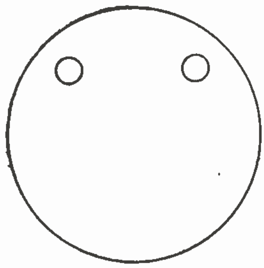


FIGURE 8A

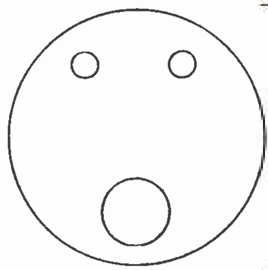


FIGURE 8B

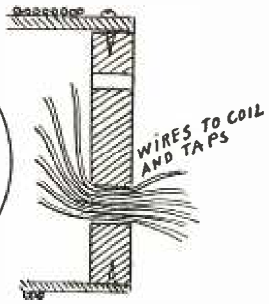


FIGURE 8C

burn irregularly from the lines by running a damp rag along the lines, or you may clean off the insulation with a sharp knife. However you do it, clean the wires until bright; if by any chance they bend or slip together, wind a string between the turns. If you have used bare wire, this burning off of the insulation will of course be unnecessary and for that reason I advise using bare wire and keeping the turns separated by twine, which may be removed after the coil is wound, although it does no harm if left there.

The coil may then be mounted by attaching it to the uprights by small screws driven through the bare end of the coil into one upright piece, as shown in Figure 5. This upright should be attached to the base, the coil fastened to it and the other upright slipped over the opposite end of the coil and fastened to the base but not to the coil. If holes are bored in the proper places through the base and into the upright before slipping it on the coil, there will be no trouble in securing it in position.

Next, cut two sections of the square brass tubing, each 1 inch in length and cut two strips of spring brass about ⅜ of an inch wide and 1/32-inch thick and bend in the form shown in Figure 6. Solder one end of each to each of the sections of square tubing as shown in Figure 6A. Bore a hole, a trifle more than ⅛-inch in diameter, through the opposite side of each section of brass tubing and over each solder a brass nut to fit the ⅛-inch brass screws. The easiest way to do this is to clamp the tube in a vise, fit a wooden pin through the nut, insert the end of the peg in the hole in the tube and while holding the nut in position solder it, as shown in Figure 6B. Then, cut the heads from two of the ⅛-inch brass screws, leaving about ¾ of an inch of the threaded shank, screw a thumb nut or knurled nut, such as you may obtain from an old dry battery, on the screw and solder it. Smooth off the solder and any projecting parts of the screw above the thumb nut with a file and wrap a little adhesive tape around the thumb-nut. (Figure 6C.)

Now slip a piece of the square brass rod through one of the sections of brass

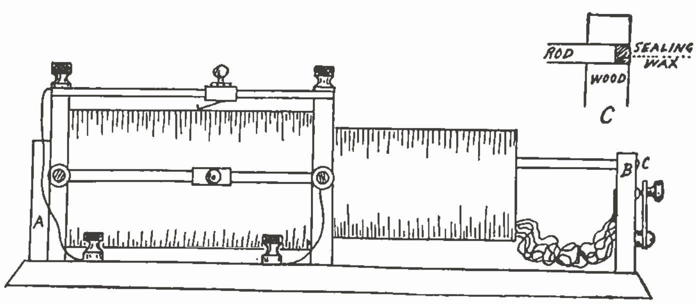


FIGURE 9 AND 9C

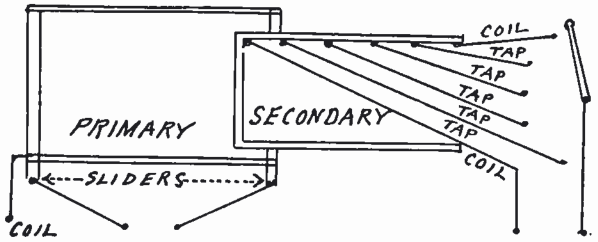


FIGURE 10

tube and lay the rod along the coil from one upright to another over the bared space on the coil wires (if they are insulated wires); when it is exactly parallel with the bared space (or with the coil if bare wire has been used), mark with a pencil where the rod comes on the uprights and cut the rod to the right length to come even with the outer edges of the uprights. Bore a 1/8-inch hole through each end of the rod, make a slightly smaller hole in the uprights under the holes in the rod, and screw one of the 1/8-inch screws into each of these. Clip off the heads of the screws, slip the rod over them, place a washer on each screw and secure the rod by means of a binding nut as shown in Figure 7, first placing a wire terminal under the washer on one screw. If you have done all this according to directions the spring on the under side of the slider should bear firmly against the wires on the coil. Then, by screwing the brass screw with the thumbnut soldered upon it (Figure 6C), into the nut soldered to the slider you can secure the slider in any position and can move it back and forth by means of the tape-covered nut as shown in Figure 7A.

The other slider should be mounted on its rod on the uprights in exactly the same manner, but over the other bared space of the coil (or, if bare wires are used, on one side of the support parallel with the axis of the coil.

The next step is to mount the secondary or inner coil. This is done by first securing the two circular pieces of wood in a vise or clamp and boring two holes 1/4-inch in diameter through both pieces a little above their center, as shown in Figure 8A. Bore another hole, large enough to admit all the tap wires and the two ends of the coil wires, through one of the wooden discs (Figure 8BC). Secure this disc in one end of the coil (first drawing the wires through the hole made for them), by small screws driven through the bare ends of the tube, as shown in Figure 8C. Then place the other disc in the other end of the tube and by sighting through the 1/4-inch holes align it with the first one. It may help you to do this if you draw pencil lines along the coil, parallel with the axis, from the two holes in the first disc; it is highly important to have the holes in the discs come in perfect alignment, as otherwise your coil will not move evenly and truly on its rods after it is assembled.

When the second disc is in the right position, secure it as you did the first by small screws. Then slip the 1/4-inch brass rods through the holes in the discs and wrap the coil smoothly with heavy paper, wrapping the paper on until the coil fits snugly inside the larger coil without forcing it. Rub some chalk or crayon on the ends of the rods that run through the small coil and while holding one of the 3 by 3 inch pieces of wood against the support to the large coil, press the two rods against it and turn them about until the chalk has marked spots where the rods touch. Then, clamp the two pieces of 3 by 3 inch wood together with edges even and bore 1/4-inch holes through both where the chalk marks show. Slip the pieces over the rods and secure them to the base. Fasten one at the end of the large coil and the other near the opposite end of the base (Figure 9AB). Remove the rods and the small coil. Remove the paper wrapping from the coil and holding the coil in front of the large coil, slip the rods through one upright, through the two end discs in the coil and through the other upright. Cut the rods so that they are not quite flush with the outer sides of their supports and secure them in place with sealing wax as shown in Figure 9C.

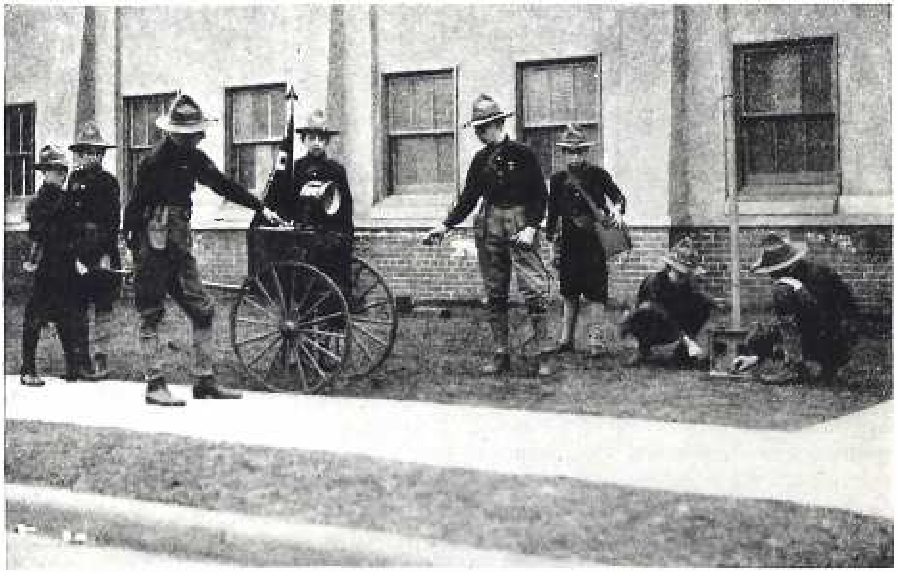
All that now remains to be done is to connect the various wires. Each of the tap wires and one of the end wires of the small coil should be carried to a separate contact on a multiple point switch which is best mounted on the upright as shown in Figures 9 and 10. If you prefer, you may place the switch on the end disc of the coil itself, but I have found this a bad plan, as in adjusting the switch you invariably move the coil somewhat.

