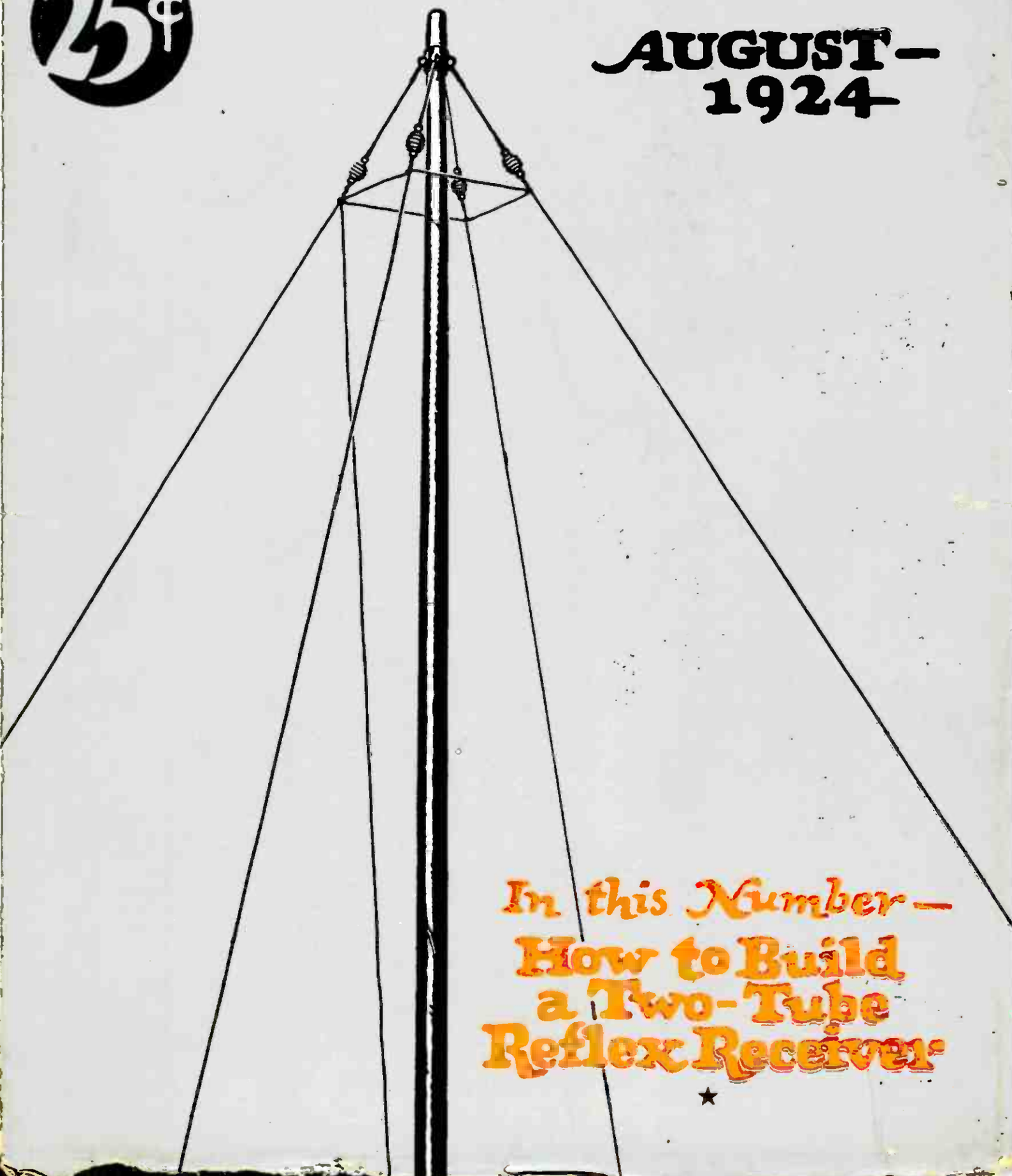
Popular Radio

Edited by KENDALL BANNING

25¢

AUGUST—
1924

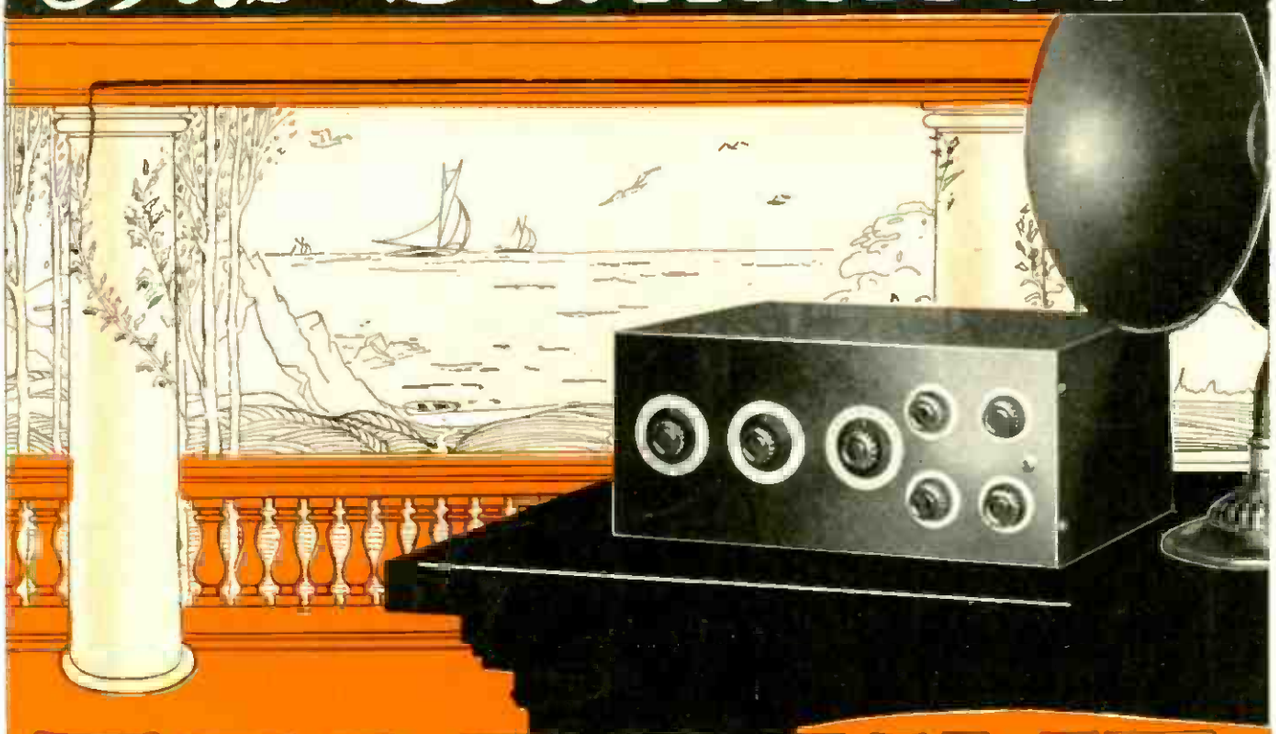


In this Number—

How to Build a Two-Tube Reflex Receiver

★

This Summer!



TELEDYNE

On a Ten Foot Antenna

Excellent volume—less interference—greater selectivity.

What's more, it makes TELEDYNE an easily portable set. Take it with you on your vacations.

Inspect TELEDYNE now. You'll find it the most compact, *practical*, *usable* receiver on the radio market. C&W Dealers everywhere will demonstrate, or write direct to—

The Cutting & Washington Radio Corp.
2344 Nicollet Ave., Minneapolis, Minn.

The horn of the Table-Talker is matched to the unit so as to give quality reproduction of all music and speech. 22 inches high. No batteries required.

$10.

Home—*comfort and entertainment!*

Enjoy the cool comfort of an easy chair and all varieties of music, sports, helpful talks and speeches. On the cool side of the porch—the calm pleasure of restful evenings with an entertainer of infinite versatility—radio and a Table-Talker.

The Brandes Table-Talker spreads its mellow tone among your guests. It brightens the evening meal with concerts that fill your largest room. It generously reproduces every part of the fascinating radio program. You comfortably enjoy the entertainers of summer nights.

Brandes

Superior *Matched Tone* Headset $6
$7 in Canada

Table-Talker $10.
50¢ extra west of the Rockies
In Canada $14

Navy Type *Matched Tone* Headset $8
$11 in Canada

The name to know in Radio

POPULAR RADIO

EDITED *by* KENDALL BANNING

CONTENTS *for* AUGUST, 1924

(Cover design by Frank B. Masters)

VOLUME VI NUMBER 2

VOLUME VI AUGUST, 1924 NUMBER 2

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

The GREBE CLARIFIER

Increases Selectivity
Increases Signal Intensity
Improves Quality
Prevents Radiation
And—
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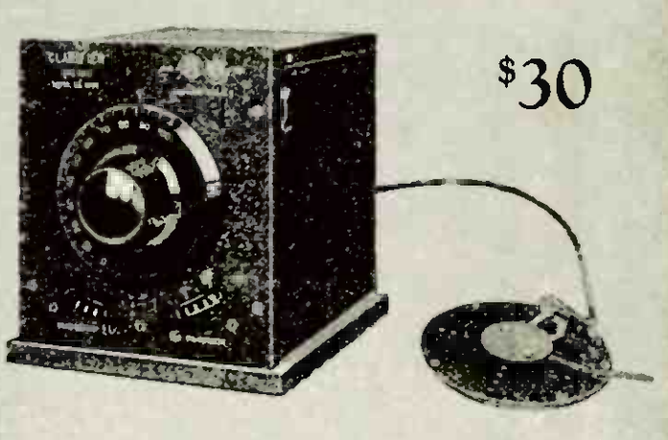

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GREBE RADIO

TRADE MARK
REG. U. S. PAT. OFF.

"Do justice to thy neighbor"
—*Confucius*

Safeguard him against objectionable sounds by the use of the Grebe Clarifier.

Doctor Thy

THE first practical, workable solution of the problem of radiation from regenerative receivers. Unlike the "wave-trap" it *increases* signal intensity.

Ask your dealer or write for literature

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PAGES WITH THE EDITOR

OF all the letters received from readers in which they expressed their preferences for the old, standard left-to-right circuit diagrams or for the new right-to-left diagrams there are two outstanding features:

* * *

FIRST, that opinions of our readers are almost equally divided, and;

Second, that those who prefer the old left-to-right diagrams are, with scarcely an exception, the more mature experimenters to whom the standard arrangement has become a standard, while those who prefer the new arrangement are almost all in the younger group, to whom the right-to-left diagram appears a more logical and legible arrangement.

* * *

FORTUNATELY, this is one of the few instances in which the Editor does not have to please one group at the expense of the other. The points that both adherents make are sound. So POPULAR RADIO will continue to use the new right-to-left diagrams in the form of picture diagrams that show the general appearance of the instruments and the exact way to run the connecting wires, in its "How-to-build" series of articles. But at the same time it will use the old standard left-to-right theoretical wiring diagrams. In this way the Editor hopes to keep in the good graces of both groups—and avoid bloodshed.

* * *

EVERY week brings new evidence of the growing popularity of the famous four-circuit tuner developed by Laurence M. Cockaday, the Technical Editor of POPULAR RADIO. "It is all the rage in Sweden," reports Mr. Oscar Stern of New York, who has just returned from a trip to that country. "Indeed, the remarkable efficiency of this set is making it pretty much the standard receiver there." . . . Which confirms the reports that are coming in from other quarters of the globe.

* * *

MAJOR GENERAL C. McK. SALTZMAN

No one more keenly appreciates the important part that radio is destined to play in warfare than the new Chief Signal Officer of the Army. The next number of POPULAR RADIO *will contain an authoritative article on this subject—prepared with the co-operation of the army officials.*

WHEN Uncle Sam first entered the World War in 1917 Charles McK. Saltzman was a lieutenant colonel in the U. S. Signal Corps, and very shortly thereafter the Editor became a major in the same branch of the service. Now it is Major General Saltzmann, Chief Signal Officer of the Army! And although the war is fading into history, the Editor got much the same old thrill that any soldier gets when he is cited when he opened the following letter from his chief:

June 4, 1924.

To Lieutenant Colonel Kendall Banning:

Your success with POPULAR RADIO *is an outstanding accomplishment. You should be justly proud of its record.*

C. McK. SALTZMAN,
Chief Signal Officer of the Army

* * *

IF POPULAR RADIO did not have a silver cover, anyway it would carry a silver citation star as an outward token of this recognition from official sources!

* * *

AT last our eagle-eyed friends of the American Radio Relay League have discovered a flaw in our editorial armor, and have pointed it out with such prompt but amiable humor that the Editor is printing the rebuke to atone for a confessed error. Here it is:

* * *

"IN looking over the June issue of POPULAR RADIO, I notice on page 603, where we are the *Amateur Radio Relay League,* and on page 625 we again appear as the 'American Amateur Relay League.'

"This is not half so bad as *American Radiator Relay League* or *American Rum Runners League* or even the *American Radio Delay League,* but just thought I would draw your attention to these two inaccuracies for the proof reader to worry about in the future."

"Experience is the Vital Factor in Excellence"

Thousands of artists have used the same colors that Gainsborough used to paint the famous "Blue Boy," but there is only one "Blue Boy."

The difference is that Gainsborough knew how to apply and mix the colors.

THOMPSON SPEAKER

The engineering principles of mechanics, electricity, and sound have been applied to the Thompson Speaker by an organization that has made radio products exclusively for the last 14 years.

The "reed"—or driving armature—in a Thompson Speaker is not found in an ordinary speaker, and this is just one of 7 Thompson features—reasons why there can be no distortion in a Thompson regardless of volume.

Why "get along" with any speaker when you can get the best that experienced radio engineers can build—the Thompson. $35 at good dealers.

• • • • • • •

The Thompson Neutrodyne, which combines features not found in the average neutrodyne, is made by the same organization. $150 without tubes and batteries.

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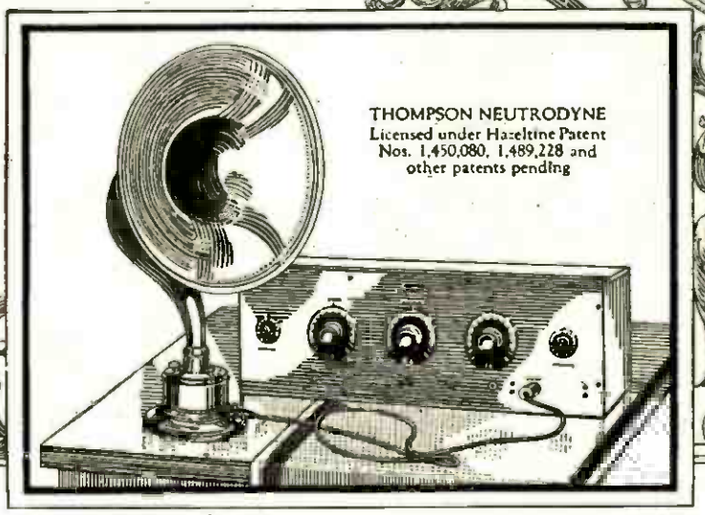


THOMPSON NEUTRODYNE
Licensed under Hazeltine Patent Nos. 1,450,080, 1,489,228 and other patents pending

PAGES WITH THE EDITOR

(*Continued from page 4*)

ONE of the first of the editorial problems to confront the Editor when POPULAR RADIO was started was whether or not specific mention of radio parts should be made in our "how-to-build" articles. None of the radio periodicals that were then in the field had done so; there was no precedent to justify such mention. On the contrary, the only radio parts that had been mentioned by name up to that time were for the most part frank "write-ups" for which the advertiser paid, directly or indirectly.

* * *

"DON'T do it," warned some. "Your readers will think that you specify only the parts that are manufactured by your advertisers. The radio public will think that you are boosting these products for selfish purposes!"

* * *

"YOU'LL never be able to convince people that specific mention by trade name of radio parts is not paid for by the manufacturers," warned others. "No matter how honest you may be in your specifications, the radio public is not accustomed to the practice and it will hold you in suspicion."

* * *

"DON'T try it," advised others. "Your competitors will try to discredit your motives and you will be held up to ridicule."

* * *

"BUT," we protested, "if these how-to-build articles are to be of real, practical value to our readers we must tell our readers *just exactly* how to build the sets and *just exactly* what parts to use. Otherwise the sets may not work. In the protection of our readers, what other decision can we make but to mention parts by name? And if our specifications are honest and sound, our readers will discover for themselves that they may be relied upon. And the manufacturers can find out easily enough for themselves if they can buy their way into our reading pages!"

* * *

So, contrary to all precedent and to all advice, POPULAR RADIO initiated the policy of telling its readers just what radio parts to get to build the sets that it described, confident in the ultimate judgment of our readers as well as in the soundness of the policy itself.

* * *

AND, sure enough, all the direful things that were predicted came about!

* * *

MANUFACTURERS and advertisers *did* resort to every expedient known to force their way into the reading pages, from withdrawal of advertising to threats of legal action unless we mentioned their products instead of the other fellow's. Some of our readers *did* assume (or claimed to) that we specified parts because we were paid to do so. And competing magazines *did* try to discredit both our specifications and our motives!

BUT POPULAR RADIO stuck to its guns and refused to yield an agate line! It believed that its policy of *service to its readers* was as sound as it knew it was honest. It believed that its readers would, by practical experience, come to the same conclusion.

* * *

AND they did!

* * *

STEADILY, month by month, the circulation and influence of POPULAR RADIO has grown. The advertisers have learned that they can *not* buy their way into the reading pages. And the problem that was once so fraught with peril is now a problem no more. Even the magazines that once attacked our policy so vehemently are now quietly following POPULAR RADIO'S lead and are themselves beginning to specify parts by name!

* * *

AND what do our readers think of the policy? In answer, the Editor will point to POPULAR RADIO'S steadily climbing circulation list. And then he will quote at random from four representative letters out of the hundreds that have poured in upon him.

* * *

"I THINK your policy of *naming the specific makes of instruments* used in the sets described in your magazine is one of your best features," writes J. J. Shoemaker of Kennett Square, Pennsylvania.

* * *

"MENTIONING the trade names of parts used in your descriptions of receivers is a very valuable feature to the man who wishes to build a set and *get results*, and also to the man who is located in a smaller place where dealers carry small and poorly selected stocks," states Archie H. Klingbeil of Ashtabula, Ohio.

* * *

"THE one feature that has always appealed to me about your articles is the wealth of specific detail that practically guarantees a successful set for the veriest beginner," writes Frederick C. Curry of Brockville, Ontario, Canada, "even to repeating in each issue the time-honored instructions for finishing the face of the panel and the much ignored caution that good parts are essential for success."

* * *

"I CANNOT but congratulate you upon the definiteness of the information that your publication gives to builder-amateurs," writes the Rev. Harold J. Marra of Wayne, Pennsylvania. "Your attitude on this point is very precious from the readers' viewpoint, and, on the part of the magazine, a policy of which you can be justly proud."

Kendall Banning

Editor, POPULAR RADIO

The Supreme Insulation

RADION Panels

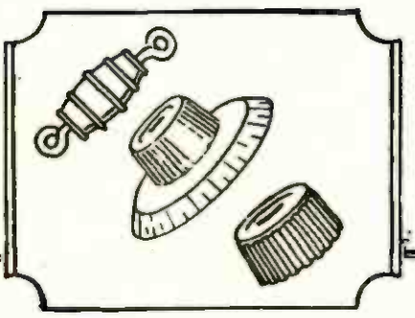
are easiest to drill, saw, or engrave with simple tools at home

21 Stock Sizes Radion Panels

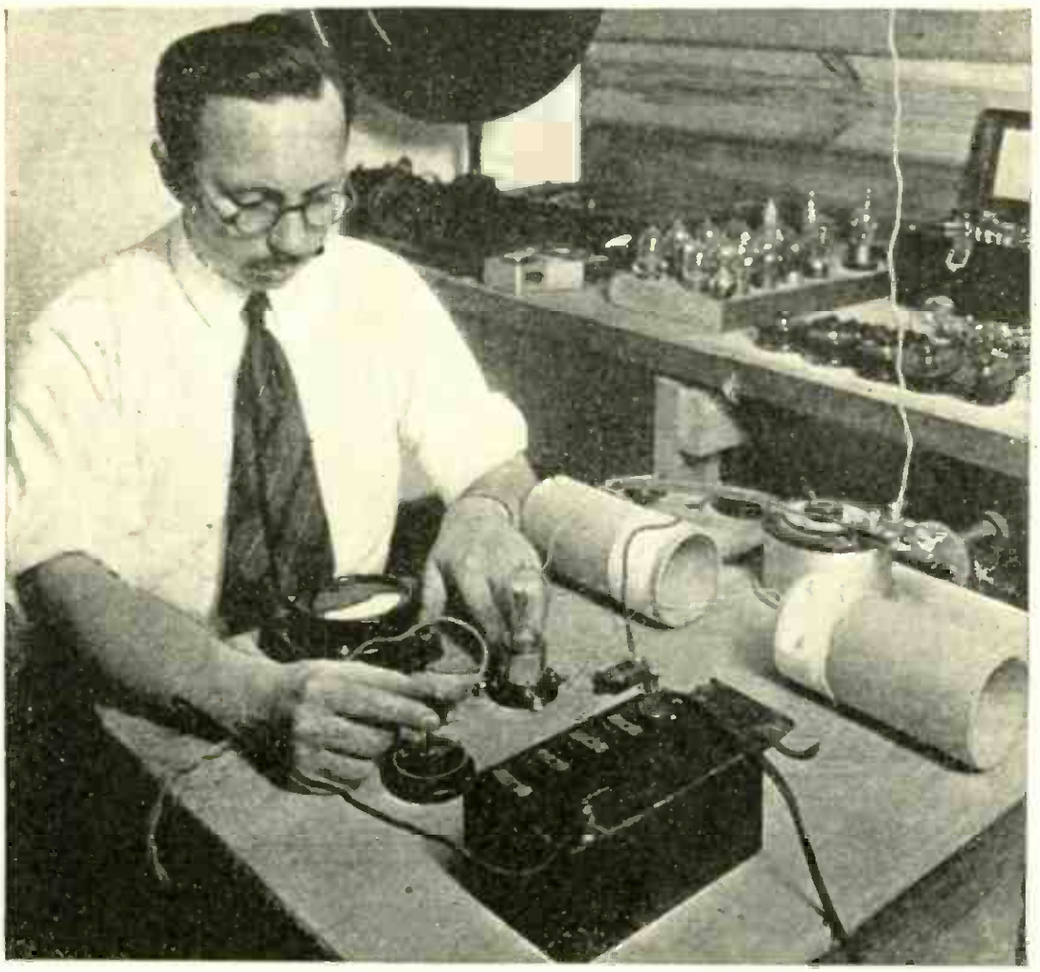
Mahoganite and Black

6 x 7	7 x 14	8 x 26
6 x 10½	7 x 18	9 x 14
6 x 14	7 x 21	10 x 12
6 x 21	7 x 24	12 x 14
7 x 9	7 x 26	12 x 21
7 x 10	7 x 30	14 x 18
7 x 12	7 x 48	20 x 24

Look for this stamp on every genuine RADION Panel. Beware of substitutes and imitations



AMERICAN HARD RUBBER CO., 11 Mercer St., N. Y.



"A Far-sighted, Alert and Courageous Magazine"

NOTHING can clear up the problems of the broadcast listener so rapidly and so effectively as the reading of dependable, clear and exact articles on the points that give him trouble. Engineers, manufacturers and users must have a medium of contact through which they can attain, as their common goal, a perfect radio service. POPULAR RADIO has already helped tremendously in showing how to achieve better broadcast reception. What can better serve us all than such a far-sighted, alert and courageous magazine?

John V. L. Hogan

Pacific & Atlantic

A Front Row Seat in Every Home

"By the development of wired radio, every chair in one of the 12,000,000 American homes now equipped with electric light may become a seat in a super-theater, a church, or a college lecture room."

—MAJOR GENERAL GEORGE O. SQUIER

(See page 140)

Popular Radio

VOLUME VI AUGUST, 1924 NUMBER 2

Do Electrons Play or Loaf?

There are two theories of how electrons behave in atoms—especially of how they send out ether waves. One of these theories is held by the majority of the physicists; the other one is sponsored chiefly by chemists. Dr. Millikan believes that these two theories are not too far apart to be reconciled; his views, as expressed in a paper delivered by him before the American Chemical Society, are of such unusual interest that they are presented in this article by special arrangement with the Society

By ROBERT A. MILLIKAN, Ph.D., ScD., M.N.A.S., F.A.A.A.S.

ALL scientists agree upon an atom which has a very minute positively charged nucleus surrounded by a number of negative electrons in its outer region, which outer region is just suited to neutralize the free positive charge upon the nucleus.

We all agree that the number of these positive charges upon the nucleus varies from one, in the case of hydrogen, by unit steps up to ninety-two in the case of uranium.

We all agree that the atoms also have outside the nucleus a number of negative electrons which varies between the limits of one and ninety-two and further that the chemical properties and most of the physical properties of all atoms are determined simply by the number of those electrons; primarily by the number of them which are found in the outermost shell. These we call the valence electrons.

We all agree, too, that the nucleus is extraordinarily minute, so that if all the dimensions of an atom were magnified ten billion times—a magnification which would make the diameter of the atom about a meter—the nucleus on this huge scale of magnification would not be larger than a tenth of a millimeter in diameter—that is, not larger than a mere pin point.

We all agree, too, that in the case of the atom of uranium there are packed into that infinitesimal nucleus 238 positive electrons and 146 negative electrons; the exact number of the posi-

tive electrons being determined merely by the atomic weight while the number of negative electrons which bind the positives is the atomic weight minus the atomic number.

We all agree that so far as physical science has now gone there have appeared but two fundamental entities; namely the positive and the negative electrons. These seem to be the building stones of the universe.

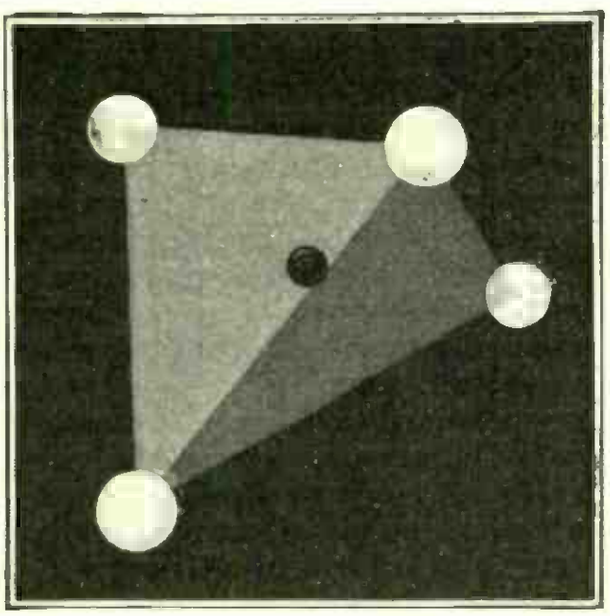
We all agree that when any of the negative electrons in the outer regions of the atom are stimulated to emit radiation they do so by virtue of falling from a level of higher potential energy to one of lower.

And we all agree that the frequency of the emitted radiation is proportional to the loss of energy in the process of changing from the one level to the other. Indeed, one of the most stimulating advances which physicists have made in the past five years consists in the complete demonstration of this Einstein-Bohr law of radiation. Very recent experiments go even so far as to indicate that this law holds not only for the radiations emitted by the changes in energy levels of the electrons outside the nucleus but also for the radiation emitted by the nucleus itself—the so-called gamma rays which accompany changes within the nucleus of radioactive atoms, like radium.

These results upon which we all agree are proof enough of the amazing advances which have taken place, mostly within the past ten years, in our ability to peer inside the atom and to see what kind of entities exist there and what they are doing when they are in the act of radiating light or other forms of electromagnetic energy.

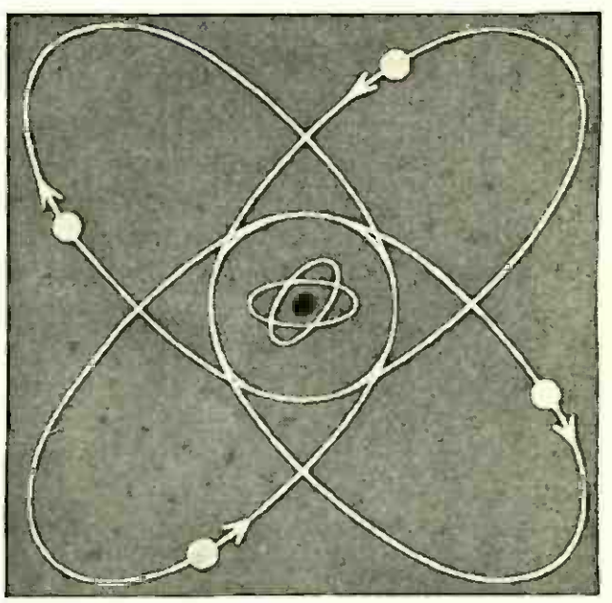
The only place where we have difference of opinion, or better, in which there are uncertainties, is in our views as to how the electrons spend their time when they are not radiating.

The chemist has been content, in general, with what I will call the "loafer electron" theory. He has imagined the electron sitting around on dry goods boxes at every corner ready



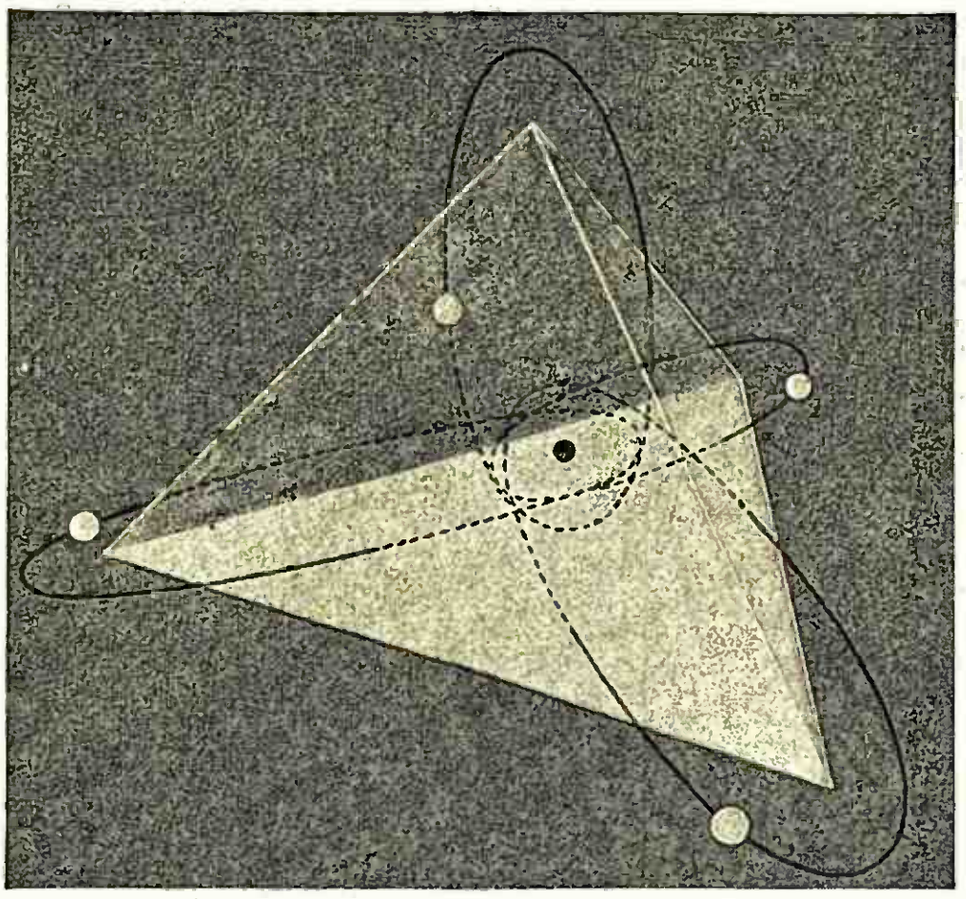
THE "LOAFER ELECTRON" THEORY

This figure illustrates the supposed position of the four outer electrons in the atom of carbon on the idea that they do not move. The solid figure is imaginary and serves merely to locate the four fixed points near which the electrons are supposed to rest, their positions being determined by electrostatic forces.



THE "MOVING ELECTRON" THEORY

According to this idea the four electrons of the carbon atom revolve in separate ellipses around the central nucleus. Close to the center are the orbits of the two inner electrons. These two inner ones are omitted from the alternative "loafer electron" diagram to the left, though present in the actual atom.



HOW THE TWO THEORIES OF ELECTRONS MAY BE HARMONIZED

If the orbits of the four outer electrons of the carbon atom (as illustrated in the right-hand diagram on page 110) be arranged in space so that outer focus of each ellipse is at one of the fixed-point corners of the imaginary solid figure, then these orbit-foci become the same as the fixed electron positions of the "loafer electron" theory.

to shake hands with, or hold on to, similar loafer electrons in other atoms.

The physicists, on the other hand, have preferred to think of the electrons as leading more active lives; as playing ring-around-the-rosy, crack-the-whip, and other interesting games. In other words he has pictured them as rotating with enormous speed in orbits and as occasionally flying out of these orbits for one reason or another.

Now the arguments for the "loafer electron" theory are two in number. The first is that such activity as the physicist postulates would soon wear away all the energy possessed by the electrons. They would tire themselves out and quit their play. There is no answer to this argument. They would indeed tire themselves out if the electromagnetic laws are universally applicable, even in the hearts of atoms. And the physicists' only answer to this argument is: "God did not make electrons that way." Why assume that the electromagnetic laws are *universally* valid when this is the first chance we have had to test them out in a region so infinitely small as the inside of an atom?

The second argument for the loafer electron theory is the existence of localized valences in chemistry. That these localized valences exist is admitted on all hands; but it is simply due to a misunderstanding that this argument ever was used against the orbit theory. For no physicist—and I wish to emphasize this fact—has ever advanced the theory that the electrons all rotate in orbits in the same plane. Localized valences are just as com-

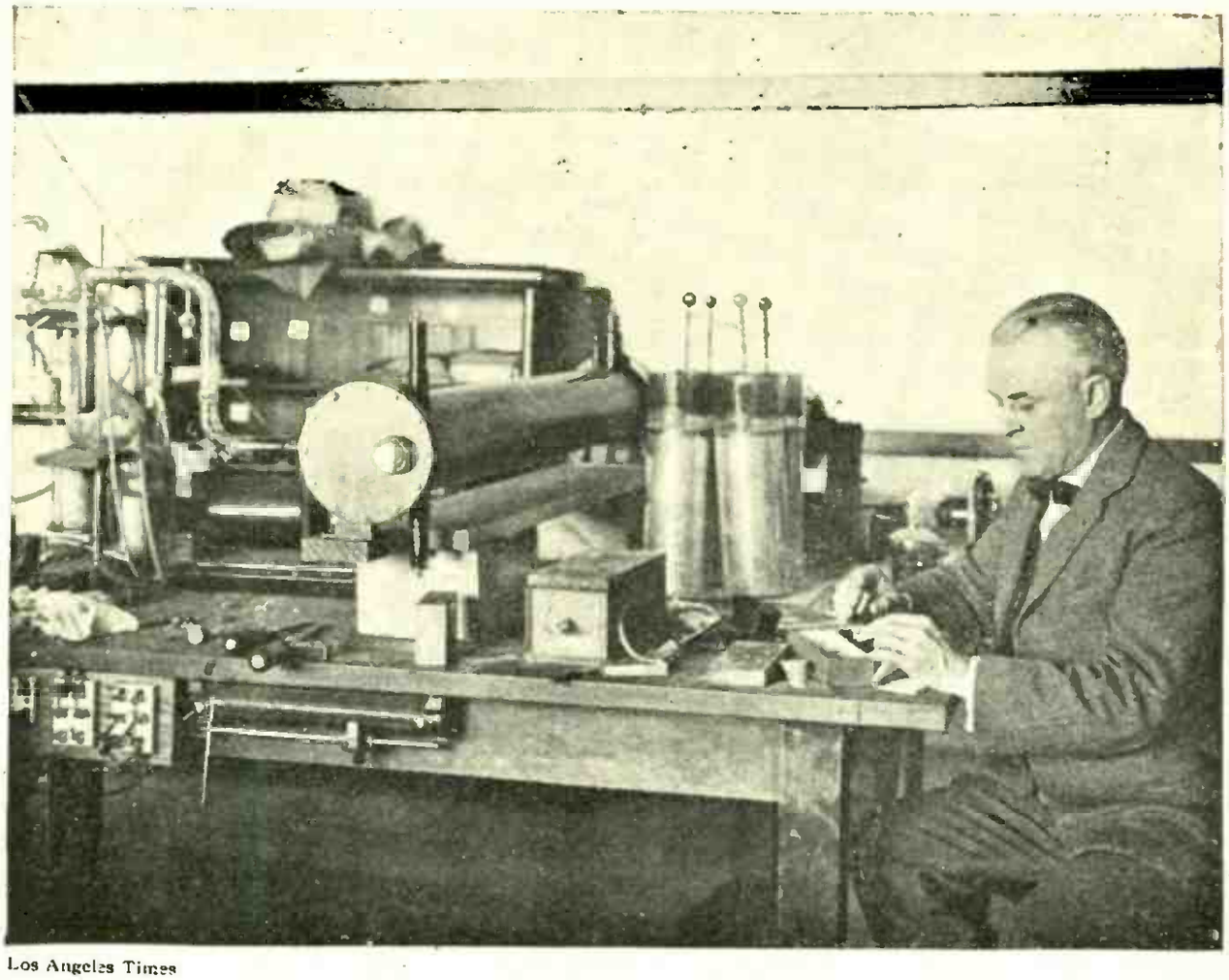
patible with the orbit theory, when the orbits are properly distributed in space, as with the stationary electron conception. All this I pointed out in 1916, trying thereby to clear up the misconception which existed in the minds of chemists as to the way in which the physicists were thinking about atoms.

Let me pass now to the arguments in favor of the orbit theory. They are all of them definite quantitative arguments in which purely theoretical considerations lead to exact numerical predictions which can be subjected to the test of experiment.

The first of these was the exact prediction with the aid of orbit equations of the so-called Rydberg spectroscopic constant. This is in agreement with an accuracy of one part in five hundred with the directly measured value.

The second quantitative argument comes from the prediction of a difference between the positions of two spectral lines; one due to helium, the other to hydrogen, which two lines should theoretically be one and the same line were it not for the fact that the nucleus of the helium atom is four times as massive as the nucleus of the hydrogen atom.

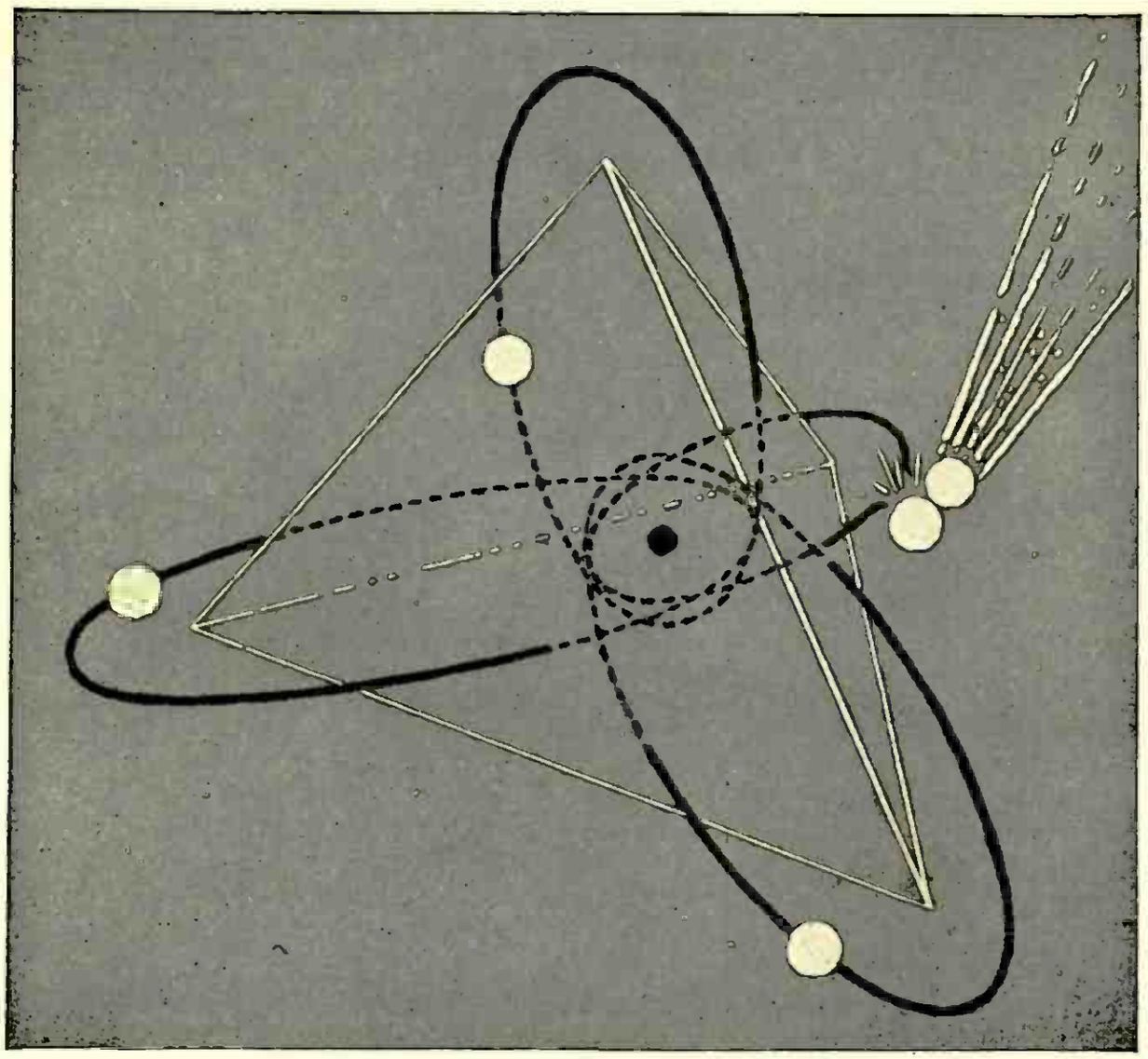
To make clear the difference which this causes let me ask you to reflect that when an electron revolves around



Los Angeles Times

WHERE DR. MILLIKAN'S "STRIPPED ATOMS" WERE PRODUCED

This photograph shows Dr. Millikan with the apparatus in which he and Dr. Bowen were able to strip the outer electrons, successively, from the central parts of the atoms of several elements, thus providing a new proof of the correctness of the moving electron theory. It was Dr. Millikan who first determined the exact amount of electricity on one electron, for which achievement he received the Nobel Prize in Physics.

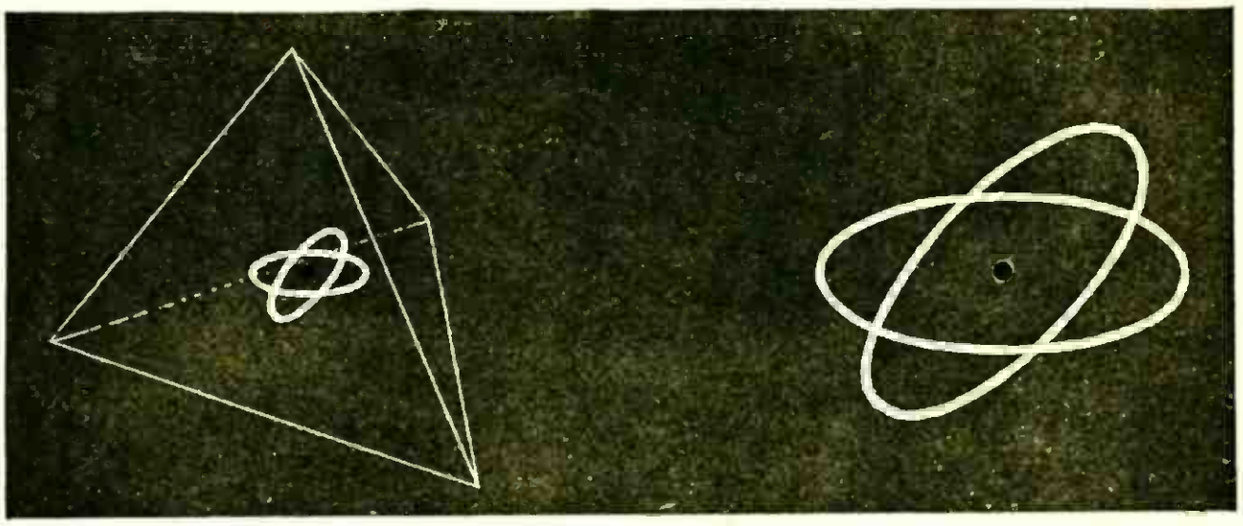


ONE OF THE WAYS TO STRIP AN ELECTRON FROM AN ATOM

If a fast-moving single electron comes along and hits an atom it may knock one of the atomic electrons altogether out of the atom. This diagram shows how this might happen to an atom of carbon, the same atom as is illustrated by the drawing on page 111.

the nucleus of an atom of hydrogen, the real thing that happens is that the two bodies revolve about their common center of gravity, but as the nucleus is 2,000 times heavier than the electron this center of gravity is exceedingly close to the hydrogen nucleus.

If now the hydrogen nucleus is replaced by the nucleus of the helium atom, which is four times as heavy as that of hydrogen, the common center of gravity is still closer to the nucleus so that the helium nucleus describes during the rotation a much smaller circle than does the hydrogen nucleus. This situation is responsible for a certain slight but accurately predictable difference in the energies of the two orbits and this should cause the spectral lines produced by electron jumps to these two different orbits to be slightly displaced from one another. This displacement is actually found between the corresponding lines in the spectra of hydrogen and helium and when the ratio of the mass of electron to the mass of the hydrogen atom is computed from this displacement of the lines it agrees with other



A STRIPPED ATOM AND AN UNSTRIPPED ONE

At the left is a carbon atom from which all four of the outer electrons have been stripped away, leaving only the two inner ones. The imaginary solid figure indicates the points where the foci of the electron orbits were. At the right is an atom of helium which never had more than two electrons, corresponding to the two remaining ones of the stripped carbon atom. But in the helium atom the orbits of these two electrons are larger, and this difference can be detected in the light which the two kinds of atoms emit.

determinations of this ratio to within a small fraction of a percent.

The third amazing quantitative success of the orbit theory came when Sommerfeld showed that the Bohr orbit theory ought to demand two different hydrogen orbits corresponding to the second quantum state; one a circular orbit, the other an ellipse. And by applying the relativity theory to the change in mass of the electron with its change in speed as it moves through the different portions of its orbit. Sommerfeld showed that these two orbits should have slightly different energies and, consequently, that the corresponding spectrum lines of both hydrogen and helium should be double.

Now the measured separation of these two doublet lines agrees precisely with the predicted value so that this again constitutes an extraordinary bit of evidence for the validity of the orbit conceptions underlying the computation.

The fourth quantitative argument was introduced by Epstein when he applied his amazing grasp of orbit theory to the exceedingly difficult problem of computing the perturbations in electron orbits (with corresponding changes in the energy of each) caused by exciting the hydrogen and helium atoms to radiate in an electrostatic field.

Epstein thus predicted the whole complex character of what we call the

THE OLDER IDEA OF VALENCE

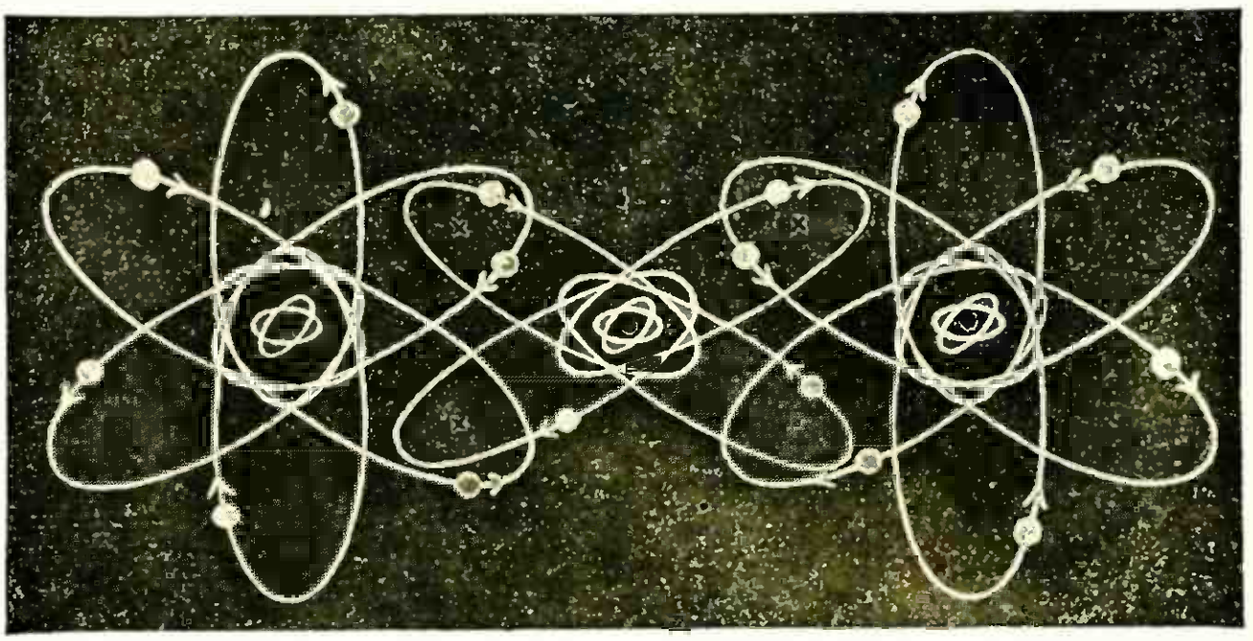
Valence is the chemist's term for the rule that controls the combination of atoms with each other to form chemical compounds. The drawing depicts a molecule of carbon dioxide gas. One atom of carbon was supposed to possess four little hooks of some kind; each atom of oxygen was supposed to have two hooks. Chemists said that carbon had a "valence" of 4; oxygen a "valence" of 2.

Stark effect, showing just how many new lines were to be expected and just where each one should fall. Then the spectroscope yielded in practically every detail precisely the result which Epstein's theory had foretold.

The fifth quantitative success of the orbit theory is one which Mr. Bowen and myself at the California Institute of Technology have just brought to light. Through creating what we call "hot sparks" in an extreme vacuum, we have succeeded in stripping in succession, one, two, three, four, five and six of the electrons off from the atoms studied. In going from lithium through beryllium, boron, and carbon to nitrogen, we have thus been able to play with stripped atoms of all these substances.

Now these stripped atoms constitute structures which are all exactly alike save that the electric fields in which the single remaining electron describes its orbit, increase in the ratios one, two, three, four, five, as we go from stripped lithium to stripped nitrogen. Now we have applied the relativity doublet formula which Sommerfeld had developed, as indicated above, for the simple nucleus-electron system found in hydrogen and ionized helium. We have found that this formula not only predicts everywhere the observed doublet separation of the spectra produced by all these stripped atoms, but that it enables us to compute the effect which the two electrons close to the nucleus of all these atoms have in screening the outer rotating electron from this nucleus.

At a sufficient distance from the nucleus these two inner electrons ought to neutralize exactly two of the free positive charges on the nucleus, provided the forces emanating from them fall off with the inverse square of the distance. Our relativity doublet formula, without the introduction of any arbitrary constants whatsoever, enabled us to predict what the screening effect due to those two electrons ought to be. And now experiment reveals that that screening is exactly two, as it must be from radioactive and chemical data. In other words, we have another method which enables us with certainty to look inside the atom and to find how many elec-



THE NEW IDEA THAT VALENCE IS CAUSED BY THE ELECTRONS

This diagram shows the compound carbon dioxide (the same as shown on page 114) according to the new electronic conception of chemical reactions. The orbits of the four outer electrons in the single carbon atom are supposed to interlock in some way with four of the electron orbits of the oxygen atoms. The black crosses indicate the common foci of the interlocking orbits.

trons are in the inmost shell. Again the answer comes out two.

Also, when we examine the spectrum due to the stripped atoms of the group of atoms from sodium to sulfur—one electron having been knocked off from sodium, two from magnesium, three from aluminum, four from silicon, five from phosphorus and six from sulfur—we should find in every case that the number of screening electrons in the two inmost shells ought to come out two plus eight, or a total of ten. And it does come out in every case precisely as predicted.

This constitutes an unambiguous proof that the electrons themselves do possess what are called Coulomb fields, that is, electric fields falling off in intensity according to the inverse square of the distance; a result that is entirely incompatible with the loafer-electron theory. The physicist has thus piled Ossa on Pelion in his quantitative proof of the existence of these electron orbits.

These new results are incompatible, however, with the *shapes* of orbits with which the physicists have been working in the field of optics during the last five years. They necessitate either the abandonment of the relativity cause for the separation of our measured spectroscopic-doublets or else they require us to cease playing with a nucleus about which the electron orbits are largely symmetrical. In other words, if we retain the relativity explanation of the spectroscopic-doublet formula, we are obliged to suppose that two orbits which have the same shape but different orientations with respect to the nucleus may exhibit widely different screening constants—which is only another way of saying these orbits may possess widely different energies.

To this extent, then, I am able to help the chemist attack the imagined electronic orbits of the physicists. I can enable him to say with a good deal of certainty that these orbits cannot be of precisely the type which we physicists have been playing with so assiduously for the past five years.

If we retain the explanation which has heretofore been given to the relativity doublet formula, an explanation which requires entirely different shapes for the two orbits corresponding to these doublets, then we must begin to work with an atom which is very much less symmetrical with respect to the different oriented orbits than we have hitherto been imagining.

Kadel & Herbert

A NOVEL, PLEATED DIAPHRAGM ON THIS LOUDSPEAKER

A large, open diaphragm possesses many advantages for loudspeaker reproduction, especially in clear rendering of the low notes of an organ or the very high notes of the singer. A difficulty with such a diaphragm has been its tendency toward harmonic vibrations of various sorts, but a French engineer claims to have solved this problem by pleating the diaphragm radially.

From a photograph made for POPULAR RADIO

AN OLD-TIME "BROADCASTING STATION"

The improvement made in radio transmission and reception since the days of the old "transmitting amateur" has been one of the outstanding accomplishments of the past three years. Until the advent of the present-day broadcasting station, amateur spark stations similar to the one pictured above and naval and commercial telegraph stations were the only transmitters that the radio fans could listen to.

HOW TO GET GOOD

BROADCAST RECEPTION

ARTICLE No. 1: *The Effects That Occur in the Transmitting Station*

This new series of articles (written by one of the foremost radio engineers in the world) is designed for the special benefit of the broadcast listener who wants to get the maximum efficiency out of his receiver—and who wants to know the scientific causes of perfect and imperfect reception

By JOHN V. L. HOGAN

THERE is just one big problem facing those who listen to broadcast radio-telephone transmission—the attainment of perfect reception.

Already the technique of radio-receiver construction has progressed to the point that even the *average* set gives a reproduction of speech and music that compares favorably with the results obtained from the average phonograph. But there is no reason why even such progress should satisfy us, for the time is coming when radio reproduction will be much better than any phonograph can give.

Last winter I delivered a series

of broadcast talks on radio, through stations WEAF, WCAP and WJAR. Listeners who heard those talks wrote me thousands of letters, explaining and asking questions about the difficulties that they were experiencing. In so far as their questions could be covered by the spoken word I replied to them. Many points came up that could not be satisfactorily explained in fifteen-minute non-illustrated lectures, however; and it is my hope that by discussing the more important of those I can include in this group of articles a quantity of information that will be generally helpful. Not every topic that I take up will meet your own particular and immediate needs, but I hope that you will nevertheless be interested in each of the subjects. Data on all of them will add to your store of radio knowledge, and you can never tell when some specific detail will be useful to you.

The Causes of Imperfect Reception

Suppose we begin, then, by finding out what it is that is responsible for imperfect broadcast reception.

We may divide up the defects or difficulties into three main groups, *i.e.,* the effects that occur in the transmitting station, those that take place as the waves flash through space, and those that happen at the receiver.

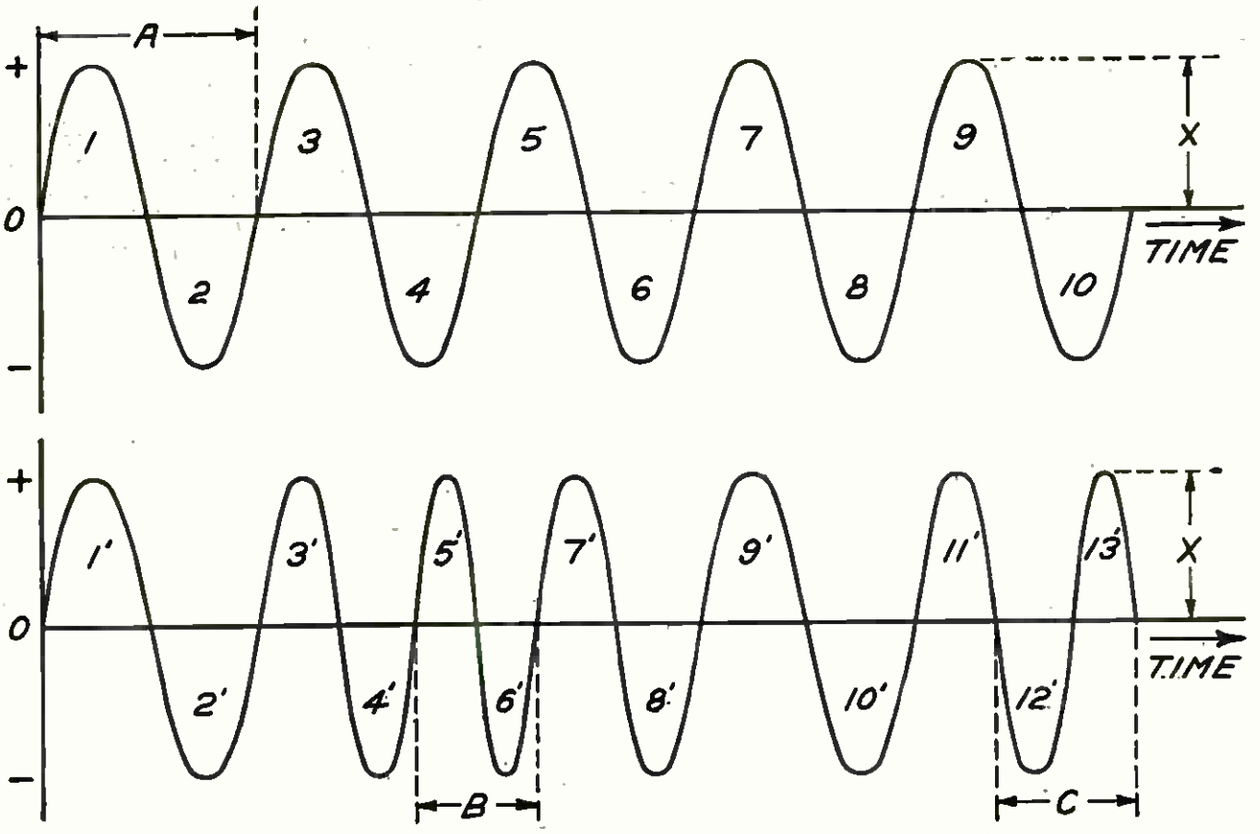
I propose to go into more detail as to the matters concerned in receiving-apparatus design and use than as to the first and second classifications, for two reasons; in the first place, the receiver is in your own hands and you yourself can improve its operation; and in the second place, there is more room for improvement in the receiving system (as a general rule) than anywhere else. Nevertheless, we should understand something of the transmitting-station and wave-movement difficulties if we are to appraise properly the performance of our receivers.

Consider the transmitter for a moment. Here we must first produce a perfectly uniform and unvarying stream of radio waves of a single definite frequency. If the wave frequency varies during transmission the signals will appear to fade away and grow stronger again as the radio wave departs from and returns to the frequency that the listening receiving sets are adjusted to intercept. If the transmitted wave frequency remains constant during any one program, but varies from night to night or day to day, this sort of artificial "fading" will not be noticed, but signals from the station will be located at different receiving tuner settings at different times. Of course, such a variation in the wave frequency makes it difficult to receive from the station in question.

Steadying the Waves

Keeping the transmitted wave steady is simply a matter of arranging the generating apparatus at the broadcasting station so that it will produce oscillations of uniform frequency, since the wave frequency must always be the same as that of the alternating currents that produce the waves. Fortunately the job of maintaining constant frequency of oscillations is no longer very difficult; most broadcast transmitters do very well on this score. The U. S. Bureau of Standards has been measuring many of the waves as received at Washington, and rates stations KDKA, WGY, WSB, WRC, WCAP and WWJ as particularly good in point of uniformity.

The fluctuations in wave frequency that cause apparent fading of signals are, of course, slow. It may require several minutes for the wave to change to a value only a few percent from its initial frequency. What would happen, then, if the variations in wave frequency occurred more rapidly? There are several general effects, and how much of each will be observed depends upon the rapidity and extent of the fluctuation. If the wave varies from its average value ten times a second, we would expect to hear a fluttering sound when



BROAD TUNING IS CAUSED BY CHANGES IN FREQUENCY

FIGURE 1: *The upper curve represents a perfect carrier wave. The lower curve shows how rapid changes in wave frequency spoil its uniformity and make close tuning impossible. Slow changes cause signal fading and the speeds in between make a warbling note in the receiver.*

listening to the station. The loudness of the flutter would increase as the amount of wave-frequency change increased. If the rate of fluctuation were increased to twenty or thirty times a second the flutter would be changed to a low-pitched rumbling tone. Still more rapid fluctuations would result in higher-pitched musical tones in our receivers. All these noises, you should bear in mind, would be heard while listening to the unmodulated and supposedly quiet "carrier wave" of the transmitter in question. Further, they would be produced by the mere changes in wave frequency even though the amplitude or intensity of the emitted wave were absolutely uniform.

One Cause of Broad Tuning

Now, let us suppose that the rate of frequency variation in the carrier wave is reduced to three or four times a second, and that the changes in value are not abrupt. The alterations in the carrier wave would not then produce a noise in the listening receiver, but we should be able to notice an effect that is quite different, namely, an apparent "broadness of tuning." It is not hard to see that, if instead of sending out a uniform carrier wave of 833,000 cycles a second frequency (corresponding to 360 meters wavelength), some particular station radiates at a frequency which slides up and down between 836,000 and 830,000 cycles, we cannot tune our receivers sharply to it at any single value between those limits.

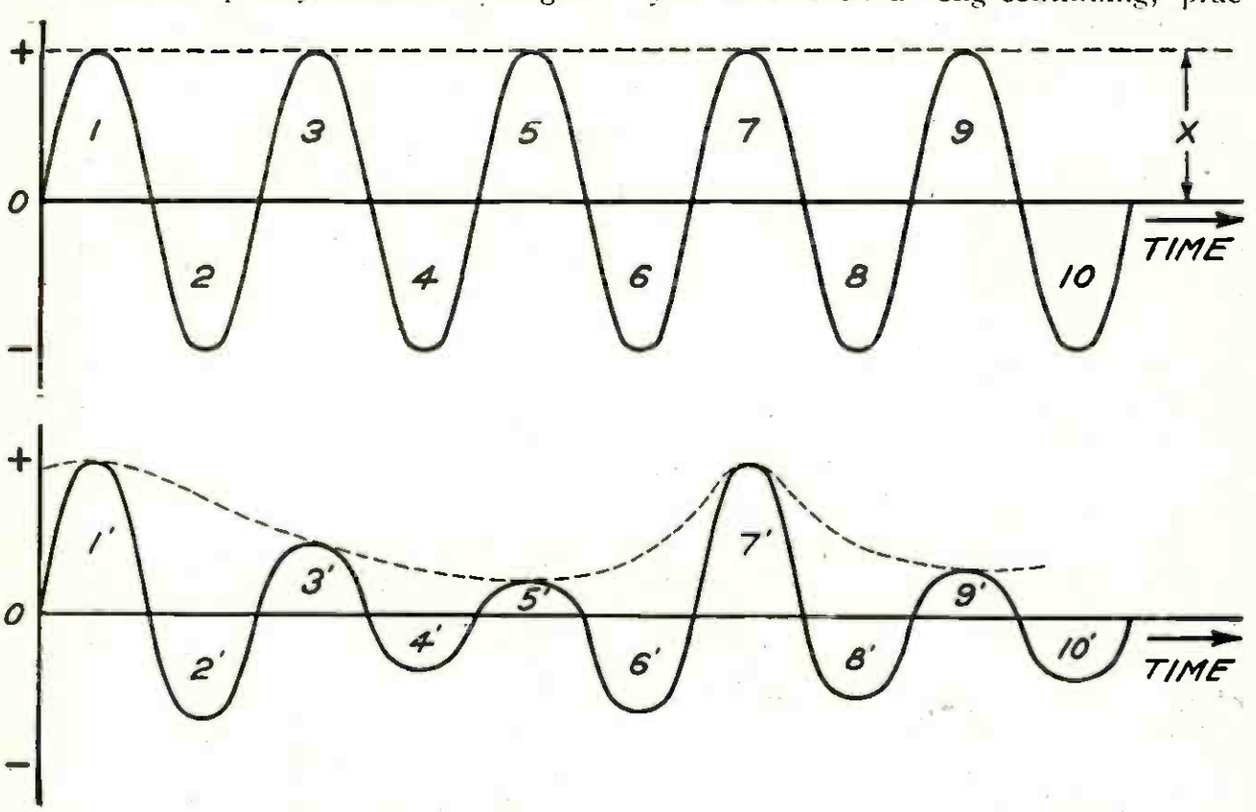
Such fluctuations in carrier-wave frequency are undoubtedly responsible for some of the cases of broadness of tuning of broadcast transmitters that have been reported, and, even today, probably account for part of the poor quality of speech and tone consistently observed in listening to some broadcasters. Thus a loss of quality, or of fidelity in tone

reproduction, that is generally blamed upon "poor modulation," may actually be caused by a very different thing. If you notice cases of wave-frequency fluctuation you can do a favor both to the broadcaster and to the radio listeners by writing to the station and telling its management in detail about your observations.

What the Steady "Whistling" Really Is

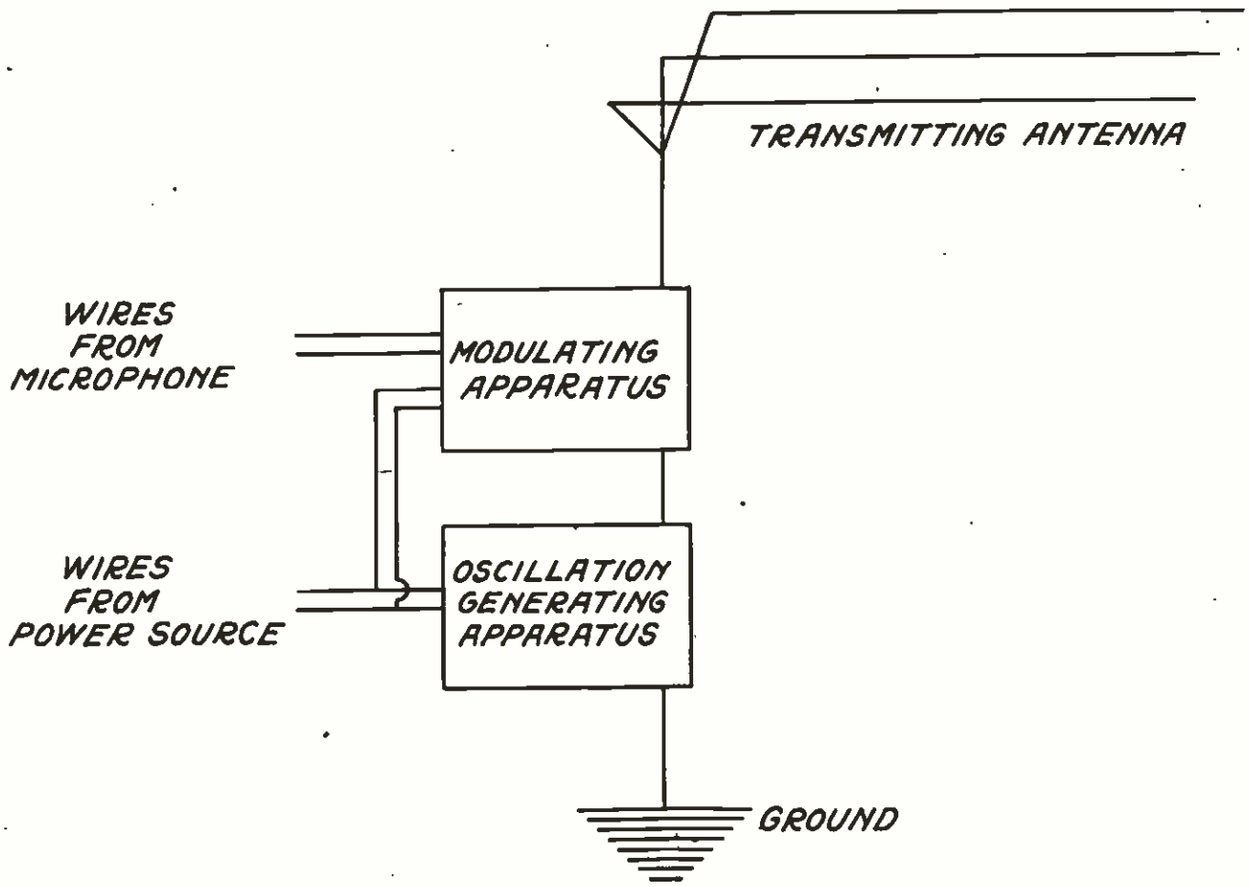
There is still another trouble that may be caused by the sending out of an incorrect wave frequency. Broadcasting stations are now licensed to radiate standard waves that have been chosen just 10,000 cycles apart in frequency. Waves so separated will not directly interfere with each other. But if, for example, station WRC in Washington, which broadcasts at 640,000 cycles (469 meters) were accidentally to increase its carrier frequency to 644,000 cycles, and if station WCAE in Pittsburgh were to reduce its frequency from the assigned value of 650,000 cycles to a new figure of 646,000 cycles, the two station waves would obviously be only 2,000 cycles apart. With such small difference in frequency any two radio waves would directly interfere with each other. By the well-known beating or heterodyne action they would produce a whistling tone of 2,000 cycles pitch, about equal to that of the third C above middle C on the piano, in every radio receiver that was so tuned and so located as to receive both waves.