The coil should move freely but not loosely. The other end of the coil wire should be led to a binding post; another wire should connect the switch arm to a second binding post and the free end of the wire from the large coil and the two wires from the slider rods should be led to other posts, all of which is shown in Figures 9 and 10.

Always remember to wind both coils in the same direction, to use flexible wire for the tap and coil leads on the secondary coil and be careful and accurate in your work.

Do *not* shellac the coils after winding and *never* use paint or enamel varnish about the coils or wires. Countersink all screw heads in the wood, leave no rough ends or jagged edges to metal or wood and try to make the finished coil a credit to your skill and to your workmanship.

¶ *The next article of this series will tell you how to make your own variable condenser at about half the cost of the ready-made devices which are on the market—but which are now so hard to find.*

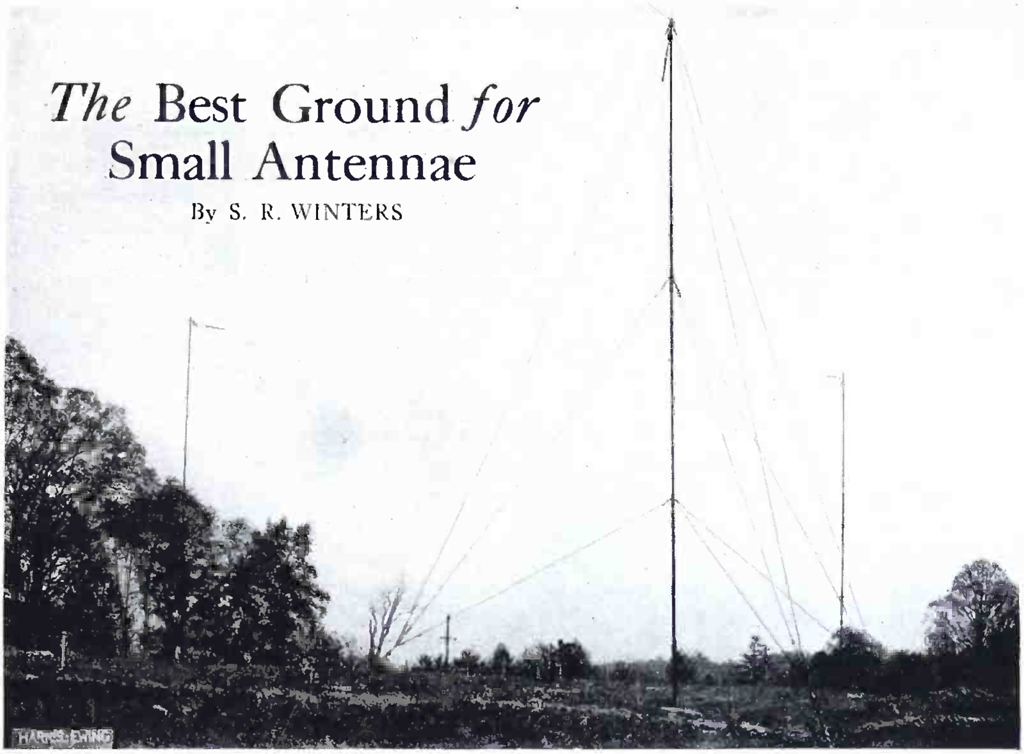


WHAT THE BOY SCOUTS ARE DOING WITH RADIO

More than any other discovery or invention of recent times, the radio has entered into the activities of the largest and one of the most valuable organizations of boys in the world. How these scouts are making themselves proficient in this art, and how they are learning to use the radio in practical ways, will be told in an article by Armstrong Perry—in a near issue of POPULAR RADIO.

The Best Ground *for* Small Antennae

By S. R. WINTERS



The lowest radiation resistance ever recorded in this country has just been attained by the use of a counterpoise ground system—a new development that makes extensive savings in electrical energy.

ON the theory that when a counterpoise is used with an antenna only low electrical resistances are possible, a series of experiments conducted by Dr. J. M. Miller of the Radio Research Laboratory, Bureau of Engineering, United States Navy Department, has abundantly justified the original conception. Measurements taken while the investigation was in progress revealed a surprisingly low minimum antenna resistance for a small antenna of 1.4 ohms, at 800 meters, and a ground and conductor opposition of only 0.7 ohms.

Novel experiments require unusual equipment. The experimental antenna was constructed near Connecticut Avenue in Washington, D. C., at a point where a slight rise in the elevation of the earth partly obscures from the view of passers-by, the physical equipment of the National Bureau of Standards, located on a commanding hilltop. Here on a vacant lot, with the nearest trees a hundred feet distant and an area unobstructed save by weeds struggling for existence, the masts of the radio installation tower skyward. These upright steel poles, fifty feet high, are three in number, and form a triangle, with a distance of a hundred feet to each side. The soil may be wealthy in humus for producing crops but is not at all favorable to the installation of equipment essential to transmission of wireless messages. Six inches below the surface of the ground, rock was struck, but the geological formation, fortunately, was pliable enough to yield to the blows of a pick.

The antenna was built in the shape of a triangle with radial wires attached at a center point, the wire was copper, No. 10, tautly drawn and insulated from the triangular-grouped masts by three 24-inch porcelain rod insulators. Originally each mast was insulated by three glass ball insulators placed under the foot and supported by nine guys, each of which was insulated near the ground by a porcelain egg insulator. The lead-in consists of a six-wire 12-inch cage of No. 16 wire. A buried ground system and a counterpoise were both investigated. The ground system embodies a circular trench, two feet deep and twenty feet in radius, circumventing the bottom of the lead-in circuit. Seventeen galvanized iron plates, two feet wide, were set on edge around the trench, overlapping each other by a margin of a few inches. One insulated wire is attached to each plate and retraces its course to the foot of the lead-in along the surface of the ground. A recent British publication favors a suspension of these wires above the earth, but experimenters in this country are not so positive as to the necessity of the English recommendation.

When the equipment was completed it was subjected to resistance measurements by the radio experts of the Radio Research Laboratory of the Navy Department, which is under the direction of Dr. L. W. Austin. During the first two or three days the electrical resistance of the ground conductor appeared to be declining; after four days a curve was plotted to show the exact ratio of the decreasing radiation resistance, a factor in the interest of efficiency. The antenna capacity was 700 micro-microfarads. The resistance curve indicated a ground and conductor resistance of approximately 2.5 ohms. Taking into account the unfavorable soil and the dimensions of the ground system, the results were pronounced extremely gratifying. The dielectric losses, however, proved excessive and further curtailment of this loss was sought. The masts and guy insulators were held responsible for a major portion of these losses.

Subsequently an antenna resistance curve was obtained with the upright poles and guys grounded. A substantial reduction of dielectric wastage was thus achieved. Measurements were then made on one of the mast and guy systems used as an antenna, and excessive dielectric loss was evident. At this juncture, modifications were made in the insulating equipment; porcelain insulators displaced glass under the masts and a notable reduction in dielectric losses was vouchsafed when the nine porcelain egg insulators in the guys were displaced by three 24-inch porcelain rod insulators. Porcelain rod insulators were also used in the counterpoise and as the capacity was small, low dielectric wastage was effected—a feat attributed to these rolling-pin like insulators.