This whistling note might be only a faint sound in the background, if one of the two interfering stations were relatively far away, or it might be so loud as to ruin reception of either or both programs. This latter would be the case when the two stations were about equally distant from, or were received at about the same intensity on, the observing receiver. Again I wish to urge you to write to the broadcast stations whenever you hear such a long-continuing, prac-



NOISY RECEPTION IS CAUSED BY CHANGES IN INTENSITY

FIGURE 2: *The upper curve represents a perfect carrier wave. The lower curve shows how variations in the power supply affect the carrier wave. Generator hum or steady sizzling and frying noises—which you hear between features on the program—are nearly all due to changes in the strength of the carrier wave.*



WHERE THE TRANSMITTING TROUBLES ORIGINATE

FIGURE 3: *Changes in frequency are due to the swinging of the antenna or local conditions within the transmitter. Uneven power supply or bad modulating apparatus cause a noisy carrier wave.*

tically uniform whistling note produced by the beating or direct interference of carrier waves. If you give specific information as to the time and place you noticed the whistle, how long it continued, about what pitch it seemed to be, and how badly it interfered with reception of the program, your letter will be very helpful.

Interference from 360-Meter Stations

There is no reason other than accident or carelessness for the occurrence of any such whistles caused by beating between the waves of broadcast stations in the United States, with the single exception of the "Class C" group that is licensed to use only 833,000-cycle waves (360 meters). Any two Class C stations are likely to interfere directly with each other, and the interference may be, and often is, so severe as to ruin their programs. If you like to listen to some particular Class C station and you find that it is continually being spoiled by a more or less steady whistling note, you should tell that fact to its management and urge them to ask for reassignment to a Class A or Class B wave frequency that will not be so disturbed.

The great majority of high-grade broadcasting stations (and particularly those in Class B) have little or no difficulty with variations in their carrier-wave frequency. If we listen to such a station as heard in an oscillating receiver, so that a beat note may be produced by the heterodyne interaction of the local oscillations and the carrier, we find that the beat tone is pure and constant in pitch. This means that the simple, unmodulated wave coming from that particular transmitter is uniform as to frequency and, consequently, that it is the ideal wave for bringing us radio-telephonic speech and music of high quality.

If it is not so nearly perfect it will not serve so satisfactorily as a radio carrier wave.

"Noisy Carrier Waves"

Leaving the matter of frequency fluctuations, let us consider another possible defect in the radio wave as it is transmitted by a broadcasting station. This is a slow or rapid variation in the intensity of the carrier wave, which may occur even though the transmitter operates at a perfectly uniform frequency. The effects produced at a listening receiver by variations in the intensity or amplitude of the transmitted wave are in some ways like those caused by changes in frequency, which have just been discussed.

For instance, if the wave intensity varies slowly, and by a considerable amount, it may produce at the receiver a corresponding variation in signal strength. If the intensity of the wave fluctuates rapidly, at a rate within the range of audible frequencies, it will make sounds in any ordinary listening apparatus and will be what is called a "noisy carrier wave." Such noises will, of course, be an obstacle to perfect reception of broadcast programs, and, at the transmitting station, they must be reduced to the practical minimum.

Whenever you hear a broadcast transmitter which sends out a noisy carrier wave, that is to say, a wave that produces a constant tone or noise in your receiver even when no speech or music is being transmitted, you should write to the station telling them about the situation. Perhaps you think that I am putting too much stress upon this matter of writing to the broadcasters; and so I would like to assure you that every station manager with whom I have come in contact is anxious to receive helpful comments as to just how well or how poorly his transmitter is performing. I feel certain that the same attitude is held by the managements of all good broadcasting stations.

How "Harmonic Waves" Interfere with Reception

There are still other characteristics of the waves sent out by broadcast transmitters that may cause trouble in reception. One of these is the radiation of waves at more than one frequency, *i.e.*, at certain definite frequencies other than the single one that is authorized for the particular station. It is not uncommon for a transmitter to send out "second harmonic" waves at twice its normal frequency, and sometimes other waves go out at other and higher multiple or harmonic frequencies. As a rule this harmonic radiation is a good deal weaker than the main or fundamental wave, and consequently it does not carry so far. However, wherever it is heard, the program of the sending station will be received on the higher wave frequency, and this may cause substantial interference.

For example, let us imagine that the Memphis station, which uses a main wave of 600,000 cycles frequency or 500 meters length, were to radiate a strong second harmonic wave. This would necessarily be at 1,200,000 cycles (double the fundamental frequency), which corresponds to 250 meters wavelength. Such harmonic radiation would severely interfere with reception from Class A stations using this 1,200,000 cycle frequency as their fundamental wave, as can easily be seen.

Irregular Interfering Waves

The extra or parasitic radiation may not be at harmonic intervals, *i.e.*, at double, triple or quadruple frequencies, as in the above instances. Cases have been observed where a single station sent out several waves at relatively closely adjacent frequencies, and, consequently, set up strong interference that disturbed reception from a number of other broadcasting plants.

Interfering radiation of any type is frowned upon by the radio laws, and the majority of important broadcasting

stations have taken special precautions to keep their full transmitted power concentrated upon the single wave frequency at which each is authorized to send. Some stations still send out these additional and interference-producing waves, however, and it would be helpful if all such cases that are observed should be reported to the stations and to the U. S. Radio Supervisors.

Summing up, we have now considered some of the things that can and do happen at transmitting stations. These are fluctuations in wave frequency, variations in wave intensity, and the emission of multiple waves.

Any of these defects will increase the difficulties of reception, and may easily prevent satisfactory operation of radio receivers. Every effort should be made to minimize and indeed to eliminate these three transmitter defects. You can do your part to help along such good work, though you should, of course, be careful not to blame upon the transmitting station any troubles that may be caused by, or happen entirely within, your own receiver.

¶ *In the future articles of this series I will show you how to distinguish between these various effects, and will try to explain how you may cure some of the difficulties that are within your own control.*

The Radio-Grouch

MANY a man has found his family surprisingly endurable in the evening. This is especially true of those who use the headphones.

* * *

A PERUSAL of the daily radio program reveals a surprising number of things that one would not listen to under any known circumstances. To sit down and tune them out is a comfort our forefathers never knew. Do not worry about those who don't know where to stop. The great majority are moderate listeners; they can take it or let it alone.

* * *

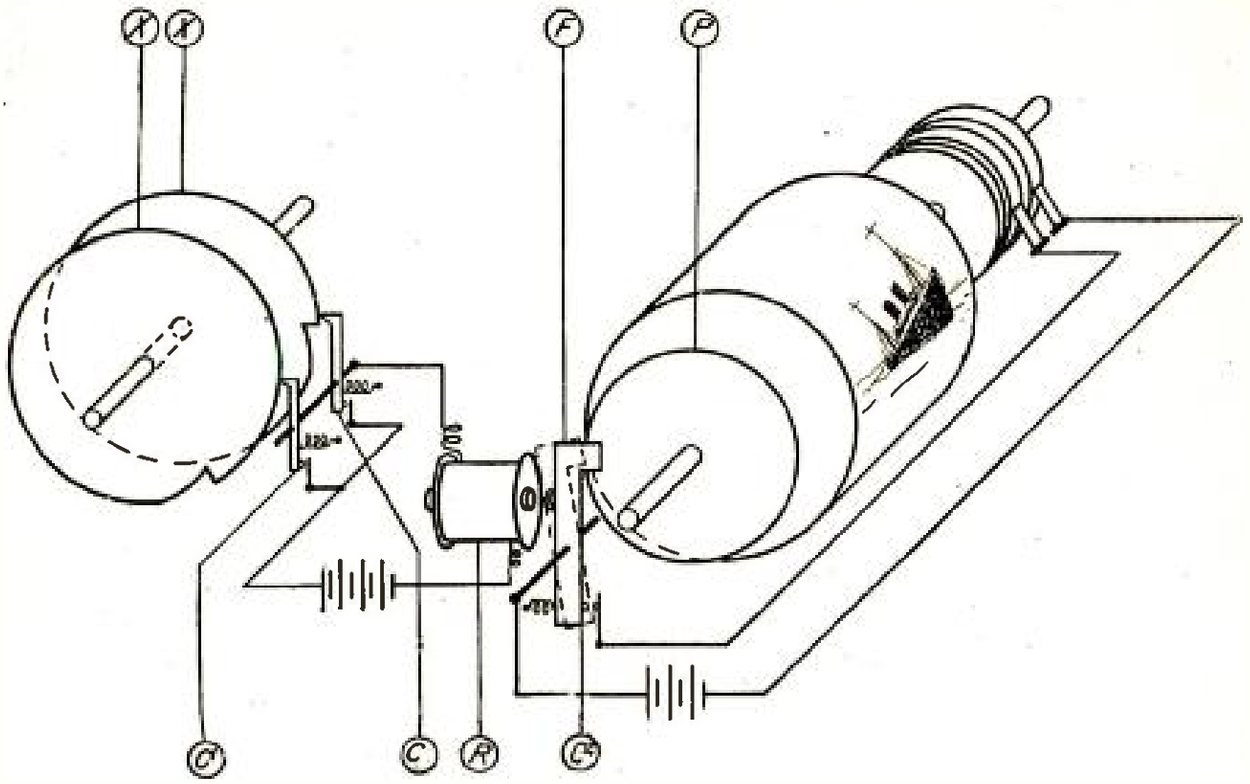
YOU can now listen to election returns without having a low representative of the triumphant party toot a horn in your ear or tickle your despondent chin.

* * *

YOU can now learn that your favorite stock has collapsed without waiting for the sheriff to come and nail something on the gate.

* * *

—HOWARD BRUBAKER



HOW THE PERIODS OF REST AND ACTION ARE CONTROLLED

FIGURE 1: *This diagram illustrates how the two crypto discs XX control the periods of rest and revolution of the cylinder P by means of an electrical relay.*

HOW I TRANSMIT

Pictures by Secret Radio Code

Here is the complete description of the remarkable apparatus for sending pictures by radio which the French inventor has called the "radiocrypto-telestereograph." This article shows not only the actual operating methods employed but also each step in the complicated process which insures not only a clear picture at the receiving end but *absolute secrecy in the transmission;* to insure accuracy the description was written by the inventor himself—

EDOUARD BELIN

THE transmission of pictures and documents by radio is an accomplished fact. It has been done by many with more or less success, depending upon the method and apparatus that has been employed.

One of the disadvantages of radio transmission is that some one may, with the proper apparatus, receive the message or document that is being sent, even though it is not addressed to him. This feature, of course, renders the apparatus almost valueless for commercial purposes, as no newspaper or police department would transmit under these circumstances any documents which should be kept inviolate.

To overcome this objection and make any picture-sending method practical, I have devised a machine which sends pictures by radio, but in such a manner as to make it impossible for the message to be received by any one except the station to which it is addressed. After several years of experiments, I have succeeded in my endeavor and have

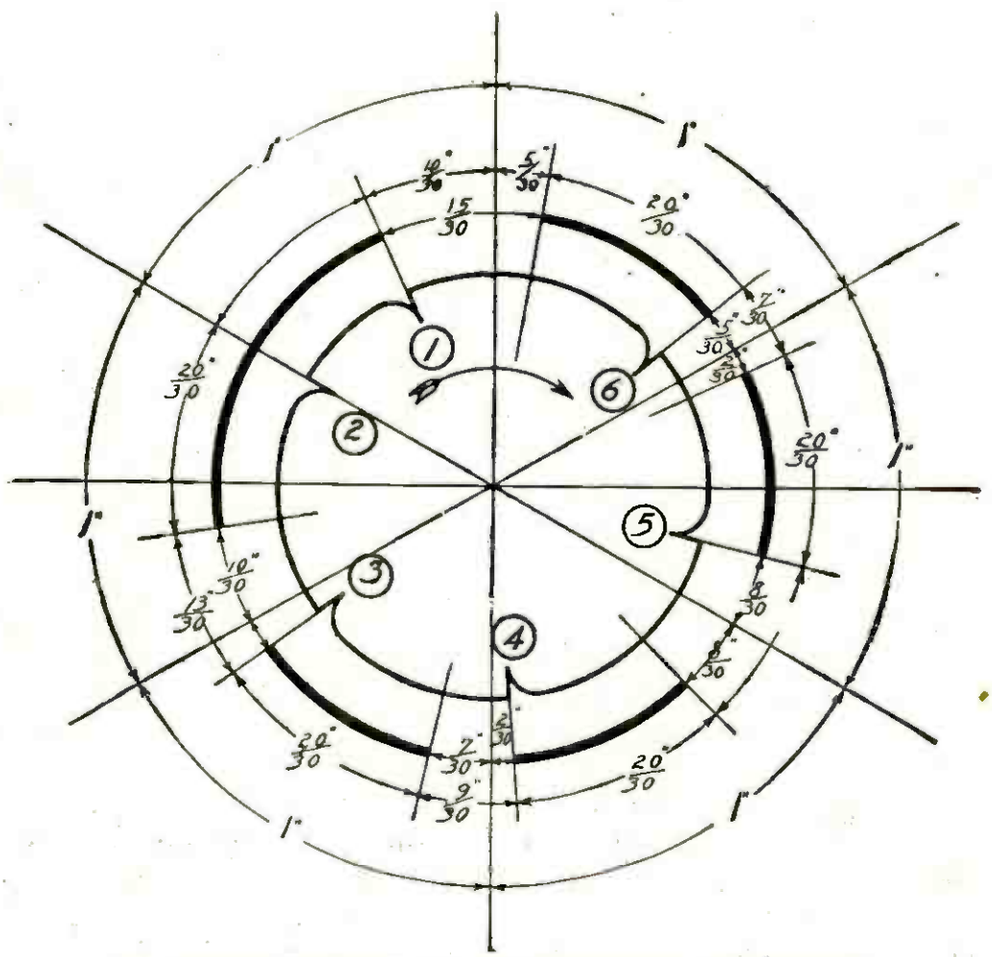
produced an apparatus that I have called the "radiocryptotelestereograph."

This apparatus (which is really a combination of two instruments) includes a transmitter and a receiver, almost identical to our telestereograph, for the transmission of pictures over land wires, and a combination system somewhat similar to those used in safes, which may be adjusted to form 999,999 different combinations. There is, therefore, but one chance in a million for the message to be intercepted by a station even if it is equipped with the proper apparatus. As an added safety, however, during the interval when no part of the picture is being sent, a special device fixed on the machine sends false signals—a feature which makes it absolutely impossible to receive the documents unless the receiving operator knows the combination number and adjusts its apparatus so that it is exactly synchronized with the transmitter. I have named the apparatus that accomplishes this feat, the "crypto," from the Greek word *cryptos*.

The crypto is composed of six discs that have cut on their circumference nine slots that are numbered from 1 to 9; these may be adjusted to form any desired combination of six figures. Once set at the proper place, a blade is set in the slots, thus making of the discs a unit which turns at the proper speed and that closes contacts in a certain order that depends upon the combination.

Figure 1 shows how at every turn the contact C, is closed, releasing by means of a relay R, the cylinder P, that bears the picture or message.

The crypto discs make one-sixth of a



A "TIME CHART" OF THE CRYPTO MACHINE

FIGURE 2: *This shows how the periods of rest and action are divided. The periods of rest are determined by the number combination in much the same manner as the combination on a safe; they are also disguised by sending out false signals which are similar to the transmitted signals which reproduce the picture.*

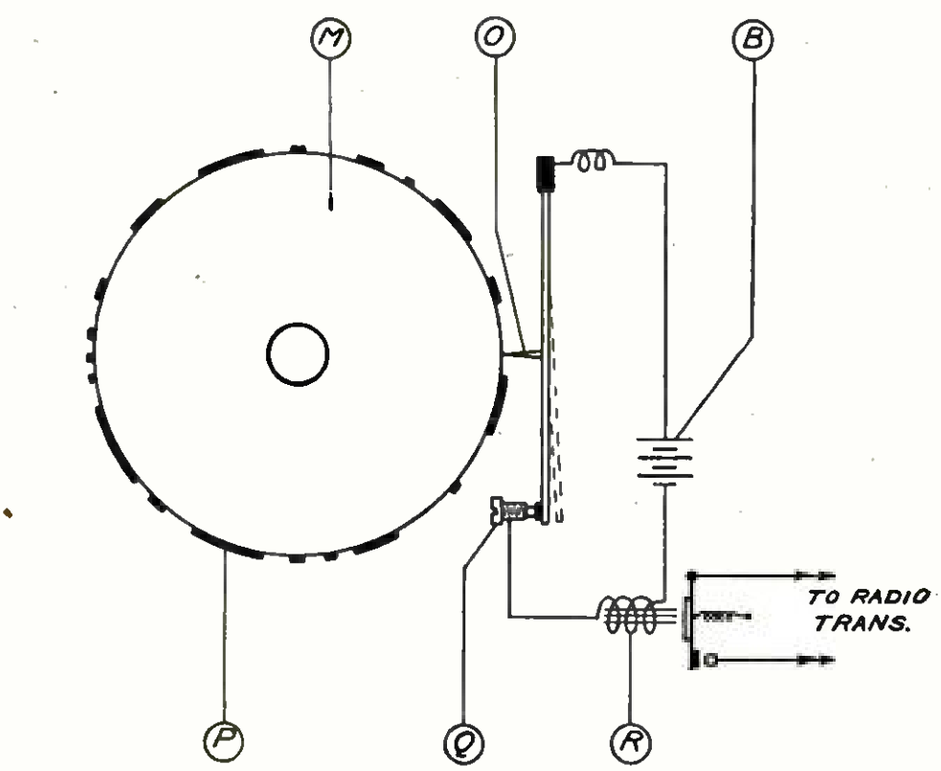
turn every second while the cylinder P, accomplishes one revolution in two-thirds of a second; therefore, when the contact C, is closed, the relay R, attracts the finger F, locking the cylinder and at the same time closing the circuit of a magnetic clutch which couples the cylinder to the rotating shaft; these operations are made instantaneously.

As the contact C, is only momentary, the relay R, is energized for only a fraction of a second and the finger F, is attracted just long enough to release the cylinder, coming again in contact with the cylinder P, and sliding on its edge until it falls again in the slot, stopping it and opening the circuit of the clutch at C^2. The same cycle of operations happens every time one of the contacts C or C^1 are closed. For the sake of clarity, only two contacts are shown in the sketch, but six contacts are used in the crypto, one for each disc.

Figure 2 illustrates clearly the method of operation, as it shows the periods of work and rest of the cylinder. The six breaks on the discs are numbered and are supposed to be set for the combination 913285.

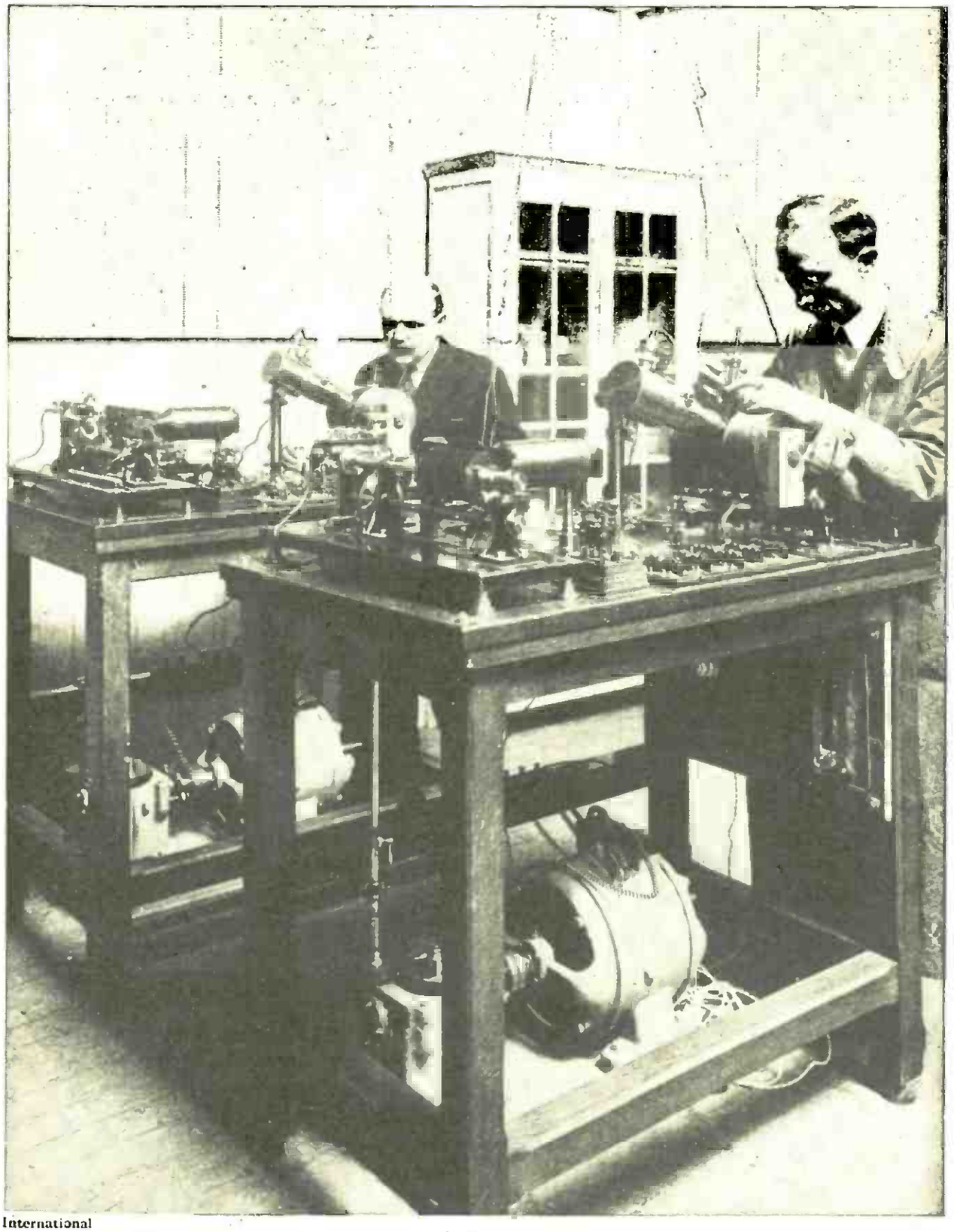
The efficient time of rotation of the cylinder upon which is fixed the picture that is being sent, is two-thirds of a second, and may be taken as twenty-thirtieths of a second. If the discs are adjusted to form the combination number 913285 (for example), there will be, before the 1st turn of the cylinder, a rest period of ten-thirtieths; at the beginning of the 2nd second, the cylinder of one turn rotates in two-thirds of a second, and stops during thirteen-thirtieths of a second, before it starts for the 3rd turn, and so on; the inactive time is determined by the arrangement of the discs.

As may be seen, therefore, the picture is sent at irregular intervals, which makes it necessary for the receiver to be exactly synchronized so as to start exactly at the same time as the transmitter. If but a single figure in the number is wrong, the lag at every turn would in-



HOW THE CRYPTO DEVICE TRANSMITS THE CODE

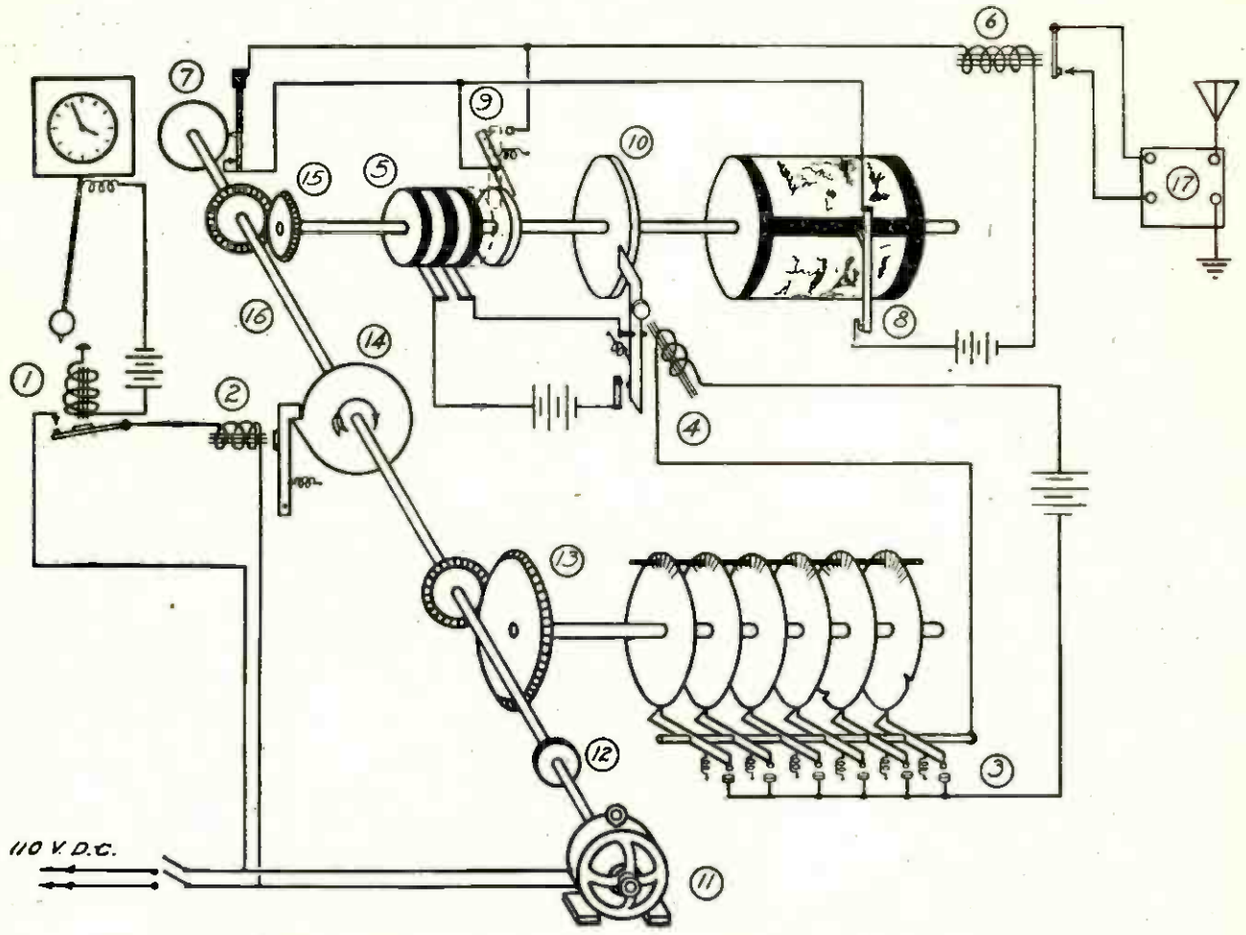
FIGURE 3: *On the disc M, the dot and dash characters P, are printed by raised portions which, by means of a needle O, close a switch Q and a relay R, thus sending a signal to the radio transmitter.*



International

THE RADIOCRYPTOTELESTEREOGRAPH IN OPERATION

Here are shown the two complete machines, one for transmitting and one for receiving pictures by the Belin process. Both machines are run by synchronous electric motors, and the receiver is timed by a radio impulse sent out at regular intervals so that both the transmitter and the receiver will keep in time; otherwise the pictures would be deciphered incorrectly and would be reproduced merely as a meaningless jumble of light and shade.



THE COMPLETE TRANSMITTING APPARATUS

FIGURE 4: *This schematic drawing shows how the apparatus insures the complete secrecy of the transmission. With this device there is less chance than one in a million that pictorial eavesdropping might be accomplished.*

crease and put the whole system out of tune, and the results on the receiving cylinder would be unintelligible, as several spots would be reproduced at irregular intervals. The false signals disc, in other words, would produce some extra spots which would render the picture or message absolutely unreadable.

All these operations are made at every turn and happen every second. The time required to send a picture or message being about 4½ minutes.

The vital factor in my machine is the synchronism which insures the transmitter and receiver turning at the same speed. It includes a clock that has a contact system which closes a local circuit every second. By means of an adjustment at the receiver, the contact may be made exactly at the same time as at the transmitter. The operator at the receiving end listens to the tick of the transmitting clock which closes the circuit of the radio transmitter, and adjusts the contact so that the local circuit of the receiving clock is closed at the same instant. Once this is adjusted, both transmitter and receiver are started and the picture sent.

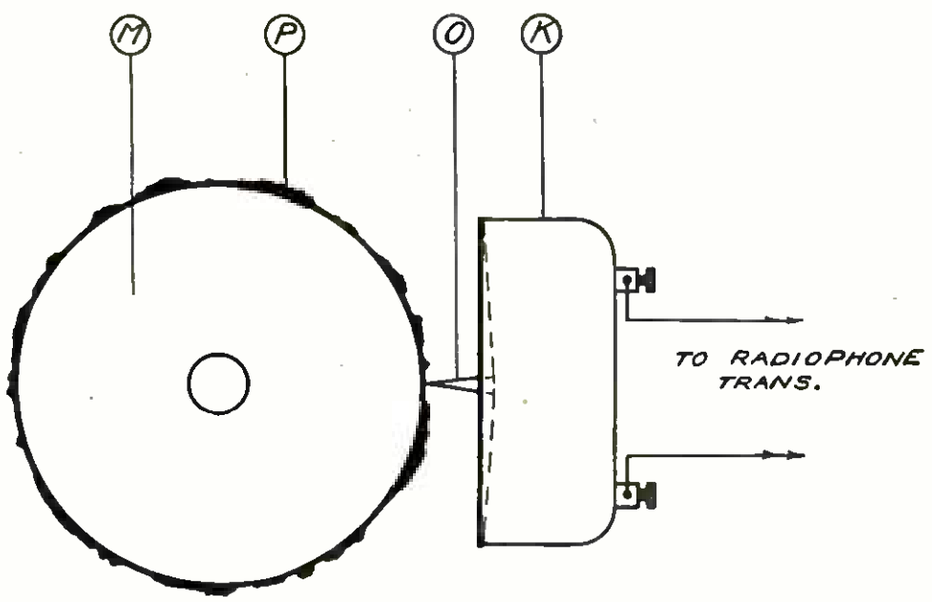
The picture to be sent is photographed on a gelatin plate which is developed and stuck on a brass cylinder over which a needle contact slides in the same fashion as the needle of an old style phonograph or of a dictaphone. The motion is such that the needle covers at each turn one-hundred-and-twenty-fifth of an inch, which has been found sufficiently accurate to reproduce details. Every time a black part of the picture passes under the needle it opens a local circuit, for these black parts are in relief; when the gelatin is developed, the white parts of the picture are eaten

away by the developer and form a depression. (See Figure 3.) Every time the local circuit is opened, the current of the battery, B, is interrupted and the circuit of the radio transmitter, controlled by the relay, R, is closed, thus sending a signal.

Figure 4 shows the complete transmitter with the crypto apparatus that insures complete secrecy of the transmission. The transmitter is operated by an electric motor upon the shaft of which are mounted a friction device, the necessary gears, the synchronizing disc and the small wheel that produces the false signals. Every second, when the clock makes a contact, the relay 1, is closed; the 110 volts that energize it flows through the relay 2, releasing the synchronizing disc which is stopped at every turn when the tooth catches on the arm of the relay. The motion is therefore transmitted to the cylinder and the picture sent as explained previously.

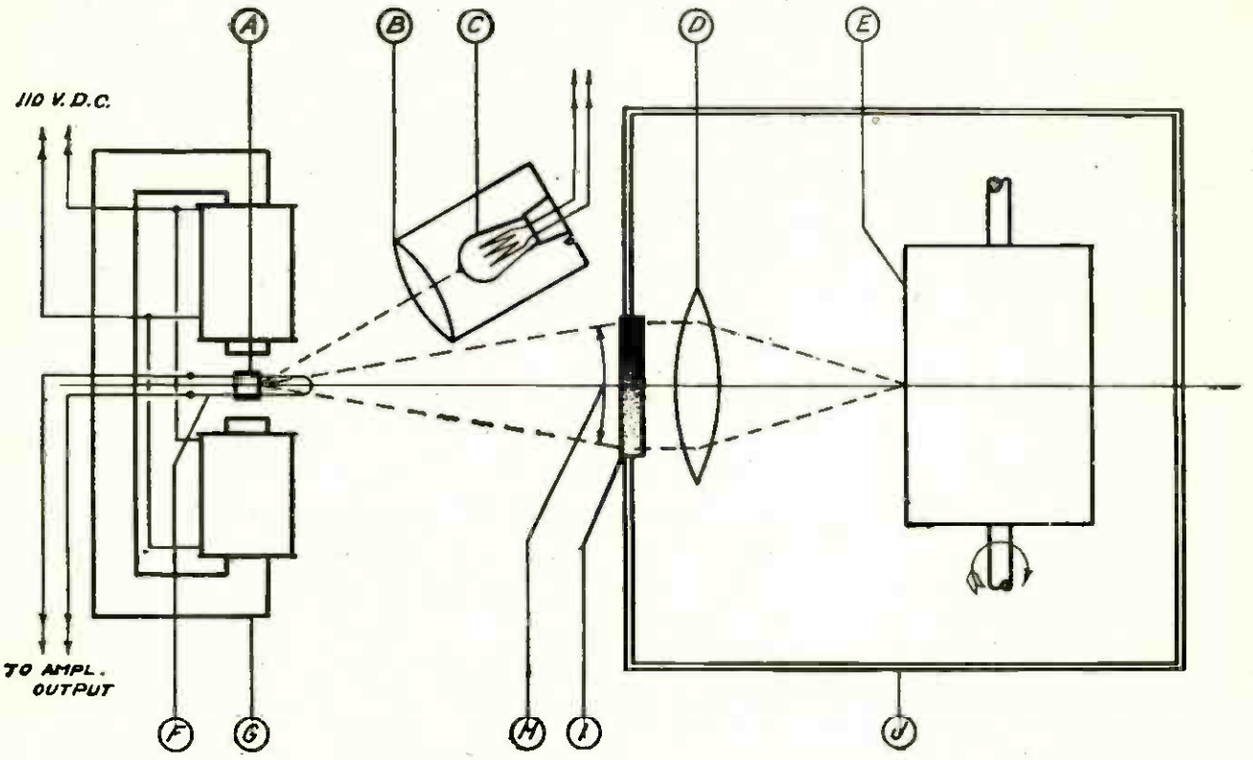
The purpose of the tooth on the synchronizing disc is to stop the cylinder at every revolution during a fraction of a second. The reason for this will be explained later. As the cylinder stops at every turn in the same position exactly where the picture ends, the contact 8, is closed, but at the same time, as the magnetic clutch 5, is released, the switch 9, is opened and is pushed back by the steel disc when released; this puts in circuit the "static machine" 7, composed of a disc corrugated so as to imitate a picture. This disc, which turns all the time with the motor, sends artificial signals that operate the radio transmitter in the same manner as if the contacts were made by the picture. However, while the picture is being sent, the "static disc" is short-circuited.

The receiving apparatus is similar to the transmitter except that the cylinder upon which the sensitive film is stretched is enclosed in a light-proof box that has but one opening about the size of a pin-hole. The received current passes through the "string" of an Einthoven galvanometer which normally obstructs a beam of light concentrated through a fine slot. When the needle passes over a black part of the picture at the transmitter, a signal is sent and causes the galvanometer string to deviate at the receiver, thus unobstructing the light beam



HOW PICTURES ARE TRANSMITTED

FIGURE 5: *For transmitting photographs and other pictures that require half-tone effects this device is used instead of that pictured in Figure 3. The microphone follows all of the various shadings between white and black, whereas the switch device can only distinguish between pure white and deep black.*



THE COMPLETE RECEIVING APPARATUS FOR PHOTOGRAPHS

FIGURE 6: *This includes the mirror A, which reflects a beam of light from the lamp C, passing through a lens B, through a shaded screen I, and a lens D onto the drum E. The screen, lens, and drum are located in a darkened chamber J. The moving coil F causes the mirror to swing, thus causing the reflected beam of light to pass through the arc H in accordance with the transmitted impulse. It is this swing which reproduces the picture by passing the beam through the clear portion or the opaque portion of the screen.*

which passes through the pin-hole, and thereby making an impression on the film.

When the entire message or picture is sent the film is developed and prints are made in the usual way. Either a negative or a positive may be received at will by merely adjusting the galvanometer so that the string obstructs the light when a signal is sent. The reason why the cylinder that supports the pictures at both the transmitter and the receiver are stopped at each turn is that it has been found by experiment that the ordinary synchronizing systems are not reliable, and that it is almost impossible to keep the two cylinders turning at the same speed unless one uses a correcting system. In our apparatus, the correction is made at every turn by having the main shaft stopped by the tooth on the synchronizing disc. Every second both cylinders start at the same time, thereby preventing any great variation to be introduced while the machines are running, even in the cases of slight speed variations that are caused by the motors.

This apparatus, which may be built in a compact form, has been used in experiments carried on aboard airplanes for sending sketches and messages from a plane to the ground. Very shortly I intend to transmit pictures from Europe to America.

The process, as here described, permits only the transmission of pictures in black and white. This is on account of the equipment of the radio stations, which can send only dots and dashes. However, when a radio telephone station of sufficient power is available, the stylus that presses against the picture, fixed on the cylinder, may be replaced by a microphone that has a needle mounted in the center of the diaphragm. Half-tones may, therefore, be sent, as the microphone transmits all the variations of

thickness of the gelatin, as shown in Figure 5.

At the receiving end, a Blondel oscillograph is substituted for the Einthoven galvanometer, so as to permit the reproduction of all the values of gray in the picture.

The oscillograph is composed of a strong electromagnet, in the field of which is an armature made of fine silver or gold wire in the shape of a long loop. Upon the wire is stuck a tiny mirror, that reflects a beam of light that is projected upon it. When the picture is being sent, the microphone modulates the radio waves in the same way as the voice does, and at the receiver the modulated current is sent through the armature of the oscillograph. This variable current, passing through the loop of fine wire, twists it more or less, and thus moves the mirror attached to it and deflects the beam of light—as shown in Figure 6.

The beam of light passes through a screen that is shaded from black to white, interposed between the galvanometer and the lens; this concentrates the beam upon the film. As the light is of variable intensity, a half-tone picture is received with all the details and shades of the original.

¶ *The latest developments in the field of radio communication between aircraft in flight and land stations—developments that mean much in the safeguarding of lives and property—will be told in a coming issue of* POPULAR RADIO *by Robert G. Skerrett.*

Is Mars Signalling to Us by Radio?

Among all the planets the one that is most like the earth is Mars. That planet is nearer to the earth this month than at any time since radio was discovered. Many astronomers believe that it is inhabited by intelligent beings. Perhaps they are trying to tell us what they are like

By FITZHUGH GREEN
Lieutenant Commander, U. S. N.

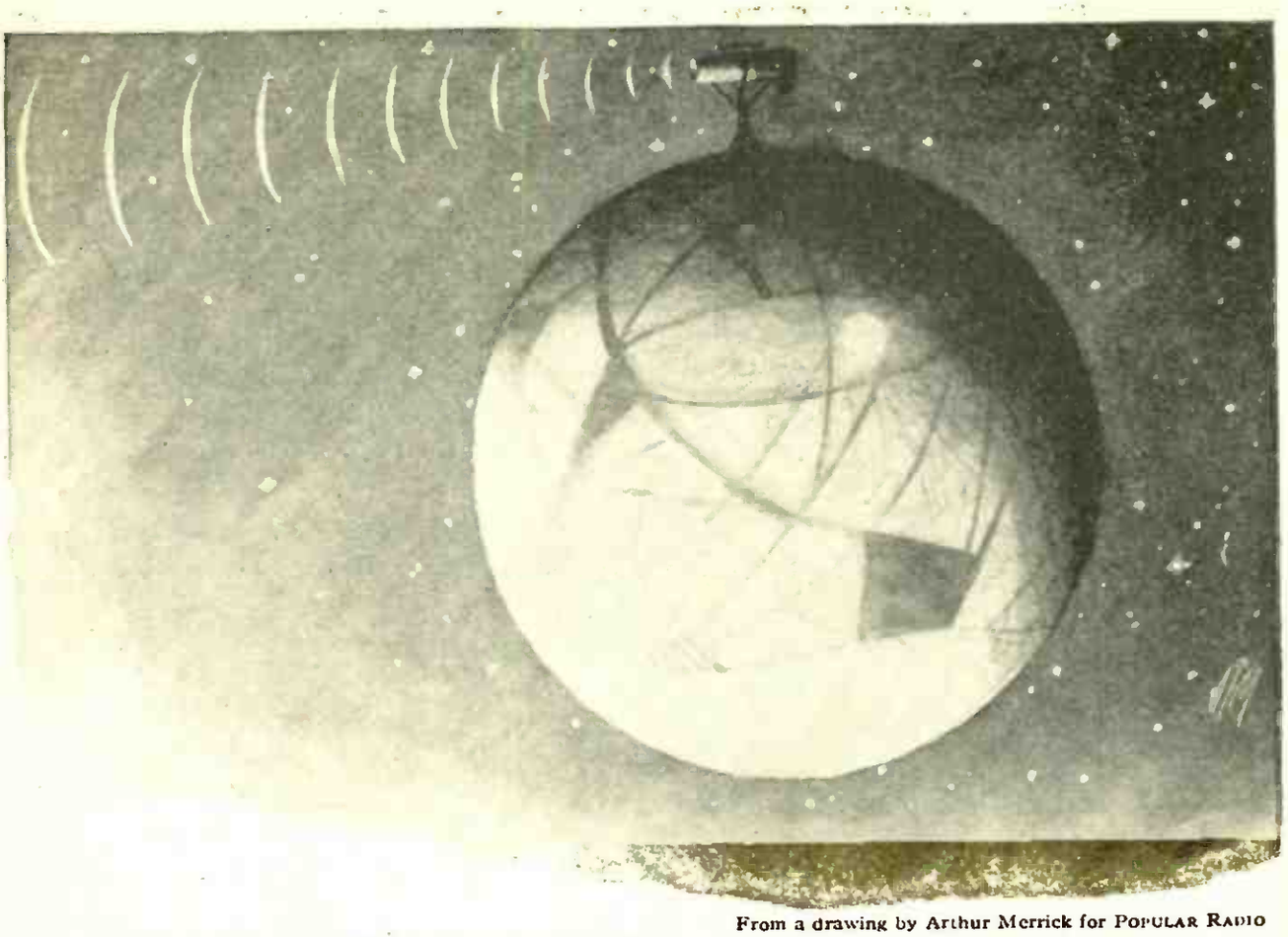
ON August 22, 1924, Mars will be in that part of its orbit which brings it nearest the earth: a distance of about 36,000,000 miles.

If Mars is inhabited, August and September will be the months in which her people are most likely to attempt communication with us.

The more we learn about Mars the more probable such a miracle becomes.

Conditions on Mars suggest life as we know it. The Martian day is 24 hours and 37 minutes long. Professor Lowell computes her mean annual temperature as 47° F., or near that of Canada.

When one of the polar regions of Mars comes into view after being turned away from the sun it is snowy white like our own. That means water. Water



From a drawing by Arthur Merrick for POPULAR RADIO

This drawing of Mars shows some of the dark-line "canals" that astronomers believe may be strips of vegetation growing along artificial aqueducts built by intelligent beings. The larger dark areas may be vegetation also. The white spot is one of the polar snow caps.

with a temperate climate means life.

In support of the theory of life are visible colors on the surface of this planet that correspond to our seasons: a blue-green in spring and summer; a warm reddish-brown in fall. Also there are dark patches that may be seas.

Further, there are the so-called Martian "canals." These are visible black lines stretching from pole to pole. They are too straight to be classed as natural phenomena. We believe they have been built to carry water from the polar regions to densely populated latitudes near the equator.

This "canal theory" is not at all illogical. We know that evaporation on Mars is immensely greater than on our earth. Water is scarce. And even if the canals extend over 2,000 miles long, as some do, the task of building them would not be so incredible as would seem at first sight. The mass of Mars is but one-ninth that of the earth. Gravity is proportionately less. Martians could easily erect in a year a gigantic pyramid that would take us a lifetime to build.

Assume, then, that Mars is inhabited by human beings; that is, by some species of animal that *reasons*.

Call this inhabitant of Mars a *Martite*. He sees the earth nearby. From its white poles, its temperate zone, its browns and blues and greens, he reasons that it, too, is inhabited.

The Martite is probably a highly developed individual. As the planet on which he lives is much smaller than the earth, it cooled off much sooner. Life must have appeared much earlier. Whence there is every reason to believe that the age of its civilization is immensely advanced over our own. The Martite may be 100,000 years ahead of you and me!

It is natural to suppose that the Martite is, like us, intensely curious about his neighboring planet. Vision tells him much; far more, no doubt, than we

know of him. For his telescopes must have become highly perfected. He may even be keeping a first-hand record of our wars, our tornadoes, our spreading cities, our dwindling forests.

Let us suppose that he invokes the aid of his physicists to tell him what is the best way to reach us by signal. Light or sound waves, they reply, would require too much energy to cover the vast intervening space. But a form of rays that travel immense distance with small impulse might do it. So the Martite begins to send out radio waves.

Have we begun to catch them?

It is highly probable that we have. Put on your telephones any quiet night about three A.M. and you will hear faint whispers sifting out of the great black pit above you. Many of these whispers cannot be explained by even our most ingenious delvers into the mysteries of wireless. So it is not at all absurd to contemplate the possibility of their originating on Mars.

But catching signals and reading them are very different things.

Two human experiences may be brought forward that demonstrate the difficulty we face in trying to interpret Martian signals.

First, is our widespread use of codes or ciphers. Codes are convenient in war, business, crime and love. In Continental Morse code three dots or short buzzes stand for *s;* three long for *o.* In business code the word *storm* may mean "deliver at earliest possible date." The lover may write *blossoms* on a post card to remind his sweetheart that they will be married in June.

All codes or ciphers fall into one of two classes: they are either of the substitution or the transposition type. In the former one letter or word is substituted for another. This was shown above in the words *storm* and *blossom.* Likewise we may use A for B, B for C; and so on. Figures or symbols may also be substituted for the alphabet.

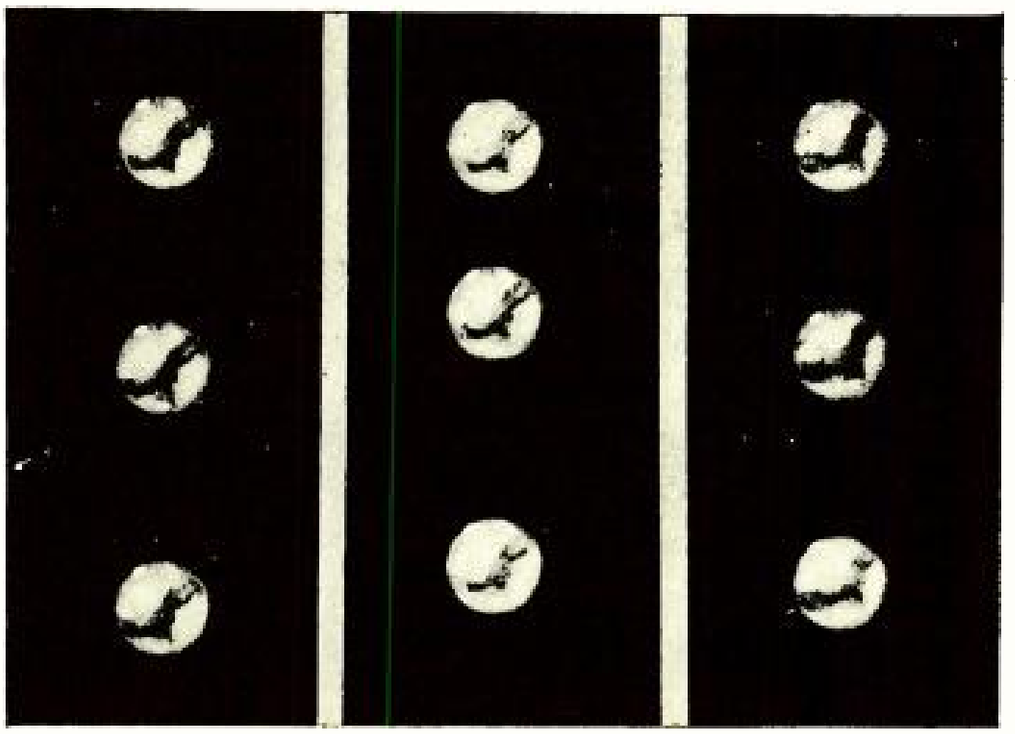
In the second form of code, meanings or letters are transposed in accordance with some prearranged plan or mechanism. Thus cipher boxes, disks, and so on are used in war. Most are too complicated to warrant explaining.

The outstanding feature of all such schemes is that *no code or cipher has ever been devised that was not capable of being deciphered!*

From a photograph loaned by Professor Goddard

WILL HIS ROCKET EVER REACH MARS?

Professor R. H. Goddard of Clark University has invented a "space rocket" that can leave the earth's atmosphere and go off into space, even as far as Mars. At Professor Goddard's right may be seen the vacuum tank in which the principle of this rocket was tested.



ACTUAL PHOTOGRAPHS OF MARS

These camera studies were made by Professor Barnard with the great Yerkes telescope at the time when Mars was last close to the earth. The polar ice cap shows clearly, as do some of the dark markings believed to be caused by vegetation. The canals are too narrow to be visible on photographs.

The reason for this is that all codes are based on human language. The code expert is primarily a linguist, and secondarily a mathematician. In the late war no code went long unbroken. The chief value of such efforts to deceive the enemy lies in the time it takes to decipher them.

With almost no exceptions language is formed from words which in turn are formed from letters. These letters are the distinct fruit of man's experience on earth as expressed by the vehicle of marks or symbols. So when we earth-born start to decipher any strange combination of marks and symbols, whether written or signalled by our fellowmen, we have a great background of human experience to go on.

Putting it another way, the human mind always works along the same general lines. In consequence, when the average man sits down to evolve a cipher he ends up in pretty much the same way as any other man would. The best ciphers the world was using in 1918 were based on those of the Abbé Tritheme, who was alive when Columbus discovered America.

Hence, no matter how easy it is for a code expert to decipher any abstruse system of human communication, he would face an entirely new sort of problem when he tackled Martian signals with no human mind or speech behind them.

This brings us to the second human experience that can help us think more clearly about inter-planetary radio; namely, the deciphering of ancient languages and inscriptions.

There are three reasons why man invented writing.

First, to recall a time something happened, *i.e.*, to fix a date, just as we build a pile of rocks to indicate our picnic spot.

Second, to mark a possession, such as a brand on cattle.

Third, to communicate with some distant person, such as send a gift or token of friendship.

In the earliest forms of writing a visible object was usually engraved on

a bone or stick. A sketch of a deer lying on its back, feet in air, with the hunter standing over it carrying his bow and arrows would signify the successful hunt. That is called pictographic writing.

But man's imagination soon carried him further. He saw that abstract ideas could be expressed in the same way. In old Egyptian inscriptions the picture of a child means *youth;* an eye means *see;* a man with a stick in his hand means violent action. In ancient Mexican language *famine* is denoted by the image of a human being with protruding ribs. In a Californian rock painting eyes from which fall tears stand for *sorrow.*

Archaeologists have painstakingly studied every tiny bit of evidence of the past. And so far they have deciphered practically all ancient writing that has been discovered. But, like the code experts, they, too, have laid their research upon a groundwork of human experience. They know how the human mind functions. They know what the instincts and emotions of the human body are. They have studied the mathematics and psychology of reasoning processes.

Wherefore, also like the code experts, our archaeologists would probably find it generally impossible to apply the principles of their deciphering methods to symbols originating from a civilization about which we can only vaguely conjecture.

Suppose you and I lived on the tops of two neighboring peaks. Daily we communicate with one another by an intricate code of signals that our race has developed after centuries of effort. Now let an archaeologist and a cipher expert enter the valley between us and watch our signals for a while. The chances are that they would eventually be perfectly able to read everything we say no matter whether we are Indians, Egyptians, or Chinese, or just hostile members of their own race signaling in code.

But suppose the signals our experts were watching—or hearing, for it makes no difference—were being made by a race of people that had evolved under conditions differing widely from anything we have ever known. Suppose that the background of human experience with which the archaeologist and the cipher expert are accustomed to work were wholly swept aside. In a word, suppose the language or code we confront our scholars with were made in Mars 36,000,000 miles away. What then?

Here first we see the problem of Martian communication in its true light.

It took the world 3,000 years to go from picture language to alphabetic writing. Where will the Martians have gone in the 100,000 years start they may have had on us? Three distinct systems of pictographic writing developed among the handful of people that settled early Europe. What one of the infinite number of conceivable pictographic combinations could have formed the beginning of Martian language, if such there be?

Again, think of how little our human experience may apply to that of the inhabitants of Mars. From our viewpoint they may be physically grotesque. Just because our reasoning species chanced to be derived from the genus *ape* is no excuse for our concluding that the reasoning species of a planet shouldn't have begun with something like a kangaroo, a fish, or fowl, or whatnot?

There is the matter of environment to be taken into consideration. In the rare Martian atmosphere its inhabitants may all possess great bulbous lungs. With scarcely any pull of gravity underfoot their legs may be fragile as a gnat's. Under the incredible glare of Martian sunlight their eyes may have developed projecting lids like glittering scales above their pinched and blackened faces.

Briefly, one is justified in letting imagination run riot on the score of the Martite's personal appearances. Hence, if we are to meet and understand him, it must be solely on the ground of experiences common to us both.

From a drawing by Arthur Merrick for POPULAR RADIO

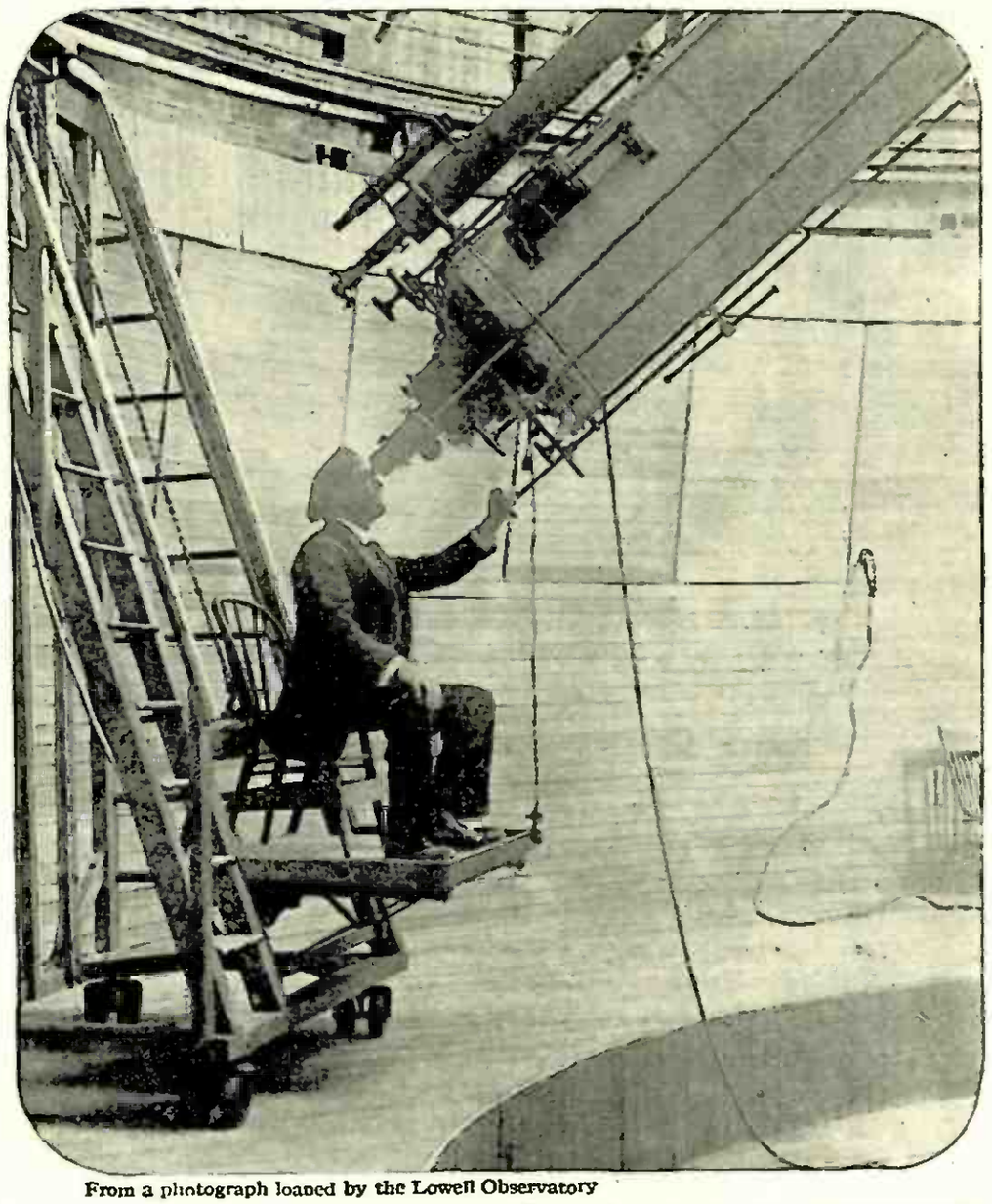
HOW THE HEAVISIDE LAYER MAY BLOCK RADIO MESSAGES TO MARS

Even if we built a radio-beam transmitter powerful enough to reach Mars across the 36,000,000 miles of intervening space we might fail to get our messages through. The Heaviside Layer would act, scientists believe, to scatter the radio waves.

This is our first real clue to the riddle. And here the archaeologist or the cipher expert must start:

What experiences would be common to the Martite and to Terrestrial men?

Reflect for a moment. Picture that ruby planet blazing in the sky. When do you see it with the naked eye? At



From a photograph loaned by the Lowell Observatory

AN ASTRONOMER WHO BELIEVED MARS TO BE INHABITED

The late Dr. Percival Lowell did more than any other astronomer to call attention to the evidence that Mars is the home of intelligent life. The best studies ever made of the Martian canals as well as of the climate and weather of our sister planet were carried out by Dr. Lowell in his famous observatory built at Flagstaff, Arizona, especially for Martian observations.

night, of course. In common, then, both planets have night and day. Or, putting it broadly, the astronomical features of their existence are generally the same.

This leads us to a second observation. As the Martites see the stars, and since we assume that they can reason, we may in turn conclude that they can count. Counting was one of man's earliest accomplishments.

Now, connecting these two facts, it is very proper to suppose that no matter what had been the histories of the human and the Martian races any intelligent representative from each would try to signal across intervening space in pretty much the same way. He would pick out some unmistakable experience common to both and give it a number, or some such symbol. and send out that number or symbol every time that experience occurred.

For instance: The people of Mars must have figured out when the moon gets between us and the sun. Hence to establish a symbol for that phenom-

enon they would send something, say groups of three long dashes, every time we had a solar eclipse. Then, after we had become convinced that the signals were coming from outside the earth, we for our part would wait until some astral body got between Mars and the sun and send a similar signal. If the signal were promptly repeated we would at once know that it was Mars with whom we were talking.

Thenceforward, three long dashes would mean literally *eclipse*. And from that one image a number of valuable abstract meanings could be evolved, such as: *stop*, because an eclipse stops light; or *night;* or death; and so on.

In like vein we could identify seasons. Possibly if the Martian telescopes were extremely powerful we could soon catalogue meteorological phenomena and give symbols to them in our growing signal code.

Along that line we should soon want to develop some large, simple, geometrical figures visible to Mars. Tesla once suggested that we arrange a number of powerful lights in rectanguar form in such a way that various combinations could be turned on from a central switching plant. Mars could read such figures easily.

Now you will understand more clearly the references to early writing and to ciphers. For the growth of earth to Mars signalling will likely have been epitomized in the development of man's ability to write.

Once the simple ideaographic signals suggested above have begun progress will no doubt be rapid. In five years we should actually exchange thoughts. For the brains of the world will be concentrated on the problem. Nothing else imaginable would appeal so strongly or so universally to the human mind.

The theme is speculative beyond a doubt. Yet, relatively speaking, Mars is no further off from us this August than was America from Europe in the days of Julius Caesar. Flammarion last December said, "Rest assured that we shall some day correspond with the inhabitants of Mars."

It would be rash to predict that we will not some day communicate with other worlds.

Altogether it is a fascinating subject to dwell upon. And while the code expert and the cryptologist will be called in to help decipher the early Martian messages, the philosopher will probably do as well as they. A philosopher is simply a man with an unusual amount of common sense. In other words, you and I have just about as much chance of being the first to listen to Mars as any genius has. Think it over.

A MINIATURE RECEIVER MADE BETWEEN THE ACTS

An old cigarette box furnishes the basis of this little crystal set that was made by the musical comedy star, Mitzi, in her dressing room. The switch points, crystal and binding posts are on the cover, and the coils and the condenser are inside.

Kadel & Herbert

[From a photograph made by Wired-Radio, Inc., for POPULAR RADIO

RECEIVING A RADIO PROGRAM PLUCKED OFF THE ELECTRIC LIGHT WIRES

A practical demonstration of General Squier's suggestion. The wired-radio receiver is the small round box at the right; at the left is an ordinary space-radio receiver which either can be connected to the line-radio receiver as an amplifier, or can be used independently to receive ordinary broadcasts.

Broadcasting on the "Pay-as-You-Enter" Plan

Here is a unique plan for defraying the costs of broadcasting. It was first proposed by General Squier, "the father of wired wireless," in a private talk to the officers of the Signal Corps of the Army on December 19, 1923, but it has such unusual interest at this time that POPULAR RADIO *has prevailed upon the author to describe his plan to a large audience in this exclusive article.*

By MAJOR GENERAL GEORGE O. SQUIER

THE problem of who shall pay the cost of broadcasting is one that we must consider very seriously. It is obvious that broadcasting is a great public service. It must not be allowed to lapse. Furthermore, the most elementary considerations of public prudence require that this, the greatest of all channels to the American ear, should be kept free from the machinations of evil or self-seeking men. A sound broadcasting policy is one of the most important essentials, it seems to me, to the progress and successful

future of the United States.

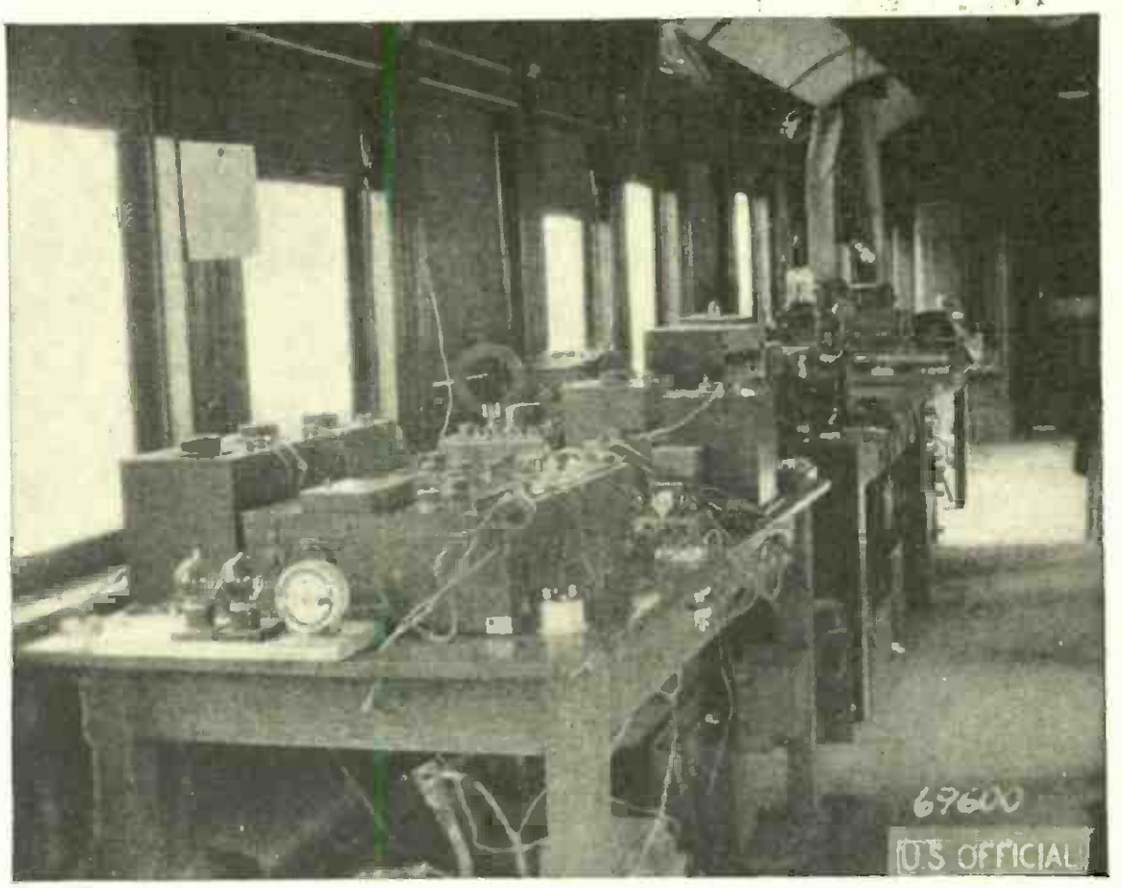
At present the whole industry lacks a sound financial basis. The purchaser of a receiving set may receive, without license, the finest sort of programs. These programs cost money now. They will cost still more in the future. Somebody must pay for them. The question is, who?

The first step is to analyze the situation.

In reality, there is no such thing as "wireless." Every radio broadcasting station is composed essentially of wires; similarly, every receiving set is composed of wires. The only "wireless" part of the system is the ether-link between the antenna of the broadcasting station and the antenna of the receiver. This ether-link it seems to me, is necessarily free. During this part of the progress of the radio wave from sender to recipient no taxation is possible without undue interference with what might be called one of the natural rights of man, the freedom of the ether.

But it is possible to control broadcasting in the public interest at either one of the two ends where this, like all forms of radio, is not wireless at all but is a matter of the use of apparatus. Such a control over the sending is now exercised through the regulation of broadcasting stations by the Department of Commerce. An analogous control over receiving is in force both in Great Britain and in Australia, where licenses are required for receiving sets and where these sets are taxed to provide the funds necessary for broadcasting.

But this policy is repugnant to the American mind. It does not seem reasonable to us, for example, that a



Signal Corps, U. S. A.

THE WIRED-WIRELESS RAILWAY CAR

This apparatus, mounted in an ordinary railway coach, was used by General Squier during the World War in working out his methods for sending radio over electric wires. It was here that the Signal Corps system of line-radio was tested and perfected.

International

When the opening game of the 1924 baseball season was played Frank Chance of the Chicago White Sox was ill in bed, but he did not have to miss the game. Radio provided his "eyes" for the occasion. This may be possible in any hotel and apartment house if General Squier's plan is adopted.

farmer should be compelled to pay out of his meagre income a heavy tax for the ownership and use of his broadcast receiver. On the other hand, there are many persons in the cities, more fortunate financially, who would not object to paying a reasonable tax.

The practical problem is to select somehow those individuals who should and will pay for broadcasting, without interfering, legally or otherwise, with the individuals who cannot afford to pay for the service and to whom, nevertheless, it is a matter of public policy that good radio service be provided.

Let us consider a definite case; for example, the use of radio in a great hotel like the Pennsylvania Hotel in New York City.

This hotel contains approximately 2,200 guest rooms. Presumably most of the guests occupying these rooms would like to enjoy the radio broadcasts at some time during the day, if provision for this could be made conveniently and at reasonable cost.