As a second chapter of the investigations inquiring into the reasons for the existence of comparatively high electrical resistances of radio antenna and ground equipment, the Radio Research Laboratory of the Navy Department installed a counterpoise for use in measurements. The design was insulated from the supporting stakes by 30-inch porcelain rod insulators, the counterpoise having a radius of approximately 55 feet and a height above the ground of three feet. Its capacity to the ground was 2,100 micro-microfarads. The measurements is determining the resistance gave surprising results; the minimum opposition of the antenna was 1.4 ohms, at 800 meters wavelength, and only 2.1 ohms at 2,000 meters. The ground and conductor resistance was 0.7 ohms. Employing the circular ground system, previously described, the corresponding value for ground and conductor resistance was 2.5 ohms.

"Considering the fact that the circular ground had a radius of 20 feet as against 55 feet for the radius of the counterpoise" (to quote Dr. J. M. Miller, radio aide of the Bureau of Steam Engineering of the United States Navy Department), "it is believed that a ground system of the same radius would not be greatly inferior to the counterpoise electrically, and very much better from a practical standpoint. It is hoped that there will be an opportunity to try out the experiments on a larger scale. Everything favors proportionately low resistances as the size of the antenna and ground system is increased. The actual ground resistance should decrease nearly in proportion to the radius of the ground system. The resistance due to dielectric loss should also decrease rapidly as the capacity of the antenna increases."

Low electrical resistance in the functioning of shore-station antenna — the primary object of this investigation—is in the interest of increased efficiency in the radiation of electro-magnetic waves. At present power is supplied the antenna and a portion of the power is usefully consumed in the radiation of waves. The remainder of the power, however, is needlessly squandered in ground and dielectric resistances. The lower these useless losses are reduced the more efficient the antenna becomes. Then, too, when the radiation resistance is at a minimum it requires less current for an antenna of specified resistance to obtain a given efficiency. High-powered radio stations realize the importance of a reduction of electrical resistance. On board ships, the problem is that of a curtailment of dielectric losses rather than a search for efficient ground connections. The latter condition is ever present on seafaring vessels. There are three different resistance components in the functioning of an antenna; the true radiation resistance is the only useful one. The other two—ground resistance and dielectric losses—are useless. Efficiency demands that they be reduced to as low a value as possible.

The results of the experiments described conclude that if the current flow in the ground is not restricted a low resistance is effected. A counterpoise covers a comparatively wide area, has a high electrical capacity to ground, and there is no concentration of current; hence the resistance is low.

Another conclusion deduced by this investigation is that in the present ground systems much of the conductor planted in the soil is useless. There is a tendency for the current to flow off the ground wires through the soil. The ground connections employed in this experimental equipment hearkens back to a system originated by Capt. Round called the "round" ground. The metal plates are set on edge in a circle in the soil around the foot of the lead-in. The insulated conductors from the circular ground are brought out above the surface of the earth, and are joined together at the foot of the lead-in. The area is effectively used—the current flow over each square

The wires that radiate from the common center connection under the table form one plate of a large air condenser; the ground is the other plate.

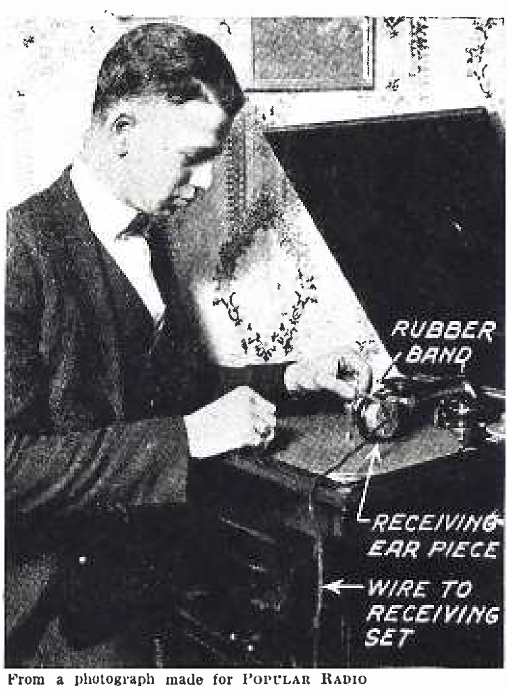
foot being about the same as every foot of buried conductor. To avoid dielectric losses the antenna was established at a considerable distance from trees and buildings. Insulators were used in both antenna and counterpoise. The symmetrical antenna with the ground system is most effectual for use with the "round" ground.

How well this experimental antenna has lent itself to the reduction of resistance—the remarkable accomplishment of 1.4 ohms at 800 meters wavelength with a small antenna—may be illustrated by the following comparisons: an extreme example is that of the portable military antenna, that has a resistance as high as 120 ohms. The average small good antenna has a resistance ranging from 6 to 8 ohms. Only the enormous high-power stations have succeeded in curtailing opposition to a minimum of 1 or 2 ohms.

How to Use Your Phonograph As a Loud Speaker

By FRED WOODWARD

AFTER one has been operating for a time a radiophone receiver equipped only with telephone receivers, one is overcome with the desire to possess a loud-speaking horn in order that he may entertain more people at one time with the music he receives from the broadcasting stations. Here is a way to hook up your radiophone to your phonograph and save yourself the expense of purchasing an amplifying horn:



From a photograph made for POPULAR RADIO

Take the reproducer off the tone-arm of the gramophone. In most talking machines this may be easily done by the removal of one small screw. This leaves two small holes at the end of the tone-arm. Then place the receiving ear piece over each of the holes at the end of the tone-arm, and fasten them in place with a stout rubber band.

Then throw on the aerial switch and tune-in for whatever you wish to receive—music, news or signals. You will be surprised with the result. The gramophone cabinet, as you know, is the sound-box of the machine. When you have hitched up the telephone receivers of your radiophone to the tone arm of the gramophone you will discover that the box does for the radiophone exactly what it does for the gramophone record and reproducer: it amplifies, or magnifies, every sound that it receives.

If your radiophone is in anything like working order the music will be easily heard all over the room. It will allow you to have your friends listen to incoming signals without the necessity of getting additional apparatus. It will amplify radiophone music to such a degree that it may even be used for dancing.

This trick cannot be done with a crystal receiving set. It is necessary to have at least a one or two-step audio frequency amplifier.

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.

The questions that are not of sufficient general interest to warrant publication in this department will be answered personally. Many ot these questions are being answered by referring the correspondents to items that have already been printed in these pages. To get the full benefit of this service, therefore, *save your copies of* Popular Radio.

Question: I would like to put up a radio set of my own, but there are no poles or trees near my home. Can I put up the antenna from the fire escape to the other window? The length of the antenna would then be about 15 feet. Would I then be able to hear distinctly? Is lead-in wire the same as copper wire No. 14 insulated or bare?

L. A. W.

Answer: The antenna you suggest would be far too short. You should have at least one wire 100 feet long for the best results. You will hear signals weakly at best with the 15 foot antenna. The lead-in wire may be No. 14 copper either insulated or bare. If bare wire is used for the lead-in, it should be mounted on insulators.

* * *

Question: Will you tell me how to eliminate the noise in a 2-step audio frequency amplifier that works all right otherwise? I am using the hook-up advised by the makers of Radiotron tubes and am using these tubes throughout, with a Radio Corporation transformer in the first step and a Federal transformer in the second step. Common 45-volt "B" battery is used for detector and amplifier with suitable taps. All wiring is bus bar type, soldered and insulated, with minimum parallelism. Transformers are placed between the tubes. Will a storage "B" battery eliminate the trouble? I am using a second Edison 6-volt storage battery for the "A" battery. Please give me a detailed hook-up to show all the apparatus necessary for one or more steps of radio frequency amplification.

W. R. Partington

Answer: One suggestion that may help is to ground the cores of the amplifying transformers. Another precaution against noises is to ground the negative terminal of the "B" battery. If the cells of the "B" battery get old they sometimes make "frying" noises. I recommend that you try the hook-up given in our June issue in this department. The storage "B" battery will not eliminate the noises unless your present "B" battery is the cause of the trouble, which could then be remedied just as well by replacement with new "B" batteries. In reply to your last request I am glad to refer you to an excellent article on radio frequency amplification to be published in a near issue of this magazine.

* * *

QUESTION: Will you send me a diagram for making up a set for receiving up to 1,500 meters? What would be the cost of such a set?

HANS J. POLL

ANSWER: In the May issue of this magazine (page 59) is given a hookup suitable for the purpose you desire. You should substitute for the three coils there given the three following coils which will give you the wavelengths you desire: Primary L-150, Secondary L-200, Tickler L-250.

* * *

QUESTION: I want to get a hook-up of a circuit for using crystal and audion detectors by merely throwing the switch. Can you give me one?

S. V. FINLY

ANSWER: You do not say whether you want to use this hookup with a single circuit tuner or a double circuit tuner. However, here is a circuit for a double circuit tuner, (Fig. 1) as this is the most efficient for tuning purposes. A single pole, double throw switch, will be required as shown connected in the diagram. To use the audion throw the switch to "A" and turn on the filament. To use the crystal detector throw the switch to "D" and turn off the filament of the audion and adjust the fine wire on the crystal detector.

QUESTION: My receiving set works all right, while I am sitting absolutely still, but if I so much as turn my head or move my arm or lean forward or backward, I hear crackling noises that nearly break my ear drums. I am using a Paragon receiver and two stage amplifier with Baldwin fones. Aside from this peculiarity the set works well and I listen to Pittsburgh, Schenectady, Detroit, and a number of other long distance broadcasting stations. Can you offer any suggestions for a remedy?

GEO. B. HILL

ANSWER: The symptoms you have given indicate that the telephone cords are worn through and when you move your body the cords also move and the fine stranded wires make and break the connection, thus causing the series of clicks and crackling noises that bother you so much. Purchase a new set of telephone cords and replace the old ones on the headset and your troubles will be ended.

* * *

QUESTION: Please tell me what a good audion set will cost that will receive over a distance of 200 miles?

A. W. ROSE

ANSWER: This set should include a detector and two-stage amplifier of the vacuum tube type. It will cost slightly over $200.00 complete.

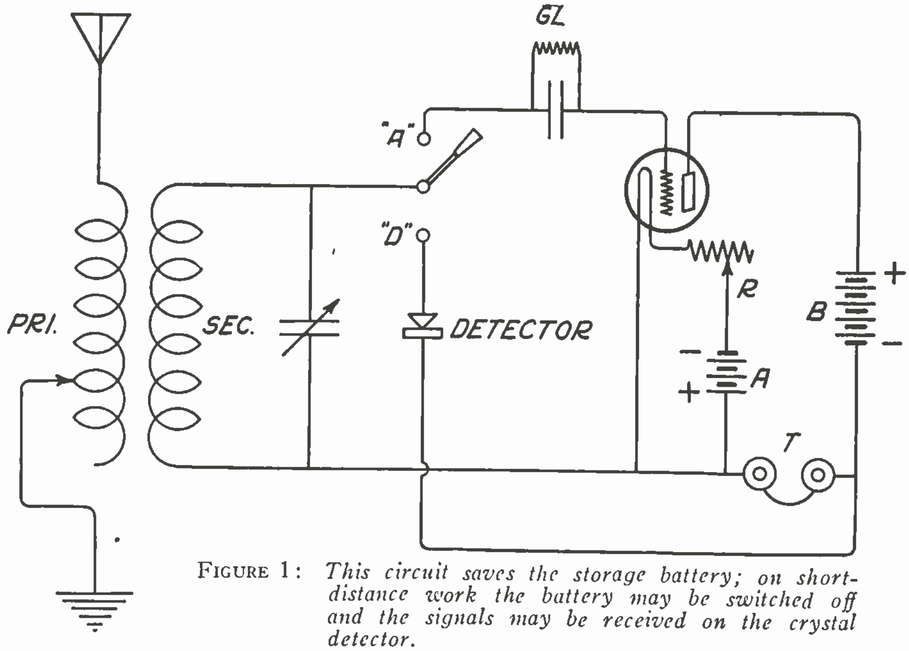


FIGURE 1: *This circuit saves the storage battery; on short-distance work the battery may be switched off and the signals may be received on the crystal detector.*

QUESTION: How far can I receive on a crystal detector and a slide coil? I have just put up a one wire aerial 150 feet long and 35 feet high. The aerial has a little slant; does that matter?

ALBERT MUNN

ANSWER: A slight slant will change the electrical characteristics of the antenna a little, but it will not interfere with the strength of your signals. You should be able to receive up to a distance of twenty-five miles from the broadcasting stations.

* * *

QUESTION: A friend of mine who lives in the apartment below mine has become so interested in my receiving set that he has asked me to get him the necessary apparatus and help him to rig it up. I agreed to do so. Will I have to put up another aerial, or can we both use the same one?

A. PAGE

ANSWER: You will not get good results on either set if you connect both sets on to the same antenna. One set would absorb most of the energy and the other would get little, in accordance with the wavelengths that both sets may be tuned to. If both sets were to be tuned to exactly the same wavelength they would divide the current between them but signals of only half strength would be received by both. Use separate antennæ.

* * *

QUESTION: Is there any way to keep a crystal detector set in adjustment? I have trouble when I try to get it set because when there are no signals coming in I do not know whether it is in adjustment or not.

ANSWER: You should build a buzzer test

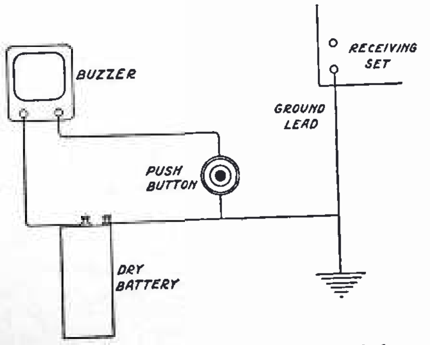


FIGURE 2: *A buzzer test for a crystal detector.*

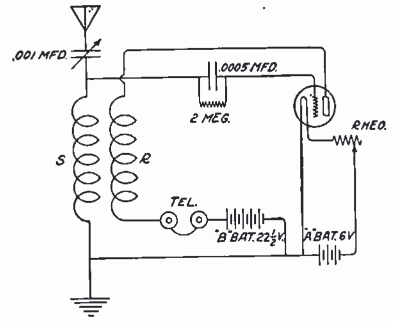


FIGURE 3: *A Hook-up for a single circuit regenerative receiver.*

for this purpose. The instruments you will need for this are the following:

1. A buzzer such as is used for code practice.
2. A dry battery.
3. A push button switch.
4. A few feet of wire.

Connect these up, as shown in Figure 2, with one wire running over and connected to the ground lead of your receiving set. When you want to adjust the detector, press the button and adjust the contact on the detector until the sound of the buzzer is heard loudest in the telephones; then the detector will be in adjustment and you can tune around with the tuning instruments; if there are any stations transmitting at the time you will hear them. The buzzer acts as a miniature transmitting set.

* * *

QUESTION: Will you give me a hook-up for a single circuit regenerative receiver that employs an audion detector?

W. S. MITCHELL

ANSWER: The circuit described uses a variometer in which the stator has been disconnected from the rotor and the rotor placed in the plate circuit. A .001 mfd. condenser in series with the stator comprise the tuning elements. All tuning is done by revolving the variable condenser knob. The regeneration is accomplished by revolving the rotor of the variometer. (See Figure 3.)

* * *

QUESTION: What is the best kind of wire to use for an antenna?

D. W. JACKSON

ANSWER: The most efficient wire to use for an antenna is a copper wire with an enamel coating. The high frequency radio currents induced in an antenna travel on the surface of the wire. Ordinary copper wire oxidizes when strung up out in the weather, and the oxidization offers resistance to these currents. The enamel coating prevents the wire from becoming oxidized.

QUESTION: Where can I get a wireless directory that gives all the calls of wireless stations, amateur, Government and commercial, which do transmitting in the United States. B. W. WHEELER

ANSWER: Send 15 cents to the Government Printing Office and ask for a copy of the yearly "Amateur Radio Stations of the U. S."