But to install a special receiving set in each room is impracticable on the

ground of cost, if for no other reason. What is the solution? It will lie, I believe, in the installation of one first-class receiving equipment in the hotel, which equipment will then distribute the received material obtained both from outside and inside the building over quite simple apparatus to all the individual rooms.

There are three ways in which this distribution might be done.

First, it would be possible to install a complete new wiring system in the hotel; a special pair of telephone lines leading from the radio central to each room. This is quite practicable from the engineering viewpoint, but it would be even more costly than providing 2,200 separate receiving sets, especially if this new wiring had to be installed in a building already constructed and in use.

Second, the broadcast material received at the radio central might be distributed over the ordinary telephone system in the hotel. This, too, has many disadvantages. For one thing, the telephone system is already in use for other purposes; also, the hotel telephones are tied-in to that marvelous network of wires and appliances which has been created by the American Telephone and Telegraph Company for its particular purpose, namely, for point-to-point two-way communication between different individuals in different parts of the United States. Any attachment of radio apparatus to this great telephone system involves, necessarily, important dangers to the system itself and tremendous engineering complexities, which it is not surprising that the engineers of the telephone company view with alarm.

But there is a *third* way of distributing received radio concerts to the guests in a hotel like the Pennsylvania. This is distribution over the lighting system.

Each room in such a great hotel contains not only the ends of the two wires coming from the telephone switchboard, but it contains another wiring system. It contains, already, a number of outlets each one connected with the two wires of the electric power system.

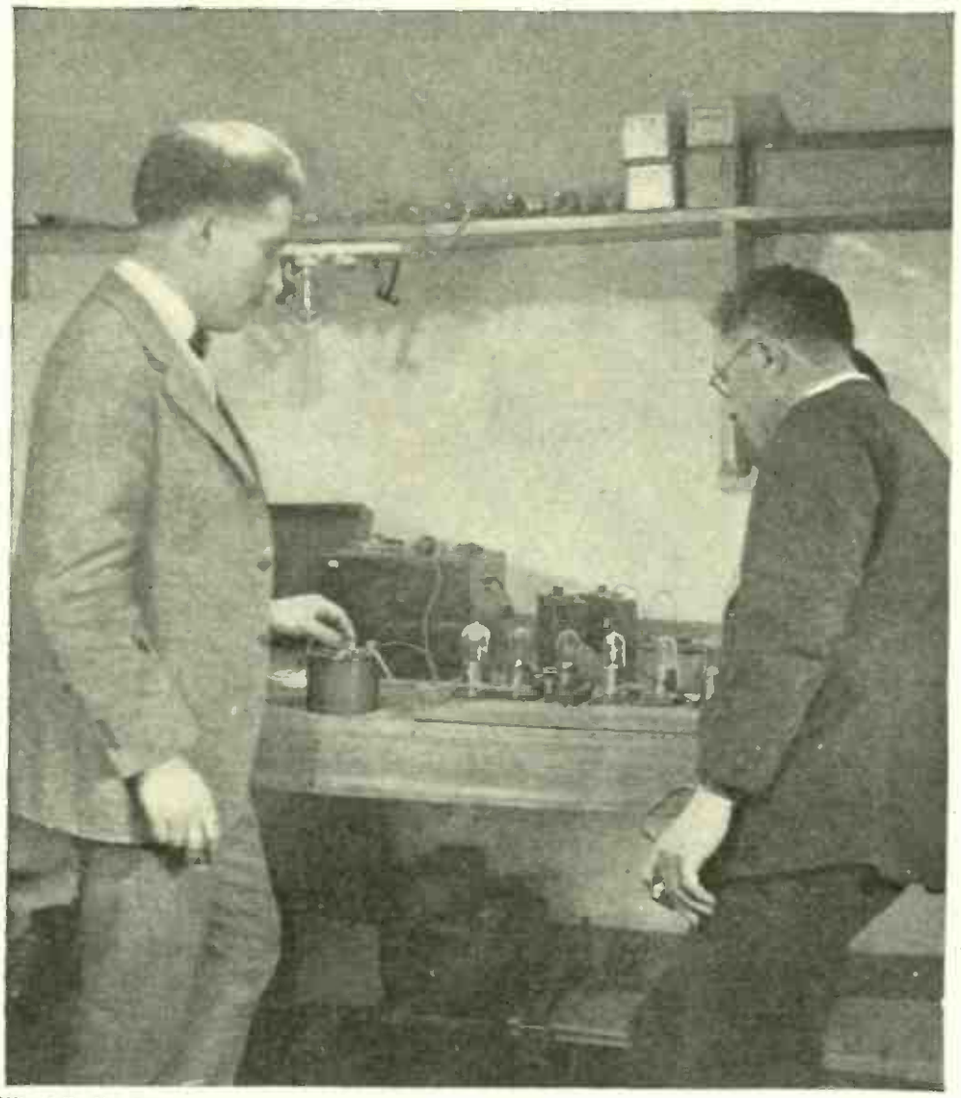
This electric power system is already a device for broadcasting. It "broadcasts" electric light to each room of the great hotel. Furthermore, we have become accustomed to using this same system to broadcast mechanical power. Motors, flat-irons and hair curlers are now "broadcast" over this system quite as successfully as radio concerts are broadcast through the ether.

What is more natural than to use this existing power-broadcasting system to distribute the received radio material to the rooms of a hotel? At some one point in the hotel there will be located a radio receiving room of the most modern design in charge of a competent radio engineer. The receiving equipment will be designed for the simultaneous reception of two, or a dozen, or even more radio broadcasts. These broadcasts will then be fed out over the electric light wires inside the hotel. Many of them can be distributed simultaneously, each one on its own carrier wave. These waves will have frequencies in general between the range of audibility and the range usually employed in radio. Each room of the hotel will be equipped with a simple crystal receiver tunable to any one of these ultra-audio frequencies, and with a pair of telephones. All the engineering equipment necessary for such an installation is already available. We are waiting merely for someone to make an actual installation.

But how would this solve, you ask, the problem of paying for broadcasting?

In the following way:

Most of the guests of a hotel or an apartment house would be quite willing to pay a small monthly fee in order to receive this distributed radio service inside their building, just as in many apartment houses they now pay for



Wired-Radio, Inc.

WHERE RADIO PROGRAMS ARE PUT ON THE LIGHT WIRES

This picture shows a part of the laboratory where radio programs are sent out over the electric light wiring on Staten Island, New York. Customers of the electric light company can subscribe to the wired-radio service at a small monthly fee.

telephone service. If any individual guest did not wish to pay the fee there would be no compulsion. The cost of the service inside the hotel would be so small as to be almost negligible and a large portion of the fees received could be made available, therefore, for payment to the broadcasters. This might be done either by mutual agreement or under the direction of some central agency organized by the government or, possibly, by payments made directly by each hotel or apartment house to specific broadcast stations for the purpose of securing specified broadcast material demanded by the guests of these houses.

These details are not vital. The important thing is that this plan will provide an income for the general radio industry. This income will be derived, as it ought to be, from the listener. Yet there will be no resentment, nor will there be any financial burden upon the persons located in country districts, upon whom, every one agrees, it is undesirable that any financial burden be placed.

People on the farms will continue to receive their broadcast concerts free of charge, just as they do now. This is right and proper. The people in the hotels, who would be paying for the service, would not only be the people who could best afford to do so but

they would be paying, really, not so much for the broadcasting itself as for an especially luxurious kind of broadcasting. They would be paying for the luxury of receiving the broadcast programs conveniently, in their own apartments, and over apparatus (in the main receiving room) much more efficient and sensitive than they would care to buy individually or than they could operate successfully even if they bought it.

This plan would not affect detrimentally any of the interests now involved in the broadcasting problem. All broadcasters of the better class would be benefited by the availability of funds for the industry as a whole and by the greater stability and certainty which this would encourage. Musicians, dramatists, actors and other professions which are now demanding pay for their services to the broadcasting stations would see in prospect a source from which this payment might be derived on a reasonable basis. Owners of broadcasting stations would see prospective relief from the present tremendous expense which they are forced to undergo.

The American Telegraph and Telephone Company would see the stabilization of the broadcasting industry which Mr. Thayer announces to be the main object of his corporation in this connection. Furthermore, this company would be insured against any requests for undue disturbance of its point-to-point communication lines. Finally, the persons interested in the radio industry as dealers or manufacturers would not be confronted by the ruin of their business which is inevitable if broadcasting stops or deteriorates.

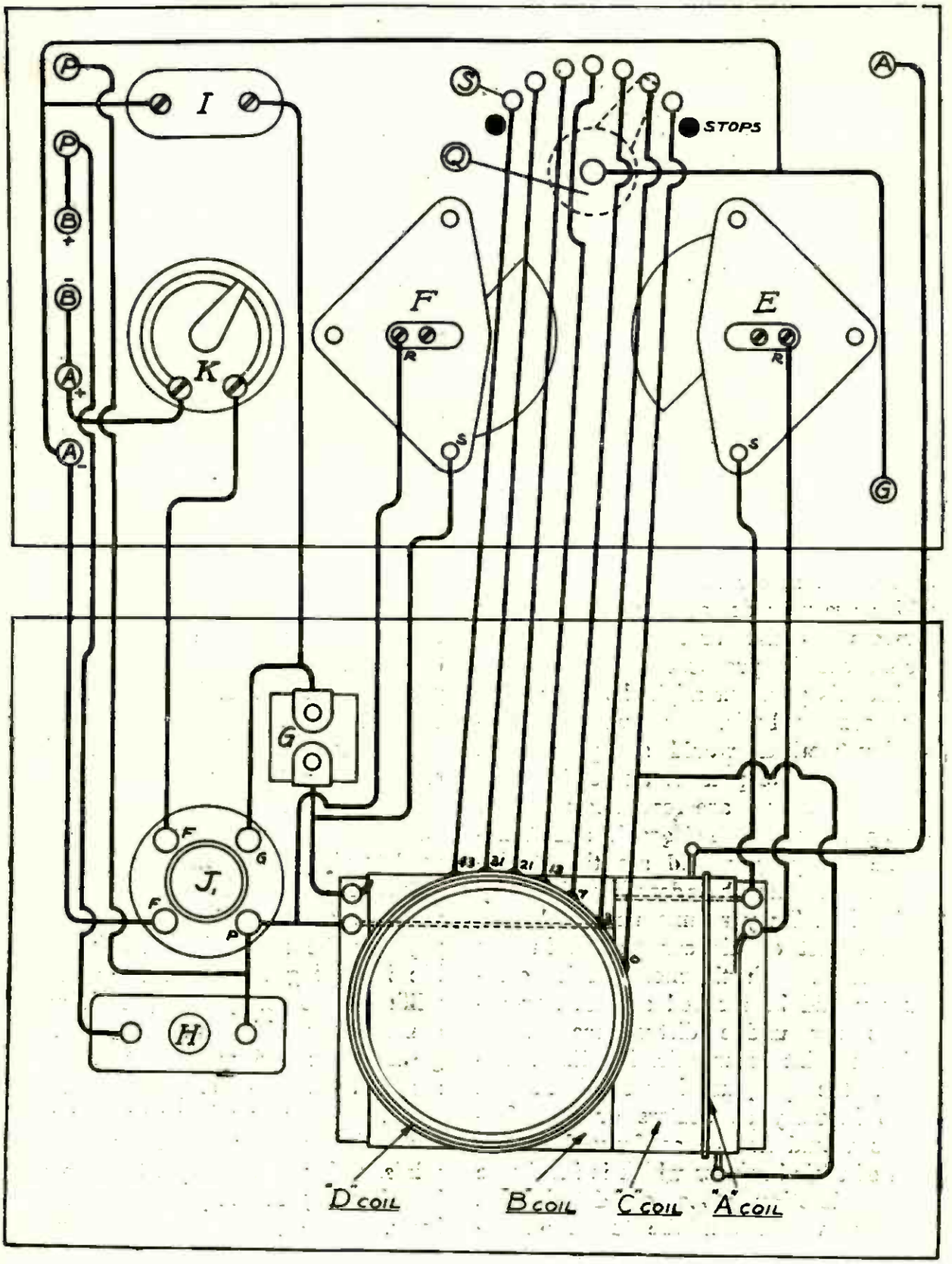
There would continue to be an active market for what might be called the luxury radio set, the five hundred or thousand-dollar equipment which the rich man wants to install in his own home. Furthermore, the building of sets by individuals inclined to do so would not be interfered with in the least, nor would the market for the cheaper forms of complete sets in small country towns be disturbed at all.

What would happen under this plan is that a class of persons who desire radio and who are amply able to pay for it—that is, the hotel and apartment dwellers—would receive far better radio service than they do at present, without interfering in the least with any of the classes that now support the radio industry. The present use of radio in hotels, apartment houses and dwellings in our great cities and urban districts is but a minute fraction of what it would be if it were more convenient for the dwellers in such places to secure satisfactory radio reception.

The man who rides in the city street cars does not resent the presence of taxicabs, although he seldom uses one. On the other hand, the man who can afford to ride always in taxicabs does not resent the charge he pays although this may be much greater than he would pay for the same ride in a street car. He is paying for a luxury and he is willing to do so. Just so, if we provide a means by which the dwellers in our great hotels and apartment houses can secure a luxury-quality of radio, they will be perfectly willing to pay for it, and what they pay, if properly administered, will be ample to support the broadcasting industry on a permanent basis.

Finding Mines by Radio

¶ *This article by Dr. E. E. Free that was announced for publication in this number has been deferred to the September number in order to provide space for Mr. Grindell-Matthews' timely and important contribution on page 148.*



A "Picture Diagram" of the Hook-up

Merely a glance at the above illustration will convince even the novice that a radio set is really easy to wire up. In this form of diagram the instruments are shown in picture form and the connecting wires are drawn in, IN THE EXACT MANNER THAT THEY SHOULD GO IN THE SET. *The terminals on the various instruments are plainly shown and the instruments are marked with designating letters that reappear in the text and the list of parts.*

Simple "How-to-build" Articles for Beginners
No. 1

How to build a single dry-cell tube, four-circuit tuner

By LAURENCE M. COCKADAY, R.E.

COST OF PARTS: *not more than $20.00*
APPROXIMATE RANGE: *1,000 miles*

HERE ARE THE ITEMS YOU WILL NEED—

A, B, C and D—Precision four-circuit coil;
E and F—U. S. Tool variable condensers, .0005 mfd., with vernier;
G—Dubilier mica fixed condenser, .00025 mfd.;
H—Amplex grid-denser;
I—Bradley leak;
J—Na-ald socket for 199 tubes;
K—Amsco rheostat, 30 ohms;
Q—switch lever;
S—switch points;
one 7 by 12 inch panel;
one 8 by 12 inch baseboard;
eight binding posts.

HAVE you ever made a radio set, yourself? Or are you afraid that you could not do it?

If so, you have missed the acute satisfaction that comes with building and operating even a simple radio receiver.

Here is your chance to start out and build a simple little set yourself. Read this article and then take the list of parts given at the head of this page to your nearest radio dealer and buy them.

You are then ready to start to construct your first set; it will be an easy matter to complete it if you follow the instructions given in the picture diagram on the page facing.

The drawing shows clearly just how to mount the variable condensers E and F, the grid-leak I, the switch and points Q and S, the rheostat K and the binding posts on the panel.

It also shows how to mount the coil (A, B, C and D), the socket J, the grid condenser G and the by-pass condenser H on the wooden base.

Of course, the panel should be fastened to the wooden base with small right-angle brass brackets before the work is started.

When you do the wiring, just follow the diagram exactly and you can make no mistake.

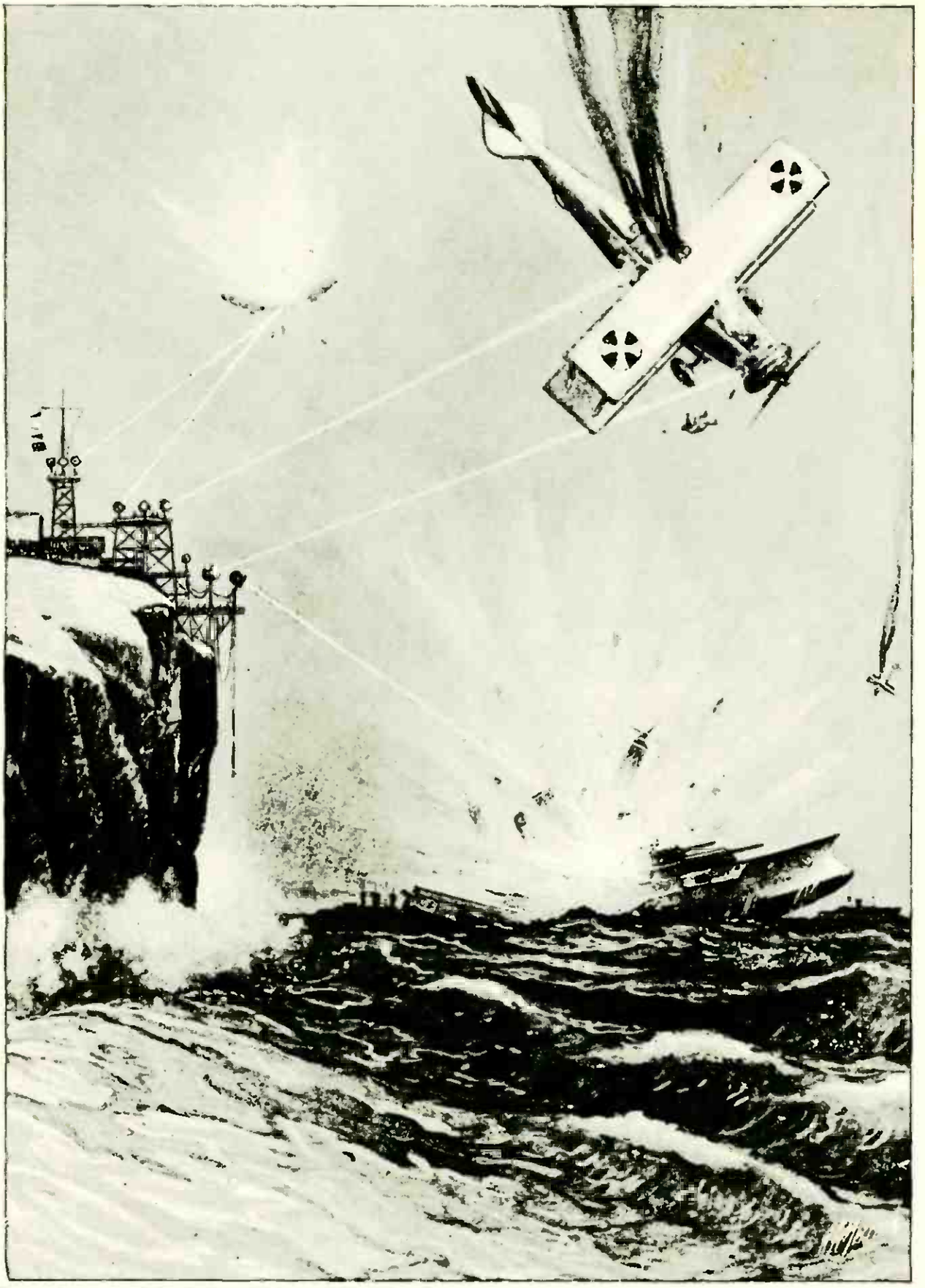
You will need one UV-199 tube or one C-299 tube, three dry cells for the "A" battery and one tapped 45-volt "B" battery.

The antenna and ground should be connected to the posts A and G. The three dry cells should be connected in series (4.5 volts) across the posts A– and A+. The 45-volt "B" battery should be connected across the two binding posts B– and B+. The telephones should be connected across the two posts marked P and P.

A 100-foot antenna is recommended for use with this set.

How to Build a Single-tube Reflex Receiver

No. 2 of this series of simple constructional articles for the beginner will describe how to make a single-tube reflex receiver with a crystal detector, at a cost for parts ranging between $22.00 and $25.00. This set has a receiving range of about 1,000 miles. The article will be illustrated with a "picture diagram" as easy to understand as the diagram on the facing page.



From a drawing made for POPULAR RADIO by Arthur Merrick

NARROW-CASTING DESTRUCTION WITH THE NEW CARRIER RAY

Power that can render machines helpless, as well as destroy life, can be directed against the enemy "much as a man may spray a stream of water from a garden hose upon a bed of plants," is one of the remarkable claims of the inventor.

The New Death-dealing

"DIABOLIC RAYS"

Has the dream of inventors come true at last? Can destructive power now be sent through space by what has been called "the most terrible invention ever made by man?" Scientists disagree. In this exclusive article the inventor himself tells what his ray can do and how it works.

By H. GRINDELL-MATTHEWS

THE projection of energy through space without the use of wires or other mechanical contrivances has long been a dream of scientists and inventors. The great Serb, Nikola Tesla, predicted this many years ago, more or less on the theory of radio waves. Other scientists have attempted the projection of beams of caloric or heat rays. Neither of these ideas proved to be successful.

Now, however, electrical energy can be transmitted across distances without the use of wires, cables, pipes, tubing or any other "visible means of support" for the current projected.

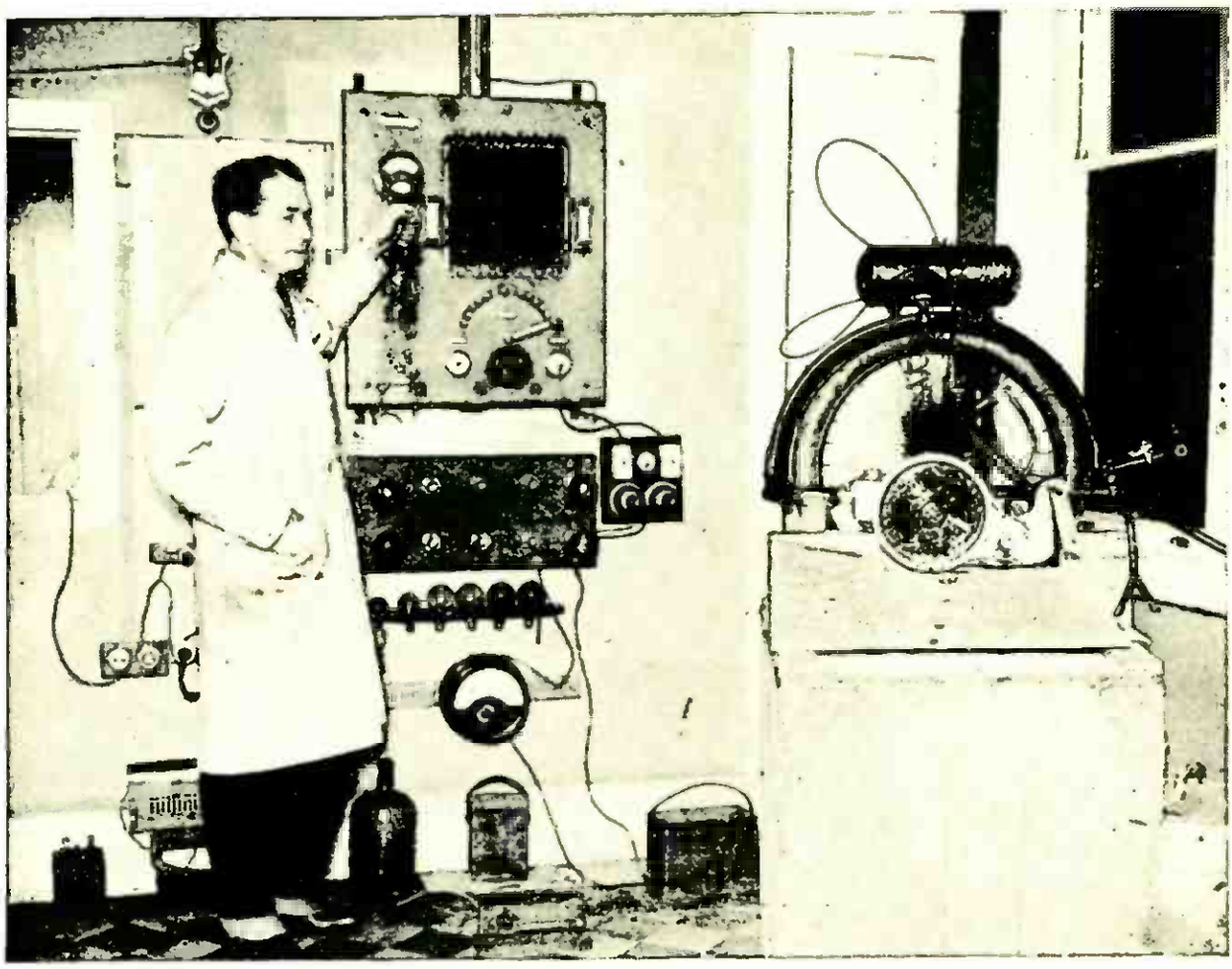
Not only that, but a current powerful enough to destroy life, machinery or any ordinary material can be controlled from the base of operations and can be directed at will against an enemy attack, much as the same attack might spray with machine-gun fire or as a man might play the stream of water from a garden hose against a bed of plants.

Many of the scientists who have attempted hitherto to accomplish this have been blocked because they were working on the theory of projecting heat rays. The natural and inevitable result was that the beams lost much of their strength with every foot traveled and became almost *nil* at a distance of thirty or forty feet.

It was reported a few years ago that a young officer of the French army had succeeded in projecting a heat ray to a distance of some sixty feet, with still greater distances in promise. The actual experiment turned out, however, to have been the explosion of detonators at a distance by means of a *light* ray impinging on a selenium cell. The projection of energy in any quantity was not involved.

Tesla's original idea was the development of a "field" of energy in the higher atmosphere. This could be tapped, he thought, at any time or place and could be used as a sort of "mine" of power from which factories, conveyances or homes might draw power as needed. People sneered at him, as they had done before. He merely said, "Very well; I was right before; I shall be right again. You will see."

The present experiments, though inspired by Tesla and by his quiet confidence in what can be done with the genii of electricity, differ considerably from his plan. That does not prove that they will fail to open the door to the prospects that he has foreseen. These experiments have been performed before witnesses; not once, but many times. At the present writing they are being carried out on a far greater scale in the new laboratory devoted entirely to this work.



F. M. Delano, Jr.

THE INVENTOR DEMONSTRATES HOW HE STOPS AN ENGINE BY MEANS OF HIS RAYS

When the carrier ray is turned on the magneto of this little motorcycle engine, the ignition system is instantly paralyzed. The motor stops. This can be done, Mr. Grindell-Matthews claims, without injuring the windings of the magneto, but, if desired, greater power can be used and the magneto or the whole engine can be destroyed.

It is easily understood that the technical secrets of the work cannot be described. There are many reasons for this.

For instance, should the methods be patented, they will become, like radio receiving circuits, the property of every amateur who is willing to spend the time and money necessary to build an apparatus of the sort.

Within these limitations, however, an attempt will be made to show that the theories and explanations that have been advanced during recent weeks by many scientists for the death-dealing rays which we have created over and over again in our London laboratory are more or less based on false premises.

The first experiment shown to witnesses was that of stopping a gasoline motor.

A small one-cylinder engine of a motor bicycle, together with the back wheel of the bicycle, were placed on a table at one end of the room and the engine was started. The generating apparatus for the "ray," about sixty feet away, was brought into action. One of the witnesses was told to give a signal at any time he wished. This had to be done by raising or dropping his arm, as the noise from the motor drowned out the human voice.

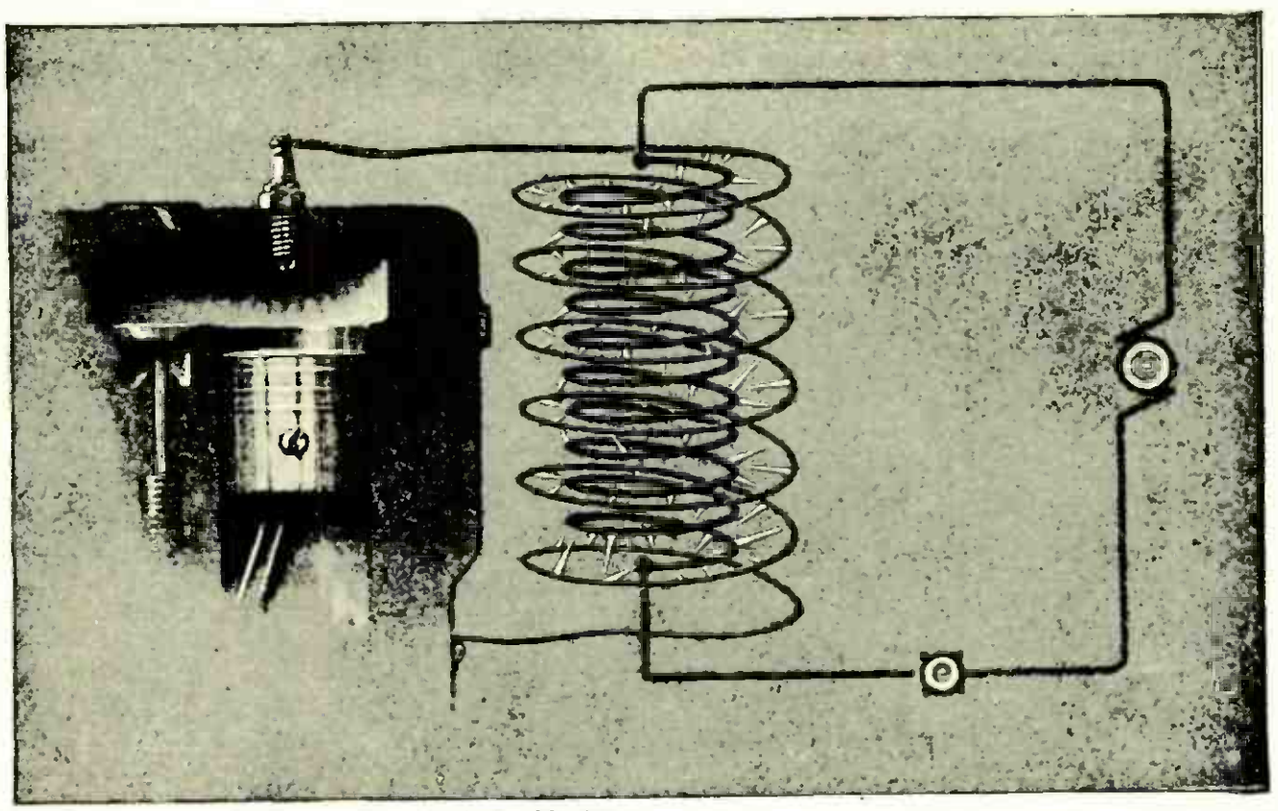
As he dropped his arm the invisible beam of the new ray was brought to bear upon the barking little engine,

searching for that heart of any gasoline motor, the magneto. As the ray touched this, the roar of the exhaust died quickly into complete silence. The stopping force was promptly removed so as not to destroy the magneto windings. Again and again this experiment was repeated. Everyone was not only allowed, but urged, to go over the motor carefully to make sure that there were no wires or other attachments from the floor or from the ceiling that could aid in its control. All were satisfied that some unseen force had stopped the firing of the engine.

Next, a bit of black gunpowder was placed in a metal container at the other end of the room, and the ray was brought to bear upon it. In no time a sharp flash registered the explosion of the powder, showing the great heat which can be generated by the power used. That this may later be employed to blow up powder magazines, battleships and other ammunition depots was suggested but it is problematical, for reasons that will be discussed further on.

A plain electric-light bulb of the usual house-lighting size was then held by two men standing well apart. The bulb was attached to two wires, one held by each of the men. There was no other connection with the rest of the laboratory or with the earth. When the ray was brought to bear upon the bulb it glowed brilliantly.

Then, as a final proof of the efficacy of the force behind this energy transmitter, a mouse was placed in a cage at the other end of the laboratory. This time, in order to make a quick and direct hit, thus avoiding unnecessary suffering, the ray was made visible as a beam of lavender or purple light. As this beam of light crept up and finally struck full upon the little animal, he reacted exactly as he would have done to the shock of a



From a drawing made for POPULAR RADIO by Arthur Merrick

HOW THE RAY "PARALYZES" THE MAGNETO WINDINGS OF AN ENGINE

The carrier ray itself, even when uncharged with power, is said to make the space around the coils of the magneto conductive of electricity. The current leaks across between the secondary windings and the primary ones. Sparks are no longer produced at the spark-plugs—and the engine stops.

light wire grounding through him. He was killed very quickly. He could have been killed instantly except for the danger of creating fire by applying the full force of the ray. The mouse was not burned or disfigured in any way.

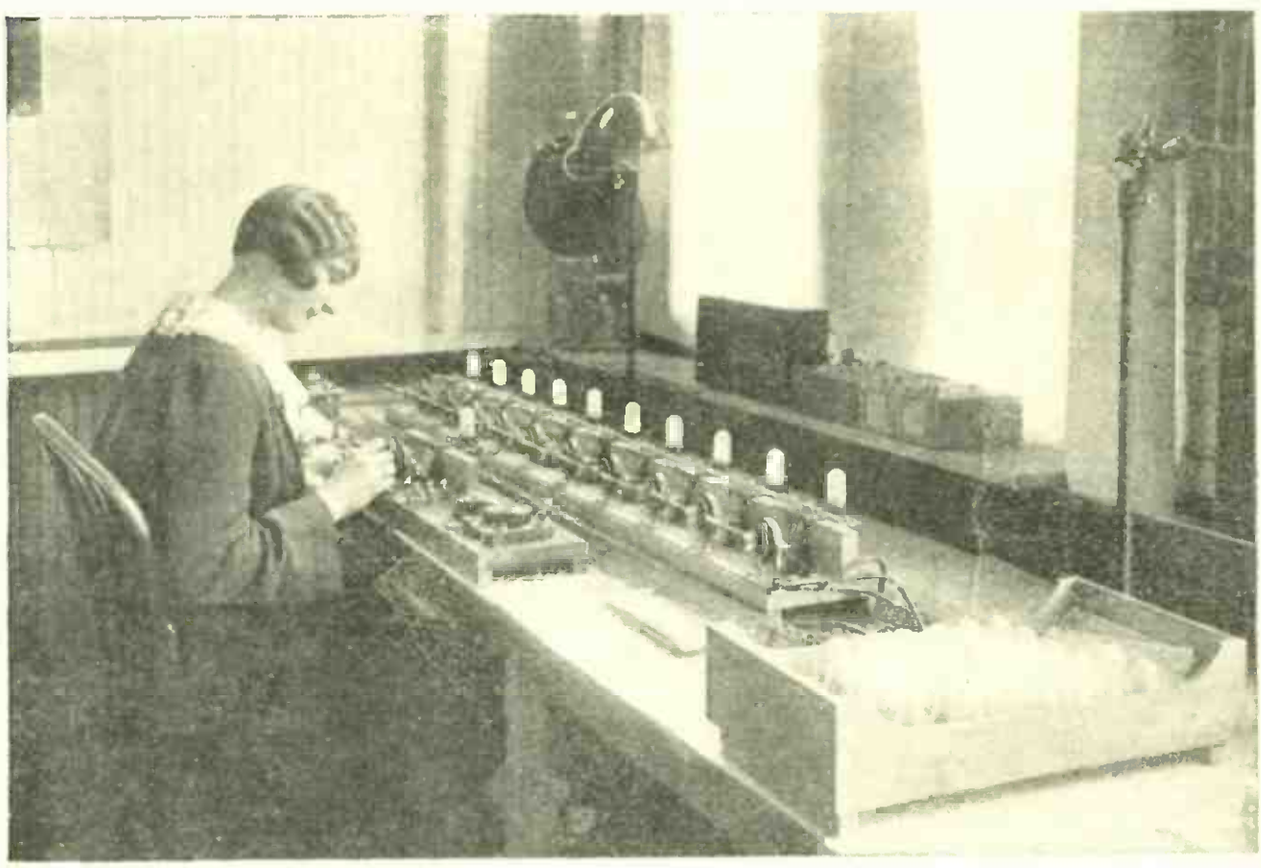
Actually, what the mouse received was an electric shock of the simplest kind. The destructive force behind the ray is nothing more than a high-potential, low-frequency current which grounds through the object with which the ray comes in contact exactly as though it were being applied through a piece of copper wire.

For example, the effect of the ray on wooden floors is the same as though the insulation had burned off the electric-light wiring or some other high-tension conductor, thus forming a short-circuit through the boards. The natural result is a little blaze as where bare wires come in contact with the flooring.

This generation of heat is the explanation of the firing of the gunpowder but it is not the secret of the stopping of the gasoline motor unless the magneto is completely destroyed. The cause of this stopping is primarily the "carrier beam" itself, along which the electric current is projected. Without the discovery of this carrier beam we would not have been able to continue our work.

This beam is nothing more or less than a conducting beam of secret composition; a development of our present knowledge of light waves and vibrations. It acts in the same way as does a cable or wire. Controlled as is a searchlight beam, it brings to bear upon the object at which it is pointed merely an electric contact. The destructive current then flows through this beam as it would through a metallic conduit.

For working on a magneto the carrier



Connecticut Telephone and Electric Company

IS IONIZATION THE SECRET OF THE NEW CARRIER RAY?

European scientists have suggested that the secret may be the use of ultra-violet light. This light ionizes the air so that it becomes conductive of electricity. Ionization is already well known in radio; it is the principle that underlies the new sodion detector tube described in POPULAR RADIO *for March, 1924. (This picture shows some of the sodion tubes under test in the laboratory.)*

From a photograph made for POPULAR RADIO

THE FIRST INVENTOR TO EXPERIMENT WITH THE TRANSMISSION OF POWER BY RADIO

Nikola Tesla undertook to send energy by radio a generation ago, with elaborate apparatus in Colorado. His enduring belief in its ultimate success "has been my inspiration," states Mr. Grindell-Matthews, "in developing the carrier ray."

beam is projected alone. As this beam comes in contact with the windings of the magneto it forms a conducting path between the primary and secondary windings, thus creating a short-circuit. For the actual destruction of magnetos an electric current could be applied to the carrier beam and transmitted along it. This would burn the insulation between the windings, thus facilitating the permanent shorting of the circuit.

For airplanes a ground is needed or the highest potential in the world could not do any damage. To form this ground and thus to complete the circuit, a second carrier beam, uncharged, is projected against the plane from a second station on the ground. Thus the plane forms the contact point between the two beams, the charged one and the uncharged one.

The current passes through the plane, which either burns up or becomes paralyzed.

An automobile or a protected ammunition dump is not so easy to attack. An armored car would need only to drag a chain or a heavy copper wire along the road. This would create a perfect ground. Current thrown, then, against the car along the carrier beam would simply enter the steel sides of the car and pass through them and the ground-chain into the earth, doing little or no damage. It might be possible, however, to project such a powerful stroke of current that the electrical field set up would stun or partially disable the driver, causing him to run off the road or into an obstacle.

With an airplane it would be practically impossible to insulate it or otherwise protect it and still have it airworthy. Should the airplane be insulated, a different form of attack could be adopted; a series of shocks being delivered against it, like the blows from a hammer, rather than a steady stream of energy. These hammer-like blows would be almost irresistible for breaking down insulation or other resistance. Indeed, we have found great difficulty in our laboratory in insulating our apparatus against the assaults of the current.

It has been found that a high-frequency current flowing along this carrier beam gives it a much higher conductivity; so that now two generator plants are being used instead of only the one. One generator produces the low-frequency current that constitutes the power passed along the beam; the other supplies the separate current of higher frequency which serves to increase the conductivity.

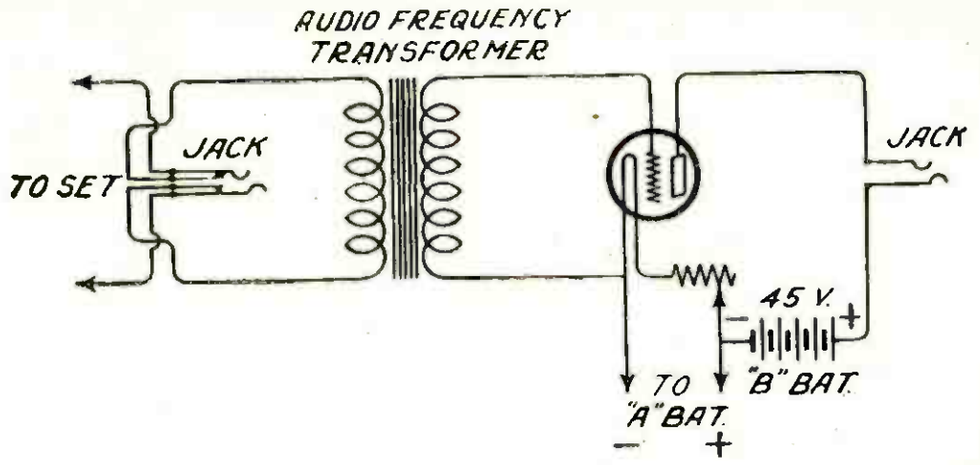
The carrier beam itself is produced in its own special apparatus and projected through a glass lens. The two electric currents are introduced into it after it has passed through this lens, which avoids any danger of melting the glass.

The spreading of the carrier beam with distance is much the same as that of a searchlight beam, so that the loss of current becomes quite high as the distance increases. Even so, a generating unit such as could be carried on an automobile truck would be sufficient, it is estimated, to supply current which would be effective at several hundred yards or even at one or two miles.

The tests were begun about eight months ago. Before the carrier-beam system was discovered the stopping of a motor (the test cited above) was being attempted at a distance of about ten inches. When at last we hit upon the carrier beam, within ten minutes, using the same generating group, the length of the laboratory had been traversed with equal success and the future of the work assured. So far, the full possible power has never been used, because of the cramped quarters.

The carrier beam can be made luminous if so desired, and this seems in the long run perhaps the most practical way of using it. The principal would be that of a tracer bullet. To see clearly what one is doing with the ray one must be able to follow it, especially at night. And if at times it seems desirable to make the ray invisible, a series of filters can be inserted which will take out the longer waves of the beam, rendering it absolutely secret.

What the outcome of this discovery will be, it is too soon yet to say. Some are of the opinion that it will cause the annihilation of the human race; others think that it will make war so terrible that it will be realized how useless it is. The optimists see in it (and I hope that they are right) the vindication of the man who has through all the discouragement and labor of my work been my inspiration and my greatest source of hope —Nikola Tesla, to me the greatest man on earth today.



SINGLE-STAGE OF AUDIO-FREQUENCY AMPLIFICATION FOR USE WITH WD-12 DRY-CELL TUBE

Cost of parts: Not more than $9.00.

Usage: With headphones.

Signal strength: Fair, when added to a single-tube set.

Quality of Reproduction: Good, if a good transformer is used.

Construction: Simple.*

Outstanding feature: May be added to any single-tube set to boost signal strength so that a number of headphones can be used with a comfortable signal.

*(See POPULAR RADIO, March, 1925, page 224, for constructional details.)

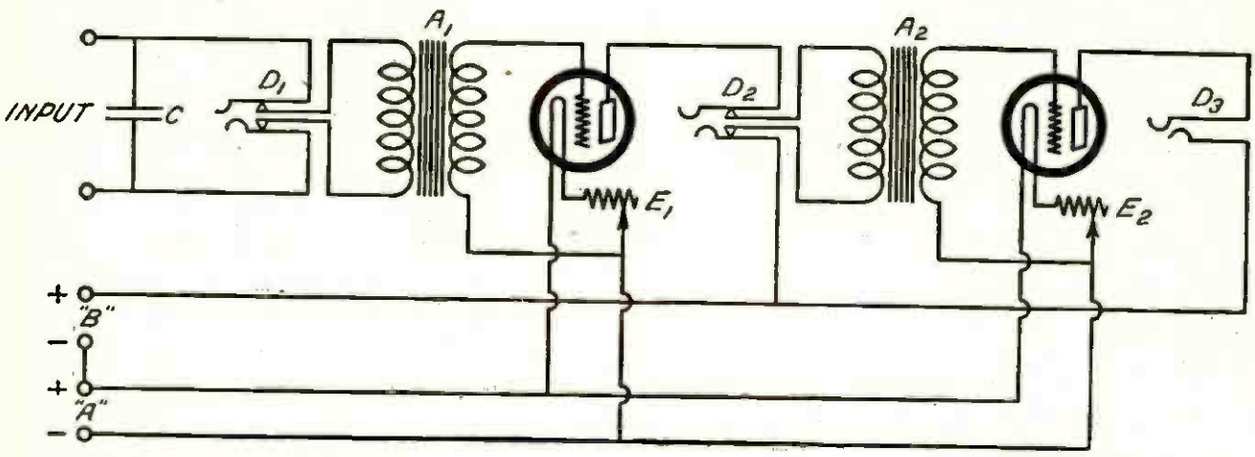
100 BEST HOOK-UPS

INSTALLMENT NO. 9

Audio-frequency amplifying circuits to be added to one-tube sets

THE preceding installments of this series of hook-ups have given a condensed review of both receiving and transmitting circuits, ranging from the most simple and inexpensive crystal set to some of the most highly developed vacuum-tube sets for long-distance reception and transmission. This present installment gives the reader a short survey of the more popular audio-frequency amplifying circuits ranging in cost from $9.00 to $30.00. These data will enable the reader to choose the type of amplification which may best serve his needs as well as his pocketbook, and to decide whether he wants merely to increase the strength of signals on his headphones or to make it of sufficient volume to use a loudspeaker.

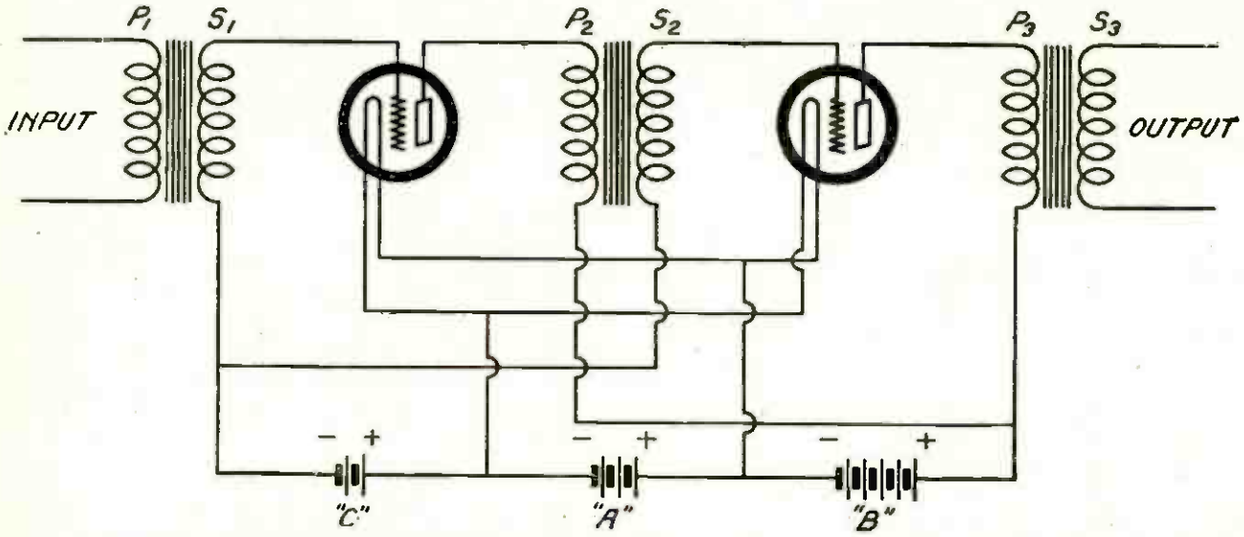
This series of features began in POPULAR RADIO *for November, 1923. Each preceding installment has referred to receiving circuits except that of April, 1924, which included only "Transmitting Sets for Amateurs."*



TWO STAGES OF TRANSFORMER-COUPLED AMPLIFICATION

Cost of parts: Not more than $19.00.
Usage: With headphones or with loudspeaker.
Signal strength: Good.
Quality of reproduction: Good, if good transformers are used.
Construction: There is nothing really difficult in putting together and wiring up such an amplifier.*
Outstanding feature: A simple circuit for getting consistent loudspeaker reception with a small number of tubes.

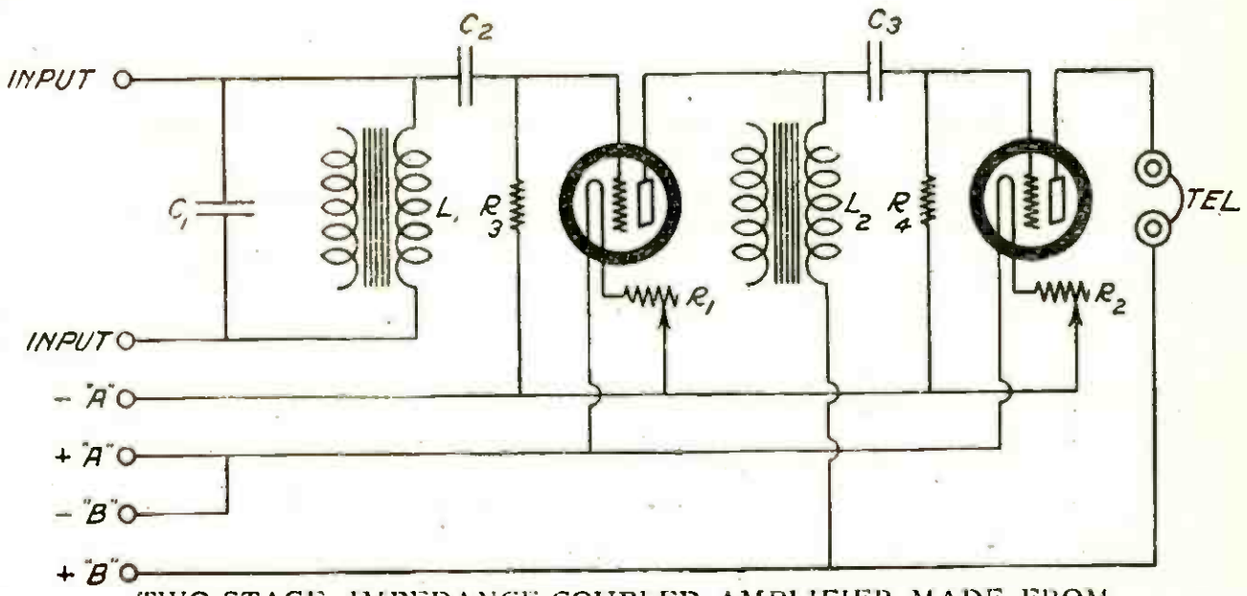
* *(See* POPULAR RADIO, *October, 1923, page 289, for constructional details.)*



TWO-STAGE, TRANSFORMER-COUPLED, POWER AMPLIFIER FOR USE WITH 5-WATT TUBES

Cost of parts: Not more than $25.00. (Note: The costs of tubes and batteries are considered as extras and are not included in the costs given in these descriptions.)
Usage: With loudspeaker.
Signal strength: Excellent, when added to a two-tube receiver.
Quality of reproduction: Good, if good transformers are used.
Construction: Not complicated.*
Outstanding features: No rheostats need be used with these tubes (Western Electric 216-a) on 6 volts. The plate circuit of the last tube includes a step-down transformer across the secondary of which is connected the loudspeaker.

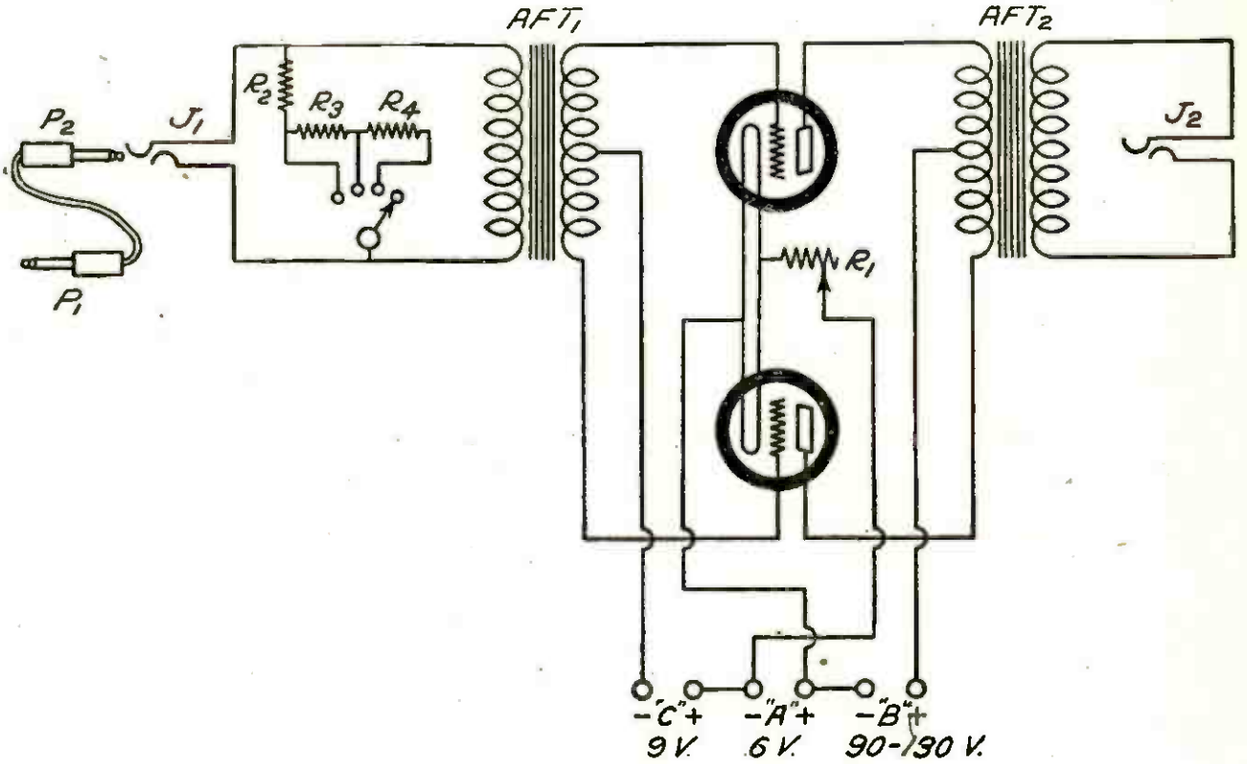
* *(See* POPULAR RADIO, *January, 1924, page 69, for constructional details.)*



TWO-STAGE, IMPEDANCE-COUPLED AMPLIFIER MADE FROM FORD SPARK COILS

Cost of parts: Not more than $15.00.
Usage: With headphones or loudspeaker.
Signal strength: Fairly good.
Quality of reproduction: Fairly good.
Construction: Simple.*
Outstanding features: Simple to make and operate, and of low cost, especially if you have some old Ford coils on hand.

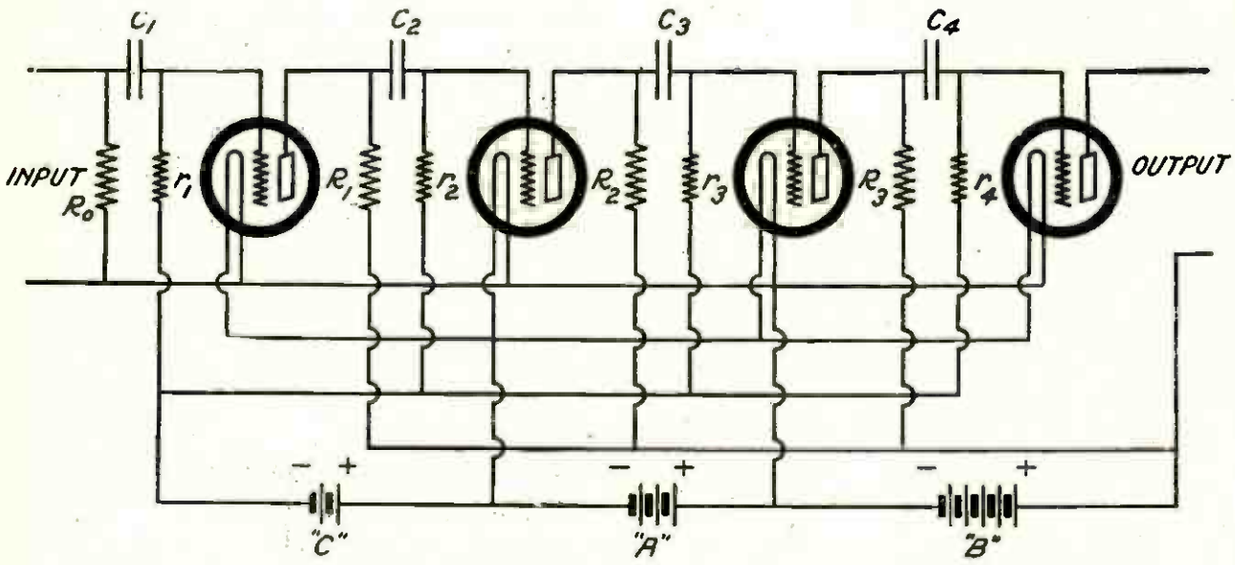
*(See POPULAR RADIO, *April, 1924, page 417, for constructional details.)*



ONE STAGE OF PUSH-AND-PULL POWER AMPLIFICATION

Cost of parts: Not more than $22.00.
Usage: With loudspeaker.
Signal strength: Very good when used with a single-stage of transformer-coupled amplification.
Quality of reproduction: Very good, if good transformers are used.
Construction: Just an ordinary acquaintance with tools and some ability in wiring up a circuit is necessary.*
Outstanding feature: This form of amplification takes advantage of both sides of the amplified alternating current that makes up audible voice signals.

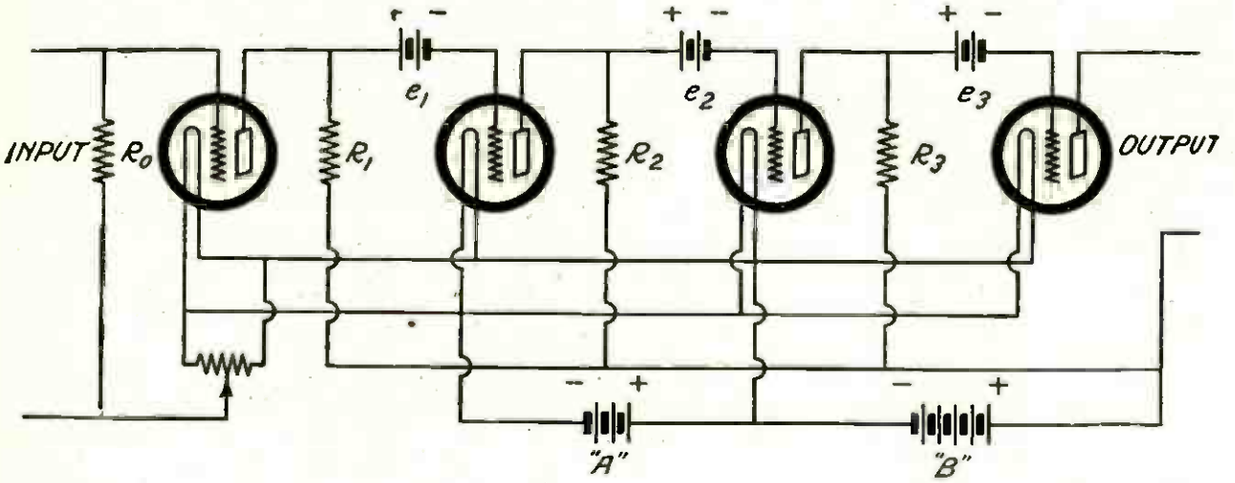
*(See POPULAR RADIO, *February, 1924, page 165, for constructional details.)*



RESISTANCE AND CONDENSER-COUPLED AMPLIFIER

Cost of parts: Not more than $20.00.
Usage: With phones or with loudspeaker.
Signal strength: Good.
Quality of reproduction: Excellent.
Construction: Fairly simple.*
Outstanding features: Truthfulness of reproduction and simplicity and low cost.

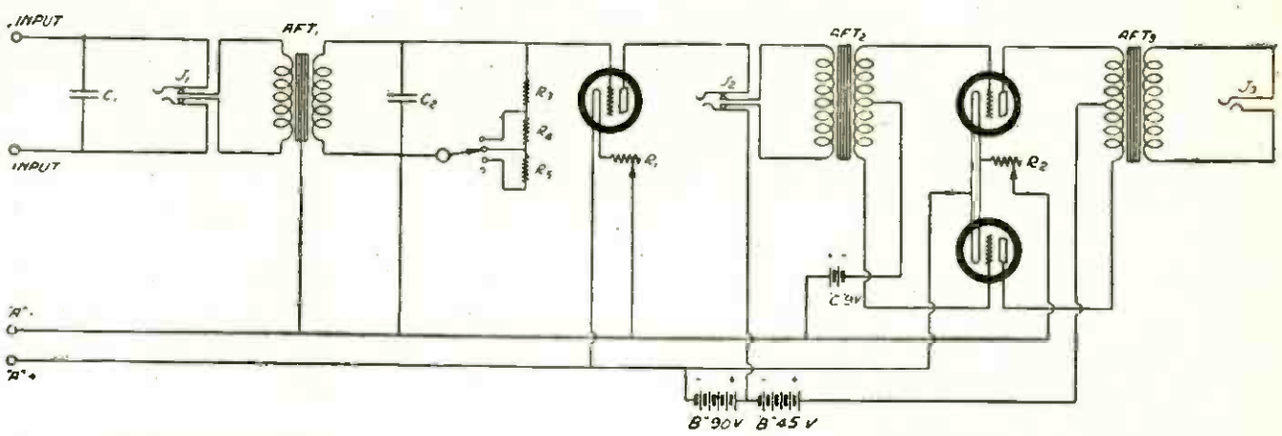
(See POPULAR RADIO, January, 1924, page 71, for constructional details.)



APERIODIC RESISTANCE-COUPLED AMPLIFIER

Cost of parts: Not more than $15.00.
Usage: With headphones or with loudspeaker.
Signal strength: Good.
Quality of reproduction: Excellent.
Construction: Simple.*
Outstanding features: Perfect reproduction, if properly adjusted. Simplicity of construction. Low cost.

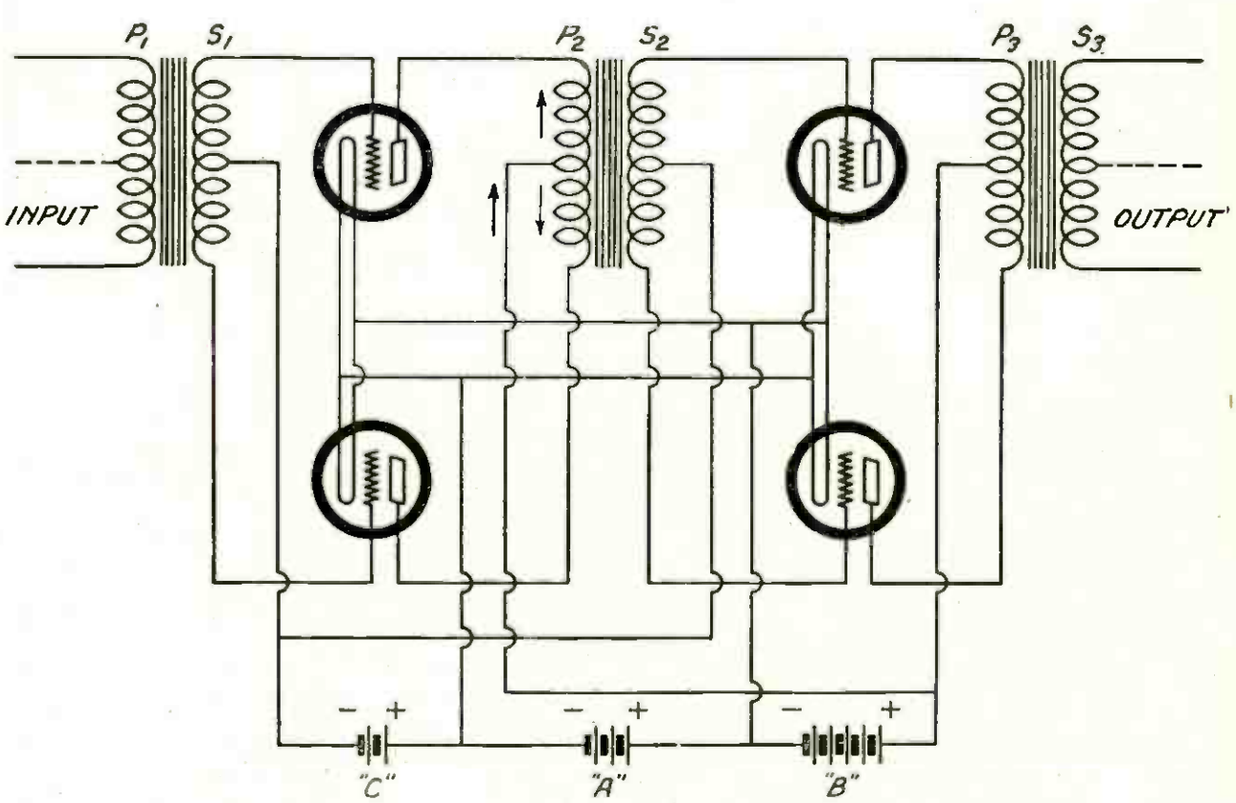
(See POPULAR RADIO, January, 1924, page 74, for constructional details.)



ONE STAGE OF TRANSFORMER-COUPLED, AND ONE STAGE OF PUSH-AND-PULL AMPLIFICATION

Cost of parts: Not more than $30.00.
Usage: With headphones or with loudspeaker.
Signal strength: Excellent.
Quality of reproduction: Very good, if good transformers are used.
Construction: Not very difficult to make.*
Outstanding feature: Large volume and good reproduction through a loudspeaker.

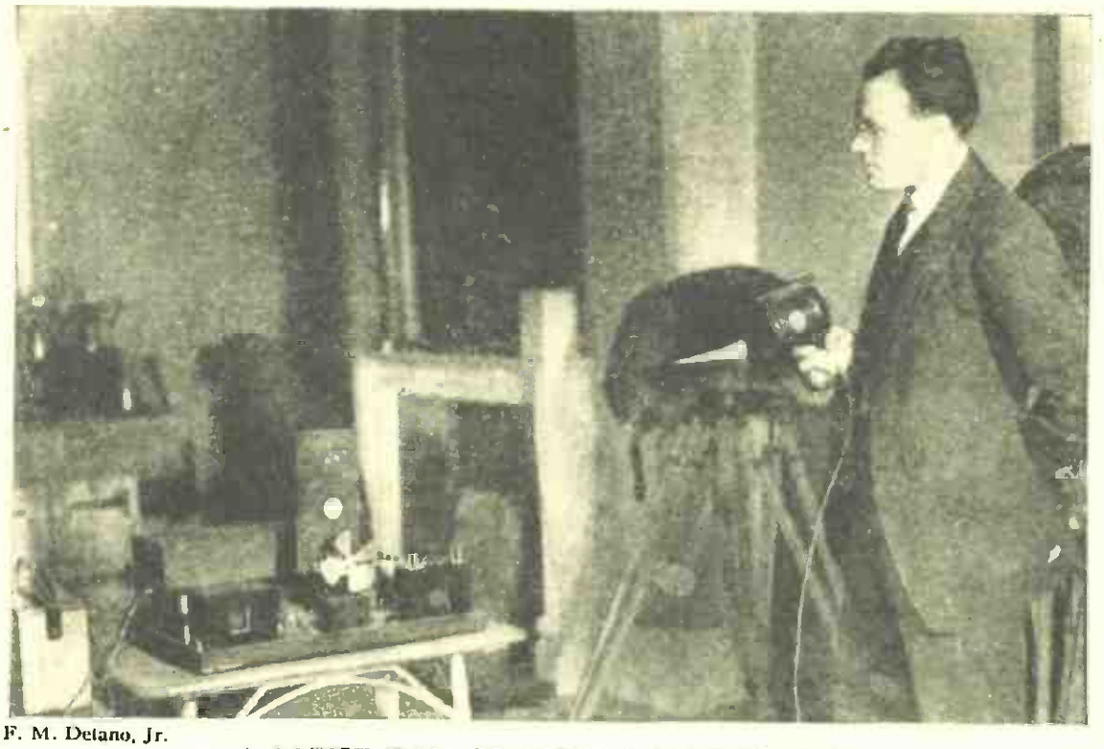
*(See POPULAR RADIO, February, 1924, pages 198-199, for constructional details.)



TWO STAGES OF PUSH-AND-PULL AMPLIFICATION

Cost of parts: Not more than $30.00.
Usage: With loudspeaker.
Signal strength: Excellent, when used as a power amplifier.
Quality of reproduction: Very good—if the transformers are good.
Construction: Rather complicated.*
Outstanding feature: Excellent for use as a power amplifier where great volume and good clarity is required.

*(See POPULAR RADIO, January, 1924, page 70, for constructional details.)



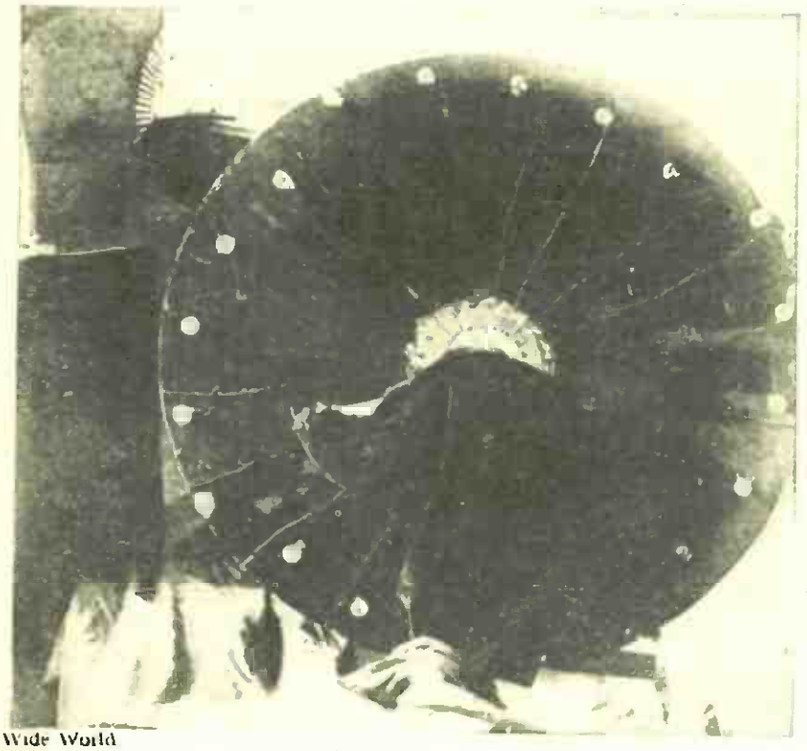
F. M. Delano, Jr.

A LIGHT RAY CONTROLS MACHINERY

Mr. Grindell-Matthews, inventor of the famous "diabolic ray," has perfected a mechanism by which light rays will stop, start or steer machines like submarines or automobiles. The light signals are received by a small selenium cell.

Hearing Light and Seeing Radio

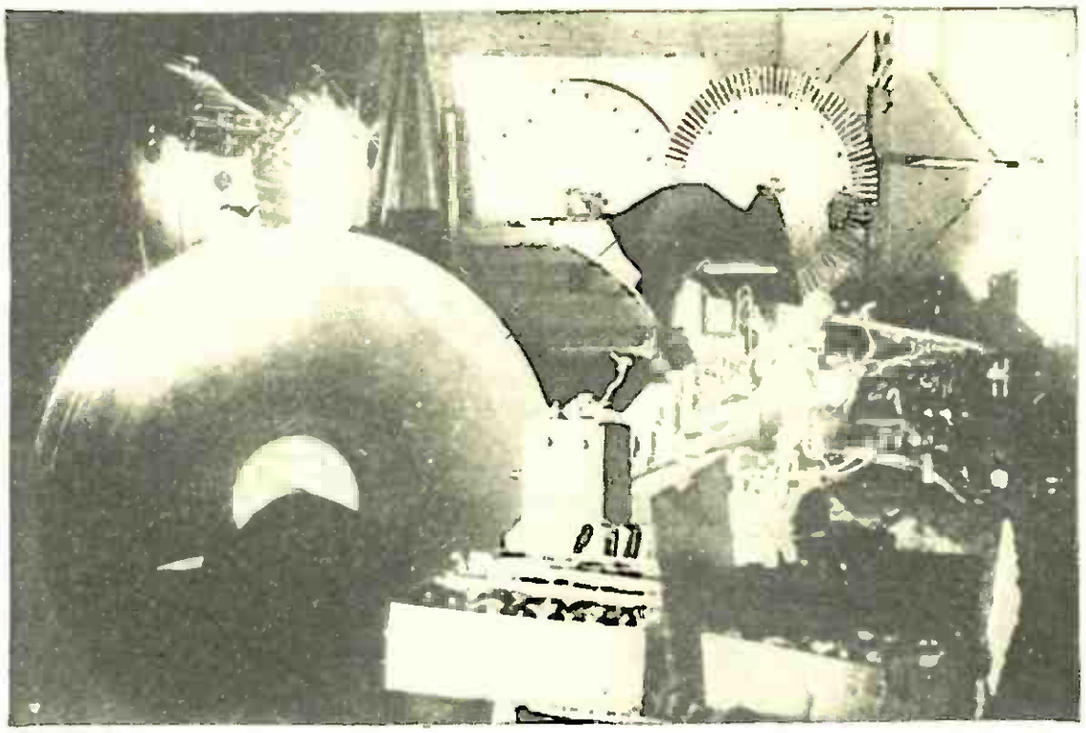
New inventions that use the metal, selenium—that remarkable element which will convert light-ray signals into electricity or into mechanical motion.



Wide World

A "RADIO TELESCOPE"

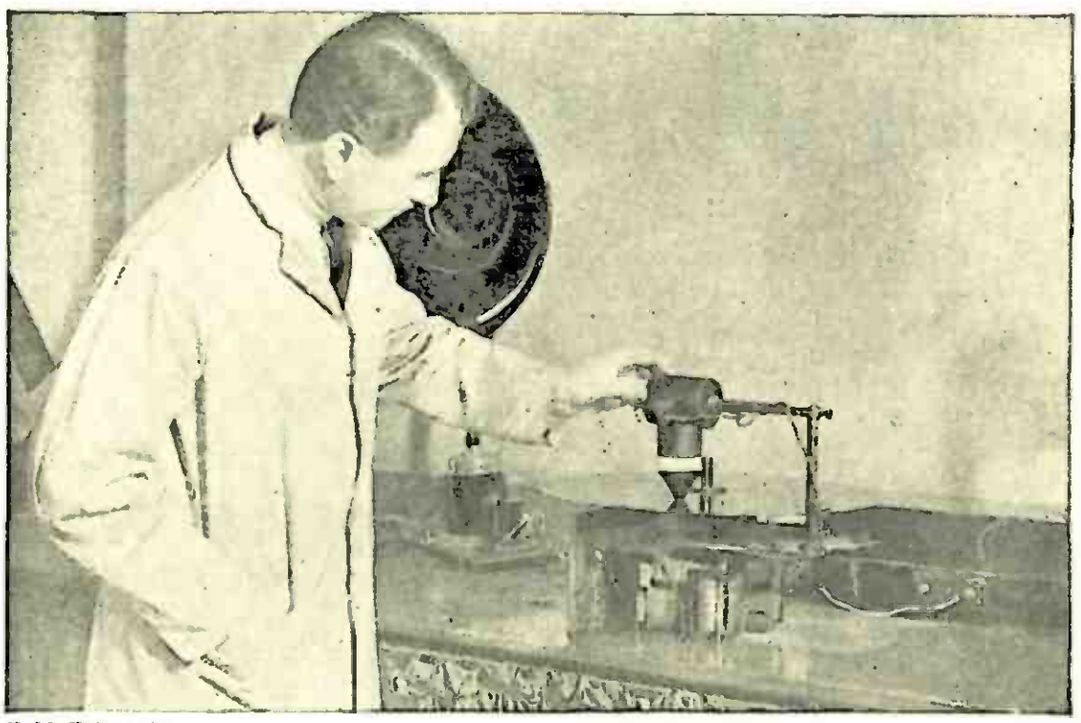
This rotating disk is part of the new apparatus invented by J. L. Baird for the conversion of radio signals into light or vice versa. The lenses on the edge of the disk produce partial images of an object or scene on an arrangement of selenium cells. The selenium converts light impulses into electric ones.



Wide World

BAIRD'S MACHINE FOR "RADIO MOVIES"

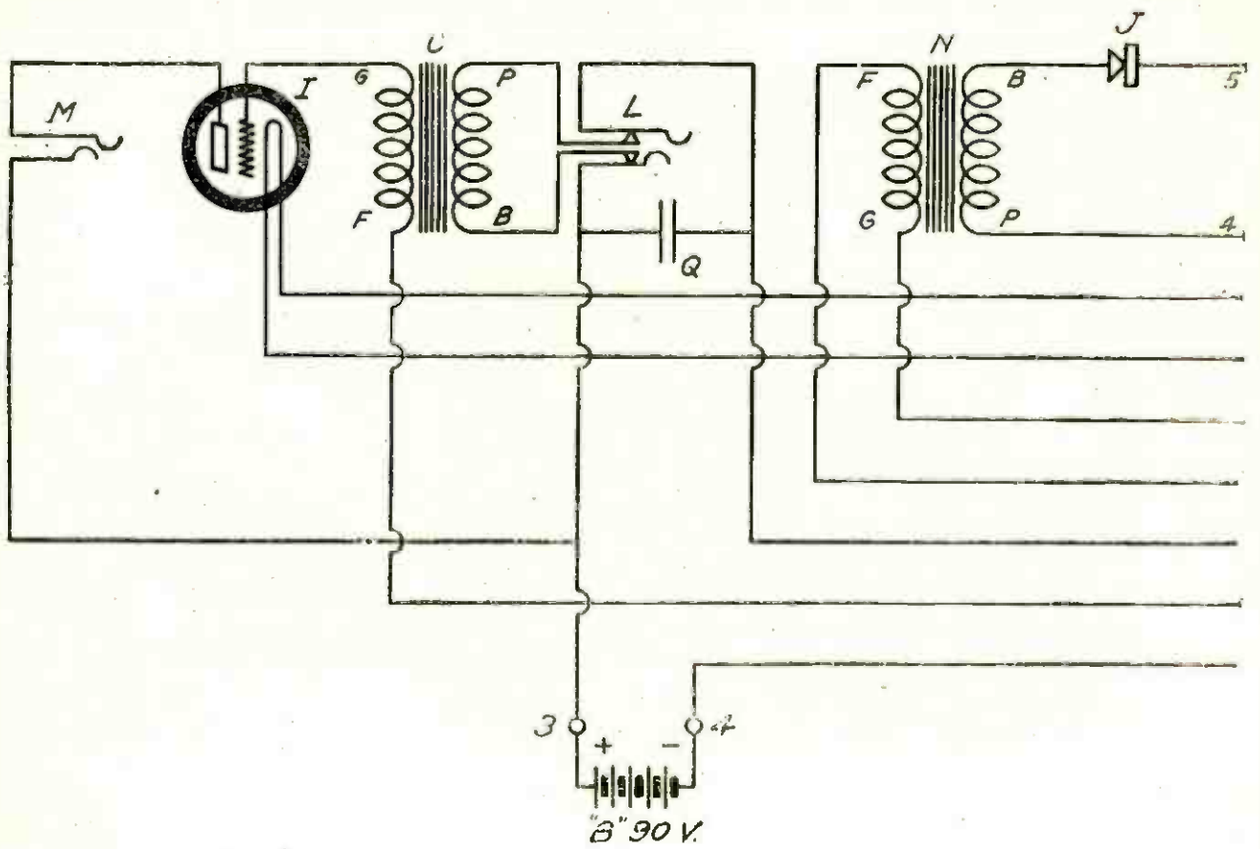
A system of rotating disks, moving lenses and selenium detectors will convert light rays into radio waves and back again, thus permitting, so the inventor claims, the transmission of motion pictures by radio. This has been accomplished, also, by the American inventor, Mr. C. Francis Jenkins.



F. M. Delano, Jr.

THE "SINGING DISK" OF GRINDELL-MATTHEWS

A beam of light passes through holes in a rotating disk and falls on a selenium cell. As the disk revolves there is produced an electric oscillation and this can be converted by a telephone into a musical note.



HOW TO BUILD A

TWO-TUBE REFLEX RECEIVER

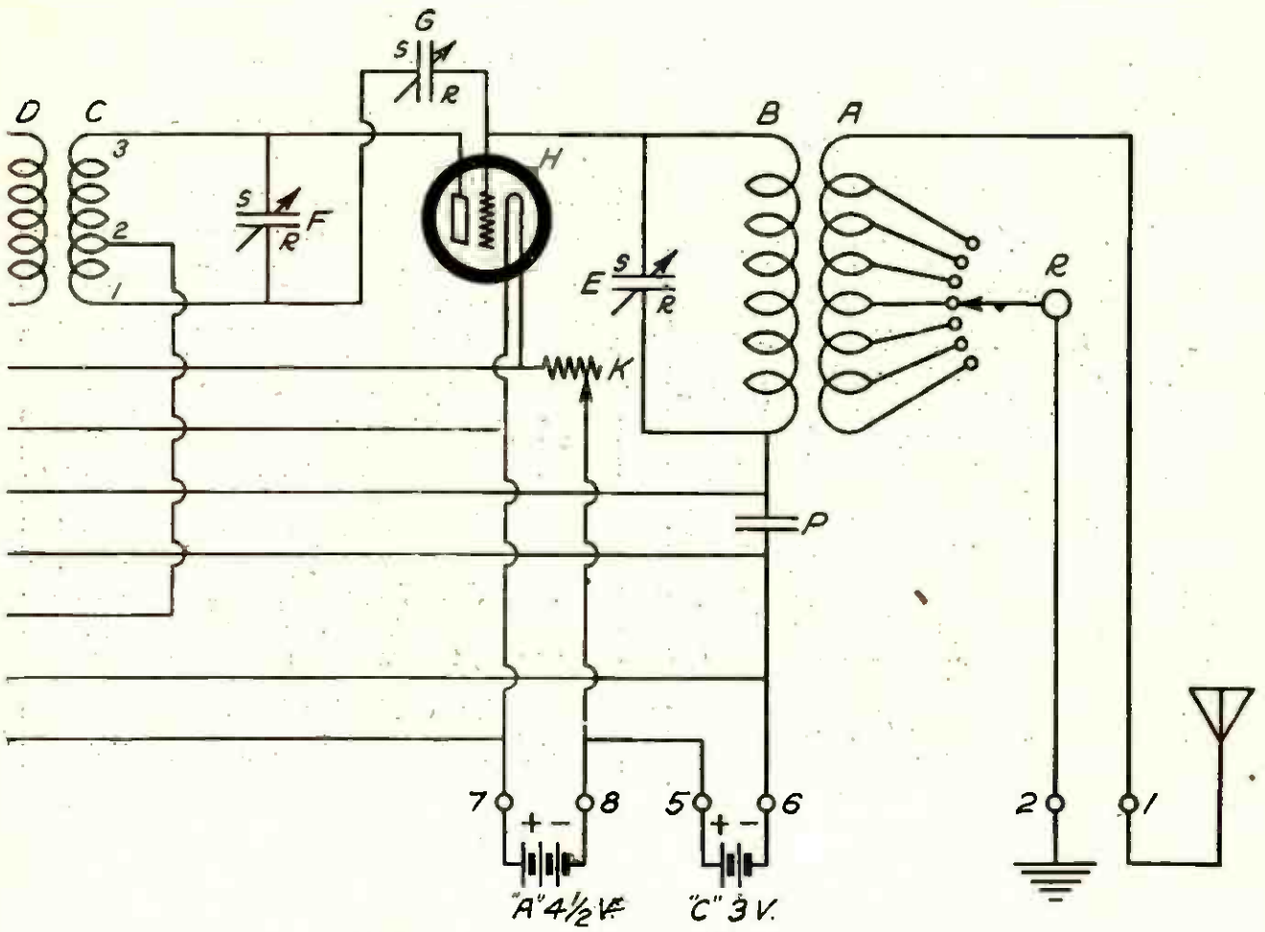
Here is the latest development of the staff of the POPULAR RADIO LABORATORY. It is a simple receiver that embodies the same principle of capacity neutralization as described in the author's article in the April issue. This receiver is much less complicated and gives both distant and local reception on a loudspeaker—and uses but *two dry-cell tubes!*

By ALBERT G. CRAIG

COST OF PARTS: *About $55.00*
RECEIVING RANGE: *Up to 1,500 Miles*

HERE ARE THE ITEMS YOU WILL NEED—

A and B—Special fixed coupler;
C and D—radio-frequency transformer;
E—Hammarlund .0005 mfd. (21-plate) condenser;
F—Hammarlund .001 mfd. (41-plate) condenser;
G—U. S. Tool 3-plate condenser;
H and I—Federal sockets for 199 tubes;
J—R-U-F semi-fixed crystal detector;
K—Amsco 30-ohm rheostat;
L—Carter double-circuit jack;
M—Carter single-circuit jack;
N—Federal No. 65 audio-frequency transformer;
O—Amertran Type AF-7 (ratio 3½ to 1) audio-frequency transformer;
P and Q—N. Y. Coil mica fixed condensers .001 mfd. (with soldering lugs);
R—Amsco switch lever, with switch points and stops;
S—composition panel;
T—hardwood sub-base;
U—cabinet;
V—condenser-mounting bracket;
8 Eby binding posts;
machine screws; wood screws; bus-wire;
2 UV-199 or C-299 vacuum tubes;
"A" battery, 3 dry cells in series, 4½ volts;
"B" battery, 90 volts;
"C" battery, 4½ volts.



THE ELECTRICAL WIRING DIAGRAM

FIGURE 1: *This drawing shows how to connect up all the various instruments and parts in their correct relation in the electrical circuit so that they will all perform their individual functions. Notice that the diagram is drawn from* RIGHT *to* LEFT, *so that the wiring is shown exactly as it goes into the set when you are wiring up.*

THERE will always be a place for a circuit that will give maximum results in the way of signal strength and quality, with a minimum of expense. When considering circuits from this viewpoint, the reflex makes a strong bid for first place. This is because it uses the same vacuum tube both as a radio and as an audio-frequency amplifier.

With the completion of the tuned radio-frequency receiver (described in the April, 1924, issue of POPULAR RADIO) it occurred to the author that this same circuit offered splendid possibilities for reflex work. Tuned radio-frequency gives the loudest signals obtainable from a radio-frequency amplifier. The scheme of neutralizing the tube capacity permits the proper grid bias for best amplification, without letting the tube oscillate. The theory of the circuit was discussed in detail in the April issue.

The circuit as finally selected for description consists of one stage of tuned radio-frequency amplification (reflexed to give one stage of audio-frequency amplification on the same tube), a crystal detector and one stage of straight audio-frequency amplification. Two vacuum tubes are necessary for this circuit and the dry-cell type were chosen as being in line with the policy of keeping the initial and also the operating expense down. The crystal detector also serves the same purpose by saving one bulb. While the volume is slightly less with the crystal detector, the quality of signals is exceptional.

This receiver is non-regenerative and will not radiate. Your neighbors will thank you for that!

A fixed coupler has been used to simplify the construction and operation of the set. The primary of the coupler

is tuned by means of a tap switch, the secondary by means of a variable condenser. These, together with the variable condenser for tuning the radio-frequency transformer, constitute the wavelength controls.

The wiring diagram of the circuit is shown in Figure 1.

The Parts Used in Building the Set

In all the diagrams in this article each part bears a designating letter. In this way the prospective builder of the set may easily determine how to mount the instruments in the correct places and connect them properly in the electric circuit. The same designating letters are used in the text and in the list of parts at the beginning of the article.

¶ *The list of parts there given includes the exact instruments used in the set from which these specifications were made up; but the experienced amateur will be able to pick out other reliable makes of instruments which may be used in the set with equally good results. For exact duplication of results, however, we recommend the parts specified to the novice.*

If instruments other than the ones listed are used it will necessitate only the use of different spacing of the holes drilled in the panel for mounting them.

How to Construct the Set

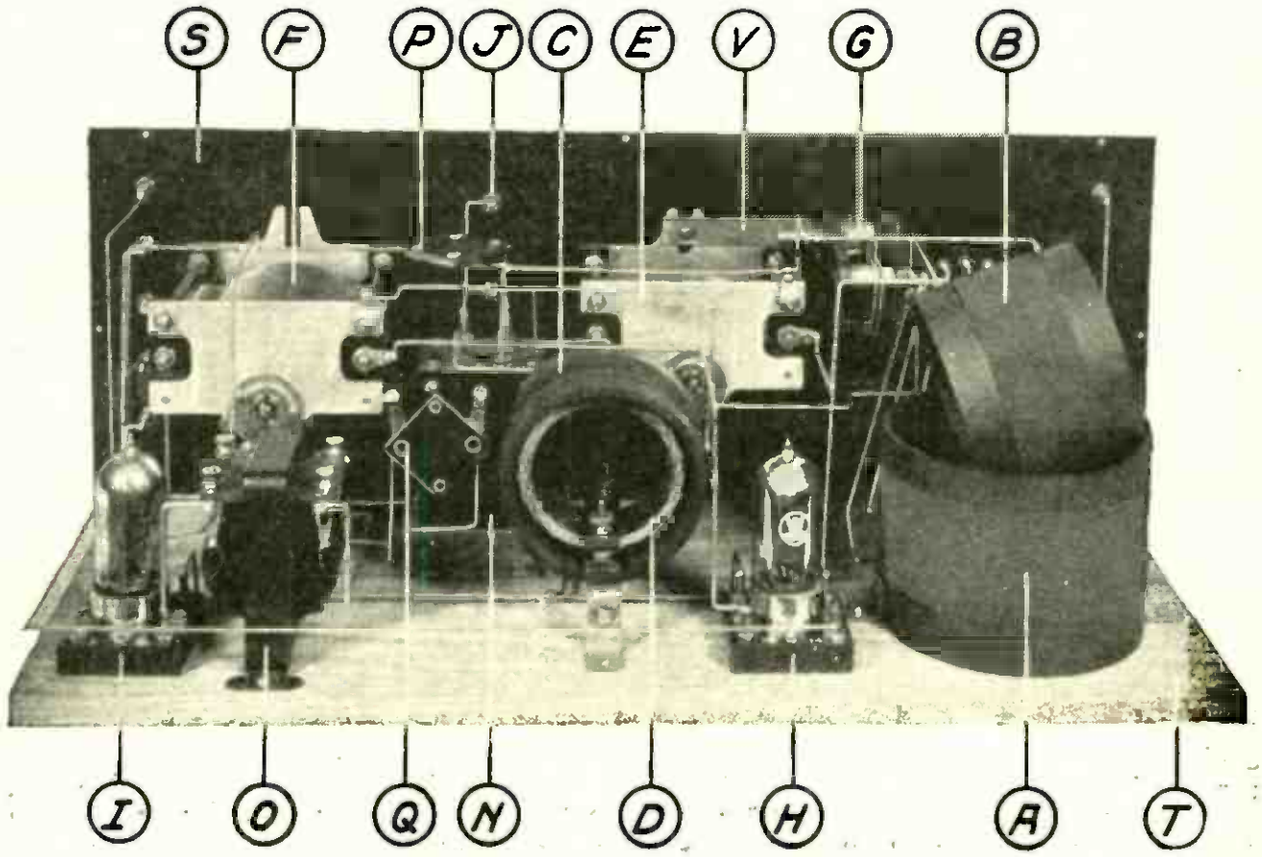
After procuring all the instruments and materials for building the set, the amateur should prepare the panel S. (Shown in Figures 2, 3, 4, 5 and 6.)

First of all, cut the panel to the correct size, 7 by 18 inches.

Then square up the edges smoothly with a file. The centers for boring the holes (which are necessary for mounting the instruments) should be laid out on the panel as shown in Figure 6. A convenient method of doing this is to lay out all center holes on a piece of paper the same size as the panel; then the piece of paper should be pasted on the panel and the centers marked directly on the panel by punching through the paper.

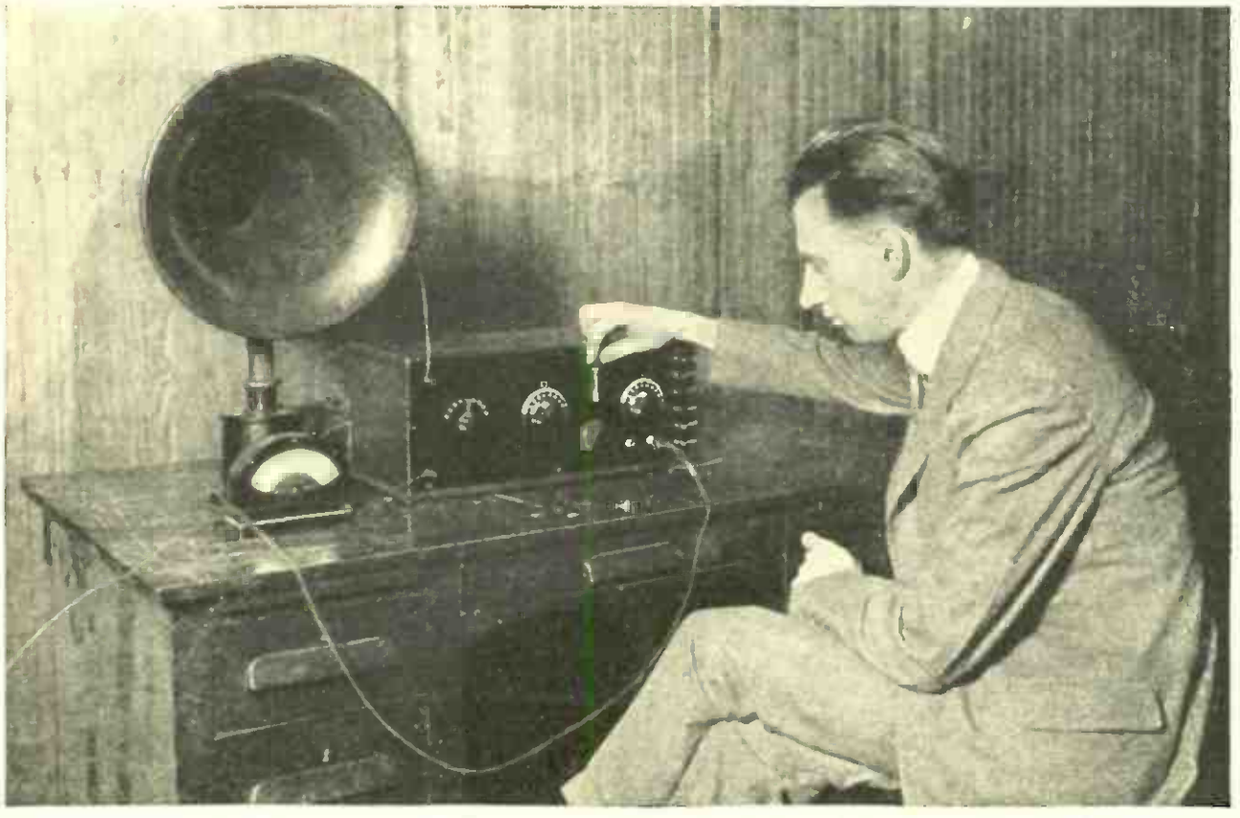
If all the holes to be drilled are first started with a small drill, one-sixteenth inch in diameter or less, they will probably be more nearly centered.

The holes outlined with a double circle should be countersunk so that the flat-head machine screws used for fastening the instruments will be flush with the panel. All the rest of the holes in the panel are straight drill holes. Sizes for the diameter of these holes have not been given, but the builder will read-



VIEW OF THE SET FROM THE REAR

FIGURE 2: *This photograph shows the general arrangement of all the instruments fastened to the panel and to the base. The exact locations for the instruments are given in Figure 3.*



THE DESIGNER DEMONSTRATES HIS COMPLETED SET

During the tests on this receiver it has been used on antennas of numerous types, both indoor and outdoor, and has proven its ability to pick up signals with fine volume and excellent clarity.

ily decide what size hole is necessary by measuring the size of the screws and shafts of instruments that must go through the holes.

When the panel is drilled, it may be given a dull finish by rubbing lengthwise with fine sandpaper until the surface is smooth; then the same process should be repeated, except that light machine oil should be applied during the rubbing. The panel should then be rubbed dry with a piece of cheese-cloth; a dull permanent finish will be the result. Or, the panel may be left with its original shiny-black finish, if care is exercised so that it is not scratched during the drilling.

The sub-base T (see Figures 2, 3, 4 and 5) should be cut to size, 7 by 17¼ inches. If a piece of ½-inch hardwood, surfaced on both sides, can be obtained, the work of squaring up and finishing the edges will be a minimum.

The special coupler, composed of coils A and B, can now be constructed as shown in detail in Figure 8.

Cut the Radion tube, for the primary coil A, to size and drill the holes for the secondary bracket W and the two angle brackets X. Wind the coil with No. 22 DSC wire, beginning 5/8 inch from the top of the tube. Taps are taken off at the 3rd, 7th, 12th, 19th, 28th, 40th and 56th turns.

Cut the Radion tube, for the secondary coil B, to size and drill the hole for the secondary mounting bracket W. Wind 43 turns of No. 22 DSC wire centrally on the tube. To center the winding, it should be started 19/32 inch from the edge of the tube.

Make the secondary mounting bracket W, and the two angle brackets X, out of 1/16 by ½-inch strip brass. (See Figure 8.)

To assemble the coupler, fasten the secondary mounting bracket W to the secondary tube B with a 6-32 brass machine screw; then fasten the bracket W to the primary tube A in a similar manner. Also secure the two angle brackets X to the bottom of the primary tube A with machine screws and nuts. The complete coupler assembly is shown in Figure 8.

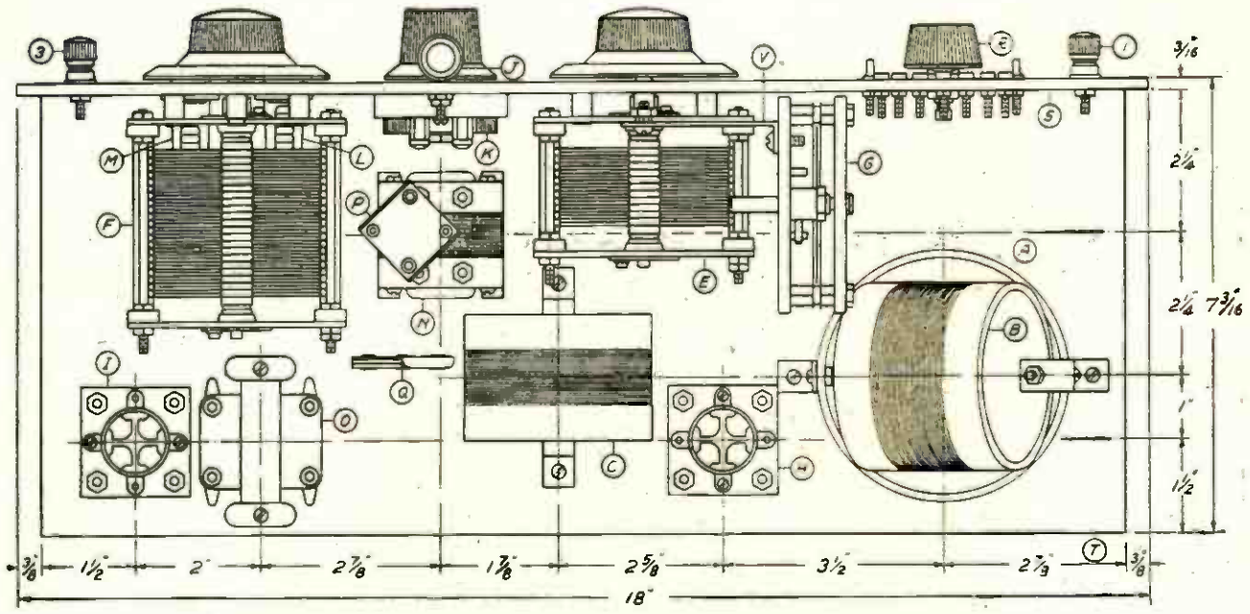
Next, construct the radio-frequency transformer C and D as shown in Figure 9.

Cut the Radion tube for the primary coil C to size, and drill holes for the mounting brackets Y. Wind 29 turns, of No. 22 DSC wire, centrally on the tube, taking off a tap on the opposite side of the tube half way between the second and third turns. The winding should be started 9/16 inch from the edge of the tube. The secondary winding D is a 75-turn Pacent duolateral coil.

Make the mounting brackets Y, for the transformer, out of 1/16 by ½-inch strip brass. Cut the two small clamping strips Z out of composition sheet. (See Figure 9.)

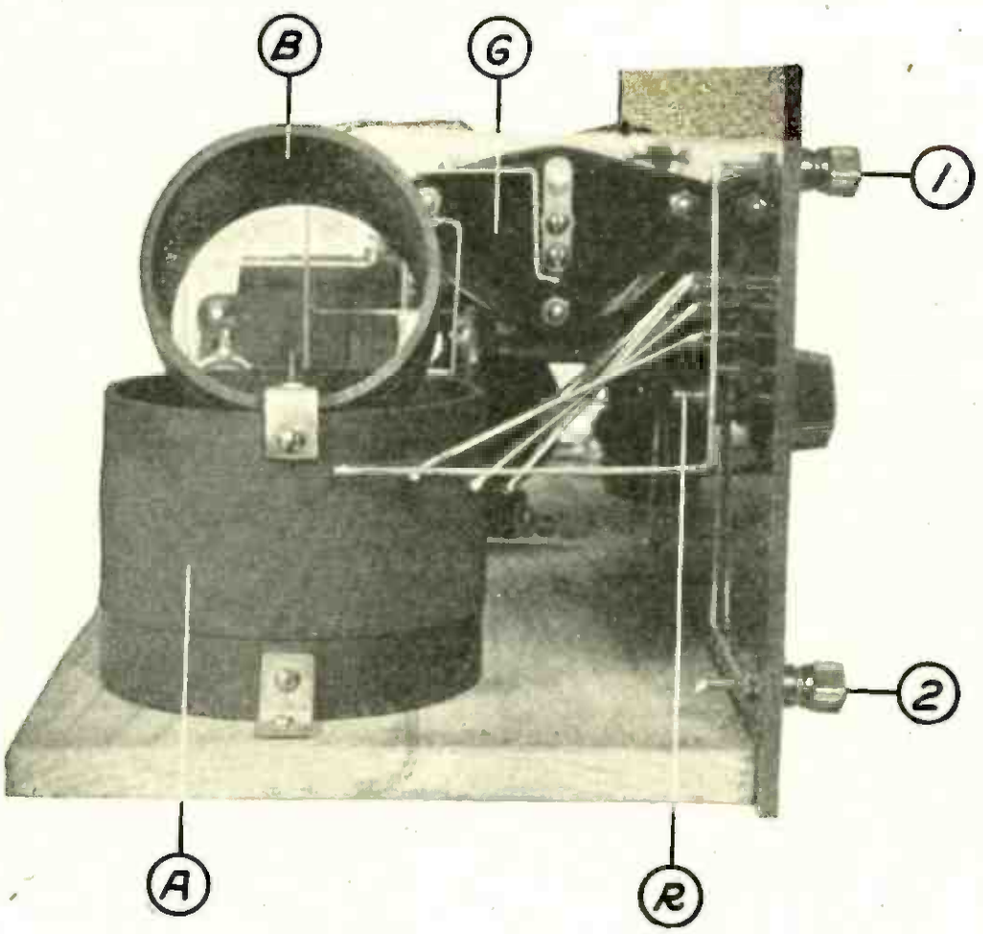
Assemble the radio-frequency transformer by passing two 6-32 brass machine screws first through the mounting brackets Y, then through one of the clamping strips Z and fasten with nuts. Place the duolateral coil in position and fasten the other clamping strip Z down with nuts on the machine screws. See Figure 9 for the radio-frequency transformer assembly.

The bracket V, for mounting the neutraliz-



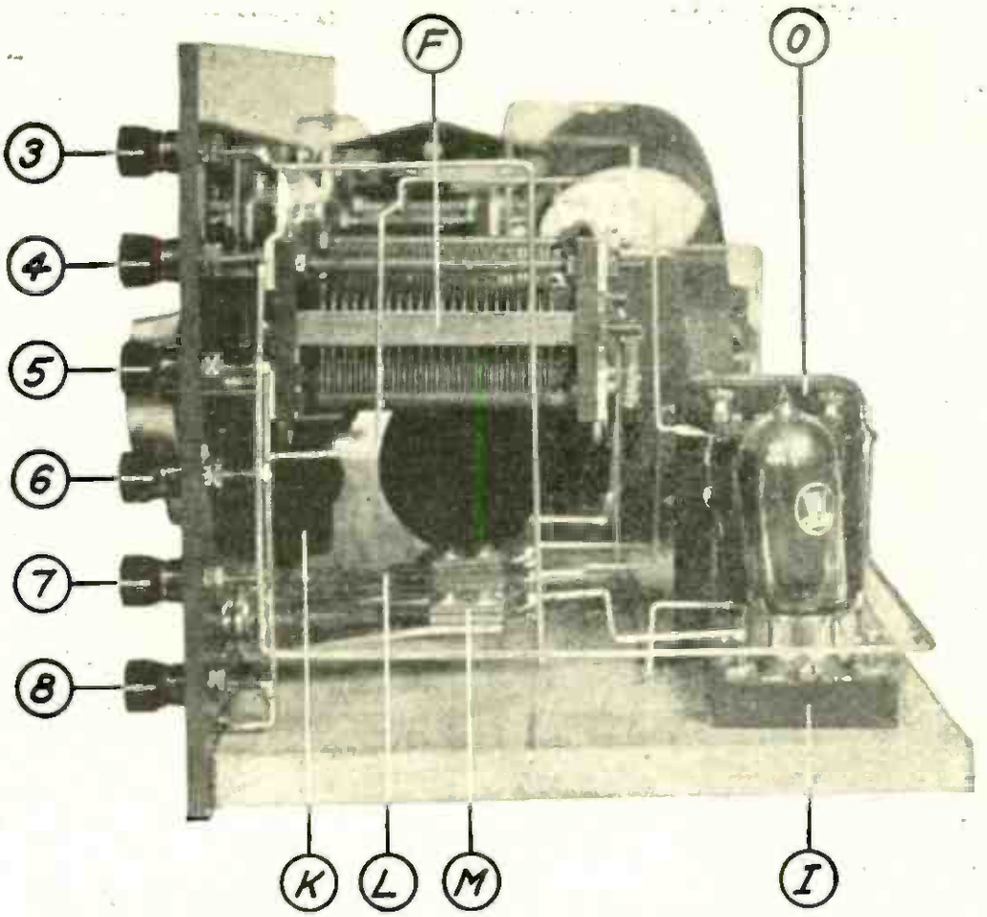
THE WORKING DRAWING FOR CONSTRUCTION

FIGURE 3: *Here are shown the correct positions for the various instruments. All the parts are designated by letters which reappear in the text and in the list of parts. The positions of these parts on the base are given, center to center.*



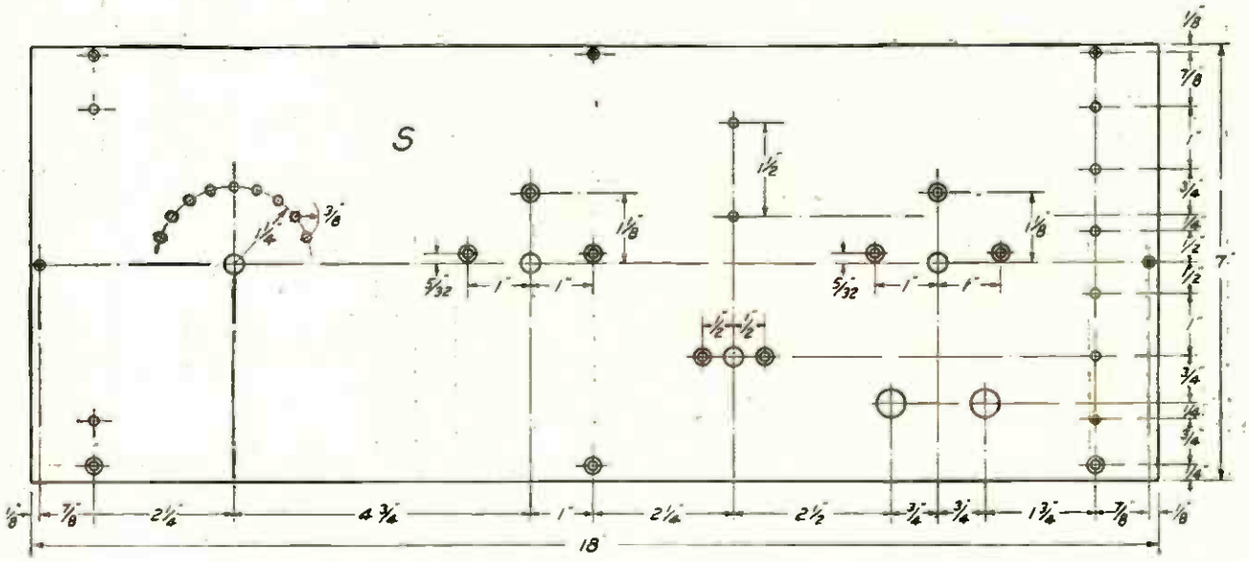
THE SET, AS VIEWED FROM THE LEFT

FIGURE 4: *This photograph shows the way to mount the coupler, and shows the method of mounting the neutralizing condenser, and the antenna and ground binding posts.*



VIEW OF THE SET FROM THE RIGHT

FIGURE 5: *This picture shows the positions of the variable condenser, the jacks, the transformer and one of the tube sockets.*



THE DRILLING PLAN FOR THE PANEL

FIGURE 6: *This drawing shows where to drill the holes for the screws and shafts of the instruments which protrude through the panel. The holes outlined with a double circle should be countersunk so that the flat heads of the screws will be flush with the surface of the panel.*

ing condenser G, is also shown in Figure 9. Make it out of 1/16 by ½-inch strip brass.

Complete specifications, for constructing the cabinet U, are given in Figure 7. It may be constructed out of ½-inch hardwood, such as mahogany, walnut or oak, and finished to suit the taste of the builder. Or the cabinet may be purchased complete from your radio dealer, as it is a standard size.

Preliminary to mounting the parts of the set, fasten the panel S to the sub-base T. (See Figures 2, 3, 4 and 5.) Make sure these two are fastened exactly at right angles. Brass wood screws about one inch long, serve to hold the panel on the sub-base.

Mount the antenna binding post No. 1 in the upper left corner of the panel, and the ground binding post No. 2 in the lower left corner. Mount the remaining binding posts on the right end of the panel in the following order, beginning at the top; "B" positive post No. 3, "B" negative post No. 4, "C" positive post No. 5, "C" negative post No. 6, "A" positive post No. 7 and "A" negative post No. 8. (See Figures 4, 5 and 6.)

Next, mount the switch lever R, together with its switch points and stops, in position as shown in Figures 2, 3 and 4.

Fasten the rheostat K to the panel in the position indicated in Figures 3 and 5. Make the connections to the rheostat before mounting the transformer N directly behind it. Otherwise it cannot be reached with a screw driver.

Now, fasten the crystal detector J in place directly above the rheostat K. (See Figures 2, 3 and 5.)

Mount the jacks L and M on the panel as shown in Figures 2 and 5. The frames of the jacks are turned down.

Then, mount the transformer N on the sub-base with secondary terminals towards the coupler end of the set. Mount the transformer O with the primary terminals towards the coupler end of the set. (See Figures 2, 3 and 5.)

Fasten the sockets H and I to the sub-base with wood screws in the positions shown in Figures 2 and 3. (Note the position of the slot in the sockets in Figure 3.)

Secure the radio-frequency transformer C and D to the sub-base with two wood screws inserted through the mounting brackets as shown in Figures 2 and 3.

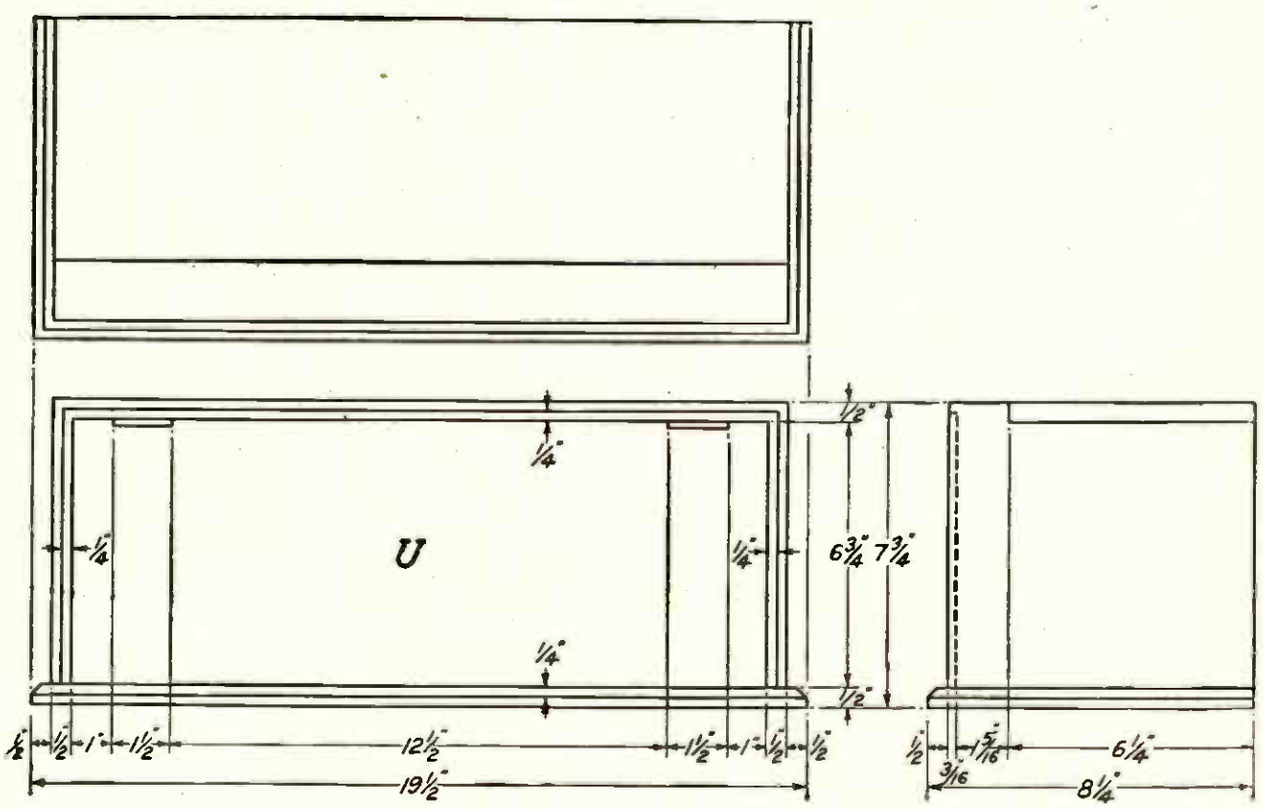
Now, put the coupler in position and fasten it by means of two wood screws through the angle brackets. (See Figures 2, 3 and 4.)

Mount the two variable condensers E and F on the panel as indicated in Figures 2 and 3. (Note that the stationary plates are turned up.)

Finally, mount the neutralizing condenser G, by means of its supporting bracket V. (See Figures 2 and 3.)

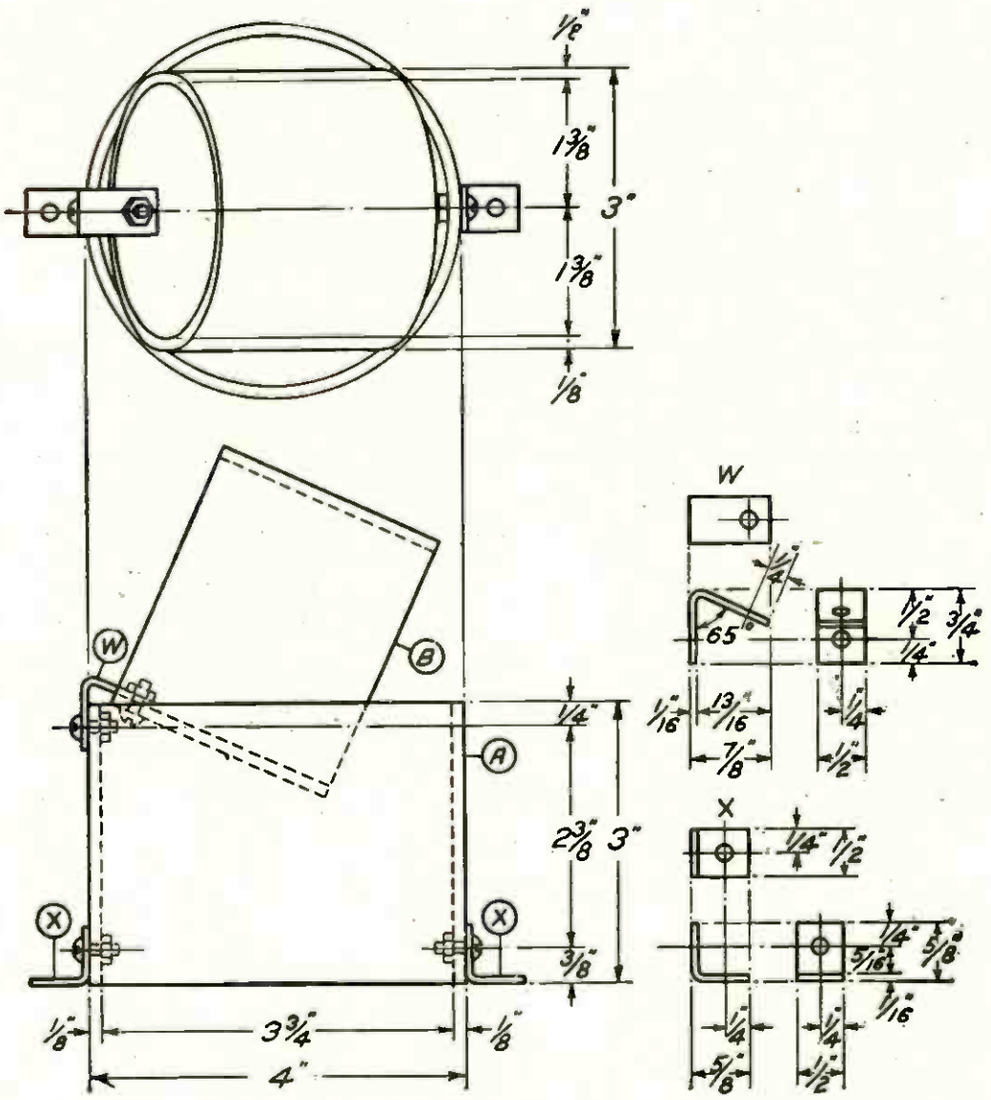
How to Wire the Set

When you do the wiring, remember that all connections from the high-voltage side of the transformers or coils (that is to say, the side next to the vacuum tubes) should be kept about



THE DIMENSIONS FOR THE CABINET

FIGURE 7: *This drawing (which contains the top, front and side measurements for the hardwood cabinet) may be turned over to a competent cabinet worker, who can build it for you from these instructions alone.*



THE MECHANICAL DETAILS OF THE COUPLER

FIGURE 8: *The drawing at the top shows the coupler from above; the lower drawing shows the coupler as seen from one side, and contains the dimensions for the little brass fittings which hold the coils in place.*

½ inch away from other wiring and should not run parallel to it for any considerable distance. This includes the wiring from the radio-frequency transformer to the condenser G.

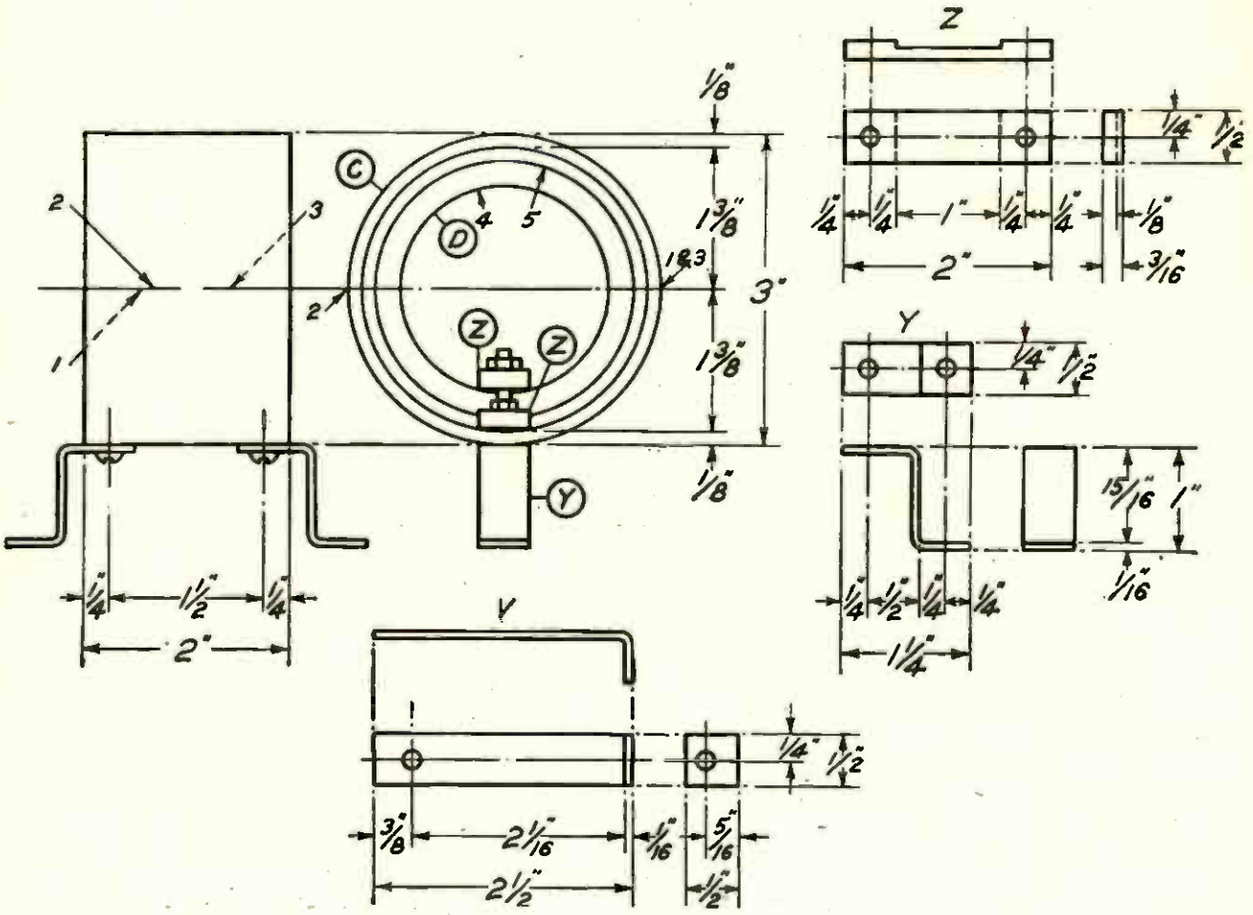
Use tinned-copper bus-wire throughout. All connections should be bent into the proper shape and then soldered in place.

Start wiring the filament-lighting circuit as shown in Figure 1. The filament circuit starts at the negative "A" binding post No. 8, goes to the rheostat K, then from the other terminal of the rheostat to the socket filament terminals nearest the front of the set. As mentioned before, the connections to the rheostat K should be made before the transformer is placed in front of it. From the rear terminals of sockets H and I, the filament circuit is completed to the positive "A" battery binding post No. 7. The negative "A" battery binding post No. 8 is also connected to the positive "C" battery binding post No. 5. Also the positive "A" battery binding post No. 7 is connected to the negative "B" battery binding post No. 4.

Now, wire up the antenna and ground circuit. The antenna binding post No. 1 connects to the top of the primary coil A (the end with the smallest number of turns between taps). Connect the remaining seven taps to the switch points and the switch arm to the ground binding post No. 2.

Connect up the grid circuit of the reflexed tube which comprises the secondary coil B, the condenser E, the grid terminal of vacuum-tube socket H, the secondary of audio-frequency transformer N, by-pass condenser P and the negative "C" battery binding post No. 6. The stationary and revolving plates of the variable condensers are marked S and R respectively in the wiring diagram.

Then, wire up the plate circuit of the reflexed tube. This embraces the plate terminal of vacuum-tube circuit H, the primary coil C of the radio-frequency transformer, condensers F and G, the jack L, the primary of the audio-frequency transformer O, the by-pass condenser Q and the positive "B" battery binding post No. 3.



THE CONSTRUCTIONAL DATA FOR THE RADIO-FREQUENCY TRANSFORMER

FIGURE 9: *Here is given the measurements for the coil supports and the tube upon which the primary coil is wound. Be sure that you make the little angles and stays of the correct dimensions as given.*

Connect up the detector circuit, which includes the secondary coil D of the radio-frequency transformer, the crystal detector J and the primary of the audio-frequency transformer N.

Next, wire up the grid circuit of the straight audio-frequency amplifying tube. This comprises the grid terminal of the vacuum-tube socket I, the secondary of the audio-frequency transformer O and the negative "C" battery binding post No. 6.

Connect the plate circuit of the same tube, consisting of the plate terminal of vacuum-tube socket I, the jack M and the positive "B" battery binding post No. 3. This completes the wiring.

How to Install the Set

After the set has been completely wired, place it in the cabinet and fasten it to the cabinet with wood screws inserted through the panel. Small flat-head brass wood screws can be used for this purpose, and the screw heads should be painted a dull black after the set is complete.

Attach the antenna to the binding post No. 1 in the upper left-hand corner of the panel (looking at the front of the set).

Connect the ground wire to the binding post No. 2 in the lower left-hand corner of the panel.

Connect the positive 90-volt "B" battery lead to the top binding post No. 3, on the right-hand side of the panel.

Connect the negative "B" battery lead to the next binding post No. 4 at the right of the panel.

Connect the positive "C" battery lead to the next binding post No. 5.

Connect the negative 3-volt "C" battery lead to the next binding post No. 6.

Connect the positive 4½-volt "A" battery lead to the next binding post No. 7.

Connect the negative "A" battery lead to the last binding post No. 8.

Insert two UV-199 or C-299 tubes in the sockets H and I.

The condenser G can be set with the rotary plate projecting about ⅛ inch out of the stationary plates, that is to say, at about nine-tenths full capacity.

Operating Data

Plug in either the loudspeaker in jack M, or the telephones in jack L.

Gradually turn the rheostat K clockwise until the vacuum-tube filaments are lighted, but burning with considerably less brilliancy than

the old carbon style of electric light bulb.

Set the tap switch R for a maximum number of turns in the antenna circuit.

Now, gradually rotate condensers E and F (keeping them at approximately equal settings) until a station is picked up. After tuning in the signal to best advantage with condensers E and F, adjust the tap switch R to the best point. This is the point with the smallest number of turns in the antenna circuit, consistent with loud reception. If too many turns are used in the antenna circuit the tuning of condenser E will be very broad. It will usually be found that, with any given antenna, there will be three or four points on which most of the tuning can be done.

The rheostat K can now be adjusted. It should be operated at the lowest point consistent with loud reception, that is, where turning the rheostat up higher does not give a noticeable increase in signal strength.

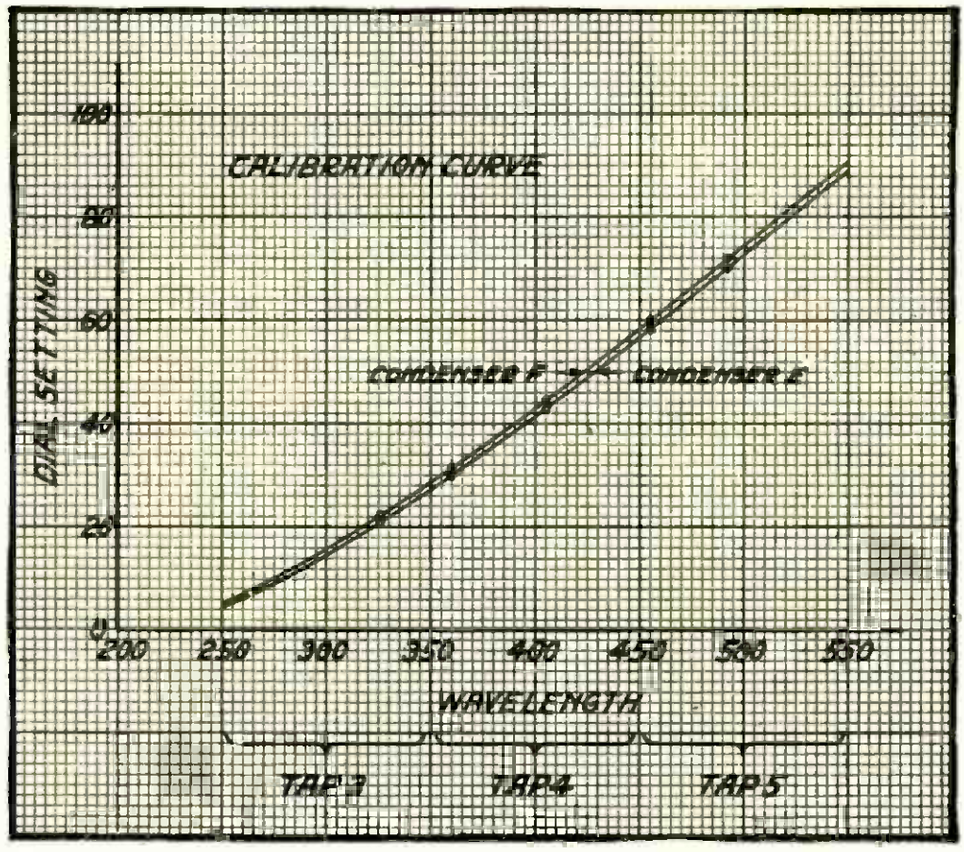
After the set has been operated on a given antenna for a short time, the owner will be able to set the tap switch R correctly for the wavelength which is to be received. Then it will only be necessary to adjust condensers E and F, keeping them on approximately equal values.

The setting of the neutralizing condenser G, as specified above, is an exact value for the instruments used in this receiver and was obtained before the set was reflexed. However, it will be found that there is considerable latitude in this respect, and values approaching the minimum can be used before the set does oscillate. This is due to the introduction of the audio-frequency transformer in the grid circuit. Condenser G is to be set permanently; for this reason it is placed within the set and no dial provided.

How to Make a Tuning Chart

Tune in as many stations as possible on different wavelengths and record the settings of condensers E and F, the setting of the primary tap switch R and the known wavelength of the station. Plot the dial setting of condenser E against the wavelength of the station; also plot the dial setting of condenser F against the wavelength of the station. Repeat the process for a number of stations and you will get sufficient points to enable you to draw a smooth curve for each condenser. A sample curve is shown in Figure 10. This chart shows how the experimental set tuned for five given stations. By inspecting your list of stations you can bracket the approximate wavelength range which each point on the primary tap switch R will cover.

With the aid of the chart just plotted you may find the exact setting for the wavelength of any given station and can set all the tuning controls at the correct values to receive the station to the best advantage.



THE CHART THAT TELLS YOU HOW TO TUNE IN

FIGURE 10: *This shows how to set the two variable condensers and the taps for various wavelengths to which you wish to tune. Notice that the two condensers tune on almost similar settings.*

Kadel & Herbert

Helpful Hints for the Broadcast Listener

By Y. Z. MUTS

Shorten Your Antenna Lead: The antenna lead-in wire should not be any longer than necessary. Many fans arrange their apparatus so that the lead-in wire must cross the set to connect with the binding post. This is, of course, wrong, and the set should be arranged differently; for example, moved across the room, which will reverse the direction of the connection.

How to Save Your Tubes: After the set has been wired and before attaching the batteries, the following test should be made to make sure that the tubes will not be blown as the result of faulty connections. Connect the "A" battery to the "B" battery binding posts and turn on the rheostat. If the wiring is correct, the tube will *not* light, and if the tube does light it shows that the "B" battery is crossed with the filament circuit.

How to Test the Parts: Before constructing a set, test your apparatus. Test your transformers by connecting primary and secondary in series with phone and battery. If the click is heard when the circuit is closed, the transformer is good. If no click is heard, replace with a new one. Test condensers in the same way; *no* click should be heard. Variocouplers, rheostats and potentiometer can be tested in the same way. Each of these *should* give a click when the circuit is closed.

Remove Your Voltmeter: Never leave either a voltmeter or an ammeter on the battery for more than a few seconds. Take the reading and remove the instrument instantly. This is especially good advice for testing "B" batteries.

Wire for Antenna Insulators: When putting up an antenna do not make the mistake of putting up a small-sized wire to hold the insulators. This only makes the antenna as strong as that bit of wire. Always use the same size wire as in the antenna.

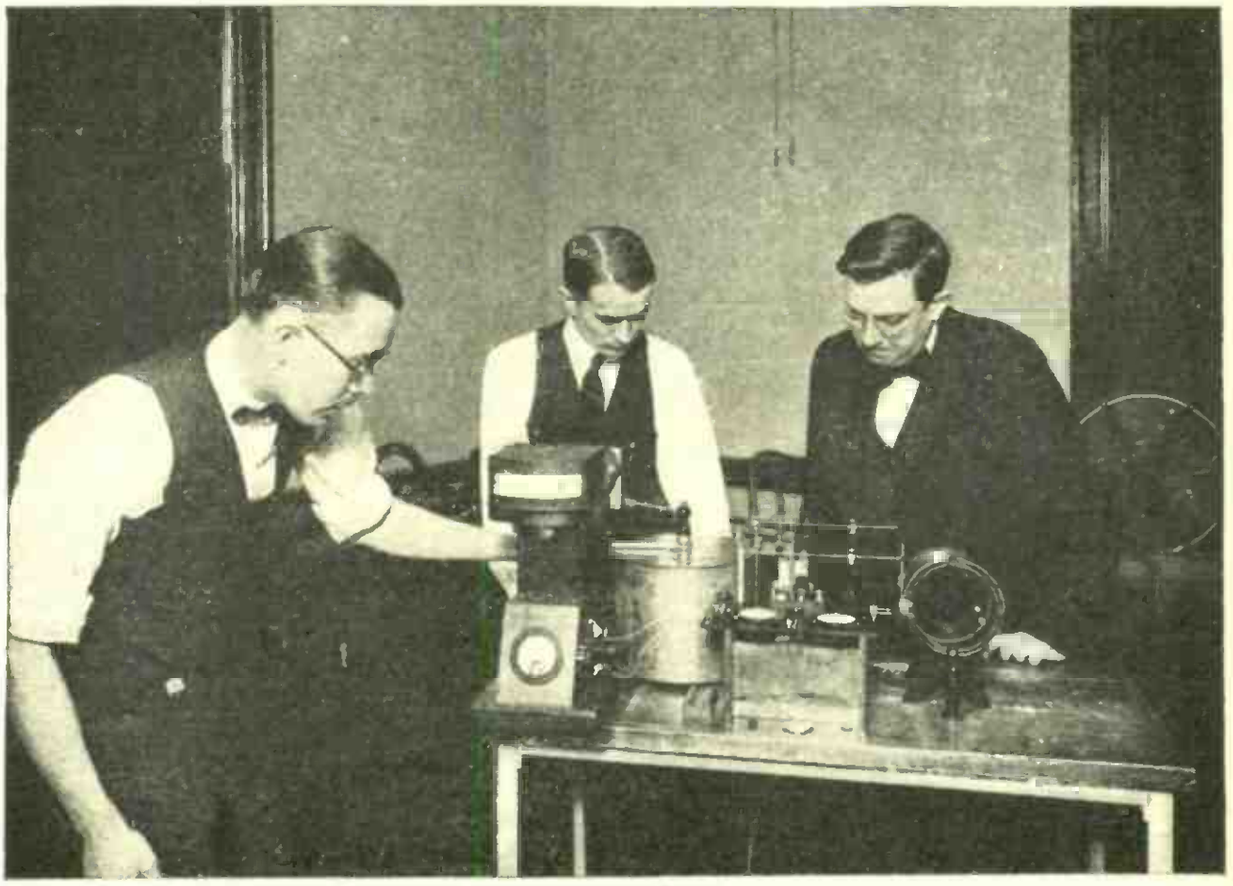
How to Check Your Tubes: If, after you have completed your set, and have checked and re-checked all your wiring, the radio set doesn't work or works poorly, don't jump to the conclusion that the circuit is no good. The trouble may be in the tube and not in the receiver. Even though the filament will light, this doesn't always show that the tube is good. Take your receiver to a friend who is obtaining good results and have him test your set with his tubes.

Tips for Handling Baseboard: When you use a baseboard, be sure it is dry, preferably kiln dried. Boil it in paraffine if possible. Never use a shellac of the common variety. Do not use paint. Have the baseboard heavy enough to offer a real support for the panel. A thickness of ¾ of an inch or an inch will suffice.

Don't Tinker With Electric Light Antennas: In using electric light antenna attachments, the manufacturers' directions should be followed implicitly, and the device should not be experimented with. Otherwise dangerous short-circuits may occur.

Where to Look for Signal Strength Trouble: If the signal strength is less while using the audio frequency than it is while using the detector alone, it may be due to the "A" battery connections being reversed; one of the transformer connections may be disconnected; or you may have the leads to the transformer reversed.

How NOT to Test Your "B" Battery: One of the most expensive stunts is to touch the ends of the two wires on the "B" battery, together, when testing it to see if there is any power left in it. This short-circuits the battery, and even if it should be in good condition, this form of test will greatly reduce its life. Use of the high-resistance voltmeter is the surest, cheapest and safest test.



From a photograph made especially for POPULAR RADIO by Harris & Ewing

THE STANDARD WAVEMETER OF THE BUREAU

The author, Mr. Hall, is shown in the center, explaining the wavemeter to Dr. E. E. Free (at the right). The indicator instruments are shown at the left and the inductor at the right. Mr. O'Keefe (at the left) is adjusting the wavemeter to resonance.