* * *

QUESTION: What is a loading coil used for? Will it help me to receive from greater distances than I now can get?

E. B. GINN

ANSWER: A loading coil is used in series with a radio circuit to increase the wavelength range of the set. It will not, however, increase the distance range from which you can receive.

* * *

QUESTION: I am using a well-known type of regenerative receiving set, but it howls and squeaks most distractingly. Is the set poorly designed or do you think that there is some connection loose?

L. J. H.

ANSWER: Most of the receivers on the market are of fairly good design and workmanship, and the trouble probably may be found in the way you tune it. You probably use too much regeneration while tuning; this causes a howling that may cover the whole scale of sounds from a shrill whistle to a low grunt. While tuning in a station, place the dial which controls the regeneration at zero; when you have the signals tuned in, slowly increase the regeneration until the signals are made strong enough without being distorted.

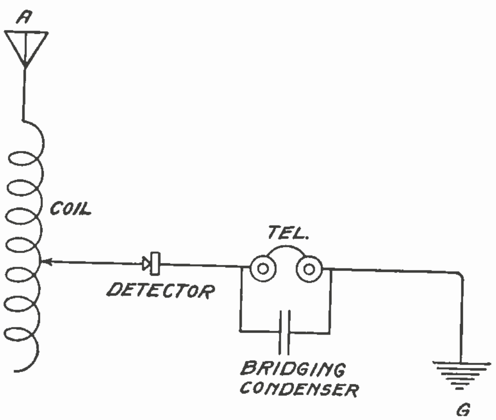


FIGURE 4: *A simple circuit for a crystal detector.*

QUESTION: I want to build a simple crystal receiver. The simplest circuit you could give me would be the best, as this will be my first attempt at building a set.

JOS. KENYON

ANSWER: The circuit shown in Figure 4 provides for a single slide tuning coil, a crystal detector, a small fixed bridging condenser, and a pair of receiving telephones. By adjusting the detector and moving the slider on the coil, different wavelength signals can be picked up. The range of this set is about 20 miles.

* * *

QUESTION: What is the best detector to use in a radio receiver?

WM. HANSEN

ANSWER: The vacuum tube or audion is by far the most efficient. The crystal detector is cheaper and simpler to operate, but it will not detect distant messages or bring in signals as loud as the audion.

* * *

QUESTION: What is the correct length of antenna to use in order to receive the radio broadcasting on 360 meters? My antenna is only 40 feet above the ground.

F. G. ORNEROD

ANSWER: You should make your one wire antenna about 100 to 150 feet in length. Use as short a lead-in as possible.

* * *

QUESTION: I have a quantity of fixture wire which I can strip of its rubber and braided covering, if it would be of any use. Will this wire be suitable or not? I do not want to do all this work only to find out that the wire is no good for such a purpose.

H. BARNES

ANSWER: You may use the wire but you do not have to strip it of its insulated covering as it will work just as well with it as without it. The insulation does not affect the antenna in the least as far as functioning efficiently is concerned.

* * *

QUESTION: What is the difference between a variable condenser and a variom eter?

L. L. ROMERSHEUSER

ANSWER: A variable condenser is an electrical instrument for controlling the amount of capacity in a circuit. A variometer is an electrical instrument for controlling the amount of inductance in a circuit.

ITEMS *of general interest that you ought to know; bits of information of practical usefulness to every radio amateur.*

There Are Now 253 Broadcasting Stations

FIGURES obtained from the Department of Commerce show that there are 253 broadcasting stations now licensed and in operation. Most of these stations are concentrated either north of the Mason-Dixon line and west of the Mississippi or on the Pacific Coast. There are practically no stations as yet in that part of the west that lies just east of the Rockies. The installation of stations has only just begun in the South.

John Bull Begins to Take an Interest in Radio

PLANS are at last being made over in England to develop radio on a large scale—but along different lines from the recent expansion in America. Up to this time the Post Office Department has made the use of radio apparatus by private persons almost impossible, owing to the licensing system which applied both to receiving sets and to sending apparatus.

Now, however, steps are being taken to change this policy and to permit the extension of radio telephony.

As soon as restrictions are removed it is understood that the Marconi Company will establish a large transmitting station, and that receiving apparatus will be hired out at a charge which will probably not be more than that of the ordinary telephone installation. It is reported that the Marconi concern is ready to make innumerable fool-proof instruments that will be rented out.

English newspapers are only just beginning to explain to their readers the general features of radio telephony.

Radio Messages Received While the Operator Is Absent

A RADIO relay recorder that receives and copies messages without the use of a trained radio operator, operates mechanism automatically in accordance with the signal received and acts as an automatic call system has been perfected by F. W. Dunmore of the radio laboratory of the Bureau of Standards. It is sensitive enough to convert accurately feeble radio signals into records, yet will operate in a vibrating airplane.

"The practical operation of relays actuated by received radio signals is a comparatively recent development, and has been made possible by the development of the electron tube amplifier," says Mr. Dunmore. "The relay recorder is designed to operate from the output terminals of a radio receiving set; it may also be operated by any other source of audio-frequency signal. By the use of special electron tube circuits the audio-frequency signal is caused to operate an ordinary telegraph relay. In order to avoid the necessity for using a sensitive relay, designed to operate on currents of a milli-

Underwood & Underwood

THE STATE CONSTABULARY IS EXPERIMENTING WITH RADIO

Every evening at about 8.50 o'clock the Boston police reports are broadcasted from the station at Medford, Mass. This picture shows how these reports are checked at headquarters of Troop A of the Massachusetts State Constabulary forces at Framingham. Experiments are being made there with radio equipment on motorcycles.

ampere or less (which would have delicate adjustments and light contacts and spring tension), advantage was taken of a vacuum tube to increase the input voltage to the relay circuit, thus making possible the use of a simple ordinary high-resistance telegraph relay. The relay device has therefore been developed to operate from the output circuit of any suitable amplifier in place of the ordinary phones."

The operation of the relay may serve to work a sounder, buzzer, tape register or any mechanism for remote control by radio. By the use of two of these relay recorders connected in series, two messages sent on practically the same wavelength but of different audio-frequencies are caught at the same time and recorded in the operator's absence.

Broadcasting Stations Must Not Interfere With Each Other

"Broadcasting stations should shut off transmitters when they are not in actual operation in order to prevent unnecessary interference from carrier wave," says an official warning from the Bureau of Navigation of the Department of Commerce.

Sending stations are also asked not to interfere with the schedules of other stations; transmitters must be adjusted so as not to produce unnecessary interference. The Bureau has found that some broadcasting stations have interfered over a band from 200 to 500 meters, which hereafter may be reported as a violation of the law, with the subsequent imposition of a penalty.

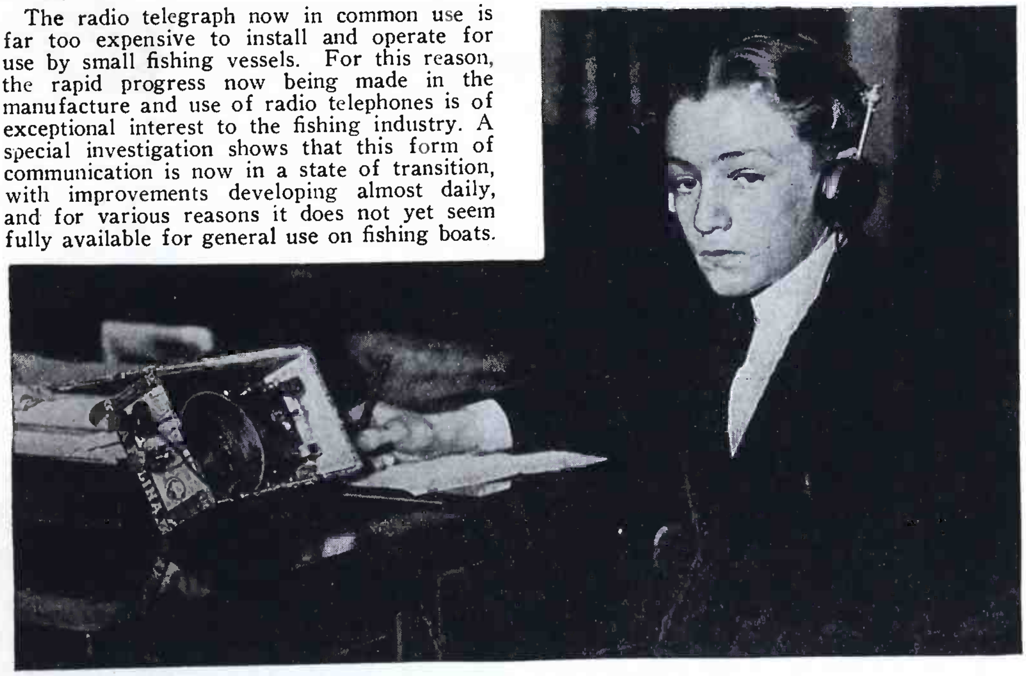
The Radiophone to Replace Carrier Pigeons