The Standard Wavemeters

—OF THE BUREAU OF STANDARDS[1]

Wavelength standards for all the broadcasting stations in the United States, as well as for other radio purposes, are set by the United States Bureau of Standards in Washington. In this article, Mr. Hall, of that organization, describes the instruments which the Bureau uses as its fundamental standards of radio frequency.

By E. L. HALL

THE primary standard of radio frequency of the Bureau of Standards consists of two standard wavemeters which cover the frequencies in general use, *viz.*, from about 18 to 4,600 kilocycles a second (16,650 to 65 meters). These wavemeters are similar in general construction, each consisting of a variable air condenser, four fixed condensers, a number of interchangeable inductors, and a resonance indicating device, all mounted in a fixed position upon a specially constructed movable table.

The variable air condenser is of about 0.001 microfarad maximum capacity and is a Bureau of Standards type of condenser, having its movable plates connected to a metal shield which is connected to ground when in use. Four shielded mica condensers are also provided having capacities of 0.001, 0.002,

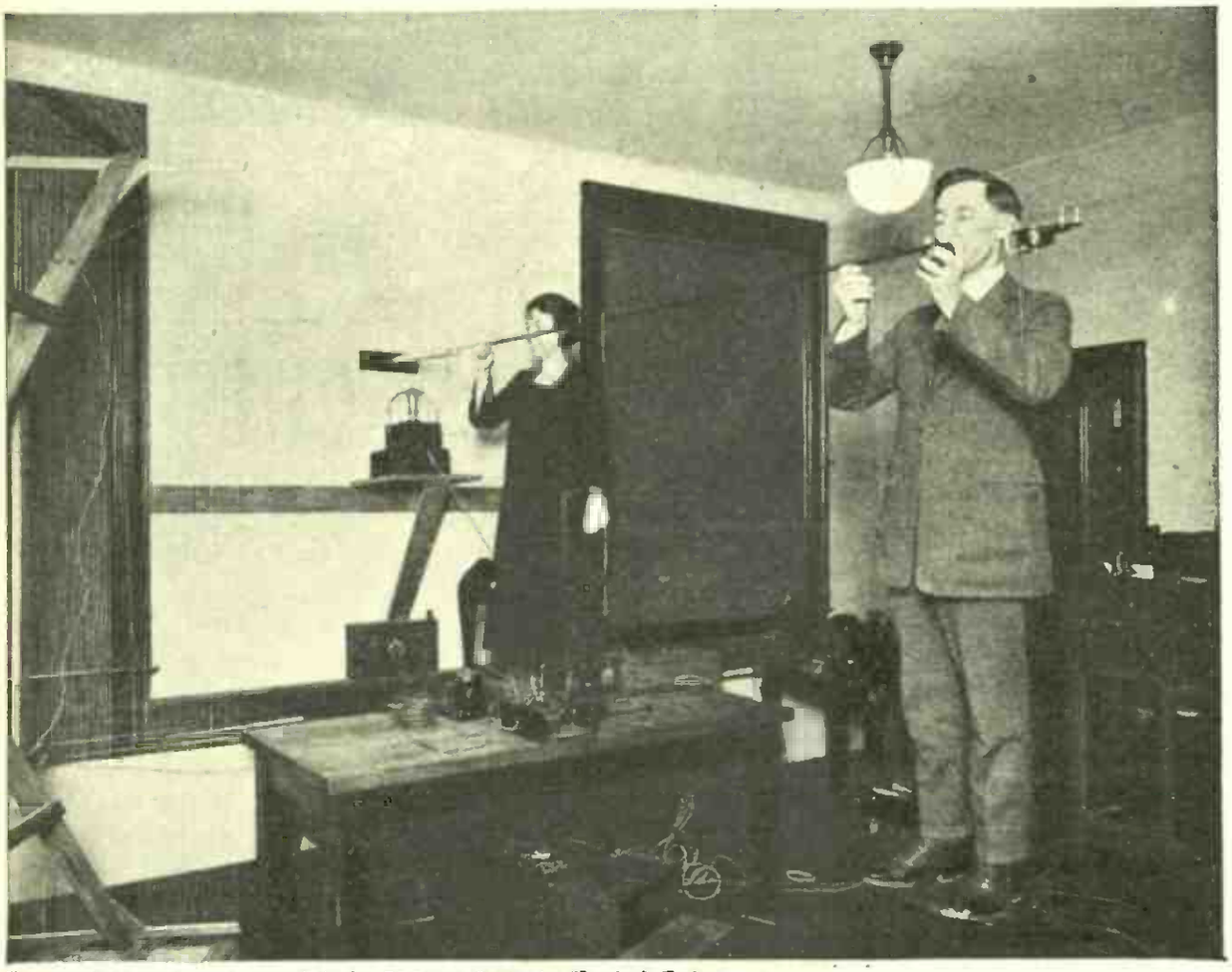
[1] Published by permission of the Director of the Bureau of Standards of the U. S. Department of Commerce.

0.004 and 0.008 microfarad, respectively.

For the one of the two wavemeters which serves as primary standard five inductors are provided. Four of these five inductors are of the single-layer, spaced-winding type, employing skeleton frames of laminated phenolic insulating material wound with high-frequency cable and forming coils of polygonal cross-section. The inductors are provided with terminals so that they are interchangeable. The three smallest coils are boxed in to prevent changes in the inductor constants from the displacement of a portion of the winding by handling.

The resonance indicator consists of two turns of heavy wire fixed in position near the wavemeter inductor and two indicating instruments. A thermo-galvanometer is used for coarse adjustments and a crystal detector and direct current milliammeter for finer adjustments, the later instrument permitting of much more accurate indication of the resonance point than the former.

In the wavemeters of this general design formerly used by the Bureau the condenser and inductors were mounted separately. After tests were completed with a wavemeter of this type, the condenser, inductor and connectors were put away in a case until needed again. There was always the chance of changing the calibration of the condenser by carrying it from one place to another, as well as the chance that errors might be introduced by using different con-



From a photograph made especially for POPULAR RADIO by Harris & Ewing

HOW WAVEMETERS THEMSELVES ARE STANDARDIZED

To check the readings of wavemeters the Bureau has devised a method of setting up very short standing waves on parallel wires and measuring these waves with a tapeline. The generator for the short waves is shown at the left. The photograph shows the method of measuring with the tape the position of a resonance point previously determined with the ammeter seen to the right of the operator's hands.

Table No. 1

CONSTANTS OF THE INDUCTORS FOR THE PRIMARY STANDARD WAVEMETER

	INDUCTOR				
	E	F	G	H	L
Diameter, centimeters	12.5	12.5	22.8	27.9	38.0
Length, centimeters	6.6	7.1	9.4	15.4	18.2
Number of turns	8	22	39	96	320
Spacing, centimeters	0.8	0.3	0.2	0.2	0.1
Size of wire (high frequency cable)	48x38	48x38	48x38	48x38	32x38
Distributed capacity, micro-microfarads	8	11	11	14	90
Pure inductance, microhenries	9.2	56	382	2439	22880
Equivalent resistance, ohms for the frequency corresponding to a 10° setting of the air condenser	2.4	2.2	6.2	11.3	—
Same for 175° setting of the air condenser	0.4	0.7	2.0	5.1	—
Direct current resistance, ohms	0.27	0.44	1.54	5.1	21.0

Table No. 2

RANGES OF VARIOUS COIL AND CONDENSER COMBINATIONS

Coil and Condenser Combinations	Frequency Kilocycles per second		Wavelength Meters (approximate)	
	10° setting	*175° setting*	*10° setting*	*175° setting*
E	4610	1500	65	200
F	1650	615	180	490
G	700	233	425	1285
G and I	241	172	1240	1740
G and II	174	142	1720	2110
H	280	93	1070	3220
H and I	95	68	3120	4380
H and II	70	57	4300	5280
L	73	29.5	4100	10160
L and I	30.3	22.0	9900	13600
L and II	22.3	18.3	13400	16400

necting wires or by accidental bending of the wires.

Much of this chance of error was overcome by mounting permanently a standard variable air condenser and connecting leads for the coil terminals upon a table equipped with rubber-tired wheels.

The resonance indicator for the wavemeter built on this principle was a combination of a single turn of wire and a Weston "thermogalvanometer" Model 425, the latter consisting of a thermo-element and a direct-current indicating instrument. The single turn of wire was mounted with its plane parallel to the turns on the wavemeter inductor but was not fixed in position. It could be moved along a line perpendicular to the axis of the wavemeter coil. The indicating instrument and the turn of wire were connected to the grounded terminal of the wavemeter. This wavemeter covered a range of from 30 to 4,600 kilocycles (10,000 to 65 meters) using a condenser of about 0.001 microfarad capacity and six fixed inductors.

Among the improvements in a wavemeter of this type was the addition of the four mica condensers which could be connected in parallel with the variable air condenser in order to extend the range of the wavemeter. A micrometer adjustment for the movable plates of the variable air condenser was added also.*

The wavemeter now in use is a still

* This wavemeter has been described in detail by Mr. R. T. Cox, "Standard Radio Wavemeter, Bureau of Standards Type R7OB." Jour. Optical Soc. of Amer. Vol. 6, No. 2, page 162 (March, 1922).

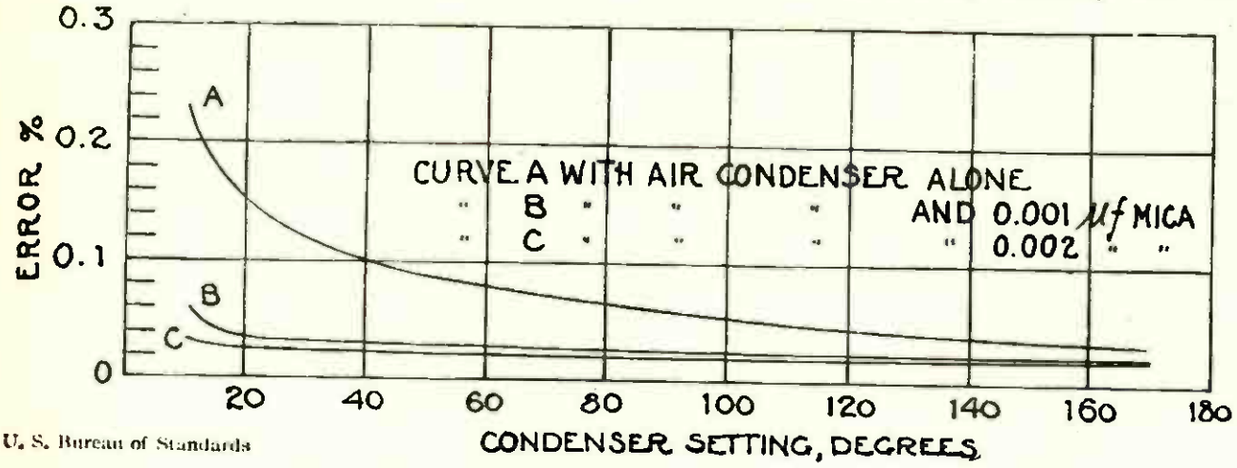
further improvement on this type. The connections to the inductor are made of 3-millimeter brass rod forming a rectangle 25 by 29 centimeters. Four rods support the connections to the inductor. The two on the insulated side of the condenser are of Pyrex glass. Of those on the grounded side of the condenser, the support nearer the condenser is of brass and connection to the ground is made through its lower extremity. The support nearer the inductor is of laminated phenolic insulating material.

The resonance indicator may be connected either to a model 425 Weston thermogalvanometer or to a crystal rectifier and direct-current milliammeter. The latter combination is much more sensitive than the former and permits much looser coupling between the radio-frequency generating set and wavemeter. The instrument shown in the photograph has a full-scale range of 2 milliamperes, but when in use the current is usually kept between 0.4 and 0.8 milliampere, which permits extremely loose coupling between the generator and the wavemeter.

The resonance indicator circuit is not grounded or connected to the wavemeter circuit in any way. A greater deflection may be obtained by grounding that circuit at certain ranges of frequency, but this is noticed particularly with the crystal rectifier and milliammeter which is more sensitive than the other instrument. The increase in deflection is caused by the apparent increase in coupling with the generator resulting from connecting to the ground connection. This is noticed particularly with the smaller inductors, where there is likely to be a change in the calibration because of the proximity of the two turns of wire which are at ground potential, to the wavemeter inductor.

This method of resonance indication permits of looser coupling than may be obtained with the indicator directly in the wavemeter circuit, except perhaps for the very high frequencies. When a crystal detector and a sensitive wall-galvanometer are used, the wavemeter may be from ten to twenty feet from the generator, but such a combination is not portable although very accurate results may be obtained in this way. When an indicating device of 4 or 5 ohms resistance is placed in the wavemeter circuit the equivalent resistance of the circuit is considerably increased and closer coupling is necessary.

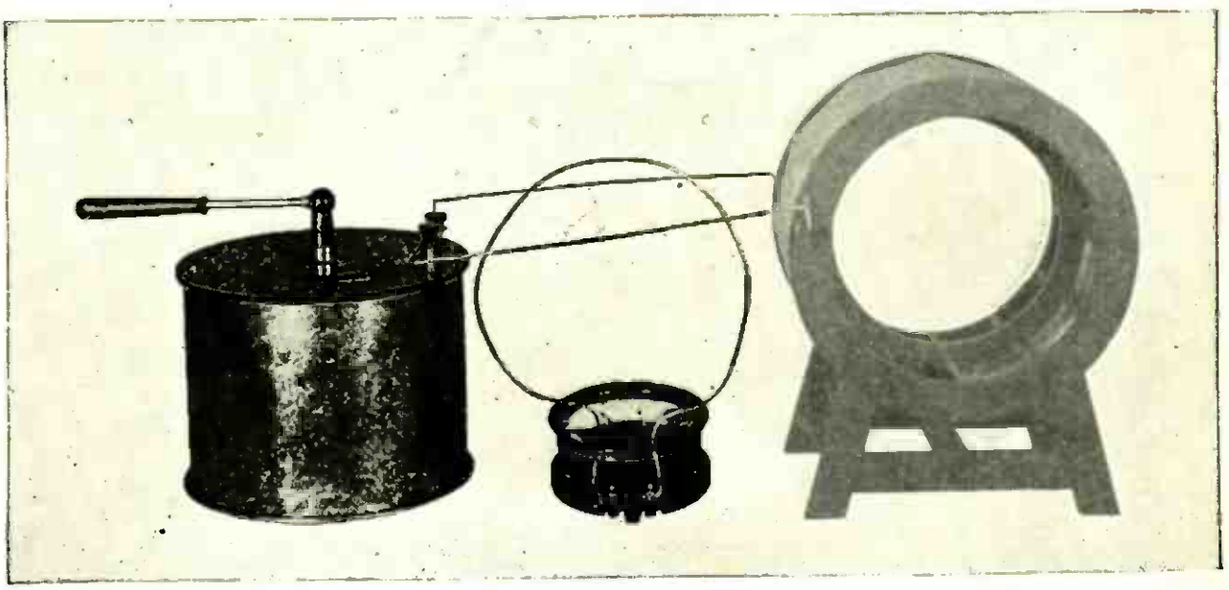
Another feature of this wavemeter of some interest is the fact that the table is made with two tops separated by pads of sponge rubber about 1½ inches thick. With this device and with the four-inch rubber-tired wheels, the air



U. S. Bureau of Standards

THESE CURVES INDICATE THE ACCURACY OF THE WAVEMETER

The percentage error encountered with three condenser combinations is shown by the three curves. Note that the maximum error, at the worst portion of the highest curve, is only a little over two-tenths of a percent; an error which is altogether negligible in practical work.



U. S. Bureau of Standards

THE MOST IMPORTANT PARTS OF THE WAVEMETER

At the left is the cased variable condenser; at the right is one of the inductors, and in the center is the indicating instrument with its loop. Note how the inductor is supported by its rigid frame of phenolic insulating material.

condenser is kept quite free from jarring when it is moved around the laboratory. This precaution is important if the calibration is to be reliable.

The wavemeter is used with a ground wire attached to the shielded side of the air condenser. This reduces the error in noting the resonance point which is likely to be caused by capacity effects between the wavemeter circuit and the body of the operator. When making measurements of frequency the wavemeter is coupled to the radio-frequency generating set as loosely as possible. The distance between the generating set and the wavemeter will vary from a few inches at high frequencies to several feet on lower radio frequencies. The operator always stands on the grounded side of the wavemeter, well away from the inductor.

The constants of the inductor coils and the frequency ranges attainable are given in the accompanying table. The precision of setting the wavemeter to a given frequency is dependent on the sharpness of the resonance point as denoted by the resonance indicating instrument, which in turn will vary with the amount of capacity in the wavemeter circuit.

For capacity values such as are in general use at this time the precision varies from 0.2 percent for low condenser settings to about 0.02 percent with fixed condensers of about 0.002 microfarad capacity. In the majority of work with the wavemeter these values will vary between 0.1 percent and 0.03 percent. The precision of measurement may be increased by using more sensitive resonance indicators.

RADIO GIVES THEM 40 MINUTES OF FREEDOM EVERY MONTH

This is the jazz-orchestra section of the full brass band that is made up entirely of convicts—ranging from mere embezzlers to murderers—who are confined in the penitentiary. They broadcast a 20-minute concert fortnightly from station WOS.

The Strangest Band that Broadcasts

By S. R. WINTERS

IF John Bunyan had been confined in the State Prison of Missouri in the Twentieth Century, instead of being thrown into a dungeon in England in the Seventeenth Century, he could not have pictured the "Slough of Despond." Instead, he might have told of the influence of radio upon lives whose ill-advised acts had brought them within prison walls. This analogy is peculiarly applicable to the Missouri State Prison, where the radio broadcasting station offers at once a temporary release to convicts and the privilege of making known their musical talents to an invisible audience of unnumbered thousands.

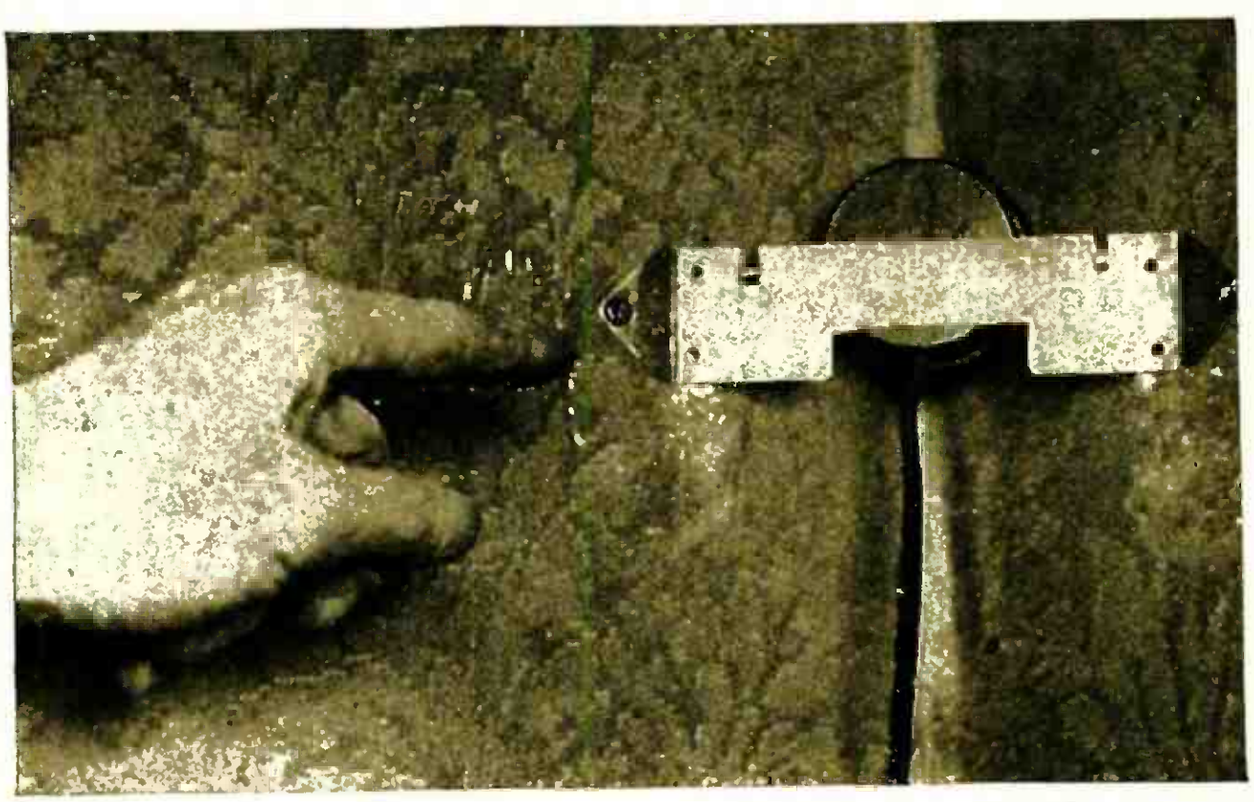
If you are ever in Jefferson City, Missouri, and should observe a motor truck conveying a large group of prisoners along the streets, do not mistake the significance of the scene. Offhand, you are likely to conclude that these convicts are being transferred to other places or quarters to complete their tenure of prison service. The mistake is a natural one, since the procedure has been reversed. A few moments before, the big iron gates at the state prison had swung open and then closed, to permit of the departure of thirty inmates of the prison, with the state capitol, strange to say, as their destination.

The distance between the state prison and the radio broadcasting station, WOS, is only seven blocks. The occupants of this motor truck comprise the Missouri State Prison Band or Missouri State Prison Orchestra. In both instances the members are convicts serving sentences ranging from two years to life terms. They are musicians, and although their liberties are restricted for

having committed crimes, their latent talents have been permitted free expression. The privilege of broadcasting music fortnightly from a radio station operated by the Missouri State Marketing Bureau is in furtherance of the humanitarian policy of a state to redeem to lives of usefulness persons who have committed ill-advised acts.

A complete transformation of scenery and environment is that of a prison and the studio of a radio broadcasting station. The former is a denial of all that mankind craves; the studio of a radio broadcasting station, on the other hand, is an outlet to all civilization—a universal medium of contact with the mansion and hovel. Among the cards and letters, telegrams and long-distance telephone messages that pour in, complimentary of the fortnightly programs of the Missouri State Prison Band, are such expressions: "Take the band out of jail—they ought to be in heaven," and, "If I were governor of the state I would open the gates of the prison to them tonight after their wonderful and inspiring concert."

Oddly enough, the radio broadcasting station WOS is located in the dome of the state capitol. Except for the presence of one or two guards, who accompany the prisoners from the penitentiary to the broadcasting station, the musicians, convicted of crimes ranging from embezzlement to murder, are temporarily divested of the shackles which curbed their liberties a few moments before and are permitted to smoke cigarettes and cigars, gifts of a gracious invisible audience. And for a few brief minutes they are no longer prisoners, but artists who perform before a vast and appreciative audience.



Photonews

HOW TO USE THE WALLS OF YOUR HOUSE AS A LOUDSPEAKER

By means of a simple metal bracket, a striking loudspeaker can be made of a single headphone. The bracket serves to hold the telephone in position facing the corner, at the intersection of the two sides of the room. The two walls, which form a right angle, act as sounding boards and throw out the sound clearly and with good volume.

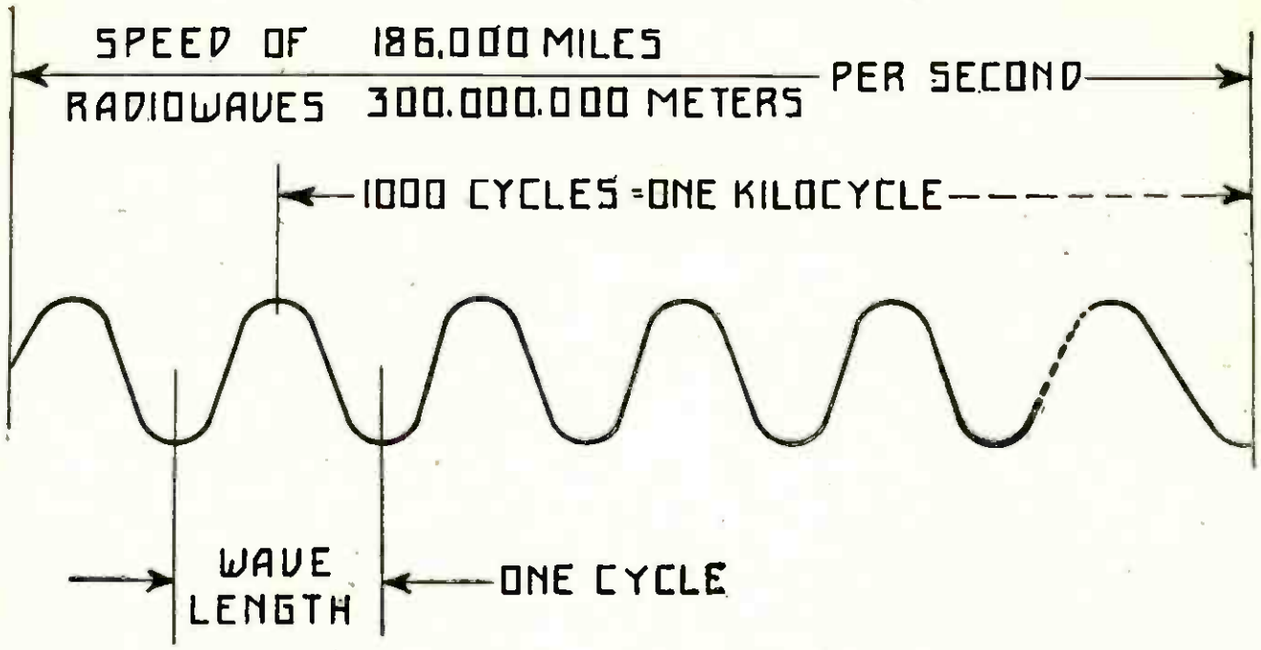


FIGURE 1: *A simple chart that shows the relation between wavelength and frequency. The distance from crest to crest is the wavelength; this corresponds to one cycle, or a complete reversal of the alternating current that produces the wave.*

A MEASUREMENT CHART

FOR CONVERTING WAVELENGTHS INTO KILOCYCLES

ARTICLE NO. 9

The previous articles contain charts *For Determining the Constants of Radio Circuits and Calculating Capacities of Condensers in Series,* in February, 1923; *For Determining the Dimensions of Your Coil,* in March, 1923; *For Determining the Capacity of a Condenser,* in May, 1923; *For Determining the Capacity of Your Antenna,* in July, 1923, and *For Determining the Constants of a Loop Antenna* in August, 1923; *For Determining the Maximum Capacity of a Variable Condenser,* in April, 1924; *For Designing a Rheostat,* in May, 1924.

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

THE speed of any ether waves is approximately 186,000 miles a second or 300,000,000 meters.

The length from the crest of one wave to the next one (see Figure 1), completing one cycle, is called the *wavelength.*

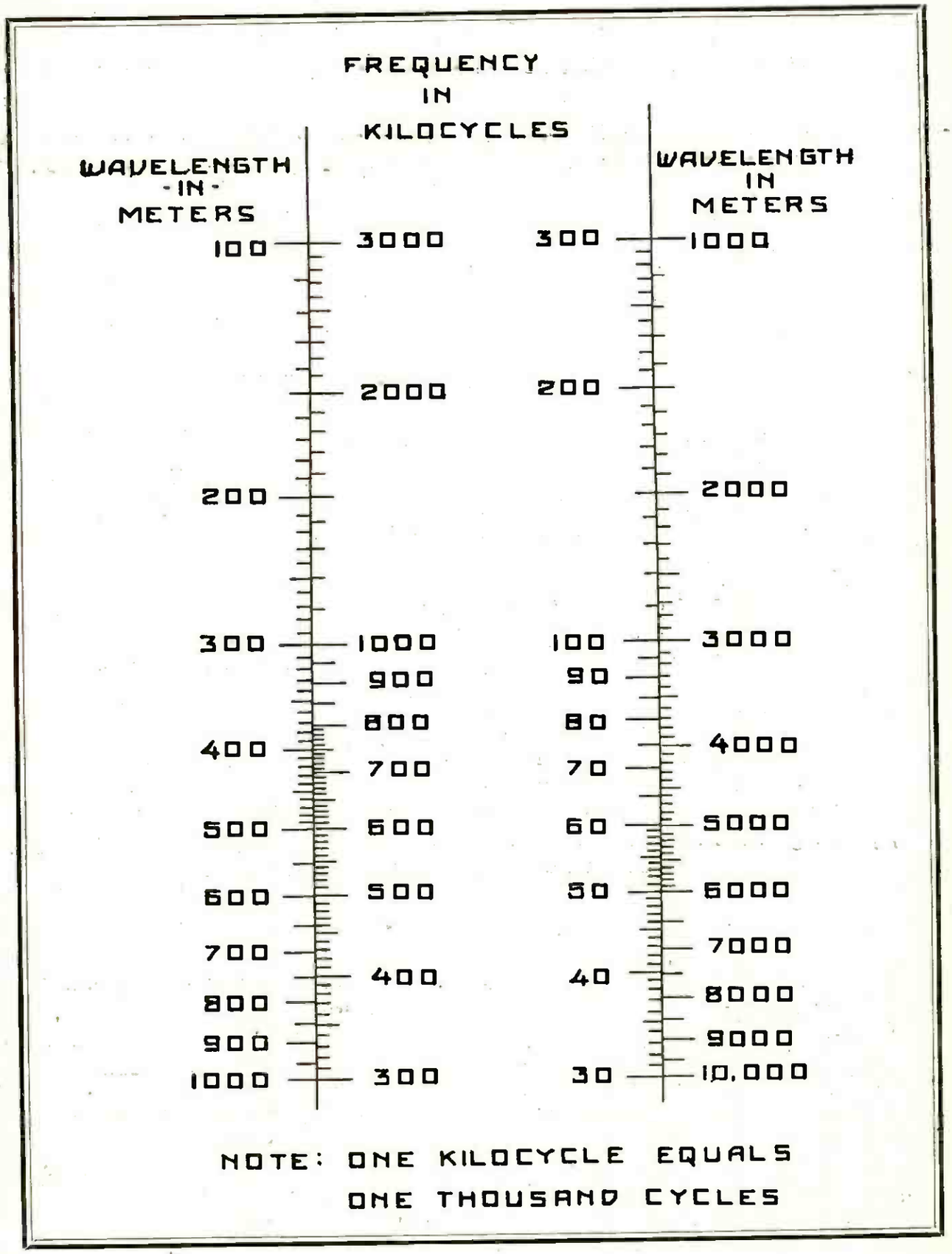
The number of waves passing a fixed point in a second is the frequency of the electric oscillations.

If we take a wavelength of 600 meters, to find the frequency per second we divide 300,000,000 by the wavelength, which in this case is 600. This will give us 500,000 cycles. The amount runs into a high number and, therefore, we can substitute for 1,000 cycles, one kilocycle (as kilo means always thousand in the metric system), giving us 500 kilocycles.

It therefore follows that the multiplication of the wavelength and the number of kilocycles must give us the figure 300,000.

To facilitate the calculation of wavelength and frequency the accompanying chart has been prepared.

Simply read the wavelength and corresponding frequency from the same horizontal line crossing the two vertical lines at the desired frequency or wavelength you wish to convert.



HOW TO USE THE CHART

On the outer edges of the two upright lines are given the wavelengths in meters, with their corresponding frequencies denoted opposite them between the two sets of upright lines. Thus, for a wavelength of 300 meters, the corresponding frequency is 1,000 kilocycles a second, and for a wavelength of 3,000 meters, the corresponding frequency is 100 kilocycles a second.

CONDUCTED BY LAURENCE M. COCKADAY

IN justice to our regular subscribers a nominal fee of fifty cents per question is charged to non-subscribers to cover the cost of this service, and this sum must be inclosed with the letter of inquiry. Subscribers' inquiries should be limited to one question or one subject.

Crystal Detector with One Stage of Tuned Radio-frequency

QUESTION: Please give me a hook-up for using the following apparatus:

Two Amrad variometers;
one Sexton variable condenser, .0005 mfd.;
one crystal detector and stand;
one C-299 vacuum tube and socket;
one pair of Holtzer-Cabot telephones.

I would like to use one stage of radio-frequency amplification with the crystal detector. As I haven't the necessary funds to buy expensive transformers, please give me something simple.

ARTHUR SEARS

ANSWER: You will find a simple circuit drawn for you in Figure 1. You will need only two more instruments, a filament rheostat of 30 ohms resistance, and a fixed condenser, of the mica dielectric type, of .00025 mfd. capacity.

Value of By-pass Condensers

QUESTION: What is the usual value of the condenser used across the primary terminals of the first transformer in an audio-frequency amplifier?

SAMUEL BROWN

ANSWER: The capacity should be .0005 mfd. for ordinary detector circuits. However, for the ultra-audion circuit some capacity lower than this may be more advantageous. For this type of circuit a variable condenser would be advisable. (One of the small semi-variable mica condensers.)

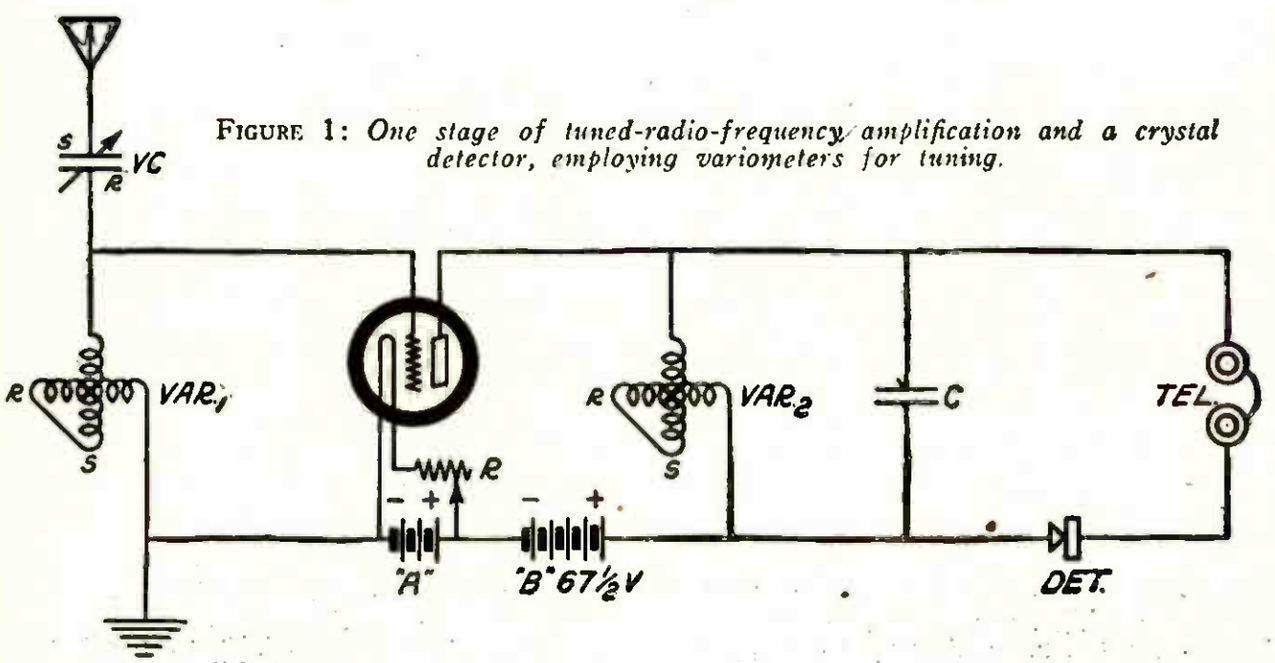


FIGURE 1: *One stage of tuned-radio-frequency amplification and a crystal detector, employing variometers for tuning.*

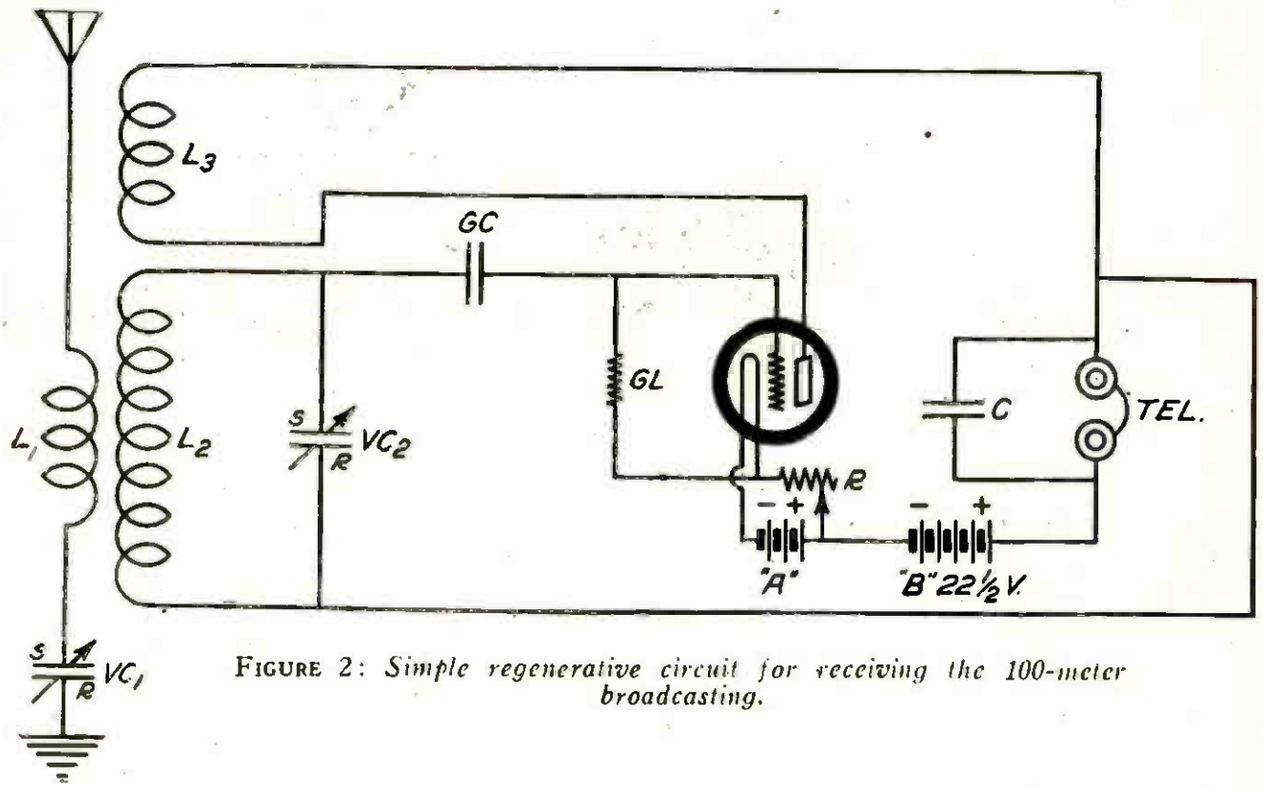


FIGURE 2: *Simple regenerative circuit for receiving the 100-meter broadcasting.*

100-Meter-wave Regenerative Receiver

QUESTION: I am very much interested in receiving the low-wavelength broadcasting from KDKA and WGY. I live about half-way between these two stations and would like to be able to make a set that would receive these two stations. Will you print a circuit diagram for a one-tube regenerative set for covering the proper low-wavelength range. If so, I will build it and, if necessary, add an audio-frequency amplifier to it for loudspeaker reception. I want only the one-tube circuit to start with, however.

JAMES FINCH

ANSWER: The circuit you require is shown in Figure 2. The proper instruments with their constants are indicated in the following list of parts:

L1, L2 and L3—honeycomb or duolateral, coils, size L-25;
VC1—variable condenser, .00025 mfd.;
VC2—variable condenser, .0005 mfd., with vernier;
GC—mica fixed condenser, .00025 mfd.;
C—mica fixed condenser, try sizes from .0001 mfd. to .0005 mfd.;
R—filament rheostat, 6 ohms;
GL—grid-leak, variable;
TEL—telephones.

The tube may be either a C-300 or a UV-200 tube. The three coils L1, L2, and L3 should be mounted, in the order given, in a three-coil honeycomb mounting.

Tuning is done with the two condensers, VC1 and VC2, and the coupling is varied by swinging the coil L1 nearer to, or farther away from, the coil L2.

Regeneration is controlled by swinging the coil L3 nearer to, or farther away from, the coil L2. The coil L2 is stationary.

Crystal or Vacuum-tube Detectors for Reflex Sets?

QUESTION: Which is the best detector to use with a reflex set? Would a crystal be better or would the vacuum tube be better? In one publication I read that the crystal is best for reflex, and then in another publication that the vacuum tube is superior.

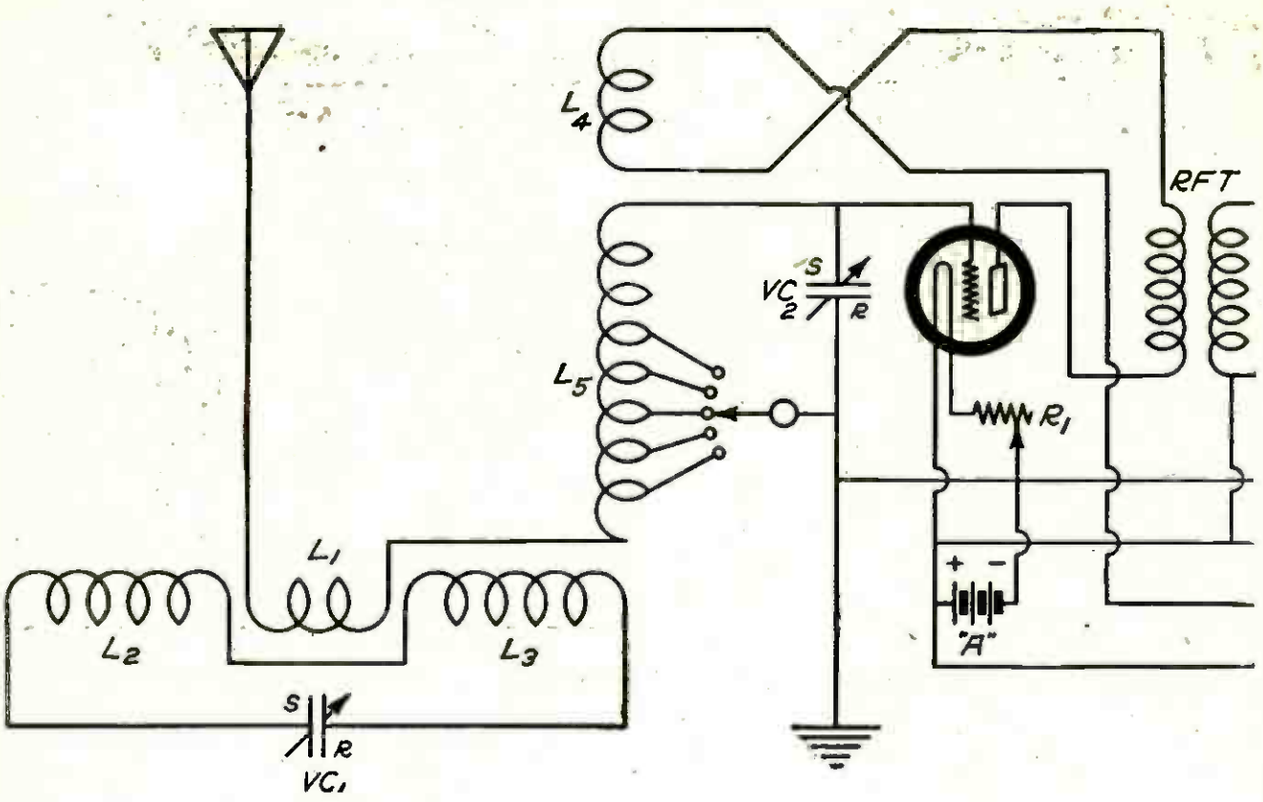
JOHN V. HALLER

ANSWER: From the standpoint of tube economy, the crystal detector is best. It saves the price of a tube, a socket, and a rheostat, as well as saving current from the storage battery, and it gives good clear reception.

From the standpoint of highest sensitivity and consistent operation, the vacuum tube is superior.

So, you see, the information you received may have been correct, although it was not complete enough.

Both the crystal and the vacuum-tube detector have their place in the reflex set, but each is better from some specific standpoint.



Combining the Four-circuit and the Superdyne Receivers

QUESTION: I have built and am using both the single-tube four-circuit receiver and the superdyne receiver with two stages of audio-frequency amplification.

I like the superdyne receiver but it cannot compare with the simple tuning that I get with the four-circuit receiver.

One of my friends said that they could be combined. He said that he saw a circuit in one of the newspapers but could not remember which one it was.

Can you tell me which paper it was in, or possibly give me the circuit or a circuit for combining both? I would appreciate it.

DONALD RICE

ANSWER: The circuit referred to is probably the one that appeared in the radio section of the *Herald-Tribune* for May 11th. However, we have drawn it for you and you will find it in Figure 3.

The parts you will require are the following:
L1—primary coupling coil;
L2 and L3—stabilizer coils;
L4 and L5—superdyne coupler;
RFT—radio-frequency transformer;
AFT1 and AFT2—audio-frequency transformers;
VC1—variable condenser, .0005 mfd.;
VC2—variable condenser, .0005 mfd.;
VC3—variable condenser, .0005 mfd.;
GC—grid condenser (mica), .00025 mfd.;
C—mica fixed condenser, .0005 mfd.;
R1, R3 and R4—filament rheostats, 20 ohms;
R2—filament rheostat, 6 ohms;
J—single-circuit jack.

Coils L1, L2 and L3 are wound on a 3½-inch composition tube. Coil L2 consists of 17 turns of No. 18 DSC wire wound on the end of the tube. Coil L1 consists of 2 turns of the same kind of wire wound alongside the first coil, and coil L3 consists of 17 turns of the same kind of wire wound alongside of the second coil.

Coils L4 and L5 are the two windings of the regular superdyne coupler.

The radio-frequency transformer RFT may be made by winding 55 turns of No. 22 DSC wire on a 3-inch composition tube. This is the secondary coil of the transformer. Then wind 10 turns of the same kind of wire, centrally on the same tube over the first winding. This forms the primary coil.

Use either C-301-a tubes, Deforest DV-3 tubes, or UV-201-a tubes for the first, third and fourth tubes in the set. The second tube in the set is the detector and this should be either a C-300 or a UV-200 tube.

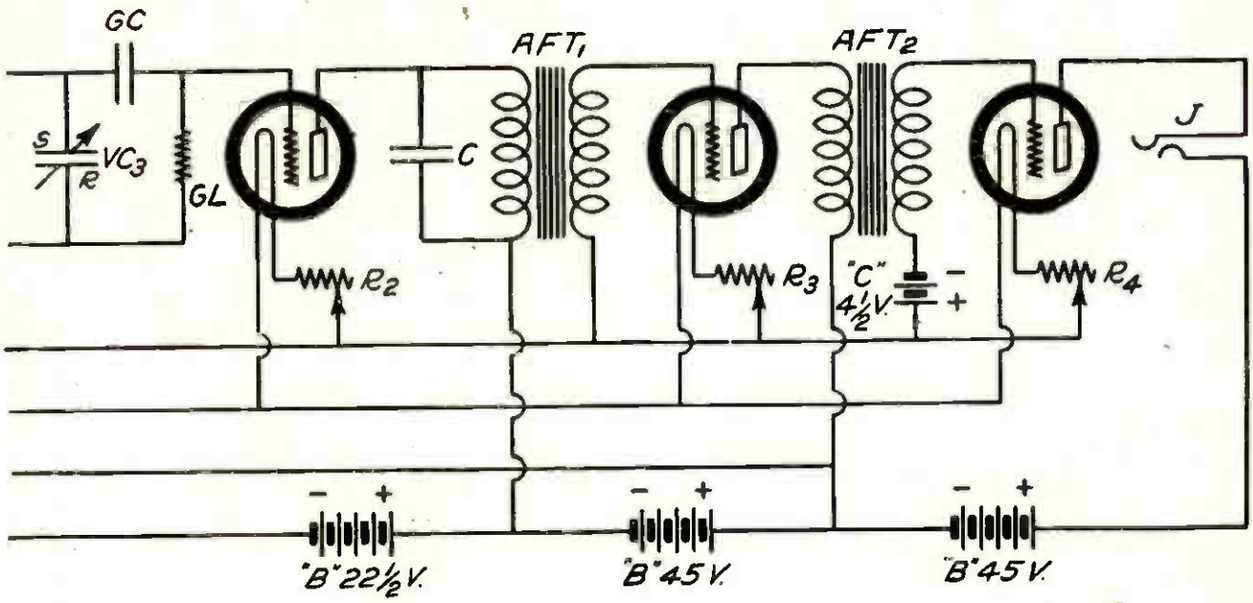
Tubing for Winding Forms for Coils

QUESTION: What kind of composition tubing do you recommend for winding coils on?

H. N.

ANSWER: Hard-rubber tubing.

FIGURE 3: *Circuit for the superdyne embodying the four-circuit tuning principle.*



Noise in an Audio-frequency Amplifier

QUESTION: How can I eliminate the crackling and sizzling noise that takes place when I use the loudspeaker in the second stage of my audio-frequency amplifier? It is eliminated when I put my fingers across the second transformer.

NELSON W. ARBUCKLE

ANSWER: You can reduce this noise in either of two ways, both of which we recommend that you try.

Try connecting a Bradleyohm No. 25 across the secondary of the second audio-frequency transformer. By varying the resistance by means of turning the knob you will eliminate a lot of noise, and also, this will function as a volume control.

Another thing to try would be to connect a small variable condenser across the secondary of the same transformer. The proper values to use will lie between .0001 mfd. and .0005 mfd. Use a small mica fixed condenser which is equipped with special clips for fastening directly on the transformer terminals. Use the smallest condenser that you find will eliminate the noise. Too large a condenser connected here will tend to eliminate too many of the overtones in the received signals and may blur music or speech. However, a simple test will tell you just what capacity will be the best.

Different makes of condensers need different values and that is the reason that we cannot tell you the exact capacity to use. The values will, however, lie between those given above.

What Length Should the Antenna Be?

QUESTION: I have a four-circuit set that was built for me by a friend. He told me that it would be advisable for me to put up a 100-foot wire for best results. Does this mean that I should use 100 feet of wire, or does it mean that I should use a 100-foot wire on the roof? If I use only 100 feet of wire, in all, I would only have about 25 feet of wire up on the roof.

Please give me the right information on this.

ALAN SEXTON

ANSWER: Use a wire of about 100 to 150 feet in length, exclusive of the lead-in.

Voltage of "B" Battery for Hard Detector Tubes

QUESTION: What is the proper voltage to use on hard tubes when they are used with a radio-frequency amplifier?

H. E.

ANSWER: Between 45 volts and 90 volts, according to the particular type of tube used. This had best be determined by experiment. Try varying the taps on your "B" battery within the limits given above and you will easily find the best by comparing the tone and volume.

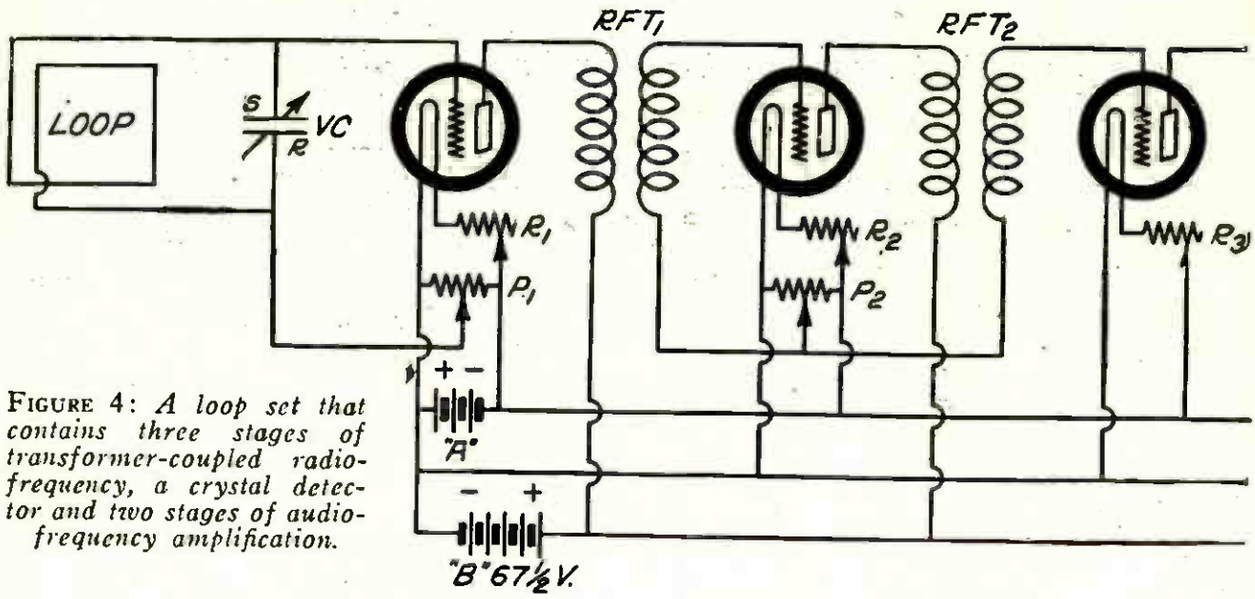


FIGURE 4: *A loop set that contains three stages of transformer-coupled radio-frequency, a crystal detector and two stages of audio-frequency amplification.*

An Efficient Loop Receiver

QUESTION: Will you kindly give me the hook-up of an efficient loop set that contains only one tuning control and uses a crystal detector? I do not want to use more than five tubes and I do not want to use the reflex principle.

DR. S. D. THOMAS

ANSWER: A circuit that will fill your requirements is given in Figure 4. The parts that you will need to complete the set are the following:

VC—variable condenser, .0005 mfd.;
RFT1, RFT2, and RFT3—radio-frequency transformers;
AFT1 and AFT2—audio-frequency transformers;
R1, R2, R3, R4, and R5—filament rheostats, 30 ohms;
P1 and P2—potentiometers, 400 ohms;
J1—double-circuit jack;
J2—single-circuit jack;
DET—crystal detector (fixed);
"A," "B," and "C" batteries;
loop antenna;
sockets.

The tubes should be either Deforest DV-3 tubes or UV-201-a tubes or C-301-a tubes. These will require, of course, a six-volt storage battery for best operation.

All tuning is accomplished with the variable condenser VC. The loop will help to eliminate directional static and interference. The potentiometers control regeneration in the radio-frequency circuits.

What Kind of Wire Is Best?

QUESTION: What kind of wire do you advise using to wind the coils of the four-circuit tuner? Shall I use No. 18 SCC, or No. 18 DSC?

T. R. SMITH

ANSWER: Use the No. 18 DSC (double-silk-covered) copper wire for all of the coils and the results will be excellent.

Single-circuit *vs.* Craig Neutrodyne

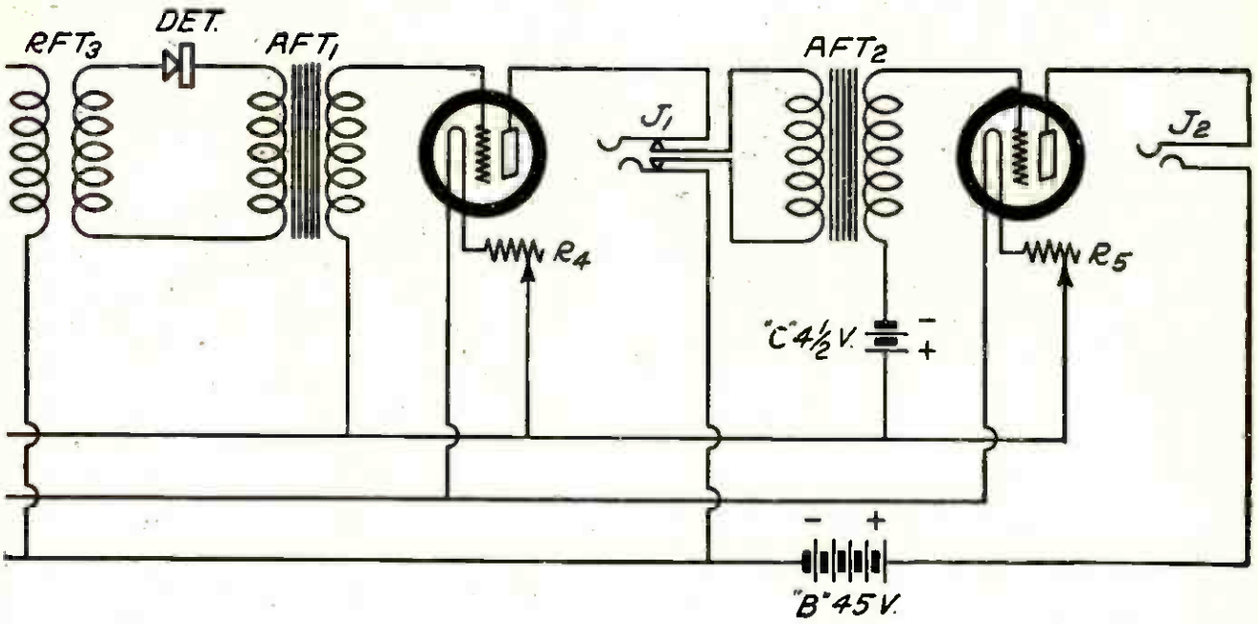
QUESTION: I have a single-tube, single-circuit set and had intended adding two more bulbs to it as audio-frequency amplifiers. But when I read Mr. Craig's article in POPULAR RADIO on the simplified neutrodyne I thought it might be advantageous to both my neighbors and myself, to make the Craig set. However, I thought I would write you and find out what you thought about the two propositions.

H. R. WHITE

ANSWER: You will find the Craig set will give you much better results than the other set, as well as eliminating any possibility of radiation. Also read Mr. Craig's article in this issue on an inexpensive reflex employing the principle of neutralization. Either of these two sets would be much better all around than the single-circuit receiver.

Induction from Telephone Lines

QUESTION: For the past year the writer has been listening to various telephone conversations by means of a radio receiving set; conversations be-



tween people in this city on the ordinary line telephone. But tonight was the climax!

We were listening to WCX on a receiver and a loudspeaker when a loud dialogue broke in on the concert and assumed such a volume that the concert was almost drowned out. It was evidently a long-distance call between Pontiac and Birmingham. Then, for ten minutes we listened to the operators at the exchange receiving calls and then it stopped.

A few minutes later, as the band at WCX stopped playing, for a short intermission, we heard two women talking. One said, "I hear music at your house." The other replied, "I heard it also but it isn't over here," A few minutes later they hung up the receivers and we could distinctly hear the click.

From their conversation, they evidently heard the band concert that was coming in over my set. How could that occur?

Our antenna or ground is not very near the telephones and we cannot understand how it can happen.

H. R. Grogg

Answer: This is a plain case of induction. The telephone wires produce an electromagnetic field around them, which varies in intensity just as the voice currents travelling over the wires vary.

Your antenna is within range of these fields and a feeble current is either induced in them or directly into the input of the audio-frequency amplifier. Possibly, your own telephone extension helps to link the amplifier of your set with the other lines.

Such an occurrence happens quite often and others like yourself write in for explanations. We receive many such letters on this particular subject.

The cause is ordinary electromagnetic induction, the same thing that causes the transfer of energy between the primary and the secondary coils in your receiver.

Resistance or Transformer-coupled Amplification?

Question: What would you advise, resistance coupling for an audio-frequency amplifier, or transformer coupling? I care nothing for expense. I want to get the best quality of reproduction no matter what the cost. I do not need excessive volume; just enough to fill a good-sized room from a loudspeaker. Will you kindly advise me which form of amplifier to incorporate in my set and how many stages will be necessary?

Anton Schleck

Answer: For your purpose, we advise the use of a resistance-coupled amplifier of not less than three stages and not more than four stages. This will give you volume enough and will give you exact amplification at all frequencies and perfect reproduction provided that the detector circuit does not distort and, likewise, that the loudspeaker does not distort.

IN THE WORLD'S LABORATORIES

CONDUCTED BY DR. E. E. FREE

Is the "Diabolic Ray" Produced with Ultra-violet Light?

THE remarkable experiments of Mr. H. Grindell-Matthews which he describes on page 148 of this issue of POPULAR RADIO, have attracted, following newspaper accounts of some of them, the widest possible attention among scientists as well as among military and naval experts. Tests have been witnessed by distinguished men of science, including a special representative of POPULAR RADIO. The power-carrying-ray—nicknamed by newspaperdom the "diabolical ray"—is apparently a reality; to the extent, at least, of what Mr. Grindell-Matthews claims for it.

The next question, and the one of major interest to the scientists, is how is the ray produced?

The obvious guess, and the one which many scientific writers on the ray have made, is that the secret lies in some special use of ultra-violet light. This variety of light, you remember, consists of waves shorter than the waves of visible light. In the rainbow-strip or spectrum, these rays lie beyond the blue or violet end of the colors; hence their name of ultra-violet. Many scientists have studied these ultra-violet rays and many curious properties of them have been discovered.

Among these properties is one that stands out in connection with the Matthews ray. It is the power of the ultra-violet waves to make gases like air conductors of electricity. The ultra-violet light "ionizes" the air. This means that it knocks electrons off atoms, leaving the atoms with charges of positive electricity. The use of this same process in the sodion tube has already been described in this Department.*

In the air, what ultra-violet light does is to remove one electron each from a number of the atoms of oxygen and of nitrogen. This produces a number of positively charged "ions" of oxygen and nitrogen. Like any other charged particles, these ions serve to carry electric currents and to make the air more or less conducting for electricity. The same process of ionization is supposed to take place in the Heaviside Layer and to be responsible for the conducting properties of this part of the upper atmosphere.

Now, if this be true, it is obvious that a beam of ultra-violet light would do to the air just what Mr. Grindell-Matthews says that his "carrier beam" does; it would make the air conducting for electricity. When asked the direct question whether this was or was not the explanation of his experiments, Mr. Grindell-Matthews stated that it was not.

It remains, nevertheless, the opinion of many scientists—an opinion which the editor of this department confesses that he shares—that *some* use of ultra-violet light or of similar radiations underlies the secret of the ray. It may be, of course, much more complicated than a simple beam of ultra-violet waves. It may include other kinds of radiations. But the correspondence between the properties claimed for the "carrier beam" and the properties which a beam of ultra-violet light in air is known to possess, is too close a correspondence to be entirely accidental.

There have been announced, by the way, several other methods of producing a power-carrying ray; notably one by Dr. T. F. Wall of Sheffield, England. Present reports of this newer ray are fragmentary but indicate that it is somewhat similar to the ray of Mr. Grindell-Matthews. Doubtless it, too, is produced by some agent, ultra-violet light or something else, that is capable of creating a conducting path through the air.

Whether or not the claims of Mr. Grindell-Matthews and of Professor Wall prove to be fully justified, it is probable, scientists agree, that a beam of ultra-violet light in air might be made to serve as a path for alternating currents. The chief difficulty is the production of the ultra-violet beam.

This fact gives a considerably increased importance to the recent success of the General Electric Company in producing large masses of transparent fused quartz. At a demonstration held recently before a number of

* POPULAR RADIO for March, 1924, pages 302-304.

scientists and others at the Lynn, Massachusetts, works of the company, which demonstration has been reported widely in the newspapers, Mr. Edward R. Berry discussed the processes and machinery developed under his direction for the production of this material.

Quartz is a mineral. Chemically it is silica; the dioxide of silicon. It is very common in nature, making up the larger part of most sandstones. It has been much used, also, in scientific work, where many of its curious properties are valuable for this or that purpose. Small lenses of quartz have been used in microscopes and other instruments, and prisms of the same material have been used in spectroscopic investigations.

One reason why these lenses and prisms are valuable is that they transmit ultra-violet light, which glass does not. Toward the ultra-violet rays a glass lens is almost as opaque as though it were made of solid lead. A quartz lens, on the other hand, is clear and transparent.

But quartz lenses of large size have not been obtainable. Most of the quartz that occurs in nature is impure and opaque. Fused quartz made in the laboratory has been even more opaque, at least when prepared in blocks of any considerable size. This is where the new process of Mr. Berry comes in. He can make fused, transparent, quartz blocks of any reasonable size. Large quartz lenses are available at last.

You see the possible importance of this for the work with power-carrying rays like that of Mr. Grindell-Matthews. If these rays ac-

General Electric

THIS LENS WILL TRANSMIT BEAMS OF ULTRA-VIOLET LIGHT

Mr. E. W. Berry, inventor of the method of making fused quartz, is holding a disk of this material that is suitable for lens making—a disk much larger than ever made before out of quartz. Quartz will transmit the ultra-violet rays that are absorbed by ordinary glass.

tually do employ ultra-violet light, or any modification of it, one of the chief difficulties of the experimenters must have been the production of large lenses capable of transmitting the rays and of focussing them into powerful beams. Glass lenses are probably useless.

The new quartz lenses may turn the trick. They may make it possible to produce beams of ultra-violet rays much more powerful than those used by anyone up to the present.

But, all this, we must not forget, is speculation. We are not yet sure that the power-carrying ray is as effective as is claimed. We are not sure that ultra-violet light is really the secret of the ray. These things, doubtless, will be disclosed in due course. And in the meantime, the American invention of a furnace for fusing quartz may prove to be quite as important in the use of the "diabolical ray" as is the invention of the ray itself.

An Oscillator That Will Hold a Constant Frequency

THE increasing use of radio apparatus and especially of the vacuum-tube oscillator in all manner of laboratory experiments has created an urgent need for an experimental oscillator circuit that permits variation of the frequency when desired but which, when once adjusted for a desired frequency, will maintain that frequency unvaried. Too many of the usual oscillator circuits are undependable in that the frequency of the delivered current may vary, as a result of small accidental changes in the potential of the grid or plate or in other characteristics of the circuits.

A new oscillator circuit which is said to be free from this variability has been suggested by Mr. Ross Gunn of Yale University.* The hook-up is given in the accompanying diagram.

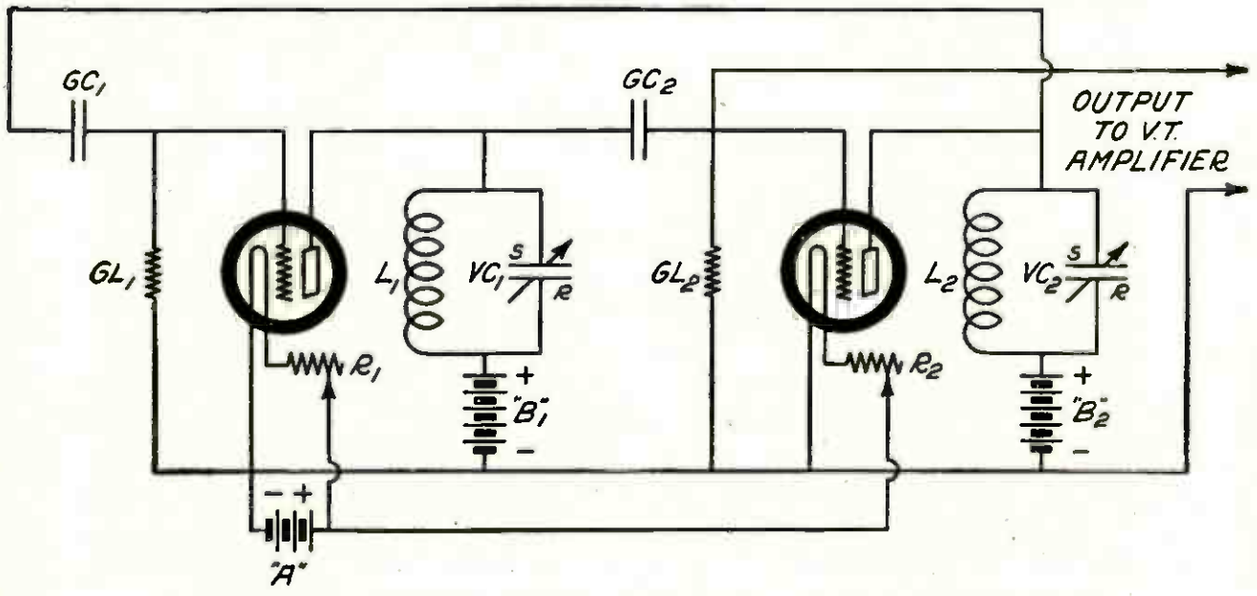
The circuit can be arranged for any frequency (within the usual ranges) by altering the constants of the tuned impedances. In place of these impedances, coupling may be accomplished by tuned, iron-free transformers or by specially designed filter sections. In an oscillator built for the very low frequency of 1,000 cycles and which Mr. Gunn describes, the inductances in the two impedances were similar and equaled approximately 230 millihenries each. The shunted condensers were .10 microfarad with a variable portion permitting increase to .12 microfarad. With this oscillator the change in frequency was less than .1 percent for a plate-voltage change of 50 percent or a filament-current change of 43 percent.

Mr. Gunn advises that when more than 10 percent of the rated capacity of the tubes is to be used the output should be connected to an amplifier and the load carried by it.

Gold, Silver and Platinum in Radio

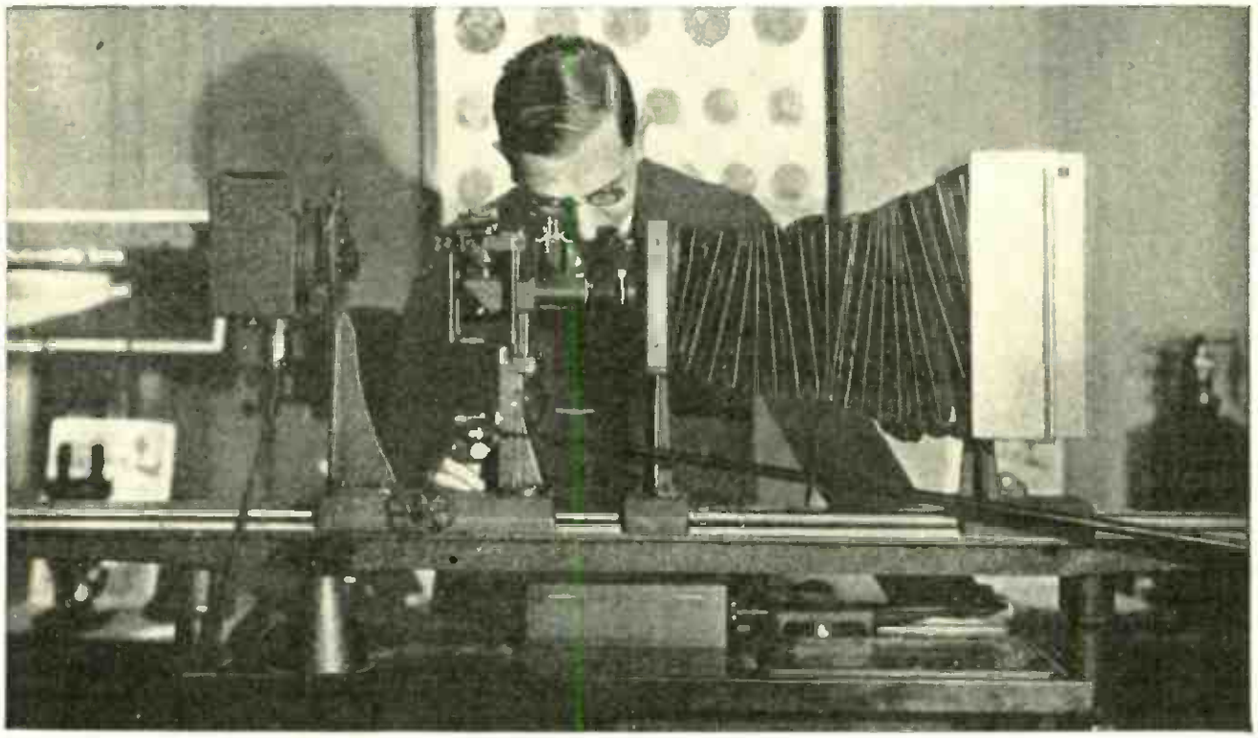
GOLD-PLATED bus-wire, sterling silver contact points and solid platinum catwhiskers are among the latest radio novelties. To many radio constructors these things seem merely extravagances. Other engineers claim that real and important benefits are obtained from the use of these precious metals. There is talk of the greater electrical conductivity of silver and of the improved electron emission from platinum.

* "A Source of Constant Frequency Oscillations," by Ross Gunn. *Journal of the Optical Society of America* (Menasha, Wisc.), vol. 8, pages 545-547 (April, 1924).



AN EXPERIMENTAL CONSTANT-FREQUENCY OSCILLATOR

This oscillator will deliver a constant frequency which is relatively unaffected by variations in the plate potential or the filament temperature. The mutual coupling of the grid and plate circuits provides a hook-up in which the two oscillating circuits stabilize each other.



From a photograph made especially for POPULAR RADIO by Brown Bros.

HOW THE SURFACE FILMS ON METALS ARE STUDIED

This apparatus, devised by the Bausch & Lomb Optical Company, permits the microscopic observation of a strongly illuminated metal surface. It is possible actually to see the corrosion films that form on metals and that may affect the use of gold and silver in radio. When desired the camera can be substituted for the eye and a photograph made of the metal surface.

The truth of the matter is that these three metals, gold, platinum and silver, derive whatever value they possess for radio use entirely from the ways in which they are affected by the air. It is the surface corrosion film that forms (or does not form) on them that makes them of interest to the radio constructor.

When copper wire, as, for example, the wire wound on a coil, is exposed to the air there forms slowly on its surface a very thin, surface layer of copper sulphide. This layer will form even underneath the wrapping of a silk-covered wire, for the silk threads are permeable to the air, and the gases that produce the copper sulphide get through them. So far as concerns the direct-current resistance of the copper wire this does not matter. The decrease in effective diameter of the wire due to the sulphide film is altogether negligible.

But for radio-frequency currents this may not be true. Such currents travel mainly near the surface of the conductor. This is what is called the "skin effect." Accordingly a poorly-conducting layer of copper sulphide on the surface of a wire *may* alter considerably the resistance of the wire for radio-frequency currents. It is not possible to say that it *does* alter the resistance, for no one has ever worked out the matter experimentally.

Now, when silver wire is exposed to the air it forms a coating of silver sulphide in very much the same way as copper does. But this silver coating, unlike the copper coating, is a good conductor of electricity; almost as good as is the metallic silver itself. Accordingly, a silver-wire coil *may* be better for radio than a copper coil is. Again, we cannot say that it *is* better. Precise experiments have never been made.

Now for the catwhiskers. We are informed by several experimenters, notably by Dr. John B. Buehler of Los Angeles, that actual experiments show a substantial advantage in the use of a catwhisker made of gold or platinum wire over one made of copper or brass or bronze wire. This, too, may be an effect of surface films.

Gold alters in air only very slightly; platinum scarcely at all. Nobody knows the theory of how the crystal detector works, but we do know that very thin, invisible films of dirt or oil or of many other things will affect the operation of the crystal very seriously. Perhaps the same is true of the film of copper sulphide that forms over the point of a catwhisker made of copper or of copper alloys. Perhaps gold, lacking this film, provides a better contact or a contact more suitable in some manner for the rectifying action upon which the operation of the crystal depends.

No field in radio cries so loudly for precise investigation as does this one of the effect of air-formed surface films on the behavior of radio apparatus. Careful and patient studies of the effects of known surface films on known metals used as wires or catwhiskers would undoubtedly be valuable, both theoretically and practically.

Line Radio Applied to Submarine Cables

THE chief difficulty in transmitting signals by submarine cables has always been the slow speed of transmission. This results, in turn, from the distortion of the electric currents due to the fact that the cable possesses great resistance as well as a large distributed capacity. This same circumstance has stood in the way of telephony by cable, except, of course, with the special cables "loaded" every few yards with inductance coils designed to counteract this distortion.

For long cables this loading method is not practicable and it has been believed that long-distance cable telephony as well as any considerable increase of speed in cable telegraphy were remote possibilities if, indeed, they were possibilities at all.

That this view is too pessimistic; that considerable increases of cable speed are likely to be possible after all; appears from a paper of Major General George O. Squier prepared for the recent meeting of the National Academy of Sciences at Washington. Because of the death of Dr. E. F. Nichols during his address to the meeting, the remainder of the program, including General Squier's paper, was abandoned. However, an abstract of the paper has been given to the press.

The paper describes results obtained in the experimental work of the Signal Corps on the design of the cable to be constructed by the Government between Seattle, Washington, and Ketchikan, Alaska. Use will be made of the well-known line-radio methods previously developed by General Squier. New devices for the employment of these methods in cable transmission have been worked out by the Signal Corps in co-operation with Mr. William M. Bruce, Jr., a cable engineer of Springfield, Ohio.

The system employs, also, the new cable and telegraph alphabet devised by General Squier.* The current sent through the cable is a sine-wave alternating current having a frequency in the range between audio and radio frequencies; that is, from 15,000 to 100,000 cycles a second. This current is then modulated for signal purposes by a current of the same frequency and coincident in phase.

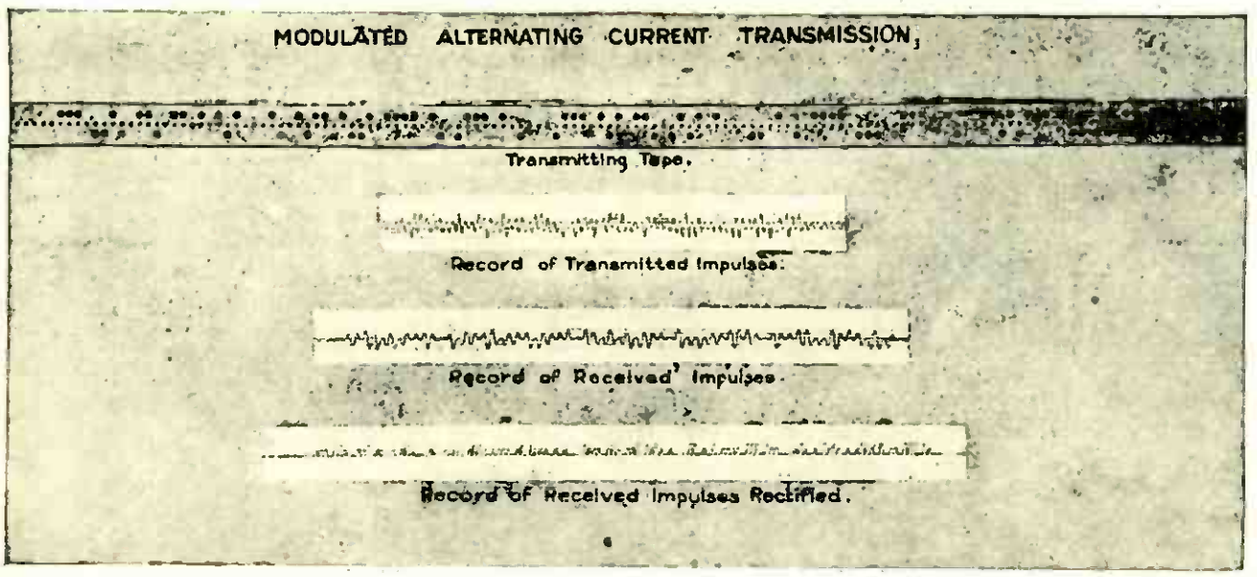
The result is merely a change in amplitude of the alterations of the original current corresponding (in radio language) to the carrier wave. A dash in the cable code is indicated by a certain increase in amplitude, a space by a decrease in amplitude. For a dot the original amplitude is left unchanged. When these increases and decreases in amplitude corresponding to the modulation have the proper relative value the speed of transmission of the wave, modulation included, through the cable is said to be very much greater than can be attained in any other way.

Automatic sending apparatus, using a perforated tape as do the usual machines, has been developed for the new method. Vacuum-tube amplifiers have been applied at the receiving end and automatic interpreting apparatus corresponding to the detector of a radio receiver has also been perfected.

The entire system has been installed on the Alaska cable. The results obtained in this service will lead doubtless to still further improvements.

The final result of these new applications of radio technique to the older art may be, General Squier believes, a revolution in cable practice all over the world.

* See "The New Signal Code," by Dr. Louis Cohen, POPULAR RADIO for July, 1923, pages 56-59.



HOW THE SQUIER ALPHABET IS PUT ON THE CABLES

The tape at the top is perforated in a special machine, so that the message is inscribed on it. These perforations actuate the switches of the transmitter and send out automatically the waves shown below. At the bottom is the final message, after rectification, just as it is printed on the receiving tape.

International

A REAL RADIO DRAMA

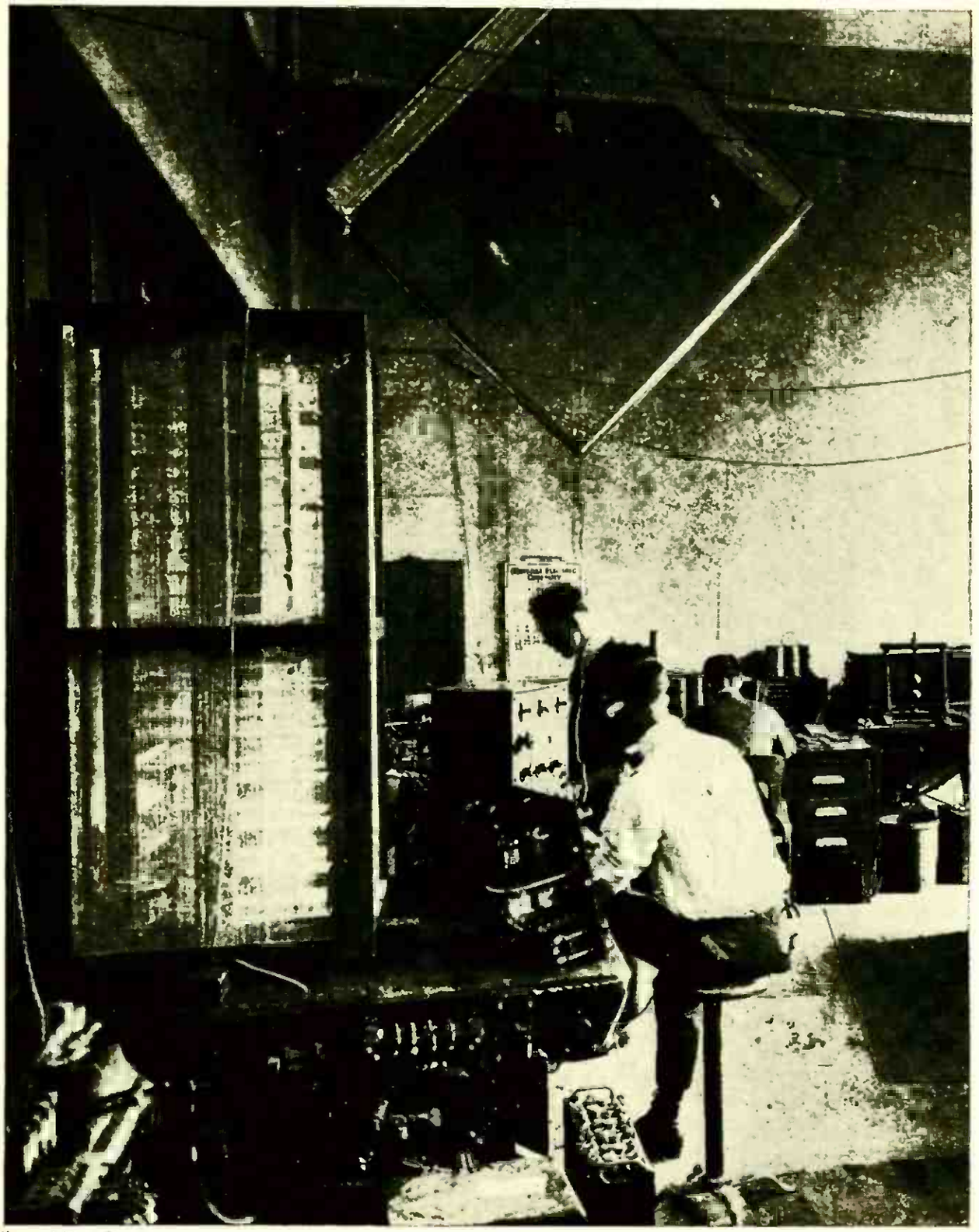
When the great airship SHENANDOAH *broke from her mooring mast at Lakehurst and drove off into the storm, radio enabled the Navy Department to keep in touch with the flight of the runaway. All broadcasting stations in the east stood by to help and to relay official messages. This photograph shows how one of the operators at WOR, Newark, New Jersey, attempted to signal the airship with torches as she went past overhead.*

Short-wave Radio for the *Shenandoah*

DURING the past few months the Navy Department engineers at the radio experiment station at Bellevue, near Washington, have perfected a 100-meter transmitting set intended for the *Shenandoah*. The set is operated by storage batteries, arranged for continual recharging during flight. The plate voltage is 750 volts, supplied by a motor generator. Telephone can be used for short distances, as, for example, in making a landing. Straight CW is used at other times. The set is described in some detail in a recent article by its designer, Dr. A. Hoyt Taylor of the Navy Department.*

The chief purpose of equipping the *Shenandoah* with a short-wave set, in addition to its powerful transmitting apparatus working on the longer and more usual wavelengths, was to try out the effectiveness of the short waves during the Polar trip of the airship; a trip that would have been made, necessarily, in nearly continual daylight. The use of this transmitter should yield valuable data concerning the propagation of short waves.

* "The Navy's Work on Short Waves," by A. Hoyt Taylor. *QST* (Hartford, Conn.), vol. 7, No. 10, pages 9-14 (May, 1924).



General Electric

A CAGE THAT KEEPS THE RADIO WAVES OUTSIDE

The box at the left, covered with wire screen, will stop most varieties of radio waves and will prevent them from affecting whatever apparatus is in use inside the screen. The recent experiments of Mr. Barfield (described on the following page) indicate that the existence of metallic circuits in such radio screens is necessary if they are to stop the waves completely.

Radio Waves Go Through Small Chinks

We are likely to talk rather loosely about the "screening" effects of steel structures, about the impossibility of receiving radio signals inside metal buildings and the like. No doubt such screening effects do occur, but their exact nature seems never to have been investigated with any accuracy and completeness. Or rather, the first investigations of this character have recently been reported to the Institution of Electrical Engineers (London) by Mr. R. H. Barfield.*

Loop antennas attached to receiving sets of great sensitiveness were placed inside continuous metal tanks, inside open-ended cylinders of wire or metal, inside cages of wire screen and in various other situations where screening was to be expected.

The results indicate that the most important feature of an effectual screen is the existence of metallic circuits in it. For example, a cage of wire netting is an effectual screen if the wire is electrically connected at all joints. A mere series of wires arranged in closed loops is effectual. But wires that do not make closed circuits or wire netting that is not electrically connected to form a similar closure are not effective.

Perhaps the most striking instance reported by Mr. Barfield is that of a receiving loop that was entirely enclosed in a soldered envelope of tinned iron, as though it were inside the inner tube of an automobile tire. The two terminals of the coil came out through very small insulated holes in the iron. This cover produced a practically perfect shield so long as the metal of it was continuous.

But when a transverse slit was cut in the metal of this envelope around the receiving coil enough of the radio waves to produce a fairly strong signal immediately penetrated the slit. Even when the slit was as narrow as it was possible to make it without producing actual metallic contact a substantial amount of radio energy continued to penetrate it.

It is hard to reconcile these results with the supposedly great screening ascribed to the steel frames of American skyscrapers. It seems evident that the exact effects of such metal structures on the radio waves deserve more careful and accurate study than they have yet received. Here is an excellent problem for amateurs who are experimentally inclined. A model of a typical skyscraper, showing the exact strength of signals obtainable on each floor and on each part of the floor, might be of the greatest value to radio science as well as to the problem of how to provide for the reception of broadcasts in such buildings.

* A paper to be published in the *Proceedings* of the Institution.

A New Way to Seal Metal Into Glass

So many amateurs are now experimenting with vacuum tubes of their own manufacture, with gas-filled spark indicators and with other devices that require a strong and gas-tight seal between metal tubes or wires and the glass parts of a bulb or tube, that any new way of accomplishing this difficult operation has much interest for all radio laboratories. The newest way of doing it is described by Mr. Ridyard of King's College, London, and does not involve the necessity of melting the glass.* The metal and glass parts are actually *soldered* together.

The glass must first be prepared for the soldering by coating it with a metal film, first of platinum and then of lead. The platinum coating is very thin and is not expensive. Mr. Ridyard suggests a platinizing solution made by dissolving half a gram of platinum chloride in a very small quantity of absolute alcohol and pouring this solution into five cubic centimeters of the oil of lavender spikes. A drop of this solution is placed on the part of the glass to be coated, spread evenly over the glass surface and then burned off carefully over a gas flame. If carefully done this makes a perfect, but extremely thin, mirror of platinum over the surface of the glass.

The next operation is to add the lead coating to this platinum one. To do this the warmed glass is dipped suddenly into a bath of molten lead, kept not much above its melting point. The relative temperatures of glass and lead are important to secure a thin but adherent lead film and these temperatures can be learned best by practice. A successful film should be as thin as possible and at the same time without holes.

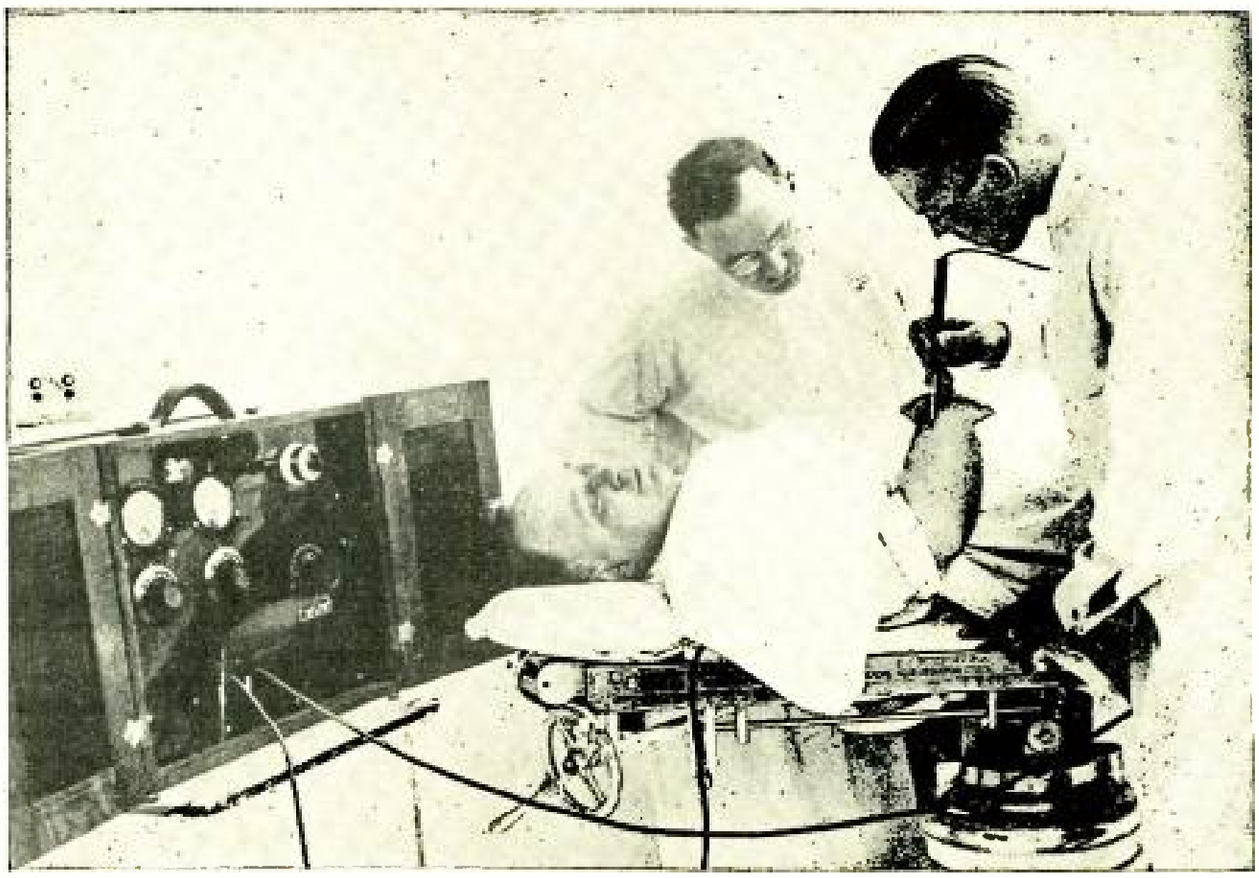
Having secured this adherent lead coating on the glass, the glass and metal parts may be soldered together in much the usual manner.

For ordinary purposes the usual fusion methods of inserting wires and other metal objects through walls of glass will doubtless remain the most convenient, but there are many operations, as, for example, the making of high-power vacuum tubes, where these usual fusion methods have proved inadequate. For these problems the new process of Mr. Ridyard deserves careful consideration.

* "A Metal-to-glass Joint," by H. N. Ridyard. *Journal of the American Chemical Society*, vol. 46, pages 287-290 (February, 1924).

How Radio Will Fight the Next War

The amazing progress made since the World War in the art of radio has opened a new field of speculation as to the part that radio is destined to play in military and naval science. An important article on this subject will appear in Popular Radio *for next month—September.*



Underwood & Underwood

RADIO HEATS THE SURGEON'S KNIFE

A radio-frequency current sent through a tiny platinum wire heats this wire so that surgeons can use it to sever living tissues as they commonly use a knife. The advantage is that the "cut" is disinfected, as the heat is fatal to all germs. Direct current has been used thus for some time, but radio-frequency currents are said to be better.

Navigating an Airplane by Radio Bearings

THE French Air Service carried out recently an interesting experiment on the possibility of navigating an airplane entirely by the bearings of radio waves received from different broadcasting stations. A directional loop receiver was mounted on a large passenger plane and the plane then made a series of trips covering most of the circumference of France, the bearings obtained by the loop receiver being the only guide used by the pilot for determining his direction of flight.*

The experiment was a practical success, but radio engineers will be less interested in this fact (which might have been expected) than in the careful records kept during the flight of errors observed from time to time in the apparent direction of the waves. After all disturbing effects have been eliminated, there is evidence of a continual deviation of the wave from any particular transmitting station. This may be due to some peculiarity of the transmitting antenna or to some feature of the surroundings, such as forests or underground conditions.

This suggests interesting inquiries. In the case of these French stations it looks as though the radio wave seldom went out from the station in exactly straight lines, as it ought to do if the simple wave theory is correct. Tests along these same lines in the United States, where we have so many broadcasting stations, ought to be very valuable.

* "Radiogoniometric Measurements in an Airplane," by P. Franck. *L'Onde Électrique* (Paris), vol. 3, pages 65-69 (February, 1924).

Some Technical Papers

(Of interest mainly to professional experimenters and radio engineers)

"The Measurement of Low-frequency Amplification," by R. L. Smith-Rose. *Wireless World* (London), vol. 13, pages 699-702, 731-734 (March 5 and March 12, 1924). A description of the methods used by the National Physical Laboratory (England) for this purpose.

"Radio-frequency Amplification," by Stuart Ballantine. *QST*, vol. 7, no. 8, pages 11-16 (March, 1924). A general explanatory article, useful especially to the amateur who already has some acquaintance with the subject.

"Small Transformers for the Amateur; Sim-

ple Fundamentals and Design," by H. F. Mason. *QST*, vol 7, No. 19, pages 53-57 (May, 1924). What the title promises.

"The Wave Antenna or Beverage Antenna," by M. F. Bedeau. *L'Onde Électrique* (Paris), vol. 3, pages 86-98 (February, 1923). An excellent analysis of the theory underlying antennas of this type. In French.

"Antenna Series Condensers — Good and Bad," by S. Kruse. *QST*, vol. 7, No. 8, pages 21-25 (March, 1924). An article especially full of useful facts.

"Heterodynes for Measurement Purposes," by G. Beauvais. *La T. S. F. Moderne* (Paris), vol 5, pages 111-120 (February, 1924). How to use the heterodyne principle for laboratory measurements of capacity, inductance, wavelength, coupling, etc. In French.

"The Resonance Curves for Different Types of Damping," by D. Roschansky. *Jahrbuch der drahtlosen Telegraphie und Telephonie* (also known now as the *Zeitschrift für Hochfrequenztechnik*) (Berlin), vol. 24, pages 23-31 (February, 1924). A thorough mathematical discussion of the theory of damping. In German.

"The Propagation of Electric Waves in a Straight Metallic Wire Provided with a Conducting Cover," by K. Försterling. *Annalen der Physik* (Leipzig),. vol. 72, pages 30-57 (July 20, 1923). An important theoretical paper having application to the transmission of radio-frequency currents through copper-clad iron wires or other wires with surface coatings. In German.

"An Electrical Frequency Analyzer," by R. L. Wegel and C. R. Moore. *Bell System Technical Journal* (New York), vol. 3, pages 299-323 (April, 1924). Description of the machine developed by the Western Electric Laboratories with which the frequencies present in a mixed wave of audio frequency can be measured separately with considerable rapidity.

"The Theory of the Generation of Alternating Currents by Means of Triodes," by N. Shuttleworth. *Journal of the Institution of Electrical Engineers* (London), vol. 61, pages 1121-1133 (October, 1923). Mathematical theory of the use of vacuum tubes as generators. Includes curves to aid the design of circuits.

"On the Dependence of the Frequency of a Transmitting Tube on the Filament Heating and on the Plate Potential," by Felix Strecker. *Jahrbuch der drahtlosen Telegraphie und Telephonie* (Berlin), vol. 22, pages 244-274 (December, 1923). The theory of tube operation with especial reference to the effect of small alterations of filament and plate conditions in modifying the generated frequency. In German.

"A Source of Loss in High-frequency Valve Circuits," by St. Clair Finlay. *Experimental Wireless* (London), vol. 1, pages 469-473 (May, 1924). An account of the effects of interelectrode capacity, with some suggestions for avoidance of detrimental effects.

"Oscillographic Study of Some Vacuum Tube Transmitters," by A. Dufour and René Mesny. *L'Onde Électrique* (Paris), vol. 2, pages 620-633 and 692-705 (November and December, 1923). A detailed scientific study of tube performance using the Dufour cathode-ray oscillograph to register the tube outputs. In French.

"The Electron Emission from Thoriated Tungsten Filaments," by Irving Langmuir. *Physical Review* (Corning, N. Y.), vol. 22, pages 357-398 (December, 1923). Scientific details concerning the thorium-coated filaments used in modern dry-cell vacuum tubes.

"A Practical Demonstration of Some Applications of the Cathode Ray Oscillograph," by N. V. Kipping. *Wireless World* (London), vol. 13, pages 705-709 (March 5, 1924). How to use the oscillograph to test tube characteristics, modulation, hysteresis, the calibration of wavemeters, etc.

"Radio Instruments and Measurements." Circular No. 74 of the United States Bureau of Standards, 345 pages, issued March 10, 1924. This is the second, revised edition of this invaluable pamphlet. It discusses all measurements usually made in radio work and has a general introduction on radio theory that is one of the best in print. The pamphlet may be obtained from the Superintendent of Documents, Washington, D. C., for 60 cents, cash or money order. Stamps not accepted.

"Varnishes in the Electrical Industry," by R. T. Fleming. *World Power* (formerly *Beama*) (London), vol. 1, pages 149-157 and 234-240 (March and April, 1924). A comprehensive and authoritative study of a class of materials as important to the radio engineer as they are to other branches of electrical engineering.

"The Development of the Standard Design for Self-supporting Radio Towers for the United Fruit and Tropical Radio Telegraph Companies," by Albert W. Buel. *Proceedings of the Institute of Radio Engineers* (New York), vol. 12, pages 29-82 (February, 1924). One of the few existing articles on the subject of tower design for the larger stations.

"Radiation," by Wheeler P. Davey. *Journal of the Franklin Institute* (Philadelphia), vol. 197, pages 439-478 and 629-666 (April and May, 1924). An excellent summary of present knowledge about the nature of ether waves, especially of light and X rays. Also an account of the modern quantum theory and of the new particle and "dart" theories of light.

"Electronic Conduction in Metals," by Arthur Bramley. *Philosophical Magazine* (London), vol. 46, pages 1053-1073 (December, 1923). A mathematical and theoretical discussion of how electrons move about between the atomic nuclei inside the substance of a metallic wire, including the radiation of electric waves by such electrons during their movement.

"The Dielectric Properties of Water for Continuous Waves." by G. C. Southworth. *Physical Review* (Corning, N. Y.), vol. 23, pages 631-640 (May, 1924). An experimental study, waves approximately 2 meters long.

CONDUCTED BY ALBERT G. CRAIG

How to Test "B" Batteries and When to Replace Them

NEVER test "B" batteries with a pair of pliers by short circuiting them to see if you get a spark.

This would be ruinous to even a new battery.

Use a high-resistance voltmeter, and even then, leave the voltmeter connected only long enough to get a reading. A 22½-volt "B" battery should be dispensed with and replaced with a new one when the voltage drops as low as 16½ volts.

Replace the 45-volt size when it drops to 33 volts. This will insure better reception for you.

Receiving Without Radiating

THIS column would not be complete without containing a warning to the owner of radiating receiving sets.

If *you* own one of these sets and tune it carelessly you will interfere with your neighbors' reception. You (perhaps) know that regenerative sets, that are closely coupled to the antenna, send out a wave for a considerable distance if they are allowed to oscillate.

You will be able to detect this by a squealing sound as you turn the dials when passing over a station's wavelength.

Never let your set squeal! It squeals into your neighbors' ears as well as your own. Turn down the filaments so that the set is operating just below the squealing point.

Low-loss Instruments Save Energy

IF you are now using poorly made and poorly designed instruments in your tuning circuits, by the use of low-loss coils, variable condensers, and grid condensers you may save enough energy to make your set function as well as if you were to add a stage of radio frequency to it. Use the best you can buy and keep your set simple but efficient.

How to Read Up on Radio

IF you are interested enough in radio to really want to know how it works and what makes it work, you will never turn from an article explaining its functioning until you understand it. If you re-read some paragraphs over and over again you will find that each time you read them you will find out a little more about what the writer is trying to impress on your mind, until you finally *do* understand what he is talking about.

Reading ten articles through once may not tell you as much, or make as great an impression, as reading a single, simple explanatory article over and over again until you understand it all, from start to finish.

How to Learn the Code

LEARN the code by the *sound* of the various combinations of dots and dashes rather than by how they *look* when printed on paper.

This will greatly help to speed up your progress during practice.

Hints for the Lead-in Wire

THE lead-in wire of the antenna does *not* have to be a covered wire. That is, you may use the same kind of wire for the lead-in as is used for the antenna itself.

Never run the lead-in wire close to the side of the building. Keep it suspended out away from the walls, especially if they are of metal or stone, by at least a couple of feet. This can be done by means of a stick of wood on the roof and another one at the window where you wish to take the lead-in into the house. An insulator should be used at the end of each stick.

Keep Water Away from the Instruments

DON'T wash any part of a radio set with water, and don't let the set stand near an open window in rainy or damp weather. Water or dampness impairs the efficiency of the coils and causes leakage. Use alcohol for cleaning panels or for taking off any excess of soldering paste from the windings or from connections.

Protecting Tubes on a New Hook-up

WHEN a set has just been completed, do not connect the "B" battery immediately. Instead, connect the "A" battery with the "B" battery terminals, insert the tubes, and turn on the rheostats. If the tubes light, something is wrong, and the error in wiring must be located and corrected. If the tubes do not light, it is safe to connect the "B" battery without danger of "blowing" the tubes.

Crystal Detectors for Economy in Reflex Sets

THE use of a crystal detector in a reflex set, or in fact in any set employing radio frequency-amplification will eliminate the use of one extra vacuum tube and simplify operation.

A Filament Battery Switch

THE use of a small push-or-pull switch, located on the face of the receiving-set panel, will prove a great convenience in turning the set on and off.

This switch should be inserted in series with the negative "A" battery lead.

By pulling it out, the set will be put into operation by allowing the "A" battery current to flow through the tube filaments. By pushing it in, the set is turned off by cutting off the "A" battery from the filaments.

This will save the trouble of turning down each of the rheostats each time the set is put out of use, and *vice versa*.

This is especially true in the case of the multi-tube set.

It will also eliminate the chance of not turning off the rheostats far enough, with the resultant useless drain on the "A" battery. The rheostats can be left in the correct position and the set turned off and on by the switch. There are a number of reliable makes on the market.

Hints for Drilling Holes in Panels

WHEN drilling the holes in a panel for the shafts of instruments, do not drill the hole the same size as the shaft, but make it large enough so that the shaft will not stick or bind if it does not run exactly true, or if you have not drilled the holes that mount the instrument exactly in the right place.

Leave about an eighth of an inch leeway all around. The dial will hide the larger holes anyway.

Be Sure of a Good Ground

REMEMBER that you can't get a ground by running a wire into a flower pot. You can usually get a good one by attaching to the water pipe nearby. Sometimes the radiator systems furnish a good ground, but the most satisfactory is the water pipe.

CONDUCTED BY S. GORDON TAYLOR

EVERY radio receiver requires a careful balancing of all of its parts if the best results are to be obtained. Two receivers made from exactly the same design may give widely different results, owing to variations in the parts used, the skill of the experimenters and the locations of the receiver. This department is conducted for the special benefit of readers who have built the radio receivers described in POPULAR RADIO *and who want to profit from the experience of others in operating them—to learn the little kinks that get the maximum results.*

Tips on the Operation of the Super-heterodyne

SINCE the series of articles on the unit-panel super-heterodyne which was described in the September, October, November and December issues of POPULAR RADIO, so much interest has been aroused in this circuit that a few words of advice and help should be extended to the great number of people who have built and are operating this set at the present time. Considering the many pitfalls that are open to the inexperienced builder of such a comparatively complicated circuit, it is surprising and gratifying to see how little trouble has been experienced by the readers of this magazine in constructing and putting into operation this set. However, for the benefit of those who have experienced difficulty in getting the set to function properly or who do not consider that they are getting the results that should be obtained with a super-heterodyne, I am going to point out here some of the common causes of trouble, such as lack of audibility, selectivity, etc., and attempt to answer the more frequent questions that have risen in regard to this set.

In the first place, this unit-panel set was designed with two chief purposes in view; to provide a receiver for use with an antenna that would allow the maximum possible distance reception under any given conditions, regardless of mechanical appearance or space requirements. Second, to make the construction of this receiver as simple to follow and as fool-proof in operation as possible.

Both of these conditions have very nearly been fulfilled. Of course, the more apparatus and wiring used in any circuit, the greater are the chances for error. And when it is realized that any single error or imperfection in one piece of apparatus in the entire circuit is likely to make the whole set inoperative, it is not to be wondered at that some people have run into trouble in the course of its construction.

The Cause of Unstability on the Short Wavelengths

PROBABLY the most common complaint is lack of stability sometimes experienced on the short wavelengths—360 meters or below. This can be invariably attributed to one thing—too much wire on the tickler coil or rotor of the antenna tuner; that is, the rotor on the coupler in the first unit. This tuning circuit was originally designed for broadcast reception, and in order to have it function properly with practically all types of tubes that were offered to the public, sufficient wire was put on the coupler rotor to provide a safety factor, so that no matter how poor the tube was, as an oscillator, it could be forced to give good regeneration. This was all right while the tuner was used by itself, or with an audio-frequency amplifier. On the other hand, when the two intermediate units, the oscillator and intermediate-stage amplifier, were added to convert this set into a super-heterodyne, if a tube was used in the

first unit which was a good oscillator it often became impossible to stop it from oscillating on the lower wavelengths, even with the tickler coupling at zero (with the rotor at right angles to the stator winding). This is because there is a much stronger tendency for the tube to oscillate when the other two units are added to it, due to the extra impedence which is added in the plate circuit. To overcome this trouble, the number of turns of wire on the rotor should be reduced; 20 turns is the proper value to employ. Then with the tickler set at right angles to the stator there is no tendency for the tube to go into oscillation anywhere over the broadcast wavelength range.

While the regenerative feature employed in this circuit gives a marked increase in volume and range when used with an antenna, it does not cause radiation interference due to the fact that the set becomes inoperative if this first tube is allowed to oscillate, and best operation is obtained when it is somewhat below the maximum regenerative point.

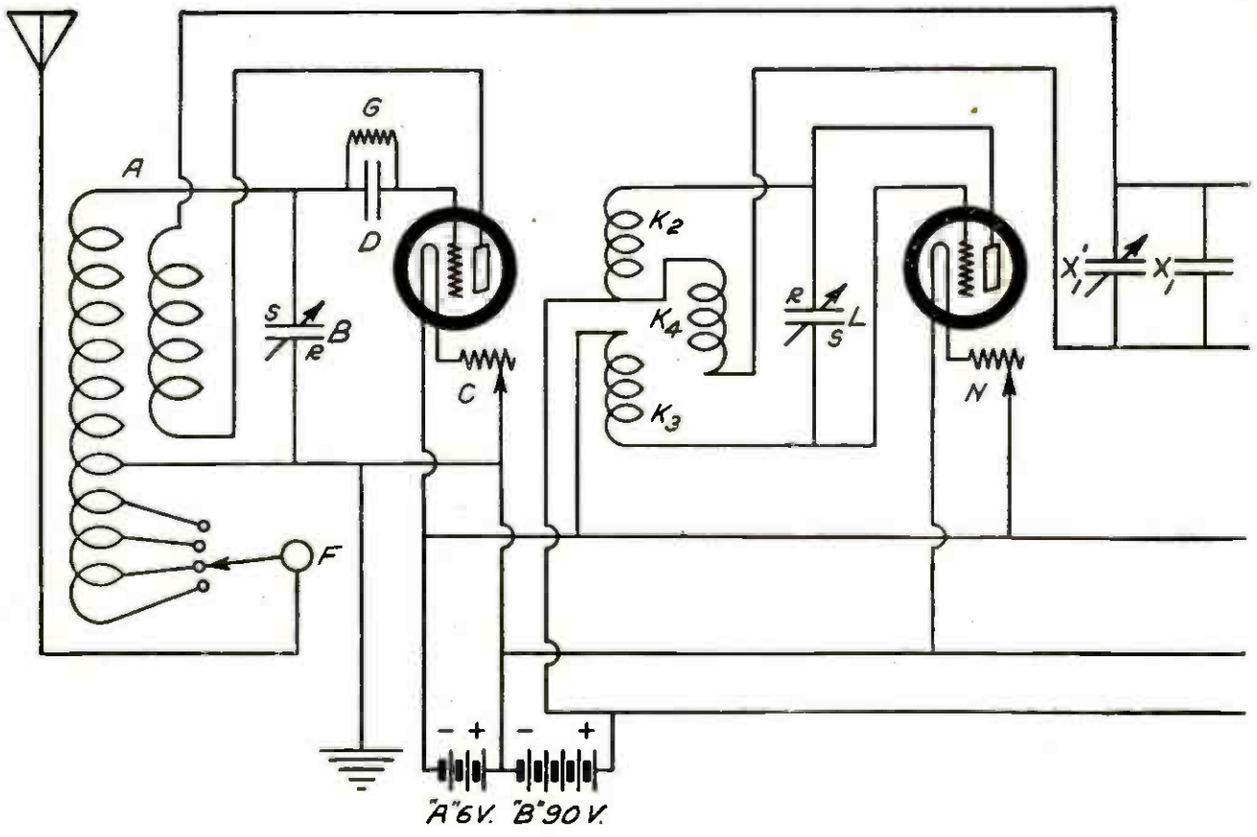
Where to Look for Trouble in the Oscillation Coupler

THE next most common trouble is due to trouble in the oscillation coupler. If the condenser on the second or oscillator panel has little or no effect on the tuning of the set, it is a sure sign that the oscillator is *not functioning*, providing, of course, that it is wired correctly. The trouble can almost invariably be found in the stator winding of the oscillation coupler. There are two separate windings on this stator, the ends of the windings being held in place by running through two holes in the stator tube, as is customary. When these four leads come out through the tube they are at right angles to the last turn of the winding in each case; if they rub against this last turn they are very likely to short circuit with it. Although this may seem a small point, a single short-circuited turn is sufficient to stop the entire oscillator from functioning. In other words, if one of these leads shorts against the preceding turn on the winding, the oscillator cannot be made to function. Now if these had been rubbed together and shorted during the course of assembly, the only thing to do is to remove two turns from each winding and center the remaining turns between the holes so that they are entirely free from the leads. It is recommended that these windings should not be shellacked and even if they should be a little loose on the tube for this reason, no harm will be done as long as they do not touch the leads where they pass at right angles. Sufficient leeway was allowed in the specifications of this coupler to enable the wavelength range to be more than covered even when these four turns are removed. A short test as to whether this unit is oscillating or not can be made by placing the phones in series with the positive "B" battery lead and touching the grid connection on the socket with the finger. There will be a distinct "plop" heard in the phones when the finger touches and is removed from this

From a photograph made for POPULAR RADIO

SELECTIVITY IS A FEATURE OF THE SUPER-HETERODYNE

Careful adjustment of the oscillator of the "super" is necessary to get the full benefit of the extreme selectivity for which this circuit is famous.



lead if the oscillator is functioning properly. This should occur over the entire condenser scale.

How to Avoid Trouble With the Radio-frequency Amplifier

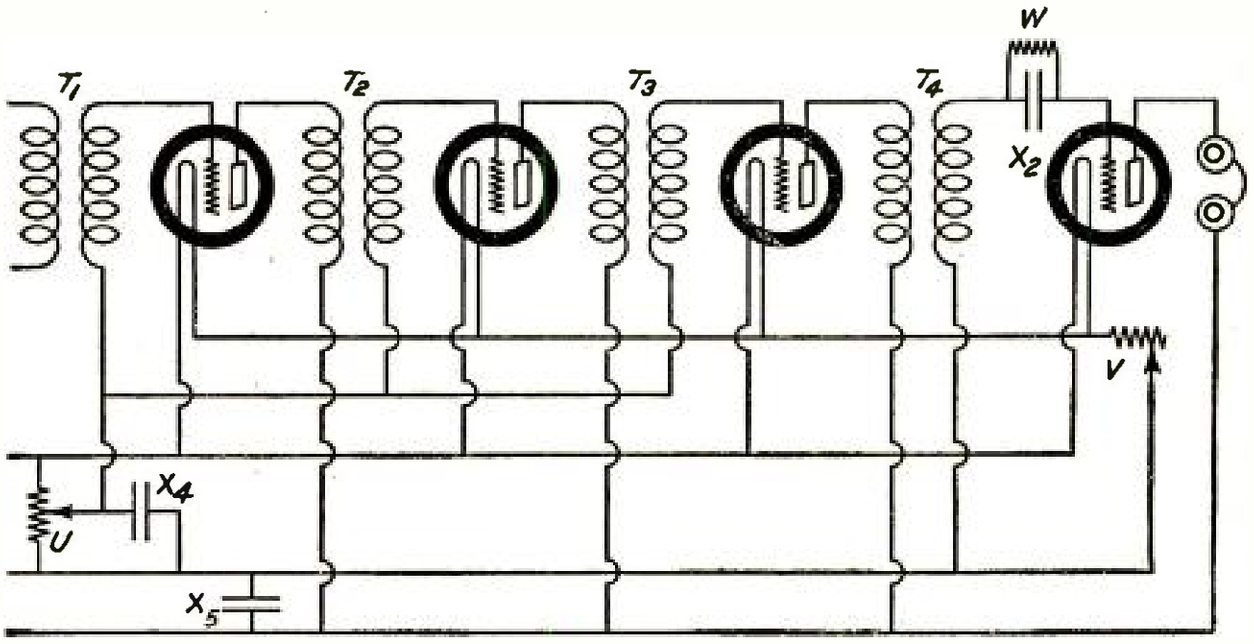
THE third unit, which is the intermediate-wave amplifier, should not give any trouble. The only thing to watch out for is a faulty piece of apparatus, such as an open circuit in the potentiometer or one of the transformers. Such a condition can be tested for, by using a voltmeter and one of the "B" batteries, merely placing the piece of apparatus to be tested for an open circuit, in series with the meter and the battery. If the meter gives a reading when the connection is made, then the circuit is complete. There is one point to be brought out that has been a source of some trouble and that is the fact that some potentiometers are wound with enameled wire and this enamelling is often *not removed* when the potentiometer leaves the factory. If this is the case, the potentiometer arm *will not make proper contact* and the inter-stage amplifier will oscillate continually, also a series of clicks will be heard in the phones when the arm is moved and sparks can be seen at the arm contact. The wire should be cleaned with a piece of fine sandpaper, care being taken not to break the winding. If the intermediate amplifier is functioning properly and the grid connections have been kept as short as possible, it should function as follows: When properly connected in the circuit with the potentiometer arm at the extreme end of the potentiometer which is connected to the positive "A" battery lead, the set should be absolutely quiet. As the potentiometer is moved around toward the negative end a point should be reached approximately one-half way round where the amplifier goes into oscillation. This is indicated by a slight hissing sound or "plop." Beyond this point the set is practically dead except for heterodyne whistles. The most sensitive point of operation is just before this condition is reached, that is, when the arm is on the *positive* side of the oscillation point.

Look Out for Bad Tubes and Grid-leaks

THERE are many little details that are liable to cause trouble which, while they seldom occur, are hard to locate if one is not familiar with the characteristics of this circuit. The most common of these is *bad tubes,* particularly in the intermediate-stage amplifier. Tubes should be changed around until the best possible combination is obtained and it is well to make this test on a comparatively weak signal. CAUTION: Do not force your U-V-201-a's. There is a strong tendency to give these tubes more filament current than is necessary. If this is done, the filament emission falls off rapidly, depending upon the extent to which they are forced. In fact a large number of the complaints which I have received on this, as well as other sets, have mentioned the fact that the receiver worked beautifully when first connected up, but had been growing worse and worse and at last that no long distance work could be done on it. Providing that the batteries are "well up," this is almost a positive indication of improperly operated tube filaments where the thorium on the filament has been burned off faster than it could work out from the inside, and consequently the elec-

CHECK YOUR SET WITH THIS DIAGRAM

In order to reproduce the super-heterodyne circuit as clearly as possible, the two-stage audio amplifier has been omitted.



tronic emission has fallen to a very low value.

Another minor difficulty, which however occurs quite frequently, is a *bad grid-leak*. Cheap grid-leaks are *not* an economy. An open grid-leak, or one with such a high resistance as to be practically open, will cause the detector tube on the third or amplifier panel to "block," and while signals can sometimes be heard, they will usually be very unstable, building up and dying down in quite regular succession, due to the blocking effect. Also, grid condensers themselves are not beyond reproach and a wide-open or short-circuited grid condenser is occasionally found and this should be tested or replaced as a last resort in looking for trouble.

How to Insure Selectivity and Volume

To a large extent both selectivity and volume in this set depend upon one thing—the .0005 mfd. condenser connected across the input transformer. Unfortunately, it is impossible to make small fixed condensers of this type absolutely accurate, in fact they are liable to vary over quite a wide range and this variation is more likely to be *under* rather than *over* the rated capacity. Accordingly, it is sometimes a distinct help to place a .0001 or .00025 condenser in parallel with the .0005 specified. This amplifier was so designed that it would take care of any slight variation here, but if this condenser throws too far one way or the other, it will cause a double resonance point, that is, there will be two points close together on the oscillator dial where the station can be heard, resulting in broad tuning as well as lack of volume. A small variable condenser with a capacity range up to about .0008 mfds. would be ideal for use here.

The minimum capacity would not need to be less than .0003.

Reasons for High Intermediate-frequency Amplification

THERE seems to be much confusion existing as to just what is the best frequency to amplify at in the intermediate-wave amplifier; the writer has had many people ask him why he prefers the use of such a high frequency as he recommends. There are several very good reasons for this. I will merely cite three important results which are attained by the use of a high intermediate-frequency, that is, wavelengths in the neighborhood of two or three thousand meters.

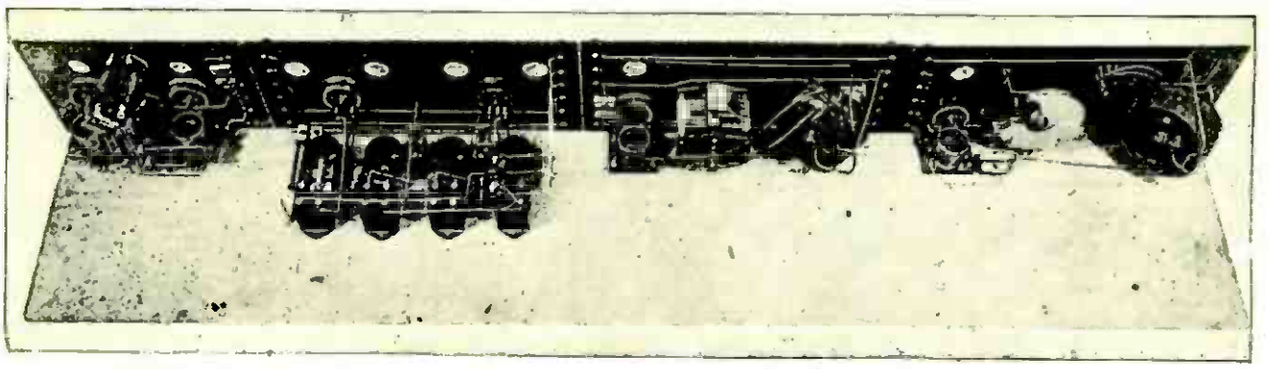
First: A low intermediate wavelength reduces the tube noise and static interference. This is a *very* important consideration in the super-heterodyne, as this noise interference is our only limiting factor in long distance reception.

Second: The lower the intermediate-wave used the sharper the tuning may be made without destroying the quality of the received signal. At wavelengths below 3,000 meters the danger of any distortion from this source is practically eliminated.

Third: A high-wave intermediate amplifier makes it possible to bring in every station in at least two points on the oscillator dial only a few degrees apart. This of course is both confusing and a nuisance, resulting in a great decrease in selectivity. This fault is overcome by using inter-stage amplifying transformers which are tuned to some wavelength slightly less than 3,000 meters, in which case the second resonance point on the oscillator dial is not reached until the entire wavelength band has been covered.

Tips on the Use of a Loop Aerial

WHILE the super-heterodyne set was primarily designed for use with an antenna it may



THE SUPER-HETERODYNE PANELS CONNECTED SIDE BY SIDE

It is also possible to arrange the oscillator and intermediate-wave amplifier panels (the two center panels in the illustration) side by side, with the tuning unit and audio amplifier above them.

be used satisfactorily with a loop aerial by the substitution of a simple control unit in place of the Haynes tuner panel. That is, a small panel can be made comprising a socket, rheostat, grid condenser and leak and loop tuning condenser, which should be a .0005, with or without a vernier. The wiring diagram and layout of this unit is identical with that of the tuner, with the exception that the coupler is omitted, the loop being connected directly across the condenser terminals in place of the coupler secondary and as there is no tickler now, the plate lead passes directly over to the pick-up coil and in-put transformer primary on the second and third panels, by connecting it directly to the top binding post.* A satisfactory loop may be made by winding fifteen turns of wire spirally on a form composed of two cross pieces approximately two and one-quarter feet long, each, spacing the wires so that the distance between them when they lay parallel is approximately one-quarter inch. As a matter of fact there are many good loops on the market today.

The Proper "B" Battery Voltage

THE best "B" battery voltage for maximum results, that is, both volume, distance and quality, can only be determined through experimenting in each particular set. As a general rule, however, 90 volts on all the tubes straight through the set works very satisfactorily. Often, however, a saving in "B" battery consumption may be made by dropping the voltage on the first two units, that is the frequency changing and oscillator tubes. A separate "B" battery tap may be taken from these and tapped in on the "B" battery at 45 or 60 volts from the negative end, with little or no loss of volume and a distinct saving in "B" battery consumption. The proper way of doing this is shown in the accompanying diagrams.

It must be realized that the detector tubes in a super-heterodyne receive considerably different treatment than a detector tube, as we usually use it, in the ordinary regenerative receiver. In the first place, the first tube which is commonly called the first detector, but in the writer's opinion is more accurately designated as the frequency changer, does not necessarily serve the function of a detector at all, it being more in the nature of a pure radio-frequency amplifier. As a proof of this fact, the grid condenser and leak in this first tube may be omitted if desired and replaced with a negative "C" battery with practically no difference in its operation. In the case of the second detector tube which follows the intermediate-frequency amplifier and is the last tube on the third panel, the voltage swing that is impressed upon its grid is at all times large, due to the heterodyne action of the oscillator, accordingly characteristics which we usually look for in the curve of a detector tube are not so important and a hard amplifying tube with a heavy plate voltage serves much better here than a soft gas tube such as the UV-200. The UV-200 may, however, be used as the first detector or frequency changer if so desired, although due to its high filament consumption and the comparatively large amount of noise that is practically always present in this type of tube, it is not desirable.

I would strongly recommend that UV-201-a or C-301-a tubes be used throughout this set. The UV-199 tubes may be used, but they must be carefully matched and it is usually necessary to have several spare tubes, in order to do this. Also, at best, they will not give the results or the quality of reproduction attained with the larger tubes.

The Best Arrangement of the Panels

I HAVE received many requests asking if the four units (including the 2-stage audio amplifier) may be placed above each other so that they will not take up so much space. This is entirely possible and works out quite as well as when they are strung out. A convenient arrangement is to place the oscillator and intermediate-wave amplifier on the bottom, side by side, with a tuning unit and audio-frequency amplifier above them. In this manner the two top units may be converted into a straight three-tube regenerative receiver merely by changing the two top connections on their panels, that is, jumping them straight across rather than leading down through the other

* Note.—A description of how to use the set on a loop appeared in the July issue of POPULAR RADIO.

two units. This makes a flexible arrangement, allowing the user to change from straight regeneration to the super-heterodyne at will.

Tips on Tuning

ALL tuning is done with the two condensers with the one in the first unit controlling either the secondary of the coupler or the loop (as the case may be), and the condenser in the oscillator panel. The latter should be the sharper of the two. The tuning of these two condensers runs approximately the same; that is, they will run up and down the scale in about the same proportion, and the setting of one has practically no effect on the other. The adjustment is identical with the first two controls of a neutrodyne, omitting the third. The potentiometer may be set for the required volume and varied only when it is desired to increase or decrease this. The tickler control should be left at zero most of the time, that is, with the rotor at right angles to the stator windings. If more volume is desired after a station is tuned in beyond that attainable by advancing the potentiometer, the tickler dial may be advanced slowly and it will be found necessary to decrease the secondary tuning condenser dial slightly as this is done. It will not, however, have any effect on the oscillator setting.

The independence of controls on the superheterodyne is one of its great advantages and providing the tickler is left in a given adjustment, the two condenser dials may be directly calibrated in wavelength or for received stations.

The tickler must of course be connected in the proper relation to the secondary, that is, if the signal is decreased as the tickler is advanced rather than increased, it should be reversed.

—A. J. HAYNES

Kadel & Herbert

A SINGLE-TUBE SET WITH A BIG RECORD

Here is a novel set-up for the single-knob receiver described in the April, 1923, issue of this magazine. The set pictured was built by Rudolph Arnold and uses a 12-inch talking-machine record in place of a panel.

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

CONDUCTED BY DAVID LAY

Transatlantic Radio Telephone Predicted

THE British Government has announced that the Post Office Department, which also has charge of the telegraph and telephone system in England, proposes to install this year a special radio station at Rugby for the purpose of attempting regular, two-way telephone communication with New York by radio. One-way experiments from America to England have been in progress for some time.

* * *

One Billionth Fly-power in a Loop

AT the last meeting of the American Chemical Society, reports *Science Service,* Dr. W. R. Whitney of the General Electric Company described a calculation he had made of the amount of power picked up by a loop one foot in diameter at Schenectady, New York, receiving radio impulses from San Francisco. The energy set free by a house fly climbing one inch up the wall was equal, the doctor said, to the energy the loop would receive in a continuous period of 35 years.

* * *

7,500 *Farmer Radio Sets in Ohio*

ACCORDING to an estimate recently made public by Mr. C. J. West, state crop statistician of Ohio, one farm in every 17 in that state has installed some kind of radio receiver. This indicates a total of some 7,500 sets on farms in that one state.

* * *

A Balloon Cable as an Antenna

A YOUNG aviation expert in the French army, Mr. J. Leray, has made an interesting observation that is quoted in a recent number of *Radio-Électricité.* The observation balloons used in the French Army are held captive to the ground by means of a steel cable. Mr. Leray noticed that when the balloon was about 600 meters high the radio reception of the Eiffel Tower on the ground near the end of the cable was especially good. The cable was evidently oscillating at four times the frequency of the Eiffel Tower station, the wavelength of that station being 2,600 meters.

* * *

A Radio Listener Annoys the King

SOME troublesome squeals and howls that have been audible recently in the private radio receiver of King George installed at Buckingham Palace, have been traced, it is reported, to an unlicensed youngster in the neighborhood who had constructed a set capable of radiating energy from its antenna. Such sets are unlawful in England and in the case of this offender there was the added horror of having annoyed the King.

* * *

Loudspeakers Made from Band Instruments

IF the opening in the ear piece of a telephone receiver is placed against the mouthpiece of any of the larger horns used in a band the result is a fairly good loudspeaker. The smaller horns, like a cornet, damp off the lower tones. A tuba is excellent and a trombone is not bad. The same thing can be arranged with the tube of a bassoon or a bass clarinet. Even placing the telephone against the wooden part of the bass drum will give a considerable increase in the sound discharged.

* * *

Broadcasting Boosts Sales of Sheet Music

A NUMBER of speakers at the British Music Industries Convention, held recently, said that broadcasting helped the sale of sheet music. This statement upsets the contention that broadcasting popular songs and instrumental selections is bad for the music dealers' business.

Receivers That Are "Set" to a Single Wavelength

SEVEN broadcasting stations are now operating in Australia. The wavelengths used range from 400 to 1,750 meters and the powers from 500 watts to 5 kilowatts. The legal regulations require that all receivers be licensed for the particular station that they are supposed to receive. They are set to this wavelength and sealed. A part of the license fee goes to the support of the station that thus secures a "customer." Experimental stations are permitted under certain legal restrictions.

* * *

Musical Notes for Call Letters

THE difficulty of understanding the call letters of distant stations supplies a continual urge to inventors of new ways of signing off. One way, suggested by Dr. C. M. Swingle of Cleveland, is to play a series of musical notes instead of to speak the letters. Probably a better device would be a short musical phrase like a bar of "Home Sweet Home" played on some instrument like the chimes. In time the fans would come to recognize this as the property of the station using it.

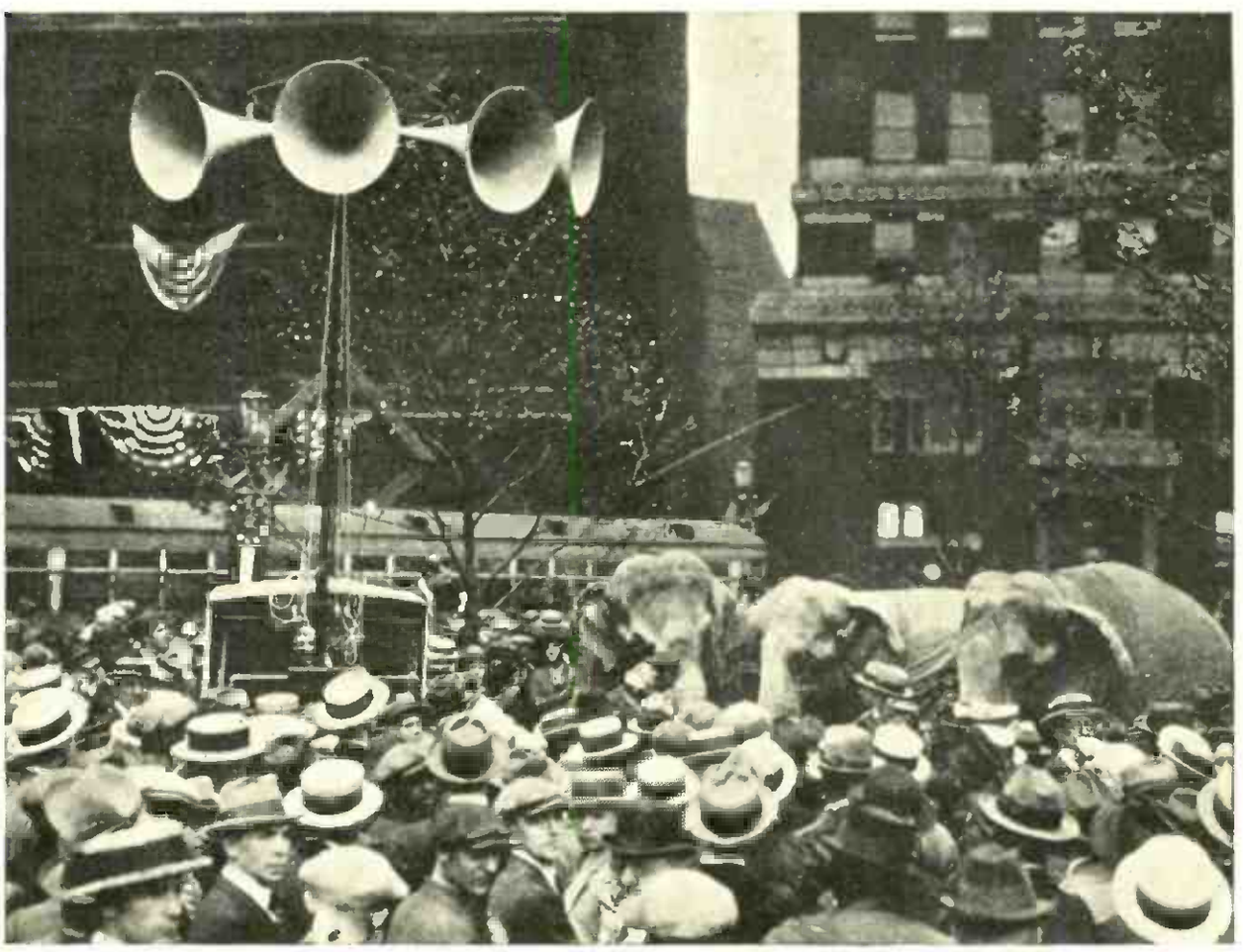
Identification by Radio

BECAUSE station WHAA modulated his voice so that it was true to life, Prof. Forest C. Ensign, of the University of Iowa, was able to cash a personal check in a strange bank. An officer of the bank recognized Professor Ensign's voice as one he had heard a short time ago giving an address from station WHAA.

* * *

Standard or Daylight Saving Time for Amateurs?

DAYLIGHT saving time in one locality and standard time in another has brought up a serious problem in connection with the amateur transmitter's quiet hours. No matter which time he adhered to, he was bound to overlap the quiet hour according to the other system. At the suggestion of the Bureau of Navigation, and with the co-operation of the American Radio Relay League, the problem has been solved by making the quiet period for amateurs extend from 7.00 P.M. to 10.30 P.M., Standard Time. This arrangement terminates October 1, when the regular 8.00 to 10.30 period will again be in force.



RESIDENTS OF CLEVELAND LISTEN IN ON THE REPUBLICAN CONVENTION

With a company of elephants to sound a genuine Republican keynote, Cleveland crowds found it easy to get into the spirit of the convention that nominated Coolidge and Dawes by means of this "public address system" that connected with the presidential convention hall.

Broadcasters Licensed by the Telephone Company

IT has been announced by the American Telephone and Telegraph Company that more than forty broadcasting stations throughout the United States have taken licenses to operate under the patents owned or controlled by that company. This is probably the final stage of the threatened contest between the Telephone Company and WHN, the licenses offered to that station and to others as a result of the controversy being generally regarded as fair and reasonable.

* * *

A Railroad Adopts Radio for Emergency Use

SOME time ago the Pennsylvania Railroad and the American Radio Relay League undertook a series of tests to discover just how much assistance might be rendered to the railroad by amateur radio operators in case the railroad's system of communication was temporarily put out of commission by storms or some other reason. The tests having been satisfactory to everybody concerned, the railroad company has announced that it will organize a formal system of co-operation with the amateurs along its lines.

Foto Topics, Inc.

JOHN L. REINARTZ HONORED WITH LOVING CUP

At the left is the famous inventor of the Reinartz Circuit, known to radio fans throughout the country. The cup was presented by W. L. Howell, President of the Second District Executive Radio Council, in behalf of the council, to Reinartz as the amateur experimenter whose developments during the year were considered most worthy of recognition.

* * *

Insurance Against Static

THE great insurance house of Lloyds, which is said to be willing to write a policy on anything from your chance of getting measles to being kicked by a mule, has had a new one. The producer of a musical review asked for a policy against the occurrence of severe static on the evening when his revue was to be broadcast to the radio audience.

* * *

Crystals Support the Einstein Theory

A FINAL report has now been issued by the Bureau of Standards on the experiments of Dr. Paul R. Heyl on the weight of large crystals, experiments that were described in POPULAR RADIO for September, 1923. The conclusion is unchanged. The crystals of topaz and other minerals weighed the same when they were upright as they did when laid on their sides. This means that gravitation and inertia are the only known properties of crystals which do not vary in different directions according to the crystal form. These being, also, the two properties of substances which the Einstein Theory declares to be of similar cause, the Washington experiments lend additional support to Einstein's viewpoint.

* * *

A Radio "Want Ad"

A FEW weeks ago a broadcasting announcer in Jefferson City, Missouri, happened to murmur into his microphone his yearning to taste again some old-fashioned cane syrup. A listener in Columbia, Louisiana, heard him, and the next day a can of the delectable liquid arrived in Jefferson City by express.