ONE of the impending applications of the radiophone is in the tuna fishing industry, which has been employing carrier pigeons in keeping the boats of the fishing fleet in occasional and uncertain communication with the canneries on the Pacific coast. The fishing vessels set forth on their tuna hunting expeditions early in the season in the waters near Coronado Islands, off San Diego, as the schools of tuna move northward the boats follow. While the fishermen keep more or less in touch with the home ports through the craft which carry back the catches, they have depended largely upon birds, which at best constituted a one-way service. The *Pacific Fisherman* thus points out the possible uses of the radio in developing the tuna fishing industry:

The radio telegraph now in common use is far too expensive to install and operate for use by small fishing vessels. For this reason, the rapid progress now being made in the manufacture and use of radio telephones is of exceptional interest to the fishing industry. A special investigation shows that this form of communication is now in a state of transition, with improvements developing almost daily, and for various reasons it does not yet seem fully available for general use on fishing boats. In certain cases, however, it might be exceedingly useful, even at the present stage. The transmission of messages is still a complicated matter, requiring the services of an expert; but receiving instruments are available at very reasonable prices, and are easily used, and the broadcasting service is expanding daily. For sending instructions from a central station to cannery tenders and trap watchmen, this equipment might be found of great value; and a few broadcasting stations in Alaska, sending out market quotations on halibut and salmon, in addition to the usual news and entertainment features, should be an exceedingly popular feature with the fishermen.

Is There to Be no Escape from the Collection Plate?

EVEN the passing of the collection plate has become a reality in the church service conducted by radio. So many listeners enjoyed a recent sermon broadcasted from the WJZ station by the Rev. Edgar S. Wiers, pastor of a church in Montclair, N. J., that they sent in by mail their money for the heathen.



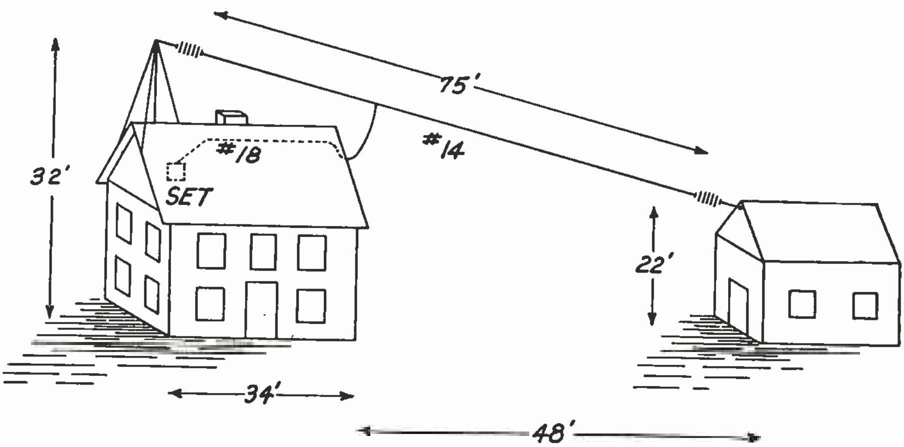
International

MUSIC FROM AN OLD CIGAR BOX

Make a wireless set for receiving with only a cigar box, parts of an old typewriter, a piece of an oatmeal box, a few clips off Christmas tree candle holders, and a piece of galena? That is exactly what Herbert Parish, sixteen years old, constructed in less than a half hour, in order to hear the broadcasting of music by radio. The set is said to work satisfactorily over short distances. Any ingenious lad who is handy with tools can do the same.

A Home-Made Radio Set That Received 300 Miles

The remarkable accomplishment of the crystal receiver described in the May issue of this magazine. The ordinary range of such an equipment is only twenty-five miles. The figure below shows the installation.



THAT the home-made crystal receiving set as evolved by the Bureau of Standards and described in detail in the May issue of POPULAR RADIO is a thoroughly practical instrument has been demonstrated by the letters which have come to the Editor. Here, for example, is what J. O. Hodge, of Washington, D. C., heard on the small set which he built himself out of material that cost him about $11.00:

Radio concerts in Schenectady, three hundred miles away, have been heard plainly on the crystal receiving set in Washington, D. C., and the Pittsburgh broadcasting program, coming from over the Alleghany Mountains, has been picked up and followed without difficulty. The set was the simple arrangement recently designed and described by the Bureau of Standards. The crystal and head-set, which was the metal diaphram type, were purchased in an ordinary supply store.

Similar results can be attained by anyone under favorable conditions. Indeed, this performance should be duplicated wherever there is a good open space for erecting an antenna. In this case the aerial consisted of a single No. 14 wire 75 feet long, 31 feet high at one end and 22 feet high at the other; it was strung between two frame houses in a neighborhood that was free from steel structures and metal framing of any sort, as shown in Figure 1. The set was mounted in a room on the upper floor below the high end of the aerial, but the connection was made by a No. 18 bell wire which ran along the ceiling of the rooms of the upper floor and was connected to the aerial after it had passed over the house about a third of the distance from the high end.

Fading was, of course, noted; that is, the strength of the signals sometimes increased and decreased for periods of 10 or 20 seconds, depending upon atmospheric conditions; this will be the case with any receiving set. Now and then the signal disappeared altogether for a few seconds. However, this was not serious, as whole concert numbers lasting five minutes or so were often received clearly and without interruptions.

C. A. Briggs.

An Electron Tube Radio Receiver Without a Storage Battery

A RADIO receiving apparatus that uses ordinary electron tubes for amplification but which does not require a storage battery has been developed by the radio experts of the Bureau of Standards.

The current to light the filaments of the electron tubes is obtained from an ordinary electric lamp socket instead of from the storage battery which the experts characterize as "a drawback to the general use of radio sets and the most expensive portion of the equipment for the person who wishes to make his own set."

How to use the electric light wires themselves as an antenna and thus eliminate entirely the need of erecting an antenna has also been worked out by the government radio engineeers in connection with this new set, although the signals are likely to come in with less

© Ewing Galloway

A SET THAT RECEIVED HALFWAY AROUND THE EARTH

That the radio equipment on the ocean lines "Vauban" is one of the best adjusted on the high seas was recently demonstrated when Chief Wireless Operator F. W. Walsh picked up a message from the Philippines while the vessel was on its way from Buenos Aires to New York—a distance of 11,500 miles.

Kadel & Herbert

WHERE THE RADIO FAN MEETS THE BASEBALL FAN

A New York boy recently entertained the younger element in his neighborhood by bringing his receiving set down on the street below his apartment and posting the scores of the games as they were announced by radio. In between times his audience were entertained by music from the loud speaker.

strength when this is done. The new design of receiving set can be used, however, with any type of antenna.

"The new receiving set consists essentially of an amplifier with minor auxiliary parts," the experts explain. "The amplifier utilizes 60-cycle current supply for both filaments and plates of the electron tubes. 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 which offers serious interference. This has been practically eliminated by balancing resistances, grid condensers and special grid leaks of comparatively low resistance, a telephone transformer in the output circuit, and a crystal detector, instead of electron tube detector. In the final form of the amplifier, there is only a slight residual hum which is not objectionable. The amplification obtained with A. C. supply was as good as that obtained with the same amplifier used with D. C. supply. The complete unit is light, compact and portable. For the reception of damped waves, the amplifier as constructed operated 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, it is expected that the amplifier will be effective for the reception of damped waves and undamped waves as long as 10,000 meters. For the reception of undamped waves, a separate heterodyne should be employed."