* * *

Vacuum Tube to Measure Atmospheric Electricity

ACCORDING to a recent paper delivered before the French Academy of Sciences, a new method has been devised to measure small variations of atmospheric electricity. An exposed electrode, like an ungrounded lightning rod, acts as a collector. This is connected to the grid of an ordinary vacuum tube. Any variations in the atmospheric potential are then reflected in variations of the plate current of the tube. These can be measured on a milleammeter or recorded by a continuous recorder.

* * *

The New "Radio Repair Ship"

THE United States Navy owns the only ship in the world, the chief duty of which is to repair radio sets and keep them in order. This is the U. S. S. *Gold Star*. Each summer it visits the Navy's chain of radio stations on the Alaskan Coast and the Aleutian Islands in order to renovate the radio apparatus and to leave supplies for the men.

Foto Topics, Inc.

FRENCH RADIO WIZARD VISITS AMERICA

Monsieur Marius Latour, the noted French electrophysicist, is now in the United States to help along action on his many radio patents. During the war M. Latour did intensive work on receiving amplification for his country, and developed a three-tube R. F. receiver which created a sensation in the Allied Signal Corps.

Radio Autos for Policemen

DETROIT is the latest city to add radio-equipped automobiles to the facilities of the city police. Three powerful touring cars have been equipped with neutrodyne receivers and loudspeakers. Armed officers patrolling the city in these cars will be in continual touch with headquarters through the police broadcasting station, which bears the appropriate letters KOP.

* * *

A New Amateur Record for Distance

THE American Radio Relay League announces what is said to be "the farthest two-way contact ever made on amateur waves." Mr. Carlos Braggio, of near Buenos Aires, South America, was in touch with Mr. J. H. O'Meara of Gisborne, New Zealand. In addition, Mr. Braggio's station is reported by Mr. E. H. Gibbs of Framingham, Massachusetts, but two-way communication was not established.

* * *

Radio Helps the Phonograph Industry

ONE by one the former opponents of radio find that their businesses are being helped, not hurt, by the great new factor in the amusement field. At the recent meeting of the Music Industries Chamber of Commerce, at New York, Mr. Beach Barrett, its assistant general manager, reported that radio had stimulated the sales of phonograph records. "Persons hear tunes broadcast," he said, "and then call at music stores for the melody in record form."

* * *

Can You Receive Two Code Messages at Once?

SOME curious psychology is involved in the claim made by many experienced radio operators that they can copy two different code messages at the same time. Many psychological phenomena suggest that the mind may operate, at times, as though it contained separate compartments, each of which is occupied with a different task. An example is the ability of many musicians to play difficult music and carry on a conversation at the same time. It would be interesting if one of these operators who can receive two different messages at the same time would allow his ability to be studied thoroughly by a competent psychologist. The results might lead to facts that would help others to acquire the same ability, or even to learn code at all.

Ether Waves as Fundamental Standards of Length

THE official standard of length for most of the civilized countries in the world is the International Prototype Meter, which is kept in the Bureau of Weights and Measures at Sèvres, near Paris. But this bar has been measured in terms of the wavelength of some of the waves of light, so that these light waves—those given out under certain conditions by hot vapor of metallic cadmium—are really the fundamental standard of length for all the world.

* * *

Radio's Farthest North

WHAT are reported to be the farthest north broadcasting stations will shortly be erected in Greenland by the Danish Government; they will be located at Julianehaab, Godthaab, Godhavn and Angmagssalik. While none of the stations will be powerful, they will at least reach the inhabitants of this bleak land, many of whom receive mail only once a year. These four stations may prove of value to the meteorological service, in mapping "dead spots," and in the study of the magnetic pole, as well as an aid to Arctic exploration.

* * *

$100,000,000 *from Three Inventions*

OVER one hundred million dollars ($109,000,000 to be exact) is the estimate of the American Chemical Society of the money value of three products of scientific research in the telephone industry. One of these inventions is the so-called phantom circuit, the second is the use of antimony instead of tin in the lead sheaths of cables and the third is the new metal alloy now used for contact points on the millions of switches needed in relays and central stations. What, we wonder, will be the money value of the research that went into the perfection of the vacuum tube? Perhaps a hundred million dollars, more likely a hundred times that sum. The Chemical Society has a new slogan and a true one. Research Pays!

* * *

Directed Radio Beam Tests

REGULAR tests are continuing on the possibility of beam transmission from the powerful stations in England clear around the earth to Australia. A power of thirty kilowatts is being used on a wavelength of 100 meters. The tests are being conducted by the Australian Amalgamated Wireless Company.

* * *

Frightened by the Broadcasting of Imitation Lightning

THE story of the man talking to his wife on the telephone when it was struck by lightning, who remarked, as he picked himself up rubbing the side of his head. "Yep, that's Martha, all right," has been matched by a new radio story. A man was listening to the radio version of "Peg o' My Heart" being broadcast from WGY. When the storm scene came along the listener relinquished the head phones. It was too unsafe, he thought, to hold onto any electrical contraption while there was lightning in the air."

International

ALL ENGLAND HEARS THE NIGHTINGALE

Recently listeners in Great Britain heard this rare songster over the radio. A sensitive microphone was placed in a garden near the town of Oxted. From here the song was transmitted over a telephone line to London, where it was broadcast.

ADVENTURE IN THE AIR

What is the biggest thrill YOU ever got over the radio? Have you ever picked up a call for help? Or located a lost friend—or helped to run down a fugitive, or listened in on a conversation of peculiar personal interest to yourself? For every anecdote, humorous or grave, ranging from 50 to 300 words in length, the Editor will pay upon acceptance. Address contributions to the Editor, ADVENTURE IN THE AIR DEPARTMENT, 627 *West 43d Street, New York City.*

How It Feels to Be Married by Radio

BROADCAST listeners throughout the whole country were interested in the recent "radio marriage" of Wendell Hall (perhaps better known as the "Red-headed Music Master") and Miss Marion Martin. The ceremony was performed in the broadcasting studio of station WEAF in New York, and was broadcast through that station as well as through WCAP, WJAR and WGN. It is estimated that about 4,000,000 fans listened in on the affair.

"How does it feel to get married by radio?" the Editor asked the bridegroom. And the bridegroom replied thus:

"How did I feel at my own wedding? I was never married before; I don't know whether the thrill was any different from that experienced by any bridegroom. I know I had it on the fellow who worries about how he will *look* at a public wedding. There was no slow march up an aisle a mile or more long with grinning friends on all sides!

"But there was thrill enough. I never faced a microphone before with so much emotion gripping at my throat—and I've faced a good many of them. Everything had been done to make the wedding perfect. The studio was banked with flowers. It was entirely free from curious crowds. Its noise-destroying curtains made us feel that we were in a little world of our own, just the five of us and the announcer. It was difficult, as Dr. Idleman, our pastor, expressed it afterwards, to realize that we were not having a quiet little wedding in the privacy of Miss Martin's own home.

"All this thoughtfulness on the part of those who arranged with us for the wedding, filled me full of gratitude. I was especially glad for Miss Martin, because the invisible radio wedding robbed her of all that makes a wedding so happy for brides—the dresses, the flowers and all that. As our friends arranged things, she got all of those thrills and it made me mighty happy. There was even a big wedding cake for her to cut after the ceremony!

"With all this splendid setting, it was really difficult to realize that millions of people were hearing us. The thought didn't occur to me until, in the middle of the organ recital that preceded the ceremony, my mind ran to my parents. I realized then that they were hearing everything out in Chicago. When I pictured them at their set, drinking in every syllable, I came nearest to breaking. And then there welled over me a tremendous sweep of cordiality for every one of the good people who had expressed themselves in the past as pleased with my radio work. I realized that, in all probability, they were attending our wedding. Generally, when singing before a microphone, I never visualize the audience. But, at that moment thousands of faces formed beyond the microphone. And they were all friendly faces, all wishing us well. I can't put into words the great surge of good will toward the whole world that I felt then and that I still feel. I shall never forget it.

"Dr. Idleman's voice broke into this spell. Miss Martin became excited and from then my thought was wholly with her. For it was her first experience with the microphone and if I, an old hand in studios, was uneasy, what must have been her emotions? She was nervous, but she has told me since that the cloistered quiet of the studio helped wonderfully and that she gave scarcely a thought to the masses that were hearing her. But any bride is nervous, isn't she, in even the most ordinary wedding surroundings? There was only once when it

was necessary to support her and that was when the beauty of the marriage service brought her near to the point of tears. It was a beautiful service, wasn't it?

"As for my feelings when realizing that I was being married to the girl I loved, well, I can't talk about that. It is too sacred. No man does.

"Many, many nights, I have sung into microphones all over the country. Every time, she has been beyond the microphone to help me. But this time she was beside me. You can imagine the significance of our radio wedding to us. There never were happier moments than those when I took her into my arms and Tom and Dorothy—Miss Fullerton, the bridesmaid—descended upon us with their congratulations. Then we emerged from a dream, long cherished, into reality—and the world had just begun."

—WENDELL HALL

* * *

Radio Fans Who Would Not Be Fooled

ARE radio fans a peculiarly sceptical class of folks? Or are they merely cautious as the result of their early experience in buying some of the cheap and inefficient apparatus that flooded the market in the early days of the "radio craze"? The following story from Massachusetts would indicate that the Down East fan is a conservative at least:

Mr. T. F. Niles, a well-known Boston radio man, is convinced that the radio fans are so afraid of being bunked that they refuse to take a chance on a legitimate proposition.

He recently tried out an interesting experiment in psychology by hanging, in the window of a Boston store, a $1.00 bill with a price tag, 90 cents, attached to it.

It remained there a whole day. Early the next morning Mr. Niles hung another sign to the effect that the price would be reduced 10 percent each day until either purchased or given away. The price tag was also changed to read 81 cents. At 10:20 on the morning of the second day, a Boston business man stepped in, paid his 81 cents and carried off the bill.

It is estimated that over 500 radio fans stopped, looked at the bill, and after reading the price tag walked away. More than fourteen hours elapsed between the time the bill was placed on sale and the time of its purchase. During that time, not one person even asked to examine it.

Incidentally, the purchaser of the bill is not a radio fan!

—WILLIAM R. HASKELL

Foto Topics

"I NEVER FACED A MICROPHONE BEFORE WITH SO MUCH EMOTION"

So confesses the bridegroom—Wendell Hall—whose wedding ceremony was listened in upon by countless thousands of fans who tuned in on stations WEAF, WCAP, WJAP and WGN on the evening of June 4.

"STATIONS I HAVE HEARD"

IF *you are getting good results with your receiving set, tell your fellow-readers of* POPULAR RADIO *how you get them. Give the call letters of the stations you hear, the locations of them, the type of apparatus that you are using and* HOW YOU ARE USING IT.

HE HAD TO TELL IT

"UNABLE to keep quiet any longer," writes Mark B. Shaffer of 1341 Lejon Street, Colorado Springs, Colo., "I must tell you about the results I have had from my Haynes Circuit, which I made from directions in POPULAR RADIO. In two months and a half I have heard exactly 100 stations. Every night I can hear from 20 to 25, and one night I received 37.

"I hear 28 real DX stations regularly. KDKA was heard six feet away from the phones one evening, using a common phonograph horn. PWX's whistle is always heard unless Kansas City is sending, and when they are alone on a clear night, I hear them well.

"Of the 28 long distance stations which I hear regularly, two are approximately 750 miles away, six are from 800 to 900, six are from 900 to 1,000, ten are between 1,000 and 1,500, and four are over 1,500 miles away from Colorado Springs. Altogether I have heard from 29 different states, two provinces in Canada, and from Cuba, and all this with one WD-12 tube.

Some of the regular visitors to Colorado Springs are KFAE, Pullman, Wash.; KFAU, Boise, Idaho; KGW, Portland, Ore.; KPO, San Francisco, Calif.; KFSG, Los Angeles, Calif.; WCX, Detroit, Mich.; WEAY, Houston, Tex.; WHAS, Louisville, Ky.; WSB, Atlanta, Ga.; CFCN, Calgary, Canada; WGR, Buffalo, N. Y.; WBZ, Springfield, Mass., and PWX, Havana, Cuba.

* * *

SIXTY-FOUR AT A TIME

SIXTY-FOUR stations in one short evening is a common performance for the three-tube set of Herbert Giffin of Gambier, Ohio. He hears from all points north, east, south and west.

Among those he submits are WDAR, Philadelphia, Pa.; WGI, Medford, Mass.; WEAN, Providence, R. I.; WBZ, Springfield, Mass.; PWX, Havana, Cuba; WSB, Atlanta, Ga.; WBBR, Brooklyn, N. Y.; WFAA, Dallas, Tex.; KGO, Oakland, Calif., and KGW, Portland, Ore.

His set is one of the simplest three-circuit receivers, easily made from parts which are for sale at practically every radio store. The parts used are a variocoupler with a variable condenser across the rotor and a variometer in the plate circuit. His tubes are of the UV-199 type and his antenna is 60 feet long.

* * *

HE LIKES HIS NEUTRODYNE

A RECORD of 27 stations logged in four hours is submitted by Fred O. Brose of 215 Miller Street, Michigan City, Indiana, who is breaking in his new neutrodyne. His set employs two stages of radio-frequency amplification, a detector and two stages of audio-frequency amplification. His antenna is a single wire in the shape of a "V" 200 feet long, and 40 feet above the ground.

Some of his most distant stations are WKAD, East Providence, R. I.; WBAP, Fort Worth, Tex.; WRW, Tarrytown, N. Y.; WSB, Atlanta, Ga., and KJS, Los Angeles, Calif.

* * *

BRITISHER HEARS FOUR STATIONS HERE

HIS four-circuit tuner picked up four American stations, Reginald Boydell writes from 215 Rockdale Road, Blackley, Manchester, England. They were KDKA of Pittsburgh, Pa.; WGY of Schenectady, N. Y.; WJZ of New York City and PWX of Havana, Cuba.

* * *

HIS RECORD IS 11,000 MILES

C. B. GILLETTE reports hearing code messages almost half-way around the world, through his station 1QO in Winsted, Conn. He copied WVY of San Jose and WVS of Joli, both U. S. A. stations in the Philippine Islands, on November 20, he states, using three tubes in a set especially designed for telegraph work.

HEARD TEN AMERICAN STATIONS

TEN American stations have been received and identified by Henry Field at Baggrave Hall, Leicestershire, England, and there are three others which have not yet signed off so that he cannot be sure who they are. He uses several American receivers, one of them a six-tube set.

The ten stations he has identified are WJZ, New York City; WGY, Schenectady, N. Y.; KDKA, Pittsburgh, Pa.; WIP, Philadelphia, Pa.; WOR, Newark, N. J.; WHAZ, Troy, N. Y.; WMAF, South Dartmouth, Mass.; WNAC, Boston, Mass.; WJY, New York City and WJAX, Troy, N. Y. The three doubtful ones are WEAN, Providence, R. I.; WJAZ, Chicago, Ill., and WDAP, also of Chicago.

"My chief difficulties are harmonics from press stations," he writes, "from static and from the difference of five hours in time between America and England. Fading is also very bad, and some stations do not give their call letters at the beginning and end of each selection. In spite of these handicaps, however, I have received and identified WJZ nine nights out of thirteen."

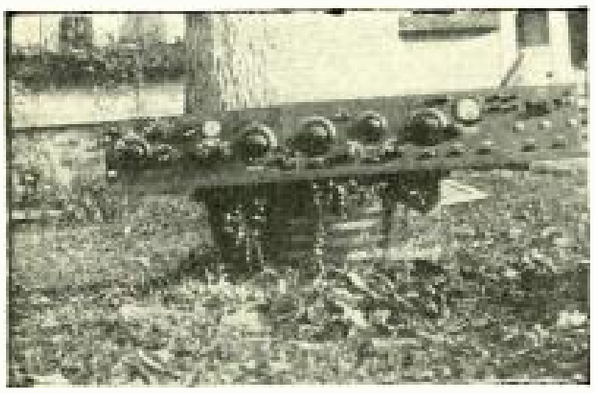
* * *

YOU CAN READ THIS, ANYWAY

IT is an easy matter to receive 5NO of Newcastle, England, on a loudspeaker at three o'clock in the afternoon, according to John C. Peters of 602 North Center Street, Casper, Wyo. This calm statement comes on top of special transatlantic tests, in which few heard even whispers from England on their superheterodynes. The letter is quoted exactly. Read it for yourself.

"I thought you might be interested in knowing that I have received 5NO, Newcastle, England, on my loudspeaker at about 3 P.M., using four stages of audio-frequency and detector along with the principle of 'resistance neutralization,' which was developed by my brother, Leo J. Peters, radio research engineer for the University of Wisconsin.

"I also have an aggregate mileage record of 305,400 miles."



HOME-MADE R. F. RECEIVER

The radio-frequency receiver of Russell Sheeley, with three stages of radio, regenerative detector, and two of audio, brings them all in on a loudspeaker, from San Francisco to Cuba.

ONE TUBE IS GOOD IN MINNESOTA

A LIST of nineteen stations heard in one short evening on one tube is submitted by A. Thomquist of Long Siding, Minn. He uses the ultra-audion circuit, which is famous for covering long distances with but a few parts in a simple hook-up.

Some of his most distant stations are KPO, San Francisco, Calif.; KDKA, Pittsburgh, Pa.; KGW, Portland, Ore.; WBAP, Fort Worth, Tex.; WRC, Washington, D. C., and KFI, Los Angeles, Calif.

His antenna is made of one wire a hundred feet long, with a lead-in of ten feet.

* * *

ABOUT THOSE NEUTRODYNES

"THE Cockaday set brings in the distant stations when two neutrodynes can't find them," is the note in a letter from Julian M. Scott of 109½ N. Main Street, Hannibal, Mo.

* * *

HONEYCOMB SET COMES BACK

THE old reliable set which uses three honeycomb coils makes its appearance again in a letter from Al. Hershkowitz, 29 Osborn Street. Brooklyn, N. Y. Distant stations are received as clear as those near-by, according to his letter.

Some of those he mentioned are WPAT, El Paso, Tex.; WPAK, Fargo, N. D.; WKAQ, San Juan, Porto Rico; WPAM, Topeka, Kan.; WCBD, Zion City, Ill., and WOS, Jefferson City, Mo.

* * *

RHODE ISLAND HEARS CALIFORNIA

"I RECENTLY tuned in station KGO of Oakland, Calif., with the new Cockaday four-circuit tuner," states Albert Dawson of Bishop Street, Pawtucket, R. I.

"The dance numbers came through well, one of which I put on the gramaphone, using a loudspeaker unit with two stages of audio-frequency amplification and one stage of push-pull amplification.

* * *

SIX TUBES ARE EASY TO HANDLE

THREE stages of radio-frequency amplification ahead of a three-step regenerative receiver are easy to handle when you know how, according to Russell Sheeley of Newfields, N. H.

"The tuning is done with three dials," he claims, "which can be calibrated to wavelength and set at any time afterward. It combines quality and quantity to a remarkable degree and is really selective, as the last stage of radio is tuned in both primary and secondary circuits with tapped primary and variable coupling.

"In heavy static with the circuit correctly tuned, the last stage can be untuned or thrown out of tune a little so as to almost lose all static. A remarkable help in controlling oscillation is the coupling feature of the last stage of radio-frequency amplification.

"Stations 1,800 to 2,000 miles away can be brought through my loudspeaker like locals. During the last few months I have had KHJ of Los Angeles on the speaker three-fourths as strong as local stations."

CONDUCTED BY RICHARD LORD

A limited number of questions of general scientific interest will be answered each month in this department. Readers are invited to send in questions that have puzzled them—but the selection of questions for answer cannot be guaranteed nor can questions outside the radio field be answered by mail.

Does an antenna work better when it is strung north and south or when it is strung east and west?

IT all depends on the directions of the stations that you want to hear; the directions of local interference, like power lines; and the directions of absorbing or re-radiating structures, like steel or stone buildings. The actual points of the compass; that is, the relation of the antenna-direction to the axis of the earth, has no known effect on radio reception.

Should the surface of panels for radio sets be smooth and polished or is it better to have panels with the dull surface that is called the "matted" surface?

IT makes very little difference. If the surfaces are entirely clean the leakage of electric energy over the smooth surface is a little less than the leakage over the matted surface. But, on the other hand, the matted surface holds more dirt and dust and this film of dust will itself cause leakage. In practical work, therefore, the leakage across a matted panel may be just as great as across a smooth panel, or even greater.

Is silicon, the mineral that is sometimes used for crystal detectors, the same thing as silica?

No. Silica is the scientific name for the common mineral called quartz or rock crystal. This silica cannot be used as a detector of radio waves. Silicon is something different. It is not a mineral at all but is a chemical element. The crystals of it are made in the electric furnace. The similarity of names arises from the fact that silica is a chemical compound of the element silicon. It is, in fact, the oxide of silicon.

Is it true that you cannot hear radio at all in some parts of the country because vast deposits of magnetic iron ore exist underground and keep away the waves?

THIS has been suggested many times as a possible cause for "dead spots" where radio reception is poor, but there is no evidence that it is really true. Possibly a buried mass of iron ore, magnetic or not, might affect the radio waves in some way, but the details of such effects have never been worked out scientifically.

What is the galvanized wire sometimes used for antennas?

IT is merely iron wire that has been dipped in melted zinc. A thin film of the zinc sticks to the wire and helps to keep it from rusting. This galvanized wire is not to be recommended for antennas. Copper wire or phosphor-bronze wire is much better.

What is the composition of the new alloy called "permalloy," now to be used for submarine cables and for other electromagnetic machinery?

IT is a mixture of nickel and iron. An analysis published by Arnold and McKeehan in the *Physical Review* (vol. 23, page 114) gives 78.5 percent of iron and 21.5 percent of nickel.

What is the chemical difference between the three kinds of bus-wire; the soft, the quarter-hard and the half-hard?

USUALLY there is no chemical difference. All three kinds are merely made of copper. The difference in hardness is produced by the way the copper is treated while the wire is being manufactured. The soft wire is "annealed." The hard wire is not annealed, or is not annealed so completely. What the annealing does, really, is to change the size of the tiny, microscopic crystals of copper in the wire, it being the sizes and arrangement of these crystals that determine the hardness.

When they mention the "ionized layer" in the upper part of the earth's atmosphere what does this mean?

AN "ion" is an atom of any kind of matter that has lost or gained an electron. For what this means see the article, "Bohr's New Theory of Atoms," in POPULAR RADIO for April, 1924. Ordinary atoms are electrically neutral. "Ions," on the other hand, have an electric charge; a negative charge if the atom has *gained* an electron, a positive charge if it has *lost* an electron. An "ionized layer" in the atmosphere (or elsewhere) is a layer of gas that contains many of these charged atoms or ions. Because of them such a layer will serve as a more or less good conductor of electricity.

How is the exact time determined in order to regulate the clocks that send out the radio time signals?

BY the rotation of the earth. Astronomers observe daily the passage of certain selected stars across the "meridian," which is the north-and-south line that runs exactly overhead above the station. The instant of the star's passage of this line serves to correct the clocks. For the United States this is done at the Naval Observatory in Washington.

What is a Leyden jar?

IT is a device for storing static electricity. It was invented at the University of Leyden many years ago and was much used in the early days of electric science; for example, in Benjamin Franklin's celebrated experiment with the kite. It is merely a glass jar or bottle with two tin-foil jackets, one inside the jar and the other outside. The tin-foil does not reach quite to the top of the jar. Accordingly, if one jacket is charged, the jar holds the charge, as any other condenser will do. The Leyden jar, in fact, is merely one form of condenser.

How can I make some "Wood's metal" for mounting crystals?

TAKE one ounce of metallic tin of the best quality, two ounces of lead, four ounces of bismuth and one ounce of cadmium. Melt them all together in a clean clay crucible or an iron ladle. When they are melted stir them well together. The result is Wood's metal. It is probable, however, that you will find it far easier to buy some of this alloy ready made than to make it.

Why do the water and acid get so hot when you mix them together in making up dilute acid for use in storage batteries?

SULPHURIC acid has a strong chemical affinity for water. When you mix them they combine chemically and set free much heat, just as hot carbon in a fire combines with the oxygen of the air and sets free heat.

How was the electron discovered?

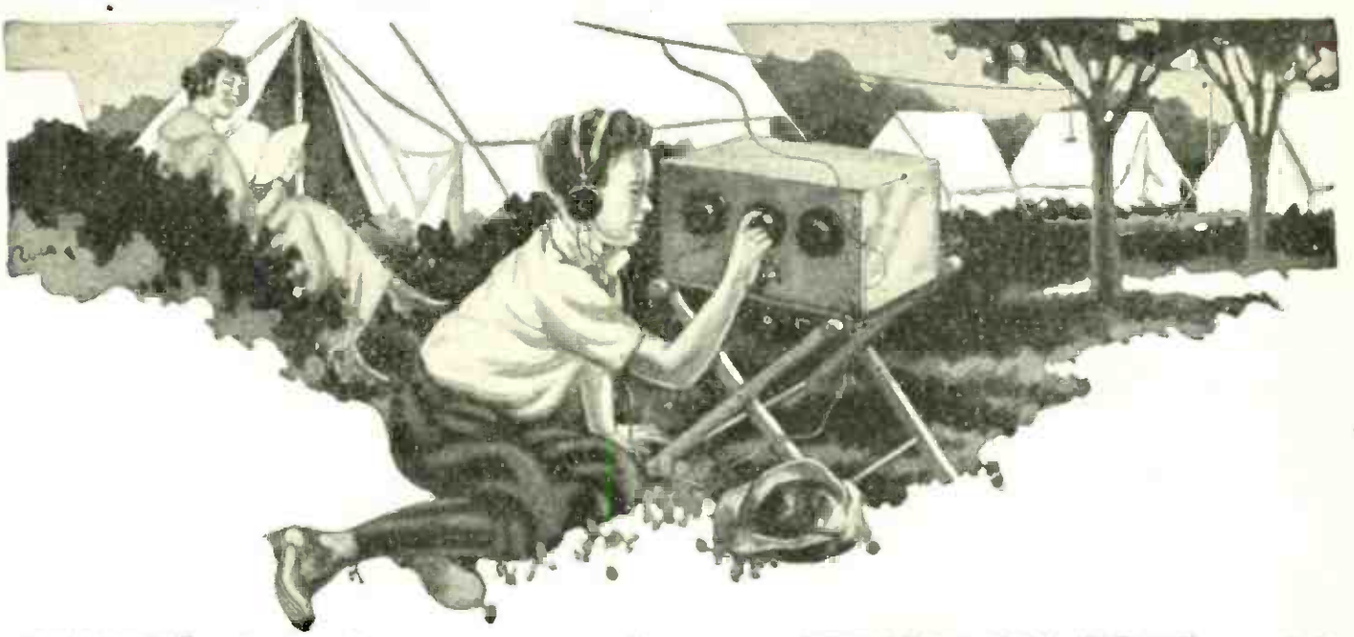
THE existence of the electron was *inferred* before it was proved to exist. Many scientists had surmised that electricity might consist of many very minute particles. Sir Joseph J. Thomson showed that his experiments with a cathode-ray tube were explainable on this assumption. Then Dr. Millikan devised an experiment for measuring the amount of electricity on a single electron. This last was probably the actual "discovery" of the electron, though it is hard to draw the line between it and the earlier work of Sir Joseph Thomson.

Why is it that the reception of radio signals is almost always worse on a rainy day than on a bright clear one?

THERE are two reasons. The first is that rain water on the antenna supports and on the insulators forms a thin film of water that is slightly conducting. Some of the signal strength leaks away through this water film. The second reason is that in rainy weather the atmosphere is likely to be disturbed and stormy. All such disturbances increase the absorption of radio waves in transit as well as increasing the percentage of fading and of static.

What was the origin of the word "radio"?

THE word exists both in Latin and in Greek. It seems to have meant, originally, a spoke of a wheel, which meaning survives in mathematics in the word "radius." From the fact that the spokes went out from the center in all directions came the derived meanings which survive in the words "radiate," "ray" and others, including "radio" itself. The original root of the word, more ancient even than Latin and Greek, was probably the very primitive root-word "ar," which meant "to go."



"This is station WXYZ–"

When evening comes at your summer camp tune in on the world with your vacation set

YOU need no longer go on a vacation and leave all the world behind. Carry a radio set with you. Every day it will bring to you the baseball scores and the favorite songs you listened to on your home set.

All you need is a simple single-tube assembly—one that will fit snugly into the old duffle bag.

Selecting your panel

Careful building of your vacation set includes mounting your instruments on a first-class panel. Thus you give your instruments the proper insulation and increase reception.

A Celoron Radio Panel will give your set just the insulation it needs. Besides, it is practically indestructible. It does not chip, crack, or buckle. Celoron may be drilled, tapped, sawed or bored, and it engraves easily without feathering. You can get it in black, oak or mahogany finishes. It is handsome in appearance and it never loses its lustre or becomes discolored.

Celoron, a bakelite material, is one of the finest insulating materials known. It is approved by the U. S. Navy and the U. S. Signal Corps and it is used by leading radio manufacturers and by thousands of radio fans.

Practically all good dealers sell Celoron Radio Panels.

Send for free booklet

If you will clip out the coupon below and mail it to us, we will send you an interesting booklet entitled, "Getting the Right Hook-up with Celoron." This little book contains many helpful suggestions for building and operating a set. Send for your copy now. It is free.

CELORON
A BAKELITE PANEL

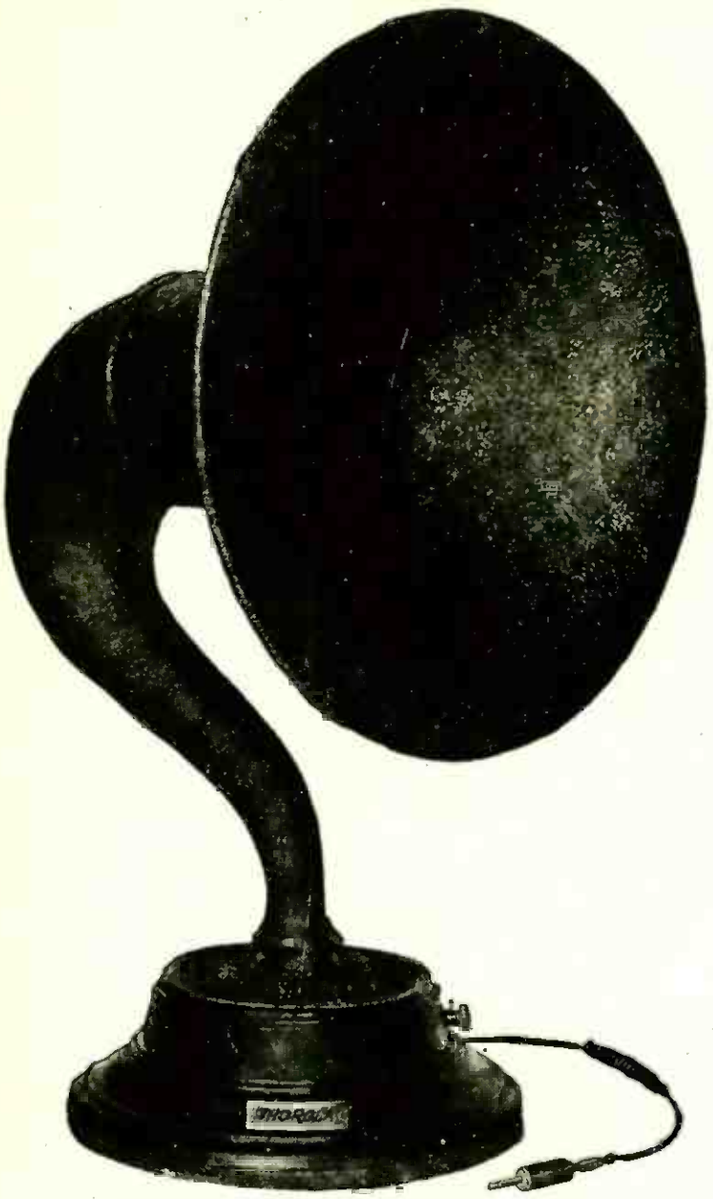
Diamond State Fibre Company

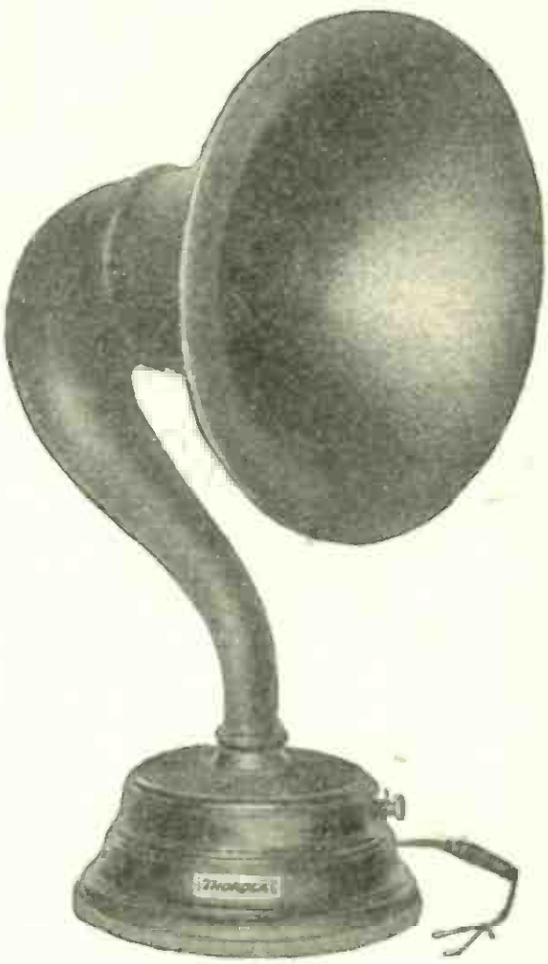
Branches in Principal Cities **Bridgeport, Pa.** **Toronto, Canada—London, England**

If you want to build a beautiful radio cabinet use Vulcawood—the new cabinet material. If your dealer does not handle Vulcawood, write us. We will send you a pamphlet telling how to make a Vulcawood cabinet and will give you the address of the nearest dealer.

Diamond State Fibre Co., Date.....
Dept. P., Bridgeport, Pa.
Please send me without charge a copy of the booklet, "Getting the Right Hook-up with Celoron." My radio dealer's name is
.....
Name.....
Address.....

Lend





THOROLA 4 $25
14½″ Bell Horn
Beautiful Black
Florentine Finish
Complete with cord and plug. Base felt-mounted

THOROLA 3 $20
12″ Bell Horn and
cord. Horn Finest
Black Florentine Finish

THORO

Us Your Ears

What if your one ear could be right in the same room with Paul Whiteman's band; in the same church with any great choir or organist, or in the White House when President Coolidge is speaking?

And suppose at that very instant your other ear could hear these same features over radio with a Thorola Loud Speaker.

It would be just like having both ears listening to the one original production. Such incredible faithfulness of radio reception has now actually been achieved in a loud speaker.

You can convince yourself of this, just as we have proved it to astonished experts. This unbelievable perfection of Thorola Loud Speaker is the natural outcome of those same laboratory facilities, that same scientific excellence which has made Thorophone the classic loud speaker in severest musical tests.

Now Thorola, like Thorophone, is acclaimed the greatest advance of its time in the loud speaker art. Thorola, like Thorophone, has the exclusive horn of famous Thorite composition, a synthetic material with perfect acoustic properties impossible in wood or metal. But no matter how the experts have praised Thorola and all its betterments, you will still want the final convincing test—your own ears.

So we make it possible for you to test Thorola quickly yourself, without risk. We are sure of your judgment on this greatest of all musical instruments. We know how millions have awaited the perfection of an instrument so good, so low in price, and needing no battery. Thorola already sweeps to record sales everywhere. But if your dealer should be unable to supply you there is no need to forego this great new radio enjoyment.

You may promptly send us the coupon below with your remittance and either model of the Thorola Loud Speaker will be shipped to you prepaid, with an absolute money-back guarantee.

Be first among your friends to exhibit this latest radio wonder. Let everybody listen to Thorola. Decide whether such rare purity of tone has ever been approached in any loud speaker regardless of price. Note the great volume on weakest signals, the absolute clearness on greatest volume, the entire absence of blare and rattle.

Never has there been such performance, size, beauty, richness at the low Thorola price.

Hear Thorola at our risk. You will agree with thousands that Thorola for the first time puts any radio set at its best. Makes summer radio reception better than under the best conditions heretofore. If you are not more than convinced at the end of thirty days you are free to send Thorola back AT OUR EXPENSE, and every cent you paid will be immediately returned to you.

This unusual offer must be withdrawn as soon as Thorola distribution catches up with demand. (Thorola is sold regularly only through retail channels.) Fill out the coupon and mail it now.

GUARANTEE

Thorola is guaranteed to provide approximately twice the volume of any loud speaker (except Thorophone itself) *in your own opinion*, or your money will be fully refunded at any time within 30 days from purchase date.

Thorola volume will be from two to three times the volume of most well-known makes of loud speakers.

Thorola improvement in tone quality is even more remarkable.

REICHMANN COMPANY, 1729-35 West 74th Street, Chicago

LA

SPECIAL 30-DAY TRIAL COUPON

(Good This Month Only)

REICHMANN COMPANY, 1729-35 West 74th Street, Chicago

I am unable to obtain Thorola from my Thorodealer. Therefore please supply me promptly, shipment prepaid. I enclose..... Cert. Chk.—Money Order—Cash in the amount of $.....for one Model.....Thorola Loud Speaker. I understand that this full amount will be promptly refunded if I return the instrument, at your expense, for any reason within 30 days from date.

Date.....

Name.....

Street Address.....

Town and State.....

The Radio Sensation!

The new American Brand Worm Drive Vernier Condenser, with a HUNDRED to ONE ratio Worm Drive geared vernier adjustment.

This is the highest ratio gear adjustment ever developed on Variable Condensers. With this adjustment the plates may be moved so slowly that the motion is hardly noticed by the eye!

A remarkable micrometer adjustment of the entire set of movable plates can be obtained. This wonderful achievement is of special importance to the radio fan seeking distant stations.

Another tremendous exclusive feature—the back panel of American Brand Condensers is adapted for the mounting of any coil desired for use in the set. A. B. Condensers are made from finest heavy brass. The plates are perfectly flat and will never get out of line. Plates and supports are in natural finish, keeping radio frequency losses at a minimum. Mechanically and electrically a perfect job.

And the price of this Super Brass Plate A. B. Condenser with Worm Drive Vernier (23 Plates .0005 mfd.) is only $5.00. 13, 17 and 44 plates with or without Worm Drive Vernier at proportionate prices.

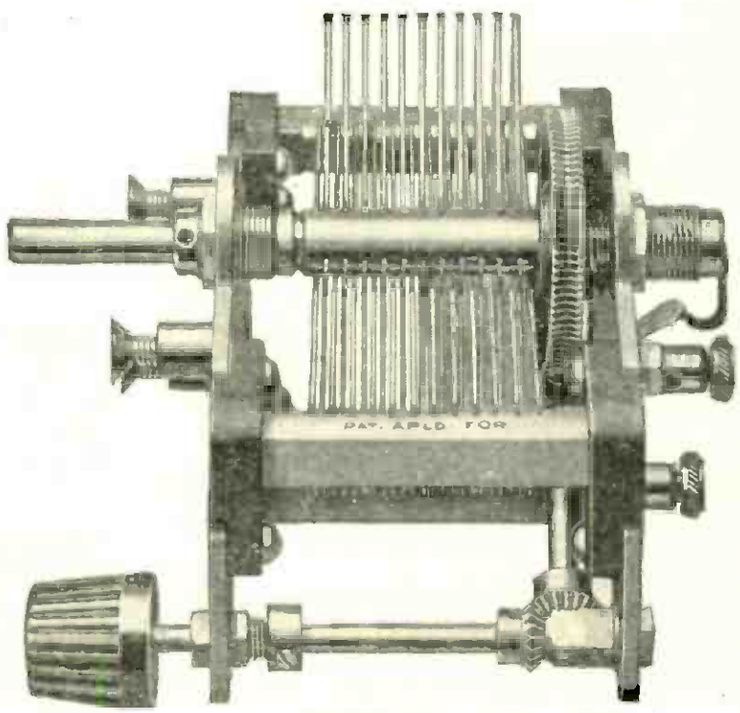
Please ask your dealer to show you this wonderful condenser. If he can't do so, write us for descriptive illustrated folder—and send us your dealer's name.

Note to Dealers: If your Jobber can't supply you with A. B. Condensers write us.

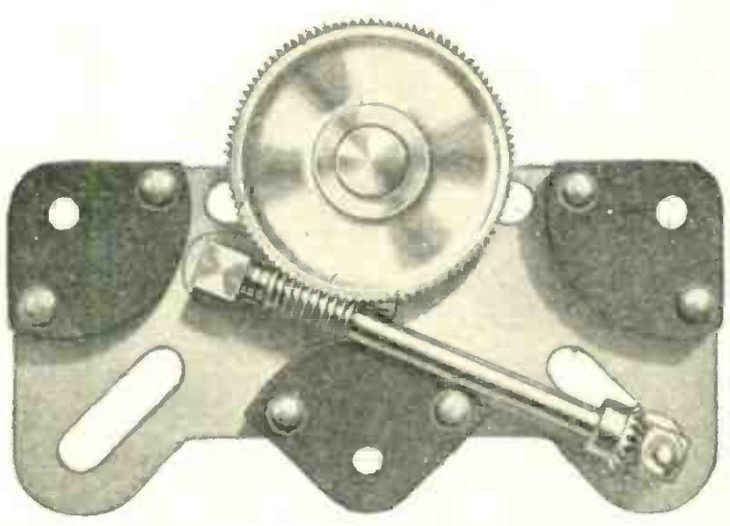
AMERICAN BRAND CORPORATION

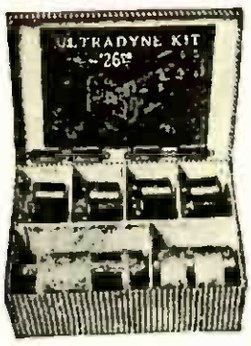
8 West Park St., Newark, N. J.

Factory—Philadelphia



The 100 to 1 Worm Drive





Ultradyne Kit

Consists of 1 type "A" Ultraformer, 8 type "B" Ultraformers, 1 Tuning Coil, 1 Oscillator Coil, 4 matched fixed Condensers.
The Ultraformers are new improved long wave radio frequency tranformers, specially designed by R.E. Lacault, Consulting Engineer of this company and inventor of the Ultradyne.
To protect the public, Mr. Lacault's personal monogram seal (R. E. L.) is placed on all genuine Ultraformers.
Ultraformers are guaranteed so long as this seal remains unbroken.

$26.00

Send for 32-page illustrated book giving latest authentic information on drilling, wiring, assembling, and tuning 6 and 8 tube Ultradyne Receivers.

50c

Greater Distance!

—and the Ultradyne received it

Faithful reproduction over great distances is no unusual performance for the Ultradyne Receiver.

The "Modulation System" of radio reception used exclusively in the Ultradyne, is a decided advance over the detector arrangement used in all other Super-Heterodynes. The "Modulation System" causes the incoming signal to modulate the oscillation produced locally just as the speech modulates the carrier wave of a broadcasting station.

This new principle, the latest development of R. E. Lacault, A.M.I.R.E., Consulting Engineer of this company and formerly Radio Research Engineer with the French Signal Corps Research Laboratories, makes it possible to get far greater distance, because of its unusual ability to provide greater rectification. Weakest signals are made to operate the loud speaker.

You will never enjoy the full pleasure of radio until you operate an Ultradyne Receiver.

Write for descriptive circular

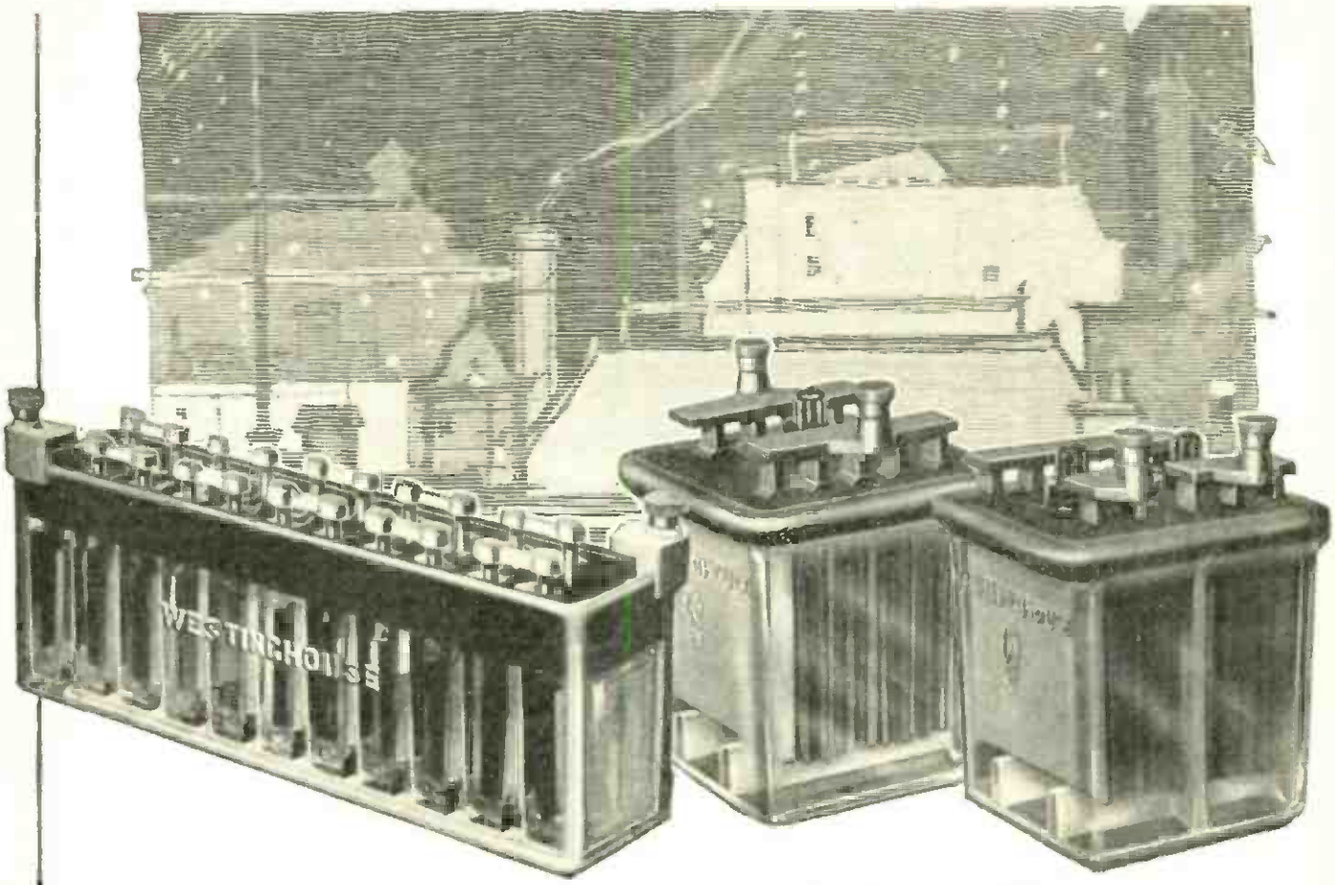
ULTRADYNE

The Improved

SUPER-HETERODYNE

PHENIX RADIO CORPORATION
7-9 Beekman St. New York

"The Standard of Comparison"



NOTHING about a radio set is so absolutely essential to satisfactory receiving as *good batteries.* Sustained voltage, slow, even discharge, ample capacity, utmost quiet, long life—these are important. Don't be satisfied with anything less than Westinghouse Radio Storage Batteries. They are built to meet the most exacting requirements of radio broadcast transmission and reception. And they last! Thoroughly insulated against current leakage. Easily recharged. A size and type for every radio need.

Westinghouse CRYSTAL CASE Radio Batteries have one-piece clear glass cases, with glass cell partitions and high glass plate rests (deep sediment spaces). "A" Batteries in 2, 4 and 6 volt sizes. 6-volt size made in rubber-case types too. "B" Batteries in 22-volt units—regular and quadruple capacities. "C" Batteries in 6-volt units.

WESTINGHOUSE UNION BATTERY COMPANY, Swissvale, Pa.

WESTINGHOUSE
RADIO
"A," "B" and "C"
BATTERIES

"Radio All Summer" Is a Fact!

TIMBRETONE

"The Loud Speaker That Does What the Others Advertise"

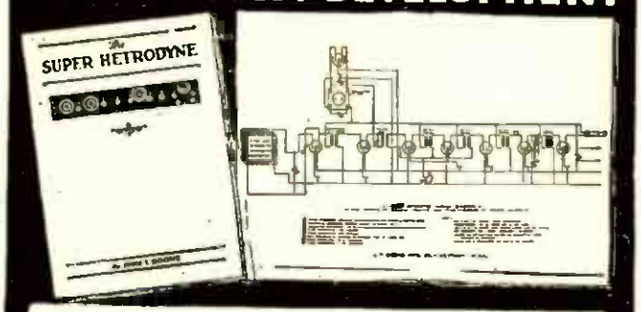
is the loud speaker called for in the list of parts given for the "Popular Radio Portable" set described by Mr. Laurence M. Cockaday in the July issue of Popular Radio on pages 60 to 71.

The requirements in this case are exacting and the features that make Timbretone's wonderful tone qualities are peculiarly adapted for the set described.

Send us the name and address of your nearest dealer and we will do the rest.

Made in Hoosick Falls, N. Y., by the Timbretone Mfg. Co.

RADIO'S LATEST DEVELOPMENT



You Need This Book!

A Complete Text Book on Super-Hetrodynes

Here for the first time is a thoroughly scientific volume treating of what the super-hetrodyne system means to radio, together with a wealth of data on its development, advantages and operation. Written by a man who was a pioneer in the development of radio, this book covers the entire field of super-hetrodyne equipment. Profusely illustrated, and liberally supplied with charts and wiring diagrams, this book gives you a fund of information found nowhere else. The price is $1.00 postpaid. Order today. Use the coupon below.

J. T. BOONE CORPORATION, Manufacturers of
BOONE SUPER-HETRODYNE TRANSFORMER KITS
BOONE SUPER FOLDING LOOP AERIALS
BOONE SUPER VARIABLE CONDENSERS
From your dealer or direct from our factory.

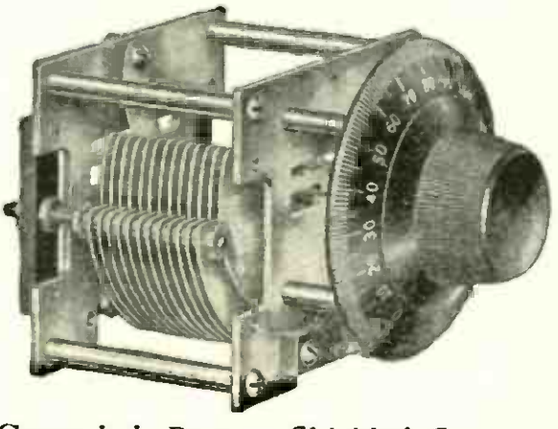
J. T. BOONE CORP., 3469 E. Jefferson, Detroit, Mich.

☐ Enclosed is $1.00 for your text book "The Super-Hetrodyne." Please also send me information on your Super-Hetrodyne Transformer Kits—Folding Loop Aerials—Low Loss Variable Condensers.

Name _____

Address _____ A1

The National Perfect Vernier Condenser



Grounded Rotor—Shielded Stator—Low Loss—Velvet Vernier—An instrument of Precision having high efficiency and extreme selectivity.

Sizes:	.001	.0005	.00035	.00025
Prices:	7.00	6.00	5.75	5.50

NATIONAL COMPANY, Inc.
Est. 1914
110 Brookline St.
Cambridge Mass.

"All right—we'll make it just like ours"

Trust boys to combine business with pleasure—to get a lot of fun out of building radio sets, and profit out of selling them to neighbors. And when their customers' radio ambitions exceed the powers of their sets, back they come to the youthful experts for advice on what kind of a set to buy. In every village and city a large proportion of the purchases of radio parts and sets is made on the advice of boys—their recommendation is sufficient, their rejection of one brand in favor of another is conclusive.

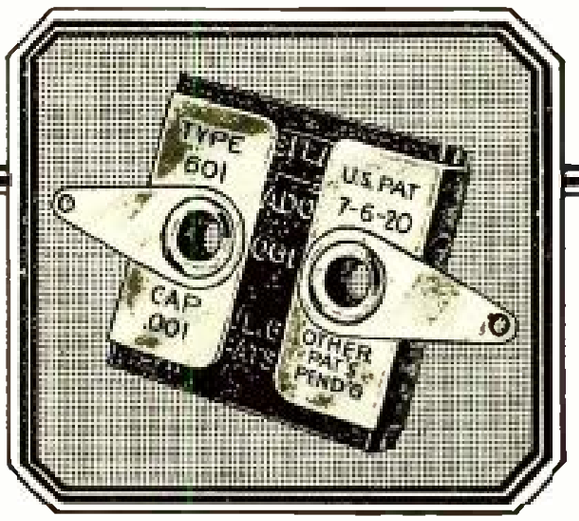
Radio experts abound among the half-million boys who read THE AMERICAN BOY. No small part of their radio knowledge has been learned from its authoritative and instructive radio articles. And most of their business training is acquired from its stories on business boys and business men. THE AMERICAN BOY powerfully influences these powers of radio.

Advertise to them in THE AMERICAN BOY. Win their preference for your radio products—a preference which will result in multiple sales in each community. Get them using your goods—recommending them to their customers, boosting them to their friends in the gang. Tell them your story in the magazine they trust—place your story in the magazine they read from cover to cover—THE AMERICAN BOY.

The fall radio boom is on. Copy reaching us by August 15th will appear in the October AMERICAN BOY.

The American Boy
"The Biggest, Brightest, Best Magazine for Boys in All the World"

Detroit **Michigan**



MICADONS

—condensers of fixed and permanent capacity

You will have condensers that maintain their fixed capacity if you buy Micadons.

These accurate Dubilier Micadons are found in over ninety per cent of the sets made by amateurs and manufacturers throughout the country.—The experts specify Micadons.

The name Dubilier on a condenser has the same meaning as the name Sterling on silverware—highest quality.

There is a Micadon for every circuit—different types are made for different requirements.

For free booklet showing method of soldering Micadons in radio circuits, address, 45-49 West 4th Street, New York

Dubilier

CONDENSER AND RADIO CORPORATION

FORERUNNERS OF RADIO

THE drum of the African savage—the smoke signals of the American Indian—the signal fires of Troy—all contributed to blazing the trail for that modern wonder Radio.

The extremely delicate forces employed in Radio make necessary the use of the finest of apparatus for your full enjoyment.

Holtzer-Cabot Loud Speakers, Phonograph Attachments and Headphones are the perfected results of thirty-five years' experience in the manufacture of delicate electrical apparatus.

Your reception will be improved through the use of Holtzer-Cabot apparatus. A trial is to be convinced. Ask your dealer.

Holtzer-Cabot Loud Speaker	**$25.00**
Loud Speaker Phonograph Attachment	**10.00**
No. 2 Universal Headphones	**9.50**
No. 4 National Headphones	**6.00**

Write for booklets explaining how the exclusive features of these instruments enable you to enjoy the wonders of Radio

THE HOLTZER-CABOT ELECTRIC CO.
125 Amory Street, Boston, Mass.
6161-65 South State Street, Chicago, Ill.
Department B-1

Holtzer-Cabot
BUSINESS ESTABLISHED 1875

Haynes-Griffin

RADIO SERVICE, Inc. 41 West 43rd St., N. Y. City

A. J. HAYNES

Designer of the Haynes Set and special parts for the Super Heterodyne

How's the Super Working?

Is your super heterodyne functioning as you think it should? Does it operate consistently and successfully on distant stations, pulling them in with the tone quality and volume that you expected? Above all, is it selective?

If it isn't, you need A. J. Haynes' new booklet, "Super Success." It embodies information which Mr. Haynes has spent years in collecting, and it concerns itself chiefly with the finer points of super heterodyne construction which the average set builder knows little about.

Mail the coupon now to be sure of a copy of the first edition.

Give Your Super a Chance

You may have built and re-built your super, wired it with the shortest possible leads, and every instrument may be functioning perfectly. Still, your results are not satisfactory.

The reason is the many tricky elements in the super which the average experimenter can not know. That is why radio experts agree that the average home-built super is only 40% efficient.

"Super Success" has been written to help you get most of the other 60%. It contains the real secrets of super heterodyne construction, special information which A. J. Haynes and his corps of laboratory assistants have discovered regarding the use in combination of intermediate frequency transformers.

Get this "inside dope" on the super and get after that lost 60%. With every copy of "Super Success", we will send complete information and a price list of the parts contained in the super heterodyne receiver which Mr. Haynes uses in his own home.

HAYNES-GRIFFIN RADIO SERVICE, Inc.

41 W. 43rd St., New York City 111 S. Clark St., Chicago, Ill.

Sold only in matched sets of four—one In-Put and three Inter-Stage Transformers. Haynes-Griffin guarantee packed with each set. Price per set, $20.00

HAYNES-GRIFFIN
41 W. 43rd St.
New York City

Send me a copy of "Super Success", also complete information and prices of the parts Mr. Haynes himself uses in his own super. I enclose 10c. to cover mailing costs.

Name .....

Address .....

.....

Enjoy Your Radio This Summer

Music Master with its rich, clear tone—unmarred by muffling, blast or distortion—will make radio a pleasure, such as you have never known before.

Summer opens a new world to good radio sets equipped with Music Master. Picnics, camping trips, boating parties, open-air dances—these are only a few of the occasions which Music Master can enliven for you.

No other reproducer is so well fitted for summer conditions. The extremely sensitive precision instrument in the base, the scientifically tapered tone chamber, and the now famous wood horn, the natural and perfect resonator—make up an instrument of balanced proportions and unequalled effectiveness.

Your radio dealer is waiting to demonstrate Music Master for you or to send one for trial with your own set.

Dealers everywhere

Music Master Corporation

Makers and Distributors of High Grade Radio Apparatus

10th and Cherry Street

Chicago PHILADELPHIA *Pittsburgh*

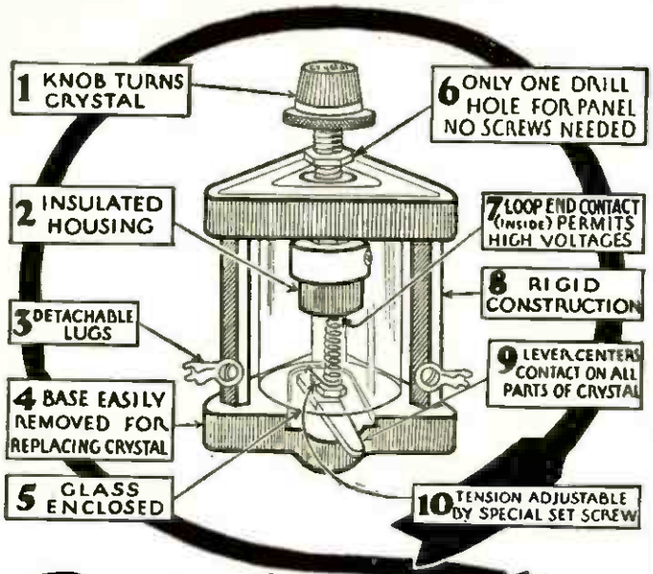
Music Master

RADIO REPRODUCER

14-inch Model, for the Home..... $30

21-inch Model, for Concerts and Dancing.... $35

Connect MUSIC MASTER in place of headphones. No batteries required. No adjustments.



Best Crystal Ever Designed!

FRESHMAN

DOUBLE ADJUSTABLE CRYSTAL DETECTOR

AT LAST the experimenter who has searched for the ideal crystal can now depend upon a perfect detector. The New Freshman Double Adjustable Crystal Detector has met every requirement of the ideal unit. It affords uninterrupted, noiseless, distortionless reception, yielding extraordinary volume with entire absence of squeals and howls often introduced by vacuum tube detectors.

The World's Best

for Crystal or reflex sets

Freshman Double Adjustable Crystal Detector for panel or base use complete.

Freshman Super Crystal with Non-Metallic Housing, fits any standard detector unit—$.50.

$1.50

At your dealers or send purchase price and you will be supplied postpaid.

FREE! Write for building plans and hook-ups of Super-Heterodyne, Reflex and other popular circuits.

Chas. Freshman Co. Inc.
Radio Condenser Products

106 SEVENTH AVE. NEW YORK CITY

NOTED EXPERIMENTERS Make This Their Headquarters For Hard-to-Get Parts

POPULAR RADIO PORTABLE RECEIVER

Marion Loop Antenna with plug attachment	$ 7.00
National Variable Vernier Condensers .00035 Mfd.	6.75
Amsco Potentiometer 400 Ohms	1.75
Unity Vernier Rheostat with switch	2.00
Hoyt Voltmeter 0 to 6 Volt Scale	3.00
3 Dubilier Duratran Transformers $5.00 each	15.00
Jefferson No. 45 Audio-Frequency Transformers	7.00
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6 Benjamen Vibrationless Sockets $1.00 each	6.00
Federal Jack Single Circuit	.60
Pacent " Double "	.80
Carrying Case	10.00
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N. Y. Coil Condenser .00025 Mfd.	.45
Grid-Leak Clips	
Daven Grid-Leak 5 Megohms	.50
N. Y. Coil Fixed Condenser .001 Mfd. with lugs	.40
Kit Consisting of Above Parts	$ 70.00

FOUR CIRCUIT IMPROVED TUNER

2 Amsco 26 Plate Vernier Condensers with Dials $ 4.50 each	9.00
3 48000 Ohm Lavite Resistances $ 1.50 each	4.50
2 Amplex Griddensers $ 1.25 each	2.50
Kit Consisting of Above Parts	$13.50

CRAIG NEUTRODYNE

Parts for Craig Coupler and R. F. Transformer	3.25
41 Plate Cardwell Condenser	6.00
21 " " "	5.00
11 " " "	4.25
Kit Consisting of Above Parts	$ 12.75

COCKADAY DISTORTIONLESS AMPLIFIER

1 Pr. Como Push and Pull Transformer	Pr. 12.50
Amertran Transformer	7.00
No. 26 Bradleyohm	2.00
5 30 " Lengths Celatsite Wire $.25 each	1.25
2 Quinby Radio Frames	2.00
Kit Consisting of Above Parts	$ 21.00

Try us on any radio parts you have been unable to secure.

MORISON
Electrical Supply Co Inc.
Wholesale *Retail*

C.O.D. Mail orders will be shipped promptly

15 East 40th Street New York City

REGAL

LABORATORY TESTED PARTS

Reform your panel! Make it neat, using REGAL 15 tap switch No. 164, which requires but one drill hole. Sold complete with knob and dial. Price $1.50.

Vernier Rheostats hold filaments at sensitive point. Smooth, firm movement. 6 and 30 ohm Verniers, $1.25. 6 and 30 ohm non-verniers, $1.00. 6 and 30 ohm Juniors. 75c. 200 ohm potentiometers, $1.50.

Ask your dealer or write direct for prices and complete descriptive folder No. 24.

The American Specialty Co.
200 Holland Ave., Bridgeport, Conn.

THE ARAGON SILVER NEUTRALIZING CONDENSER for MARVELOUS RECEPTION

BUY ARAGON SILVER WIRE

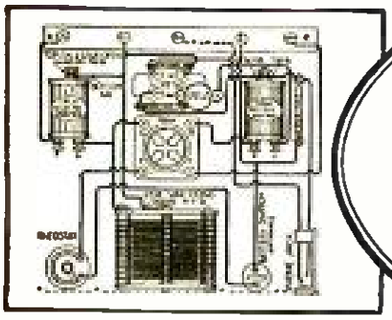
Metal Parts Silver
Neatly mounted

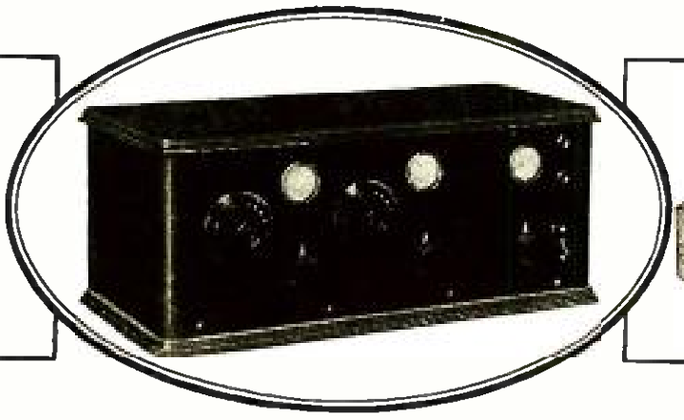
Most perfect Conductor known.
No Current Loss—Easy to Solder
25-foot Coils—no waste—**$1.25**

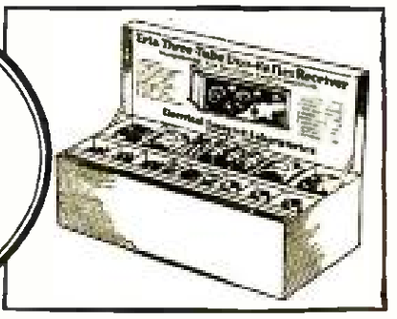
$1.25

ARAGON RADIO CO.
6 E. Lake St. Chicago.

Superior Erla Circuits Are Now Also Easiest to Build







Providing greatly improved selectivity and simplified control in reflex circuits, Erla Selectoformer records material advancement. $5 ea.

Unrivaled ability to meet the requirements of high resistance loud speakers gives first place to Erla push-pull audios. Pair $10

Nickeled shell and moulded Bakelite base of Erla sockets combine maximum beauty, electrical efficiency and strength. Two sizes, 65-75c

Factory Sealed Complete Parts Guarantee Perfect Results

TO the singular efficiency of Erla Duo-Reflex Circuits, tube for tube, the most powerful circuits ever built, now is added maximum ease of construction.

Complete parts for each circuit, down to the last screw and nut, are packed in sealed factory cartons that eliminate all difficulty and doubt in the purchase and assembly of materials.

Synchronizing reflex and audio transformers, tested capacity condensers, balanced crystals, every unit especially designed for the circuit in which it is to function — these positively assure success to the amateur builder.

And, as a final guarantee of accurate, flawless assembly, there is also included a drilled and lettered panel, stenciled baseboard showing the exact location of each piece of apparatus, and full-size blueprints that make child's play of wiring. Even soldering is eliminated, through Erla solderless connectors.

For surest enjoyment of all that radio affords, for purest tone quality, maximum selectivity and ease of control, as well as range and volume, ask your dealer about Erla knock-down receivers, in the factory-sealed carton. Or write direct, giving your dealer's name.

Electrical Research Laboratories
Dept. R 2500 Cottage Grove Ave., Chicago

ERLA

Materially improved range and volume, over the whole broadcasting waveband, follows the installation of Erla reflex transformers. List $5

Exclusive core construction is but one of many reasons for unduplicated Erla ability to amplify three audio stages without distortion. List $5

Panel layouts are improved 100% through patented Erla bezels, in 1" and 1⅛" diameter, for ⅛" to ¼" panels. Nickel, black, gold. 20-30c

A Vertical "B" Battery

Upright in Shape
—Upright in Use

WHERE weight, table or cabinet space is a factor in your selection of Burgess Radio "B" Batteries, buy the Burgess vertical "B" No. 5158.

It is right at home in any position in your cabinet. Its sturdy compactness is almost a necessity in portable receiving sets.

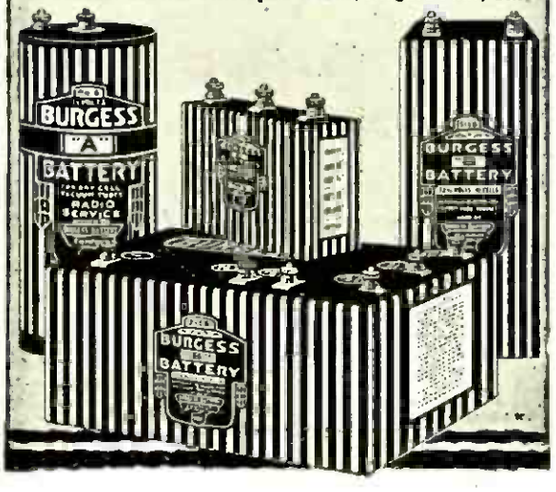
Its height, width and weight coincide exactly with the double strength Burgess Radio "A" Battery. You are sure to be pleased with both the convenience and service offered by such an assembly of "A" and "B" Radio Batteries.

"ASK ANY RADIO ENGINEER"

BURGESS
RADIO BATTERIES

BURGESS BATTERY COMPANY

Engineers - DRY BATTERIES - *Manufacturers*
FLASHLIGHT - RADIO - IGNITION - TELEPHONE
General Sales Office: Harris Trust Bldg., Chicago
Laboratories and Works: Madison, Wisconsin
In Canada: General Offices and Works, Niagara Falls, Ont.



"Take No Chances—Use Como"

COMO DUPLEX
The World's Standard Push Pull Transformer

PRICE $12.50 per pair
For maximum volume without distortion

What Prominent Writers on Radio Subjects say About Como.

Lewis B. Hagerman, Technical Editor, *Chicago Post:* "Actual Tests show this transformer to be far superior to any others of similar makes."

R. J. Robbins, *New York Sun:* "After consideration of several well-known makes of push pull transformers which are available "COMO DUPLEX" was selected as most satisfactory."

C. White, *Radio World:* "COMO DUPLEX" is infinitely superior — most other push pull transformers seem to be ordinary transformers with a center tap brought out as a makeshift."

E. P. Gordon, *Open Road:* "A system of audio-amplification which is becoming increasingly popular. Its use . . . will give surprising results in both quality and volume, and is thoroughly recommended by this department."

NEED WE SAY MORE?

COMO APPARATUS COMPANY
446 Tremont St. Boston, Mass.
For Sale at Leading Dealers

Timmons Talkers

The Most Beautiful Loud Speakers in the World.

Adjustable $35 **Non-adjustable $25**

TIMMONS TALKERS, INC.
339 E. Tulpehocken St., Germantown, Phila., Pa.

Don't You Get Tired

of only hearing LOCAL stations on your Crystal Set. There's music on your aerial every night from stations far away. If you want to hear it without buying a tube set, WRITE ME TODAY.

LEON LAMBERT
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Charge Your Battery For A Nickel

The Gold Seal Homecharger charges Radio and Auto Batteries at home overnight for a nickel. Your dealer has it. Write for FREE booklet and list of broadcasting stations.

The Automatic Electrical Devices Co.
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CALL at your dealer's today and ask him to show you a Magnavox M4 Reproducer.

Try out the instrument critically; satisfy yourself that its clear tone and natural volume are sustained throughout the entire musical range; examine each essential detail of convenient size, handsome finish and sturdy construction; note that its operation requires no battery.

M4 is a definite contribution to the radio art—and one particularly welcome to the moderate income.

There is a Magnavox for every receiving set

Reproducers

M4—requires no battery . $25.00
M1—also requiring no battery $30.00
R3—new model with Volume Control . . . $35.00
R2—same as R3 but larger size $50.00

Combination Sets

A1-R and A2-R—combining Reproducer and Power Amplifier in one unit . . $59.00, $85.00

Power Amplifiers

A1, AC-2-C, AC-3-C—Audio-frequency Amplifiers: one, two and three stage $27.50 to $60.00

To obtain the fullest enjoyment from your receiving set, equip it with the Magnavox.

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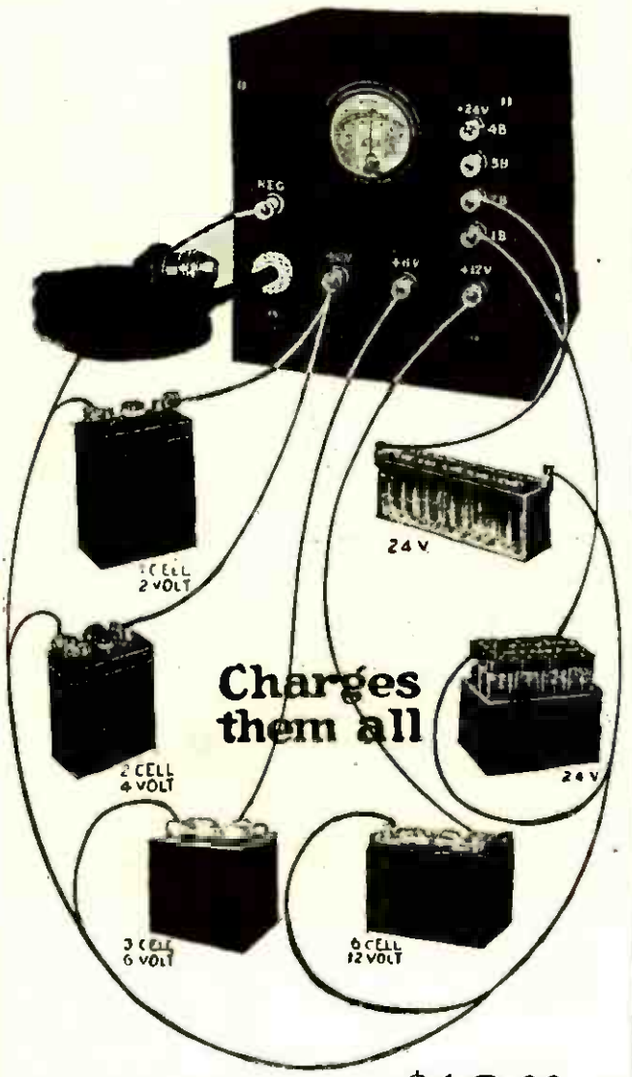
8R

M4
$25.00

MAGNAVOX Radio

ULTRA HANDY CHARGER



Charges them all

ULTRA MODEL $18.00
f. o. b. ST. LOUIS

Note

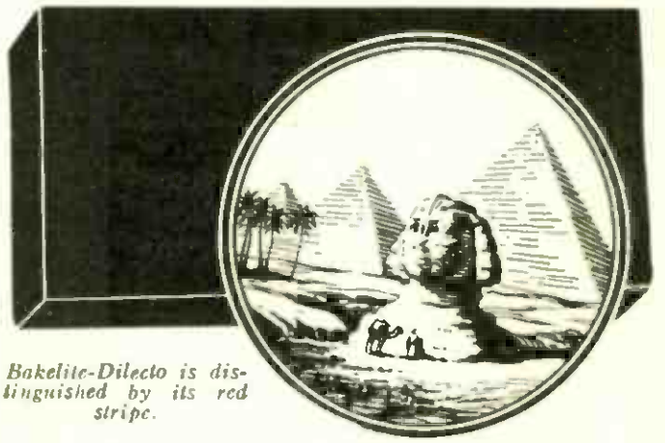
"Handy Charger" Features

No bulbs to break.
No acids to spill.
No fast-wearing parts.
No auxiliaries necessary.
No sticking contacts.
No wood used—Fireproof.

The most complete, most flexible and quickest battery charger on the market at any price. Will charge every radio and automobile battery in the one machine. Furnished complete with a precision *Weston Ammeter.*

Beautifully finished Case — automatic in operation. Costs less than 1 cent per hour to run. Ask your dealer. Illustrated descriptive folder on request. Write us.

INTERSTATE ELECTRIC CO.
of St. Louis, Mo. 4339 Duncan Ave.



Bakelite-Dilecto is distinguished by its red stripe.

durable!

A Bakelite-Dilecto Panel wears like iron. None has ever been known to fail in any one of its many duties as radio insulation.

bakelite-dilecto

(A Laminated Phenolic Condensation Material)

Has a ten-year record of satisfactory service in the U. S. Navy and Signal Corps. Handsome. Tough. Readily Machined. *Highest* in dielectric strength. Your dealer will get it cut for you.

THE CONTINENTAL FIBRE CO.
Factory: Newark, Delaware
Service from:

New York, Woolworth Bldg.
Chicago, Wrigley Bldg.
Pittsburgh, 301 Fifth Ave.
San Francisco, 75 Fremont St.
Los Angeles, 307 S. Hill St.
Seattle, 1041 Sixth Ave. So.

Radio DIAMOND Plate

"B" BATTERIES

Hook them up and Forget them
—Good for Months

DIAMOND ELECTRIC SPECIALTIES CORP.
102 SO. ORANGE AVE., NEWARK, N. J.
Dealers—Jobbers, Write for Proposition

METALECTRIC SOLDERING IRON

"Accepted as the logical solution to radio problems by leading amateurs, manufacturers, and Governmental departments."

Write for descriptive literature.

Post Electric Co. (Inst. Division) 30 E. 42d St., New York

GENUINE LAVITE RESISTANCES

The ONLY perfect distortionless resistances, for resistance coupled amplification.

12,000
48,000
50,000
100,000
} Ohms

Price **$1.50** each

Special sizes to order. Dept. P. R.

Mail Orders Filled Dealers Communicate **Eastern Coil Corp.** 22 Warren St. New York, N. Y.

Bristol Single Control Radio Receiver

Complicated combinations are eliminated when tuning in with Bristol Single Control Radio Receiver—every station is on the one dial. It gives the joys of radio with technicalities left out.

The well-known Grimes Inverse Duplex System (non reradiating) is utilized in this Receiving Set. Because of the reflex, only four tubes are required to give power equivalent to six. The price, without accessories, $190.00.

Audiophone Loud Speaker

You forget the radio equipment when listening thru the Audiophone Loud Speaker. The tone is full, clear and pleasing. It gives a true reproduction of the original. Made in three models—Senior $30.00, Junior $22.50, and Baby $12.50.

Ask for Bulletins Nos. 3014 and 3015-L.

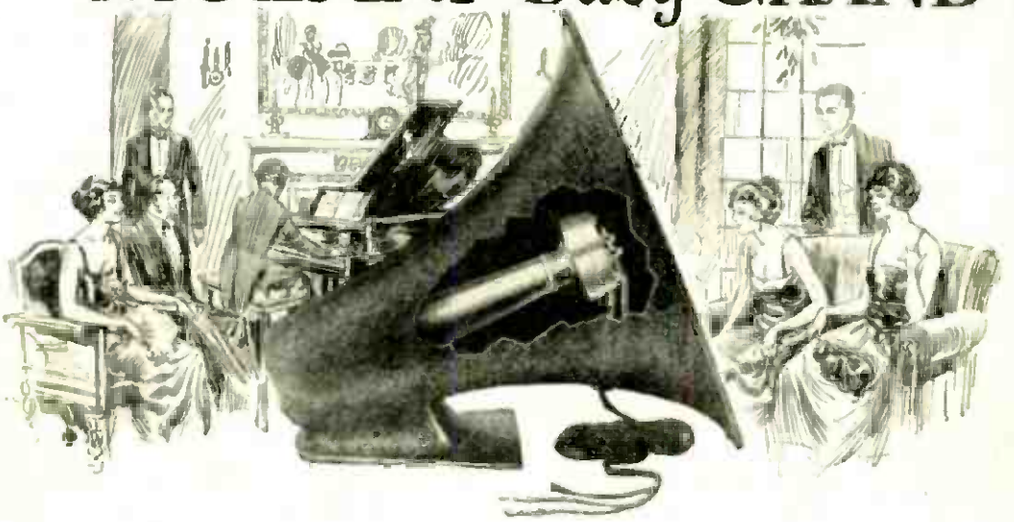
Made and sold by

THE BRISTOL COMPANY

Waterbury, Conn.

"Reflected Tone" in

The MOZART Baby GRAND



There has been so much advertising under the heading of tone, volume, acoustics, resonance, etc., that it was not our intention of even alluding to the subject in this series. Recently, however we ran across a competitor's ad, which we consider of sufficient interest to quote from as follows:

"Two horns are used --- the smaller throws the"
"sounds against the major or reflecting horn."
"The operation is similar to the strings and"
"sounding-board of your piano --- We found"
"that this was the only way we could reproduce"
"all tone really round and full. The middle"
"tones sound well on practically any good loud"
"speaker, but we found that high and low"
"tones were true, only when they were"
"'reflected'."

Assuming our respected friends also made this discovery themselves, independently, we take off our hats to them. The system is exactly similar to the Mozart-Grand and is only another reason for the latter's phenomenal success to date.

PRICES F. O. B. Factory

Reproducer complete with (gold plated) unit and polarity-indicating rod	$12.00
Unit only with polarity-indicating cord, gold plated	5.00
Unit only with polarity-indicating cord, nickel plated	4.00

Shipping weight of reproducer 8 lbs. (approx.)
Dimensions—Diameter of bell 12". Length and height overall, 12".
No extra Batteries required.
Orders shipped direct from the factory or through your dealer.

RADIO DIVISION

The MOZART-GRAND CO.

Manufacturers of Fine Instruments

Newark, N. J. U. S. A.

Atlas floods the room with the best that's in your set

ATLAS is an instrument designed for clear, lifelike reproduction of *every* type of program, with *any* good receiving set.

Since its base, of mahogany colored Bakelite, highly polished and permanent, contains no iron, no external magnetic field can influence the sound-producing coils.

Responsible dealers everywhere sell Atlas speakers for $25.00. Informative booklet on request.

Multiple Electric Products, Co., Inc.
36 Spring St., Newark, N. J., Dept. B

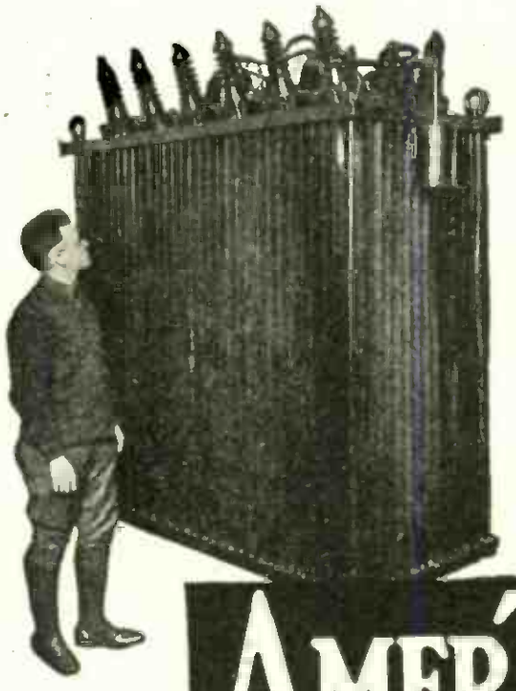
New York, Boston, Philadelphia, Baltimore, Pittsburgh, Detroit, Chicago, St. Louis, Denver.

550 Howard Street, San Francisco.

With the Atlas Unit and phonograph attachment coupling at $13.50 your phonograph may be converted in a twinkling for Atlas Radio Reproduction.

Atlas
TRADE MARK
RADIO REPRODUCTION
speaker

Voices across the sea



Special service transformer at Radio Central, Rocky Point, L. I.—300 k.v.a., 60-cycle, 3-phase, 22,000 volt, oil-cooled; made by American Transformer Company.

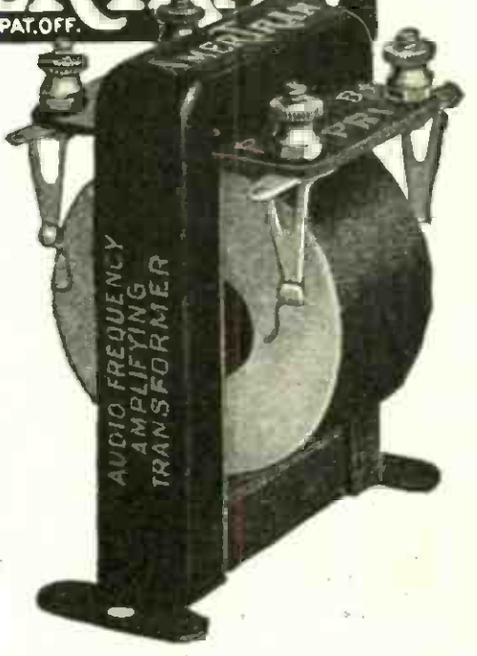
By courtesy of Western Electric Co.

Used in the recent successful demonstration of

Talking to Europe

AMERTRAN

TRADE MARK REG. U.S. PAT. OFF.



An important element in the receiving sets which were successful in

Receiving from Europe

Now made in two types: AmerTran AF-6 (Turn ratio 5)—for first stage; AmerTran AF-7 (Turn ratio 3½)—a companion transformer for use in further stages when AF-6 is used in the 1st stage.

Price, either type $7.00 at your Dealer's

American Transformer Company

Designers and builders of radio transformers for over 23 years

175 EMMET STREET **NEWARK, N. J.**

Resistance Coupled Amplification

The tone quality from a **Daven Resistance Coupled Amplifier** is the most perfect known to the Radio Art.

Our tpye 3-C illustrated contains all the necessary parts to build a three stage resistance coupled amplifier that cannot distort.

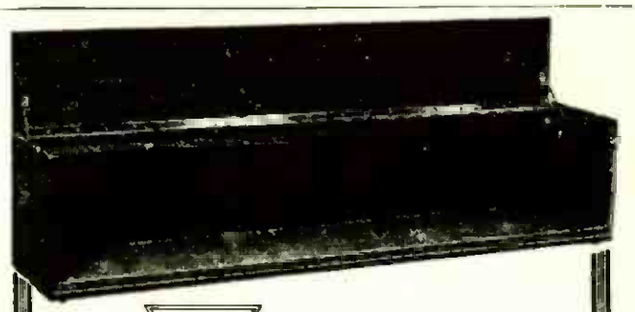
SOLD EVERYWHERE

$13.50

Read our booklet, "Resistors—Their Application To Radio Reception" By Zeh Bouck

Price—15 Cents

DAVEN RADIO CORP.
"Resistor Specialists"
9 Campbell Street, Newark, N.J.



BLANDIN TRIPLE A

And Now Super Radio Cabinets

Panel size 8 x 40-8 inches deep. Made of solid select mahogany with basswood bottom, varnished and hand rubbed to a piano finish. Built by experienced workmen—experts on cabinet design and construction.

BLANDIN TRIPLE "A" DE LUXE SERIES

Full De Luxe equipment including extra mounting board—inlet flush lid—continuous piano hinge—folding lid supports—rubber feet.

Also Neutrodyne sizes. 7 x 24-7" and 7 x 26-7". Smaller sizes, 7 x 14-7", 7 x 18-7" and 7 x 21-7". Write for illustrated price list and name of your nearest jobber or dealer.

Jobbers and dealers, write for discounts

BLANDIN PHONOGRAPH COMPANY, INC.
1500 16th St. :: :: RACINE, WIS.

DUTCH RADIO VALVE

D-201-A

.25 Amp. 5-6 Volts

Detector - Amplifier

Guaranteed

Rigidly tested by expert engineers

LIST PRICE $4.00

Special discounts to dealers—A few more distributors wanted

Sole distributors for U. S.
D. R. V. IMPORTING CO.
515 Orange St., Newark, N. J.

Dealers write to Distributors in your territory

Distributors

CALIF.—Marshank Sales Co.
1240 South Main St., Los Angeles, Cal.
MISSOURI—St. Louis Radio Tube Laboratory
3572 Olive Street, St. Louis, Mo.
CANADA—Consolidated Lamp Co., 43 Queen St., E. Toronto, Ontario

WE REPAIR
The Following
RADIO TUBES

WD-11	$2 50	DV-6A	$2.50
WD-12	2 50	UV-199	2.50
UV-200	2 50	C-299	2.50
UV-201	2.50	UV-201A	2.50
C-300	2 50	C-301A	2.50
C-301	2.50	Marconi	2.50
DV-6	2 50	Moorhead	2.50
DV-1	2.50	6v.Plain Detector	2.50
DV-2	2.50	6v.Plain Amplifier	2.50

Mail orders solicited and promptly attended to.

Dealers and Agents Write for Special Discount.

H. & H. RADIO COMPANY
Clinton Hill Sta. P. O. Box 22-E. Newark, N. J.

SOLDER WITH INSULATION
At Least 1,000 Miles More Distance

is the usual reward if you can solder without impairing the insulation of your set.

If you are building a radio-frequency amplifier you should read our free booklet:

"HOW TO SOLDER RADIO SETS"

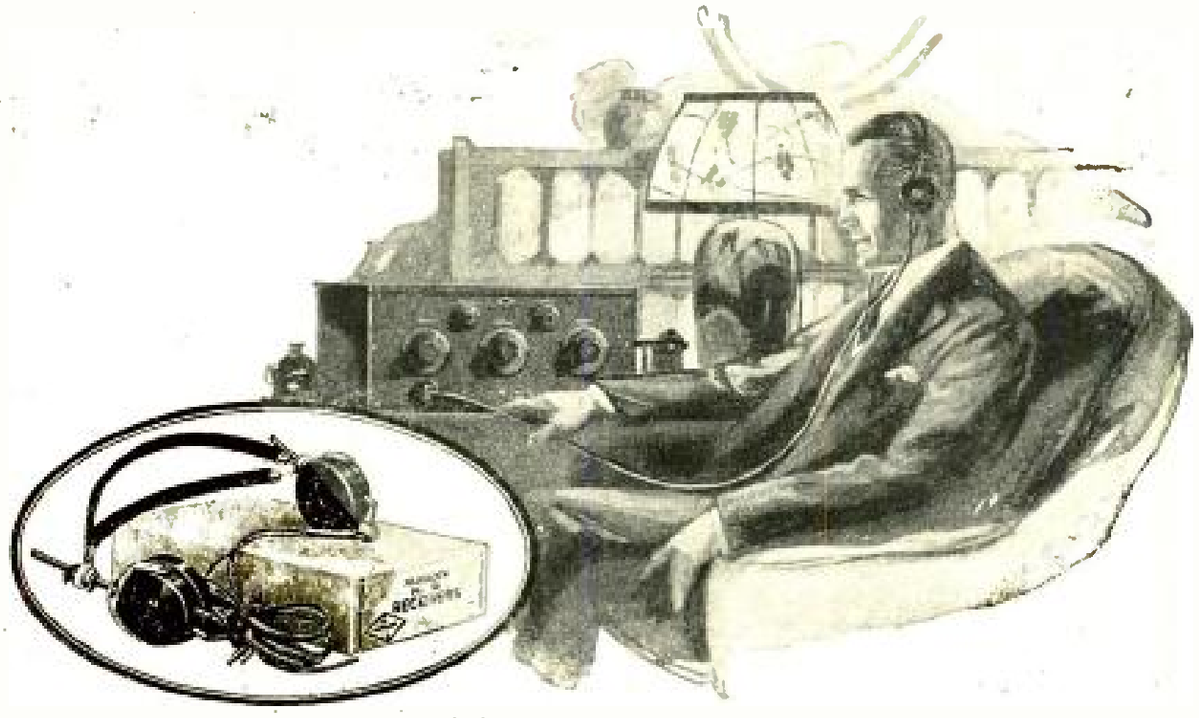
Write for it

THE VALLEY FORGE CHEMICAL CO., Valley Forge, Pa.

Make $100 Weekly In Spare Time

Sell what the public wants—long distance radio receiving sets. Two sales weekly pays $100 profit. No big investment, no canvassing. Sharpe of Colorado made $955 in one month. Representatives wanted at once. This plan is sweeping the country—write today before your county is gone.

OZARKA, 855 Washington Blvd., CHICAGO



They're as comfortable —*as your hat!*

DINNER is over. You want to relax. You sit down at your radio—to see what's on the air. You have a great many programs to select from—local and distant. You choose the one that suits your mood. The enjoyment you get depends upon the headphones you use. If they are inferior—the results will be unsatisfactory.

Murdock Radio Phones are famous for clear reproduction—and comfort. They are equipped with powerful magnets and sensitive diaphragms—correctly seated and clamped. This permits you to receive distant broadcastings—with great volume and clearness.

The headband is of new design. It is flat and featherweight—and does not bind the head. The ear caps are moulded to fit the ears and exclude outside noises. Result—you can wear Murdocks for a whole evening without being conscious that you have them on.

Murdocks sell at a moderate price. They will bring out the latent possibilities of your receiving set. Get a pair from your dealer to-day. They are fully guaranteed.

Built, not assembled

Murdocks are made in a single unit, of superior moulded insulation. Each part is fitted by one process into its proper place. They are moulded together — assuring firmness, strength and durability. And they can't get out of adjustment.

WM. J. MURDOCK COMPANY,
376 Washington Avenue. Chelsea. Mass.
Branch Offices: New York. Chicago and San Francisco

MURDOCK RADIO PHONES

Standard since 1904

—MAIL COUPON FOR FREE BOOKLET—

Wm. J. Murdock Co.
376 Washington Ave., Chelsea, Mass.

Gentlemen: Please send me, without obligation, your free booklet, "The Ears of Radio," which explains the importance of radio 'phones to efficient radio reception.

Name .....

Street .....

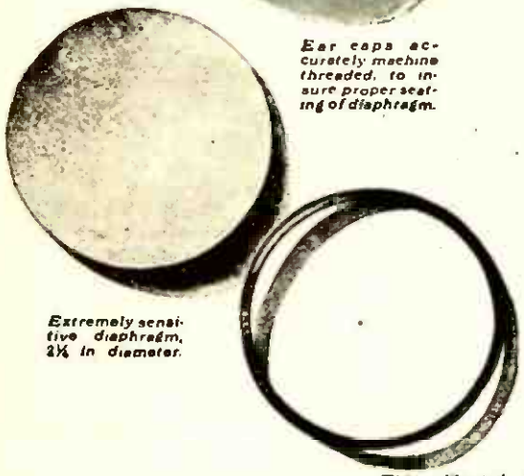
City ..... *State* .....

N&K

Imported PHONES

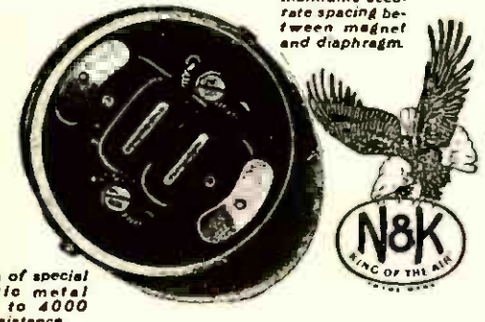
N & K Phones, Model D, 4000 ohms, reproduce more clearly because of their watch-like accuracy of construction, and the increased diaphragm area. The slightly larger ear caps and the sanitary leather covered head bands make them the most comfortable head set. Price $8.50

Ear caps accurately machine threaded, to insure proper seating of diaphragm.



Extremely sensitive diaphragm, 2¼ in diameter.

Thin, calibrated metal washer maintains accurate spacing between magnet and diaphragm.



Magnets of special magnetic metal wound to 4000 ohms resistance.

Built like a watch

THE scientific design and painstaking workmanship of European watches have earned a worldwide reputation. These identical qualities are what have given N & K Phones their remarkable reputation.

As in fine watches, the design is absolutely scientific, the workmanship is of the highest type. The magnets are made of a special magnetic metal of a quality that insures uniformity and long life. The ohmage (4000 ohms total D.C. resistance) has been proved by tests to be the most efficient for all general purposes. The diaphragms are peculiarly and unusually sensitive and have a *greater area.* The spacing between the diaphragms and the magnet poles is scientifically correct.

Clear, mellow Tone

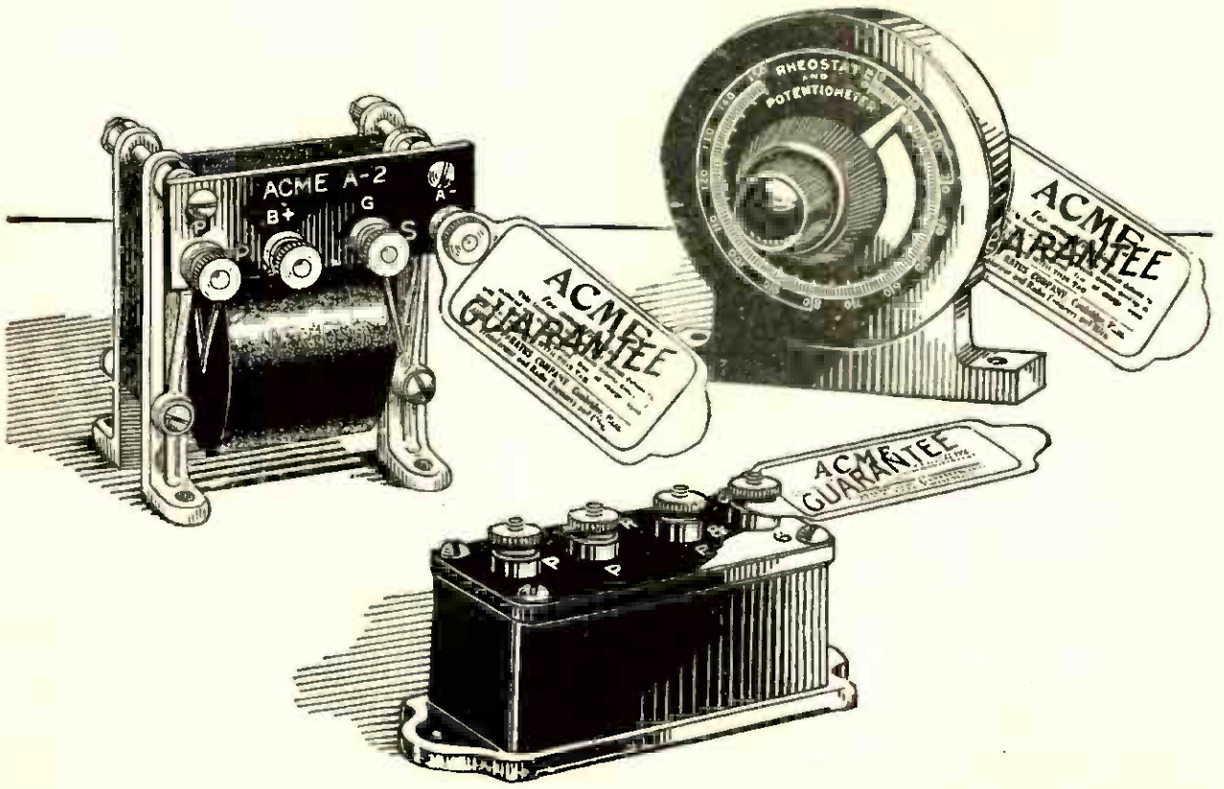
The results of this scientific design and painstaking workmanship are evident from the first moment you listen to broadcast music through N & K Phones. The entire reproduction is clearer, mellower, more natural. Every note, highest to lowest, of voice or musical instrument is heard distinctly. Compare them with any other phones you know of and you'll prefer N & K. Sold on a money-back guarantee.

"THE PHONES THE FANS ARE ALL TALKING ABOUT" is a folder describing N & K Phones in detail. Write for it.

Dealers: N & K Head Sets mean easy sales, excellent profit. Use them to demonstrate your radio sets, especially the small ones. They'll sell the set for you every time. Show your customers the sanitary leather-covered head bands—so easily cleaned. And take advantage of the important fact that there are no come-backs on N & K Head Sets. As an N & K dealer said after handling them for a year: "I have yet to see one pair come back for repairs." If your jobber is not yet supplied with N & K Head Sets, write us.

TH. GOLDSCHMIDT CORPORATION, Dept. P8, 15 William Street, NEW YORK

What ACME means
by a guarantee



THERE are no ACME seconds. All ACME transformers are rigidly inspected. Take the coils on audio frequency transformers, for instance, thousands of turns of small wire—one short circuited turn, and out they go.

Take the radio frequency transformers, each one of them tested in a radio frequency amplifier and if they don't give a standard amount of amplification at three different wave lengths (250-360-550 meters) out they go.

You may say, "Why the rigid inspection? The user can't make these tests," and we'll say "Insurance." Insurance on the product and insurance on the future. ACME has grown by making a superior product and making good should a defect in material or workmanship develop. Frankly, we cannot afford to put out a single inferior article.

Acme Engineering Service

If you think you are not getting the proper results with Acme Apparatus, write to the Acme Engineering Service, Cambridge, Mass. Send 10 cents for 36-page book—"Amplification without Distortion," which contains many diagrams and valuable hints on how to build a set and how to get the most out of it.

ACME APPARATUS COMPANY

Transformer and Radio Engineers and Manufacturers

Cambridge, Mass.

ACME
~ *for amplification*

ACME APPARATUS COMPANY
Dept. 91, Cambridge, Mass.

Gentlemen:—I enclose 10 cents (U. S. stamps or coin) for a copy of new edition of "Amplification without Distortion," containing many wiring diagrams and valuable hints on how to build a set and how to get the most out of it.

Name.....

Street.....

City..... *State*.....

Between Times

A Word of Explanation

This season of the year always finds the magazine publisher facing a short period of slackened activity. It is right between subscription seasons and the observant reader has learned that it is the one time in the whole year to look for real bargain prices in subscriptions.

You Are Invited

That POPULAR RADIO maintains the fullest confidence and approval of its readers is evidenced by the fact that it still leads all other radio publications in the number of paid subscribers on its list.

But we want twice as many subscribers, and to secure them, invite you and every other reader to show this issue to at least one friend, who is not now a subscriber. Explain how much helpful information and how many interesting facts you find in it every month. Tell him that the magazine alone is tremendous value at $3 a year. But that by subscribing now he is entitled to any set of Blueprints described on page 64, *free*, and can at any time avail himself of the Technical Information Service outlined on page 60, *without charge*. Let him know that the new members added to the Editorial and Laboratory Staffs—the enlarged and newly equipped Laboratory—and the new Departments and Features in the magazine—all insure increasing greatness and popularity for POPULAR RADIO in the months to come.

For your courtesy in boosting POPULAR RADIO we will enter your name on our mailing list to receive *the next six issues free*, as soon as we receive your remittance of $3.00 covering the new subscriber's order. Get two friends to subscribe, send us $6.00 and you will have a *12 months' subscription free*. There's no limit! Six months free for you for every new twelve months' subscription, including set of Blueprints, at $3.00 that you send us. If you are already a subscriber the free subscriptions will be entered as renewals at the expiration of your present term.

Just use your enthusiasm for POPULAR RADIO and do yourself and us a good turn.

Another Special Offer

You know POPULAR RADIO too well to require any review of its special merits, and here is an offer that speaks for itself. For the next thirty days we will accept twenty-four months' subscription orders, new or renewal, for $5.00. Or for $5.00 we will enter or extend two twelve months' subscriptions. No other inducements are included with either a two-year order or two one-year orders on this offer. The price saving alone will prove attractive to enough people to keep our clerical force busy for the next four weeks. Send all orders to

POPULAR RADIO
Department 87
627 West Forty-third St.
New York City

Service That Serves

Without charge, every Popular Radio subscriber is privileged to submit any radio problems to Mr. Cockaday for answer by personal letter.

MANY radio problems are peculiar to the individual case. It is to help readers solve these troubles that POPULAR RADIO's Technical Service Bureau is maintained under Mr. Cockaday's personal supervision.

This Service is free to all subscribers. It is requested that you confine your questions to one general subject, write on one side of the sheet and enclose a stamped, addressed return envelope. But write as often as you wish in the assurance that a personal answer will be mailed promptly. This same Service is available to other readers who are not subscribers upon payment of a nominal charge of 50c. per inquiry.

Obviously the Service cannot be expected to answer questions that have already been covered in the magazine. Below is a condensed index to articles that have been published in previous issues. If you haven't these issues in your files we'll be glad to supply them at 35c. a copy.

May, 1922

—Harnessing waves to wire.
—How to tune a Regenerating Receiver.
—Symbols that help in reading diagrams.
—How to make soldered connections.
—How Radio waves are sent and received.

June, 1922

—Wireless that we can see.
—Can we talk to the dead by Radio?
—How electricity is generated.
—Tones that do and don't broadcast.
—How to make a simple tube Receiving Set.

July, 1922

—Steinmetz on ether waves.
—How to learn the code.
—How to make a two-circuit Receiving Set.
—How high frequency currents are generated.
—Pointers for preventing interference.
—How to make a loose-coupler coil.

August, 1922

—How machines are controlled by Radio.
—How Radio circuits are coupled and tuned.
—What "call letters" mean.
—How to make a variable condenser.

September, 1922

—How to build the Armstrong Circuit Receiver.
—A resonance wave coil for reducing static.
—How to make a rotary plate condenser.
—The simplest receiving antenna.

October, 1922

—How to make a spider-web tuner.
—How to make your own grid condenser.
—Don'ts for Radio fans.
—How to use a Regenerative Set as a transmitter.
—How to restore worn-out crystals.

November, 1922

—Sir Oliver Lodge on ether waves.
—How to add a Vacuum Tube to your crystal set.
—The most popular transmitting aerial.
—How to make a novel variocoupler.

December, 1922 (Out of stock.)

January, 1923 (Out of stock.)

(A Reprint of Mr. Cockaday's article describing the DX Regenerative Receiver may be had for 25 cents.)

February, 1923 (Out of stock.)

March, 1923 (Out of stock.)

April, 1923 (Out of stock.)

May, 1923 (Out of stock.)

(A full description, however, of Mr. Cockaday's original 4-Circuit Tuner will be found in POPULAR RADIO's handbook, "How to Build Your Radio Receiver," advertised on page 58.)

June, 1923 (Out of stock.)

July, 1923

—The ratio in size between your antenna and your coil.
—Useful facts about ear-phones.
—How to make a dry-cell tube Regenerative Set.
—How to keep up your storage battery.

August, 1923 (Out of stock.)

(A full description, however, of the Tuned Radio Frequency Receiver will be found in POPULAR RADIO's handbook, "How to Build Your Radio Receiver," advertised on page 58.)

September, 1923

—How to get a radio license.
—How weak signals are regenerated.
—How to make a battery charging rectifier.
—How to build the Haynes DX receiver.

October, 1923

—Practical hints for Coil Calculations.
—How to make a Two-stage Audio-frequency Amplifier.
—Ten good rules for Broadcast Listeners.
—How to make a simple Honeycomb Receiver.

November, 1923

—The 100 Best Hook-ups (Part 1).
—Receiving without Antennas.
—How to build the New Regenerative Super-heterodyne Receiver (Part 1).
—How to build a combination Short and Long-wave Receiver.

December, 1923

—How to Select your Radio Parts.
—The 100 Best Hook-Ups (Part 2).
—How to Read a Diagram (Part 1).
—How to build an efficient Crystal Receiver
—How to Build the Super-heterodyne Receiver (Part 2).

January, 1924

—How to Build the Improved Four-circuit Tuner.
—100 Best Hook-ups (Part 3).
—How to Read a Diagram (Part 2).
—How to Make a Chopping Bowl Loudspeaker.

February, 1924

—How to add "Push and Pull" amplification to the original 3 tube Cockaday 4-Circuit tuner.
—The original 4-Circuit Tuner as a Portable Set with Loop.
—The 100 Best Hook-ups (Part 4).
—How to build a 3-tube Reflex Receiver (Part 1).

March, 1924

—Hoffman Transformer Measurement Chart.
—The 100 Best Hook-ups (Part 5).
—How to Build an Amateur Transmitter.
—A 3-tube Reflex Receiver (Part 2).

April, 1924

—How to Build a Simplified Neutrodyne Receiver.
—The 100 Best Hook-ups (Part 6).
—How NOT to Tune the Single Circuit Receiver.
—A Novel Substitute for "B" Batteries.

May, 1924

—A Compact Radio Kit for a Spring Hike.
—How to Get the Maximum Radio-frequency Amplification.
—100 Best Hook-ups (Part 6).
—Where Interference Comes In.
—How to Make an Audio-frequency Amplifier that Does Not Distort.

June, 1924

—How to Install a Receiver on your Boat.
—The 100 Best Hook-ups (Part 7).
—How to Make Your Own Grid Condensers.
—How to Build a Regenerative Receiver for Use with an Indoor Antenna.
—How to Make a Two-Slide Tuner.
—How to Calculate the Wiring of Coils

July, 1924

—How to Avoid Local Interference.
—How "Resistance" Affects Radio Circuits.
—An Ideal Set for Summer-time Reception.
—100 Best Hook-ups (Part 8).
—How to Do Your Soldering Correctly.
—How to Build the POPULAR RADIO Portable.

A Buffalo Radio Fan Gets London with the help of a KIC-O

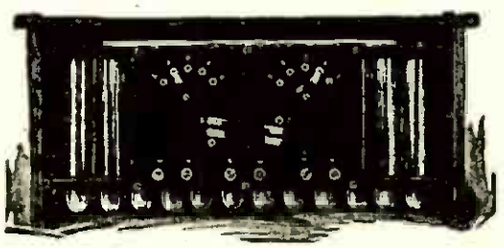
Mr. E. C. Lewis on March 18th heard Mr. Marconi's voice on a Model 10 Atwater Kent Machine. He said it would have been impossible without a KIC-O Battery. Improve your set with a KIC-O. Our guarantee protects you.

GUARANTEE
Your money back on any KIC-O Battery if not satisfied within 30 days' trial.

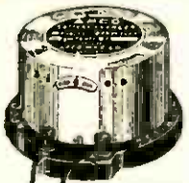
Write for full information on "A" and "B" Batteries

Volts	Price, Plain	With Panels
22	$5.50	
32	7.25	$11.75
48	9.50	14.00
68	12.50	17.00
100	17.50	22.50
145	23.50	28.50

Kimley Electric Company
2667 Main St. **Buffalo, N.Y.**



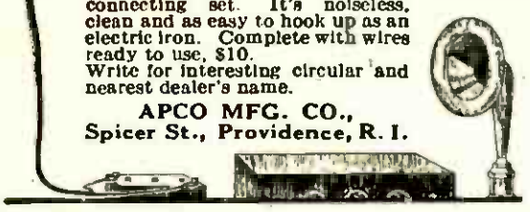
100 VOLT TYPE



You Can Also Charge "B" Batteries at Home!

The APCO "B" Battery Charger is a worthy ally to the successful APCO Charger for "A" batteries. Renews any 24 or 48 volt wet "B" battery in ten hours—without disconnecting set. It's noiseless, clean and as easy to hook up as an electric iron. Complete with wires ready to use, $10.
Write for interesting circular and nearest dealer's name.

APCO MFG. CO.,
Spicer St., Providence, R. I.



DX ANTENNA WIRE

Hard drawn copper—with CORRUGATED surface—gives increased range and clearer signal. Sold in coils of 100, 200, and 500 ft. $2.00 per 100 ft.

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The World's Standard Loud Speaker

Drills Easier!

—and furthermore, you can depend upon Spaulding Bakelite-Duresto panels as combining in one material these vital qualities—

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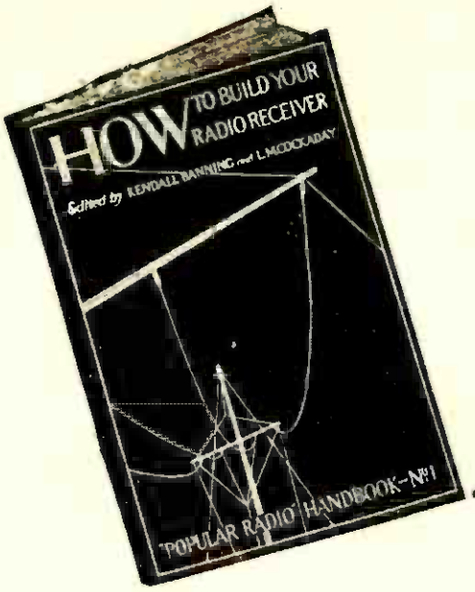

POPULAR RADIO

7 Months for $2.00

Including copy of this big 100-page Handbook in full cloth binding.

"How to Build Your Radio Receiver"

Compiled by Kendall Banning and L. M. Cockaday

Radio Simplified

The mounting interest in radio is due in large part to the ever increasing number of people now building their own sets. Correspondence to the Editors of POPULAR RADIO disclosed that many more would build receivers if it weren't for the forbidding looking hook-up diagrams and the unintelligible directions that accompany them.

This situation prompted the publication of "How to Build Your Radio Receiver." It is a primer in the best sense of the word. Thirty minutes' attention to the first half-dozen pages will enable you to read and understand the most complicated diagram.

You have a wide range of receivers from which to select the one that best suits your needs. And the clear, simple and concise instructions, supplemented by photographs and drawings, make it easy for you to construct a receiving set that will operate beyond your expectations. You can't appreciate the full fascination of radio until you have listened to a set of your own making.

"How to Build Your Radio Receiver" is now in its second edition, and the enthusiastic response of those who have secured copies assures a third edition soon. The Editors have accomplished something unusual inasmuch as experts have expressed themselves delighted with it as a reference volume and beginners have found it invaluable as a real instruction book.

An Attractive Combination Offer

For a limited time this big book will be included with a seven months' subscription for POPULAR RADIO, which will give you all the privileges of the Technical Service Bureau explained on page 60. All for $2.00. POPULAR RADIO carries only satisfied readers, so bear in mind that you run no risk and mail your remittance today.

Our unconditional guarantee protects you entirely. If you are not *more than satisfied*, notify us within ten days and your remittance will be returned in full.

Dept. 85
Popular Radio
627 West 43d St.
New York City

Enclosed remittance of $2.00 is payment in full for a 7 months' subscription for POPULAR RADIO. Also send me all charges paid, a copy of your 100-page, cloth-bound book, "How to Build Your Radio Receiver," by Kendall Banning and L. M. Cockaday.

Name.....

Address.....

City..... State.....

Offer expires August 31, 1924.

In "How to Build Your Radio Receiver" you will find complete constructional diagrams, specifications, photographs and instructions for building the following sets. Each has been selected as representative of its circuit because in laboratory tests it proved the best for distance, selectivity, tone volume, simplicity of construction, ease in tuning, reliability and all-around satisfaction.

A $5 CRYSTAL SET

The simplest up-to-date set for local broadcast reception. Approximate range, 15 miles, though distances up to 400 miles are not extraordinary. Gives clear signals on headset without distortion. No operating cost whatever.

THE HAYNES SINGLE TUBE RECEIVER

An efficient set that may be made by a novice at an approximate cost of only $15 for parts. Simple to tune, selective, good audibility. Long distance range up to 1,000 miles on earphones. Six-volt storage battery and 22½-volt "B" battery required, or may be adapted for dry cells and dry cell tubes.

A TWO-STAGE AUDIO-FREQUENCY AMPLIFIER

This instrument may be added to any set, crystal or tube, to strengthen the received signals, so that they will operate a loudspeaker. It is easy to construct, efficient and inexpensive, costing only $15 for parts. Operates on the same "A" battery that is used on the vacuum-tube detector unit.

THE COCKADAY 4-CIRCUIT TUNER

A 3-tube set, famous for its high selectivity and beautiful tone. So neat and compact that it may be kept in a bureau drawer. Cost of parts about $40. Receiving range approximately 1,500 miles on a loudspeaker. Operates on a 6-volt storage battery and two 45-volt "B" batteries, or may be adapted to dry cells and dry cell tubes.

A 5-TUBE TUNED RADIO-FREQUENCY RECEIVER

Two stages of tuned radio-frequency amplification, detector, and two stages of audio-frequency amplification are here employed so that the possibility of "oscillation and re-radiation" is eliminated. The set can be operated on a loop antenna and may be built at a cost of only $90 for parts. Six-volt storage battery and two 45-volt "B" batteries required. Range about 1,000 miles on loop or indoor antenna, and 2,500 to 3,000 miles on an outdoor antenna.

THE "IMPROVED" COCKADAY 4-CIRCUIT TUNER

Probably the most important contribution yet made to the equipment of the radio fan. A compact 5-tube set with a receiving range of over 3,000 miles. Cost of parts about $95. Wavelengths range from 150 to 675 meters. Automatic tuning and power amplification. Maximum volume of sound, excellent reproduction and no interference. Requires a 6-volt "A" battery, three 45-volt "B" batteries, one 22½-volt "B" battery and a 9-volt "C" battery.

THE REGENERATIVE SUPER-HETERODYNE RECEIVER

More sensitive, more selective and more simple to tune than any other 6-tube receiver yet developed. A three-section, 6-tube set employing the Haynes Single Tube Receiver as tuner. May be further extended to a four-section, 8-tube set by the addition of the two-stage audio-frequency amplifier. The cost of parts approximately $100. Range of 3,000 to 4,000 miles on a loudspeaker. Has been called the "Rolls-Royce" of radio receivers.

POPULAR RADIO

627 West 43d Street :: New York City

Service That Serves

Without charge, every Popular Radio subscriber is privileged to submit any radio problems to Mr. Cockaday for answer by personal letter.

MANY radio problems are peculiar to the individual case. It is to help readers solve these troubles that POPULAR RADIO's Technical Service Bureau is maintained under Mr. Cockaday's personal supervision.

This Service is free to all subscribers. It is requested that you confine your questions to one general subject, write on one side of the sheet and enclose a stamped, addressed return envelope. But write as often as you wish in the assurance that a personal answer will be mailed promptly. This same Service is available to other readers who are not subscribers upon payment of a nominal charge of 50c. per inquiry.

Obviously the Service cannot be expected to answer questions that have already been covered in the magazine. Below is a condensed index to articles that have been published in previous issues. If you haven't these issues in your files we'll be glad to supply them at 35c. a copy.

May, 1922

—Harnessing waves to wire.
—How to tune a Regenerating Receiver.
—Symbols that help in reading diagrams.
—How to make soldered connections.
—How Radio waves are sent and received.

June, 1922

—Wireless that we can see.
—Can we talk to the dead by Radio?
—How electricity is generated.
—Tones that do and don't broadcast.
—How to make a simple tube Receiving Set.

July, 1922

—Steinmetz on ether waves.
—How to learn the code.
—How to make a two-circuit Receiving Set.
—How high frequency currents are generated.
—Pointers for preveuting interference.
—How to make a loose-coupler coil.

August, 1922

—How machines are controlled by Radio.
—How Radio circuits are coupled and tuned.
—What "call letters" mean.
—How to make a variable condenser.

September, 1922

—How to build the Armstrong Circuit Receiver.
—A resonance wave coil for reducing static.
—How to make a rotary plate condenser.
—The simplest receiving antenna.

October, 1922

—How to make a spider-web tuner.
—How to make your own grid condenser.
—Don'ts for Radio fans.
—How to use a Regenerative Set as a transmitter.
—How to restore worn-out crystals.

November, 1922

—Sir Oliver Lodge on ether waves.
—How to add a Vacuum Tube to your crystal set.
—The most popular transmitting aerial.
—How to make a novel variocoupler.

December, 1922 (Out of stock.)

January, 1923 (Out of stock.)

(A Reprint of Mr. Cockaday's article describing the DX Regenerative Receiver may be had for 25 cents.)

February, 1923 (Out of stock.)

March, 1923 (Out of stock.)

April, 1923 (Out of stock.)

May, 1923 (Out of stock.)

(A full description, however, of Mr. Cockaday's original 4-Circuit Tuner will be found in POPULAR RADIO's handbook, "How to Build Your Radio Receiver," advertised on page 58.)

June, 1923 (Out of stock.)

July, 1923

—The ratio in size between your antenna and your coil.
—Useful facts about ear-phones.
—How to make a dry-cell tube Regenerative Set.
—How to keep up your storage battery.

August, 1923 (Out of stock.)

(A full description, however, of the Tuned Radio Frequency Receiver will be found in POPULAR RADIO's handbook, "How to Build Your Radio Receiver," advertised on page 58.)

September, 1923

—How to get a radio license.
—How weak signals are regenerated.
—How to make a battery charging rectifier.
—How to build the Haynes DX receiver.

October, 1923

—Practical hints for Coil Calculations.
—How to make a Two-stage Audio-frequency Amplifier.
—Ten good rules for Broadcast Listeners.
—How to make a simple Honeycomb Receiver.

November, 1923

—The 100 Best Hook-ups (Part 1).
—Receiving without Antennas.
—How to build the New Regenerative Super-heterodyne Receiver (Part 1).
—How to build a combination Short and Long-wave Receiver.

December, 1923

—How to Select your Radio Parts.
—The 100 Best Hook-Ups (Part 2).
—How to Read a Diagram (Part 1).
—How to build an efficient Crystal Receiver
—How to Build the Super-heterodyne Receiver (Part 2).

January, 1924

—How to Build the Improved Four-circuit Tuner.
—100 Best Hook-ups (Part 3).
—How to Read a Diagram (Part 2).
—How to Make a Chopping Bowl Loudspeaker.

February, 1924

—How to add "Push and Pull" amplification to the original 3 tube Cockaday 4-Circuit tuner.
—The original 4-Circuit Tuner as a Portable Set with Loop.
—The 100 Best Hook-ups (Part 4).
—How to build a 3-tube Reflex Receiver (Part 1).

March, 1924

—Hoffman Transformer Measurement Chart.
—The 100 Best Hook-ups (Part 5).
—How to Build an Amateur Transmitter.
—A 3-tube Reflex Receiver (Part 2).

April, 1924

—How to Build a Simplified Neutrodyne Receiver.
—The 100 Best Hook-ups (Part 6).
—How NOT to Tune the Single Circuit Receiver.
—A Novel Substitute for "B" Batteries.

May, 1924

—A Compact Radio Kit for a Spring Hike.
—How to Get the Maximum Radio-frequency Amplification.
—100 Best Hook-ups (Part 6).
—Where Interference Comes In.
—How to Make an Audio-frequency Amplifier that Does Not Distort.

June, 1924

—How to Install a Receiver on your Boat.
—The 100 Best Hook-ups (Part 7).
—How to Make Your Own Grid Condensers.
—How to Build a Regenerative Receiver for Use with an Indoor Antenna.
—How to Make a Two-Slide Tuner.
—How to Calculate the Wiring of Coils

July, 1924

—How to Avoid Local Interference.
—How "Resistance" Affects Radio Circuits.
—An Ideal Set for Summer-time Reception.
—100 Best Hook-ups (Part 8).
—How to Do Your Soldering Correctly.
—How to Build the POPULAR RADIO Portable.

POPULAR RADIO, INC.

627 West 43d Street **Dept. 88** **New York City**

Build it at Our Expense

POPULAR RADIO will give you, free of charge, any or all of the parts listed below, as reward for securing a few subscription orders from your friends

HERE is an opportunity for you to secure all or any of the parts needed to build complete either of two very popular receivers or an amplifier—and at no expense. You, surely, are well acquainted with the features of POPULAR RADIO that have given it more subscribers than any other radio publication. Won't it be easy to use your enthusiasm in inducing your friends and their friends to subscribe too?

To make it possible for you to secure an order from everyone we will permit you to make the following offers:

POPULAR RADIO

24 Months	for	$5.00	counts	75	credits
12 "	"	3.00	"	50	"
8 "	"	2.00	"	33	"
6 "	"	1.50	"	25	"
4 "	"	1.00	"	16	"

You remit the full amount collected with names and addresses of subscribers and ask for the parts that your total CREDITS entitle you to; or, if you prefer, let us credit them to you and when you have a substantial total, order the parts you want and we will charge against your CREDIT account.

As a further concession, suppose you have sent us 5 annual subscriptions for POPULAR RADIO, and in addition to a set of Approved Cockaday Coils want a 6-ohm Amsco Rheostat. The Coils are 220 CREDITS and the Rheostat, 50 CREDITS. The subscriptions total only 250 CREDITS and you need 20 CREDITS more. We will permit you to buy the additional CREDITS at 3c. apiece—so for 5 annual subscriptions and 60c. in cash we will ship the two parts you want.

Your choice is not limited to the parts listed below. On request we'll gladly quote you the CREDITS required for any radio material of any make you prefer.

CREDITS Needed for Parts Required for the "Improved" Cockaday 4-Circuit Tuner

(Described and illustrated in POPULAR RADIO for January, 1924)

Quantity	Item	Credits
1	set Approved Cockaday Coils	220
2	23-plate Amsco Vernier Variable Condensers @ 180	360
2	Amplex Grid-densers @ 50	100
1	Bradleyleak	74
5	Melco Vacuum tube sockets @ 40	200
1	6-ohm Amsco Rheostat	50
2	Pacent double circuit jacks @ 40	80
1	Pacent single circuit jack	28
2	American Transformers @ 280	560
1	Pair Como push-pull transformers	500
2	Switch levers and knobs @ 12	24
11	Switch points @ 3/5	7
4	Switch stops @ 3/5	2
1	.0005 mica condenser-transformer mounting	18
1	.00025 mica condenser with clips for grid leak	18
3	48,000-ohm Lavite resistances @ 60	180
1	400-ohm Amsco potentiometer	70
12	Hard rubber binding posts @ 4	48
1	7 x 24" panel—hard rubber	120
1	3 x 2¼" panel—hard rubber	16
1	12 x 1" panel—hard rubber	16
3	20-ohm Amsco rheostats @ 60	180
1	Durham variable grid leak	30
		2901

CREDITS Needed for Parts Required for the Tuned Radio-Frequency Reflex Receiver

(Described and illustrated in this issue of POPULAR RADIO)

Quantity	Item	Credits
1	Hammarlund .0005 mfd. (21-plate) condenser	240
1	Hammarlund .001 mfd. (41-plate) condenser	280
1	U. S. Tool 3-plate condenser	60
1	R. U. F. semi-fixed crystal detector	50
1	Amsco 30-ohm rheostat	50
1	Carter double-circuit jack	40
1	Carter single-circuit jack	36
1	Federal No. 65 audio-frequency transformer	280
1	Amertran Type AF-7 (ratio 3½ to 1) audio-frequency transformer	280
2	N. Y. Coil mica fixed condensers, .001 mfd. (with soldering lugs) @ 16	32
	Amsco switch lever with switch points and stops	19
	Materials for the construction of the special fixed coupler and the radio-frequency transformer	85
2	Federal sockets for 199 tubes @ 40	80
1	Composition panel (Radion 7" x 18")	90
1	Cabinet (Shepco 18")	190
8	Eby Binding Posts @ 8	64
2	UV-199 or C-299 vacuum tubes @ 200	400
		2276

CREDITS Needed for Parts Required for the Non-Regenerative Tuned-Radio-Frequency Receiver

(simplified neutrodyne)

(Described and illustrated in POPULAR RADIO for April, 1924)

Quantity	Item	Credits
	Materials for the construction of the special variocoupler and the radio-frequency transformer:	
	½ lb. of No. 22 D. S. C. magnet wire	36
	¼" diameter brass rod, 7½" long	6
	Bakelite tubing 4" inside diameter, 1/16" wall, 4½" long	24
	Bakelite tubing 3" inside diameter, 1/16" wall, 2" long	10
	Bakelite tubing 3" inside diameter, 1/16" wall, 1¾" long	10
	One Pacent honeycomb coil, 75 turns	24
	(These special variocouplers and radio-frequency transformers cannot at the present time be purchased already made up.)	
1	21-plate Cardwell condenser (.0005 mfd.)	200
1	41-plate Cardwell condenser (.001 mfd.)	240
1	11-plate Cardwell condenser (.00025 mfd.)	170
1	Dubilier mica fixed condenser .00025 mfd. (with grid-leak clips)	18
1	Dubilier mica fixed condenser .0025 mfd.	18
1	Daven grid-leak 3 megohms	20
4	Alden-Napier standard sockets (type 400) @ 30	120
2	Cutler-Hammer rheostats (6 ohms) @ 40	80
1	Federal double-circuit jack	32
1	Federal single-circuit jack	24
1	Amertran transformer 5-1 ratio	280
1	General Radio transformer 3½-1 ratio	200
1	Cutler-Hammer filament switch	24
1	Amsco switch lever	12
7	Switch points and 2 stops @ 11/5	11
1	7" x 26" composition panel	110
1	Special knocked-down solid mahogany cabinet which requires no sub-base	400
1	Hard rubber binding post panel, 1" x 10" by 3/16" thick	10
1	Strip of brass 24" long, ½" wide, 1/8" thick for condenser brackets	14
8	Eby binding posts @ 8	64
		2157

For only 44 Credits we can supply the famous POPULAR RADIO Blueprints for the Amplifier or either Receiver listed above. Full description of these *actual size prints* will be found on page 64.

POPULAR RADIO
Department 81
627 West 43d Street, New York City

VISION AND JEFFERSON TRANSFORMERS

Radio amplification is due in no small degree to Jefferson's vision of Radio possibilities.

Jefferson experiments in amplification predate the public's acceptance of Radio—the time when it was looked upon generally as an impossibility. As a consequence Jefferson Transformers have set a standard in transformer design. Owing to the years of experience back of Jefferson Transformers they give true modulation over the entire vocal and instrumental range.

Install Jefferson's in Your Set

If you are building a set requiring Radio Intermediate or Audio Frequency Amplification, and want to obtain the finest results, install Jefferson's —the quality choice of professional and amateur radioists.

There's a Jefferson Transformer for Every Circuit

An interesting bulletin, "Putting Quality into Radio," will be sent to you upon request.

Jefferson Electric Mfg. Co.
427 So. Green St. Chicago, Ill.

Are you getting DX?

This book will show you how to get more!

It tells all about vacuum tubes and how to control them so as to get greatest D X, most volume and longest life from tubes and batteries. How to get maximum regeneration, clearest signals. Tells how vacuum tubes work.

IT'S FREE, WRITE FOR IT TO

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Dept. PR 824 Harrisburg, Penna.

A-C DAYTON

In the September Popular Radio, we will announce the new A-C Dayton XL-5 Receiver, licensed, approved and guaranteed by the Polydyne Corporation of N. Y.

Circular describing this wonderful set mailed on request

THE A-C ELECTRICAL MFG. CO.

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Makers of Electrical Devices for over 20 Years

Every Question ANSWERED for only $1

At last you have under one cover a Complete Radio Handbook

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514 PAGES

Compiled by

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NO more need you turn from book to book, hoping to find what you want. It is all here, in 514 pages crammed full of every possible radio detail. Written in plain language, by engineers for laymen. Clears up the mysteries, tells you what you want to know. A complete index puts everything within your reach in a few seconds.

IT EXPLAINS: Electrical terms and circuits, antennas, batteries, generators and motors, electron (vacuum) tubes, every receiving hook-up, radio and audio frequency amplification, broadcast and commercial transmitters and receivers, super-regeneration, codes, license rules. Many other features.

Under one cover. Yes, it is all in one volume of 514 pages of clear type with hundreds of diagrams and illustrations. Takes the place of eleven or more specialized texts, each costing from two to ten times the dollar you pay for this single book. Belongs in every radio-equipped home, on every amateur's table.

Send $1 to-day and get this 514-page I. C. S. Radio Handbook—the biggest value in radio to-day. Money back if not satisfied.

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Box 8254-C, Scranton, Penna.

I enclose One Dollar. Please send me—post-paid—the 514-page I. C. S. Radio Handbook. It is understood that if I am not entirely satisfied I may return this book within five days and you will refund my money.

Name.....

Address.....

Blueprints!

Full satisfied enjoyment of radio comes from building your own. Economy of time, labor and money is insured by using POPULAR RADIO SIMPLIFIED BLUEPRINTS.

EACH set consists of three prints; (A) Panel Pattern; (B) Instrument Layout; (C) Wiring Diagram.

Panel Pattern.

This blueprint is the exact size of the actual set. So accurate that you need merely lay it on your panel and drill as indicated. You can readily appreciate the convenience of this Blueprint. No scaling to do, no danger of ruining the panel through faulty calculation.

Instrument Layout.

Again you have an actual size print of each instrument and binding post and its exact location both on the panel and within the cabinet. Even the cabinet structure is clearly shown.

Wiring Diagram.

The unusual feature of this Blueprint is that it is a **full size picture diagram** of the finished set. Each instrument or other part appears exact size and the wires are so clearly traced from one contact to another that you can connect all terminals accurately without even knowing how to read a hook-up diagram.

Blueprints Ready.

At the present time three sets of Blueprints are available and have been priced at the very low figure of $1.10 per set, postpaid. Each set consists of three Blueprints and we cannot break a set to supply single prints.

"Improved" Cockaday 4-Circuit Tuner was described in the January, 1924, issue of POPULAR RADIO. It is a simplified regenerative set that can be built with about $95.00 worth of parts. It provides for automatic tuning, practically unlimited distance range, maximum volume excellent reproduction and no interference.
Set of three constructional Blueprints $1.10.

The Non-Regenerative (Simplified Neutrodyne) Tuned-Radio-Frequency Receiver, described in the April, 1924, issue of POPULAR RADIO, can be built with parts costing about $70.00. This circuit has remarkable sensitivity and is notable for its ease of control, distance range and clarity of reception.
Set of three constructional Blueprints, $1.10.

In the May, 1924, issue of POPULAR RADIO, is a complete description of an **Audio-Frequency Amplifier.** This is a newly developed type of amplifier that is entirely unmarred by distortion. The parts will cost about $45.00. Blueprints further simplified by showing circuit diagrams in right-to-left sequence—the way you build.
Set of three constructional Blueprints, $1.10.

For convenience use the coupon below in ordering sets of Blueprints. If you desire any of the descriptive articles mentioned above, enclose 35c additional for each article wanted. Complete list on page 60.

POPULAR RADIO, INC.

627 West 43rd Street **Dept. 84** **New York City**

POPULAR RADIO, Inc., Dept. 84
627 West 43rd St., New York City Date.....

Enclosed is my remittance of $....., for which kindly send me Blueprint Set (s) consisting of Panel Pattern, Instrument Layout and Wiring Diagram as checked below:

- ☐ **"Improved" Cockaday 4-Circuit Tuner.**
- ☐ **Non-Regenerative Tuned-Radio-Frequency Receiver.**
- ☐ **Audio-Frequency Amplifier.**

Name.....

Address.....

City..... State.....

Any one set of three Blueprints for $1.10; any two sets for $2.20; all three sets for $3.30

NOTE:

Dealers write for terms

RECEPTRAD

Replacement Parts

Supreme for the SUPER-HETERODYNE

The efficiency and perfect construction of RECEPTRAD Parts combine to produce a Super-Heterodyne set that is unsurpassed in volume, clarity and distance.

FREE

Super-Heterodyne Blue Print showing complete hookup of the wonderful Greiff Super. Merely send a post card mentioning your dealer's name and address.

RADIO RECEPTOR CO.

59 Bank St., New York City

RECEPTRAD RR PRODUCTS

all free! **RADIO LIBRARY**

JUST SEND A POST CARD

YOU GET absolutely free—the A-K "Library of Latest Radio Literature," written by foremost radio authorities. Contains HUNDREDS of valuable wiring diagrams, HOOK-UPS, illustrations, articles, data, etc.

EXPLAINS in clear, understandable language the popular new circuits: reflex, neutrodyne, plusiform, "nameless," superheterodyne, etc., and how to build sets. Covers long and short wave amplification, push-pull and audio amplifiers. Latest information on multitudes of other radio subjects. LOG BOOK INCLUDED FREE. Also our latest Radio Catalog featuring NATIONALLY ADVERTISED lines at attractive savings. Write today—offer limited. Address

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ATWOOD KING INC.

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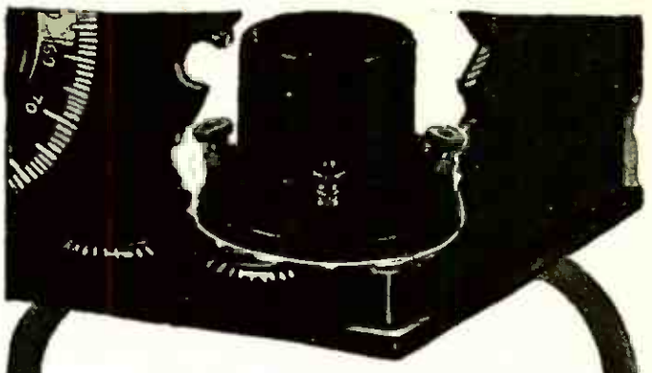
SICKLES

Tuned Transformer Coil

Specially designed for tuned antenna circuits and tuned radio frequency amplifier circuits.

The F. W. SICKLES CO.
Springfield, Mass.

Dept. B. **337 Worthington St.**



Get Directly at Them

Are the contacts in the sockets of your radio set easily accessible for ordinary and necessary cleaning?

With Na-ald De Luxe Sockets in use you need neither sandpaper nor an extra reach to keep contact strips and tube terminals bright and clean.

Just rotate the tube three or four times. Instantly the dual-wipe laminated contacts remove corrosion, making a bright perfect connection. This action is on the side of the tube terminals away from the soldered ends. "It's the contact that counts."

Make your Superheterodyne set free from socket trouble by using Na-ald De Luxe Sockets.

Sockets and panel mounts for all tubes. Prices 35c to 75c. Send for catalog.

ALDEN MANUFACTURING CO. Dept. C. Springfield, Mass.

NA-ALD

5 Radio Winners!

Micrometer Control With One Knob
Noiseless—Stepless—Selective

Bradleystat
PERFECT FILAMENT CONTROL

Noiseless, stepless filament current control for ALL tubes. Is standard equipment on many sets, including Amrad Console models.

Price - - $1.85

Bradleyleak
THE PERFECT GRID LEAK

Range—½ to 10 Megohms. A grid condenser of 0.00025 mf supplied extra. Endorsed by Cockaday, Amrad, Flewelling, Crosley, etc.

Price - - $1.85
Condenser - .35

Bradleyohm
THE PERFECT RESISTOR

An adjustable resistor for radio circuits. Made in three ranges.

10,000 to 100,000 ohms
25,000 to 250,000 ohms
50,000 to 500,000 ohms

Price, any range, $2.00

Bradleyometer
THE PERFECT POTENTIOMETER

A stepless, non-inductive potentiometer for all radio circuits. Complete range in half turn of knob. Made in 200 and 400 ohms.

Price,
200-ohm - $2.00
400-ohm - 3.00

Bradleyswitch
PERFECT BATTERY SWITCH

For A and B battery circuits. Only ONE hole required in panel to mount the switch. Nickel-plated and totally enclosed.

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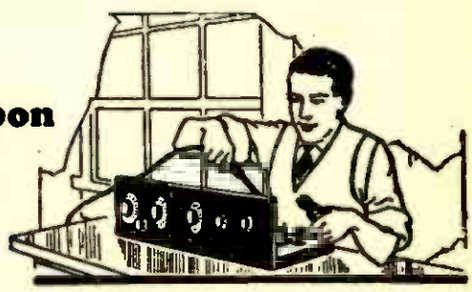

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