JIMMY—"You take this wireless receiver I just finished makin', and go downstairs in the cellar; hold it close to your ear and listen."

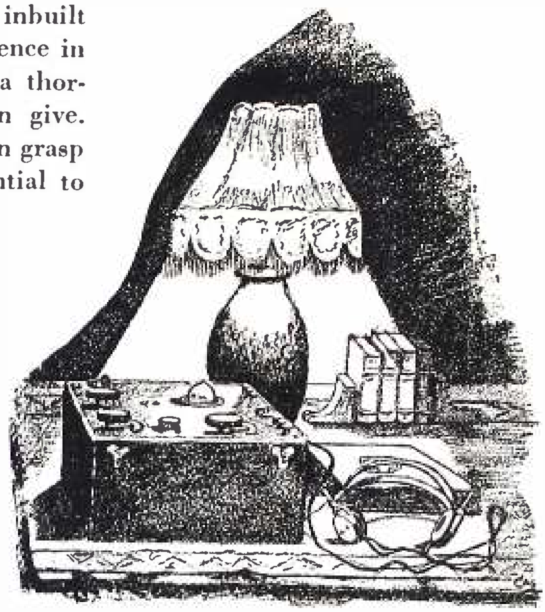
FREDDY—(*After waiting in suspense for several moments in the cellar*), "Aw—it's a fake, I didn't hear a thing."

JIMMY—"Good! That shows it's workin' right. I didn't say anything yet."

DE FOREST Dependability is an inbuilt quality that only years of experience in the building of radio apparatus and a thorough knowledge of radio science can give. It is not a tangible element that one can grasp or point out, yet its presence is essential to satisfactory performance.

To those who are looking for satisfactory performance, De Forest Radiophones also present technically correct design, handsome appearance and unequalled efficiency.

The Everyman Receiver is for 30 mile reception; the Radio-home Receiver is a vacuum tube set efficient up to 100 miles; for use with either of these sets there is the "DT-800" Two-Stage Amplifier. MR-6 Receiver includes an unsurpassed tuner, tube detector and two-stages of amplification. Ask your friends who use them.



De Forest Radiophones

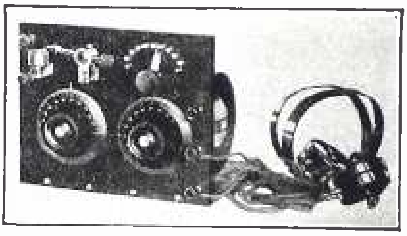
"The Standard of Dependability"

DUCK'S NEW CATALOG No. 16 *256 Pages. A Catalog De luxe*

"Over fifty pages of the latest hook-ups [wiring diagrams], and invaluable and up-to-date data and information on radio, including important instructions for building antenna."

Type CV Crystal Receiving Set $20.50

Beyond doubt the most advanced type of crystal set on the market for the clear and efficient reception of radio speech and music and telephone reception. Wave length range 700



meters. Headset Extra. Murdock. We caution the public unfamiliar with radio to be careful about the cheap, inefficient and poorly constructed crystal sets that are beginning to flood the market. We are the oldest dealers in America selling complete everything in radio. Established 1908. In tests with this set the radio telephone station at Detroit (60 miles distant) was heard in Toledo with the greatest clearness and sweetness. Ideal set for persons residing within range of powerful radio stations in New York City, Springfield, Mass., Pittsburgh, Chicago and Detroit, where wonderful concerts are broadcasted every evening.

Our exclusive feature is the extra binding post for connection to our No. B 212 Detector Panel and B 214 2-step amplifier Panel, same height as panel on receiver. With this combination we have clearly heard radio concerts from all stations 500 miles from Toledo.

"Send 25c in coin carefully wrapped, for your copy of this wonderful book, the most unusual and complete catalog ever put between the pages of two covers. Not sent otherwise. It is not only a catalog, but a wonderful textbook on radio. Enormous cost and tremendous demand prevents further distribution at a less retainer."

Never in the history of radio has there been such a catalog.

The radio data and diagrams embracing upwards of fifty pages gives the experimenter more valuable and up-to-date information than will be found in many textbooks selling for $2.00, and $1.00 could be spent for a dozen different radio catalogs before you could gather together the comprehensive listing of worth while radio goods found in this great catalog.

A brief summary of the radio goods listed in this catalog:

The entire radio catalog of the Radio Corporation, with a wealth of scientific and technical data on C.W. transmitting sets, and all the diagrams for the assembling of these sets; the complete Remler line, which embraces 25 pages; the Westinghouse, Colin Kennedy, Murdock, Federal, DeForest, Western Electric, Brandes, Connecticut Company, Thordarson, Turney, Magnavox Company lines; the best products of Adams-Morgan, Signal and countless other manufacturers, including our own complete line of radio apparatus, and many individual items and parts used in radio work today.

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We want live, responsible dealers in every city and town in the United States, both for the sale of our extensive line of radio apparatus and all other worth while lines of radio goods, on all of which we can quote attractive dealers' discounts. We can offer you facilities and advantages that no other radio house can offer.

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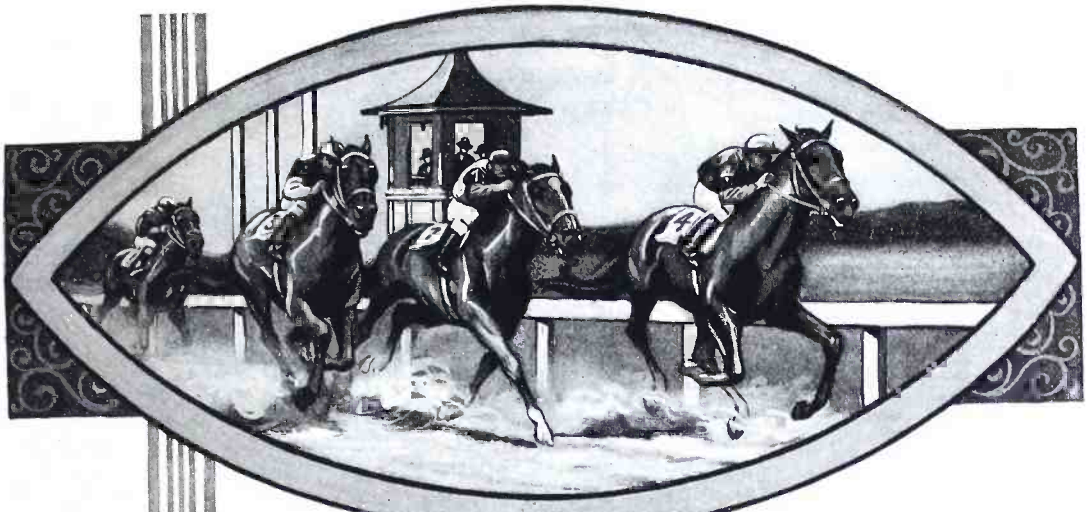

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MGG
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OFF the beaten path and on the trail to a worth-while goal, "Thoroughbred Apparatus" has been constantly winning new friends and has hung up some enviable records as a quality leader in radio apparatus.

Our goal is *unwavering superiority,* and we intend to come under the wire *with* "Thoroughbred Apparatus" in the lead of the radio field.

On June 1st we moved into our new factory. Now, with greatly increased facilities, we are prepared to handle your orders as they come. Write for our interesting offer to reliable dealers.

"Thoroughbred Apparatus" consists of: Moulded Variometers, Vario-couplers, "Read 'em" Binding Posts, 17 styles, Amplifier Panels, Detector Panels, Variable Condensers, Fixed Condensers, Binding Posts, Contact Points and Stop Pins, Switch Levers, Dials, Single Sockets, Rheostats, Crystal Detectors.

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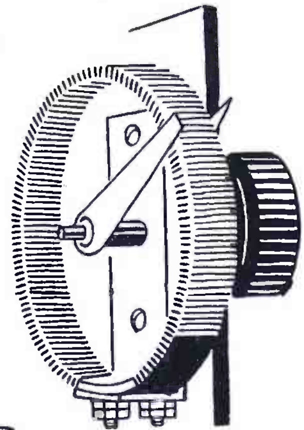
Thoroughbred Apparatus

RADIO **CROSLEY** PARTS

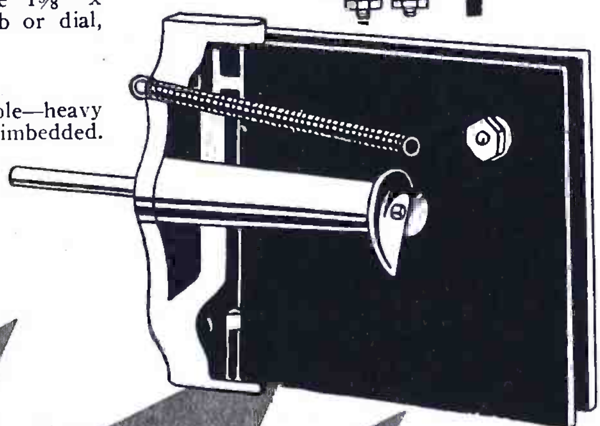
MANUFACTURING CO., CINCINNATI, O.

Improved Radio Units of proven efficiency and moderate price



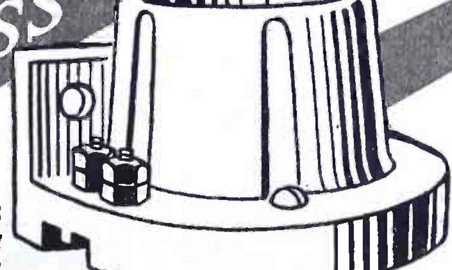
Crosley Rheostats complete with knob, pointers, etc. Constructed for mounting on panels up to 3/8" in thickness—wound with non-corrosive resistance wire. 7 ohms resistance. Carries 1 ampere without heating. Suitable for detector and amplifier tubes. Price 60c.

Crosley Model "B" Variable Condenser is proving to be a much more efficient condenser than the plate type. Having no appreciable body or hand capacity it is easier to tune in C.W. and I.C.W. than with any other type. 0005 M.F. capacity. Size 1 3/8" x 3 3/8" x 3 1/2". Price without knob or dial, $1.75.



Crosley V-T Socket
For all radio purposes, unbreakable—heavy porcelain. Bayonet catch deeply imbedded. Soldering irons will not melt. Base and panel mounting—an exclusive Crosley feature. Retail price, 60c.

"Better costs less"



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Illustrates and describes full Crosley line of Radio Receiving Apparatus and Radio Parts

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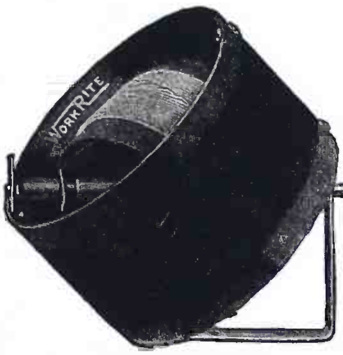

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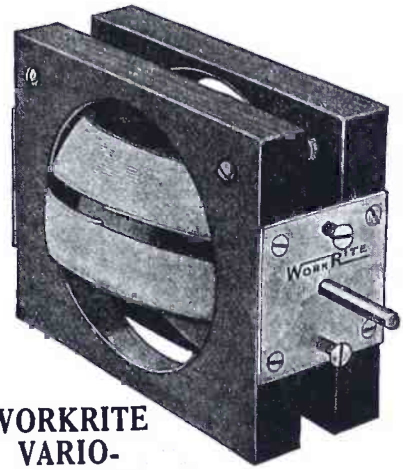

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WORKRITE
VARIO-
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One WorkRite Varicoupler and two WorkRite Variometers are guaranteed to give you a tuner that cannot be excelled by anything on the market.

NEW PRICES

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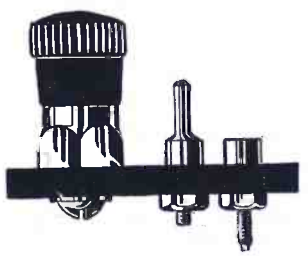
WorkRite Variometer $5.25

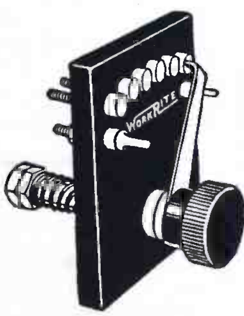


WorkRite Binding Posts, 12c

WorkRite Switch Points, 4c

WorkRite Switch Stops, 6c

WorkRite Switch Arm with Bushing, 50c



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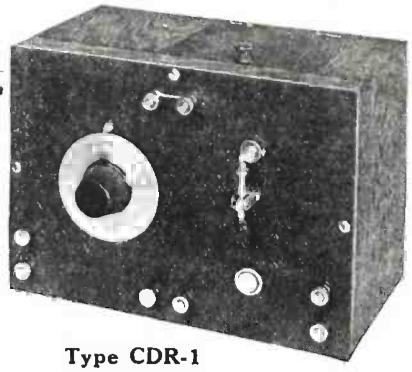

Type CDR-1

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The Man-Day Radio

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GREAT advances have been made in radio in the last few months, but none more important or impressive than the Man-Day. The big advance step in the Man-Day is its circuit—a circuit which is responsible for the sensitiveness and sharpness of this receiving set.

Type CDR-1 is a complete Man-Day Radio outfit, *guaranteed to receive clearly 35 miles from the larger broadcasting stations.*

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Type TRB-1 is a tube receiver efficient as the CDR-1, but requires only the turning up of the tube for reception. Price $38.00.

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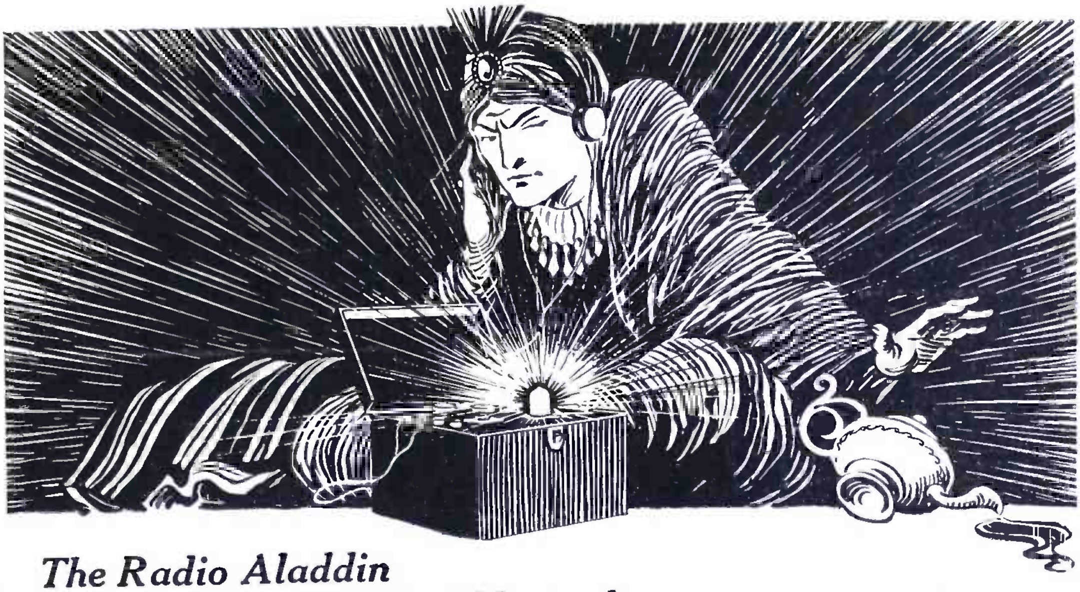

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